South Africa

COTO

Committee of Transport Officials

Standard Specifications for Road and Bridge Works for South African Road Authorities

Draft Standard (DS)

CHAPTER 12: GEOTECHNICAL APPLICATIONS

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12.1 GROUND ANCHORS

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A12.2 GROUND ANCHORS

PART A: SPECIFICATIONS

A12.2.1 SCOPE

This Section covers the design, supply, installation, stressing and testing of cable and rigid anchors.

A12.2.2 DEFINITIONS

The following definitions shall apply to these specifications:

Cable anchor - is a generic term covering all types of wire-strand cable ground anchors which are generally subdivided into rock anchors and soil anchors. It is an installation which is capable of transmitting an applied tensile load to a stable load bearing stratum. The installation generally consists of a stressing anchorage, a tendon with an uncoupled/free length and an anchored/ fixed length in the load bearing stratum.

Temporary anchor / Rockbolt / Soil nail / Dowel - installations used during the construction phase of a project to provide support for the period until the permanent works are in place.

Test Anchor - is an anchor installed according to the Contractor's proposed method statements whereby the Contractor shall demonstrate both the suitability of the plant and equipment, the design of the anchors as well as their competency to install the anchors as designed and specified. The term 'test anchor' shall include 'proving', 'trial' and 'site suitability' anchors as referred to elsewhere in this specification and other supporting documents referred to.

Deadman Anchor - are anchors that have anchorages at both ends of the tendon or bar. One end of the anchor may be permanently fixed into an anchor block which generally will be buried during construction or may be a retaining structure/element allowing tensioning to be carried out from the other end. Other types have anchorages at both ends allowing tensioning from either end.

Permanent Anchor / Rockbolt / Soil Nail / Dowel - an installation required to ensure the stability and satisfactory performance of the permanent works being supported.

Stressing Anchorage - is a component of a ground anchor capable of transferring the tensile load from the tendon to the surface of the ground or structure requiring support:

- Normal type - An anchorage designed to permit the load in the anchor tendon to be raised or lowered within the entire range of operating stress levels and measured when necessary to meet the requirements of acceptance testing. This is only possible during the initial stressing phase as protruding tendons are cut making further measurement or adjustment impossible.
- Re-stressable type - An anchorage meeting all the requirements of the normal anchorage and permitting the load on the anchor tendon, throughout the life of the support structure, to be measured by check lifting. It also allows small losses of up to 10 % of the working load to be recovered.

- De-tensionable type - An anchorage meeting all the requirements of the re-stressable type and in addition permitting the anchor tendon to be de-tensioned in a controlled manner at any time during the life of the anchor.

Fixed Anchor Length - is the designed length of the anchor over which the tensile load is transferred to stable load bearing strata.

Free Anchor Length - is the design length between the proximal end of the fixed anchor length and the stressing anchorage.

Proximal End - is nearest to the stressing anchorage or collar head.

Distal End - is furthest from the stressing anchorage or collar head.

Anchor Jacking End - the jacking end of the anchor is defined as the concrete bearing pad and the steel thrust plate.

Anchor Tendon - is that part of the anchor which transfers the tensile load from the fixed anchor to the stressing anchorage. Tendons can comprise single 7 wire strands or multiples thereof.

Anchor Tendon Bond Length - is the length of the anchor tendon which is bonded directly to the encapsulating grout within the fixed anchor length.

Capsule Bond Length - is the overall length of the outer perimeter of the capsule within the fixed length which is bonded to the surrounding homing grout.

Fixed anchor length - the length of tendon/ anchor over which the tensile load is transmitted to the surrounding ground.

Tube- a- manchette - comprises single or multiple holes provided in a discrete section of a high pressure grout tube tightly sheathed with plastic tubing which allows the outward passage of grout under high pressure.

Anchor assemblage - comprises the tendon, in its corrugated sheathing, complete with spiralled external grout pipes

Calculated Free Tendon Length - the calculated length of the anchor tendon is the length of tendon at the point at which it effectively bonds with the encapsulating grout in the fixed length once it is stressed. This can only be determined during the initial stressing operation from load extension tests. The nominal free anchor tendon length may be extended by the stressing length depending on the type of stressing system employed.

Homing Grout - the grout injected before or after tendon homing, and prior to stressing.

Primary Grout - the grout injected to secure the fixed length of the anchor within the sheath. The Contract Documentation may allow for the grouting of the free length under this operation or may specify that the free length only be grouted on the successful completion of the stressing.

High Pressure Grout - secures the fixed length to the surrounding stable strata.

Secondary Grout - is the grout injected after stressing to bond and/or protect the free length of the tendon where post stressing grouting of the free length is specified in the Contract Documentation.

Lift-Off Load - is the minimum load monitored during a stressing or load checking operation which provides a defined clearance, typically 0,1 mm – 1,0 mm, between the anchor head or ring nut and the anchor plate.

Relaxation - is the decrease of load in the tendon over time.

Creep - is the movement of the fixed length, with time, under load.

Skin Friction - is the bond value at the ground/grout interface over the fixed anchor length.

De-bonding - is the breakdown of bond at the grout/tendon or ground/grout interface.

Decoupling - is the separation of tendons over the free length from the surrounding ground and/or grout, via greased sheathing.

Characteristic Strength - the value of cube strength of grout or concrete or the ultimate tensile strength of the steel in the wire strand, below which not more than 5 % of the test results fall.

Rigid Anchors - is a generic term covering all types of generally non flexible anchors including rock dowels, rockbolts and soil nails.

Rock Dowel - is a generic term covering all types of steel bars and/or polymeric rods in rock which are fully bonded and untensioned.

Rockbolt - is a generic term covering all types of steel bars and/or polymeric rods in rock which are partially or fully bonded and tensioned.

Soil Nail - is a generic term covering steel bars and/or polymeric rods in soil which are fully bonded but generally untensioned.

Bolting - describes the drilling of holes by means of percussion or hydraulic equipment in rock and the subsequent insertion and grouting or mechanical anchoring of steel bars within these holes. Face plates, washers/spacers and nuts are generally secured to the protruding end of the bolts which are provided with a thread.

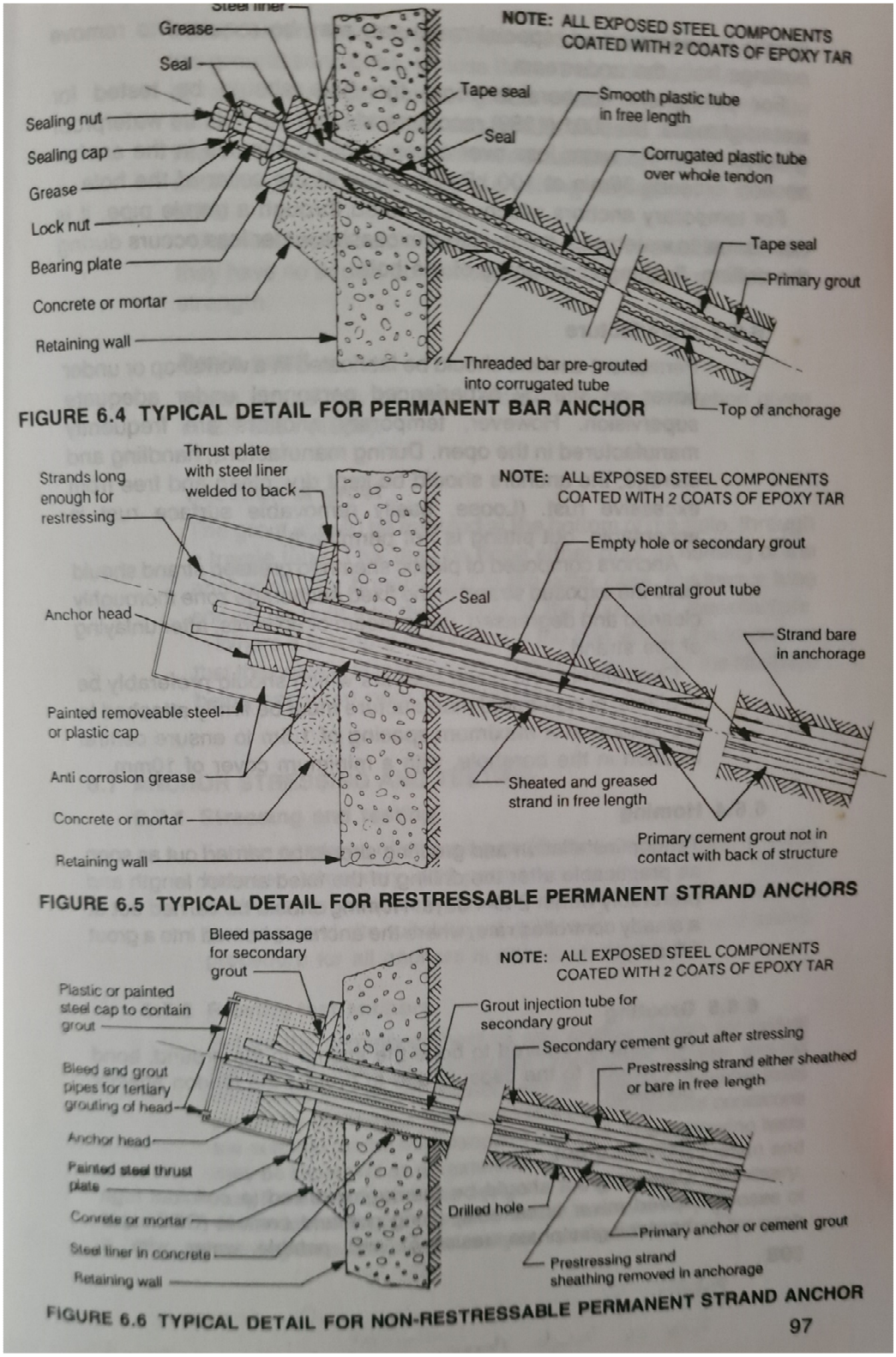
Soil Nailing - as for bolting but inserted into soil and/or highly/completely weathered or friable rock.

Self-Drilling Anchors - are hollow stem anchors provided with sacrificial drilling bits with grout introduced concurrently through the stem so that the grouting is completed on drilling of the anchor. The sacrificial drilling bit must be capable of drilling through obstacles such as concrete and rock boulders and capable of intersecting rock if required.

Anchor Head Protection - serves to both protect the bolt head and face plate against vandalism / corrosion and to camouflage it so that it blends in with the surrounding ground surface.

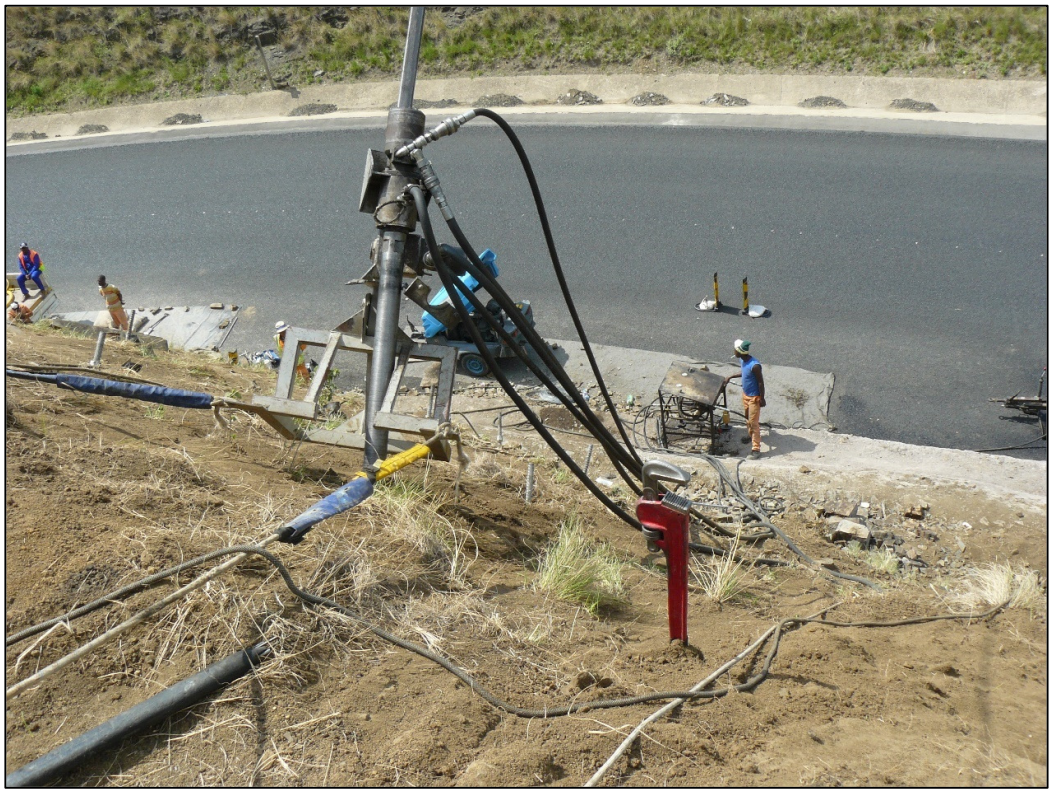
Driven Tipping Anchor - describes all types of anchors first driven into soil and then pulled back to engage the tipping anchoring mechanism. Pre-drilling may be required before driving in competent formations such as very soft rock and/or stiff/dense soils.

Screw Anchor - describes all types of screw and helical earth anchors. They shall be used in soil only.



From Code of Practice 1989

N10 Olifantskop Pass



Port St Johns Cuttings

N9 Lootsberg & Naudesberg Passes

A12.2.3 GENERAL

A12.2.3.1 Method Statements

Where so indicated by the Engineer the Contractor shall prepare detailed method statements for each facet of the work describing key aspects such as construction methodology, key plant, materials, personnel as well as any programme constraints of the envisaged construction process.

These method statements shall be prepared and submitted to the Engineer for approval prior to commencement of that activity, within time scales specified. The onus lies with the Contractor to ensure that the information is obtained and that associated activities are completed expeditiously to avoid any delays in the commencement, continuation and completion of the required works. Unless otherwise specified or provided for in the Contract Documentation no permanent works shall be commenced until the Engineer's approval of the relevant method statement. The Contractor shall, however, remain responsible for all work-methods, materials, plant and equipment used, notwithstanding acceptance by the Engineer.

The Contractor shall be required to construct test or trial anchors and the testing thereof as specified herein and shall make due allowance therefore in his programme. Allowance shall also be made for allow for the Engineer's assessment of constructed anchors, procedures followed, and materials and plant utilised and test data. Production anchoring shall not be permitted until it is shown and accepted by the Engineer that the Contractor possesses the necessary experience, plant and equipment to carry out the works as specified in the Contract Documentation.

It should be noted that work shall only be performed by personnel listed by the Contractor. If personnel changes need to be made during the project, works shall be suspended until replacement personnel are approved by the Engineer. Time lost due to incomplete submissions, unacceptable submissions, or obtaining approval of replacement personnel will not be considered as cause for extension of time or delay claims. All costs associated with incomplete, replacement, or unacceptable submissions shall be to the Contractor's cost.

Once approved in writing by the Engineer, these shall become the method statements in accordance whereby the relevant portion of the works shall henceforth be executed. Notwithstanding, the Engineer may require revision from time to time if circumstances during construction arise which warrants change.

A12.2.3.2 Materials and materials design approvals

All materials used in the works described hereunder shall meet the appropriate standards given below and/or specified in the Contract Documentation and shall be subject to the approval of the Engineer. The Contractor shall submit product certificates, conformance documentation related to the specifications, test results as required together with samples of materials and where applicable, materials designs that he proposes to use in the construction of the works to the Engineer for his acceptance/approval as provided for in the Contract Documentation.

Due allowance shall be made for obtaining materials, resubmissions and re-designs, all to the required/approved standards, methods and practices in attending to these requirements. Particular attention shall be paid to the early submission of materials-, concrete- and grout mix designs where parameters at various ages may be specified. No consideration for extension of the contract period will be entertained for delays incurred in meeting these requirements.

The Contractor's attention is drawn to the approvals required as indicated in Table A12.2.3-1 below regarding works carried out under this section of the works:

Table A12.2.3-1: Required Approvals

Clause	Requirements	Period
	Materials Design Approvals	
A12.2.5.1b)	Design for the homing, encapsulation and high pressure grout	4 weeks before trial anchor construction
	Materials approvals	
A12.2.5.1b)	Samples, prototypes and technical details of the proposed anchoring materials	4 weeks before the approved programmed trial/test anchor construction activity.
A12.2.6.1d)	Full details of the tensioning system(s), materials and equipment, and methods to be adopted in tensioning and related operations	4 weeks before the approved programmed trial anchor construction activity
	Construction Approvals	
A12.2.7.2 a)	Construction Method Statement for trial/test cable anchors	Two weeks prior to commencement of trial/test anchor installations
A12.2.7.2 a)	Construction Method Statement for working/production cable anchors	Four weeks after Engineer's approval of the installation and test results
A12.2.7.2 a)	Installation of working/production cable anchors	One week after Engineer's approval of Construction Method Statement
A12.2.7.3 b)	Construction Method Statement for trial/test rock bolts/ soil nails	Two weeks prior to commencement of trial/test rock bolt/ soil nail installations
A12.2.7.3 b)	Contractor's Construction Method Statement for rock bolting / soil nailing	4 weeks prior to commencement of any permanent rock bolting / soil nailing.
A12.2.7.3 b)	Installation of working rock bolts/ soil nails	Engineer's approval of Construction Method Statement for production rock bolts/ soil nails

A12.2.3.3 Additional requirements

The works in this section comprise the design, manufacture, installation, tensioning, testing, protection and the performance monitoring of cable anchors, soil nails, rockbolts and mechanical earth anchors for the application as described in the Contract Documentation. The works are of a highly specialised nature and shall only be carried out by Contractors who have the necessary experience, expertise, plant and equipment, to carry out the works as specified. The CV's of all key personnel shall be submitted for approval by the Engineer.

- Unless otherwise specified in the Contract Documentation all ground anchors shall be designed and constructed in compliance with these specifications and in compliance with the following standards/codes of practice:
  - Lateral Support in Surface Excavations: Code of Practice 1989: SAICE.
  - Execution of Special Geotechnical Works-Ground Anchors; BS EN 1537: 2013.
  - British Standard Code of Practice for Ground Anchorages; BS 8081: 2015
  - BS EN 14490:2010. Execution of Special Geotechnical Works- Soil Nailing

The installation of working cable anchors, soil nails or rockbolts or mechanical earth anchors shall only commence when the Engineer has given his written acceptance of the designs for which the Contractor is responsible in terms of the Contract Documentation, the Contractor's method statements, the proposed materials, the proposed drilling methods and of the Contractor's successful installation and testing of the trial anchors/ soil nails/rockbolts.

A12.2.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

The Contractor shall, unless otherwise indicated in the Contract Documentation, be responsible for the design of the ground anchors to meet the performance requirements specified by the Engineer. The Contractor shall similarly be responsible for the design of all grout, concrete and/ specialised cementitious products required for the installation and protection of the ground anchors.

The following shall be applicable in this regard:

- The ground anchors shall be designed in compliance with these specifications and in addition, the following in the order of precedence shown, unless specified otherwise by the Engineer:
  - Lateral Support in Surface Excavations: Code of Practice 1989: SAICE.
  - Execution of Special Geotechnical Works-Ground Anchors; BS EN 1537: 2013.
  - British Standard Code of Practice for Ground Anchorages; BS 8081: 2015
  - BS EN 14490:2010. Execution of special geotechnical works. Soil nailing

- The Engineer shall specify the following design criteria:
  - Sequencing of the works in the event that it impacts on the design
  - Whether the anchors are permanent or temporary
  - Working load
  - Class and type of anchor
  - Corrosion protection
  - Minimum free length
  - Minimum fixed anchor length
  - Inclination
  - Directional tolerances

- The following geotechnical information will be provided to the Contractor:
  - Rock or ground Engineering characteristics
  - Borehole logs and cores for inspection
  - All other pertinent factual geotechnical information as may be available

The Contractor shall in carrying out his design obligations, familiarise himself with the available information and shall, at his own cost, carry out whatever further investigations are required. This aspect must be catered for in the programme. In carrying out these obligations the Contractor shall take note of the following:

- No cable anchor may be installed closer than 1,0 m from any point on the exterior of a known service, service duct or culvert.
- The anchors shall be designed such that the working stress in the tendons does not exceed 53% of the characteristic breaking stress for permanent anchors and 64 % for temporary anchors.
- The Contractor shall assess the suitability of the bursting reinforcement in the concrete bearing pad to ensure that it is compatible with the stressing system he intends using and will efficiently transfer and maintain the anchoring forces. Allowance shall be made by the Contractor for any additional reinforcement required for the anchorage of his anchors. Payment for this additional reinforcement shall be deemed to be included in the rates for the anchors.
- Test and/or site suitability anchors shall be carried out to the Engineer's requirements and as specified in the Contract Documentation.
- The Contractor may not commence with the manufacture and installation of ground anchors until the Engineer has given written approval of the Contractor's design.

A12.2.5 MATERIALS

All elements subject to hot dip galvanising shall be treated in accordance with SANS 121/ISO 1461 to a mean coating thickness of 85µm and thereafter passivated using a non-toxic approved product.

A12.2.5.1 Materials for cable anchors

a) General

All materials used in the ground anchors shall comply with the requirements of Clause A13.5.5 of Chapter 13 and all equipment used in the fabrication, grouting and stressing shall comply with the requirements of Clause A13.5.6 of Chapter 13.

All materials shall also comply with the following additional requirements:

The tendons shall be manufactured from class1 relaxation high tensile non-alloy 7-wire strand with a nominal tensile strength of 1 770 MPa or multiples thereof in accordance with BS 5896 (2012). The sheathing and injection of the grease into the annulus between the strand and the sheathing shall all be performed during the course of manufacture, and the grease shall comply with the requirements given in Table A12.2.5-1 for rust-inhibiting properties. The minimum thickness of the sheathing shall be 1,0 mm.

Each batch of strand delivered to site shall be accompanied by a test certificate issued by a recognised accredited testing authority specifying the characteristic strength of the strand, plus a proof stress/strain diagram reflecting a test on a sample of the strand from that particular batch of manufacture, indicating the 0,1 % and 0,2 % proof stress.

Prestressing steel shall be clean, free from faults or defects, and without any harmful films and matter which may impair adhesion to the grout or concrete. The sheathing shall be free of any holes, cuts or abrasions through which the injected grease may escape. Deficient strands will be rejected. Strands damaged in removing the sheathing on the fixed length or on the working length shall similarly be rejected.

b) Cementitious grout

Cement grout shall be manufactured using the cement as specified in the Contract Documentation. CEM1 42.5 or as otherwise approved using potable water, with or without additives with a water/cement ratio ranging from 0.35 to 0.70. For anchorages installed in low permeability ground, i.e. rock or clay, the water/cement ratio should not exceed 0.45. The use of additives shall be subject to the Engineer's approval and demonstrated performance in the testing of the grout.

Bleeding at 20°C measured in accordance with Clause A20.1.5.6b)(iv) of Chapter 20 shall not exceed 2 % by volume 3 hours after the grout has been mixed, and the maximum bleeding shall not exceed 4 %. In addition, the separated (bleed) water must be reabsorbed after 24 hours.

The Contractor shall submit the design for the homing, encapsulation and high pressure grouting to the Engineer together with samples of all the constituents four weeks before the commencement of trial anchor installation together with the test results indicating the 7 and 14 day strengths obtained using the mix. At least two sets (3 cubes each) shall be presented on the prescribed form. The mixing, manufacture, curing and testing of the cubes shall be carried out by an approved, SANAS accredited laboratory facility in terms of their accredited tests. The cube compressive strength of 100 mm cubes made of the grout and cured in a moist atmosphere for the first 24 hours and then in water at 20°C shall exceed 20 MPa at 7 days. Sampling and testing of anchorage grout will be required as specified in Clause A12.2.8.1a).

The consistency of each batch of grout shall be tested with the flow cone and any variation exceeding 20 % of the average daily recorded shall be immediately brought to the attention of the Engineer.

c) Water

Water for grout shall comply with SANS 241.

d) Corrugated sheathing

The fixed anchorage length of the anchor shall be encapsulated in a corrugated high-density polyethylene, polypropylene or similar approved inert sheathing, of 1,0 mm minimum wall thickness. The pitch of the corrugations shall be within six to twelve times the sheath wall thickness and the amplitude of corrugations not less than three times the wall thickness. Alternative profiles may be offered but "curved" corrugations are preferred to the "square" type. The internal diameter of the corrugated sheathing shall provide a minimum cover of 10 mm between the strand and the corrugated sheathing. If the anchor design provides for the corrugated sheathing to be extended over the free length as well as the fixed anchorage length, this sheathing shall comply with the same requirements as those for the fixed anchorage length, and will continue, preferably without jointing up the full length of the tendon.

If it becomes necessary to join two sections of corrugated sheathing, such joints shall be sealed to occlude the passage of fluids. The Contractor shall demonstrate this and obtain the Engineer's approval before employing such sheathing on working anchors.

e) Grout tubes

The grout tubes shall have a minimum external diameter of 20 mm and sufficient internal diameter to allow for the insertion of a washing tube. The tubes shall have sufficient capacity to cater for the grouting pressures to which they will be subjected. The tubes shall have a spare capacity of at least 20% above that of the highest pressure required to successfully grout the fixed length of the anchors.

f) Tube-a-manchettes

The grout tubes required for the tube-a-manchettes shall cater for the very high pressures which may be required to create appropriate anchorages for the given ground conditions over the fixed length. Manchettes shall be provided at no greater spacing than 750 mm along the fixed anchorage length to enable re-injection of this portion of the anchor to be performed. These manchettes will be required for all ground anchors. The end of the high pressure injection tube shall be fitted with a clamp, valve or device capable of withstanding the maximum pressures that it shall be subject to plus 10 %, without loss of grout.

g) Anchor heads and pull bars

Anchor heads shall unless otherwise specified in the Contract Documentation, be of the re-stressable type, such that monitoring of the residual load in the anchor and re-tensioning can be carried out. Anchorages and couplers shall comply with BS EN 13391. They shall be capable of sustaining twice the working load with an angular deviation of not more than 5° from the tendon axis and without excessive distortion.

The anchor head and proposed pull bar should be compatible and shall have been tested by a competent instance to withstand twice the required loads.

The Contractor shall submit samples and technical details of the proposed anchor heads as well as details of the pull bar to the Engineer for his acceptance at least 4 weeks before the intended use. The pull bar details shall include Engineering drawings that can be used for the manufacture of replacement pull bars by others. If so specified the pull bar used shall remain the possession of the Employer.

h) Wedges

Wedges shall comply with BS EN 13391.The Contractor shall submit samples and technical details of the wedges to the Engineer for approval at least 4 weeks before the intended use.

i) External centralisers

External centralisers to the corrugated sleeve may consist of a solid polyethylene core, with an external diameter not less than 10mm, wrapped in a spiral in order to centralise the entire anchor assembly.

If the spacer system around the corrugated sheathing is intended to take the form of a helically wrapped tube, which also functions as an injection tube, this tube shall not be smaller than 20 mm diameter and the pitch of the helix shall not be greater than 1 m. The Contractor shall submit samples and technical details of the centralisers to the Engineer for approval at least 4 weeks before the intended use.

j) Tendon spacers / centralisers

Tendon spacers/ centralisers shall be provided over the full length of all tendons or encapsulations to ensure tendon centralisation, spacing and separation of the components to achieve effective grout penetration and a minimum grout cover of 10 mm. The spacer shall be designed to provide a clear spacing between individual tendon components of not less than 5,0 mm.

Tendon spacers / centralisers to retain the strands shall be located at no greater distance than 1,5 m centre to centre and shall be of an approved type capable of carrying the mass of the tendon without deflection, distortion or compression. The design of these centralisers shall be such to permit the smooth flow of grout and avoid the formation of pockets of water or air adjacent to them. The Contractor shall submit samples and technical details of the centralisers to the Engineer for approval at least 4 weeks before the intended use.

k) Shims

All shims shall be manufactured from grade 300W mild steel and be suitably machined to ensure a uniform, even bearing surface. The shape shall facilitate easy installation and extraction. The Contractor shall submit samples and technical details of the shims to the Engineer for approval at least 4 weeks before the intended use.

l) Anchor head covers

The anchor head covers shall be compatible with the approved anchor heads and shims, provide 50-year corrosion-resistance and be vandal proof. They shall be filled with grease, complying with BS 8081.

The covers shall be fitted with suitable gaskets and shall be coupled to the anchor thrust plates securely to avoid grease loss. Covers leaking grease shall immediately be replaced, re-greased all at the Contractor's expense.

The Contractor shall submit samples and technical details of the anchor head covers to the Engineer for approval at least 4 weeks before the intended use.

m) Anchor thrust plate

The steel thrust plate shall be manufactured to the dimensions indicated in the Contract Documentation and on the drawings. Unless otherwise specified the thrust plates shall be hot dip galvanised in accordance with SANS 121 /ISO4998, with a minimum mean coating thickness of 85µm. The Contractor shall submit samples and technical details of the anchor thrust plate to the Engineer for approval at least 4 weeks before the intended use.

n) Anchor component compatibility

A prototype shall be assembled where appropriate and the complete anchor system presented for inspection.

o) Grease

Grease shall comply with the requirements in Table A12.2.5-1 for rust-inhibiting properties.

Table A12.2.5-1: Properties for rust inhibiting grease

PROPERTY	UNIT	METHOD	REQUIREMENTS
Drop point (^{O}C)	^{0}C	ASTM D127 ASTM D 566 ASTM2265/IP396	65 min
Flash point	^{0}C	ASTM D92 ASTM D93	150 min
Penetration: un- worked @ 25 ^{0}C	mm^{-1}	ASTM D217	> 150
Penetration: worked @ 25^{0} C	mm^{-1}	ASTM D217	>250< 350
Oxidation stability: @100 hrs @400hrs @1000hrs	Loss in kPa	ASTM 942	70 max 140 max 210 max
Corrosion resistance/rust test 14 days@25^{0} C and 100 % rel. hum.	(visual)	ASTM D1743	Pass (rating 2)
Salt spray:1,0 mm grease@500 hrs		ASTM B117	No corrosion
Acid and Base number	mgKOH/g	ASTM D974-85 (mod)	0.6 max
Oil separation	%	ASTM D1742 FTMS791C	3 % max
Water washout	% m/m	ISO 11009 ASTM D1264	≤5
Water content	% m/m	ASTM D95 ISO 3733	<0.1
Evaporation loss*	% m/m	ASTM D972-56	0.5 max
chloride content*	ppm	ASTM D512 ASTM D432-7	5 max
Nitrate content*	ppm,	ASTM D432-7	5 max
Sulphide content*	ppm	ASTM D432-7	5 max

*** Recommended limits**

p) Cement

The cement used in the manufacture of grout shall be CEM 1 42.5 N unless otherwise specified in the Contract Documentation.

A12.2.5.2 Materials for rockbolts, dowels and soil nails

a) General

All materials used for rockbolt, dowels and soil nails shall comply with the following standards:

SABS 920 – Steel bars for concrete reinforcement

SABS 1024 – Welded steel fabric for concrete reinforcement

SAICE Lateral Support in Surface Excavations: Code of Practice 1989

BS EN 14490:2010. Execution of special geotechnical works- Soil nailing

b) Rockbolts, dowels and soil nails

These shall be steel bars and/or polymeric rods, either solid or hollow stem. The steel bars shall be hot-rolled, deformed, continuously coarse-threaded high-yield steel (greater than 500 MPa) of specified diameter and length. Steel for hollow-stem self-drilling anchors shall also comply with EN 10210 (Hot finished structural hollow sections of non-alloy and fine grain structural steels and SANS 920.
Polymeric rock bolts and dowels may be used as specified in the Contract Documentation.

Mechanically end-anchored rockbolts and dowels shall be permitted, including 'split set', 'swellex' and other types.

c) Steel face plates, washers & nuts

Steel faceplates, hemispherical washers and nuts shall be supplied with each soil nail. All soil nails and face plates nuts and washers shall be hot dip galvanised in accordance with SANS 121/ISO1461 to a mean coating thickness of 85µm. The soil nails, face plates, nuts and washers shall thereafter be passivated using a non-toxic approved product. When used in conjunction with wire netting galvanised spike plates may be specified.

d) Cementitious grout

Only CEM I 42.5 N / CEM II 35.2.N.BV which complies with the requirements of SANS 50197 shall be used unless otherwise specified in the Contract Documentation.

The temperature of the cement shall be less than 40°C.

Fine aggregate if used in the mix shall consist of siliceous granules, finely ground limestone or very fine sand. It shall all pass a 0,600 mm sieve and shall be subject to the approval of the Engineer. The aggregate content in the grout shall not exceed 30% of the mass of the cement.

Admixtures shall not be used in the grout without the approval of the Engineer. Admixtures shall be free of any product liable to damage the steel or the grout itself, such as halides, nitrates, sulphides, sulphates, etc. The amount of admixture to be used shall be in accordance with the manufacturer's instructions.

The mixed grout shall have the following properties:

- C1-ions content shall not exceed 750 mg per litre.
- Viscosity will be measured in a standard flow cone or similar approved. Flow shall not be less than 12 seconds and not more than 30 seconds. Any other approved cone shall be calibrated against the standard cone.
- Bleeding at 20°C shall not exceed 2 % by volume, 3 hours after mixing, and the maximum bleeding shall not exceed 4 %. After the initial grouting of the nails, any bleed shall be compensated for by topping up the hole.
- The compressive strength of 100 mm cubes made of the grout and cured in a moist atmosphere for the first 24 hours and thereafter in water at 20°C shall exceed 20 MPa at 7 days.
- Grout must be tested on a daily basis.

e) Resin grout

Resin grout shall comply with the recommendations of BS 8081 and prepared and applied in accordance with the manufacturer's prescription.

f) Water

Water for grout shall comply with SANS 241.

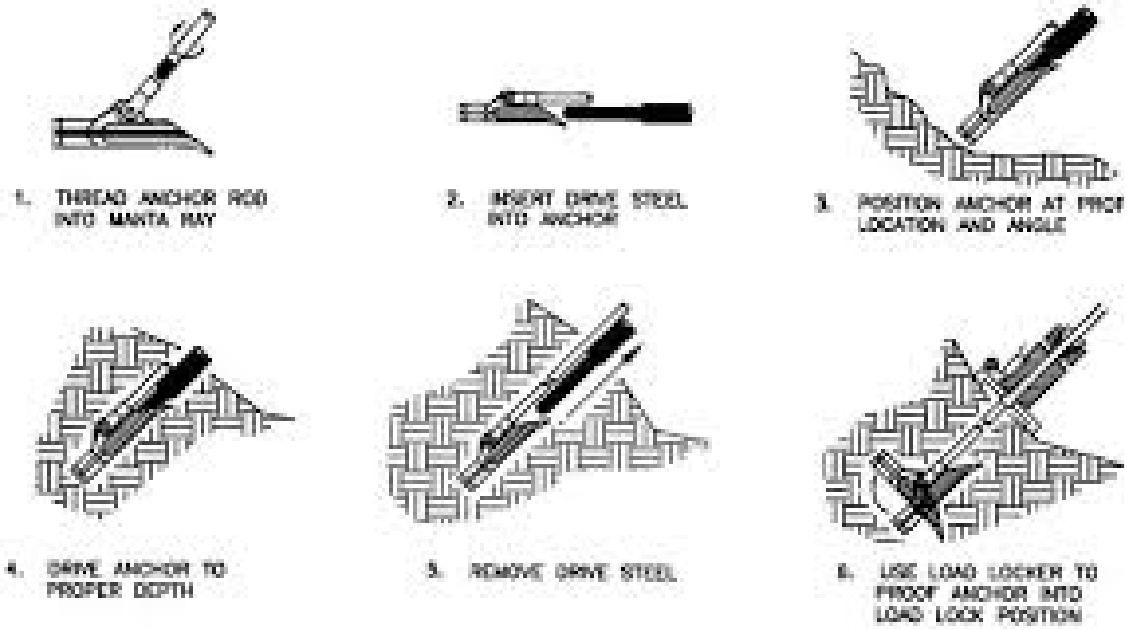
A12.2.5.3 Materials for tipping anchors

The numerous proprietary products shall comply with the following specifications:

Steel: SANS 920

Iron: SANS 920

Galvanising: SANS 121/ISO1461


1. THREAD ANCHOR ROD INTO MANTA RAY
2. INSERT DRIVE STEEL INTO ANCHOR
3. POSITION ANCHOR AT PROF LOCATION AND ANGLE
4. DRIVE ANCHOR TO PROPER DEPTH
5. REMOVE DRIVE STEEL
6. USE LOAD LOCKER TO PROOF ANCHOR INTO LOAD LOCK POSITION

A12.2.5.4 Materials for mechanical screw earth anchors

The materials used shall comply with the requirements in the Contract Documentation.

A12.2.6 CONSTRUCTION EQUIPMENT

A12.2.6.1 Construction equipment for ground anchors

a) Drilling equipment

The drill rig and equipment shall be in good working order and capable of producing the anchor/bolt or soil nail hole to the required dimensions, tolerances, direction and inclination without undue disturbance of the surrounding material. Should the type of rig and/or equipment prove inappropriate for the requirements or conditions on site, these shall be replaced by suitable equipment at the Contractor's cost. The drill rig/equipment shall be able to install and remove casings as required during drilling operations, without loss of direction or inclination, in all materials.

b) Grout mixer

The mixer used for the manufacture of grout for anchoring purposes shall be a high shear colloidal mixer. The holding tank shall be fitted with an agitator capable of maintaining the colloidal condition and fluidity of the mix. The outlet shall be fitted with a suitable filter with openings of less than 1,0 mm to remove any aggregations.

c) Grout pump

The grout pump shall be a positive-displacement type and shall, unless otherwise specified, be capable of exerting a constant pressure of at least 20bar or as may be required for high pressure grouting. The pump shall be fitted with a currently calibrated pressure gauge with a dial of a suitable diameter enabling accurate readings to the nearest bar and a valve which can be locked-off without pressure loss. The hoses used shall be appropriately rated for the pressures required.

d) Tensioning/pre-stressing system

All tensioning systems will be subject to approval by the Engineer. At least 4 weeks before commencing with tensioning operations, the Contractor shall submit further and full details regarding the stressing system(s), materials, equipment and methods to be adopted in the tensioning and related operations for approval by the Engineer. The information shall include detailed drawings, proof of successful previous use, performance certificates from an approved independent testing authority, and calculations substantiating the adequacy of the system.

The system shall comply with BS EN 13391. The Contractor's proposed system shall comply with the following:

- The tensioning equipment shall be driven by hydraulic power pack, capable of gradual application of a controlled equally distributed and aligned force to each tendon and anchorage,
- The pressure monitoring unit shall comprise three glycerine damped calibrated gauges complying with BS 1780 (1985), have dials at least 150 mm in diameter and be used within the range of 50 – 90 % of their full capacity at maximum service pressure. The unit's gauges shall measure the tensioning force to an accuracy of ±2 %,
- The hydraulic circuits shall have self-sealing connections, and all gauges and hydraulic jacks shall be calibrated immediately prior to use on site, by an approved, competent authority, and recalibrated as required by the Engineer during the course of the project.

The Engineer may at his discretion approve the use of suitable digital pressure gauges calibrated as specified above. At least two gauges shall be used. Such approval may be withdrawn if in the opinion of the Engineer the performance is not satisfactory.

A12.2.6.2 Construction equipment for tipping anchors

Equipment necessary for the driving of tipping anchors shall vary according to the anchor size, application, earth characteristics, and objective of a particular project as indicated in the Contract Documentation. Driving mechanisms may include handheld or machine-mounted equipment.

A12.2.6.3 Construction equipment for screw earth anchors

Equipment necessary for the installation of screw earth anchors shall be appropriate for the anchor size, application, soil characteristics, and objective as indicated in the Contract Documentation. Driving mechanisms may include handheld or machine-mounted equipment.

A12.2.7 EXECUTION OF THE WORKS

A12.2.7.1 General

Permanent lateral support shall be provided as per the Contract Documentation and as detailed in the construction drawings.

A12.2.7.2 Cable anchors

a) Test anchors

Test anchors shall be installed by the Contractor as indicated in the Contract Documentation. The positions shall be agreed with the Engineer on site. The Contractor shall provide the Engineer with a method statement for the installation of the test anchors covering all aspects of the installation including the drilling of the holes anchor materials, fabrication, installation, grouting, tensioning and protection as detailed in these specifications at least two weeks prior to the commencement of the test anchor installation. The test anchors shall be constructed utilising the same methodology, equipment, materials and workmanship as contemplated for the working anchors. Test anchors shall be proof loaded and stressed in accordance with the provisions given in Clause A12.2.7.2f). In the case of a test anchor being defective, the Contractor shall re-design and install a further set of test anchors.

The installation of working anchors will only be permitted on the successful completion and testing of the test anchors. The Contractor shall revise his method statement as may be necessary following the test anchor installation and submit the revised method statement to the Engineer for his approval. The Installation of working anchors shall only commence once the Engineer's written approval has been obtained. Payment will only be made for successful anchors as instructed by the Engineer.

b) Drilling

(i) General

Holes shall be drilled to the diameter, depth, position and tolerances specified. The length of hole drilled shall be 300 mm greater than anchor length.

The drilling rig assembly shall be sufficiently rigid and the working platform stable and durable to ensure the specified directional alignment is achieved.

(ii) Drilling methods

The drilling methods may either be auger, rotary, percussive, rotary-percussive or vibratory and shall be chosen to optimally penetrate the substrata and achieve minimal disturbance of surrounding ground.

The use and selection of any method shall be entirely at the Contractor's risk. If the selected method does not produce satisfactory results, alternative methods shall be used to achieve the required result at no additional cost or extension of time.

If in the opinion of the Engineer the required results are not obtained, or the Contractor's work method is adversely affecting the in-situ ground conditions, he will have the right to stop the works. The onus is on the Contractor to propose corrective measures and present these to the Engineer for approval. No standing time or extension of time will apply during such stoppages.

The use of casing in the free length is permitted, unless otherwise specified in the Contract Documentation.

Where casing is specified or used by the Contractor over the free length to stabilise the holes, the individual casing lengths shall be welded using a jig designed to ensure that the line remains true and the welds are not severed during installation. The diameter of such casing should provide for the specified cover over the anchor sheathing to be achieved. The casing shall be trimmed to ensure that it remains clear of the stressing head throughout the stressing cycles.

The use of drilling fluid is subject to the following conditions:

It shall not cause swelling or softening of the ground.

It shall have no deleterious effect on the ground, tendon or grout.

Special care shall be taken when drilling into ground water with artesian pressure. In such circumstances the Contractor shall propose an appropriate drilling method to the Engineer for approval.

Should the Contractor encounter ground conditions that differ from those on which the design is based, drilling shall be discontinued, and the Engineer shall immediately be notified. The Contractor shall propose appropriate measures for approval by the Engineer to progress the works.

(iii) Tolerances

The holes shall comply with the following:

Minimum hole diameter	anchor assemblage plus 10 mm

Inclination at collar of hole	±2,5° of specified inclination
Position of collar at hole	±75 mm of specified position
Length from collar of hole	specified length +0,3 m

(iv) Water testing

On completion of drilling the fixed length in rock the drilled hole shall be tested for water tightness. If the loss of water over a period of 10 minutes exceeds 3 l/min at a pressure of 100kPa at collar level the hole shall be grouted and re-drilled. The water proofing grout shall be cement grout of similar composition to the anchor grouting. The Contractor shall provide the necessary equipment for carrying out the testing inclusive of all packers, manifolds and other equipment required to carry out these tests.

The re-drilling shall not commence for at least twelve hours after the waterproof grouting has been completed.

(v) Loss of hole

Where a hole is lost or has to be abandoned due to mechanical breakdowns or failures or any other causes arising from the Contractor's activities or failure to protect the works, a new hole shall be drilled, entirely at the Contractor's cost.

c) Manufacture

(i) Storage, handling and protection

During storage, transit, construction and after installation the sheaths, tendons and anchorages shall be protected against damage or permanent deformation. The materials shall be stored in weatherproof sheds. All materials shall be stored clear of the ground and while in storage shall not be exposed to the weather.

When the tendons are stored for a prolonged period and there is evidence of deterioration, the Contractor may be called on to prove by tests that the quality of the steel is not impaired and complies with the provisions of these specifications. All damaged materials shall be replaced at the Contractor's cost.

(ii) Fabrication

The tendons shall be assembled on site under the supervision of approved key personnel. In addition to the Contractor's process control, the Engineer reserves the right to carry out inspections of all components and assembled anchors. All completed assemblies shall be numbered. Records of the process control shall be kept by the Contractor and submitted to the Engineer before installation.

Anchors shall be assembled above ground on suitable trestles or stands. Cutting of strand shall be via high-speed abrasive cutting wheels. Flame-cutting is not permitted.

The Contractor shall allow a minimum working length of 1,0 m in excess of specified free length plus fixed length. Strands and anchorages shall be prevented from coming into contact with splashes from flame-cutting or welding processes in the vicinity.

In removing the sheathing, care shall be taken to avoid damage to the strands. Damaged strands shall be rejected. The grease shall be completely removed from the fixed length of each strand using a suitable solvent. The wires shall be unwound during this operation. The approved centralisers shall be placed at intervals no greater than 1,5 m centre to centre firmly affixed to the individual strands and internal fixed length grout pipes. The distal end shall be fitted with a securely attached approved cap or centraliser to prevent either splaying or congregation of strands. The Engineer's acceptance shall be obtained before any assembled tendon is inserted into the corrugated sheathing**.** The corrugated sheathing shall be fitted with a water/grout-proof end cap securely affixed/fastened to the bottom of the corrugated sheathing and able to withstand the rigours of tendon-insertion, homing and grouting. The prepared tendon or cable shall be labelled to show the tendon or cable number.

The homing grout tubes shall be wound in a spiral around the corrugated sheathing at a pitch less than 1,5 m to provide cover greater than 10 mm to the outside of the tubes. Where the homing grout tube is located internally and not helically wound around the corrugated sheath, centralisers shall be placed at intervals less than 1,5 m along the corrugated sheath to provide cover greater than 10 mm.

If specified in the Contract Documentation, high pressure tubes shall be attached in a spiral around the corrugated sheathing at a pitch less than 1,5 m to provide cover greater than 10 mm to the outside of the tubes. High pressure grouting tubes shall be of the tube-a-manchette (TAM) type, provided with holes (greater and/or equal to 6,0 mm ϕ) and sheaths (manchettes) at a spacing less than 750 mm over the fixed length of the anchor. All grout injection tubes shall be colour coded to ensure their correct utilisation.

The assembled anchor shall be stored on trestles or stands and be protected against the ingress of water and other foreign objects. After fabrication, the cable ends shall be covered with protective wrapping.

d) Homing and grouting

(i) General

Unless otherwise indicated in the Contract Documentation the tendon installation / homing of an anchor and grouting shall be carried out within 2-4 days after the drilling of the fixed anchor length.

Generally, the anchor shall be homed into a water-filled hole and grout tremmied from the bottom of the hole to completely encase the anchor. Where indicated in the Contract Documentation the anchor shall be homed in a partially filled tremie grouted hole. Primary grout operations follow.

The homing shall be carried out at a steady controlled rate. Should any obstructions be encountered during this process or the full depth not be attained, the cable shall be removed, and the problem rectified by appropriate means.

Sampling and testing of anchorage grout will be required as specified in Clause A12.2.8.1a).

(ii) Homing and encapsulating grouting

Borehole or homing grouting is the tremie grouting of the annulus between the corrugated sheathing and the sides of the hole or casing.

Encapsulation grouting is the encapsulation of the anchor within the corrugated sheath. Encapsulation grouting may be done prior to homing or after homing dependant on the type of anchor.

Prior to commencing with the homing- and encapsulation grouting the anchor assembly shall be centred by suitable means to ensure that the strands remain parallel to the centre of the anchor and perpendicular to the thrust plated when grouted.

The grout shall be injected at the distal end of the hole, through the appropriate grout tubes. These shall be clearly demarcated, or colour coded.

Grout injection shall be continuous. Injection shall continue until the grout flowing from the hole (homing grout) or from the corrugated sheath (encapsulation grouting) is of the same consistency as that of the injected grout. The grout levels shall be topped up after grouting to ensure that the required levels are achieved in the process. Unless a retarder is used in the grout mix, the grout not used within 60 minutes of mixing shall be discarded.

The fixed anchorage shall be encapsulated in the corrugated sheathing through the primary grout tube. This encapsulation, if done by pre-injection prior to homing of the anchor, shall be performed in such a manner that no pockets of air or water will remain in the apexes of the corrugations, and the Contractor shall demonstrate his ability to achieve this to the Engineer whilst installing the trial/site suitability anchors prior to the adoption of this method for the working anchors.

If the encapsulation is done concurrently with the homing of the anchors, and there is the risk of pockets of air or water being entrapped in the apexes of the corrugations, the cover over the strand shall be increased to accommodate this. Under these circumstances, it will be the responsibility of the Contractor to submit the proposed method statement for achieving this to the Engineer.

If delays are encountered in commencement of the grouting process after homing, the anchor shall be removed, and the process recommenced when the causes have been addressed.

If a blockage occurs during the course of grouting the anchor shall be withdrawn from the hole and removed from the corrugated sheathing and thoroughly cleaned. Re-assembly shall be done as specified. The hole shall be flushed / re-drilled as directed by the Engineer.

If in the course of grouting the grout take is in excess of three times the calculated theoretical volume, grouting shall be terminated, the anchor removed and cleaned as specified. The hole shall then be re-drilled.

Grouting shall not be carried out during very cold weather when the ambient air temperature drops below 5°C.

(iii) High pressure grouting

If deemed necessary or specified, high pressure grouting of the fixed length shall be achieved by the injection of grout under high pressure after the homing and primary grout attains a cube strength greater than 10 MPa.

Water shall initially be used to open the manchettes and to break open the homing grout body. Thereafter, grout shall be used. The grout shall be injected at a sufficiently high pressure to pass the tube-a-manchettes and penetrate or exert high radial stresses on the surrounding material to penetrate and/or create extra volume facilitating bonding with the surrounding material and/or creation of a bulbous anchorage.

Multiple injections may be required. The pressures and volumes of grout per injection will be dependent on ground conditions and class of tube used. After each re-injection the system shall be thoroughly flushed and further high-pressure grouting carried out until the grout injection rate less than 1 l/min at the injection pressure. Once the re-injections prove compliance and the grout attained the specified strength, tensioning may proceed.

Full details of grouting stages performed on the ground anchor shall be recorded on approved forms and submitted to the Engineer as the work proceeds.

e) Thrust plate seating

The thrust plate shall be seated on a thin mortar bedding of approved materials to bear evenly on the concrete bearing pad, and the tendon axis shall be perpendicular to the bearing surface of the anchorage.

f) Tensioning

(i) General

Tensioning and testing of anchors as well as the recording shall be carried out by approved, appropriately qualified and experienced personnel. Tensioning shall only commence once the high pressure grout attains a cube strength equal to or greater than 25 MPa and the Engineer has given approval for the work to commence. The sequence of the anchors to be tensioned shall be as instructed by the Engineer.

All instrumentation shall be protected from the elements during tensioning.

Prior to applying any load, the anchor head assembly shall be positioned so that the strands are centrally located within the hole through the thrust plate and that none snag against it. Wedges shall be oil-free and clean to prevent slippage from occurring and to allow movement between the wedge and the anchor. Wedges shall be simultaneously knocked tightly in place ensuring uniform grip.

Tensioning shall commence with the uppermost strand, by applying a small load (5-10 % of the final value) to each one to take up slack and prevent entanglement. This will allow the zero position for measuring the extension to be determined, gripping devices, position and alignment of the jacks, to be checked. Jacks shall be kept flush with the thrust plate when load is applied utilising hoisting mechanisms if necessary. The load shall be gradually increased to the full specified tensioning force with intermediate load and extensions recorded at specified increments. Wedge draw in and possible strand slippage shall be closely monitored.

For recording of tendon/cable extension, a dial gauge or electronic vernier calliper, attached to a free-standing tripod or similar approved mechanism, shall be used. The instrument shall have an accuracy of 0,01 mm or better.

Prior to tensioning and to detect any slippage, protruding strands shall be marked and cut equidistant from the anchor head such that more than 700 mm protrudes from the wedge. Cognisance shall also be taken of the projected extension and equipment dimensions.

Tensioning by single-strand jack is permissible, provided the sequential load increment between successive strands is less than 0.1 Tw.

The free length of a tendon may, in certain conditions be such that the extension under load is greater than can be accommodated by the tensioning jack over the specified range. Single-strand tensioning of the anchor up to 0.5 Tw (the design working load) is permissible. Full details of the Contractor's proposals shall be given in the method statements for the tensioning and testing of the anchors and the Engineer's approval shall be obtained before commencement therewith.

At tensioning, the following data shall be recorded:

- Date and time started and completed
- Names of personnel responsible for tensioning
- Ground anchor number
- Free and fixed length of anchor
- Tendon type and E-value of steel
- Design, working load (Tw), proof load (1.5 Tw or 1.25 Tw) and lock-off load (1.1 Tw)
- Date of last calibration of gauges and accuracy of gauges
- Type of jack used and ram area of jack
- Tendon extensions during the course of loading and release
- Pressure gauge readings at each load increment
- Ground type

(ii) Testing

Testing of anchors comprise lift-off tests to establish loads on the anchor and to determine the efficacy of installation, by comparing measured load/extension data with theoretical values. This enables actual free length of the anchor to be determined. Lift-off tests shall be carried out at 1 day, at 3 days and, in addition for test anchors, at 10 days after initial stressing.

The Contractor shall provide necessary plant, equipment, instruments, calibration certificates and labour to carry out the tests and monitoring operations to the Engineer's requirements. All the equipment shall be in good working order. The Contractor shall provide the Engineer with a programme indicating dates of tensioning and/or testing of all anchors.

Within two days of completing a test, the Contractor shall supply the Engineer with load extension curves, neatly plotted, as well as tensioning records in accordance with requirements.

(iii) Permissible loads in tendons

No tendon shall at any stage during a test be tensioned beyond 80 % of the characteristic strength.

(iv) Tensioning and testing process

Tensioning and testing of anchors shall be carried out as follows (Tw is the design working load):

1. Tension the anchor and record and plot load/extension data continuously over the range 0.25 to 1.50 Tw in increments of less than 0.25 Tw. Temporary anchors shall be loaded to 1.25 Tw.
2. The extensions shall be measured relative to a fixed datum independent of the concrete work or surface against which the anchor is stressed.
3. Each load increment shall be held for a minimum period of 1 minute with the exception of the proof load of 1.50 Tw which shall be held for 15 minutes.

4. Evaluate additional extension over the 15 minute period in 1. above. This additional extension should be less than 5 % of the total elastic extension at 1.50 Tw.

5. De-tension the anchor to 0.25 Tw in three equal decrements and record and plot the load/extension values for each step.

6. Calculate the apparent free length of the anchor from the load/extension curve using the manufacturer's load/extension curves allowing for the effects of bedding-in of anchor head and any other extraneous factors. The analysis should be carried out over the range 0.25 Tw to 1.50 Tw. The apparent anchor free length shall be greater than 90 % of the designed free length nor more than the intended free length plus 50 % of the designed fixed anchorage length. If the apparent free length does not comply with these limits, the anchor shall be regarded as defective.

7. Repeat the first cycle of loading and unloading and record results as described in points 1 to 3 above.

8. On completion of the second load cycle, reload in one operation and lock off at 1.10Tw utilising selected shims.

   Carry out a lift-off test immediately after lock-off to establish initial residual load. If below 1.10 Tw, insert additional shims to increase the anchor load to 1.10Tw.

9. Lift-off tests should be carried out at 1 and 3 days (and 10 days for test anchors) after initial tensioning. Zero-time is the point at which the lift-off test, immediately after initial tensioning, reflects a residual load in the anchor of 1.10 Tw. The loss of tension in the anchor shall be less than 0.06 Tw at 1 day, less than 0.07 Tw at 3 days and less than 0.08 Tw at 10 days.

If during any of these lift-off tests the loss of tension exceeds the amounts specified above, the anchor shall again be tensioned as described in points 1 to 8 above and locked off at 1.10 Tw. The lift-off tests shall then be repeated at 1, 3 and 10 days as previously described, after relocking the anchor at 1.10 Tw.

If after such re-tensioning to 1.10 Tw, a test anchor fails to comply with the maximum permissible losses in tension indicated above, the anchor shall be regarded as defective. This anchor shall be condemned or de-rated or otherwise dealt with as directed by the Engineer. If the losses in tension do not exceed the percentages specified above at 1 and 3 days (and 10 days for test anchors) the anchors shall be considered acceptable.

After stressing, a check should be carried out to ensure that all of the cables are properly tensioned. This includes checking for the following:

- Broken wires which lead to other wires slipping past the broken wire as tensioning continues, leaving the end of the broken wire protruding beyond the ends of the other wires;
- Wedges inadequately seated as evidenced by non-uniform embedment; and
- Wedges not adequately gripping strands, evidenced by disparate lengths of strands.
- Any deficiencies shall immediately be brought to the Engineer's attention.

g) Routine acceptance tests for working anchors

Each working anchor shall be subjected to routine acceptance testing and checking of the free length as described in points 1 to 10 above. The 10-day lift-off test shall, however, not be required. Provided the apparent free length complies with (d), the anchor shall be deemed to be acceptable if at 24 hours after lock-off, the loss of load does not exceed 6 % Tw and at 3 days after lock-off the loss of load does not exceed 7 % Tw. If at the 24-hour lift-off test or at the 3-day lift-off test the loss of prestress exceeds the allowable (6 %, 7 % Tw respectively), the anchor shall again be locked off at 110 % and subjected to further tests at 24 hours and 3 days. If after either the second 24 hour or 3 day re-test, the loss of prestress is still greater than the allowable, the anchor shall be regarded as a defective anchor and the anchors shall be condemned or de-rated or otherwise dealt with as directed by the Engineer.

h) Protection

After the tensioning and testing have been completed and approved, the anchorages at the jacking end shall be filled with grease with particular attention being paid to the annulus behind the anchor head. This shall be completely filled with the approved grease employing a suitable pump, injecting the grease under pressure until it exudes between the wires of the individual strands. The anchor head shall then be thoroughly coated with the grease before fitting and securing the partially grease filled permanent cover. Grease shall then be pumped through the lower grease nipple until it exudes from the upper grease nipple hole.

The permanent covers shall then be cleaned and monitored for any loss of grease, externally or internally over the defects notification period. Defective seals or gaskets shall be replaced and the covers refilled with grease all at the Contractor's cost.

All anchor components shall be protected against damage or corrosion and shall be stored under cover until assembled / installation. Assembled anchors shall be stored on trestles or similar approved installations and protected against ingress of water or other materials

All drilled holes shall be suitably sealed to prevent the ingress of water and foreign objects. Should the measures taken by the Contractor fail in this regard the Engineer shall instruct the Contractor as to what measures shall be carried out to redress the situation. Holes lost due to the Contractor's negligence shall be re-drilled at his own cost. All other extra costs incurred thereby will be to the Contractor's cost.

Installed but not yet tensioned anchors or not yet treated with rust inhibiting grease and permanent grease caps shall be suitably protected from dust, water and other contaminants to the satisfaction of the Engineer. The works shall also be protected against vandalism by outsiders until all the works have been completed and handed over.

A12.2.7.3 Soil nails, rockbolts

a) General

Soil nailing shall be further undertaken with special reference to BS EN 14490:2010.

Rockbolts or soil nails or mechanical earth anchors of varying length shall be placed at orientations on the excavation face or on other locations to provide support requirements. Spacing may be random; patterned or inserted as spot bolts / nails. Bolt / nail length; spacing; diameter; strength and protection against corrosion shall be as specified. The Engineer shall be accorded access to the bolting/ nailing position; to assess the stability of the cut face or natural slope. The Engineer shall indicate the number, sequence, precise location, length and orientation of bolts required, and may increase or decrease the number as necessary.

Soil nails or rock bolts shall be installed immediately as part of the excavation cycle at intervals specified by the Engineer to ensure its stability and to limit defamations as the excavations advances and be complete and approved before the ensuing excavation advance may commence, unless otherwise instructed by the Engineer in writing.

b) Trials

The Contractor shall provide the Engineer with a method statement for the installation of test soil nails/ rockbolts. The Contractor shall carry out comprehensive trials to the satisfaction of the Engineer at least four weeks prior to the commencement of any permanent rock bolting / soil nailing. Rock bolt / soil nail pull out tests will also be undertaken on the test bolts/nails in accordance with specifications. Changes as necessitated by the outcomes of these tests, shall be made to the method statement which shall be submitted to the Engineer for approval four weeks before being allowed to proceed with production work. Trials which are unsuccessful and/or which in the opinion of the Engineer do not meet the requirements of the specification will not be measured or paid for.

c) Inspection by the Engineer

The Contractor shall provide suitable plant, equipment and training, together with a competent operator to ensure safe and appropriate access for the Engineer right up to any part of the site requiring stabilisation to undertake whatever, observations, measurements or samples that may be required. No work which could pose a hazard to or disrupt these specialist inspections shall be undertaken by the Contractor on or near the area under inspection for the full duration of the inspection.

Notwithstanding the Contractor's previous finishing efforts, the Engineer will determine the final positions of rock bolts or soil nails required as well identify all blocks or wedges of rock or boulders or any other protuberances which require removal or stabilisation. The Engineer will confirm the final number, location, length, and orientation of each rock bolt / soil nail within two working days of inspecting a works zone.

d) Drilling

(i) General

The drilling methods for the installation of nails or bolts may either be by rotary, percussive, rotary-percussive, augering or vibratory methods, with or without using temporary casing and shall be chosen to ensure the minimum possible disturbance to the surrounding ground and a stable hole which will facilitate the insertion and grouting of the soil nails or rock bolts to the required tolerances and specification. Unless otherwise specified or instructed by the Engineer, the selection of method shall be entirely at the Contractor's risk. Should the selected method result in unstable holes or prevent efficient execution of work which does not meet the requirements of these specifications, the Engineer may instruct the Contractor to stop work and the Contractor shall adopt alternative drilling methods. No additional payment shall be made in this regard other than provided in the pricing schedule. No standing time or extensions of time shall be granted.

The use of drilling fluid shall not adversely affect ground conditions. Special care shall be taken when drilling into artesian ground water.

Work must immediately stop should conditions other than indicated in the Contract Documentation be encountered and the Engineer informed. Works shall only proceed on instruction of the Engineer.

(ii) Drilling requirements

Holes for rock bolts / soil nails shall be drilled to a diameter at least 25 mm greater than the nominal diameter of the bolt/ nail.

To avoid excessive deviation particular care is required when advancing the hole. The following tolerances are applicable:

- Diameter of hole: + 10 mm and – 5,0 mm,
- Position of hole: less than 75 mm from specified position,
- Alignment: less than 2,5 % of specified inclination,
- 50mm less than length of drill hole less than 250 mm of required hole length.

After each hole is drilled to its full length and flushed via compressed air and/or water to remove all loose materials, it shall be probed to ensure collapse has not occurred and that it is clean over its full length. Thereafter the hole shall immediately be plugged to prevent debris from entering.

Where a hole is lost or abandoned due to mechanical breakdowns, failures or any other causes arising from the Contractor's omission to protect the works, a new hole shall be drilled, entirely at the Contractor's cost.

e) Bolt / nail insertion

The bolts are to be fitted with centralisers or a spirally wound grout tube providing the specified cover less than 1,5 m spacing/pitch, homed and grouted to the collar as specified. A minimum of two centralisers are required for bolts less than 2,0 m, with a centraliser 300 mm from the proximal and distal ends. The bolt must protrude or be trimmed sufficiently for the application envisaged.

Mechanically end-anchored expansion shell rockbolts shall comprise a screwed end tapered cone with an internal thread and a pair of wedges secured by a bail. The full assemblage is inserted into a pre-drilled hole, 100 mm longer than the bolt, to ensure the bail is not dislodged when forced against the end of the pre-drilled hole.

Split-set bolts are inserted into pre-drilled holes of diameter less than bolt Ø to ensure frictional anchorage along its entire length via the radial force generated through compression of the C-shaped tube.

Swellex dowels, folded during manufacture, are activated after insertion into a predrilled hole, by injection of high pressure (greater than 30MPa) water discharge.

Corrosion-resistant coatings are mandatory for both split-set and proprietary expandable folded tube rockbolts and dowels.

f) Grouting

All rock bolts / soil nails shall be grouted to the collar of the hole, either by way of cement grout with or without additives or using cement or resin cartridges as approved by the Engineer. The Contractor shall ensure that whatever method is used, the grout cover to the bolts / nails is continuous and completely fills the annulus between the bolts and rock or soil. Special precaution is required to inhibit bleed and shrinkage of cement grouts. All cartridge grouts must be sufficiently mixed to ensure required homogeneity.

If for any reason, grouting is interrupted and/or the installation of the bolts is delayed, the bolt shall be removed timeously from the hole before hardening. The grout shall then be removed by flushing or re-drilling and the bolt re-installed.

Grout shall be injected at the distal end of the hole, through appropriate tubes. Injection shall be continuous until flow occurs from the collar.

g) Rockbolt head protection and camouflage

After rock bolts / soil nails are installed successfully, grouted, tensioned where required, and approved by the Engineer, the bolt head shall be trimmed as specified. The exposed face plate and protruding end of the bolt shall be camouflaged to blend with the surrounding area and protected via a suitably pigmented patch of shotcrete, or hand-packed mortar with minimum of 150 mm greater than plate dimensions and cover greater than 50 mm or by a corrosion-inhibiting suitably-pigmented paint, equipped with an Engineer-specified (non-spot welded) suitable anti-theft mechanism.

h) Tensioning

Tensioning of rock bolts shall be carried out by experienced personnel. Tensioning to less than $0.57T_{ult}$ shall be either by manual or pneumatic torque wrench or jacks as specified.

A12.2.7.4 Mechanical Driven Tipping Anchors (MDTA)

a) General

Mechanical driven tipping anchors (MDTA's) shall be driven into the soil using hand held hammers or appropriate mechanised methods, depending on anchor capacity and soil condition. Once inserted to design depth, the anchor shall be tipped and tensioned to attain its working load. Smaller anchors are hand-tensioned but larger anchors require load locking to both seat the anchor tip and ensure tensioning to the design load. In all cases care shall be taken not to remove the drive steel from the anchor during the adding of coupled extensions, drive steel and steel anchor rods, since this may cause the anchor to rotate into its locked position and possibly inhibit further advance and circumvent later removal of the anchor to a new position.

b) Installation

Pre-drilled holes are required for installation in dense to very dense soils or highly/completely weathered rock. Weathered rock requires a larger pre-drilled hole than dense soils since the anchor tends to slide in harder incompressible rock material.

Removal of the drive steel shall generally be accomplished by hand, hammer vibration or use of a load locker.

A12.2.7.5 Mechanical screw anchors

Screw anchors shall be rotated into the soil using manual methods or by mechanical shaft rotation equipment for higher capacity applications. Length and depth of installation shall be specified and tested as required by the Engineer following field trials.

A12.2.8 WORKMANSHIP

A12.2.8.1 Cable anchors

a) Cementitious grout

Immediately after mixing, and also during injection, the fluidity of the grout shall be tested at regular intervals in accordance with Clause A20.1.5.6b)(iv) of Chapter 20. Viscosity tests may also be specified in the Contract Documentation.

During the course of grouting, 100 mm cubes shall be made, cured and tested in accordance with SANS 3001-CO11.

Six cubes per batch of anchorage grout shall be made, of which two shall be tested at 3 days, two at 7 days and two at 28 days. The testing shall be carried out by an approved, SANAS accredited laboratory facility in terms of their accredited tests. The compressive strength of 100 mm cubes made of the grout and cured in a moist atmosphere for the first 24 hours and thereafter in water at 20°C shall exceed 30 MPa at 7 days and 40 MPa at 28 days. The test results shall be reported within two days of the test date.

The fluidity and consistency of each grout batch mixed shall also be measured with a flow cone and, if specified, with a viscometer in accordance with Clause A20.1.5.6b)(iv) of Chapter 20.

Grouting shall only be undertaken when the ambient air temperature is greater than 5°C.

b) Concrete

All concrete for structural work associated with ground anchors and which is not covered elsewhere in the project documents shall comply with the provisions of relevant Clauses of Chapter 13.

The Contractor shall bear the cost of all acceptance tests specified in the contract or prescribed by the Engineer and which are not listed in the pricing schedule.

The results of tests on concrete shall be assessed according to Clause A20.1.7.5b) (ii) (Judgement Plan B) of Chapter 20.

c) Records

(i) Daily records

Daily records shall be kept in respect of each of the following phases of anchor construction:

- Drilling
- Anchor installation
- Anchor tensioning

(ii) Project records

- The project records to be prepared by the Contractor and submitted to the Engineer on completion of the anchoring shall include, as a minimum, the following:
- Project details
- Anchoring details (numbers, positions, types, orientation, protection)
- per anchor, the following (as applicable):
    - Anchor Number Anchor details (type, free length, fixed length, no of strands, design load)
    - Date drilled
    - Date installed
    - Date grouted
    - High pressure grouting details (dates, pressures, grout takes)
    - Date tensioned, working load (Tw), proof load (1.5 Tw or 1.25 Tw) and lock-off load (1.1 Tw)
    - Grout Test Data

The format shall be approved by the Engineer.

A12.2.8.2 Rockbolts, soil nails

a) Tests on cement grouts----as for cable anchors

The provisions in Clause A12.2.8.1a) for Cable Anchors shall apply where cement grouts are to be utilised.

The fluidity of the grout shall at all times be measured with a CSRA flow cone or similar approved and calibrated as specified.

b) Rock bolts / soil nails

The Contractor shall carry out process control testing to demonstrate that the rock bolts / soil nails are able to withstand the specified working loads. For this purpose the Contractor shall provide connectors to the protruding rock bolts / soil nails in order to execute this work. 10 % of bolts / nails, up to a maximum of 30, shall be tested. If excessive percentages of failure occur the number of bolts to be tested may be increased at the discretion of the Engineer.

The bolts/ nails shall be tested in accordance with prEN 22477-6, Methods A and B. Testing shall only be done until the grout and/or shotcrete facing have cured for at least 72 hours and have obtained the specified 3-day compressive strength.

There is currently some consensus that prEN 224777-6 (2015 document where 'pr' meant 'in preparation') be substituted by EN ISO 22477-5:2018 in Chapter 12.

Alternatively should BS EN 14490-2010 – "Execution of special geotechnical works – soil nailing" not be used? This is a comprehensive document regarding the installation and testing of sacrificial and production nail/dowel testing.

SIST EN ISO 22477-5:2018

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN ISO 22477-5

September 2018

ICS 93.020

English Version

Geotechnical investigation and testing - Testing of geotechnical structures - Part 5: Testing of grouted anchors (ISO 22477-5:2018)

Reconnaissance et essais géotechniques - Essais des structures géotechniques - Partie 5: Essais de tirants d'ancrage (ISO 22477-5:2018)

Geotechnische Erkundung und Untersuchung - Prüfung von geotechnischen Bauwerken und Bauwerksteilen - Teil 5: Prüfung von Verpressankern (ISO 22477-5:2018)

This European Standard was approved by CEN on 19 August 2018.

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Ref. No. EN ISO 22477-5:2018 E

The rock bolts / soil nails shall be tested to 115 % of the required working load no sooner than 3 (three) days after grouting has been completed. The tests will be undertaken with a suitably light hydraulic jack fitted with three pressure gauges which can be read to an accuracy of 1kN. Deflections of the bolt head are to be measured with a dial gauge to an accuracy of 0,1 mm. The jack and dial gauge will be required to be calibrated by an accredited laboratory approved by the Engineer at the commencement of the project, and whenever this may be required again. The certificate of calibration must be submitted to the Engineer for his approval. All rock bolt pull out tests shall be undertaken in the presence and to the requirements of Engineer.

Should a rock bolt fail a test, the Engineer will instruct the Contractor to either remove; re-drill, and install the defective bolt, or if this is not possible, to re-drill and install a new bolt at the position and orientation directed by the Engineer. This additional work will be undertaken at the Contractor's cost. Payment for bolts which have been measured and subsequently found to be defective will be subtracted from the following payment certificate. The bolt will be tested again once it has been re-installed or replaced. Once the Contractor has demonstrated that the bolt can withstand 115 % of the required working load it will be re-measured for payment.

In the case of mechanical driven tipping anchors and mechanical screw earth anchors, the products are very varied. Quality and workmanship shall be controlled as per the manufacturer's design and installation specifications or to specification as instructed by the Engineer in the Contract Documentation

The cost of all such tests shall form part of the Contractor's normal process control and shall be deemed to be included in the tendered rates and shall not be paid for separately.

c) Records

During the drilling operations, all changes in penetration rate and changes in ground type shall be recorded together with notes on water levels encountered, drilling rates, flushing losses or gains, and stoppages. The Contractor shall, notwithstanding the above, notify the Engineer immediately of any ground conditions contrary to that recorded on the drawings are encountered. The Contractor shall further record the date and times during which each hole is drilled and the subsequent date on which the bolts are grouted and installed. Before work commences the Contractor shall submit a suitable *pro forma* of the proposed daily record. Once approved by the Engineer, the Contractor shall submit these records to the resident Engineer on a daily basis for approval and measurement purposes.

A12.2.8.3 Performance monitoring

a) Cable anchors

(i) Long term monitoring

Monitoring to determine creep and other losses for permanent anchors shall be carried out by means of lift-off tests between 9 and 12 months after construction thereof (i.e. within the defects notification period).

If the residual force in the tendon during monitoring is below 0.92Tw, the Engineer will decide whether to proof load again to 1.5Tw and lock off at 1.1Tw, followed by 24 hour, 3 day and 10 day tests, or whether to conduct further lift-off tests at shorter intervals.

(ii) Defective ground anchors

Anchors unable to retain a load of 0.92Tw shall be considered defective. These ground anchors shall be corrected by one of the following methods approved by the Engineer:

Abandoning the ground anchor and replacing with a new ground anchor,

Post-grouting and retesting the ground anchor,

Revisiting the design by the Engineer to establish what additional measures may be required to ensure the long-term performance of the anchored structure.

If the loss of tension is attributable to deficiencies in the Contractor's work, the above remedies shall be at his cost.

Where additional works are instructed by the Engineer that is not due to Contractor deficiencies, these shall be paid at tendered rates, except for the re-establishment which shall be paid for separately.

B12.2 GROUND ANCHORS

PART B: LABOUR ENHANCEMENT

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B12.2.1 SCOPE

The provisions of Part A shall apply.

B12.2.2 DEFINITIONS

The provisions of Part A shall apply.

B12.2.3 GENERAL

The provisions of Part A shall apply.

B12.2.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

The provisions of Part A shall apply.

B12.2.5 MATERIALS

The provisions of Part A shall apply.

B12.2.6 CONSTRUCTION EQUIPMENT

The provisions of Part A shall apply.

B12.2.7 EXECUTION OF THE WORKS

The provisions of Part A shall apply.

B12.2.8 WORKMANSHIP

The provisions of Part A shall apply.

C12.2 GROUND ANCHORS

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each pay item shall include full compensation for providing, operating, maintaining and decommissioning upon completion, of all the construction equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the pay item as specified, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

1. Unless otherwise ordered or stated in the Contract Documentation, trench depths will be measured from the surface of the ground along the centre-line of the trench to the bottom of the specified bedding layer (as applicable). Where no bedding is required it shall be measured to the underside of the duct or pipe.
2. The ground surface will be that existing after any bulk earthworks have been carried out, i.e. the excavated surface or embankment surface, unless a different sequence of execution has been ordered.
3. Excavations will be measured as if taken out with vertical sides, regardless of whether they have been taken out with sloping sides.
4. The length used for trench computations will be the total through-length of a pipe or duct etc. from end to end and no deduction will be made for manholes or access chambers etc.
5. Wherever volumetric measurement is required, the volume will be computed from the depth determined as indicated in 1. and 2. above and using the authorised width (W) determined in accordance with the specification.
6. Where shoring is specified or ordered, the length of shoring measured for payment will be the length of the centre-line of the trench.

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as the Contractor deems appropriate:

1. No separate payment will be made for backfilling excess excavations, disposing of surplus material etc. or any other contingent work, unless the work is specifically specified or ordered.
2. No separate payment will be made for setting out the works.
3. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities and for complying with all the requirements of Clause A2.1.3.4 of Chapter 2.
4. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
5. No separate payment will be made for the loading of any materials.
6. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to, 1,0 km.
7. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
8. No separate payment will be made for the removal of any surplus material imported to complete the works.

(iv) Items to be measured and paid for using items specified elsewhere in the specifications

Not applicable to this Section.

(v) Items specifically for this Section of the specification

Item	Description	Unit
C12.2.1	**Establishment on site for anchoring**	lump sum

The unit of measurement shall be a lump sum.

The tendered lump sum for anchoring shall include full compensation for establishing all necessary plant and equipment on site to carry out the works, preparing the work area for drilling, grouting and subsequent anchoring, and for removal from site of all such plant and equipment including all temporary works such as access roads, staging, platforms and such like on completion of the works.

The work shall be paid as a lump sum, 50 % of which shall be due when all equipment is on site, trials (if any) are completed and the first production anchor is installed to the satisfaction of the Engineer. The second instalment of 25 % shall be payable after half the number of positions are anchored and the final 25 % instalment after all anchoring is complete, tested, accepted and equipment removed from site.

The tendered lump sum shall include full compensation for all post-construction requirements as specified.

No extra payment shall be made for establishment of additional plant should the established plant not be capable of achieving desired objectives.

Item	Description	Unit
C12.2.2	**Re-establishment on site for additional work** (type indicated)	**lump sum**

The unit of measurement shall be a lump sum.

The tendered lump sum for anchoring shall include full compensation for re-establishing all necessary plant and equipment on site to carry out additional works as instructed by the Engineer and shall include all aspects detailed in Clause A12.2.8.3a)(ii).

Item	Description	Unit
C12.2.3	**Provision of access to anchor positions**	**lump sum**

The unit of measurement shall be the provision of access to the anchor positions as specified in the Contract Documentation.

The tendered rate shall include for all labour, plant and equipment required to provide access to the anchor positions as specified.

Item	Description	Unit
C12.2.4	**Moving to, and setting up the equipment for drilling the holes at each position**	number (No)

The unit of measurement shall be the number of positions to which the drilling equipment has to be moved and set up in position to drill an anchor hole. The quantity measured shall be the number of set ups at anchor positions as well as at site suitability /trial anchor positions or at positions where the Engineer has ordered re-drilling of the holes.

The tendered rate shall include full compensation for all costs involved in moving and setting up any equipment.

Item	Description	Unit
C12.2.5	**Drill holes with a diameter of** (diameter indicated) **to the specified depths and inclinations**	**metre (m)**

The unit of measurement shall be the metre of hole, including the depth of the bulbous base formed, as may be applicable. The depth of the bulbous base shall be deemed to be equal to the diameter of a sphere, the volume of which shall be equal to the quantity of compacted concrete in the bulbous base.

The tendered rate for forming augered holes shall include full compensation for augering and disposing of surplus material resulting from the hole having been formed.

The tendered rate for forming bored holes shall include full compensation for boring, supplying, installing and extracting the driven temporary casing as well as for disposing of surplus material resulting from the hole having been formed.

Item	Description	Unit
C12.2.6	**Installation of permanent casing** (size and length indicated)	**metre (m)**

The unit of measurement shall be the metre of permanent casing installed.

The tendered rate for installing permanent casing shall include full compensation for the supply and installation of permanent steel casings, complete with casing shoes and ringbits, including all welding, plant, labour and overhead costs in the indicated lengths.

Item	Description	Unit
C12.2.7	**Water tests**	**number (No)**

The unit of measurement shall be the number of holes tested.

The tendered rate shall include full compensation for installing and the subsequent dismantling and removal of the testing equipment, conducting the test and processing and submitting the results.

Item	Description	Unit
C12.2.8	**Grouting and re-drilling the holes**	**metre (m)**

The unit of measurement shall be the metre of hole grouted and re-drilled.

The tendered rate shall include full compensation for all grouting materials and equipment, the grouting operation, re-setting up drilling equipment, the re-drilling operation, flushing and cleaning the hole to provide a watertight hole.

Item	Description	Unit
C12.2.9	**Cable anchor tendons:**	
C12.2.9.1	Free anchor length	meganewton-metre (MN-m)
C12.2.9.2	Fixed anchor length	meganewton-metre (MN-m)

The unit of measurement shall be the meganewton-metre which is calculated as the product of the characteristic strength (in megapascals) of the prestressing steel, the cross-sectional area of the tendon (in square metres) and the length of the tendon (in metres) between the outer faces of the anchorages. In the case of fan and loop anchorages the "length of the tendon" shall include the length of tendon forming the loop or fan.

The tendered rates shall include full compensation for preparing and submitting the drawings, supplying, storing, handling and protecting all materials (excluding anchorages and couplers at the jacking end), fabricating, supporting and installing the cables, lubricating, permanently protecting and bonding the tendons, for the using of all the equipment, as well as for all work and incidentals required for completing the work as specified.

Item	Description	Unit
C12.2.10	**Anchorages and couplers:**	
C12.2.10.1	anchorage at jacking end	meganewton (MN)
C12.2.10.2	Coupler at jacking end	meganewton (MN)

The unit of measurement shall be the meganewton which is calculated as the product of the characteristic strength in megapascals of the pre-stressing steel and the cross-sectional area of the tendon in square metres, effectively anchored or coupled.

The tendered rates shall include full compensation for supplying, storing, handling, fabricating and protecting the complete anchorage or coupler assembly, anchorage reinforcing, constructing the recesses for the anchorage or coupler, tensioning of the tendons, anchoring and/or coupling, trimming the tendon ends, using all the equipment, as well as for all work and incidentals required for completing the work as specified. It shall also include full compensation for testing the tendons to the specified test force in accordance with the prescribed methods.

The coupler shall include the complete assembly consisting of the anchorage built into the first-stage construction and the part coupled to it.

Item	Description	Unit
C12.2.11	**Encasing the anchorages at the jacking end in concrete**	**number (No)**

The unit of measurement shall be the number of anchorages encased.

The tendered rate shall include full compensation for all materials, equipment, plant and labour required for protecting the anchorages at the jacking end with approved grease filled permanent covers as specified and detailed on the drawings.

Item	Description	Unit
C12.2.12	**Performance monitoring of anchors**	
C12.2.12.1	Establishment of lift-off testing team and equipment	lump sum
C12.2.12.2	Lift-off tests	number (No)

The tendered lump sum shall include full compensation for establishment on site and subsequent removal of all the plant, equipment and incidentals required for monitoring by means of lift – off tests and the re-tensioning of the anchors.

This work will be paid for as a lump sum, of which 75 % will become payable when all equipment is on site and the first anchor has been monitored and the remaining 25 % will become payable after all anchors have been monitored and re-tensioned where required and the equipment has been removed from site.

The unit of measurement for the lift-off tests shall be the number of anchors monitored or re-tensioned.

The tendered rate shall include for the supply and installation of all testing equipment, material, incidentals (including transport and accommodation) as well as competent experienced personnel for the testing of the anchors as specified and for the preparation and submission of tensioning records. The tendered lump sum shall also include for the removal and replacement of the grease cap, the refilling of the crease cap with similar approved grease and ensuring a leak proof seal thereto. rockbolts, dowels, soil nails

Item	Description	Unit
C12.2.13	**Establishment on the site for drilling of rockbolts, dowels, soil nails or mechanical anchors** (type indicated)	**lump sum**

The tendered lump sum shall include full compensation for generally levelling the drilling site to the required post construction levels (where applicable), establishing on site with and subsequent removal of all structural platforms, rafts and all special plant and equipment for drilling and for carrying out operations, the cost of which does not vary with the actual amount of drilling done.

No additional payment will be made for the establishment of other or supplementary plant and ancillary equipment should that initially established by the Contractor be incapable of penetrating the subsurface soil or rock formations, or achieving the desired hole formation without undue disturbance of the surrounding material, or achieving the required production rate.

This work will be paid by lump sum: 50% payable when all equipment for the works is on site and the first hole has been drilled. The next 25% of the lump sum will be payable after half the total number of holes have been drilled, and the final 25% after all the holes have been drilled and the equipment has been removed from the site.

Item	Description	Unit
C12.2.14	**Move to and set up at each rockbolt, dowel, soil nail or mechanical anchor position**	**number (No)**

The unit of measurement shall be the number of set ups as instructed and approved by the Engineer.

Item	Description	Unit

C12.2.15	**Install, grout and protect soil nails or rock bolts** (lengths indicated)	**number (No)**

The unit of measurement shall be the number of rock bolts / soil nails installed as specified and as approved by the Engineer.

The tendered rate shall include full compensation for drilling, cleaning drill holes, procuring, corrosion protection, installing and seating rock bolts with all ancillary face plates, washers and nuts, grouting, protection of bolt ends and face plates, testing bolts as required, all labour, materials and all other incidentals required to complete the work in accordance with the Contract Documentation and the Engineer's instructions. All pull out test requirements and costs are deemed to have been included in this payment item and no extra payment will be made in this regard.

Item	Description	Unit
C12.2.16	**Extra over for tensioning soil nails or rockbolts**	**number (No)**

The unit of measurement shall be the number of rock bolts / soil nails tensioned in accordance with the Engineer's instruction.

The tendered rate shall include full compensation for labour, plant, equipment, materials and all other incidentals required to complete the work in accordance with the Contract Documentation and as instructed by the Engineer.

Item	Description	Unit
C12.2.17	**Apply rock bolt protection and camouflage**	**number (No)**

The unit of measurement shall be the number of rock bolt heads protected and / or camouflaged as instructed and approved by the Engineer.

The tendered rate shall include full compensation for the supply of all materials and work required to apply the protection and / or camouflage layer.

Item	Description	Unit
C12.2.18	**Move to and set up at each mechanical driven tipping anchor/ mechanical screw anchor position** (type indicated)	**number (No)**

The unit of measurement shall be the number of set ups as instructed and approved by the Engineer.

The tendered rate shall include full compensation for access to the work face or position, dismantling, moving, erecting and commissioning all plant, equipment and instruments required at anchoring location. The rate shall also include for undertaking the specified process control testing and providing the Engineer with access to the work face. This item shall be paid for only after the entire anchoring operation has been completed and approved by the Engineer.

Item	Description	Unit
C12.2.19	**Install mechanically driven tipping anchors / mechanical screw anchors** (type and lengths indicated)	**number (No)**

The unit of measurement shall be the number of mechanical driven tipping plate soil anchors / installed to depths as instructed and approved by the Engineer.

The tendered rate shall include full compensation for procurement of materials, corrosion protection, installation, and seating of anchors, load locking, tensioning to the design working load and testing, as may be applicable. Installation shall include all ancillary face plates, washers and nuts, protection of anchor ends and face plates, testing anchors as required, all labour, materials and all other incidentals required to complete the work in accordance with the Contract Documentation and Engineer's instructions. All pull out test requirements and costs are deemed to have been included in this payment item and shall not be paid for separately.

D12.2 GROUND ANCHORS

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

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B12.2.6 CONSTRUCTION EQUIPMENT

B12.2.7 EXECUTION OF THE WORKS

B12.2.8 WORKMANSHIP

D12.2.1 SCOPE

The scope of this Section covers the following:

- Guarantees and compliance certificates
- Product conformance specifications

D12.2.2 GENERAL

The Contractor shall provide detailed specifications, test data, performance data and compliance certificates from independent reputable agencies for all proprietary systems, processes and materials proposed for use. These shall demonstrate conformance with the performance requirements specified in the Contract Documentation.

Unless otherwise specified, all proprietary materials shall be used and placed in strict accordance with the relevant manufacturer's current published instructions

D12.2.3 PERFORMANCE GUARANTEE REQUIREMENTS

The Contractor shall, within 28 days of entering into the contract with the Employer, submit to the Engineer conformance documentation related to the specifications.

Conformance documentation shall be provided for the following:

- Materials and Materials Design as per Clause A12.2.3.2
- Materials as per Clause A12.2.5,
- Construction Equipment as per Clause A12.2.6
- Execution of the Works as per A12.2.7.

Performance specifications shall be provided for the following:

Prestressing system:

a) Proven track record;
b) Compliance with an internationally recognized standard such as EN 13391.

D12.2.4 FUNCTIONAL PERFORMANCE ASSESSMENTS

No specific items in this Section.

D12.2.5 VISUALLY ASSESSED PROPERTIES

No specific items in this Section.

D12.2.6 INSTRUMENTALLY ASSESSED PROPERTIES

No specific items in this Section.

D12.2.7 EVALUATION FOR ACCEPTANCE

No specific items in this Section.

D12.2.8 ADDITIONAL PROCEDURES TO BE ADOPTED IN THE EVENT OF FAILURE

No specific items in this Section.

D12.2.9 NOTIFICATION OF REMEDIAL WORK

No specific items in this Section.

D12.2.10 REMEDIAL WORKS

No specific items in this Section.

QUESTIONS?

12.2 LATERAL SUPPORT

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A12.4 LATERAL SUPPORT

PART A: SPECIFICATIONS

A12.4.1 SCOPE

This Section covers some of the various techniques employed to provide lateral support including Sheet Piling and Diaphragm Walls where this forms part of the permanent works and provision is made for the payment thereof in the Contract Documentation.

Other commonly used methods such as secant/contiguous piling, soil nailing, rockbolting and rock doweling, shotcreting, etc are addressed elsewhere.

A12.4.2 DEFINITIONS

The following definitions shall apply to these specifications:

Embedded wall - is a structural wall, partially or fully embedded in subsoils. Embedment may be achieved by driving the structure or elements of the structure into the subsoils or by placement into preformed holes or trenches. The structural wall is designed either as a cantilever to provide the primary support, or to act as a support system against which braced or tie-back forces are mobilised. Embedded walls may comprise:

- Steel sheet piles
- Precast concrete sheet piles
- Steel soldiers
- Concrete soldier piles
- Contiguous and secant pile walls
- Diaphragm walls

Sheet pile wall - is an embedded wall comprising individual steel or precast concrete sheet piles linked together and driven into the ground to provide lateral support and/ or an impermeable barrier. Steel sheet piles are more common than precast concrete.

Steel sheet piles - are Z- and U-shaped hot rolled steel sheet pile elements (manufactured and imported from Europe or the UK).

Pile threader - is a mechanical device used to interlock sheet piles into panels for grouped installation.

Slinging Hole - is a lifting hole located near individual pile sheets approximately 32 mm in diameter usually located 150 mm from the sheet ends.

Interlock - sheet pile interlock is preformed through coupling edges allowing individual steel piles to lock onto one another thereby providing a tight high-strength bond.

Crimping - is spot pressure indentation which permanently locks one sheet pile to another in order to increase resistance against bending, and thereby allowing faster pile installation.

Tie rods - are anchors used in sheet piling to retain sheet pile walls to remote deadman anchorages. They may comprise stand- alone steel elements suitable protected against corrosion or reinforced concrete beams.

Turnbuckle - a turnbuckle joins plain tie-rod ends to upset end of a tie rod.

Waler - is a horizontal beam capable of transferring load between individual anchor elements (tie-rods, props, ground anchors, etc).

Combined Sheet Pile Wall - is an embedded wall using a combination of sheet piles and king piles (box, H, tubular steel tubes, etc) to create large bending resistance. King piles can also be used as end-bearing piles with the intermediary sheet piles acting mainly as soil-retaining and load-transferring elements.

Guide Frame - is a frame used to enable exact placement and vertical orientation of king pile elements in combined sheet pile walls.

Driving cap - is a sheet pile capping to provide consistent energy transfer between hammer and sheet pile section thus preventing damage to top end of pile.

Pile extractor - is used in temporary works to extract piles for re-use.

Diaphragm wall - is an embedded wall constructed using a narrow trench excavated into in situ ground and supported by an Engineered fluid (typically bentonite slurry) until the slurry is replaced by permanent material. Permanent material generally comprises reinforced concrete, though unreinforced walls can also be used.

Guidewall - comprises of two shallow reinforced concrete, brick –or concrete block walls constructed to ensure panel excavations are aligned within acceptable tolerances. The internal wall is usually removed after completion of the diaphragm wall.

Stop end - is a vertical steel tube, polystyrene or precast concrete column placed at panel edges to provide, on withdrawal, a recess joint between adjacent panels. The recess joint promotes water tightness.

Diaphragm Panel - comprises of one individual unit of the wall constructed against another (one side or two) in pre-planned rotation to final completion of the diaphragm wall.

Pitching - means raising or lifting construction elements into a vertical position.

Panel Recess - panel recessing via stop ends is required to link individual reinforced concrete panels into a continuous watertight wall.

A12.4.3 GENERAL

A12.4.3.1 Method Statements

Where so indicated by the Engineer the Contractor shall prepare detailed method statements for each facet of the work describing key aspects such as construction methodology, key plant, materials, personnel as well as any programme constraints of the envisaged construction process.

These method statements shall be prepared and submitted to the Engineer for approval prior to commencement of that activity, within time scales specified. The onus lies with the Contractor to ensure that the information is obtained and that associated activities are completed expeditiously to avoid any delays in the commencement, continuation and completion of the required works. Unless otherwise specified or provided for in the Contract Documentation no permanent works shall be commenced until the Engineer's approval of the relevant method statement. The Contractor shall, however, remain responsible for all work-methods, materials, plant and equipment used, notwithstanding acceptance by the Engineer.

The Contractor shall be required to construct trials and the testing thereof as specified herein and shall make due allowance therefore in his programme. Allowance shall also be made for allow for the Engineer's assessment of constructed works, procedures followed, and materials and plant utilised and test data. Production work shall not be permitted until it is shown and accepted by the Engineer that the Contractor possesses the necessary experience, plant and equipment to carry out the works as specified in the Contract Documentation.

It should be noted that work shall only be performed by personnel listed by the Contractor. If personnel changes need to be made during the project, works shall be suspended until replacement personnel are approved by the Engineer. Time lost due to incomplete submissions, unacceptable submissions, or obtaining approval of replacement personnel will not be considered as cause for extension of time or delay claims. All costs associated with incomplete, replacement, or unacceptable submissions shall be to the Contractor's cost.

Once approved in writing by the Engineer, these shall become the method statements in accordance whereby the relevant portion of the works shall henceforth be executed. Notwithstanding, the Engineer may require revision from time to time if circumstances during construction arise which warrants change.

A12.4.3.2 Materials and materials design approvals

All materials used in the works described hereunder shall meet the appropriate standards given below and/or specified in the Contract Documentation and shall be subject to the approval of the Engineer. The Contractor shall submit product certificates, conformance documentation related to the specifications, test results as required together with samples of materials and where applicable, materials designs that he proposes to use in the construction of the works to the Engineer for his acceptance/approval as provided for in the Contract Documentation.

Due allowance shall be made for obtaining materials, resubmissions and re-designs, all to the required/approved standards, methods and practices in attending to these requirements. Particular attention shall be paid to the early submission of materials-, concrete- and grout mix designs where parameters at various ages may be specified. No consideration for extension of the contract period will be entertained for delays incurred in meeting these requirements.

The Contractor's attention is drawn to the approvals required as indicated in Table A12.4.3-1 below regarding works carried out under this section of the works:

Table A12.4.3-1: Approvals Required

CLAUSE	REQUIREMENTS*	PERIOD/WORKS PUT ON HOLD
	Materials Design Approvals	
A12.4.4.3	Concrete mix design for Diaphragm walls	6 weeks before placement
	Materials Approvals	
A12.4.5.1	Sheet piling materials	2 weeks before utilisation
	Construction Method Approvals	
A12.4.4.2	Sheet piling method statement	2 weeks before works commenced
A12.4.4.3	Diaphragm wall method statement	2 weeks before works commenced
A12.4.5.1	Sheet pile damage remediation	2 days before commencement
A12.4.5.1	Burning or drilling of lifting holes	2 days before commencement

A12.4.3.3 Sheet piling

Sheet piling is construction of an embedded wall achieved by combining individual steel or precast concrete sheet piles linked together and driven either to refusal or predetermined depth, into the ground to provide lateral support and/or an impermeable barrier. Each sheet pile has a pair of clutches that allow the male of one sheet to interlock with the female of another. The resultant structural wall forms an integral part of the overall lateral support system and is designed either as a cantilever to provide primary method of support, or to act as a support system against which braced or tie-back forces are mobilised.

Sheet piles are mostly constructed from steel sheets imported from the United Kingdom or Europe. Precast concrete elements are generally manufactured locally.

The commencement of the production may only commence when the Engineer has given written acceptance of designs for which the Contractor is responsible in terms of the Contract Documentation, the Contractor's method statements, and approval of plant and equipment.

A12.4.3.4 Diaphragm walls

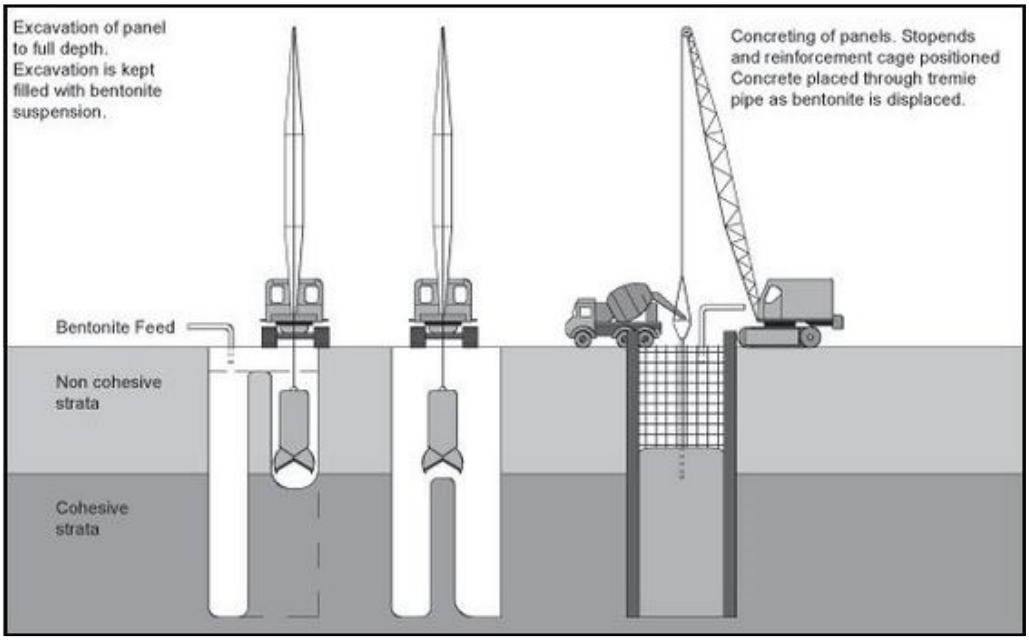
Diaphragm walls are cast in situ concrete walls, generally reinforced, using under-slurry techniques. Diaphragm walls are necessary:

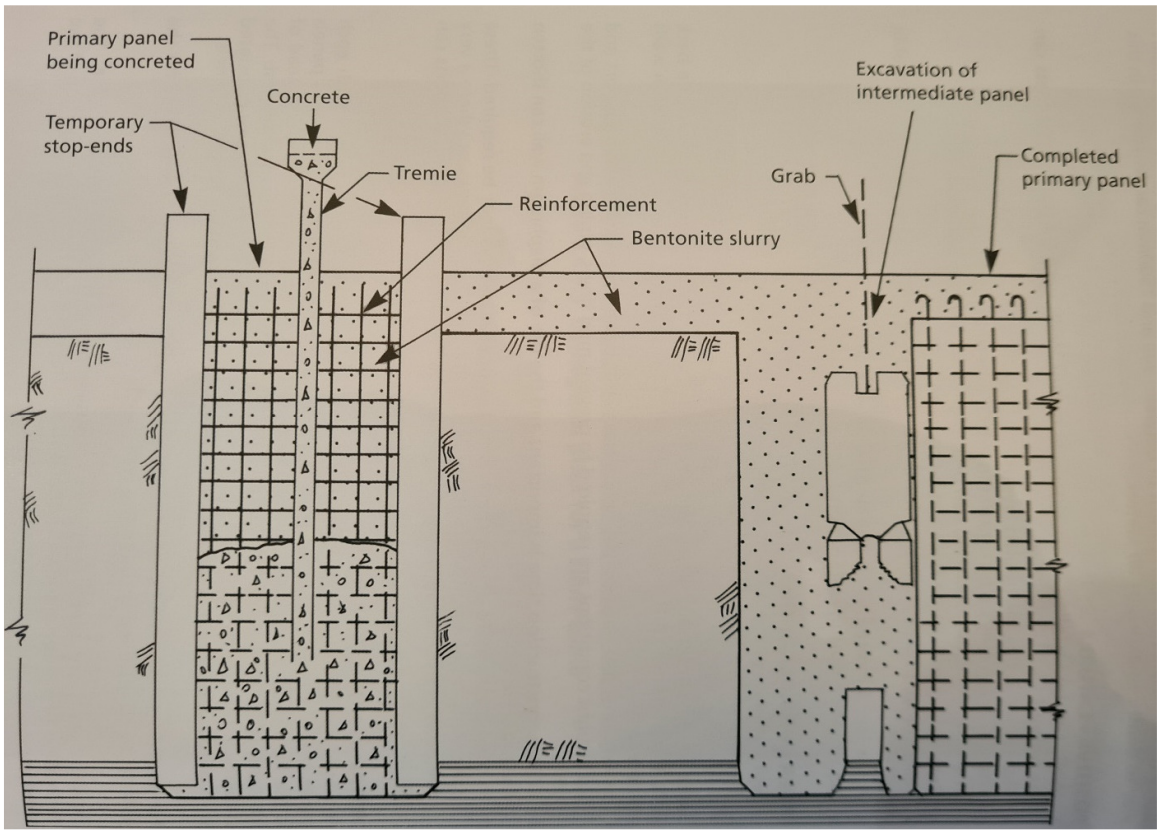
- In very unstable soil profiles beneath the water table where continuous support and watertight joints are required to prevent mudflows, piping and erosion of soils
- Where time is limited and the construction of a diaphragm wall to provide support and/or water retention allows earlier subsurface excavations. In conditions where deeper than normal cantilever support may be required, for example, where the wall acts as cantilever only, or where a very deep initial excavation is required before the first braced or tie-back support can be installed.

Diaphragm walls require a large site area. They are not suited to small or shallow basement excavations.

Wall widths from 600 mm to 1500 mm can be formed using diaphragm walls, to depths greater than 60 m. The resultant structural wall forms an integral part of deep lateral support and is designed either as a cantilever to provide primary support or water retention/dewatering, or to act as a support system against which braced or tie-back forces are mobilised. Cantilever is generally effective between 4,0 and 6,0 m; bracing up to 10 m, and anchored walls to 25 m and higher.

Commencement of production shall only start when the Engineer has given written acceptance of designs for which the Contractor is responsible for in terms of the Contract Documentation, the Contractor's method statements, and approval of plant and equipment.




Primary panel being concreted
Concrete
Temporary stop-ends
Tremie
Reinforcement
Bentonite slurry
Excavation of intermediate panel
Grab
Completed primary panel

Photographs and figures – with thanks – from "A Guide to Practical Engineering in Africa" Franki 5th Edition 2019

A12.4.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

A12.4.4.1 General

The Contractor shall design the concrete and/or grout used in carrying out the works as specified. Mix designs shall be complete, be presented on the required forms and shall be presented to the Engineer with samples of all the constituents as required at least 6 weeks prior to placement

Where design by the Contractor for any specialised/proprietary technique to be carried out is, in terms of project specification the responsibility of the Contractor, all the aspects given below shall be taken into consideration in carrying out these obligations.

The following shall normally be specified (where applicable) by the Engineer and reflected in the Contract Documentation:

- Techniques and methods to be followed
- Material type and quality
- Site specific requirements
- Limits of areas and depths to be treated
- Concrete mix design
- Bentonite slurry mix design
- Reinforced concrete strength, panel characteristics, post-treatment properties, durability and any other deliverables as may be appropriate
- Layout of lateral support
- Sequence of installation
- Permissible limits (pressures, flow rates)
- Quantities of grout/other materials (if required) to be injected/used
- Monitoring of works
- Quality and workmanship requirements
- Measurable properties to be achieved over the life span of project
- Anti-corrosion requirements
- Environmental and safety requirements specific to techniques to be executed
- Monitoring and record keeping requirements.

The following information will be generally provided in the Contract Documentation:

- Definition of objectives and control criteria
- Investigation data including subsurface geological information, hydrological data and geotechnical parameters
- Test data, borehole logs and recovered core samples
- Limitations including information on subsurface services
- Availability of materials on site.

The following aspects, where applicable shall also be addressed:

Finishing off of treatment areas to specified lines and levels, whether materials are to be removed, removed and replaced by other materials, processing of materials and all other measures to be carried out in meeting requirements as specified in Contract Documentation.

The Contractor shall provide a quality management plan indicating his proposed quality assurance testing program which shall allow, if necessary, testing at each treatment position as required. Testing methods to be employed shall be as specified in the Contract Documentation.

A12.4.4.2 Sheet piling

The Contractor, where so specified, shall prepare a detailed construction proposal/design detailing all plant, equipment and materials to be employed in meeting the sheet piling objectives and performance requirements detailed in the Contract Documentation as well as address all the aspects given in Clause A12.4.4.1.

The Contractor shall be responsible for the acquisition and conveyance to site of sheet piling materials of suitable quality with manufacturer specifications, the latter presented for approval by the Engineer prior to delivery/purchase.

Before commencement of any piling works, the Contractor shall submit a method statement to the Engineer for approval which shall include the following information:

- Programme of works detailing sequence and timing of individual portions of the works
- Maximum proposed lead at any stage of driving between a pile and its neighbour and the limitations of same if hard driving is encountered
- Height, spacing, stability and type of piling guidance system and the number of piles in each panel (if applicable)
- Full details of installation plant to be utilised including manufacturers information, proof of servicing/ recent upkeep and assessment of actual input energy to the piles and a definition of driving refusal for each type of plant proposed
- Proposed phasing of any excavation/ filling operations such that design stresses in the piles and frames/ supports are not exceeded
- Contingency plan in the event of encountering obstructions or reaching driving refusal to minimise disruption/ delay especially when using pitch and drive methods
- Predicted noise levels and confirmation these are within statutory requirements
- Confirmation that vibration levels are within requirements of Contract Documentation.

Sheet pile design shall be carried out by competent personnel following on from relevant approved/ specified design requirements.

Engineer approval of the Contractor's method statement shall not be unduly withheld with acceptance lead time as per Table A12.4.3-1.

A12.4.4.3 Diaphragm walls

The Contractor, where so specified, shall prepare a detailed construction proposal/design detailing all plant, equipment and materials to be employed in meeting diaphragm wall objectives and performance requirements detailed in the Contract Documentation as well as address all the aspects given in Clause A12.4.4.1.

Before commencement of any work, the Contractor shall submit to the Engineer a Method Statement for approval which shall include the following information:

- Program of works detailing sequence and timing of individual portions of the works
- Full details of installation plant to be utilised including manufacturers information; proof of servicing/ recent upkeep; and logistics of planned plant rotation to fulfil construction requirements
- Correct layout of panels and means to achieve this on the ground. The layout plan must take into consideration factors such as grab size; wall plan shape; dimension of steel reinforcement cages, and site logistics
- Proposed panel rotation for excavation; reinforcement installation, and concreting
- Dimensions; depth (minimum 1,2 m), and strength of the concrete guide walls
- Proposed mixing; batching and removal to storage of bentonite slurry and a back-up plan for sudden loss of suspension
- Proposed method of reinforcement cage construction; pitching and installation
- Stop end type, insertion and removal with confirmation of panel edge recessing
- Steel sleeve (block-out) location and method of prop or tie-back anchorage
- Contingency plan in the event of encountering obstructions
- Confirmation that all requirements of Contract Documentation are being achieved.

Planning and construction of diaphragm walls shall be carried out by competent and experienced construction personnel following on from relevant approved/ specified design requirements.

Engineer approval of the Contractor's method statement shall not be unduly withheld with acceptance lead time as per Table A12.4.3-1.

The Contractor shall be responsible for the design of a suitable cementitious concrete mix and bentonite slurry for construction of the diaphragm wall which shall be presented by for approval by the Engineer with due consideration of the following:

Availability of cementitious products in the quantities required for production
The achievement of the specified characteristic strength in the mix
Workability of the concrete during displacement of the bentonite slurry

The following procedure shall be applicable:

- Obtaining samples of the mix constituents
- Carrying out the mix designs
- Production of trial mixes in the laboratory to allow for the sampling and testing of concrete
- Production of trial mixes by production plant to allow for the sampling and testing of concrete
- Carrying out adjustments to the mix designs as may be required and repeating laboratory and production plant trial mixes to allow for the sampling and testing of concrete

- Obtaining Engineer's approval of the mix.

Concrete mix design shall be carried out by competent personnel following the relevant approved/ specified mix design procedures and SANS Methods for the sampling, curing and testing procedures. The relative density as well as the fluidity of the various mixes shall be determined to provide a basis for ongoing quality assurance during diaphragm wall construction.

The Contractor shall submit his proposed mix design for the concrete accompanied by all relevant information to the Engineer for approval. A lead time, as per Table A12.4.3-1, is required for this information. Construction shall only proceed once the Engineer is satisfied that the mix meets the minimum performance criteria specified including the 28 day characteristic strength of the concrete as specified in the Contract Documentation. Any changes to the mix after the Engineer's approval has been obtained shall only be permitted if approved in writing by the Engineer.

A12.4.5 MATERIALS

A12.4.5.1 Sheet piling

Sheet pile sections are available in ordered lengths. Recommended maximum lengths, as dictated mainly by handling and driving requirements are as follows:

Table A12.4.5-1: Recommended sheet pile lengths

Moment of Inertia of Section cm^4 per metre width	Maximum recommended length in metres	Typical wall thickness (mm)	Typical section half depth (mm)
4110	6		
13513	14		
23885	18	10,0	150
39831	23	10,5	220
49262	24	13,0	220
92298	26	19,0	230

Sheet pile lengths may be successfully extended by specialist welding of sections or shortened by cutting. Length changes must ensure no damage or distortion occurs to adjacent piles.

Steel sheet pile sections are manufactured from various grades of steel in accordance with EN10249-1-1995 as per Table A12.4.5-2 below for cold-formed U and Z sections:

Table A12.4.5-2: Steel grades

Grade of steel	Minimum yield strength R_{eH} (MPa)	Tensile strength R_m (MPa)	Former UK reference
S 235 JRC	235	340 – 470	40B
S 275 JRC	275	410 – 560	43B
S 355 JRC	355	490 – 630	50C

In hard driving conditions it may be necessary to increase the pile section size to achieve the required penetration and/ or adopt a higher grade of steel. The Engineer's approval shall be obtained before orders for any sheet pile sections are placed.

Piles shall be stacked on site in accordance with the manufacturer's recommendations. The Contractor shall ensure that operations involving loading, transporting, offloading, handling, stacking and pitching the piles, are carried out in a manner that shall prevent damage to them or their coatings. The Engineer shall be immediately informed of any damage and the Contractor shall the submit proposals for remedial measures, the cost of which shall be borne by the Contractor. Lifting holes shall not be burned or drilled through sheet pile without prior approval by the Engineer and shall be made good after use. The same pile sections; lengths and steel grades shall be stored in different stacks clearly marked or colour-coded to avoid placement errors.

Driving caps for diesel hammers shall be manufactured from cast steel and have an arrangement of guiding grooves for the different sheet pile sections on its lower side. A wooden or plastic/composite dolly (cushion) shall be fitted into recesses on top of the driving cap.

Walers, tie-rods and ground anchors shall be as specified in the Contract Documentation.

A12.4.5.2 Diaphragm Wall

a) Bentonite slurry

Bentonite slurry is a viscous mixture of approximately 4 % - 6 % of bentonite powder by mass with water and be of such consistency that soil and other heavy particles mixed with this bentonite slurry during excavation are held in suspension and do not settle to pile base.

Bentonite shall either be of sodium origin or calcium *derivation* and checked for required thixotropic properties, quality, moisture content, grading and sand content.

b) Cement

Cement used in cementitious grout shall be CEMI or CEMII complying with SANS 50197 -1 or such other cements as specified in the Contract Documentation. The Engineer may allow or specify the use of other cements and certain additives to improve workability of the tremied concrete in order to optimise construction of the wall.

c) Water

Water used for batching of grout and bentonite slurry shall be potable, complying with SANS 51008.

d) Sand

Sand shall be clean, non-plastic, non-angular and well-graded particles sized from 0,06 – 2,0 mm.

e) Coarse aggregate

Coarse aggregate shall comprise of clean, durable, hard rock aggregate as per SANS 1083 or as specified in the Contract Documentation.

f) Steel

Steel for the reinforced cage shall be as indicated in the Contract Documentation and as per the requirements of this document.

A12.4.6 CONSTRUCTION EQUIPMENT

A12.4.6.1 Sheet piling

a) Driving equipment

A wide variety of plant is available for sheet piling including small to large vibratory, drop, hydraulic, pneumatic, diesel hammers; employing various techniques for insertion. Selection of plant shall be determined by its ability to install pile sections while considering economies of scale. Choice of plant shall also be influenced by noise; vibration type and output for specific site locations. Equipment used shall be in good working order and properly maintained.

b) Pile threader/ Guide frame

Pile threaders/ guide frames shall be used to interlock individual piles at ground level to eliminate manually guiding piles to interlock. Lifting shackles are required to lift, and guide piles, into position in the threader.

c) Pile extractors

Sheet piles intended to serve only as temporary works shall be extracted for re-use by means of suitable pile extractors. Cranes used in extraction shall have an appropriately sized jib to prevent damage when extraction forces are applied.

d) Ancillary equipment

All ancillary equipment (cranes; driving caps; generators, etc.) required to execute pile installation shall be fit-for-purpose.

A12.4.6.2 Diaphragm walls

a) Excavation equipment

Diaphragm wall panels shall be excavated using one or more of several types of equipment as may be appropriate to the project requirements including:

- Hydraulic Cutters - These are capable of excavating even into rock but require large bentonite slurry plants and large cranes to hold cutters. Steel mechanisms built into the grab body provide a high degree of verticality control.
- Hydraulic Grab - Hydraulic grabs have hydraulically operated closing jaws able to exert considerable closing force to excavate dense sand; stiff clay, or soft/ very soft rock. They can include steering mechanisms.
- Cable Grab - Cable grabs use only pulley forces to close grab jaws and are more suited to soft ground
- Kelly Grab - Kelly grab types are rigidly suspended from a base machine opposed to rope-suspended grabs as detailed above. Kelly grabs provide reasonable excavation force and verticality control but are slower than other methods.

Typical diaphragm wall widths are 0,6 to 1,5 m although other sizes may be constructed.

b) Bentonite slurry equipment

Bentonite slurry equipment shall comprise a storage facility for bulk or bagged material; colloidal mixer; hydration storage tank, and slurry pump. Slurry mixing plants shall be equipped with high-speed/ high-shear colloidal mixers or high-velocity/high shear jet mixers used in conjunction with a high-speed/high-shear centrifugal pump. Plant shall be equipped with a mechanically, or hydraulically, agitated sump and shall include pumps, valves, hoses, supply lines, tools and other equipment and materials required to manufacture the slurry and deliver it in a continuous supply from hydration ponds (or tanks) to diaphragm panels. Mixers shall be capable of achieving complete dispersion of bentonite

and additives and shall be capable of continual-mixing slurry to provide and maintain a uniform blend. Slurry pumps shall be of sufficient capacity to ensure adequate supply of slurry during panel excavations and capable of pumping the concrete displaced slurry back to storage. Sufficient ponds or tanks for storage shall be provided on site and fluid reserve capable of filling two panels shall be kept in stock in case of rapid loss of suspension. Slurry cleaning equipment shall be available for cleaning of return slurry with equipment capable of reducing sand; sediment, or other solids as necessary. This equipment may include but not be limited to vibratory shaker screens; centrifugal sand separators, and/or stilling ponds.

c) Concrete mixer

The concrete mixer used for manufacture of concrete and shall have sufficient capacity to ensure an adequate supply of concrete as required for continuous production. This mixer shall be fitted with calibrated loadcells to enable the accurate weigh batching of cementitious materials.

d) Water supply

Water tank/s shall have sufficient capacity to ensure adequate supply during a working shift. Pumps used shall be of sufficient capacity to provide the required flow and pressure.

e) Hoses

Hoses used shall be appropriately rated for pressures required.

A12.4.7 EXECUTION OF THE WORKS

A12.4.7.1 Sheet piling

a) General

Works may only commence after the Engineers approval of the Contractors method statements as required by these and the Contract Documentation.

The Contractor shall set out the works utilising appropriate and approved methods. The setting out shall be approved by the Engineer before piling work commences.

b) Process

(i) Set-up

Sheet piles shall be lifted up one at a time and threaded one end into the other interlocking piles prior to driving. A crane shall be used for this purpose and a pile threader/ guide frame/ or scaffold platform constructed to provide support for assembled sheets readied for driving.

(ii) Driving

Sheet piles shall be installed by driving or vibrating into the ground. Driving can be achieved by the use of vibratory hammers; drop hammers; or diesel, hydraulic or air hammers. Driving shall be by 'Pitch and Pile' where each pile or pile pair shall be driven to finished level before repeating the operation – a method suited to relatively short piles in softer ground where obstructions are unlikely. Alternatively, y 'Panel Driving', which is the more common method can be used. Once guide frames have been positioned for panel driving the first pair of piles shall be carefully pitched, plumbed and partly driven to form a guide for adjacent piles. The remaining panel of piles (usually 10 – 20 m run of wall panel) is then pitched and interlocked. The last pair of piles shall then be partially driven followed by partial driving of the rest of the panel working back to the first pair in the panel. There shall be no departure from the vertical. The top guide wailings can at this stage be removed and then all but the last pair of piles in the panel driven to level. The last pair shall be left partially upstanding to form the guide pair for commencement of the next panel. It is essential, to ensure verticality, and to make sure the pile driving hammer orientation is lined up with the pile axis.

Driving caps (also termed 'helmets') provide protection of the sheet pile head during driving. The cap shall be close fitting and rigid to provide even energy distribution from a hammer blow. Buckling of steel sheet pile heads or damage to the heads of concrete piles can otherwise occur in driving through very hard ground. In vibratory hammers a driving cap is unnecessary since the hammer clamps the sheet pile hydraulically.

All changes to the initially approved method statements shall be approved in writing by the Engineer and all production work shall be in strict accordance with the approved methodology and specifications.

(iii) Obstructions

When obstructions are encountered the remainder of the panel shall be completed so that the piles obstructed have support from adjacent piles during attempts to drive through the obstruction. If unsuccessful, driving can continue whilst the obstruction is removed thereby minimising construction delays. Sheet pile toes can be damaged when driving through cobble or boulder layers. Measures to limit risk of damage include the use of sheet piles made from high tensile steel; reinforcement of the sheet pile toe by welding on additional strengthening plates; and reducing hammer energy blow.

Pile toes shall, if necessary, be secured into underlying rock using steel pins. These may be required where it is not feasible to drive piles to required penetration, or where there is concern piles may slide down a sloping rock surface. Pins shall be welded onto piles before driving or installed via tubes attached to and driven with the piles. For the latter holes are drilled into rock and pins grouted into position.

(iv) Ground pre-treatment

It may be cost effective to consider pre-treatment of ground to allow lighter section installation where piling is dominated by driving rather than moment capacity. This could include:

Pre-auguring to weaken or replace hard ground

Driving a heavier section than required; extraction of the heavy unit followed by driving of working pile sheets in the same ground

Controlled blasting to reduce very dense soil or obstructions to granular material: without displacement.

(v) Water tightness

The only possibility of water infiltrating through a sheet pile is by flowing through the interlock. The interlock shape naturally provides high resistance to seepage where sealing systems are unnecessary for applications such as temporary retaining walls where moderate rates of seepage are acceptable. If medium to high seepage resistance is required double sheet piles or welding of joints shall be required. Alternatively, elastic sealants such as silane modified polymers (MS-Polymers) shall be considered. Typically, the sealant products manufactured with silyl modified polymers have good adhesion on a wide range of substrate materials, and have good temperature and ultraviolet resistance.

For concrete sheet piles interlock shall be provided by tongue and groove methodology. One side of toe shall be chamfered to force the concrete sheets to stay together during driving. A sealant grout sock shall provide water tightness.

Where seepage beneath installed sheet piles cannot be addressed by further driving of the piles it may be necessary to carry out grouting to seal off the base to address water ingress. Provision is made for payment of such localised grouting. Where such grouting is approved by the Engineer, it shall be carried out in accordance with the applicable specifications for the technique utilised.

(vi) Durability of steel sheet piles

Life of a sheet pile wall is very much dependant on corrosiveness of the surrounding environment, and the South African coastline in particular is a highly corrosive making for poor permanent marine sheet pile applications. Corrosion is usually lowest in the buried section of the wall; followed next by the zone permanently below water; with the zone above the minimum water level requiring extensive corrosive protection coatings of the highest quality.

The service life of a sheet pile wall shall be extended by one or a combination, of the following as specified in the Contract Documentation:

- Protection coating by first light shot blasting (sheet piles are received without any protective coating) followed by application of Tar Vinyl (an aromatic pitch modified with suitable vinyl resins) in coat thickness up to 150 microns; or blasted clean followed by application of High-Build Isocyanate cured, Epoxy Pitch (special coal tar pitch, modified with epoxy resins, cured with isocyanate adducts) in coat thickness up to 400 microns; or painting via a wide range of epoxy primers (seawater immersion & chemical resistance), polyurethanes (for colour and gloss retention) up to 480 microns
- Use of stronger section or higher steel grade to create a 'statical reserve'
- Use of Marine Grade Steel (ASTM A690) in the splash zone
- Avoiding significant bending moments in high corrosion zones
- Extension of the concrete capping beams to below the low-water level
- Cathodic protection by impressed sacrificial anodes which constantly protect surfaces in contact with water
- Special corrosion resistant steel in the permanent and low water zone where maximum bending moments and consequent highest steel stresses derive. Tests indicate loss of steel thickness can be reduced by a factor of 3 in the permanent immersion zone and 5 in the low water zone when compared to standard structural steel

c) Anchors

Where ground anchors are required they shall conform to specification of Section A12.2: Ground Anchors. Tie-rods shall be suitably sized, corrosion-protected steel bars, tied between pile walls and anchorages.

Anchored raked piles shall also be considered as anchorage.

d) Monitoring and records

The Contractor shall, on a continuous basis and at an agreed frequency, monitor ground or movements of structures with sufficient accuracy to ensure that any displacements are within specified allowable tolerances. The proposed method of monitoring shall be approved by the Engineer before any works are commenced.

Daily records shall be kept of all works, materials utilised and quality control activities carried out in accordance with Contract Documentation and the approved method statements. These records shall be submitted to the Engineer before noon on the following working day and shall include:

- Daily records of all sheet piling positions, driving depths, lateral extents, start and stop times, piling equipment, anchorage installed, details of all stoppages, breakdowns and m^2 of sheet pile installation completed at each position
- Daily records of sheet piles used, driving type and effort, and other details that may be required for measurement purposes
- Results of routine consistency tests in terms of sheet pile verticality and horizontal alignment;
- Results of pull-out tests on anchors
- Details of daily excavation and support measures (type, number, location)
- Any change in subsurface conditions which have, or may affect, changes in methodology or progress.

A12.4.7.2 Diaphragm walls

a) General

Prior to commencing with production, the Contractor shall provide the Engineer with a plan showing the proposed rotation sequence of panel construction for approval. Operational matters such as waste disposal shall also be addressed.

b) Trials

The Contractor shall be required to construct a trial panel as specified in the Contract Documentation and shall allow for the Engineer's assessment of this panel. This will require partial exposure of the completed panel to ascertain whether it meets specified requirements in terms of verticality; dimensions, and uniformity, and to allow execution of tests and measurements for quality assessment purposes. Trial panels shall be placed to eventually become part of the completed diaphragm wall. Trial panels shall have assigned test parameters agreed with the Engineer and shall be exposed by excavation to the depths indicated in Contract Documentation to allow visual appraisal, dimensional and geometric measurements and integrity testing. Successfully installed trial panels meeting the specified requirements shall be measured for payment. Defective panels shall be assessed by the Engineer as per Clause A12.4.8. All excavations shall be backfilled in 150 mm thick layers using the excavated or other approved materials to the specified density. Construction of the test panels shall be witnessed by the Engineer.

c) Construction

(i) Guidewall

A shallow guide wall shall first be constructed on the alignment of the proposed wall. The guide wall serves to locate the excavation equipment within acceptable tolerances before the diaphragm wall construction commences. It shall be constructed from reinforced concrete typically 1,0 to 1,5 m deep. Walls shall be constructed to tight verticality tolerance.

(ii) Excavation

Excavation for diaphragm walls shall be carried out in panel widths. A typical panel is excavated in three bites; a left bite, a right bite and lastly removal of a middle dumpling. Bite widths depend on the grab type used but 2,0 to 2,8 m wide, and 0,3 to 1,5 m wide, is typical, with panels 3,0 to 6,0 m wide requiring rotated bites. Simultaneously with soil removal, bentonite slurry shall be pumped into the excavation to support the surrounding soil preventing collapse into the excavated trench. Excavation shall continue until all bites reach design depth.

(iii) Bentonite slurry

Bentonite slurry shall be batched in on-site plant; allowed to hydrate to gain full gelling properties, before being used for temporary excavation support. Bentonite powder in bulk, or bagged form, shall be added to water and rapidly mixed in a colloidal mixer to produce desired concentrations of bentonite slurry. Slurry shall be pumped to a storage tank for hydration for approximately 12 hours. Bentonite particles swell and absorb water before use to support excavations and shall be fully hydrated to design requirements before use. Hydrated slurry, or recycled slurry/ mud, or a mixture of the two shall be pumped into the excavation trench to replace excavated soil, maintaining a constant head of slurry above prevailing in situ groundwater levels. Quality of the slurry is paramount in obviating problems of slurry trappings on steel reinforcing elements. Excavation of the panels continues under slurry until both left; right and centre bites are excavated down to the required panel toe level. Slurry shall maintain a minimum1,5 m positive head above the water table in order to create a 2,0 to 3,0 mm impermeable bentonite cake on the excavation sidewalls.

(iv) Concrete

Concrete shall have high workability, utilising using well-rounded aggregate and high slump so that it behaves in placement as a heavy viscous fluid. Vibration shall not be used as it promotes segregation with compaction achieved by gravity deemed adequate. Distance of lateral flow required to fill a panel or panel section from any single tremie position shall be limited to 2,5 – 3,0 m.

(v) Stop-ends

Steel or precast concrete stop-ends shall be inserted at the edges of excavated panels. These stop-ends may contain a rubber water bar that is later embedded into the concrete panel. Water bars minimise water ingress between panel joints once earth is excavated inside diaphragm wall. The stop-end is removed from the cast panel during excavation of the following panel.

(vi) Steel reinforcement cage

The prefabricated steel reinforcement cage shall be carefully lowered into the excavation between stop ends. Block-outs for floor slab connections; ground anchors or other penetrations shall be included within the reinforcement cage. The cage shall be secured in position by approved means to ensure the specified inclination and cover is maintained.

(vii) Concreting

Concrete shall be placed using a tremie. Concrete shall have a slump of 150 – 200 mm and poured using a hopper and steel tremie tube extending to the base of the excavation.

Typically, two hoppers are used for a 6,0 m wide panel. Hoppers and tubes shall be charged with concrete before lifting off the excavation base allowing concrete to flow and displace overlying bentonite upwards. Bentonite shall be pumped back to the recycling plant as it is displaced. Tremie pipe lengths shall be shortened as concrete level rises in panels to ensure fresh concrete is present at the bentonite/ concrete interfaces. The discharge end of the tremie shall be at least 500 mm below the surface of the concrete. Tremie pipes shall be removed when concrete rises to required levels. Concrete shall be cast to a minimum of 750 mm above the required cut-off level and finished according to the Contract Documentation.

(viii) Panel rotation

The first panel constructed in a run of wall is termed a primary panel. During concreting excavation grab and base crane shall be moved to a second location away from concreted panel to a position as designed by the Contractor to achieve his planned panel construction rotation. There excavation shall be commenced on a second primary panel. The newly excavated panel shall then be completed and concreted in the same manner as previously described. Subsequent panels completed adjacent to completed panels are termed secondary or running panels. The final panel completed in a run of wall is termed the closing panel since it closes out the length of wall.

(ix) Spoil

The Contractor shall, at his own cost, remove all spoil from the site and at all times ensure a clean and orderly workspace.

d) Water tightness

Water tightness shall be ensured through care in ensuring formation of the required recess through stop-end retrieval. A water stop shall be considered when an impermeable condition is sought.

e) Anchors

Where ground anchors are required these shall be specified in the Contract Documentation and the requirements given in Section A12.2: Ground Anchors and shall be installed at the specified locations.

f) Obstructions

Obstructions encountered during construction shall be dealt with as per the Contractor's plan methodology presented and agreed as in Clause A12.4.4.3.

g) Monitoring and records

Monitoring and logging of all diaphragm wall construction operations shall be undertaken by Contractor and records shall be submitted to Engineer before noon the following working day.

The records shall include:

- Daily records of all panel positions; depths of excavation, start and stop times, all construction parameters used, details of all stoppages, breakdowns, slurry and concrete pumped at each position.
- Daily records of excavation quantities; bentonite usage, cement usage; steel installed; and any other details that may be required for measurement purposes.
- Results of routine consistency tests (flow cone, density tests as specified) carried out on all batches of bentonite/ concrete mixed and utilised,
- Any change in subsurface conditions which have or may affect changes in methodology or progress.
- Spoil volumes
- Details of anchors placed

Records shall be in a format agreed with the Engineer.

A12.4.8 WORKMANSHIP

A12.4.8.1 General

The Engineer shall undertake routine inspections and conduct routine tests to determine whether the quality of materials and workmanship provided comply with the requirements of this section. Test results and measurements will be assessed by the Engineer for compliance with the requirements specified in the Contract Documentation. The Contractor shall carry out the necessary process control measures required in terms of Clause A1.2.8.1 of Chapter 1, as indicated in the approved Quality Assurance Plan and as may be specified in the Contract Documentation.

A12.4.8.2 Sheet piling

The following approved quality control measures shall be carried out as may be applicable and as may be specified in the Contract Documentation

a) Evaluation of exposed sheet pile walls

The Engineer shall inspect the exposed sheet pile sections for final workmanship; finishing off; horizontal and vertical alignment; and anchor installations. Where walls are required for water control purposes borehole permeability tests may be specified in the Contract Documentation.

b) Pull-out tests

Pull-out tests on anchors shall be performed according to Section A12.2: Ground Anchors and any other tests as may be prescribed in the Contract Documentation.

A12.4.8.3 Diaphragm walls

The following approved quality control measures shall be carried out as may be applicable and as may be specified in the Contract Documentation**.**

a) Evaluation of exposed diaphragm panel tops

The Engineer will direct which upper portions of which panels are to be exposed for uniformity, verticality and width measurements and for further testing. Such testing may comprise coring 100 mm diameter cores from top or from the exposed sides of exposed panels. Where specified, full length coring of the completed panels shall be carried out utilising appropriate, approved equipment, bits

and core barrels in the size indicated. Testing of selected core lengths may be instructed to prove the strength of the constructed panels. Where diaphragm walls are required for water control purposes borehole permeability tests may be specified in the Contract Documentation. All core holes shall be reinstated with a suitable non shrink grout as approved by the Engineer. Backfilling of any excavations shall be done in 150 mm thick layers using the excavated or other approved materials to the specified density.

b) Acceptance criteria

The characteristic strength of concrete shall be as specified in the Contract Documentation. Results of strength tests on the concrete shall be assessed according to Clause 20.1.7.5d) (Judgement Plan B) of Chapter 20.

(i) Concrete panels:

Testing on completed / cast concrete panels shall be carried out as follows;

- UCS Testing of 100 mm diameter, 200-250 mm long drilled cores from constructed panels
- Coring the centre of constructed panels and UCS testing of selected cores
- Indicative compressive strength tests on 100 mm cubes made from concrete mix
- Any other tests as may be prescribed in the Contract Documentation

(ii) Concrete

- Consistency - The consistency and workability of each batch of concrete shall be tested for consistency with the Slump Cone. The slump shall be more than 150 mm and less than 200 mm. Ranges in values shall be determined as works proceed and any significant variation from running average shall be immediately investigated and brought to the attention of the Engineer.

- Concrete Cube Strength Testing - 150 mm cubes shall be made, cured and tested in accordance with SANS 3001-CO11 at frequencies specified in the Contract Documentation. Three cubes per test shall be required. The results of strength tests on the concrete shall be assessed according to Clause A20.1.7.5d) (Judgement Plan B) of Chapter 20.

c) Bentonite slurry

A minimum of 2 samples of bentonite slurry shall be sampled daily. One 0,3 m below the panel surface and a second one at panel mid-depth for process control testing by the Contractor. Important parameters for testing are:

- Measure of rheology to ensure slurry is appropriately fluid
- Slurry density prior to concreting to ensure satisfactory displacement
- Sand content to determine re-use
- pH of fresh bentonite
- pH of slurry as check for cement or other contamination
- Filtrate loss to check ability to form a seal (surface filtration via 'filter cake' formation) or geared toward deep filtration (percolating through the filter cake) or rheological blocking (flow until restrained by shear strength)

The Engineer shall generally request testing to determine the density; viscosity (Marsh Cone); Fluid loss; pH, and sand content to verify uniformity and compliance with the parameters established in the mix design and that listed in Table A12.4.8-1: Acceptance criteria below.

d) Acceptance criteria

Acceptance or rejection shall be based on the Contractor's ability to achieve the specified criteria which may include:

(i) For concrete

- Required consistency and workability
- Attainment of 28 day specified characteristic strength of concrete cubes,
- Attainment of specified UCS results on cores,

*(ii) For bentonite powder**:*

- Yield Point/ Plastic Viscosity Ratio of maximum 6
- Plastic viscosity greater than 10
- Moisture contentless than 15 %
- Less than 2,5 % remaining on a 75 micron sieve
- A 6,4 % suspension of bentonite in distilled water, aged for 24 hours, should have a minimum viscometer dial reading of 30 at 600 rpm (American Petroleum Institute (API)RP13B).

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(iii) For bentonite slurry:

The following table (API) provides acceptance criteria:

Table A12.4.8-1: Acceptance criteria

Property	Units	Stages			Test equipment
		Fresh	Ready for re-use	Before concreting	
Density	g/ml	<1,10	<1,25	<1,15	Mud balance

Marsh viscosity (946ml)	sec	32 - 50	32 - 60	32 - 50	Marsh funnel
Fluid loss (30 min)	ml	<30	<50	n/a	Filter press
pH		7 - 11	7 - 12	n/a	pH meter
Sand content	%	n/a	n/a	<4	Sand content set

A12.4.8.4 Performance monitoring

Where so specified in the Contract Documentation wall movements shall be monitored by survey of other approved methods to ensure the safety of any excavations and/or the efficacy of the support installed.

B12.4 LATERAL SUPPORT

PART B: LABOUR ENHANCEMENT

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B12.4.1 SCOPE
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B12.4.8 WORKMANSHIP

B12.4.1 SCOPE

The provisions of Part A shall apply.

B12.4.2 DEFINITIONS

The provisions of Part A shall apply.

B12.4.3 GENERAL

The provisions of Part A shall apply.

B12.4.4 DESIGN BY CONTRACTOR/PERFORMANCE BASED SYSTEMS

The provisions of Part A shall apply.

B12.4.5 MATERIALS

The provisions of Part A shall apply.

B12.4.6 CONSTRUCTION EQUIPMENT

The provisions of Part A shall apply.

B12.4.7 EXECUTION OF THE WORKS

The provisions of Part A shall apply.

B12.4.8 WORKMANSHIP

The provisions of Part A shall apply.

C12.4 LATERAL SUPPORT

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each pay item shall include full compensation for providing, operating, maintaining and decommissioning upon completion, of all the construction equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the pay item as specified, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

1. Unless otherwise ordered or stated in the Contract Documentation, trench depths will be measured from the surface of the ground along the centre-line of the trench to the bottom of the specified bedding layer (as applicable). Where no bedding is required it shall be measured to the underside of the duct or pipe.
2. The ground surface will be that existing after any bulk earthworks have been carried out, i.e. the excavated surface or embankment surface, unless a different sequence of execution has been ordered.
3. Excavations will be measured as if taken out with vertical sides, regardless of whether they have been taken out with sloping sides.
4. The length used for trench computations will be the total through-length of a pipe or duct etc. from end to end and no deduction will be made for manholes or access chambers etc.
5. Wherever volumetric measurement is required, the volume will be computed from the depth determined as indicated in 1. and 2. above and using the authorised width (W) determined in accordance with the specification.
6. Where shoring is specified or ordered, the length of shoring measured for payment will be the length of the centre-line of the trench.

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as the Contractor deems appropriate:

1. No separate payment will be made for backfilling excess excavations, disposing of surplus material etc. or any other contingent work, unless the work is specifically specified or ordered.
2. No separate payment will be made for setting out the works.
3. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities and for complying with all the requirements of Clause A2.1.3.4 of Chapter 2.
4. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
5. No separate payment will be made for the loading of any materials.
6. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to, 1,0 km.
7. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
8. No separate payment will be made for the removal of any surplus material imported to complete the works.

(iv) Items to be measured and paid for using items specified elsewhere in the specifications

Not applicable to this Section.

(v) Items specifically for this Section of the specification

Item	Description	Unit
C12.4.1	**Site Establishment**	
C12.4.1.1	Sheet Piling	lump sum
C12.4.1.2	Diaphragm Walls	lump sum

The unit of measurement shall be the lump sum.

The tendered lump sum for site establishment shall include full compensation for establishing all necessary plant, equipment and services on site to carry out the works as specified including all work in preparing the works area for construction activities and subsequent removal from site of all such plant and equipment including all temporary works such as access roads, staging, platforms, coffer dams and such like.

The work will be paid for by way of a lump sum, 50 % of which shall be payable when all major necessary equipment is on site, trials (if any) are completed and the first production work started. The second instalment of 25 % is payable after half the specified work is complete. The final instalment shall be payable after all work is complete, all equipment removed and the site restored as specified in the Contract Documentation.

Item	Description	Unit
C12.4.2	**Moving to and setting up equipment at sections or sites to be defined**	
C12.4.2.1	Sheet Piling	number (No)
C12.4.2.2	Diaphragm Walls	number (No)

The unit of measurement shall be the number of positions to which equipment is moved and set up in position to execute the works as described in the Contract Documentation. The quantity measured shall be the number of set ups at designated works positions (individual pile position, or panel section of steel sheet piles, or diaphragm panel, as specified) inclusive of approved trial works positions as well as any additional positions as may be instructed by the Engineer.

The tendered rates shall include full compensation for all costs involved in moving to and setting up required equipment at each works position. Tendered rates shall include all costs in setting-up equipment and subsequent decommissioning.

Item	Description	Unit
C12.4.3	**Setting out of works at sheet piling or diaphragm panel positions**	**metre (m)**

The unit of measurement shall be metres in length set out by a registered surveyor as per the Contract Documentation or as instructed by the Engineer.

The tendered rate shall include for all costs incurred in setting out the works inclusive of transport, labour and all incidentals required to carry out the work as specified. Payment will not be made for the re-setting out of positions lost for whatever reason.

Item	Description	Unit
C12.4.4	**Sheet pile driving** (individual sheet pile type or sheet panel extent specified)	**square metre (m^2)**

The unit of measurement shall be the net square metre of sheet piles installed.

The tendered rate shall include full compensation for supply of sheet piles to site; correct handling and storage of sheet pile elements, driven installation and for all labour, plant and equipment required for installation to depths as required by the Contract Documentation, or as instructed by the Engineer.

Item	Description	Unit
C12.4.5	**Sheet pile extraction**	**square metre (m^2)**

The unit of measurement shall be the area of pile sheet extracted.

The tendered rate shall include full compensation for sheet piles extracted, handling and storage; and ultimate removal from site inclusive of all labour, plant and equipment required for these works as required by the Contract Documentation, or as instructed by the Engineer.

Item	Description	Unit
C12.4.6	Sheet pile and diaphragm wall supports (as specified)	
C12.4.6.1	Props	number (No)
C12.4.6.2	Anchors	number (No)
C12.4.6.3	Tie-bars	number (No)

The unit of measurement shall be the number of props or anchors or tie-bars (including designed deadman anchorages).

The tendered rate shall include full compensation for installation to Contract Documentation detail, including all labour, plant, materials and equipment required.

Item	Description	Unit
C12.4.7	**Sheet pile grouting**	
C12.4.7.1	Chemical grouting	kilogram (kg)
C12.4.7.2	Jet grouting	kilogram (kg)
C12.4.7.3	Compaction grouting	kilogram (kg)

The unit of measurement shall be the kilograms (kg) of chemical or cement actually utilised for grouting as specified and approved by the Engineer.

The tendered rates shall include for all labour, plant, equipment, materials, delivery, storing, mixing, pumping, drilling, injection and all incidentals required. No payment will be made for any wastage or for rejected batches. Only verified quantities will be accepted for measurement and payment.

The rates shall include quality control measures, testing of materials, monitoring and supervision of the works and the provision of daily records for all items specified in the Contract Documentation.

Item	Description	Unit
C12.4.8	**Concrete placed by tremie under slurry in diaphragm walls** (class of concrete indicated)	**cubic metre (m^3)**

The unit of measurement shall be the cubic metre (m^3) of concrete placed by tremie under bentonite slurry for the construction of diaphragm walls.

The tendered rate shall include full compensation for supplying and storing all material, providing all plant, mixing, transporting and placing the concrete by tremie methods

Item	Description	Unit
C12.4.9	**Partial Excavation of Panels**	**cubic metre (m^3)**

The unit of measurement shall be the cubic metre (m^3) of material excavated for inspections and testing adjacent to panels and removed to stockpile for backfilling operations or to spoil.

The tendered rate shall include full compensation for the excavation to expose the panels and shall include for the backfilling thereof as specified. The rate shall include for all labour, plant and equipment required for such removal and backfilling as required by the Contract Documentation, or as instructed by the Engineer. No overbreak shall be paid for excavation beyond the theoretical excavation boundaries.

Item	Description	Unit
C12.4.10	**Cement, additives, bentonite, aggregate and fillers)**	
C12.4.10.1	Cement	kilogram (kg)
C12.4.10.2	Bentonite	kilogram (kg)
C12.4.10.3	Fine/ coarse aggregate (specify)	kilogram (kg)
C12.4.10.4	Other fillers (specify)	kilogram (kg)

The unit of measurement shall be the kilogram of materials actually utilised for diaphragm wall construction as specified and approved by the Engineer.

The tendered rates shall include for all labour, plant, equipment, materials, delivery, storing, mixing, pumping, placement and all incidentals required. No payment will be made for wastage or rejected batches. Only verified quantities will be accepted for measurement and payment.

The rates shall include quality control measures, testing of materials, monitoring and supervision of the works, daily records of all items specified in the Contract Documentation.

Item	Description	Unit
C12.4.11	**Bentonite slurry re-use**	cubic metre (m^3)

The unit of measurement shall be the volume of bentonite slurry pumped for re-use.

The tendered rate for re-used bentonite slurry shall be for full compensation of pumping from completed panels to storage; cleaning and removal of sand from used slurry to design standards; storage and pumping to new panel positions. Rates shall include for all plant; labour and equipment necessary for this process. All activities associated with bentonite slurry re-use shall be to the requirements of the Contract Documentation, or as instructed by the Engineer.

Item	Description	Unit
C12.4.12	**Steel reinforcement**	**ton (t)**

The unit of measure for steel bars shall be the ton of reinforcing steel in place in accordance with the drawings or as authorised.

The tendered rate shall be for full compensation in procuring the steel, bending, cage reinforcement construction, pitching and installation and shall include for all plant required for reinforcement cage installation; labour and equipment necessary

Item	Description	Unit
C12.4.13	**Exposing tops of selected concrete panels**	**number (No)**

The unit of measurement shall be the number of concrete panel tops exposed for inspection, measurement and testing.

The tendered rate shall include for all plant, excavating the material around selected panels as well as backfilling of excavations with suitable approved material in 150mm layers compacted to the required density.

Item	Description	Unit
C12.4.14	**Coring of concrete panels**	
C12.4.14.1	Setting up at completed panels	number (No)
C12.4.14.2	Drilling and core recovery (size indicated)	metre (m)
C12.4.14.3	Provision of core boxes	number (No)

C12.4.14.4 Extra-over for inclined drilling metre (m)

The unit of measurement shall be per set-up at coring positions selected and pointed out by the Engineer; length of core actually recovered; the provision of core boxes capable of accommodating a minimum 7,5 m of core, and for inclined drilling into panel sides.

The tendered rate shall include for establishment; labour, plant, delivery, core storage, monitoring, drilling supervision, core logging, removal of samples for laboratory testing, and demobilisation shall be included in the above rates tendered.

D12.4 LATERAL SUPPORT

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

The Contractor shall provide detailed specifications and certificates from independent reputable agencies for all proprietary casing/sleeves and materials proposed for use. These shall demonstrate conformance with the performance requirements stipulated in the Contract Documentation.

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D12.4.9 NOTIFICATION OF REMEDIAL WORK

D12.4.10 REMEDIAL WORKS

No specific items in this Section.

Where applicable, details must be provided in the Contract Documentation.

QUESTIONS?

12.3 SHOTCRETE

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A12.5 SHOTCRETE

PART A: SPECIFICATIONS

A12.5.1 SCOPE

This Section covers supply and application of shotcrete to rock and soil cut faces, soil nail faces, slope stabilisation and slope remediation, and other areas as directed by the Engineer. It includes supply and application of shotcrete by either dry or wet-mix methods and for reinforcement included in shotcrete layers. Sprayed concrete applied onto concrete faces is covered in Section A14.6 of Chapter 14: Rehabilitation of Structures.

A12.5.2 DEFINITIONS

Dry-mix **shotcrete** - constituent materials, comprising of a mixture of cementitious binder and aggregates, are mixed and delivered to the application nozzle in dry form. Water and admixtures are added at the application nozzle under high pressure while being sprayed onto the receiving surface.

Shotcrete - means mortar or concrete which can be pneumatically projected at high velocity onto a surface.

Dental Shotcrete - is shotcrete applied to fill/cover or repair of a specific area/feature.

Shotcreting - is the process whereby mortar or concrete is pneumatically projected at high velocity onto a surface. It can comprise of dry-mix or wet-mix shotcreting.

Wet-mix **shotcrete** - constituent materials, comprising of a mixture of cementitious binder, aggregates, water and admixtures, are premixed and delivered to the application nozzle as a wet-mix before being sprayed onto the receiving surface.

A12.5.3 GENERAL

A12.5.3.1 Method Statements

Where so indicated by the Engineer the Contractor shall prepare detailed method statements for each facet of the work describing key aspects such as construction methodology, key plant, materials, personnel as well as any programme constraints of the envisaged construction process.

These method statements shall be prepared and submitted to the Engineer for approval prior to commencement of that activity, within time scales specified. The onus lies with the Contractor to ensure that the information is obtained and that associated activities are completed expeditiously to avoid any delays in the commencement, continuation and completion of the required works. Unless otherwise specified or provided for in the Contract Documentation no permanent works shall be commenced until the Engineer's approval of the relevant method statement. The Contractor shall, however, remain responsible for all work-methods, materials, plant and equipment used, notwithstanding acceptance by the Engineer.

The Contractor shall be required to construct trials and the testing thereof as specified herein and shall make due allowance therefore in his programme. Allowance shall also be made for allow for the Engineer's assessment of constructed works, procedures followed, and materials and plant utilised and test data. Production work shall not be permitted until it is shown and accepted by the Engineer that the Contractor possesses the necessary experience, plant and equipment to carry out the works as specified in the Contract Documentation.

It should be noted that work shall only be performed by personnel listed by the Contractor. If personnel changes need to be made during the project, works shall be suspended until replacement personnel are approved by the Engineer. Time lost due to incomplete submissions, unacceptable submissions, or obtaining approval of replacement personnel will not be considered as cause for extension of time or delay claims. All costs associated with incomplete, replacement, or unacceptable submissions shall be to the Contractor's cost.

Once approved in writing by the Engineer, these shall become the method statements in accordance whereby the relevant portion of the works shall henceforth be executed. Notwithstanding, the Engineer may require revision from time to time if circumstances during construction arise which warrants change.

A12.5.3.2 Materials and materials design approvals

All materials used in the works described hereunder shall meet the appropriate standards given below and/or specified in the Contract Documentation and shall be subject to the approval of the Engineer. The Contractor shall submit product certificates, conformance documentation (as per Part D) related to the specifications, test results as required together with samples of materials and where applicable, materials designs that he proposes to use in the construction of the works to the Engineer for his acceptance/approval as provided for in the Contract Documentation.

Due allowance shall be made for obtaining materials, resubmissions and re-designs, all to the required/approved standards, methods and practices in attending to these requirements. Particular attention shall be paid to the early submission of materials-, concrete- and grout mix designs where parameters at various ages may be specified. No consideration for extension of the contract period will be entertained for delays incurred in meeting these requirements.

The Contractor's attention is drawn to the approvals required as indicated in Table A12.5.3-1 below regarding works carried out under this section of the works:

Table A12.5.3-1: Approvals required

Clause	Requirements*	Period
	Materials Design Approvals	
A12.5.4.2	Shotcrete mix design	6 weeks before construction
	Materials Approvals	
A12.5.5.4	Admixtures	1 week prior to use
A12.5.5.11	Curing compounds	1 week prior to use
A12.5.5.4	Test panels	6 weeks before construction
	Construction Method Statements*	
A12.5.7	Method statements	6 weeks before construction
A12.5.7.6	Fixing systems for reinforcement	1 week prior to use

* Including all relevant information

A12.5.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

A12.5.4.1 General

The Contractor shall design the shotcrete mix used in carrying out the works as specified. Mix designs shall be complete, be presented on the required forms and shall be presented to the Engineer with samples of all the constituents as required at least 6 weeks prior to placement

Where design by the Contractor for any technique to be carried out, is, in terms of the Contract Documentation, the responsibility of the Contractor, all aspects given below shall be taken into consideration in carrying out these obligations.

The following shall be specified (where applicable) by the Engineer and reflected in the Contract Documentation:

- Techniques and methods to be followed
- Site specific requirements
- Limits of the area and thickness/ cover
- Shotcrete mix composition
- Shotcrete pigmentation
- Shotcrete strengths, post treatment properties, durability and any other deliverables as may be appropriate
- Layout of treatment positions
- Sequence of shotcrete applications
- Ancillary items such as reinforcing and drainage
- Quantities of shotcrete to be used
- Monitoring of works
- Measurable properties to be achieved over the life span of the project
- Environmental and safety requirements specific to the techniques to be executed

- Monitoring and record keeping requirements.

The following information will be generally provided in the Contract Documentation:

- A definition of the objectives and the control criteria
- Investigation data including subsurface geological information, hydrological data and geotechnical parameters
- Test data, borehole logs and recovered core samples

The following additional aspects, shall also be addressed where applicable:

- Finishing off of treatment area to specified lines and levels, whether materials are to be removed, removed and replaced by other materials, processing of materials and all other measure to be carried out in meeting requirements as specified in the Contract Documentation**.**
- The Contractor shall provide a quality management plan indicating his proposed quality assurance testing program which shall allow for testing at each treatment position. Testing methods to be employed shall be as specified in the Contract Documentation.

A12.5.4.2 Shotcreting

Where so specified the Contractor shall prepare a detailed construction proposal detailing all plant, equipment and materials to be employed in meeting the geotechnical shotcreting objectives and performance requirements detailed in the Contract Documentation. In compliance herewith the Contractor shall address all the aspects given in Clause A12.5.4.1.

The Contractor shall be responsible for the design of a suitable cementitious mix for shotcreting which shall be presented for approval by the Engineer with due consideration of the following:

- Availability of cementitious products in the quantities required for production
- Achievement of specified characteristic strength in the mix
- Consistency and pump-ability of the shotcrete

The following procedure shall be applicable:

- Obtaining samples of mix constituents with verification of required properties through laboratory testing
- Carrying out mix designs
- Production of trial mixes in the laboratory to allow for sampling and testing of shotcrete
- Production of trial mixes by production plant to allow for the sampling and testing of the shotcrete test panels
- Carrying out adjustments to mix designs as may be required and repeating laboratory and production plant trial mixes to allow for sampling and testing of shotcrete
- Obtaining the Engineer's approval of the mix.

Note that the above design shall be carried out by competent personnel following the relevant approved/ specified mix design procedures. Slump of various mixes shall be determined to provide a basis for ongoing quality assurance during production shotcreting.

The Contractor shall submit his proposed cementitious shotcrete mix design for shotcreting accompanied by all relevant information for approval by the Engineer. Lead time as per Table A12.5.3-1 is required for this information. It should be noted that shotcreting will only permitted to proceed if the Engineer is satisfied that the mix meets the minimum performance criteria specified including 28 day characteristic strength of the shotcrete as specified in the Contract Documentation.

Any changes to the mix after the Engineer's approval shall only be permitted if approved in writing by the Engineer.

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Process; test panels; mesh; spiders

A12.5.5 MATERIALS

A12.5.5.1 Cementitious binder

Refer to Clause A14.4.5.2a) of Chapter 14.

a) Cement

Cement shall be CEM I or CEM II with a strength class of 42,5 or greater. Where site blends are proposed, they shall conform to the particular requirements of SANS 50197 - 1. (As per Clause A14.4.5.2a) of Chapter 14).

b) Supplementary cementitious materials

Refer to Clause A13.4.5.1b) of Chapter 13.

A12.5.5.2 Aggregates

Aggregate shall conform to the requirements of Clause A13.4.5.7 of Chapter 13 and SANS 1083.

A12.5.5.3 Water

Water used for batching of shotcrete hall be potable, complying with SANS 51008.

The supply of water to the mixing nozzle shall be such that a pressure of at least 400 kPa can be maintained.

A12.5.5.4 Admixtures

Shotcrete admixtures shall comply with SANS 50934 and shall be submitted to the Engineer together with the proposed mix design for approval prior to commencement of work. Admixtures shall have no deleterious effects on reinforcement or shotcrete, and shall not contain any chlorides, nitrates, sulphides or sulphites. Where more than one admixture is included in the shotcrete mixture, they shall be chemically compatible. Approval of the shotcrete admixture shall be subject to satisfactory demonstration of suitability of the proposed shotcrete mixture through the construction of trial panels and acceptable quality assessments conducted on a minimum of three test panels representing three independently batched shotcrete mixes.

A12.5.5.5 Integral permeability reducing technology

Refer to Clause A13.4.5.5 of Chapter 13.

A12.5.5.6 Pigments and colouring agents

Pigments and colouring agents shall comply with the requirements of Clause A14.6.5.6 of Chapter 14.

A12.5.5.7 Fibres

Fibres shall conform to the requirements of Clause A14.6.5.7 of Chapter 14.

A12.5.5.8 Reinforcement

All reinforcement shall comply with Section A13.3 of Chapter 13. Reinforcement type and description shall be welded steel fabric mesh reference number 395 (SANS 1024) unless otherwise specified in the drawings or Contract Documentation.

A12.5.5.9 Compressive strength, ultimate flexural strength and energy absorption capacity

The Contractor shall be responsible for design of the shotcrete mix in order to produce shotcrete that complies with the requirements for each class of shotcrete.

Class of shotcrete is indicated by the designated code SP, the characteristic cylinder compressive strength in MPa at 28 days. For example, SP25 means shotcrete with a characteristic cylinder strength of 25 MPa after 28 days.

Minimum ultimate flexural strength requirements shall be as shown in drawings or as specified in the Contract Documentation.

In special applications, reinforcement in the form of flexible high tensile wire mesh, double twist mesh and chain link-type systems shall be specified in the Contract Documentation or shown on drawings as encapsulated in shotcrete. Particular details of the earth spikes, soil nails, rockbolts and other reinforcement fastening system shall be shown on the drawings or specified in the Contract Documentation.

Where required, the minimum energy absorption capacity of fibre reinforced shotcrete shall be specified in the Contract Documentation or indicated on the drawings. Energy absorption capacity shall be determined from a slab specimen, tested at 28 days in accordance with EN 14488-5.

A12.5.5.10 Drainage systems, geopipe collectors and weepholes

Weephole material shall be U-PVC pipes and shall comply with SANS 966-1.

Water collection geopipes shall be perforated or slotted U-PVC pipes that comply with SANS 791.The size of perforations in perforated pipes shall in all cases be 8,0 mm in diameter plus or minus 1,5 mm, and the number of perforations per metre shall not be fewer than twenty-six for 100 mm pipes and fifty-two for 150 mm pipes. Perforations shall be spaced in two rows for 100 mm pipes and in four rows for 150 mm pipes. Slotted pipes shall have a slot width of 8,0 mm with a tolerance of 1,5 mm. Arrangement of slots shall be subject to approval by the Engineer, but the total slot area shall not be less than that specified for perforations.

Installed pipes shall protrude 20 mm beyond the surface of final shotcrete layer and have their inner slotted section end wrapped with a single layer of approved geosynthetic.

Pipes without slots or perforations required for transporting water from the drainage system to point of discharge shall be U-PVC.

Geocomposite/geosynthetic drains shall be of type specified in the Contract Documentation and shown on the drawings. Strip or band drains generally 150mm wide geosynthetic which discharge into weepholes installed through shotcrete lining are commonly specified. Such shall be detailed on the drawings where these drain types are specified.

These materials shall be protected against sunlight and mechanical damage during storage and installation. Geosynthetics shall be non-woven, spun or thermic-bonded filament consisting of more than 85 % by mass of polypropylene, polyester or other approved material and manufactured for civil-Engineering applications by a recognised manufacturer.

In special applications requiring particular drainage measures, shotcrete may require application over vegetation, matting or other bonded open-structured geosynthetic. Geosynthetic requirements shall be specified in the Contract Documentation and shown on drawings.

A12.5.5.11 Curing compound

a) General

Refer to Clause A13.4.5.8 of Chapter 13.

b) Storing materials

Constituent materials shall be stored and handled so that quality is not impaired, for example by action of climates, intermingling or contamination, and that their conformity with the respective standard is maintained.

c) Cement

Cement stored on the site shall be kept under cover which provides adequate protection against moisture and other factors which may promote deterioration.

Cement supplied in bags shall be closely and neatly stacked to a height less than twelve bags and arranged so that they will not be in contact with ground, floors or walls, and can be used in the order in which they were delivered to site.

Cement supplied in bulk shall be stored in waterproof containers designed to prevent any dead spots from forming.

Cement drawn for use shall be measured by mass.

Cement shall not be kept in storage for more than 8 weeks without the Engineer's approval and different brands or types of cement shall be stored separately as determined by the manufacturer's requirements.

d) Pre-bagged shotcrete mixture

Dry pre-bagged shotcrete mixtures shall comply with EN1504-3 and shall be stored on site according to the requirements for storing

cement. Pre-bagged shotcrete mixtures shall not exceed shelf life determined by manufacturer and shall not be kept in storage for

longer than eight weeks without the Engineer's permission.

e) Aggregates

Aggregates stockpiled on site shall not be contaminated.

Aggregates of different nominal sizes shall be stored separately and in such a manner to avoid segregation from occurring. Intermixing of different materials and contamination by foreign matter shall be avoided. Aggregates exposed to a marine environment shall be covered to protect them from salt contamination.

Fine aggregate shall be stored in such a manner that moisture content is kept constant at all times. The moisture content of fine aggregate stockpiles shall be less than 8 % by mass when a dry mix shotcrete is used.

Where shotcrete is batched on site, aggregates shall be stored in covered heaps placed on a suitable impermeable floor lining to prevent contamination during storing and handling aggregate. This lining shall be sloped to facilitate drainage.

f) Storage capacity

Storage capacity provided and quantity of material stored, whether cement, aggregates, admixtures or water, shall be sufficient to ensure that no interruptions to work-progress of the project is occasioned by any lack of materials.

g) Deteriorated material

Deteriorated, contaminated or otherwise damaged material shall not be used in shotcrete. Rebound material shall be deemed to be contaminated material. Such material shall be removed from site and spoiled without delay.

A12.5.6 CONSTRUCTION EQUIPMENT

A12.5.6.1 General

Plant used for shotcreting shall be based on proven technology within the industry and shall be in good working order. Plant shall be inspected, serviced and calibrated at regular intervals and tested to ensure system functionality, efficiency and accuracy; all to Engineer-satisfaction.

A12.5.6.2 Spraying equipment

Type and capacity of delivery hoses and nozzles shall be such as to ensure a uniform mix and supply of mix ingredients to mixing nozzle, thereby obtaining correct consistency and a uniform discharge rate from nozzle.

The Contractor shall provide on-site a standby hose of capacity similar to the one in use to maintain continuity of work in case of a hose blockage. Hoses shall be blown clean before any work is stopped.

a) Dry-mix process

Air operating pressure supply at the gun outlet shall be greater than 240 kPa, and shall, as a minimum, be capable at all times of maintaining a discharge nozzle velocity of 90 to 120 m/sec. Water added at nozzle shall be supplied at a uniform pressure of 100kPa greater than air pressure at nozzle.

Supply of water to mixing nozzle shall be such that a pressure of greater than 400 kPa or as dictated in the approved method statement can be maintained.

b) Wet-mix process

Air compressors and delivery hose lines shall be of adequate capacity and size to provide a pressure of greater than 240 kPa at nozzle for 25 mm nozzles and proportionally greater for larger nozzles or as dictated in the approved method statement.

A12.5.7 EXECUTION OF THE WORKS

A12.5.7.1 Mix design

The Contractor shall submit details of the proposed shotcrete mix proportions prior to commencement of shotcrete activities for approval as per Clause A12.5.4.2. Shotcrete operations shall only commence after approval of the mix design. The Contractor shall allow adequate programme-time for design and approval of the shotcrete mix design. Mix ingredients and material source shall not be altered during construction without the prior approval of the Engineer. Shotcrete shall be designed to yield a 28-day characteristic compressive strength as shown on the drawings for different application areas or as specified in the Contract Documentation. ALSO 7-DAY

A12.5.7.2 Certification of skilled operators

Only experienced foremen, gunmen, nozzlemen and rodmen shall be employed, and satisfactory evidence of such experience shall be furnished with the Engineer. Nozzlemen shall be highly skilled craftsman with demonstrable personal project history exceeding 4000 hours of spraying concrete as the responsible nozzleman, or minimum 5 years' referenced experience as responsible nozzleman. A nozzleman without demonstrable practical experience as specified above shall be trained and certified as a nozzleman for the proposed shotcrete process and proposed spraying orientation in accordance with the standards of, for example, the Shotcrete/ Sprayed Concrete Association (UK), American Shotcrete Association, American Concrete Institute or other relevant certification authority approved by the Engineer.

Preconstruction trial panels

The Contractor shall provide trial panel formers made of nominal 20 mm thick shutter ply, size 600 mm by 900 mm skirted with reinforcement as detailed in drawings, or where no reinforcement is required a light expanded metal mesh, standing at least 200 mm high around panel-edges.

Where ultimate flexural strength requirements are specified, additional trial panels will be required.

Where energy absorption capacity is specified, specimen slabs constructed in accordance with EN14488 shall be required.

A12.5.7.3 Surface and slope preparation

All soil and rock to be covered with shotcrete shall be neatly trimmed manually where required and thoroughly cleaned with compressed air to remove all loose fragments of rock and soil as required, the Contractor must make allowance for the Engineer to approach within 2,0 m of any portion of area to be covered with shotcrete. Where soft material is to be covered with shotcrete, only obviously loose material shall be removed and boulders shall be thoroughly cleaned with compressed air. The area of soft material shall be accurately graded to plan dimensions and shall be thoroughly compacted, with sufficient moisture to provide a firm foundation to prevent absorption of water from the shotcrete, without free surface-water. An initial layer of shotcrete with specified nominal thickness shall be applied to approved, clean areas of soft material with minimum time delay. Irregular and rough rock contours, particularly rock surfaces resulting from drill and blast excavation techniques, may require the application of an initial smoothening layer of shotcrete to a specified nominal thickness.

When shown on the drawings, joints, side formwork, headers, and shooting strips shall be provided for backing or panelling, stainless steel gauging wires, spacers, inserts and profile boards shall be used where necessary to establish and control thicknesses, surface planes, and finish lines during application of the shotcrete.

Geocomposite band drains shall be installed at the required locations as specified in the Contract Documentation and drawings prior to initial shotcrete application. Groundwater seepage shall be collected in hoses, pipes or other drainage systems to prevent damage, and reduced shotcrete quality.

A12.5.7.4 Formwork

Formwork and shooting strips for shotcrete shall be employed to ensure square corners, straight lines and a plane surface of shotcrete, except as otherwise permitted by the drawings or the Engineer's approval. Formwork and shooting strips shall be designed and placed to avoid pockets of rebound.

A12.5.7.5 Fixing of reinforcement

Reinforcement shall be securely fixed over initial shotcrete layer/s by fastening to dowels and, where necessary, ties embedded in shotcrete via gun nails, "n" bolts or other approved fixing systems.

Reinforcement shall be fixed so that it lies snugly against the initial shotcrete layer ensuring it will not vibrate during application of successive shotcrete layers thereby ensuring voids are not formed between the shotcrete layers. Where sudden concave or convex surfaces preclude this, the reinforcement may be cut so that smaller pieces can be formed into the curved surfaces. The minimum overlap of mesh reinforcement shall be 150 mm, unless otherwise mandated by specific requirements of flexural or energy absorption reinforcement systems. Spacers shall be used behind mesh where required and where no flashcoat has been placed.

The Contractor shall provide details of the fixing system he proposes to use to the Engineer one week prior to use. Improvements/ changes shall be carried out during shotcreting as directed by the Engineer. SPIDERS TO PREVENT PUNCH-OUT

A12.5.7.6 Weather limitations

Shotcrete shall not be placed on a frozen surface or when ambient temperature is less than 5 degrees Celsius; nor shall it be placed when it is anticipated that temperature during the following 24 hours will drop below 1 degree Celsius. Application of shotcrete shall be suspended if high winds prevent proper application, or if rain occurs since this would wash out shotcrete mortar.

A12.5.7.7 Mixing and batching

Cement, aggregates, fibres, admixtures and approved additives shall be batched by mass to an accuracy of approximately 5 %.

For wet- and dry-mix spraying methods, the mixer shall be capable of achieving a uniform distribution of constituent materials. Mixing shall continue until the mix exhibits a homogenous appearance, ensuring complete coating of fine aggregate particles with cementitious material and for a period of more than 90 seconds thereafter. Special care shall be taken when adding fibres to ensure uniform dispersion.

Any mix spilled during handling or ejected from shotcreting equipment shall not be re-used. The mix shall be screened prior to gun-loading to prevent inclusion of stones, cement bag scraps or other foreign materials. Prepared batches shall be discharged through the nozzle within 60 minutes of mixing.

A12.5.7.8 Delivery

a) Dry-mix process

Shotcrete shall be applied as dry as practicable to prevent shrinkage cracking, while ensuring a compacted dense homogeneous mass. Appropriate measures shall be taken to ensure that fresh concrete remains sufficiently workable until end of spraying.

Dry mix compositions with moist aggregate shall normally be applied within 60 minutes after mixing and shall be discarded after such elapsed period. If more than 60 minutes is required until the end of spraying of a batch, open time provided by the chosen measures shall be demonstrated and verified in advance to the Engineer's satisfaction.

Dry mix composition with oven or kiln dried aggregate may be stored for a limited time but shall be applied immediately after mixing with water. Oven or kiln dried material should be pre-dampened before the nozzle or before it is loaded in the spraying machine. When adverse weather conditions require use of quickset cement, procedures shall be adjusted to allow for limited open time of the mix.

Detrimental changes in the dry mix, such as segregation, or other changes shall be minimized during loading, transporting and unloading as well as during conveying on site. Plant shall be chosen, screened off and suitably controlled in a manner that prevents excessive cement dust generation and aggregate separation.

b) Wet-mix process

Measures shall be taken to ensure that mixed constituents remain sufficiently workable until end of spraying. Normal workability time shall be determined by pre-construction tests on test panels. If work requires longer workability times it shall be verified by additional tests. Wet mix compositions shall be applied within 60 minutes after mixing and shall be discarded after such elapsed period. Detrimental changes to the base mix, such as segregation, bleeding, paste loss, or other changes shall be minimized during loading, transporting and unloading as well as when being conveyed on site.

A12.5.7.9 Application of shotcrete

Mix temperature and consistency of shotcrete on site shall be monitored and controlled to ensure conformity before shotcreting. All adjustments of the shotcrete stream through nozzle, whether air pressure, accelerator or shotcrete stream, shall only be performed when the nozzle is turned away from the substrate. Shotcrete shall be composed and sprayed in a manner to limit rebound. Important factors influencing rebound, such as concrete composition, nozzle angle and the distance to substrate, accelerator dosage, particular area of application, etc. shall be carefully controlled and monitored on a continuous basis during application by competent Contractor supervisory staff.

The nozzle shall be directed, wherever possible, normal to the application surface, to produce a layer of optimum density and thickness, with full encasement of reinforcement and minimum rebound. The distance between the nozzle and shotcrete surface is determined according to site conditions and the possibility of obtaining good compaction, full encasement of reinforcement, and minimum rebound. For rock support normally a distance of 1,0 m to 2,0 m is recommended, although site conditions may dictate an application distance outside this suggested range.

Thickness of each shotcrete layer depends on several parameters and shall be based on site conditions and composition of the mix. Specified nominal shotcrete thickness may necessitate the application of two or more layers in order to avoid sagging and sloughing, particularly with overhead work. Thickness of layers may be increased via use of admixtures such as accelerators; extenders such as silica fume, or the use rapid-hardening cements.

A subsequent layer shall not be applied before the preceding layer is able to support it. Earlier applied shotcrete, should considerable time elapse between placement of different layers to obtain specified nominal thickness, shall be cleaned either by blowing with compressed air, high pressure washing, brushing or sand blasting and rewetted until suction of substrate, and consequent risk of an adverse influence on the subsequent shotcrete layer, is mitigated, as approved by the Engineer.

All shotcrete shall be of a homogenous composition without any inclusion of rebound. Overspray and loose rebound material shall be removed from surrounding areas and from substrate before shotcrete is applied to new or subsequent sections. Pre-wetted substrates shall be free from running water.

When spraying on or through reinforcement, consequence of rebound and shadow effects shall be carefully taken into account and particular attention given to minimize all possible negative effects. Mitigation measures may include ensuring that the air stream velocity around reinforcement is sufficient and ensuring encapsulation of reinforcement is completed as soon as practical with adequate cover over reinforcement and preventing poor compaction, if spraying with fibres onto other types of reinforcement.

A12.5.7.10 Finishing

The finished surface shall generally follow the contours of the roughly trimmed face such that it mimics the natural rock faces. It shall, however, be free from rebound pockets or other defects. The inclusion of fibres may affect the finish obtained. The types of finish shall be designated on the drawings by the following:

- SU: Undisturbed nozzle finish
- ST: Trowelled finish
- STB: Trowelled and brushed
- STF: Trowelled and flash-coated
- STW: Trowelled and wood floated.

The general procedure for achieving required finishes shall be:

Undisturbed nozzle finish (SU)

- The sprayed surface shall be brushed with a soft plasterer's brush approximately one hour after placement to remove adhering rebound dust and to prevent surface crazing.

Trowelled finish (ST)

- The surface shall be trowelled when the shotcrete exhibits initial set to obtain a uniform curved or plain surface true to line and shall then be finished with one of the following treatments if so specified:

Brush-coated (STB)

- Coating of the trowelled surface with a cement mortar slurry using a soft broom or brush to give a soft "brushed effect"

Flash-coated (STF)

- Coating the trowelled surface with a thin uniform layer approximately 3,0 mm thick of shotcrete at least four hours after trowelling but not later than eight hours.

Wood-floated (STW)

- Floating the trowelled surface with a wood float to produce a smooth even surface free from trowel marks

A12.5.7.11 Rebound material

Rebound material shall not be re-used. Rebound material shall be removed from all future working areas and may not be covered up by subsequent applications of shotcrete. It shall also be cleaned from the surface of any finished work. Where coarse aggregate >10 mm is used, higher rebound volumes are anticipated. There may be an increased proportion of fibres in rebound when fibres are used. Appropriate correction to mix design will be required.

A12.5.7.12 Properties of hardened shotcrete

a) Compressive strength

For the purpose of determining compressive strength, characteristic cylinder strength, determined from cores extracted from test panels, using 75 mm diameter, 150 mm high cylinders prepared strictly in accordance with SANS 3001-CO2-2 and tested in accordance with SANS 3001-CO2-3 at a sample age of 28 days. Compressive strength classes shall conform to Table A14.6.7-1 of Chapter 14. For particular uses, it may be necessary to specify compressive strength at ages earlier or later than 28 days, or after storage under special conditions. In assessing strength, other sizes of specimens and other curing regimes may be used provided that relationship to those standardised is established and documented.

b) Flexural strength

Ultimate flexural strength shall be determined from beam specimens cut from test panels, tested at 28 days in accordance with SANS 5864.

c) Energy absorption capacity

Energy absorption capacity shall be determined from a test panel slab specimen, tested at 28 days, in accordance with EN 14488-5, and shall conform to specified energy absorption class defined in Table A14.6.7-2 of Chapter 14.

A12.5.7.13 Construction joints

Once a section of work has commenced, the application of shotcrete shall be continuous up to the construction joints shown on the drawings or up to approved locations. All construction joints shall be standard feathered type joints, for last mix of the day the shotcrete layer shall be tapered to a fine edge which shall be wet and cleaned with an air or water blast before joining the following day's work.

Irregular edges shall be cut back to straight lines before commencing with further work.

A12.5.7.14 Weepholes

Weepholes comprising nominal 50 mm diameter U-PVC piping shall be installed at those positions indicated on the drawings or as otherwise Engineer-instructed. Pipes shall protrude 20 mm beyond the surface of final shotcrete layer and have their inner end wrapped with a single layer of geosynthetic. Weepholes shall be positioned to intersect seepage anticipated from soft zones or fixed in position to butt against angled or vertical geosynthetic band drains. Weepholes shall be positioned prior to application of initial shotcrete layer with the geosynthetic end hard against substrate face.

Outer ends of the pipes shall be adequately protected during application of shotcrete. Protective plugs shall be removed after spraying and pipe checked to ensure no shotcrete material entered any of the weepholes.

A12.5.7.15 Control test panels

The Contractor shall produce control test panels, fully complying with requirements of the preconstruction trial panels, alongside every new stage of the work. A minimum of one control test panel required per lot of shotcrete, and at least one per day. At the start of or during work, nozzle operator shall produce test panels alongside and in similar orientation to the work. These test panels shall be protected and cured in the same manner as the work.

A12.5.7.16 Edge detail of shotcrete

Details of finishing off shotcrete at the brow and edges shall be indicated on drawings. Methods to terminate shotcrete at the perimeter shall prevent surface water from undermining the shotcrete. For tender purposes, allowance shall be made for trench excavation along the perimeter with nominal dimensions of 0,5 m wide and 0,5 m deep or as indicated on the drawings, in order to allow for the finishing off of shotcrete at the edges

Where boulders or suitable quality rock outcrop occur at a cut-brow, no cut off may be required, if Engineer-instructed, and shotcrete shall be neatly stopped at rock surface -top.

Where specified on drawings, shotcrete shall be terminated to facilitate incorporation of precast coping units.

A12.5.7.17 Aesthetic appearance

The Contractor shall take due care in assessing variation in texture and colouring of natural adjacent rock and soil slopes. Finish of all permanently visible shotcrete surfaces shall be in harmony with surrounding environment.

The Contractor shall pay particular attention during application of shotcrete to carefully control desired variations in colouring and texture of shotcrete to suit the natural local environment. Colour pigmentation shall be agreed in collaboration with, and approval of the Engineer via trial colour panels. In some locations, the Engineer may instruct the formation of planting boxes in which vegetation may be planted. Where so required details shall be given in the Contract Documentation.

A12.5.7.18 Protection of adjacent work

During the shotcreting progress, where appearance is important, adjacent facilities or structures which may be permanently discoloured, stained, or otherwise damaged by overspray, dust or rebound, shall be adequately protected and, if contacted, shall be cleaned at the Contractor's cost by early scraping, brushing, or washing, as surroundings permit.

A12.5.7.19 Blasting restriction

In order to prevent damage to shotcrete, no blasting shall be carried out within 50 m of a shotcrete section within 72 hours of shotcrete-application. The total explosive charge detonated instantaneously shall be such that Peak Particle Velocity (PPV) less than 50 mm/s. All completed works shall be inspected after any blasting within 100 m of the shotcreted area.

A12.5.7.20 Protection and curing

a) Protection from adverse environmental conditions

Refer to Clause A14.6.7.17a) of Chapter 14.

b) Curing

Refer to Clause A14.6.7.17b) of Chapter 14.

A12.5.8 WORKMANSHIP

A12.5.8.1 Tolerances

The tolerances provided below shall be maximum permissible deviations from specified dimensions, levels, alignment, positions, etc., as shown on drawings.

- Position: the lesser of 100 mm or the specified position of the total shotcrete member.
- Thickness - Arithmetic mean value per lot: minimum 100 % of specified layer thickness, maximum thickness not specified.
- Individual depth at any measurement point: minimum 80 % of specified layer thickness, maximum thickness not specified.
- Surface regularity (where applicable): maximum value of any individual irregularity, measured with a custom template that ensures specified layer thickness is achieved and is less than 25 mm.

A12.5.8.2 Acceptance criteria

Routine inspection and quality control shall be performed by the Contractor or Engineer as specified in clauses A1.2.8.1 and A1.2.8.2 of Chapter 1. Compressive strength shall be determined using cored cylinder specimens prepared in accordance with SANS 3001-CO2-2 and tested in accordance with SANS 3001-CO2-3 at the age of 28 days.

Ultimate flexural strength shall be determined from beam specimens prepared from test panels and tested at 28 days in accordance with SANS 3001-CO2-5.

Criteria for compliance with requirements specified for 28-day characteristic compressive and ultimate flexural strength shall be as specified in Clause A20 1.7.5d) (Plan B) of Chapter 20.

The Contractor's attention is drawn to Clause A1.2.8.1 of Chapter 1: Process quality control.

A12.5.8.3 Procedure in event of non-compliance with requirements

Any lot represented by test cores failing to comply with the criteria specified above for characteristic strength shall be rejected.

The Contractor, in all cases where shotcrete as supplied fails to comply with requirements, shall immediately take required remedial action by changing mix proportions to obtain required strength.

A12.5.8.4 Special tests ordered by Engineer

The Engineer may order the Contractor to have concrete cores, flexural beams and or energy absorption slabs, which were prepared under direction of the Engineer, tested at an approved testing laboratory, in which case payment will be made for such tests in accordance with provisions of Section C20.1 of Chapter 20.

B12.5 SHOTCRETE

PART B: LABOUR ENHANCEMENT

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B12.5.8 WORKMANSHIP

B12.5.1 SCOPE

The provisions of Part A shall apply.

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The provisions of Part A shall apply.

B12.5.3 GENERAL

The provisions of Part A shall apply.

B12.5.4 DESIGN BY CONTRACTOR/PERFORMANCE BASED SYSTEMS

The provisions of Part A shall apply.

B12.5.5 MATERIALS

The provisions of Part A shall apply.

B12.5.6 CONSTRUCTION EQUIPMENT

The provisions of Part A shall apply.

B12.5.7 EXECUTION OF THE WORKS

The provisions of Part A shall apply.

B12.5.8 WORKMANSHIP

The provisions of Part A shall apply.

C12.5 SHOTCRETE

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each pay item shall include full compensation for providing, operating, maintaining and decommissioning upon completion, of all the construction equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the pay item as specified, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

1. Unless otherwise ordered or stated in the Contract Documentation, trench depths will be measured from the surface of the ground along the centre-line of the trench to the bottom of the specified bedding layer (as applicable). Where no bedding is required it shall be measured to the underside of the duct or pipe.
2. The ground surface will be that existing after any bulk earthworks have been carried out, i.e. the excavated surface or embankment surface, unless a different sequence of execution has been ordered.
3. Excavations will be measured as if taken out with vertical sides, regardless of whether they have been taken out with sloping sides.
4. The length used for trench computations will be the total through-length of a pipe or duct etc. from end to end and no deduction will be made for manholes or access chambers etc.
5. Wherever volumetric measurement is required, the volume will be computed from the depth determined as indicated in 1. and 2. above and using the authorised width (W) determined in accordance with the specification.
6. Where shoring is specified or ordered, the length of shoring measured for payment will be the length of the centre-line of the trench.

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as the Contractor deems appropriate:

1. No separate payment will be made for backfilling excess excavations, disposing of surplus material etc. or any other contingent work, unless the work is specifically specified or ordered.
2. No separate payment will be made for setting out the works.
3. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities and for complying with all the requirements of Clause A2.1.3.4 of Chapter 2.
4. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
5. No separate payment will be made for the loading of any materials.
6. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to, 1,0 km.
7. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
8. No separate payment will be made for the removal of any surplus material imported to complete the works.

(iv) Items to be measured and paid for using items specified elsewhere in the specifications

Not applicable to this Section.

(v) Items specifically for this Section of the specification

Item	Description	Unit
C12.5.1	**Establishment on site**	lump sum

The tendered lump sum shall include full compensation for establishing on site all plant and equipment, scaffolding, platforms, materials and personnel necessary to carry out the specified work and for the removal from site of all such plant and equipment including all temporary works such as access roads, staging, platforms and such like on completion of the works.

Work shall be paid as Lump Sum, 50 % of which will be due when all equipment is on site, trials (if any) are completed, and the first production shotcrete has been applied to full thickness as specified. A second instalment of 25 % shall be payable after half the shotcreting has been completed and final 25 % after all the shotcrete has been applied - and accepted - and all equipment and plant removed from site

Item	Description	Unit

C12.5.2	**Surface preparation for shotcreting**	**square metre (m^2)**

The unit of measurement shall be the square metre of face/slope cleared of all loose or unwanted material, including indicated vegetation, and manually trimmed to designed lines and levels as specified.

The tendered rate shall include full compensation for trimming all material, and for all equipment, labour and other incidentals necessary to complete the specified work.

Item	Description	Unit
C12.5.3	**Supply and installation of reinforcement:**	
C12.5.3.1	Welded steel mesh fabric (Ref. 395)	square metre (m^2)
C12.5.3.2	Fibre (type indicated)	kilogram (kg)
C12.5.3.3	Other special reinforcement systems as specified	square metre (m^2)

The unit of measurement for steel mesh shall be the net square metre of reinforcement actually incorporated into shotcrete. Measurement shall be based on square metre of soil and or rock slope covered with mesh and measured on the plane of the slope. No overlaps of mesh and or reinforcement system shall be measured.

The unit of measure for fibre shall be the mass in kilograms of fibre actually used, as determined by the kilogram of fibre per cubic metre of shotcrete specified.

The tendered rate shall include full compensation for supply and installation, including all equipment, plant, materials, labour and incidentals necessary to carry out the specified work and including specifically supply and installation of pins, earth spikes, soil nails/ rockbolts, wire ties, gun nails and any other approved fastenings for the completion of the work as specified.

Item	Description	Unit
C12.5.4	**Shotcrete (of specified thickness or volume):**	
C12.5.4.1	Flash/base coat (unreinforced) (specify thickness)	square metre (m^2)
C12.5.4.2	Intermediate coat/s (specify thickness and number of layers)	square metre (m^2)
C12.5.4.3	Final coat (specify thickness, pigmentation and finish	square metre (m^2)
C12.5.4.4	Dental shotcrete	square metre (m^2)

The unit of measurement shall be the net square metre of face measured in the plane of the cutting face, which is protected by shotcrete of specified nominal thickness, installed as specified. No separate allowance shall be made for an uneven surface when measuring the area over which shotcrete is applied.

The unit of measurement for dental shotcrete shall be the cubic metre of shotcrete of measured batch volume, agreed with the Engineer and installed in accordance with the specifications.

The tendered rate shall include for everything necessary to carry out specified work as specified. and shall include safe access for the Engineer to any portion of the cut face or slope.

Item	Description	Unit
C12.5.5	**Removal to spoil of material trimmed from slope**	**cubic metre - km (m^3.km)**

The unit of measurement shall be the cubic metre - kilometre which is calculated as the product of the quantity of material cleared, temporarily stockpiled, loaded, transported in excess of 1.0 kilometre and disposed at approved spoil site, in accordance with the requirements multiplied by the applicable haul distance which shall be calculated as defined in Clause A1.7.3.1 of Chapter 1.

The tendered rate shall include full compensation for trimming all material, and for all equipment, labour and other incidentals necessary to complete specified work. Haul distance shall be measured from mass-centre to mass-centre.

The volume of such material shall be taken to be equal to 70 % of the loose struck volume measured in the truck.

Item	Description	Unit
C12.5.6	**Edge finishing of shotcrete**	**metre (m)**

The unit of measurement shall be the linear metre of perimeter where shotcrete is required to be finished off as detailed in the drawings, all as specified.

The tendered rate shall include full compensation for excavation and spoiling of material from trenches, bending of mesh or reinforcement, application of shotcrete irrespective of volume involved as well as all equipment, labour, transport and other incidentals necessary to complete the specified work.

Item	Description	Unit

C12.5.7	**Geopipe collectors and weepholes:**	
C12.5.7.1	50 mm diameter U-PVC weephole piping (specify length and class)	number (No)
C12.5.7.2	Geopipe collectors (specify type, diameter and class)	metre (m)
C12.5.7.3	Other piping (specify type, diameter and class	metre (m)

The unit of measurement for the U-PVC weephole piping shall be the number of weepholes installed. Unit of measurement of the geopipe collectors and other pipes shall be the metre length installed.

The tendered rate shall include full compensation for supply, installation, protection during shotcreting, geosynthetic wrapping, plant, equipment, labour and all other incidentals necessary to complete the specified work.

Item	Description	Unit
C12.5.8	**Geocomposite/geosynthetic drain as specified**	**metre (m)**

The unit of measurement shall be the linear metre of geocomposite drain installed as specified at spacings or positions specified or as indicated on the drawings.

The tendered rate shall include full compensation for supply, installation, protection during spraying, plant, equipment, labour and all other incidentals necessary to complete the specified work.

D12.5 SHOTCRETE

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

The Contractor shall provide detail b ed specifications and certificates from independent reputable agencies for all proprietary casing/sleeves and materials proposed for use. These shall demonstrate conformance with the performance requirements stipulated in the Contract Documentation.

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D12.5.9 NOTIFICATION OF REMEDIAL WORK

D12.5.10 REMEDIAL WORKS

Where applicable, details must be provided in the Contract Documentation.

D12.5.1 SCOPE

The scope of this Section covers the following:

- Guarantees and compliance certificates
- Product conformance specifications

D12.5.2 GENERAL

The Contractor shall provide detailed specifications, test data, performance data and compliance certificates from independent reputable agencies for all proprietary systems, processes and materials proposed for use. These shall demonstrate conformance with the performance requirements specified in the Contract Documentation.

Unless otherwise specified, all proprietary materials shall be used and placed in strict accordance with the relevant manufacturer's current published instructions.

D12.5.3 PERFORMANCE GUARANTEE REQUIREMENTS

The Contractor shall, within 28 days of entering into the contract with the Employer, submit to the Engineer conformance documentation related to the specifications.

Conformance documentation shall be provided for the following:

- Materials and Materials Design as per Clause A12.6.3.
- Materials as per Clause A12.6.5,
- Construction Equipment as per Clause A12.6.6
- Execution of the Works as per Clause A12.6.7

D12.5.4 FUNCTIONAL PERFORMANCE ASSESSMENTS

No specific items in this Section.

D12.4.5 VISUALLY ASSESSED PROPERTIES

No specific items in this Section.

D12.5.6 INSTRUMENTALLY ASSESSED PROPERTIES

No specific items in this Section.

D12.5.7 EVALUATION FOR ACCEPTANCE

No specific items in this Section.

D12.5.8 ADDITIONAL PROCEDURES TO BE ADOPTED IN THE EVENT OF FAILURE

No specific items in this Section.

D12.5.9 NOTIFICATION OF REMEDIAL WORK

No specific items in this Section.

D12.5.10 REMEDIAL WORKS

No specific items in this Section.

QUESTIONS?

12.4 TRENCHLESS METHODS

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A12.7 TRENCHLESS METHODS

PART A: SPECIFICATIONS

A12.7.1 SCOPE

This Section covers various trenchless methods to install various forms of underground conduit under existing infrastructure or obstruction which may not be cost-effectively installed from surface or by open excavation. Methods covered include, but are not limited to, pipe jacking, micro-tunnelling, pipe ramming or horizontal directional drilling (HDD) methods.

A12.7.2 DEFINITIONS

Trenchless Methods - are methods of installing various forms of underground conduit without the excavation of trenches over the installed length of conduit. These methods include Pipe Jacking, Directional Drilling, Pipe Ramming and Micro-Tunnelling.

Pipe Jacking - is a method for installing a conduit/pipe that serves as initial construction lining and support, installed for stability and safety during construction, and finally as the service pipe. The pipe is forced forward, or jacked, to advance the conduit.

Micro-tunnelling - is a method of installing a conduit by jacking a pipe behind a micro-tunnel boring machine, generally precluding man entry.

Pipe Ramming - is a method by which a cylindrical tool uses air pressure to pound its way through the ground underneath an obstruction, simultaneously installing a conduit.

Horizontal directional drilling (HDD) - is a steerable drilling method of installing a small diameter underground services conduit.

Micro-tunnel Boring Machine - is a mechanized excavating machine that is remotely-controlled, steerable, guided and articulated, connected to and shoved forward by the pipe being installed, usually precluding man entry.

Zone of Active Excavation - the zone of active excavation is the area located within a radial distance about a surface point immediately above the face of excavation equal to depth to bottom of excavation.

Critical Structure - is an existing service, any building, structure, bridge, pier, or similar construction partially or entirely located within a zone of active excavation.

Inlet and outlet structures - may be entry and exit points for some applications to especially designed jacking pits in others. Names used in this text include, entrance/entry and exit, jacking and receiving. These may be circular or rectangular shafts.

A12.7.3 GENERAL

A12.7.3.1 Services and obstructions

A geotechnical investigation shall have been carried out to select the route least affected by known services and which is free of apparent obstructions. Details of known services and other objects which may constitute an obstruction on site shall be detailed in the Contract Documentation. Notwithstanding this, unidentified obstructions/services may be encountered.

Before any work can commence the Contractor shall verify the actual position of each known service and bring to the attention of the Engineer any service that is not recorded in the Contract Documentation.

Should an unidentified obstruction be encountered which prohibits further advance of equipment, the Engineer and Contractor shall jointly devise a method for penetration/avoidance/possible relocation. The cost of additional operations required for this task shall be agreed between Engineer and Contactor prior to commencement.

The provisions of Clause A2.1.3.2 of Chapter 2 regarding the protection of services shall be applicable.

A12.7.3.2 Method Statements

Where so indicated by the Engineer the Contractor shall prepare detailed method statements for each facet of the work describing key aspects such as construction methodology, key plant, materials, personnel as well as any programme constraints of the envisaged construction process.

These method statements shall be prepared and submitted to the Engineer for approval prior to commencement of that activity, within time scales specified. The onus lies with the Contractor to ensure that the information is obtained and that associated activities are completed expeditiously to avoid any delays in the commencement, continuation and completion of the required works. Unless otherwise specified or provided for in the Contract Documentation no permanent works shall be commenced until the Engineer's approval of the relevant method statement. The Contractor shall, however, remain responsible for all work-methods, materials, plant and equipment used, notwithstanding acceptance by the Engineer.

The Contractor shall be required to construct trials and the testing thereof as specified herein and shall make due allowance therefore in his programme. Allowance shall also be made for allow for the Engineer's assessment of constructed works, procedures followed, and materials and plant utilised and test data. Production work shall not be permitted until it is shown and accepted by the Engineer that the Contractor possesses the necessary experience, plant and equipment to carry out the works as specified in the Contract Documentation.

It should be noted that work shall only be performed by personnel listed by the Contractor. If personnel changes need to be made during the project, works shall be suspended until replacement personnel are approved by the Engineer. Time lost due to incomplete submissions, unacceptable submissions, or obtaining approval of replacement personnel will not be considered as cause for extension of time or delay claims. All costs associated with incomplete, replacement, or unacceptable submissions shall be to the Contractor's cost.

Once approved in writing by the Engineer, these shall become the method statements in accordance whereby the relevant portion of the works shall henceforth be executed. Notwithstanding, the Engineer may require revision from time to time if circumstances during construction arise which warrants change.

A12.7.3.3 Materials and materials design approvals

All materials used in the works described hereunder shall meet the appropriate standards given below and/or specified in the Contract Documentation and shall be subject to the approval of the Engineer. The Contractor shall submit product certificates, conformance documentation (as per Part D) related to the specifications, test results as required together with samples of materials and where applicable, materials designs that he proposes to use in the construction of the works to the Engineer for his acceptance/approval as provided for in the Contract Documentation.

Due allowance shall be made for obtaining materials, resubmissions and re-designs, all to the required/approved standards, methods and practices in attending to these requirements. Particular attention shall be paid to the early submission of materials-, concrete- and grout mix designs where parameters at various ages may be specified. No consideration for extension of the contract period will be entertained for delays incurred in meeting these requirements.

The Contractor's attention is drawn to the approvals required as indicated in Table A12.7.3-1 below regarding works carried out under this section of the works:

Table A12.7.3-1: Approvals required

Clause	Requirements*	Period
	Materials Design Approvals	
A12.7.7.1	Compatible materials for pipe jacking	4 weeks before construction
	Materials Approvals	
A12.7.5.1	Details and product certificates for materials for Pipe jacking, Horizontal directional drilling, Pipe ramming or Micro-Tunnelling	2 weeks before ordering or delivery
A12.7.7	**Construction Method Statements**	
A12.7.7.2 b)	Execution of Pipe jacking works	4 weeks before construction
A12.7.7.3 b)	Execution of Horizontal directional drilling	
A12.7.7.4 a)	Execution of Pipe ramming	
A12.7.7.5 a)	Execution of Micro-tunnelling	4 weeks before construction

A12.7.3.4 Removal of surplus material/ spoil

Removal of excess material/ spoil is the Contractor's responsibility as is well as restoration of the site to conditions which existed prior to construction. The method for removal or final disposal of spoil shall be not be detrimental to and shall be appropriate to the works. The costs of removal and final disposal shall be included in his rates.

A12.7.3.5 Pipe jacking

Pipe jacking is a method for installing a casing or sleeve that may serve as a direct conduit for liquids or gases, or as a duct for pipe, cable, or wire line services. It is a multi-stage process consisting of constructing a temporary horizontal jacking platform and a starting alignment track in an entrance jacking pit at the desired elevation. The sleeve/conduit is then jacked from a thrust block by manual control along the starting alignment track while simultaneous excavation of soil/rock is accomplished by excavating the face under a shield.

Spoil is transported back to the entrance pit either manually or using light wagons on rails. Pipe jacking typically provides limited tracking and steering as well as limited support to the excavation faces.

Pipe jack through solid dolerite – really??

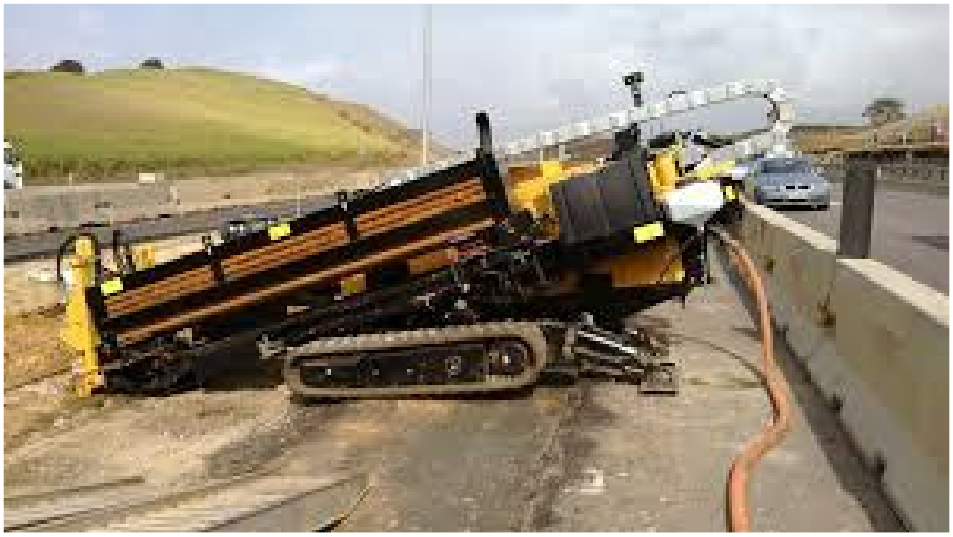
Strapping of the main line JHB to Durban after pipe jack gone wrong and sinkhole formation + slumping below rail

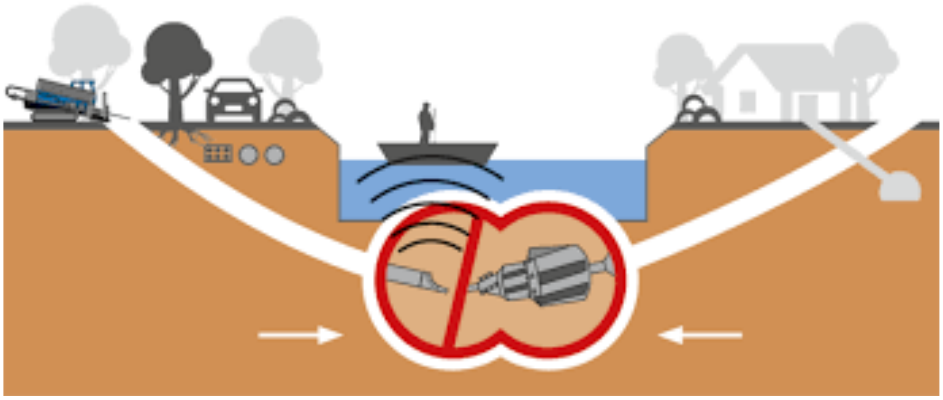
New shaft

Break out inclined and stuck segment

A12.7.3.6 Horizontal directional drilling

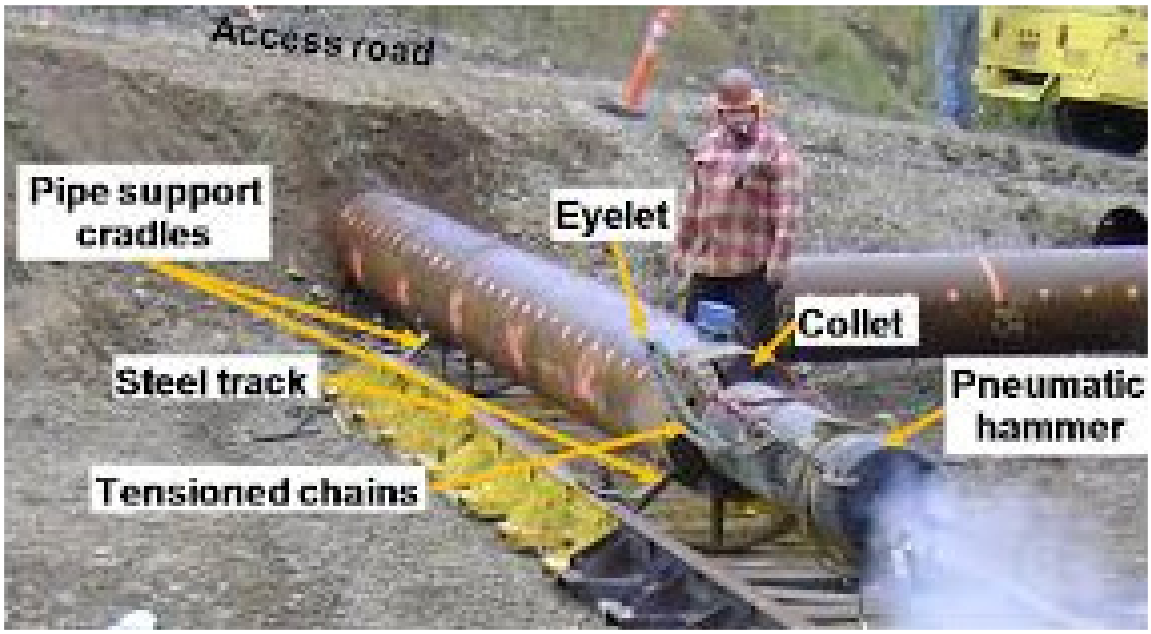
Horizontal directional drilling is a trenchless method for installing a casing/sleeve that serves as a direct conduit for liquids or gases, or as a duct for pipe, cable, or wire line products. It is a multi-stage process consisting of drilling a pilot bore along a predetermined path and then pulling the desired casing/sleeve back through the drilled space. The vertical profile of bore alignment is typically in shape of an inverted arc. When necessary, enlargement of the pilot bore hole to accommodate a casing/sleeve greater than the pilot bore cross section is accomplished by back-reaming. This is accomplished by the casing/sleeve being simultaneously pulled back through the pilot bore space. Bore steering is accomplished by the orientation of drill bit head as it is being pushed along an alignment by an above-ground hydraulic jack. Orientation and tracking of drill bit are determined by an above-ground radio-detection device which picks up a signal generated from a radio transmitter contained within the drilling bit. This radio signal is translated into depth and alignment. In order to minimise friction and provide a soil stabilising agent, a purpose-selected, appropriate drilling fluid is introduced to the annular space created during boring operations. Rotation of the bit in soil wetted by drilling fluid creates a slurry. This slurry acts to stabilise the surrounding soils and prevents collapse of the borehole and loss of lubrication. Drilling fluid quantities must be designed for the soil and ground water conditions. In order to confine any free-flowing slurry at the ground surface during pull back or drilling, sump areas shall be created to contain any escaping slurry that might damage or be hazardous in the surrounding areas. All residual slurry shall be removed from the surface and the site restored to pre-construction conditions.

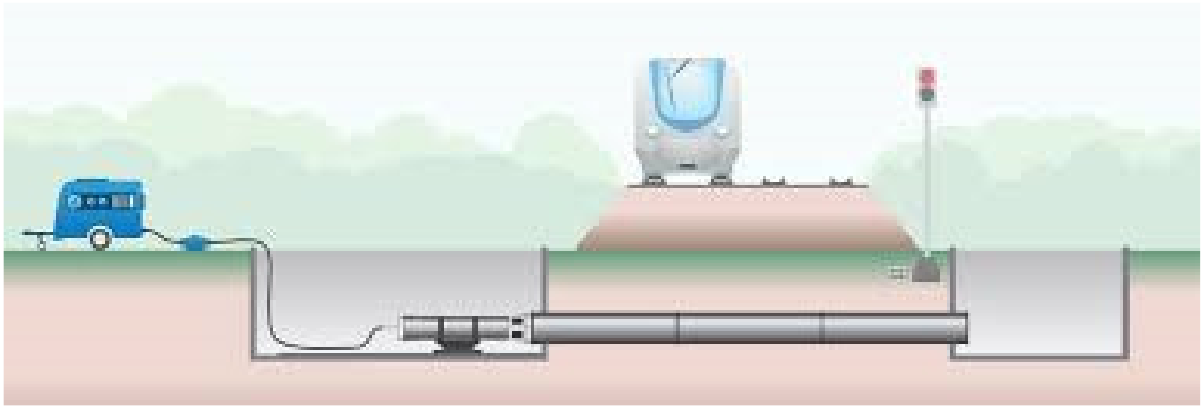




A12.7.3.7 Pipe ramming

Pipe Ramming uses a tool and compressed air to drive a bit through ground under the desired/existing facility. The tool is cylindrical in shape and ranges in size from 25 to 200 mm in diameter and between 1,0 and 2,0 m long. It is made from metal. Different manufacturers have different front styles and control mechanisms. Some have bullet-shaped fronts and others have a stepped front similar to a uni-bit (cone or truncated cone bit).





A12.7.3.8 Micro tunnelling

Micro-tunneling is the construction of conduits by one-pass methods without man entry. These construction methods involve jacking pipe following hand-shield excavation or a micro-tunnel boring machine, with the pipe serving as both tunnel liner during construction and pipe after completion of construction.

Micro-tunneling is a remotely controlled, guided pipe installation process that provides continuous support to the excavation faces. Guidance systems usually consist of a laser mounted in the tunnelling drive shaft which communicates a reference line to a target mounted inside the micro-tunnel boring machine articulated steering head. The micro-tunneling process provides the ability to control excavation face stability by applying mechanical or fluid pressure to counterbalance earth and hydrostatic pressures.

A12.7.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

A12.7.4.1 General

Where design by the Contractor for any technique to be carried out, is, in terms of the Contract Documentation, the responsibility of the Contractor, all the aspects given below shall be taken into consideration in carrying out these obligations.

The following shall normally be specified (where applicable) by the Engineer and reflected in the Contract Documentation:

- Techniques and methods to be followed,
- Material type and quality and properties,
- Site specific requirements,
- Limits of the area and depths to which boring shall be conducted,
- Concrete/grout mix design,
- Bentonite slurry mix design,
- Sequence of installation,
- Permissible limits (pressures, flow rates),
- Quantities of grout/other materials (if required) to be injected/used,
- Monitoring of works,
- Quality and workmanship requirements,
- Measurable properties to be achieved over the life span of the project,
- Anti-corrosion requirements,
- Environmental and safety requirements specific to the techniques to be executed,
- Monitoring and record keeping requirements.

The following information will be generally provided in the Contract Documentation:

- A definition of objectives and control criteria,
- Investigation data including subsurface geological information, hydrological data and geotechnical parameters
- Test data, borehole logs and recovered core samples,
- Limitations including information on subsurface services,
- Availability of materials on site.

The following additional aspects, where applicable shall also be addressed:

- Finishing off of treatment areas to specified lines and levels, whether materials are to be removed, removed and replaced by other materials, processing of materials and all other measures to be carried out in meeting the requirements as specified in the Contract Documentation.
- The Contractor shall provide a quality management plan indicating his proposed quality assurance testing programme which shall allow, if necessary, testing at each treatment position as required. Testing methods to be employed shall be as specified in the Contract Documentation.

A12.7.4.2 Contractor's design

The Contractor shall submit the following in his detailed method statement for the specified works

a) Works methodology

A brief description of proposed methodology shall be given. The description should be sufficient to convey the following:

- The proposed method of construction and type of face support where relevant,
- Manufacturer of and type of equipment proposed,
- The type of lighting and ventilation systems where man entry is desired
- The number and duration of shifts planned to be worked each day,
- The sequence of operations,
- The locations of access shafts and work sites,
- The method of spoil transportation from face, surface storage and disposal location,
- The capacity of jacking equipment and type of cushioning,
- Identify critical structures and utility crossings and special precautions proposed.

b) Drawings and calculations

The Contractor shall, for record purposes, submit drawings, and calculations for any support system designed by him. The drawings shall be adequate for construction and include installation and joint details. Documents must be signed by a Professional Engineer.

Calculations shall include clear statements of criteria used for design as described below:

- The Contractor is responsible for the selection of appropriate pipe and pipe joints to withstand jacking forces, pulling or other forces and any or other construction loads in combination with overburden, earth and hydrostatic loads. Design of any pipe indicated on the drawings considers in-place loads only and does not take into account any construction loads. Criteria for the longitudinal loading (jacking forces) on pipe and joints shall be determined by the Contractor, based on the selected method of construction.
- Jacked pipe shall be designed to withstand the thrust or pulling forces of Pipe jacking, Pipe ramming, Micro-Tunnelling, shield or pipe advance, without damage or distortion. Propulsion jacks shall be configured so that the thrust is uniformly distributed and will not damage or distort the pipe.
- Loads from handling and storing shall be taken into account.
- The criteria contained in TMH 7 parts 1 and 2 are to be used.
- The Contractor shall provide pipes of diameter shown on the drawings. Substitution of the pipe/s with larger diameters to suit Pipe Ramming,

Pipe jacking, Horizontal Directional Drilling or Micro-tunnel boring machine equipment availability will only be permitted if the Contractor demonstrates that design flows and velocities can be achieved.

A12.7.5 MATERIALS

A12.7.5.1 General

All materials used in the works described hereunder shall meet the appropriate standards given below and/or specified in the Contract Documentation and shall be subject to the approval of the Engineer. The Contractor shall submit details and product certificates where appropriate to the Engineer two weeks before ordering and delivery to site.

A12.7.5.2 Horizontal directional drilling

a) Drilling Fluids

A mixture of bentonite clay or other approved slurry and potable water shall be used as a cutting and soil stabilisation fluid. Viscosity shall be varied to best fit the soil conditions encountered. Water shall be clean and fresh, with a pH greater than 6.

No other chemicals or polymer surfactants are to be used in drilling-fluids without the written consent of the Engineer and after a determination is made that the chemicals to be added are not harmful or corrosive to the facility and are environmentally safe.

b) Pipes

Materials must meet or exceed following standards:

Table A12.7.5-1: Material Standards for DD Installation

Material Type	Pressure
Polyethylene (PE)	SANS/ISO 4437 ASTM D 2447 ASTM 2513,
High Density Polyethylene (HDPE)	SANS 4427 STM D 2447 ASTM D 3350 ASTM F714 ASTM 2513
Polyvinyl-Chloride (PVC)	SANS /ISO 966-1 SANS /ISO 966-2
Un-plasticised Polyvinyl-Chloride (U-PVC)	SANS/ISO 16422
Steel	AWWA C200API 2B ASTM A139 Grade BAPI 2B (Non-pressure)

A12.7.5.3 Pipe jacking

a) Materials approved for installation within the road reserve shall be selected based on their suitability for the construction methods as defined in Table A12.7.5-2 below.

Table A12.7.5-2: Casing/sleeve suitability by construction method

Type	Pipe/Casing installation Mode	Suitable Pipe/Casing Material
Pipe **Jacking (PJ)**	Jacking	Steel Reinforced concrete pipes (SC type, D100)
Micro-tunnelling (MT)	Jacking	Ductile iron pipes, fibreglass reinforced polymer mortar pipes, polymer concrete pipes , pre-stressed concrete cylinder pipes, reinforced concrete cylinder pipes, reinforced concrete pipes, steel pipes , PVC pipes

b) Materials standards for pipes are given in in Table A12.7.5-3 below.

Table A12.7.5-3: Material standards for Pipe Ramming and Micro Tunnelling installations

Material Type	Non-Pressure	Pressure
Ductile Iron (DI)	AWWA C150/C151 ASTM A716, A747	SANS 1835: 2017 AWWA C150/C151
Fibreglass Reinforced Polymer Mortar (FRPM)	ASTM D 3262	ASTM D3517AWWA C950
Polymer Concrete (PC)	DIN 54815-1 & 2	N/A

Material Type	Non-Pressure	Pressure
Pre-stressed Concrete Cylinder Pipe (PCCP)	N/A	AWWA C300
Reinforced Concrete Cylinder Pipe (RCCP)	N/A	ASTM C361
Reinforced Concrete Pipe (RCP)	ASTM C 79 ASCE 27-00	SANS 676, SANS 677 ASTM C 361AWWA C300/C302
Steel	ASTM A139 Grade B(1) API 2B(2)	AWWA C200API 2B(2)
Vitrified Clay Pipe (VCP)	ASTM C1208EN 295-7	N/A

Note (1) No hydrostatic test required (2) Dimensional tolerances only

A12.7.5.4 Pipe ramming and Micro-tunnelling

a) Steel pipe casing

The Institute of Welding which is an Authorized National Body (ANB) of the International Institute of Welding (IWW) require that the steel casing diameter shall be more than 150 mm larger than the largest outside diameter of the carrier pipe. Casing pipe shall be straight seam or seamless pipe. All steel pipe may be bare inside and out, with the manufacturers' recommended minimum nominal wall thicknesses to meet the installation and loading requirements. Coatings to extend service life may be specified. All steel casing pipe shall be square cut and have dead-even lengths which are compatible with the pipe ramming or pipe jacking equipment.

All steel pipe casings and welds shall meet or exceed the thickness requirements to achieve service life requirements in the Contract Documentation. Steel pipe casing of insufficient length shall achieve the required length through fully welded joints. Joints shall be air-tight and continuous over the entire pipe-circumference with a bead greater than that required to meet thickness criteria of the pipe wall. All welding shall be performed by a welder qualified from the Southern African Institute of Welding which is an Authorised National Body (ANB) of the International Institute of Welding (IWW).

b) Reinforced concrete pipe casing

In addition to above concrete pipe standards, pipe shall comply with the following minimum requirements:

- 35 MPa concrete compressive strength at 28 days,
- Full circular inner and/or outer reinforcing cage
- Multiple layers of steel reinforcing cages, wire splices, laps and spacers that are permanently secured together by welding in place
- Straight outside pipe wall with no bell modification,
- Elliptical reinforcing steel shall not be used.
- Single cage reinforcement shall have 25 mm minimum cover from the inside wall,
- Double cage reinforcement shall have 25 mm minimum cover from each wall,
- Joints shall be the gasket type,
- Additional joint reinforcement/bracing shall be provided if required.
- Upon installation, the Engineer may, at his discretion, require that the Contractor perform concrete wiping or injection of joints if it is believed the joints did not maintain water tightness. No additional payment will be made for this operation.

A12.7.6 CONSTRUCTION EQUIPMENT

A12.7.6.1 Pipe jacking equipment

The pipe jacking system shall:

- Have main jacks mounted in a jacking frame located in the start jacking pit/shaft,
- Have a jacking frame which successively pushes a string of connected pipes following the excavation equipment towards a receiving pit/shaft,
- Have enough jacking capacity to push the excavation equipment and a string of pipes through ground and may incorporate intermediate jacking stations, if required,
- Have a capacity at least 20 % greater than the calculated maximum jacking load,
- Each set of jacks shall be fitted with a suitably calibrated pressure gauge in good working order such the actual jacking forces can be read at any time during the jacking operation
- Develop a uniform distribution of jacking forces on the pipe-end using spreader rings and packing, measured by operating gauges,
- Provide and maintain a pipe lubrication system at all times to lower the friction developed on the pipe surface during jacking,
- Use jack thrust reactions for pipe jacking that are adequate to support the jacking pressure developed by the main jacking system. Special care shall be taken when setting the pipe guide rails in the jacking shaft to ensure correctness of alignment, grade, and stability,
- Provide equipment to maintain proper air quality of manned tunnel operations during construction in accordance with OHS requirements,
- Enclose lighting fixtures in watertight enclosures with suitable guards and provide separate circuits for lighting, and other equipment,
- Have electrical systems that conform to the appropriate codes,

- Use a tunnel shield. If a hand shield is used for pipe-jacking (with or without attached mechanised excavating equipment), this shield must be capable of handling the various anticipated ground conditions. In addition, the shield shall:
- Conform to the tunnel shape with a uniform perimeter that is free of projections that could produce over-excavation or voids. An appropriately sized overcutting bead may be provided to facilitate steering,
- Be designed to allow the tunnel face to be closed by use of gates or breasting boards without loss of ground.

A12.7.6.2 Horizontal directional drilling

a) Installation equipment

The Contractor shall ensure that appropriate equipment is provided to facilitate the installation as follows:

- Equipment shall be matched to the pipe size installed.
- Contractor to ensure drill rod meets required bend radius,
- Multiple pipe or conduit installations shall be less than the total outside pipe diameter.

The equipment shall be in good working order. Should the type of rig and/or equipment prove inappropriate for the requirements or conditions on site, these shall be replaced by suitable equipment at the Contractor's cost.

b) Locating and tracking

The Contractor shall provide details of his proposed method of locating and tracking the drill head during pilot boring. Walkover, wire line, and wire line with surface grid verification as approved by the Engineer, shall be accepted methods of tracking directional bores. Locating and tracking systems shall be capable of ensuring the intended installation is achieved. If an area of radio signal interference is expected to exceed 2,0 m, the Contractor shall provide a suitable alternative tracking system. Locating and tracking systems shall provide information on:

- Clock and pitch,
- Depth,
- Transmitter temperature,
- Battery status,
- Position (x and y),
- Azimuth, where direct overhead readings (walkover) are not possible (i.e. subaqueous or limited access) transportation facility,
- Proper calibration of equipment,
- Alignment readings or plot points shall be taken and recorded every 2,0 m.

c) Monitoring/survey

All facilities shall be installed in such a way that their location can be readily determined by electronic designation after installation. For non-conductive installations this shall be accomplished by attachment of a continuous conductive material either externally, internally, or integrally with casing/sleeve. Either a copper wire line or a coated conductive tape for this material may be used. Any break in conductor must be connected by an electrical clamp of brass or solder and coated with a rubber or plastic insulator to maintain the integrity of connection from corrosion.

A12.7.6.3 Pipe ramming

a) General

The tool, comprising a bit of either bullet, cone or truncated-cone shape, varying from 25 to 200 mm in diameter and 1,0 to 2,0 m length is powered by oil and compressed air in jack-hammer fashion. As the tool pounds through the ground it compresses the soil and this compaction ensures a stiffened annulus which prevents collapse, facilitating casing installation.

The Contractor shall make use of specialist Sub-Contractors experienced in the use and maintenance of the above equipment.

A12.7.6.4 Micro-tunnelling boring machine

a) General

Full directional guidance of a shield shall be used. The Contractor shall employ micro-tunnelling equipment capable of handling the various anticipated ground conditions and is capable of minimising the loss of soil ahead of and around the machine and shall provide satisfactory support of the excavated face.

Micro-tunnel boring machines shall conform to the tunnel shape with a uniform perimeter that is free of projections that could produce over-excavation or voids. An appropriately sized overcutting bead may be provided to facilitate steering. In addition it shall be:

- Capable of full-face closure,
- Equipped with appropriate seals to prevent the loss of bentonite lubricant,
- Capable of correcting roll by reverse drive or utilising fins,
- Designed to handle adverse ground conditions including ground water ingress,
- Equipped with a visual display to show the operator the actual position of the micro-tunnel boring machine relative to the design reference.

b) Performance requirements

Micro-tunnel boring machines shall be:

- Capable of providing positive face support regardless of micro-tunnel boring machines type,
- Articulated to enable the controlled sheeting in both vertical and horizontal directions to a tolerance of ± 25 mm from design alignment,
- Controlled remotely from a surface unit,
- Capable of controlling rotation. This is accomplished using a bi-directional drive on cutter head or by using anti-roll fins or grippers,
- Capable of injecting lubricant around the exterior of pipe being jacked,
- Capable of controlling the rise and fall to acceptable tolerances as indicated in the Contract Documentation.

c) Main control system

The main control system of micro-tunnel boring machines shall provide the following information to the operator as a minimum required for successful operation of micro-tunnel boring machine:

- Deviation of micro-tunnel boring machine from required line and grade of pipeline (normally by reference to a laser beam),
- Grade and roll of micro-tunnel boring machine
- Jacking load,
- Torque and rotation velocity of cutter head,
- Instantaneous jacking rate and total distance jacked,
- Indication of the steering direction.

d) Remote control system

Micro-tunnel boring machines shall have the following features:

- Operation of the system without need for personnel to enter the tunnel. A display available to the operator, at a remote operation console, showing the shield position in relation to a design reference together with other information such as face pressure, roll, pitch, steering attitude, valve positions, thrust force, and cutter head torque; the rate of advance and the installed length,
- An integrated system of excavation and removal of spoil and its simultaneous replacement by conduit.

e) Active direction control

Micro-tunnel boring machines shall have the following features:

- Line and grade control by a guidance system that relates actual position of the micro-tunnel boring machine to a design reference, e.g. by a laser beam transmitted from the jacking shaft along pipe to a shield-mounted target,
- Active steering information which shall be monitored and transmitted to operating console,

f) Jacking system

The jacking system shall have the capability of pushing the micro-tunnel boring machine and pipe through the ground in a controlled manner compatible with the anticipated jacking loads and pipe capacity.

g) Spoil transportation systems

Where any of the above techniques use a spoil-transportation system, this shall balance soil and ground water pressures using a slurry or earth pressure balance system, capable of adjustments required to maintain the face stability for the particular soil condition and shall monitor and continuously balance the soil and ground water pressure to prevent loss of slurry or uncontrolled soil and ground water inflow.

In the case of a slurry-spoil transportation system it shall:

- Provide pressure at the excavation face using slurry pumps, pressure control valves, and a flow meter.
- Include a slurry bypass unit to allow the direction of flow to be changed and isolated, as necessary.
- Include a separation process. The design shall provide adequate separation of the spoil from the slurry so that slurry with sediment content within limits required for successful micro-tunnelling can be returned to the cutting face for reuse.
- Appropriately contain spoil on site prior to disposal.
- Use a type of separation process suited to the size of tunnel being constructed, the soil type being excavated, and the workspace available at each work area for the operating plant.
- Allow composition of slurry to be monitored to maintain slurry density and viscosity limits required.

Where a cased auger earth pressure balance system is used:

- It shall be capable of adjustments required to maintain the face stability for the particular soil conditions encountered.
- It shall monitor and continuously balance the soil and ground water pressure to prevent loss of soil or uncontrolled ground water inflow. Using this system, pressure at the excavation face is managed by controlling the volume of spoil removed with respect to the advance rate.
- Speed of rotation of the auger flight, and the addition of water shall be monitored.

A generator which is suitably insulated for noise ("hospital" type) shall be used in residential or commercial areas.

A12.7.7 EXECUTION OF THE WORKS

a) General

Operations shall be conducted in accordance with applicable safety rules and regulations, OHS standards and the Contractor's safety plan. Methods which include due regard for safety of work-persons, adjacent structures, utilities, and public shall be used. Clean, safe and neat working conditions shall be maintained.

The Contractor shall identify suitable sources of fresh water for mixing drilling mud. Approvals and permits are required. Methods for operations shall be used that will minimize ground settlement. The method shall control flow of water and prevent loss of soil into tunnel and provide stability of face under anticipated conditions.

Power distribution systems shall be identified under the contract or permit provisions. Noise constraints shall be identified.

The Contractor shall establish and maintain construction control points, reference lines and grades for locating bore tip and detect movement of ground surface and adjacent structures, in any of the Pipe jacking, Horizontal directional drilling, Pipe ramming or Micro-Tunnelling operations. The control points shall be sufficiently far from work so as not to be affected by activities on site.

If settlement of ground surface occurs during boring which disturbs temporary benchmarks, the Contractor shall re-establish these.
Installation of instrumentation shall not preclude the Engineer, through an independent Contractor or consultant, from installing instrumentation in, on, near, or adjacent to construction work. Access shall be provided to works for such independent installations.

Spoil shall be removed so as not to create a hindrance to other activities in the area.

Entry, recovery pits, slurry sump pits, or any other excavation which contain drilling fluids shall be restored and cleaned of all excess slurry left on/in the ground after installation of casing/sleeve. Removal and final disposal of excess slurry or spoils as casing/sleeve is introduced shall be the Contractor's responsibility. The cost of restoring damaged pavement, kerbs, sidewalks, driveways, lawns, storm drains, landscape, and other facilities shall be borne by the Contractor.

A12.7.7.1 Pipe jacking

a) General

Construction Installation shall be carried out in accordance with SANS 2001-DP8.

b) Locating and tracking

For all installations, the Contractor shall include in detailed method statements his proposed strategy for providing:

- A true indication of where the leading edge of the casing is located with respect to line and grade. This may be provided by a water gauge (manometer), electronic transmitting and receiving devices, or other approved methods. The Contractor shall indicate the proposed intervals for checking line and grade, and record keeping on site.
- Equipment of adequate size and capability to install the project. This includes the equipment manufacturer's information for all power equipment used in the installation,
- Means for controlling over-cut to a minimum, with maximum limited to a 20 mm space around casing pipe circumference,
- Adequate casing lubrication with a bentonite slurry or other approved lubricant and other/or other support measures to ensure no loss of grout,
- An adequate band around the leading edge of casing to provide extra strength, which reduces skin friction as well as providing a method for the slurry lubricant to coat the outside of casing,

c) Process

The following shall be complied with in pipe jacking operations:

- The excavation shall be kept within reserves indicated on the drawings and to the lines and grades designated on the drawings and/or given in the Contract Documentation,
- Operations shall be performed in a manner that will minimize the movement of ground in front of and surrounding the jack,
- Damage to structures and utilities above and in vicinity of operations shall be prevented,
- Open-faced excavations shall be kept breasted or otherwise supported to prevent falls, excessive raveling, or erosion. Standby face supports shall be provided for immediate use when required. During shut-down periods, the excavation-face shall be supported by positive means and no support shall rely solely on hydraulic pressure unless continuously attended by a responsible person.
- The excavated diameter shall be to a minimum size to permit pipe installation by jacking with allowance for bentonite injection into the annular space,
- Whenever there is a condition encountered which could lead to face collapse and/or destabilisation of adjacent structures, operations shall continue uninterrupted 24 hours per day until this condition no longer exists,
- The Contractor shall be responsible for damage due to settlement from any construction-induced activities.
- Pipe joints shall be cushioned as necessary to transmit the jacking forces without damage to the pipe or pipe joints,
- An envelope of bentonite slurry shall be maintained around the pipe exterior during jacking and excavation operations to reduce exterior friction and possibility of the pipe seizing in place,
- If the pipe seizes in place and Contractor elects to construct a recovery access shaft, approval shall be obtained from appropriate local authorities to coordinate traffic control measures as may be applicable and utility adjustments as necessary prior to commencing the work,
- If a pipe section is damaged during jacking operations, or joint failure occurs, as evidenced by inspection, visible ground water inflow or other observations, the Contractor shall submit his methods for the repair or replacement for approval by the Engineer.
- All facilities shall be such that their location can be readily determined by electronic detection. Non-conductive conduits shall be fitted with a continuous metallic strip.

A12.7.7.2 Horizontal directional drilling

a) General

Installations shall be carried out as per ASTM 1962 as directed by the Engineer.

b) Process

For all installations, the Contractor shall include in his detailed method statements his proposed strategy. Monitoring of pumping rate, pressures, viscosity, and density of drilling fluids shall be carried out during pilot bore, back-reaming, and pipe installation stages, to ensure adequate removal of the soil cuttings and the stability of borehole. Holes may be used as necessary for excess-pressure relief. To minimise heave during pullback, the pullback rate shall be determined in order to maximise the removal of soil cuttings without building excess down-hole pressure. Excess drilling fluids shall be contained at the entry and exit points until they are recycled or removed from site. Entry and exit pits shall be of sufficient size to contain the expected return of drilling fluids and soil cuttings.

The Contractor shall ensure that all drilling fluids are disposed of or recycled in a manner acceptable to the appropriate regulatory agencies. When drilling in suspected contaminated ground, the drilling fluid shall be tested for contamination and disposed of appropriately. Any excess material shall be removed upon completion of bore.

If during installation an obstruction is encountered which prevents installation of pipe in accordance with this specification, this pipe may be taken out of service and left in place at discretion of the Engineer and shall immediately be filled with an approved cementitious grout. A new installation procedure and revised plans must be submitted and approved by the Engineer before work resumes.

Restoration for damage remains the responsibility of the Contractor. Any pavement heaving or settlement damage shall be repaired to the Engineer's satisfaction.

The diameters given in Table A12.7.7-1 shall be applicable:

Table A12.7.7-1: Maximum Back-Ream Hole Diameter

Pilot Hole Diameter (mm)	Back-Ream Hole Diameter (mm)
50	100
75	150
100	200
150	250
200	300
250	350
≥300	Maximum Casing/sleeve OD plus 150 mm

A12.7.7.3 Pipe ramming

a) General

For all installations, the Contractor shall provide detailed method statements indicating his proposed strategy.

b) Process and quality control

After setting up on site, the probe tip shall be inserted and advanced into the ground using percussive pneumatic/hydraulic techniques under control of the guidance system such that the desired location at any point along the length is obtained. On exit of the ram-boring probe, back-reaming techniques shall be used to insert the desired casing/tubing into the pre-formed hole.

A12.7.7.4 Micro-tunnelling

a) General

For all installations, the Contractor shall provide detailed method statements indicating his proposed strategy.

b) Specific micro-tunnel boring machine requirements

Continuous pressure shall be provided to the excavation face to balance groundwater and earth pressures. Shafts shall be of sufficient size to accommodate the equipment and pipe selected, and to allow for safe working practices. Entry and exit seals shall be provided at the shaft walls to prevent inflow of groundwater, soil, slurry, and lubricants. Thrust blocks shall be designed to distribute the loads in a uniform manner so that any deflection of the thrust block is uniform and does not impart excessive loads on the shaft itself or cause the jacking frame to become misaligned.

The jacking forces applied to pipes shall be monitored and not exceed pipe manufacturer's recommendations.

Pipe lubrication systems shall be functional at all times and sufficient to reduce the jacking loads. The systems shall include mixing/ holding tanks and pumps to convey the lubricant from the holding tank to the application points at the rear of MTBM. Sufficient fluids shall be maintained on site to circumvent loss of lubrication.

c) Process

The Contractor shall make immediate corrections to alignment before allowable tolerances are exceeded.
When the excavation is off line or grade, alignment corrections shall be made to avoid reverse grades in gravity sewers,

The volume of slurry flow shall be monitored in both supply and return side of the slurry loop and position of the slurry by-pass valve.

The following shall be recorded:

The pipe jacking pressures per drive,

- The location, elevation and brief soil descriptions of soil strata,
- The ground water control operations and piezometric levels,
- Any lost ground or other ground movement or any unusual conditions or events,
- If a drive is halted the Contractor shall indicate reasons for if a drive is halted operational shutdown.

A12.7.7.5 Monitoring and records

The Contractor shall:

- Record elevations to an accuracy of 3,0 mm for each monitoring point location Monitoring points should be established at locations protected from damage by construction operations, tampering, or other external influences. Elevations shall be recorded to an accuracy of 3,0 mm for each monitoring point location.
- Record the ground surface elevations on the centerline ahead of operations at a minimum of 20 m intervals or at least three locations per tunnel drive. For pipes greater than 1,5 m diameter, also record similar data at approximately 5,0 m each side of centerline. Settlement monitoring points must be clearly marked by studs or paint for ease of locating,
- Monitor ground settlement directly above and 3,0 m before and after utility or pipeline intersection.
  - Prior to zone of active excavation reaching that point,
  - When tunnel face reaches a monitoring point (in plan), and,
  - When the zone of active excavation has been passed and no further movement is detected.

All records shall be gathered and maintained by the Contractor in an electronic format as per layout, frequency and detail required by the Engineer or as he might require modified from time to time. Where so specified these shall be uploaded to an agreed data base on a daily basis which will be available to the Engineer at all times.

The Contractor shall provide a monitoring report to the Engineer within 14 days of completion of each bore.

Completed As-Built drawings shall be submitted to the Engineer within 30 calendar days. No payment shall be made until required records are delivered.

A12.7.8 WORKMANSHIP

A12.7.8.1 Pipe jacking, directional drilling, pipe ramming and micro-tunnelling

On completion of any casing or non-casing carrier installation, the Engineer shall order pressure tests and any other testing as may be specified in the Contract Documentation.

B12.7 TRENCHLESS METHODS
PART B: LABOUR ENHANCEMENT

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B12.7.5 MATERIALS
B12.7.6 CONSTRUCTION EQUIPMENT
B12.7.7 EXECUTION OF THE WORKS
B12.7.8 WORKMANSHIP

B12.7.1 SCOPE

The provisions of Part A shall apply.

B12.7.2 DEFINITIONS

The provisions of Part A shall apply.

B12.7.3 GENERAL

The provisions of Part A shall apply.

B12.7.4 DESIGN BY CONTRACTOR/PERFORMANCE BASED SYSTEMS

The provisions of Part A shall apply.

B12.7.5 MATERIALS

The provisions of Part A shall apply.

B12.7.6 CONSTRUCTION EQUIPMENT

The provisions of Part A shall apply.

B12.7.7 EXECUTION OF THE WORKS

The provisions of Part A shall apply.

B12.7.8 WORKMANSHIP

The provisions of Part A shall apply.

C12.7 TRENCHLESS METHODS

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each pay item shall include full compensation for providing, operating, maintaining and decommissioning upon completion, of all the construction equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the pay item as specified, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

1. Unless otherwise ordered or stated in the Contract Documentation, trench depths will be measured from the surface of the ground along the centre-line of the trench to the bottom of the specified bedding layer (as applicable). Where no bedding is required it shall be measured to the underside of the duct or pipe.
2. The ground surface will be that existing after any bulk earthworks have been carried out, i.e. the excavated surface or embankment surface, unless a different sequence of execution has been ordered.
3. Excavations will be measured as if taken out with vertical sides, regardless of whether they have been taken out with sloping sides.
4. The length used for trench computations will be the total through-length of a pipe or duct etc. from end to end and no deduction will be made for manholes or access chambers etc.
5. Wherever volumetric measurement is required, the volume will be computed from the depth determined as indicated in 1. and 2. above and using the authorised width (W) determined in accordance with the specification.
6. Where shoring is specified or ordered, the length of shoring measured for payment will be the length of the centre-line of the trench.

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as the Contractor deems appropriate:

1. No separate payment will be made for backfilling excess excavations, disposing of surplus material etc. or any other contingent work, unless the work is specifically specified or ordered.
2. No separate payment will be made for setting out the works.
3. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities and for complying with all the requirements of Clause A2.1.3.4 of Chapter 2.
4. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
5. No separate payment will be made for the loading of any materials.
6. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to, 1,0 km.
7. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
8. No separate payment will be made for the removal of any surplus material imported to complete the works.

(iv) Items to be measured and paid for using items specified elsewhere in the specifications

Not applicable to this Section.

(v) Items specifically for this Section of the specification

Item	Description	Unit
C12.7.1	**Establishment on site for:** (indicate type of operation: Pipe Jacking, Horizontal directional drilling, Pipe Ramming, or Micro-tunnelling)	**lump sum**

The unit of measurement shall be a lump sum. The tendered lump sum for above shall include full compensation for establishing all necessary plant and equipment on site to carry out the works and for removal from site of all such plant and equipment including all temporary works such as access roads, staging, platforms and such like on completion of the works.

Work shall be paid as a lump sum, 50 % of which shall be due when all the equipment is on site and trials (if any) are successfully completed to the Engineer's satisfaction. The second instalment of 25 % shall be payable after half-length is installed and the final 25% instalment after full-length, in service, acceptable installation, and all equipment is removed from site.

The tendered lump sum shall include full compensation for all post-construction requirements as specified.

No extra payment shall be made for establishment of additional plant, should established plant not be capable of achieving desired objectives.

Item	Description	Unit
C12.7.2	**Moving to and setting up equipment at each position for** (indicate type of operation)	**number (No)**

The unit of measurement shall be the number of positions to which equipment is moved and set up in position. The quantity measured shall be number of set ups at positions as well as at trial positions or at positions where Engineer ordered re-setup.

The tendered rate shall include full compensation for all costs involved in moving and setting up any equipment.

Item	Description	Unit
C12.7.3	**Installing holes** (diameter, lining type indicated) **to required length for** (indicate type of operation)	**metre (m)**

The unit of measurement shall be the metre of hole installed to length required.

The tendered rate shall include full compensation for inlet and outlet structures, including dewatering sumps and operation of pumps to keep the Works dry, supplying, installing and extracting temporary casing, installing permanent casing as well as for excavating and disposing of material resulting from conduit formation.

Item	Description	Unit
C12.7.4	**Penetrating unidentified obstructions/services** (indicate type of operation, i.e. Pipe Jacking, Horizontal directional drilling, Pipe Ramming or Micro-tunnelling) **for penetration of**:	
C12.7.4.1	Steel or iron	metre (m)
C12.7.4.2	Concrete	metre (m)
C12.7.4.3	Rock of UCS > 3 MPa	metre (m)

The unit of measurement shall be the metre of obstruction penetrated.

The tendered rate for drilling shall include full compensation for drilling, cutting, blasting as may be necessary, as well as supplying, installing and extracting temporary, and installing permanent casing as well as for disposing of surplus material resulting from penetrating unidentified obstructions.

D12.7 TRENCHLESS METHODS

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

The Contractor shall provide detailed specifications and certificates from independent reputable agencies for all proprietary casing/sleeves and materials proposed for use. These shall demonstrate conformance with the performance requirements stipulated in the Contract Documentation.

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D12.7.1 SCOPE

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D12.7.9 NOTIFICATION OF REMEDIAL WORK

D12.7.10 REMEDIAL WORKS

Where applicable, details must be provided in the Contract Documentation.

D12.7.1 SCOPE

The scope of this Section covers the following:

- Guarantees and compliance certificates
- Product conformance specifications

D12.7.2 GENERAL

The Contractor shall provide detailed specifications, test data, performance data and compliance certificates from independent reputable agencies for all proprietary systems, processes and materials proposed for use. These shall demonstrate conformance with the performance requirements specified in the Contract Documentation.

D12.7.3 PERFORMANCE GUARANTEE REQUIREMENTS

The Contractor shall, within 28 days of entering into the contract with the Employer, submit to the Engineer conformance documentation related to the specifications.

Conformance documentation shall be provided for the following:

- Materials and Materials Design as per Clause A12.7.3
- Materials as per Clause A12.7 5
- Construction Equipment as per Clause A12.7.6
- Execution of the Works as per A12.7.7

D12.7.4 FUNCTIONAL PERFORMANCE ASSESSMENTS

No specific items in this Section.

D12.7.5 VISUALLY ASSESSED PROPERTIES

No specific items in this Section.

D12.4.6 INSTRUMENTALLY ASSESSED PROPERTIES

No specific items in this Section.

D12.7.7 EVALUATION FOR ACCEPTANCE

No specific items in this Section.

D12.7.8 ADDITIONAL PROCEDURES TO BE ADOPTED IN THE EVENT OF FAILURE

No specific items in this Section.

D12.7.9 NOTIFICATION OF REMEDIAL WORK

No specific items in this Section.

D12.7.10 REMEDIAL WORKS

No specific items in this Section.

QUESTIONS?

THANKS EVERYONE

GV PRICE