AUG 2022

ROCK ANCHOR SYSTEM SPECIFICATION

COASTAL WALKWAY UPGRADE CELL 5 AND 5

GREY GULLY AND KURNABINNA SWING BRIDGES

ASPECT STUDIO

Ref. ADL2022-0229 AD Rev1



Date	Revision	Comments
16 March 2022	0	ADL2022-0050AD – Initial Design Report
18 March 2022	1	ADL2022-0050AD –Design Report update for 40mm threaded DCP Bar

Date	Revision	Comments
18 August 2022	0	ADL2022-0229AB Specification given revised loads and additional reinforcement elements. Grouting to be undertaken on site.
19 August 2022	1	ADL2022-0229AB Specification

Table of Contents

1 GENERAL 1
1.1 Scope 1
1.2 Definitions 2
1.3 Rock Anchor Systems 3
1.4 Anchoring Supervisor 3
1.5 General Requirements 4
1.6 Requirements for Assurance of Long-Term Corrosion Protection 4
2 ADDITIONAL QUALITY SYSTEM REQUIREMENTS 5
3 ROCK ANCHORS 6
3.1 Design Conformance 6
3.1.1 General 6
3.1.2 Proving Tests 6
3.1.3 Acceptance Tests 6
3.2 Test Anchors 6
3.3 Manufacture of Rock Anchors 7
3.3.1 Supply of Materials 7
3.3.2 Material Requirements 7
3.3.3 Testing Requirements 11
3.3.4 Handling and Storage on Site 11
3.3.5 Off-Site Assembly 12
3.3.6 Assembly of Rock Anchors 12
3.3.7 Conformance Records 13
3.4 Drilling of Rock Anchor Holes 13
3.4.1 General 13
3.4.2 Drilling and Cleaning of Drillholes 13
3.4.3 Stability of the Rock Anchor Hole 13
3.5 Installation of Rock Anchors 14
3.5.1 General 14
3.5.2 Installation Procedure Requirements 14
3.6 Grouting of Rock Anchors 14
3.6.1 General 14
3.6.2 Grout Materials and Mix Design 14
3.6.3 Testing of Grout 15
3.6.4 Grout Mixing 15
3.6.5 Grout Pumping Equipment 15
3.6.6 Grouting Procedure Requirements 16
3.6.7 Conformance Records 16
3.7 Stressing and Testing of Rock Anchors 16
3.7.1 General 16
3.7.2 Proving Test Anchors 16
3.7.3 Acceptance Testing of Anchors 16
3.7.4 Measurement of Anchor Bar Load and Elongation 20
3.7.5 Conformance Records 20
3.8 Cutting Off Anchor Bars 20
3.9 Protection of Anchor Heads 20
3.10 Anchor Construction Records 21

3.11 Periodic Testing Anchor Bars.....22

APPENDIX

Appendix A: Threaded Bar Double Coupled Protected 40mm Bar Product Specifications

Appendix B: 15.2mm Permanent Multistrand Anchor Product Specifications

1 GENERAL

1.1 Scope

This Specification sets out the requirements for the supply, installation, grouting, testing and stressing of permanent rock anchors, and includes the drilling and waterproofing of the holes to receive the anchors. This specification also includes proving testing of test anchors which will not form part of the permanent anchor system. It applies to rock anchors which are to be constructed for the Kurnabinna and Grey Gully Swing Bridges Rock Anchor Systems.

The anchor bars is a steel 40mm thread bar or a 15.2mm Permanent Multistrand Anchor each with a corrosion protection PVC sheath.

Unless otherwise stated, it has been assumed in this Specification that the anchor bar free length will be fully encapsulated, and that the Contractor will place the anchor bar in a PVC sheathing before installation of the anchor in the hole. It has also been assumed that grouting will be a single stage operation, with no requirement for secondary grouting of the free length of the anchor bar.

1.2 Reference Design Documents

CMW have generated two (2) design reports that provide details to the quantities and locations of the anchor bar elements for this Project Specification. These reports

- ADL2022-0229AB Rev2 Kurnabinna Revised Load Design dated 15/8/22; and
- ADL2022-0229AC Rev0 Grey Gully Revised Load Design dated 15/8/22.

Innovis Drawings for this project to be referenced are:

- J0439-STR-SKT-0110_ABUTMENT DETAILS Rev D
- J0439-STR-SKT-0111_ABUTMENT DETAILS Rev D
- J0439-STR-SKT-0112_ABUTMENT DETAILS Rev D
- J0439-STR-SKT-0113_ABUTMENT DETAILS Rev D
- J0439-STR-SKT-0114_ABUTMENT DETAILS Rev D
- J0439-CIV-DRG-1065 Rev B
- J0439-CIV-DRG-1066 Rev B
- J0439-CIV-DRG-1067-2 Rev B
- J0439-CIV-DRG-1068-2 Rev B

Moodie Bridge design loads for this Specification to be referenced are:

- 2402B-REACT ION MARKS (002) (002)

The following soil/rock structure interaction of the geotechnical design criteria has been applied to the design:

- The subsurface conditions are assessed under drained condition and lower quartile of bond strength given a grouted element in soil or rock.
- Bored piles for the anchor, portal and landing structures in accordance with AS2159 2009.
- Subsurface parameters for vertical and lateral resistance parameters are as per Bridge code AS5100 2004.
- Pull out resistance as per FHWA/IF/99/05

- Under static loading a Factor of Safety (FOS) of 1.5 is to be achieved at all sites for the global slope prior to loading.
- Under dynamic loading a Factor of Safety (FOS) of 1.1 is present at all sites for the global slope prior to loading. A horizontal seismic loading of 0.05g is to be applied.
- Under static and dynamic loads and a bored pile and spread footing system is required. There has been no separation of the live and dead loads.
- Reinforcement elements are able to be placed only a maximum borehole size of 120mm to a maximum depth of 20m on an inclined angle and 10m on a vertical angle.
- Reinforcement elements to be designed to Tensile Yield strength not Ultimate Tensile strength.
- Reinforcement elements to have a maximum of 9 to 12% elongation of the element during pre-yield force or the manufacturers specifications, whichever is the lowest.
- The analysis of the above ground structure is not included in the above design considerations.

1.3 Definitions

The following definitions shall apply to this Specification:

(a) Principal: City of Marion

(b) Superintendent: (Overall works supervisor appointed by City of Marion).

(c) Anchor bar: That part of an anchor acting as a tension, compression and shear member which is capable of transmitting the tensile compression and shear load from the bond length to the anchor head. The overall length consists of the free length, (where required) and bond length and includes spacers and bands which locate the bars in the anchor holes. Anchor bar refers to threaded bar 40mm and multistrand anchor 15.2mm.

(d) Anchor Head Assembly: That part at the top of an anchor bar which transfers the anchor bar load to the rock, including anchor head, bearing plate, anchor pad (between bearing plate and rock) protective cover and all associated fittings and materials.

(e) Free Length: That length (in metres) of an anchor bar between the anchorage assembly and the bonded length which does not transfer any anchor bar load to the grout or surrounding rock. The free length shall be provided with a sheath to ensure that the anchor bar does not bond with the grout over the free length.

(f) Effective Free Length: The apparent length (in metres) over which the anchor bar is assumed to extend elastically as determined by stressing tests. It is calculated from the load/elastic displacement data following testing, to indicate the length of anchor bar which is apparently fully decoupled from the surrounding grout.

(g) Bond Length: That length (in metres) at the bottom of an anchor bar within which provision is made for the load transfer to the surrounding grout then rock.

(h) Design Working Load: The long-term load (in kN) which is required in the anchor bar.

(i) Lock-off Load: The load (in kN) equal to the design working load plus an allowance for loss of prestress.

(j) Peak Test Load: The maximum load (in kN) to which an anchor bar is subjected in the short term for Proving, Suitability and Acceptance Tests.

(k) Minimum Breaking Load: The minimum breaking load (in kN) of the anchor bar. This is calculated from the minimum strength of the component material as nominated by the supplier and verified by testing.

(l) Accepted Anchor: An anchor that passes being acceptance tested.

(m) Test Anchor: An anchor that is to be tested periodically as per Section 3.1.2.

(n) Residual Load: Load (in kN) remaining in the anchor bar at any time after locking- off, usually measured by a lift-off test.

(o) Lift-off Test: Test to determine the residual load in the anchor bar. Lift-off occurs when an applied load in excess of the residual load causes a very small but perceptible movement of the stressing head, nut or other locking device away from the anchor base plate (usual range of movement 0.2-1.0 mm).

(p) Anchoring Supervisor: Employee of the Contractor approved by the Principal to supervise anchoring work using an accepted post-tensioning system.

(q) Anchoring System Supplier: Supplier of components of an accepted anchoring and post-tensioning system in accordance with the conditions of approval for the system.

(r) Critical Anchoring Activity: An activity which must be supervised by the Anchoring Supervisor.

(s) Water Proofing the Hole: This is the process of full grouting a borehole that has during water found along a section of the borehole. Project specific grout is to be installed by a grout tube pushed to the rear of the hole and grouted from the end of the hole till grout is present at the collar and the grouted continuously as the grout tube is extracted from the hole.

1.4 Rock Anchor Systems

The Contractor shall plan on constructing the number and arrangement of rock anchors shown in the Drawings unless an alternative has been accepted by the Principal.

Where any modifications are necessary to suit a particular construction methodology for an approved anchoring system (for the product anchor type, number and arrangement of rock anchors shown in the Drawings), the Contractor shall submit to the Superintendent, working drawings (to the same scale as the Drawings) of all modifications necessary together with design calculations carried out and certified by a practising Engineer who is experienced in this type of work. All such modifications, calculations and drawings shall be carried out at no cost to the Principal.

1.5 Anchoring Supervisor

Critical Anchoring Activities shall be carried out under the supervision of an Anchoring Supervisor (nominated by the Contractor). The Critical Activities which need to be supervised shall include:

(a) drilling and cleaning of drillholes (refer to Clause 3.4);

(b) water testing and waterproofing of drillholes;

(c) placing of rock anchor components and water testing if required (refer to Clause 3.5);

(d) grouting of rock anchors (refer to Clause 3.6); and

(e) testing and stressing of rock anchors (refer to Clause 3.7).

The Anchoring Supervisor shall certify that the following work conforms to this specification:

(i) information listed to be supplied (refer to Clause 3.3.7);

(ii) manufacture, installation and stressing of test anchors (refer to Clause 3.3, Clause 3.4, Clause 3.5, Clause 3.6 and Clause 3.7);

(iii) the grease proposed for use conforms with the requirements of Table 1 (refer to Clause 3.3.2.6);

(iv) all plastic sheathing proposed for use conforms with the requirements of Table 2 (refer to Clause 3.3.2.7);

(v) assembly of rock anchors including the marking of anchor bars prior to installation and provision of the listed data (refer to Clause 3.3.6);

(vi) submission of conformance records for the manufacture of rock anchors (refer to Clause 3.3.7);

(vii) submission of conformance records for the hole preparation prior to installing an anchor in the hole (refer to Clause 3.6.7); and

(viii) submission of records of the monitoring of each anchor within three days of completion of monitoring (refer to Clause 3.10).

1.6 General Requirements

The required end-product is a set of anchors located and aligned as shown in the Drawings, each anchor having the specified load capacity and the minimum bond length shown in the Drawings, and each having the specified residual load in the anchor bar.

Rock anchors shall incorporate corrosion protection measures that will perform satisfactorily for a minimum expected service life of 50 years.

1.7 Requirements for Assurance of Long-Term Corrosion Protection

Pre-grouting operations (if required) and the final grouting operations shall be carried out so that the anchor remains centralised in the hole, and the annular space between the sheathing and the sides of the hole is filled and remains filled with grout.

Note: The outer annular column of grout surrounding the anchor shall not be relied upon to provide the only long-term corrosion protection for steel bar anchors. Steel anchor bars will be hot dip galvanized in accordance with AS/NZS4680 and, over the free length corrosion protection shall be assumed to be provided additionally by the sheathing.

Care is required during the installation of the anchors on site such that the protective coating on the anchors is not damaged.

Any anchor plates (for the 15.2mm multistrand anchors) that is exposed to the elements (as compared to be being embedded in concrete – 40mm DCP threaded bar) must be galvanised in accordance with AS/NZS4680, with an additional layer of epoxy coating on top of the galvanised layer to achieve long-term corrosion protection.

The material and dimensional properties of the free length sheathing and its method of manufacture, installation and testing shall provide assurance that no cracks occur before or during stressing and that the anchor bar will perform satisfactorily during the specified service life.

The Contractor shall supply documented evidence from the manufacturer to demonstrate that the proposed sheathing complies with the above requirements.

2 ADDITIONAL QUALITY SYSTEM REQUIREMENTS

Refer to Appendix A for the manufacturer's specification of steel reinforcement bars and plates (Dywidag WR DCP Anchor 01 (Double Corrosion Protected (DCP) Permanent Ground Anchor) and Appendix B for Multistrand Anchors. It is understood from discussions that:

- The internal and external grouting of the bar element (within the sheath to the bar) is undertake on site by the Contractor and supervised by the Anchoring Supervisor. As such Quality Control of the bar element will be required. Refer below for these requirements.
- The installation method will be unable to be installed the bar as one length. An alternative is available from the manufacturer that is acceptable to the design. This process includes:
    - The manufacturing of shorter length or bar. Increments of bar lengths can be connected by couplers (in both the bond and free length). These couplers are to be installed as per the manufacturer's specification. Corrosion protection of this join is achieved by applying anticorrosion compound to the bar and coupler and covering the splice with a heat shrink sleeve. For couplers in the free length an additional debonding tube is inserted over the DCP couplers.

Any alternative to the above installation method must be approved by the Contract Superintendent. Noting the alternative design must be derived and also determined to meet the design intent of the project by a suitably qualified engineers.

The information to be submitted to the Superintendent (at least 14 days before the activity commences) by the Contractor as part of its Project Quality Plan shall include, but not be limited to method statements covering the following:

(a) Details of alternatives submitted with the Tender and accepted by the Principal (refer to Clause 3.3.2);

(b) Manufacture, installation and stressing of test anchors (refer to Clause 3.3, Clause 3.4, Clause 3.5, Clause 3.6 and Clause 3.7);

(c) Procedure to demonstrate that each of the proposed suppliers has the specified quality systems in place (refer to Clause 3.3);

(d) Procedure to evaluate suppliers and copies of suppliers' procedures nominated by the Superintendent (refer to Clause 3.3);

(e) Calculations and/or experimental evidence to substantiate the design of the bearing plates or castings (refer to Clause 3.3);

(f) Procedure to demonstrate that all anchor bar materials and anchorage components are identifiable and traceable (refer to Clause 3.3);

(g) Fully detailed technical procedures for assembly of rock anchors (refer to Clause 3.3.6);

(h) Detailed procedures for the fixing of the lower end of the sheathing and of the anchor bar (refer to Clause 3.3.6);

(i) Procedures for preparation of rock anchor holes (refer to Clause 3.4);

(j) Procedures to check that the specified alignment and deviation from straight are being maintained (refer to Clause 3.4);

(k) Procedure for installing rock anchors (refer to Clause 3.5);

(m) Technical procedure for the grouting operation in Clause 3.6. The personnel required to carry out the operations together with proof of any relevant training and experience shall be included;

(n) Technical procedures for the stressing operation in Clause 3.7. The personnel required to carry out the operations together with proof of any relevant training and experience shall be included; and

(o) A copy of the proposed proforma record forms (refer to Clause 3.10).

For each of the above construction operations or activities, sample record sheets which show full conformance of the anchors after final stressing shall be provided.

3 ROCK ANCHORS

3.1 Design Conformance

3.1.1 General

To confirm the basis of design, the following testing must be used:

- Proving test anchors;
- Acceptance testing (including visual confirmation of hole length is achieved); and
- Periodic testing of anchors.

3.1.2 Proving Tests

Two sets of proving test anchors (1x40mm DCP threaded bar and 1x15.2mm multistrand anchors) are to be installed into slightly weathered to fresh, medium strength rock (as per AS1726) at each footing (Portal, Landing and Anchor) for each Swing Bridge abutment (Kurnabinna and Grey Gully).

Refer to Section 3.7.2 for proving test specification.

3.1.3 Acceptance Tests

All anchors installed must be acceptance tested.

Refer to Section 3.7.3 for acceptance test specification.

3.1.4 Periodic test anchors

One (1) set of proving test anchors tested in the first 1 to 25 year period and the second (2) set of proving test anchors tested in the design life period of 26 to 50 years are to be installed between 20m to 30m from each abutment foundation at Kurnabinna and Grey Gully.

A set is to include a steel 40mm thread bar or a 15.2mm Permanent Multistrand Anchor each with a corrosion protection PVC sheath installed as per the manufacturer's specifications.

3.2 Test Anchors

Where test anchors (both proving test anchors and periodic test anchors) are specified, they shall be installed and stressed prior to the drilling of the remaining acceptance anchors represented by the test anchors at each bridge abutment.

The test anchors shall confirm that the lengths and locations of the bond lengths shown in the Drawings will, in conjunction with the specified procedure requirements, produce rock anchors which conform to the specified performance requirements.

Test anchors shall be manufactured, installed and stressed in accordance with this Specification. The stressing procedure requirements and assessment shall be as specified for Proving Tests (Clause 3.7.2).

No test anchor operation shall proceed before the relevant procedures and other relevant documentation from the Quality Plan have been submitted and approved as adequate.

3.3 Manufacture of Rock Anchors

3.3.1 Supply of Materials

Anchor bar and anchorage materials shall be obtained only from suppliers who have implemented quality management systems meeting the requirements of AS/NZS ISO 9001.

Regarding the supply of sheathing, the Contractor shall determine the level of quality system required to ensure that the material complies with the requirements of this Specification.

The Contractor shall provide the Superintendent with evidence which demonstrates that each of the proposed suppliers has the specified quality systems in place, and that the proposed materials comply with the requirements of this Specification.

3.3.2 Material Requirements

3.3.2.1 Anchor Bars

The quality, dimensions and mechanical properties of the anchor bar materials shall be in accordance with AS4672 for steel bars.

Steel anchor bars shall be hot dipped galvanised to AS/NZS 4680, except that the minimum average coating weight shall be 600 g/m2 (85 microns). The galvanised bar shall be made passive by being dipped in a 2% sodium dichromate solution after galvanising to prevent any adverse reactions between the zinc coating and the cement grout.

The Contractor shall submit a certificate, from a laboratory with appropriate NATA registration, which indicates conformance with the relevant standard, for all anchor bar materials supplied.

3.3.2.2 Friction Reducing Sheathing for Anchor Bars

Each anchor bar shall be enclosed in grease filled plastic sheathing of minimum 1 mm thickness over the free length. The grease shall conform with the requirements of Clause 3.2.2.6. The plastic in the sheathing shall conform with the requirements of Clause 3.2.2.7.

The joint between the sheathing and the anchor bar at the bottom of the free length shall be sealed to prevent escape of grease or ingress of grout or bleed water into the sheathing. The sealing system shall ensure that with flexure of the anchor bars on installation that the seal is not broken. PVC tape shall not be used in any part of the cable fabrication or installation.

The sheathing may be extruded on to greased anchor bars by the anchor bar manufacturer or the anchor bar may be inserted into the sheathing on site. The inside diameter of the sheathing shall be the minimum that will allow easy insertion of the anchor bar where applicable. The thickness of the sheathing shall be such that grout pressure exerted on the sheathing is not transferred to the anchor bar with consequent increase in friction.

Where the anchor bar is not supplied greased and pre-coated with sheathing by the manufacturer the grease shall be pre-injected into the sheathing prior to anchor bar insertion to eliminate voids within the sheathing and achieve full greasing of the anchor bar/sheathing system. During insertion of the uncoated anchor bar into the sheathing, all voids shall be completely filled with grease.

3.3.2.3 Anchor Heads and Bolts

Anchor heads shall comply with the requirements of AS 1314.

The anchor head shall possess a centering device so that the anchor bar force is applied uniformly to the contact surface between the anchor head and the bearing plate. The combined anchorage shall be capable of being loaded in stages so that accurate elongation measurements can be taken without indeterminate losses between stages.

3.3.2.4 Anchorage Castings and Bearing Plates

Unless otherwise approved, the steel for anchorage bearing plates shall be Grade 250 to AS 3678 and the bearing stress at the contact surface between the anchor head and the plate shall not exceed 300 MPa.

Bearing plates shall be spike plates with a seating to suit the hemispherical nut which is used to lock off the anchor.

Anchorage castings or bearing plates manufactured from higher strength materials than Grade 250 steel may be used provided supporting calculations and experimental evidence are supplied by the Contractor to demonstrate that an adequate factor of safety exists at the higher stresses involved.

The Contractor shall submit calculations and/or experimental evidence from the supplier of the anchoring system to substantiate the design of the bearing plates or castings.

Bearing plates for anchors applied directly to rock shall be to the size shown in the Drawings. The Superintendent will need to be provided with calculations to confirm adequate thickness and shape to spread the load uniformly to the underlying rock without overstressing either the rock or the anchor pad between the plate and the rock if an alternative bearing plates is to be used.

A suitably located grease nipple shall be incorporated in each plate to enable the grease filled cavity at the top of the anchor bar to be topped up and pressurised in accordance with Clause 3.8.

3.3.2.5 Protective Caps

Protective caps shall be provided as per the manufacturers specifications and to cover each anchor head and protruding unstressed length of anchor bar in accordance with Clause 3.8.

The cap shall provide a watertight seal and shall incorporate a system for complete drainage of and refilling with grease and for visual monitoring of the internal grease level. To allow for physical inspection of the anchor head the complete cap shall be removable. Unless otherwise approved, the cap shall be of steel with a minimum thickness of 7 mm and galvanised to AS/NZS 4680 with an additional coating of epoxy for durability.

3.3.2.6 Grease

Grease for anchor bars with sheathing and for the protection of anchor heads shall be neutral, inert and free from any materials or additives which could promote corrosion or reduce the life of the anchor bars.

The grease shall comply with the requirements of the manufacturer’s specification and Table 1.

The Contractor shall submit a certificate from a suitably accredited testing authority, showing conformance with the requirements of Table 1, for the grease proposed for use.

Table 1 - Properties of Grease

Property	Test Method	Acceptance Criterion
Base number	ASTM D 974 (modified)	0.5 min.
Water content	ASTM D 95	0.1% by mass max.
Chloride ion content	ASTM D 4327	5 ppm by mass max.
Nitrate ion content	ASTM D 4327	5 ppm by mass max.
Sulphide ion content	APHA Part 427	5 ppm by mass max.
Cone penetration	ASTM D 217	175-340 units (1 unit = 0.1mm)
Corrosion prevention (48 hrs at 52°C & 100% relative humidity)	ASTM D 1743	No corrosion is rated 1. Incipient corrosion (no more than 3 spots of visible size) is rated 1. Max. rating = 2.
Oil Separation	ASTM D 1742	3% by mass max.
Evaporation Loss	ASTM D 972	0.5% by mass max.
Flash Point	ASTM D 93	150°C min.
Drop Point	ASTM D 566	60°C min.
Oxidation stability: 100hrs 400hrs 1000hrs	ASTM D 942	Max loss: 70kPa 140kPa 210kPa
Effects of salt spray testing (1mm thick layer 500hrs)	ASTM B 117	No corrosion

3.3.2.7 Plastic

Plastic for sheathing shall comply with the requirements of Table 2.

The Contractor shall submit a certificate, from a suitably accredited testing authority, showing conformance with the requirements of Table 2, for all plastic sheathing.

Table 2 - Properties of Plastic

Property	Test	Unit	Acceptance Criterion (1)		
			PVC	PP	HDPE
Density	BS2782: Part 6 Method 260A	kg/m^3	1350-1400	900-910	950-940
Tensile Strength at yield at 23°C (straining rate 50mm/min)	BS2782: Part 3 Method 320C	MPa	0.45	0.30	0.29
Softening point (Vicat)	BS2782: Part 1 Method 120A	°C	75	150	110
Hardness (Shore D)	BS2782: Part 3 Method 365B	-	65		
Environmental stress cracking resistance	ASTM D 1693	hrs	200 (no cracking)		
Fungal resistance	ASTM G21	-	Rating 1 or less (2)		
Bacterial resistance	ASTM G22	-	No bacterial growth on surface of specimen		
Water absorption at 23°C +/-1°C	ASTM D 570 (Long term immersion)	% increase in weight	Max. 0.5%		
Hydrostatic pressure resistance	BS 6427	-	No localised swelling, leaking or weeping		

Notes:

(1) PVC = polyvinyl chloride; PP = polypropylene; HDPE = high density polyethylene

(2)	Observed traces of fungal growth shall not cover more than 10% of the surface area
(3)	Manufacturers' certificates in respect of all the properties listed in this table shall be presented to show compliance with this Specification.

3.3.3 Testing Requirements

3.3.3.1 Anchor Bar Materials

Each delivery of materials shall be accompanied by documentation showing the lot numbers from which each bar is taken, together with a certificate, from a laboratory with appropriate NATA registration, which indicates conformance with the relevant standards.

In addition, testing of anchor bars shall be carried out in accordance with the testing requirements of AS 4672. The frequency of testing shall be at least one sample per 50m of bar material.

The following information shall be obtained during testing and submitted to the Superintendent:

(a) Breaking force.

(b) Yield strength and elongation.

(c) Load-strain plot.

(d) Cross-sectional area of anchor bar.

3.3.3.2 Anchorage Components

All anchor bar materials and anchorage components including bearing plates and cast in anchorages shall at all times be identifiable and traceable to the relevant lots and to the relevant test reports which shall be available on site. The means for ensuring this shall be incorporated in the Contractor's Inspection and Test Plan.

Where anchor bars are composed of material from more than one batch the identification process shall be maintained until stressing is completed.

Anchor bars of any type that are damaged, kinked or bent, shall not be used. Anchor bars shall be kept free from rust, oil, grease, tar, paint, mud, or any other deleterious substance. Steel which is visibly pitted by rust shall be treated as non-conforming.

Anchor bars shall be individually inspected for superficial tears, nicks, roller marks or any other form of surface imperfection. A bar with surface imperfections that range up to 0.40 mm deep may be accepted provided that imperfections ranging from 0.15 mm to 0.40 mm in depth are filed smooth with a fine-cut half round file. A bar with surface imperfections that exceed 0.40 mm in depth shall be treated as non-conforming.

3.3.4 Handling and Storage on Site

Material for anchor bars whether made up or not, including sheathing and anchorage fittings, shall be stored under a waterproof shelter and supported above the surface of the ground, and shall be protected from damage and from deterioration due to exposure.

3.3.5 Off-Site Assembly

If the Contractor proposes to assemble rock anchors off-site, the Contractor shall not commence assembly operations without having received acceptance to its proposed procedures for both assembly and transport.

No anchor assembly can take place before the results of the anchor proving tests are accepted by the Superintendent and any required anchor re-design is complete and documented.

The transport procedures shall incorporate all necessary measures to prevent damage to the sheathing, grout tubes or sealing devices, or which would in any way reduce the capacity of the anchor to provide the specified performance.

3.3.6 Assembly of Rock Anchors

The Contractor's Quality Plan shall include fully detailed technical procedures for assembly of Rock Anchors, which shall be accompanied by appropriate drawings including all relevant cross-sections, detailing the method of assembly and clearly designating all components of the rock anchors.

Cutting of anchor bar shall be carried out using high speed carborundum disk cutters. The use of flame cutting will not be permitted under any circumstances. Care shall be taken to ensure the electrodes of any electric welding equipment do not arc with the anchor bars. Any anchor bar which has been affected by arcing shall not be used.

The anchor bars shall be arranged and located uniformly over the cross section of the sheathing without twisting. Centralisers shall be provided in the bond length to ensure separation between the individual anchor bars and the drill hole and thus to ensure the effective penetration of grout to provide adequate bond and load transfer between the anchor bars and the grout and between the grout and the hole sides.

The anchor bar assembly shall make suitable provision for grout tubes and centralisers and shall permit the free flow of grout to and around all components providing a complete grout cover. Components shall be so spaced and formed to ensure no pockets of grout, bleed water or air can be trapped inside the anchor bar hole.

Where required an independent feeder tube shall be provided for grouting and this tube shall extend to the bottom of the anchor. The tube shall also be sufficiently robust to ensure that they are not damaged during handling and installation and shall have adequate strength to resist the grouting pressures.

Prior to installation, anchor bars shall be clearly marked with a reference mark at the upper end and the following data shall be provided (to ± 0.05 rn):

(a) Depth of hole in metres

(b) Length from reference mark to commencement of bond length sheathing in metres

(c) Length from reference mark to lower end of bond length sheathing in metres

(d) Length from reference mark to lowest point of anchor bar in metres

(e) Length from reference mark to commencement of zone of termination of grease filled tubing for individual anchor bars in metres

(f) Length from reference mark to lower end of zone of termination of grease filled tubing for individual anchor bars in metres

(g) Length from reference mark to the termination of grout tube

Care shall be taken that anchor bars are not damaged, kinked or bent. Any such anchor bars shall not be used.

3.3.7 Conformance Records

The Contractor shall submit conformance records for the manufacture of rock anchors (including quality control of anchor bar materials and anchorage components) at least three (3) working days before the proposed date to install these anchors.

3.4 Drilling of Rock Anchor Holes

3.4.1 General

When drilling in rock a percussion drill or similar with an air flush shall be used to drill into the rock. Water and other drilling fluids are not permitted. Percussion hammers shall not be used. The tolerance on the hole diameter shall be -0, +10 mm unless otherwise specified.

The minimum grout cover to the anchor bar is to be 40mm for a threaded anchor bar and 30mm for a multistrand anchor.

In the case of anchors penetrating through material other than rock, the Contractor shall give full details of its proposed procedures for supporting this material during drilling, installation and grouting in the Project Quality Plan.

Where the anchors are applied directly to rock, the proposed criteria for a satisfactory rock surface together with the proposed procedures for installing the bearing plate on its pad shall be included in the Project Quality Plan.

3.4.2 Drilling and Cleaning of Drillholes

Drilling and cleaning of drill holes are Critical Anchoring Activities which are required to be carried out under the supervision of an Anchoring Supervisor. Holes for the rock anchors shall be drilled to the minimum diameter shown in the Drawings and shall provide for the minimum grout cover requirements of Clause 3.3.1.

Holes shall be drilled at least to the depths indicated in the Drawings or as directed by the Superintendent. An extra length of 500 mm shall be provided below the bond length, to leave space for the deposition of cuttings that cannot be flushed out of the drill hole.

Holes shall be drilled with a deviation in alignment which shall not exceed 1 in 20. Deviation from straight shall not exceed 20 mm in any 3 m length of hole. The entry point of every hole shall be positioned within a tolerance of ± 75 mm.

The Contractor shall include in its procedures the measures he proposes to check that the specified alignment and deviation from straight are being maintained.

In ground likely to collapse, the sides of the drillhole shall be supported by suitable lining tubes until supported by the grout.

Drillholes shall be cleaned of all deleterious material on completion of drilling (or reaming where waterproofing is required) and the opening sealed to prevent the entry of foreign matter. Cleaning shall generally be carried out using an air flush, so as to ensure removal of all drill cuttings from the walls and bottom of the drillholes. The Contractor shall submit details of its cleaning methods and tools to suit variations in subsurface conditions.

3.4.3 Stability of the Rock Anchor Hole

Where a rock anchor hole collapses or is deemed unable to be redrilled or cleaned out by the drill operator, the details of the borehole are to be recorded by the Anchoring Supervisor and provided to the Superintendent. These details are to include the items in Section 3.4.

This hole is to be filled with grout and the location demarked.

An alternative hole will be required to be bored and reinforcement installed. The Superintendent is to seek advice from an appropriately qualified Geotechnical Engineer to ensure the design intent of the structure is met.

3.5 Installation of Rock Anchors

3.5.1 General

Placing of rock anchor components are Critical Anchoring Activities which are required to be carried out under the supervision of an Anchoring Supervisor.

The Contractor shall give at least one working day notice of its intention to commence installation and its proposed procedures shall be submitted as part of the Project Quality Plan.

3.5.2 Installation Procedure Requirements

Each drill hole shall be kept sealed until the anchor is ready to be installed and preparations have been completed for grouting the anchor as soon as it has been installed.

Immediately prior to installing the anchor, the walls and bottom of the hole into which it is to be installed shall be cleaned of all deleterious materials or accumulations which would impair the effectiveness of the anchor or protection of the anchor bars. This shall be accomplished in accordance with Clause 5.2. Following cleaning, the hole shall be gauged to confirm that it is unobstructed for the full depth and to the full diameter.

Anchors shall be installed and grouted on the same day as the drilling of the anchor hole.

During installation the curvature of the anchor shall be controlled to prevent kinking or crumpling of the sheathing.

During and after installation the anchor shall be held at such a level and in such a manner that neither the anchor bar nor the sheathing is subjected to compressive forces or localised lateral displacements from the required centralised position in the hole.

Effective measures shall be taken immediately after the anchor is placed to protect the hole from being infiltrated by any materials, including waste grout from other anchors, which would adversely affect the subsequent grouting operation.

3.6 Grouting of Rock Anchors

3.6.1 General

Grouting of rock anchors is a Critical Anchoring Activity which is required to be carried out under the supervision of an Anchoring Supervisor.

No anchor shall be grouted until full conformance records for the hole and the anchor have been made available to the Superintendent.

Grouting of rock anchors shall commence within 3 hours of cleaning the hole in accordance with Clause 3.5. Where this period is likely to be exceeded the anchor shall be removed from the hole and the operations in Clause 6 repeated, unless otherwise approved by the Superintendent.

The Anchoring Supervisor shall also inspect the rock anchor assemblies prior to installation and verify that grouting tubes have been correctly installed.

3.6.2 Grout Materials and Mix Design

Cement used for grouting anchors shall comply with AS 3972.

Only fresh cement, free from lumps, shall be used. Adequate stocks of cement shall be held at the mixers to ensure no interruptions to the continuity of grouting operations.

The grout mix shall be designed to achieve a minimum of 30 MPa at 7 days. The grout shall comprise water and cement in a ratio (by weight) of not more than 0.45.

Bleeding shall not exceed 2% of the volume at 90 minutes after mixing when measured at 20°C in a covered cylinder of 100 mm internal diameter and with a grout depth of 300 mm. Also, bleeding shall not exceed 4% of the volume at any time. In addition, the separated water must be reabsorbed within 24 hours.

Additives shall not be used unless the Contractor can demonstrate that the additive will not be deleterious to the properties of the grout or any other anchor components.

Water used in grout shall be clean and free from oil, acid, alkali, organic or vegetable matter and from any ingredients harmful to steel or cement grout. Water shall not contain more than 500 mg/l of chloride ions. Water temperatures measured at the mixer shall not be less than 5°C nor more than 27°C.

3.6.3 Testing of Grout

Representative test specimens shall be pairs of 50 mm diameter by 100 mm long cylinders prepared and cured in accordance with AS1012.8 but stored in a NATA proved testing authority under standard curing conditions of 23°C and 100% relative humidity for a period of 7 days. Grout tests shall be submitted to the NATA approved laboratory within the day of sampled and tested as per this specification.

During production, at least one pair of cylinders shall be taken from each rock anchor.

Grout cylinders shall be tested in accordance with AS1012.9 except that end preparation shall comprise saw-cutting and grinding each end to produce smooth parallel end surfaces. Conformance of the lot shall be met when the grout cylinders achieve the minimum compressive strength specified in Clause 3.5.2.

3.6.4 Grout Mixing

Batching into mixers shall be carried out by measuring the water by volume and using whole bags of cement. Any additives shall be premeasured into individual doses per batch.

The grout shall be mixed in a high-speed mixer (minimum 1000 rpm) capable of imparting a high shear to the grout components so that a colloidal grout of uniform consistency is produced in a mixing time of less than five minutes.

The grout mixing process shall utilise a recirculating system where the grout is continuously discharged and recharged into the mixing unit during the mixing period. After mixing, the grout shall be kept continuously agitated. The grout shall be passed through a nominal 1.2 mm sieve prior to injection. The grout shall be used as soon as possible after mixing and in any case within 30 minutes of adding cement.

3.6.5 Grout Pumping Equipment

Grout pumps shall be efficient and capable of running continuously for the duration of grouting of each anchor bar. They shall be capable of pumping the grout specified at a rate appropriate to the complete the grout in the holes as set out in the method statement.

Grouting shall be carried out by use of supply lines directly connecting the pumps to the down-hole tubes.

Grout fittings shall be appropriately located to control the injection of grout to the down-hole tubes. Fittings at the tops of holes shall include a valve discharging to waste and a pressure gauge. Pressure gauges shall be maintained in calibration.

3.6.6 Grouting Procedure Requirements

Prior to the commencement of grouting, the Contractor shall determine the volumes of the over drill core and outer annulus over the full length of the anchor, as a basis for control of volumes and rates of grout injected.

Prior to grouting, the grout tubes shall be checked individually to ensure that they have not been compressed or blocked.

Grouting shall proceed by injection through the feeder tube to the bottom of the anchor bar. Grouting shall be continuous until all the ground water is displaced from the hole and the emerging grout is the same consistency as the grout entering the feeder tube.

Once the emerging grout has reached the specified consistency, observation shall be continued by an experienced operator, and the grout discharge shall be allowed to continue until there is no reasonable doubt that all zones of low quality grout have been displaced.

The grout which has over-flowed from the hole shall be discarded to waste and disposed of. The anchor shall be supported for a minimum of 24 hours following completion of grouting.

Within 30 minutes of completion of grouting the top of the grout column shall be flushed out to sufficient depth so that at the upper end of the free length the anchor bars can accommodate the anchor head.

3.6.7 Conformance Records

Prior to stressing of anchors, the Contractor shall submit conformance records for grouting of rock anchors.

Where a non-conformance occurs, the Superintendent is to be informed in writing within 24 hours of being identified by the Contractor. The Superintendent is to seek advice from an appropriately qualified Geotechnical Engineer to ensure the design intent of the structure is met before approving works to proceed.

3.7 Stressing and Testing of Rock Anchors

3.7.1 General

The test procedure will be in accordance with BS8081 & EN1537:2000.

3.7.2 Proving Test Anchors

One destructive proving test adjacent to each potential large structural failure as identified in Section 3.1.2 should be undertaken to no greater than 80% of the characteristic tensile strength of the anchor bar or to grout/rock bond failure, whichever comes first.

The locations of the test anchors will be determined on site by the Superintendent. They shall be a minimum of 3m from each Bridge structural foundation site and be drilled and installed at each site of a portal, landing and anchor for each bridge abutment.

3.7.3 Acceptance Testing of Anchors

3.7.3.1 General

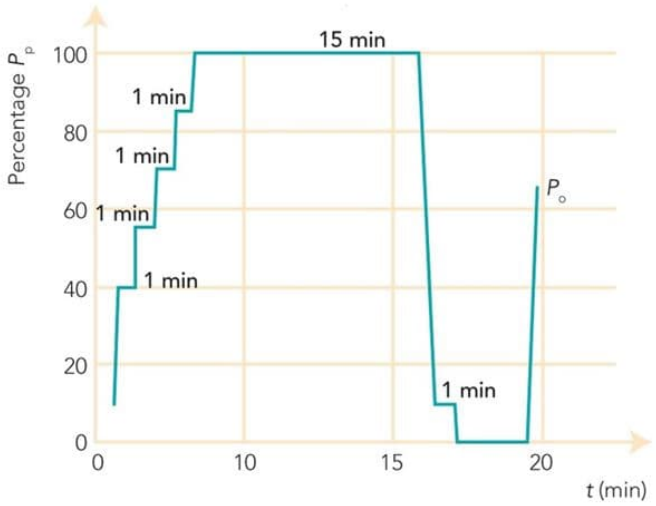
All anchors installed shall be acceptance tested as outlined herein. Each ground anchor bar is tested after installation and prior to being put into service to tensile loads that exceed the design load. This load testing methodology, combined with specific acceptance criteria is used to verify that the ground anchor can carry the design load without excessive deformations.

3.7.3.2 Method:

Following a period of 7 days after installation of the reinforcement bar and grout placement. All grouted anchor bars are pull tested using a jack. This testing will require the cap to be removed from the bar.

This test must be undertaken by a suitable trained person and the results assessed and certified by a structural engineer. Testing of the anchors bars should be undertaken in accordance with BS8081 & EN1537:2000, Section 9.7 & Annex E.

An example of the pull testing process is provided in Picture 1. In this example the anchor bar is loaded stepwise by load cycles increasing from the datum load to the proof load. At each load step, the displacement of the tendon end is measured during a fixed time period.



Picture 1. Example loading sequence for acceptance test in fine soil

This design requires the same load cycles steps but each load step to be held until there is a stable measurement in the displacement of the bar over a 5-minute period. Only once this stable movement is achieved can a next loading stage be undertaken. At the peak test load the load must be held for a minimum of 1 hour.

All bars must be tested to this process to the Peak Test Load.

Peak Test Load: The maximum load 500kN to which an anchor bar is subjected in the short term as an Acceptance Tests. With a maximum of 0.2 to 1% elongation of the free length steel element. This load test allows for a method of Acceptance Testing of all anchors.

3.7.3.3 Control of Stressing Operations

Stressing operations shall be performed only by personnel with proven training and experience in this type of work.

During stressing, the tensioning force shall be applied smoothly and at an even rate and the jacking force shall be released gradually.

The anchors shall be stressed in the order indicated in the Drawings or as directed by the Superintendent, and the operation completed without interruption in as short a time as possible.

The true tensioning force shall be determined from the jack calibration curve and checked using a load cell, making allowances as per supplier's recommendations for friction losses in the anchorages.

Under no circumstances shall the maximum jacking force exceed 85% of the specified minimum breaking load of the anchor bar, or the rated capacity of the jacking equipment used, whichever is the lesser.

3.7.3.4 Commencement of Stressing Operations

Stressing of rock anchors is a Critical Anchoring Activity which is required to be carried out under the supervision of an Anchoring Supervisor.

Anchors shall not be stressed until the grout surrounding the anchor has attained an age of seven days and the average compressive strength of the grout in the hole has reached 30 MPa as proved by test results.

No anchor shall be stressed until full conformance records for the grouted anchor have been made available to the Superintendent.

The Contractor shall, for each anchor, give the Superintendent at least one day's notice of its intention to stress.

3.7.3.5 Stressing Procedure

(a) An initial load shall be selected so that the anchor stressing assembly is perpendicular to the stressing plate.

(b) A datum shall be established to measure anchor elongation and anchor plate settlement. The movement of this datum under the influence of anchor stressing shall not exceed 0.5% of the calculated anchor extension.

3.7.3.6 Safety Precautions

Care shall be taken during tensioning to ensure the safety of all personnel engaged on the work and of other persons in the vicinity. Jacks shall be secured in such a manner that they will be restrained should they lose their grip on the anchor bars. No person shall be allowed to stand behind the jacks while tensioning is in progress. The operation of the jacks, the measurement of the elongation, and associated operations shall be carried out in such a manner and from such positions that the safety of all concerned is ensured.

3.7.3.7 Stressing Equipment

Stressing equipment shall be capable of tensioning the complete anchor bar to more than 80% of its minimum breaking load in one stroke.

The design of the jacking system shall be such as to allow the required measurements to be taken to the accuracy stated in this Clause.

A jack stool shall be used to enable the anchor to be tightened while the anchor bar is under tension.

The pump unit shall be equipped with a site-regulated pressure overload relief valve to prevent anchor bar damage by over tensioning. All flexible connections between the pump and the jack shall have a burst pressure of at least twice the maximum pump pressure rating.

Pressure gauges shall be concentric scale gauges complying with the requirements of AS 1349 and shall not be less than 150 mm in nominal diameter.

Pressure gauges shall be fitted with a snubber or similar device to protect the gauge against sudden release of pressure. When required for audit purposes a master gauge shall be made available for

checking the accuracy of working gauges. Provision shall be made for the attachment of a second working gauge to be used for audit purposes.

In addition to jack pressure gauges, a load cell shall be used within the jacking assembly to accurately measure the jacking force.

All sets of load cells, jacks, pumps and pressure gauges shall be accompanied by currently valid calibration certificates. Calibration of all equipment shall be carried out in a NATA registered laboratory. The equipment calibration certificates shall comply with the following requirements:

(a) Stressing Jacks, Pumps and Pressure Gauges.

The calibration certificates for each stressing unit consisting of a stressing jack, pump and pressure gauge(s) shall have been issued within the preceding six months. More than one pressure gauge may be calibrated as part of a unit with a stressing jack and pump, with each pressure gauge being a separate calibration.

Each certificate shall be accompanied by the related calibration curve and tabulated record of hydraulic pressure against jack load. The calibration shall be performed for the loading and unloading operations of the jack over its full working range.

In addition to the above requirements, any pressure gauge shall not be used for more than fifty stressing operations before recalibration as part of the stressing jack, pump and pressure gauge unit.

Where complementary gauges are mounted in parallel and no significant variation between them is observed, the time and number of operation requirements may be extended to double those stated.

Where a gauge has sustained hydraulic or other shock it shall be replaced immediately by another gauge calibrated in accordance with the above requirements.

(b) Load Cells.

The calibration certificates shall have been issued within the last 50 stressing operations for which the device was used or within 28 days, whichever is less. If the cells are electrical, the calibration tests shall be conducted using the connecting cables that will be used on site.

(c) Dial Gauges

The calibration certificates shall have been issued within the preceding 12 months. The gauge shall be inspected prior to the start of each stressing operation and if found to be defective, it shall be replaced immediately by another gauge calibrated in accordance with the above.

(d) Flowmeters and Pressure Gauges Used During Grouting.

The calibration certificates shall have been issued within the last 100 operations for which the device was used or within the last 60 days, whichever is less. When the gauge has sustained hydraulic or other shock, it shall be replaced immediately by another gauge.

3.7.3.8 Installation of Anchorage Bearing Plates

The bearing plate shall be designed to eliminate any contact between the plate and anchor bar and shall, together with the anchor head, be located concentrically with the axis of the anchor bar and the formed hole.

The anchor nut or anchor wedge restraining/holding the bearing plate in position is to be placed and tensioned to the manufacturer's specifications.

Where the bearing plate has been previously cast in concrete, any misalignment of the plate shall be compensated for prior to stressing.

3.7.4 Measurement of Anchor Bar Load and Elongation

Actual movements of the anchor head and the base plate relative to a datum shall be measured with instruments which have an accuracy of ± 0.1mm. Forces in the anchor bar shall be measured with instruments which have an accuracy of ± 2% of the anchor breaking force.

Anchor bar extensions shall be measured from a datum point unaffected by stressing operations in order to exclude the effects of relative movement between anchor bar components, both during jacking and after lock-off.

Where loads are to be held constant for nominated periods, extensions shall be recorded at the beginning and end of those periods.

All loads and extensions shall be recorded and plotted as a load versus extension curve.

3.7.5 Prestressing Anchor Bars

Following the Acceptance Testing of all anchor bar prestress the bar to a Lock-off Load or Residual Load. This load (in kN) is the required prestress plus an allowance for loss of prestress (i.e. 100kN plus 10% loss of prestress, a 110kN load per anchor bar.

Where required, following prestressing the anchor bar is required to be regreased (with an anti-corrosion compound) and a cap placed on all anchors to the manufacturers specifications.

3.7.6 Conformance Records

The Contractor shall provide the Superintendent with conformance records including record forms and plots, for each stressed anchor within seven (7) days of completion of the stressing operations.

3.8 Cutting Off Anchor Bars

No anchor bars shall be cut off until a full set of conformance records for the rock anchors has been made available to the Superintendent for audit and review.

Specific anchors (as per drawings) shall not be cut off but left as anchors which can be check loaded in the future. The Superintendent will decide the location of these specific anchors which anchors are not to be cut off.

After the submission of full conformance records, the Contractor shall give at least three (3) working days' notice of the proposed date for cutting off or capping the unstressed anchor bar ends.

The Contractor shall trim excess anchor bar protruding above the anchorage assembly to a length compatible with monitoring, restressing and destressing requirements.

Cutting off of stressed anchor bars shall be by a high speed abrasive disc or wheel.

Where steel is cut, corrosion treatments must be applied. Refer to Section 3.3.2.1 for corrosion treatments.

3.9 Protection of Anchor Heads

Where it is required that long term provision be made for monitoring, restressing and destressing of a rock anchor bar it shall be provided with a protective cap complying with Clause 4.2.5.

All anchor bars, before trimming and installation of caps, shall be covered with grease, complying with Clause 4.2.6 and adequately protected against corrosion and against damage.

The Contractor shall install caps and apply the corrosion protection system to the anchorage assembly. The Contractor shall ensure that the space between the bearing plate and top of the grout inside the anchor bar hole as well as the space under the protective caps is completely filled with the protective grease.

All works to be undertaken to the manufacturer's specifications.

3.10 Anchor Construction Records

Prototype record forms shall be submitted with the relevant technical procedures prior to the commencement of anchor and mesh installation. The data to be recorded during construction shall include the following:-

(a) Rock anchor No.

(b) Rock anchor type (type, number and size of anchor bars, etc) and nominal minimum breaking load.

(c) Design working load, lock-off load and test load (actual values and as % of minimum breaking load).

(d) Nominal bond length and free length of anchor bar.

(e) Grout mix details, estimated rock/grout bond stress at minimum breaking load.

(f) Location, diameter of hole and total drilling depth (depth in overburden and depth in rock also recorded separately).

(g) Times at start and finish of drilling.

(h) Times at start and finish of water-testing.

(i) Whether water-proofing was necessary.

(j) Time of installation of rock anchor.

(k) Times and details of any interruption to grouting.

(l) Times at start and finish of grouting.

(m) Time of adding aluminium powder to cement and water.

(n) Age of grout at stressing and 7 day grout strength.

(o) Average grout injection pressure.

(p) Volume of grout injected.

(q) Batch No(s) from which anchor bar was cut, together with estimated breaking load and elastic modulus.

(r) Stressing records, to include:

  (i) Identification number of jacks, gauges and pumps.

  (ii) Initial force (or pressure).

  (iii) Final force (or pressure).

  (iv) Elongation remaining after release of jacks.

  (v) Effective free length.

  (vi) Graph showing elongation versus force for the cyclic loading required.

  (vii) Lift-off test results.

(s) Details of cutting off of anchor bars and installation of anchor head protection.

(t) Details of any unusual events relating to the drilling and installation of the rock anchor.

(u) Details of any unusual events relating to stressing.

(v) Monitoring records (if applicable), to include:

(i) Identification number of anchor, type, ultimate capacity, test load, design working load, lock-off load and residual load immediately after locking-off.

(ii) Identification number and calibration reference of jacks, gauges, pumps and load cells.

A set of fully completed records shall be supplied to the Superintendent for the use of the Principal, within one month of stressing having been completed.

3.11 Periodic Testing Anchor Bars

Following the peak test load, lift off testing and prestressing is required for all anchors. This testing is to be undertaken at the period of 12 months following peak test load, and every 5 years thereafter throughout the design life of 50 years.

At the specified anchor testing locations, this periodic test will require the bar cap to be removed from each anchor bar. This test must be undertaken by a suitable trained person and the results assessed and certified by a structural engineer.

Lift-off Test: Test to determine the residual load in the anchor bar and is the maximum load 500kN to which an anchor bar is subjected in the long term as an Acceptance Tests. With a maximum of 0.2 to 1% elongation of the free length steel element.

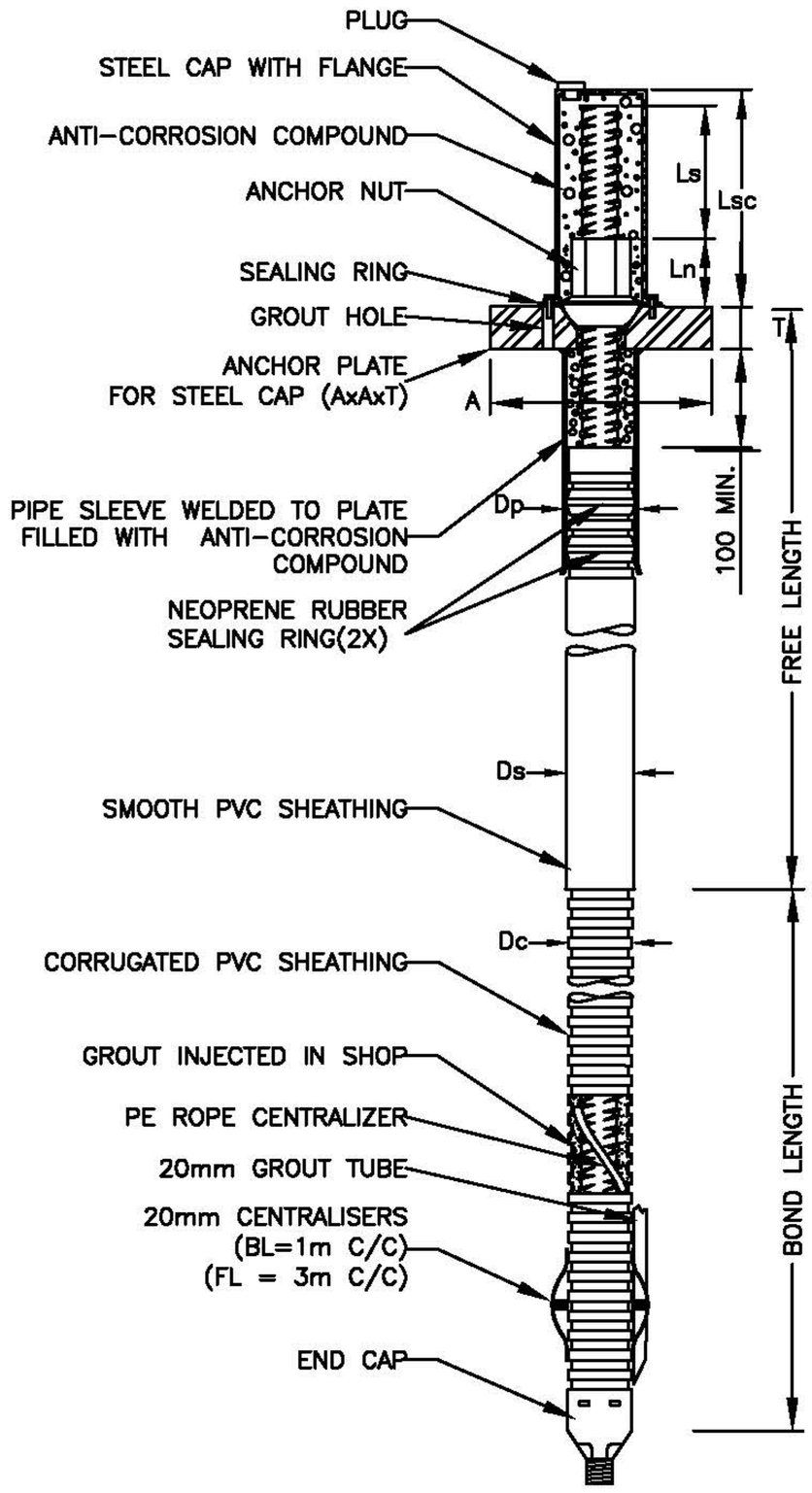
Following lift off testing of the bar, prestress the bar to a Lock-off Load or Residual Load. This load (in kN) is the required prestress plus an allowance for loss of prestress (i.e. 100kN plus 10% loss of prestress, a 100kN load per anchor bar.

Following prestressing the anchor bar is required to be regreased (with an anti-corrosion compound) and a cap placed on all anchors.

All engineers' reports are to be submitted to Contract Superintendent and City of Marion Council for verification that the foundation is meeting the design intent. It is highly recommended a suitably qualified geotechnical engineer support the City of Marion Council when reviewing these results.

Appendix A: Threaded Bar Double Coupled Protected 40mm Bar Product Specifications

No.	REVISION	DATE	ECN
A	Update Document	27/3/15	024
B	Add 57, 65 & 75mm Details	11/11/20	



ANCHOR–DETAILS

Physical Properties

Grade	(Mpa)	WR (950 / 1050)					E (835 / 1035)		
Diameter	(mm)	26.5	32	36	40	47	57	65	75
Ultimate	(kN)	579	844	1069	1319	1820	2671	3447	4572
Yield	(kN)	524	764	967	1194	1652	2155	2780	3690
Area	(mm2)	552	804	1018	1257	1735	2581	3331	4418

Dimensions (mm)

Bar Diameter		26.5	32	36	40	47	57	65	75
Bearing plate	A x T	180x40	20x45	220x50	240x55	260x50	330x70	370x75	420x85
Pipe OD	Dp	64	70	76	76	114	127	127	168.3
Nut Length	Ln	60	72	75	83	105	120*	130*	145*
Stressing Length	Ls	90	100	110	130	135	120	130	145
Capped Length	Lsc	210	210	210	240	280	280	280	280
Smooth Sheat OD	Ds	58	63	73	76	85	110	110	125
Corrugated Sheath OD	Dc	50	56	65	65	80	100	100	114

* Hex Nut

CHARACTERISTICS

1) POST–TENSIONING TENDONS ARE DSI THREADBAR, DOUBLE CORROSION PROTECTED SYSTEM, SHOP ASSEMBLED AND GROUTED.
2) THREADBARS ARE PROOF STRESSED AND STRESS RELEIVED.
3) SHOP GROUT: CEMENTITIOUS NEAT LEAN GROUT W/O AGGREGATES, MAXIMUM WATER CEMENT RATIO=0.36 (BY WEIGHT), CEMENT: GENERAL PURPOSE TYPE GP ADDITIVE: VISCOCRETE 10, 0.25% (BY WEIGHT).
4) DURING TENSIONING, DRAW IN AT NUT=1mm & COUPLER SLIP=1.5mm.

INSTALLATION PROCEDURE

1) DRILL HOLE; GROUT AND RE–DRILL IF REQUIRED.
2) ASSEMBLE PRE–GROUTED BARS WITH PLATES, NUTS, GROUT TUBES, CENTRALISERS AND COUPLERS (IF APPLICABLE) AND INSERT ANCHOR IN HOLE.
3) TREMIE GROUT ALONG ENTIRE ANCHOR LENGTH.
4) ONCE GROUT REACHES REQUIRED STRENGTH, TEST ACCORDING TO SPECIFICATIONS.
5) INSTALL PROTECTIVE CAPS (IF REQUIRED).

CAUTION

DO NOT WELD TO BAR
DO NOT USE BAR AS GROUND FOR WELDING
DO NOT ALLOW HOT SLAG OR SPARKS TO TOUCH BAR
DO NOT DAMAGE BAR SURFACE
DO NOT USE BARS WITH KINKS OR SHARP BENDS
FAILURE TO HEED THIS WARNING COULD CAUSE BAR TO BREAK RESULTING IN INJURY OR DAMAGE.

WARNING

AT NO TIME DURING STRESSING AND REMOVAL OF THE JACK, SHALL PERSONS STAND IN LINE WITH THE TENDONS OR BEND OVER ALREADY STRESSED TENDONS.

DYWIDAG-Systems International Construction P/L
ABN: 23 630 281 615
PO Box 2034
Gateshead, NSW, 2290
Ph: +61 2 4081 5501
www.dsicivil.com.au
Office Address:
24 Groves Road,
Bennetts Green, NSW, 2290
Australia
DYWIDAG
civil.sales@dywidag-systems.com.au

PROJECT	A4	PRODUCT CODE	DATE JUL '10	DRAWN	MV
			SCALE NTS	CHECKED AUTH	SD
DESCRIPTION DOUBLE CORROSION PROTECTED (DCP) PERMANENT GROUND ANCHOR SYSTEM		DWG No. WR DCP Anchor 01		REV. B	

24 Groves Rd, Bennetts Green,
NSW, Australia, 2295
Tel.: 02 4947 5527
www.dsicivil.com.au

The DSI THREADBAR is a steel bar with continuous coarse threads hot rolled on two opposite sides. The continuous threads allow for anchorage and coupler installation anywhere along the bar. The coarse threads provide excellent bond to grout and are insensitive to dirt and damage. In addition, there is no loss of strength due to thread cutting.

Post-Tensioning Threadbar: WR & E Grade

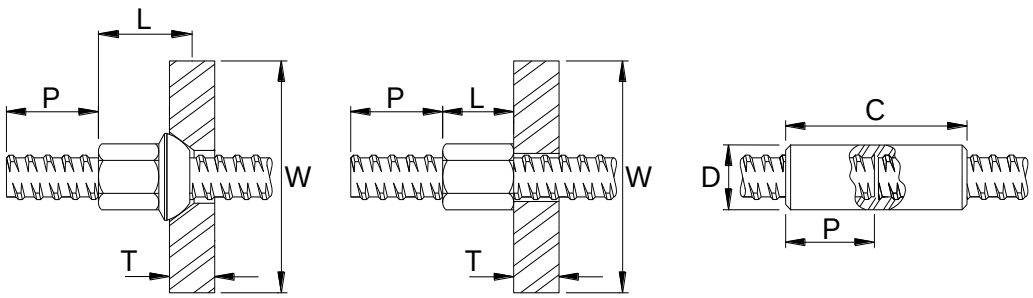
Designation		WR	WR	WR	WR	WR	E	E	E
Minimum Ultimate Grade (MPa)		1050	1050	1050	1050	1050	1035	1035	1035
Minimum Yield Grade (MPa)		950	950	950	950	950	835	835	835
Nominal Diameter (mm)		26.5	32	36	40	47	57	65	75
Minimum Breaking Load (kN)		579	844	1069	1319	1820	2671	3447	4572
Minimum Yield Load (kN)		524	764	967	1194	1650	2155	2780	3690
Cross-section Area (mm^2)		552	804	1018	1257	1735	2581	3331	4418
Maximum Thread Diameter (mm)		30.5	36.3	41.4	45.3	53	64	72	82
Unit Weight (kg/m)		4.48	6.53	8.27	10.21	14.10	20.95	27.10	35.90
Minimum Bar Protrusion: $P_{1)}$ (mm)		85	100	105	125	135	120	130	145
Dome Nut p/n: D 2001	L (mm)	75	90	100	115	135	-	-	-
	$A/F_{2)}$ (mm)	50	60	65	70	80	-	-	-
Hex Nut p/n: WR 2002	L (mm)	80	90	110	120	140	120	130	145
	$A/F_{2)}$ (mm)	46	55	60	70	80	90	100	105
Coupler p/n: D 3003	C (mm)	170	200	210	250	270	240	260	290
	D (mm)	55	65	72	71	83	95	105	114
Typical Plate	W (mm)	180	200	220	240	260	330	370	420
	T (mm)	40	45	50	55	50	70	75	85

Typical applications: Prestressed soil and rock anchors, concrete prestressing, tie-rods, tie-downs and rock bolting.

Specifications: Threads are right hand. Threadbars are proof stressed to 80% of their ultimate strength and stress relieved at the mill.

Notes

1) Minimum Threadbar protrusion to accommodate tensioning or coupling; P=½C (mm).
2) Width measured across flats of nut.
3) Other hardware available not shown.
4) Corrosion protection available: pre-grouting in sheathing (DCP), hot dipped galvanising or thermal diffusion galvanising & epoxy coating.
5) Hot dip galvanziing of high tensile steels could induce hydrogen embrittlement, which can directly affect the capacity of the Threadbar.



DYWIDAG-SYSTEMS INTERNATIONAL

THREADBAR Anchors



Contents

THREADBAR Anchors
THREADBAR Anchor System **4**
Design Considerations **5**
THREADBAR System for Bar Anchors **6**
THREADBAR Anchors with Double Corrosion Protection (DCP) **7**
THREADBAR Anchor Properties and Dimensions **8**
GEWI® Threadbar Anchor Properties and Dimensions **9**
THREADBAR Anchor Hardware & Tensioning Equipment **10**
On-site Assembly and Installation Instructions for DCP Threadbar Anchors **11**



THREADBAR Anchor System

General Notes
Today, DSI is a world leader in the development of bar anchor systems and technology. The Double Corrosion Protected (DCP) THREADBAR anchor is universally recognised as the "standard" for anchor performance and corrosion protection.

As a full service organisation, DSI is prepared to supply design assistance and practical field know-how. This service can also be used to optimise the design process, by helping to select the anchor system best suited to meet specific project requirements.
To minimise site labour and to optimise quality control, a variety of shop prefabricating services are available for THREADBAR anchors.

Advantages
Simple and Rugged
The THREADBAR has a continuous coarse thread hot-rolled on two opposite sides which allows anchorage hardware or couplers to thread onto the bar at any point. The coarse thread is almost indestructible under normal job site conditions and insensitive to dirt. In addition, there is no loss of strength due to thread cutting. Every bar is proof stressed to its yield and stress relieved at the mill to improve their relaxation & fatigue characteristics.

Positive Anchorage
The bar is anchored using a threaded nut, which, unlike a wedge type anchorage, is not liable to slip when the anchor force is reduced due to possible ground movements.

Easy to Splice
The continuous thread makes it possible to extend the THREADBAR to any length, simplifying transportation and installation. Extending the bar beyond the stressing end to connect to another structural member is also a simple operation.

High Bond Strength
The coarse continuous thread provides excellent bond between the bar and cement grout, making it possible for a reliable transfer from the anchor prestress load into the grout without the need for additional mechanical devices. The narrow spacing of the thread assures close crack spacing in the surrounding grout and therefore the smaller crack width further supports the corrosion protection.

Easy to Stress
The reliable threaded nut anchorage has almost no anchor set. Its hemispherical shape easily accommodates the small angular misalignments between bar and anchorage due to construction tolerances. Lightweight, durable equipment makes stressing, re-stressing and adjusting the anchor load up or down easy to do.

Easy to Check Actual Prestress Load & Restress
The threaded design makes it possible to make a lift off test/or adjust the anchor load at any time during the service life of the anchor. Corrosion protection can be maintained at all times.

Removable
The THREADBAR can be removed after de-stressing the anchor by unscrewing the unbonded portion of the bar from a coupler or out of an embedded end anchorage. Bars with end anchors and sleeved within the bond length can be completely removed. This is especially important where temporary anchors are installed below adjacent properties and must be removed after use.

Unprotected Anchors
Unprotected anchors are used for temporary applications. The free stressing length is debonded while the bond length is embedded in the cement grout body.

Corrosion Protection Options
For permanent applications, a wide variety of corrosion protection options are available to choose from depending upon the expected length of service and the aggressiveness of the environment.

Insurance Against Anchor Failure
In cohesive and other poor soils, a proven and reliable DSI Post-grouting System can be used to increase the capacity of an anchor.

Design Considerations

Prestressed bar anchors have become an important tool for geotechnical engineers. Their safe and reliable use in both permanent and temporary applications is accepted throughout the world.

Soil Anchors are post-tensioned-tendons installed in either cohesive or non-cohesive soil or loose rock. In the bond length, the anchors transfer forces into the ground by means of a steel tendon and a well defined grout body. In the free stressing length the anchor remains unbonded and free to move during tensioning.

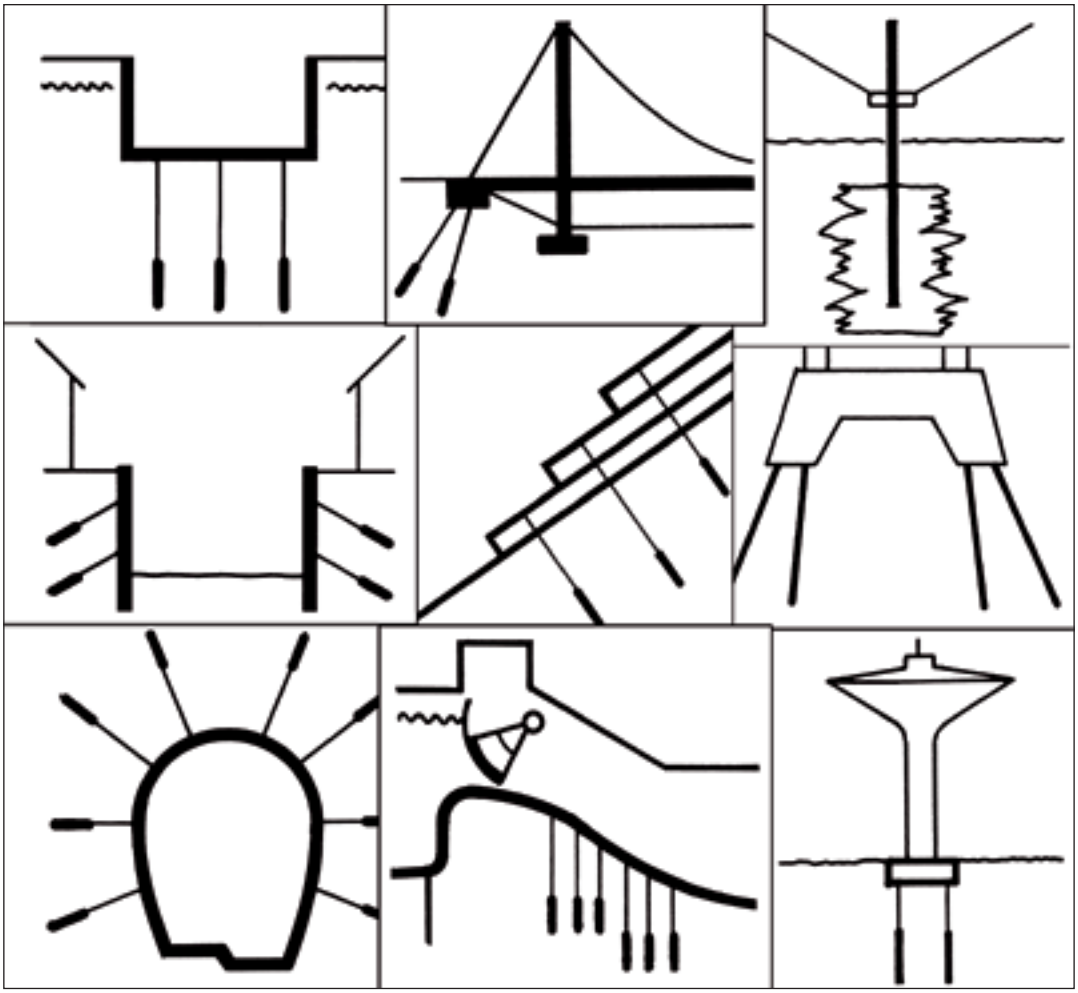
Soil anchors are generally used to:

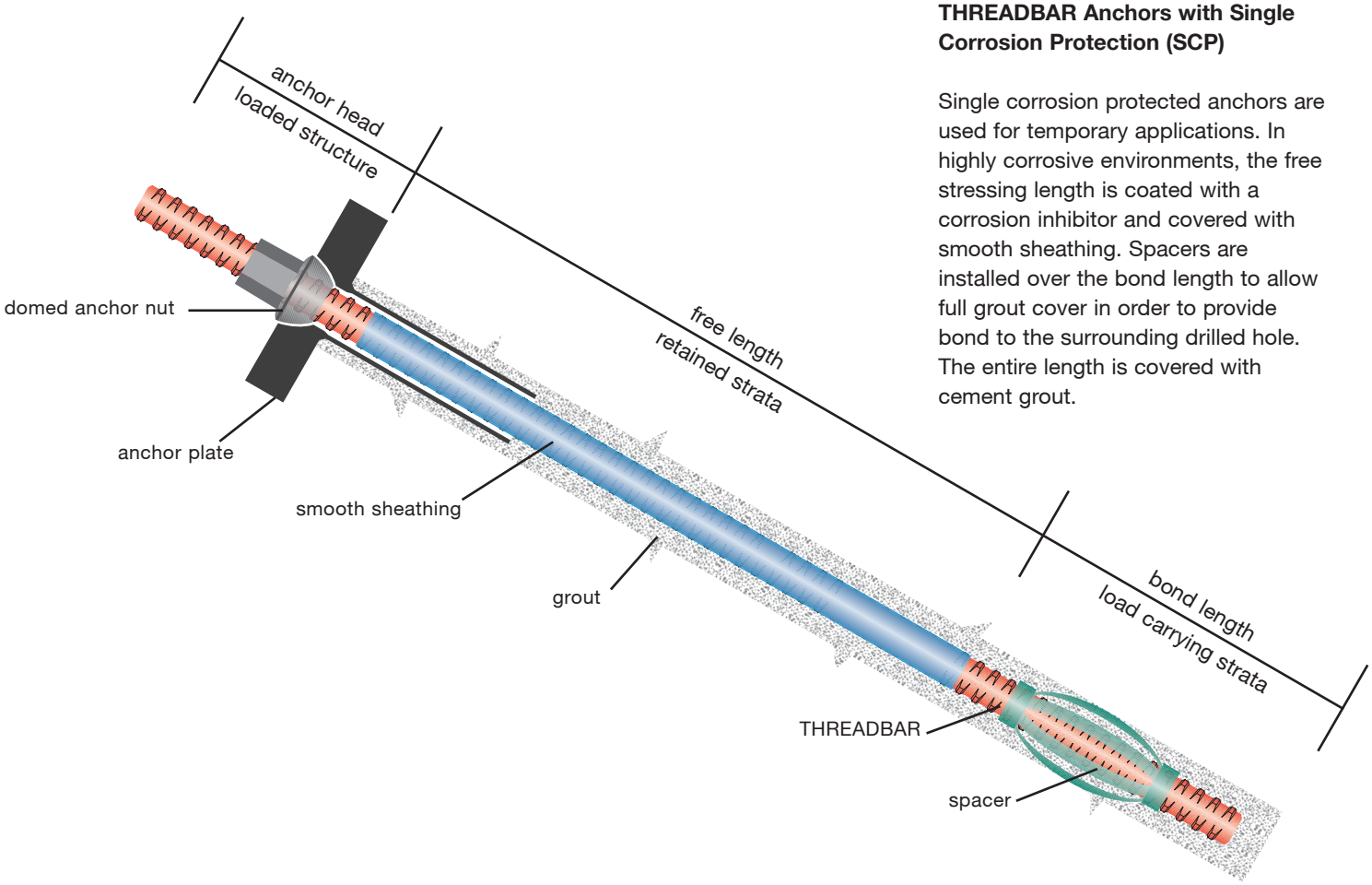
- Anchor support structures for excavations such as sheet pile walls, soldier piles and lagging, drilled piles and slurry walls
- Counteract uplift forces in structures subjected to buoyancy and lateral loads
- Transfer external forces to the ground; e.g. wind, earthquake
- Stabilise eccentrically loaded foundations
- Stabilise material or excavated slopes.

Rock Anchors are post-tensioned tendons installed in drilled holes for which at least the entire bond length is located in rock. The anchor force is transmitted to the rock by bond between the grout body and the rock. Rock anchors can remain unbonded in the free stressing length allowing the anchor to be checked and re-tensioned at any time. In such cases, adequate corrosion protection for the stressing anchorage and the free stressing length must be provided. On the other hand, the free stressing length can also be fully grouted after the anchor has been stressed, in which case force adjustment is no longer possible.

Rock anchors are generally used to:

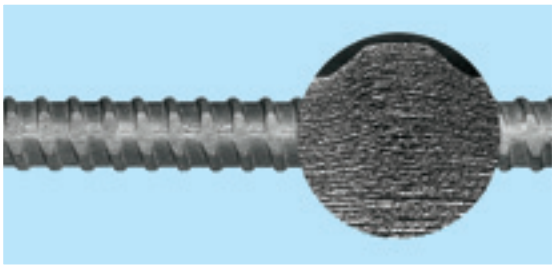
- Anchor external forces and uplift forces
- Anchor retaining walls
- Stabilise eccentrically loaded foundations, slopes, rock walls and cuts
- Stabilise underground excavations and tunnels
- Increase the stability of dams against overturning and uplift.





THREADBAR Anchors with Single Corrosion Protection (SCP)

Single corrosion protected anchors are used for temporary applications. In highly corrosive environments, the free stressing length is coated with a corrosion inhibitor and covered with smooth sheathing. Spacers are installed over the bond length to allow full grout cover in order to provide bond to the surrounding drilled hole. The entire length is covered with cement grout.



THREADBAR Anchors with Double Corrosion Protection (DCP)

DCP anchors are recommended for anchors with a long service life and for an environment where aggressive materials are expected.

The DSI permanent THREADBAR anchors use a double corrosion protection system to fully encapsulate the steel bars over their entire length. It consists of cement grout injected into the annular space between the centralised THREADBAR and the high strength corrugated PVC sheathing over the bond and free lengths. The cement grout inside the corrugated sheathing acts as the first level of protection embedding the bar in an alkaline environment.

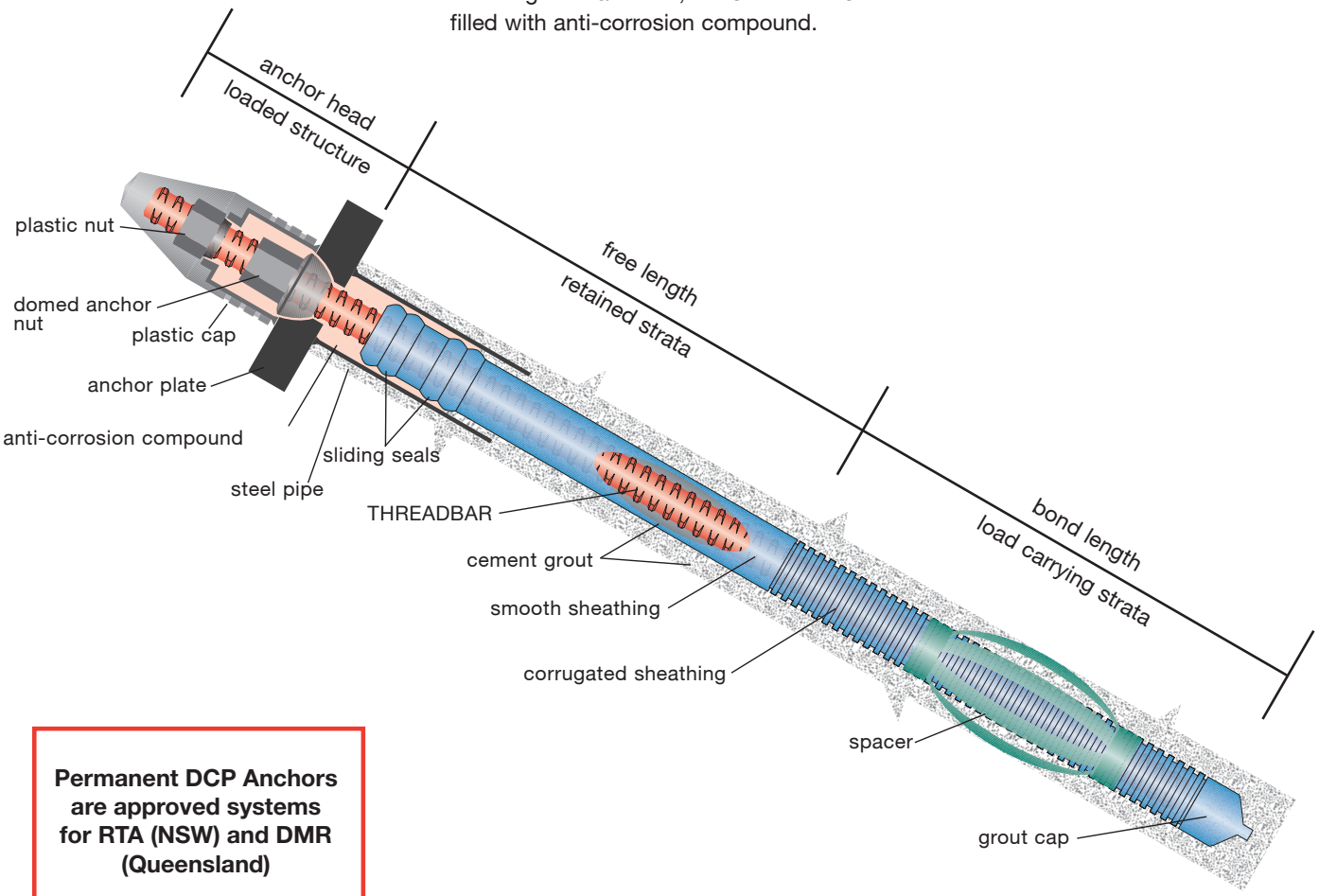
The corrugated PVC sheathing is impermeable to any corrosive substances such as ground water and gases and acts as the second level of protection. Permanent anchors are pre-grouted in a controlled factory environment to ensure adequate corrosion protection during transport, storage, installation and design life.

In the bond length, the corrugations of the sheathing transfer the load to the grout in the drilled hole. In the free length, the load transfer is prevented by inserting smooth sheathing over the corrugated sheathing.

In order to accommodate for elongation of the anchor during tensioning, a short segment of the THREADBAR remains ungrouted underneath the anchor plate. Full encapsulation is provided at this location by a steel tube welded to the underside of the plate and fits tightly over the sliding seals at the top of the free length. In addition, the steel tube is filled with anti-corrosion compound.

The anchor nut and the bar above the anchor plate are covered by removable protective caps filled with anti-corrosion compound. Caps can be made of either plastic or hot-dipped galvanised steel. This design permits re-stressing, de-stressing and load monitoring at any time.

The two levels of corrosion protection for couplers in both the bond and free lengths are achieved by applying anti-corrosion compound to the bar and coupler and covering the splice with a heat-shrink sleeve. For couplers in the free length, an additional debonding tube is inserted over the DCP couplers to ensure free movement of the couplers during stressing.



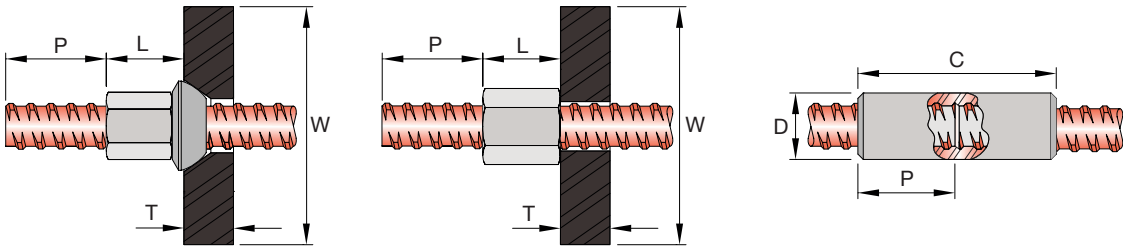
Permanent DCP Anchors are approved systems for RTA (NSW) and DMR (Queensland)

THREADBAR Anchor Properties: WR Grade

Nominal Diameter (mm)	26.5	32	36	40
Minimum Ultimate Steel Grade (MPa)	1,050	1,050	1,050	1,050
Minimum Yield Steel Grade (MPa)	950	950	950	950
Minimum Breaking Load (kN)	579	844	1,069	1,319
Minimum Yield Load (kN)	524	764	967	1,194
Cross-Section Area (mm^2)	552	804	1,018	1,257
Maximum Thread Diameter (mm)	30.5	36.3	41.4	45.3
Unit Weight (kg/m)	4.48	6.53	8.27	10.21
Minimum Bar Protrusion P* (mm)	85	100	105	125

THREADBAR Anchor Hardware Dimensions

Nominal Diameter (mm)	26.5	32	36	40
Domed Nut L (mm)	60	72	75	83
A/F** (mm)	50	60	65	70
Hex Nut L (mm)	85	105	120	120
A/F** (mm)	50	60	65	70
Coupler C (mm)	170	200	210	250
D (mm)	55	65	72	71
Typical Plate for Rock Anchors W (mm)	180	200	220	240
T (mm)	40	45	50	55
Corrugated Sheathing Diameter (mm)	50	60	65	65
Smooth Sheathing Diameter (mm)	60	72	75	75



Notes:

*Minimum THREADBAR protrusion to accommodate tensioning or coupling: P=½C (mm).

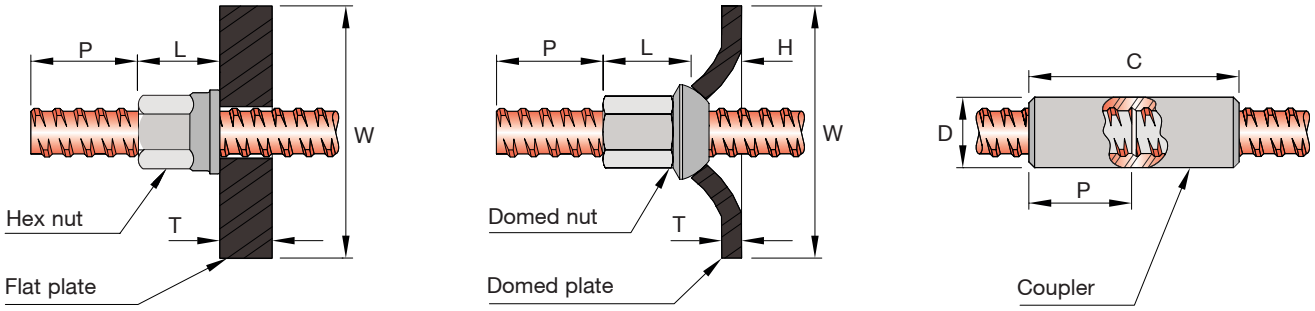
**Width measured across flat of nut.

GEWI® Threadbar Anchor Properties: T Grade

Nominal Diameter (mm)	20	25	28	32	40	50	63.5
Minimum Ultimate Steel Grade (MPa)	600	550	550	550	550	550	700
Minimum Yield Steel Grade (MPa)	500	500	500	500	500	500	555
Minimum Breaking Load (kN)	188	270	339	442	691	1,080	2,217
Minimum Yield Load (kN)	157	245	308	402	628	982	1,758
Cross-Section Area (mm^2)	314	491	616	804	1,257	1,964	3,167
Minimum Thread Diameter (mm)	22.8	27.9	31.6	35.7	44.2	55.6	69.0
Unit Weight (kg/m)	2.47	3.85	4.83	6.31	9.86	15.41	24.86
Minimum Bar Protrusion P* (mm)	55	58	63	70	80	100	130

GEWI® Threadbar Anchor Hardware Dimensions

Nominal Diameter (mm)	20	25	28	32	40	50	63.5
Domed Nut L (mm)	35	40	46	51			
A/F** (mm)	36	38	43	46			
Hex Nut L (mm)	35	50	55	60	70	85	115
A/F** (mm)	36	41	46	55	65	80	100
Coupler C (mm)	110	115	125	140	160	200	260
D (mm)	37	42	48	55	68	84	106
Domed Plates W (mm)	150	150/200	200				
T (mm)	8/10	10/12	16				
Flat Plates W (mm)			200	200/250	250	250	200
T (mm)			16/20	20/25	20/25	20/25	25
Corrugated Sheathing Diameter (mm)	50	50	56	56	65	80	100



Notes:

*Minimum THREADBAR protrusion to accommodate tensioning or coupling: P=½C (mm).

**Width measured across flat of nut.

THREADBAR Anchor Hardware

Domed Nut
- The spherical sheathing allows for small angle compensation (3-4°)
- The width across the flat of the hex portion matches the tightening socket inside the DSI jack
- Protective caps are available.

Flat Plate for Rock Anchors
- Installed on flat bearing surfaces
- Various dimensions and grouting hole positions are available
- Hot-dipped galvanising is required for permanent applications.

Coupler
- Used for extending to the desired length
- Double corrosion protection is required for permanent applications
- Couplers are designed and produced to exceed the tensile capacity of the bars

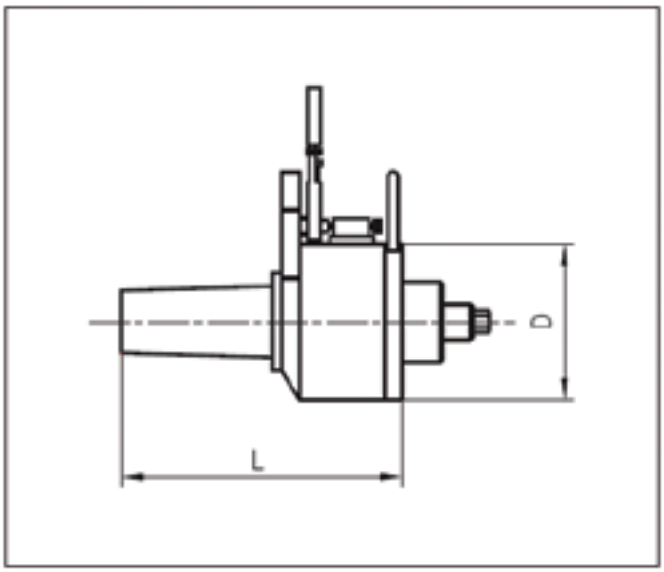
Slip-on or Segment Spacers
- Installed on the anchors to ensure a grout cover around the anchor inside the drilled hole.

Grout Tube
- Grout tube is used to inject cement grout
- Grout tubes are manufactured from polyethylene material.

THREADBAR Anchor Tensioning Equipment

Tensioning jacks are available for customer hire. Every DSI tensioning jack is calibrated with its corresponding hydraulic gauge.

During bar tensioning, the operater tightens the nut by pulling on a ratchet handle linked to a socket which fits over the anchor nut.





Jack 600kN Series 04

Jack Type	Length L	Diameter D	Stroke	Piston Area	Weight
	(mm)	(mm)	(mm)	(cm^2)	(kg)
600kN	400	190	50	132.5	36
1,100kN	494	267	50	235.6	46
1,100kN	594	267	150	235.6	54
1,500kN	870	336	250	302.4	125

On-site Assembly and Installation Instructions for DCP Threadbar Anchors

1. Receiving the anchors
- Check for possible transportation damage.
- Do not use anchors that have been bent or that have any surface damage, do not use bars as ground for welding, do not allow hot slag to touch the bars, do not weld to bars.
- Handle anchors with care using nylon lifting slings (2 legs minimum).
- Upon unloading, protect the bars from dirt and mechanical damage.
- Important: the bars must not be dropped, thrown or dragged.

2. DCP couplers in the bond and free lengths
- Grease both bar ends thoroughly.
- Install coupler, bar ends must be centred inside coupler.
- Torque bar against each other.
- If applicable, tighten set-screws against flat side of the bar.
- Grease coupler thoroughly.
- Install heat-shrink sleeve. Important: do not burn the heat-shrink sleeve nor the plastic sheathing.

3. DCP couplers in the free length only
- Centre coupler tube over the heat-shrink sleeve (refer to 2. above) allowing for displacement of the heat-shrink sleeve during stressing.
- Secure coupler tube firmly by taping both end to the smooth sheathing.

4. Grout tube and outer spacer assembly
- Install outer spacers (alternatively: segment spacers) within the bond length using adhesive tape and/or wire at the required spacing.
- If applicable, install grout tube using adhesive tape. The grout tube must start 50 to 100mm from the bottom of the anchor and extend at least 1 metre above the anchor head.

5. Installing the bar plates and bar nuts
- Install anchor plates pre-filled with anti-corrosion compound over the bar leaving enough bar protruding behind the plate for the anchor nut and the stressing coupler. Also, ensure that there is sufficient bare bar (typically 100 mm) inside the steel tube welded to the steel plate to allow for free movement of the vent cap during tensioning of the anchor.
- Screw anchor nut tight against the bearing plate making sure that the spherical end of the nut contacts the plate.

6. Installing the bearing & wedge washer and anchor nut
- Install the wedge washer (2 pcs maximum) followed by the bearing washer with welded steel tube prefilled with anti-corrosion compound over the bar leaving enough bar protruding behind the plate for the anchor nut and the stressing coupler. Also, ensure that there is sufficient bare bar inside to steel tube welded to the steel plate to allow for free movement of the vent cap during tensioning of the anchor.
- Screw anchor nut hand tight against the bearing plate making sure that the spherical end of the nut contacts the plate.

7. Inserting the anchor into the borehole
- If necessary, water-test the borehole according to the project specifications.
- Using a lifting eye or another equivalent attachment, lift the anchor from the anchor head end, Important: do not drag.
- Insert the anchor into the borehole gradually making sure that it does not get damaged.

8. Grouting the anchors with plates and nuts installed
- Grout the anchor along its entire length in one stage according to the project specifications.

9. Grouting the anchors without plates and nuts installed
- Ensure that the anchor is centred in the borehole.
- Leave enough bar protruding behind the plate for the anchor nut and the stressing coupler. Also, ensure that there will be sufficient bare bar inside the steel tube welded to the steel plate to allow for free movement of the vent cap during tensioning of the bar. Grout the entire anchor in one stage according to the project specifications.
- While the grout is still wet, wash-out half a metre below the location of the anchor plate.
- Install the anchor plate and nut as instructed above (Installing the anchor plates and anchor nuts).
- Tremmie grout the entire void behind the plate.

10. Testing and stressing
- Stress the bars according to project specifications and contract drawings. CAUTION: the stressing equipment is capable of developing very large forces. Read the safety and operating instructions.

11. Installing protective caps
- Pre-fill the caps with anti-corrosion compound and install it over the anchor nut with corresponding seals.

Tunneling and Civil

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Approvals available upon request.

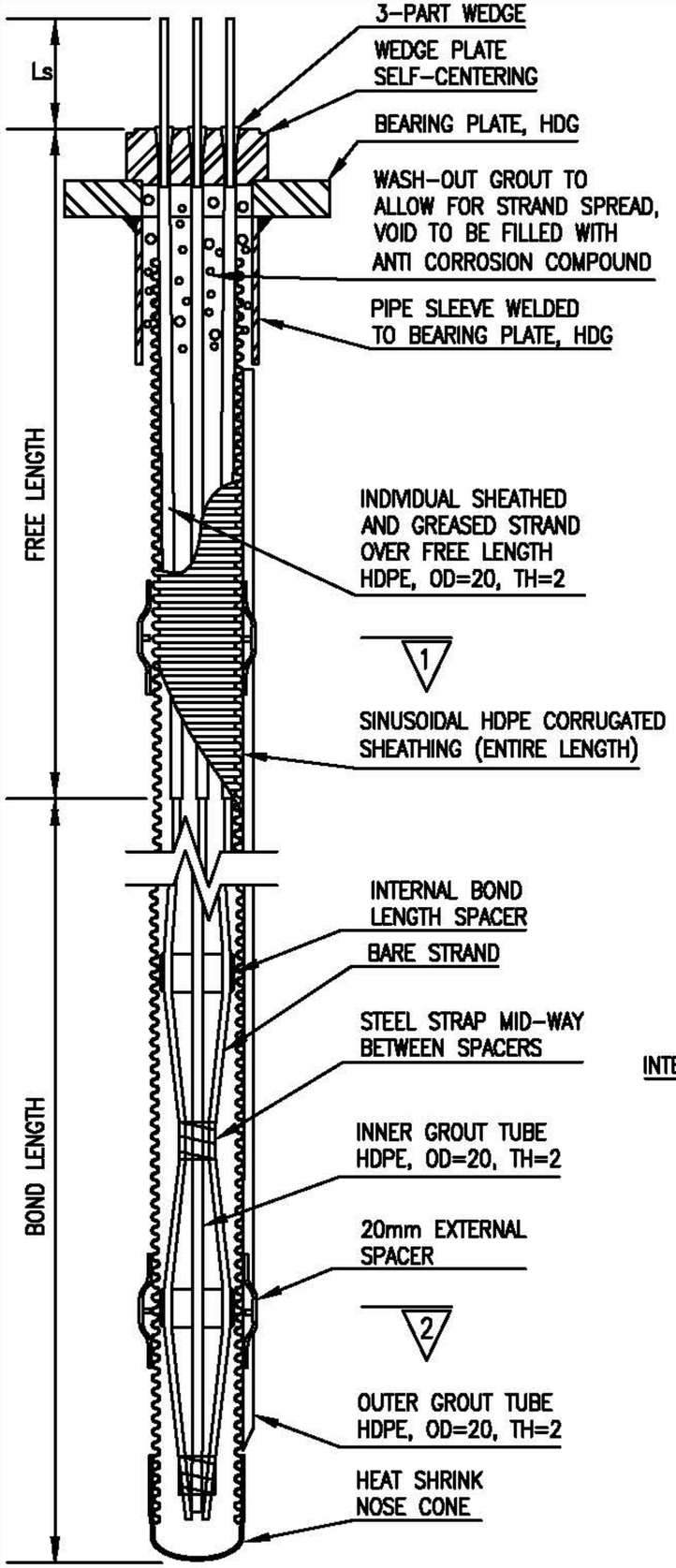
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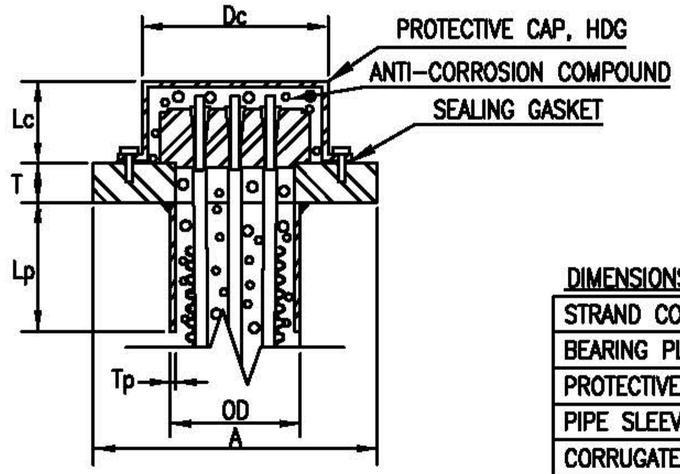
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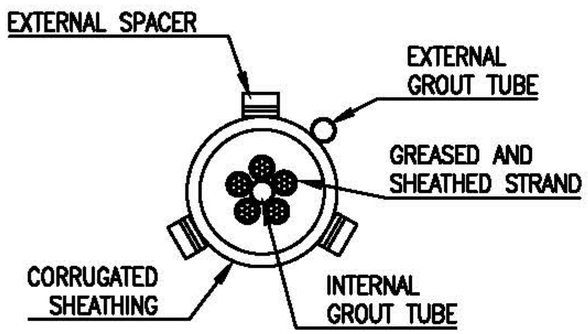
Appendix B: 15.2mm Permanent Multistrand Anchor Product Specifications



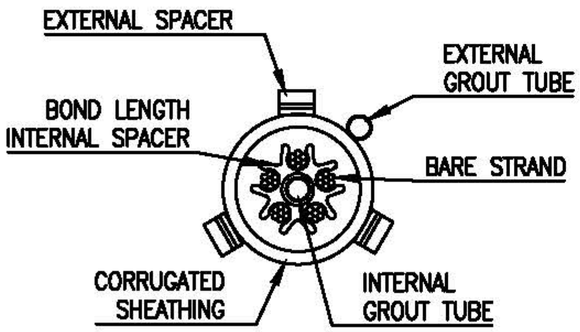
ANCHOR DETAILS



ANCHOR HEAD PROTECTION



SECTION 1 – FREE LENGTH



SECTION 2 – BOND LENGTH

No.	REVISION	DATE	ECN
A	PIPE & CAP CHANGES	OCT' 12	000
B	CORRUGATED SHEATHING UPDATED	AUG' 14	020
C	31 & 37 ADDED	JUL' 15	025

15.2mm STRAND PROPERTIES

EXTRA HIGH TENSILE STRENGTH LOW RELAXATION STRAND
A=143mm2 MBL=261kN

DIMENSIONS (mm)

STRAND CONFIGURATIONS	2 – 5	6 – 7	8 – 9	10 – 12	13 – 15
BEARING PLATE (AxT)	250x32	290x36	330x40	380x45	420x50
PROTECTIVE CAP (DcxLc)	161x85	205x95	205x95	212x170	256.4x120
PIPE SLEEVE (LpxODxTp)	350x114.3x6.0	400x114.3x6.0	500x168.3x6.4	550x168.3x6.4	650x168.3x6.4
CORRUGATED SHEATH (ODxID)	92x78	92x78	92x78	117x101	117x101
STRESSING LENGTH (Ls)	750	1000	1500	1500	1500

DIMENSIONS (mm)

STRAND CONFIGURATIONS	16 – 19	20 – 22	23 – 31	32 – 37
BEARING PLATE (AxT)	470x60	500x70	600x80	650x100
PROTECTIVE CAP (DcxLc)	256.4x120	256.4x120	323.8x150	323.8x150
PIPE SLEEVE (LpxODxTp)	700x219.1x6.4	800x219.1x6.4	1000x273.1x6.4	1000x273.1x6.4
CORRUGATED SHEATH (ODxID)	145x127	145x127	241x203	241x203
STRESSING LENGTH (Ls)	1500	1500	2000	2000

CAUTION

DO NOT WELD TO STRAND
DO NOT USE STRAND AS GROUND FOR WELDING
DO NOT ALLOW HOT SLAG OR SPARKS TO TOUCH STRAND
DO NOT DAMAGE STRAND SURFACE
DO NOT USE STRAND WITH KINKS OR SHARP BENDS
FAILURE TO HEED THIS WARNING COULD CAUSE STRAND TO BREAK RESULTING IN INJURY OR DAMAGE.

INSTALLATION PROCEDURE

1) DRILL REQUIRED HOLES. IF APPLICABLE, GROUT AND RE-DRILL UNTIL WATER TIGHT.
2) INSERT CORRUGATE SHEATHING WITH PRE-ASSEMBLED OUTER GROUT TUBE & SPACERS.
3) INSERT STRAND ANCHORS PRE-ASSEMBLED WITH INNER SPACERS AND GROUT TUBE.
4) WATER TEST SHEATHING.
5) SIMULTANEOUSLY GROUT THE INNER AND OUTER ANNULUS OF THE ENTIRE ANCHOR.
6) 4 HOURS AFTER GROUTING, WASHOUT 0.5m BELOW PLATE.
7) INSTALL BEARING PLATE WITH PIPE.
8) FILL ANCHOR HEAD WITH GREASE.
9) INSTALL WEDGE PLATE AND WEDGES.
10) ONCE GROUT REACHES MIN. 32MPa AND 7-DAYS, PERFORM TESTING AND LOCKING-OFF.
11) ONCE TESTING & LOCKING-OFF ARE APPROVED, CUT STRANDS AND CAP.

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PROJECT			
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		SCALE NTS	CHECKED AUTH
TITLE PERMANENT MULTISTRAND ANCHOR DETAILS	DWG No. PermStrand01		REV. C

DYWIDAG Multistrand Anchors



Contents

DYWIDAG Multistrand Anchors
DYWIDAG Multistrand Anchor System **4**
DYWIDAG Multistrand Anchor Properties and Dimensions **6**
DYWIDAG Multistrand Anchor Equipment **7**





DYWIDAG Multistrand Anchor System

General Notes

DYWIDAG Multistrand Rock and Soil Anchor System is based on the proven prestressing technology of the DYWIDAG Post-Tensioning System and decades of experience in anchor technology. The system is extremely versatile and can be adapted to meet almost any project requirement. Because of their small bending radius, strand anchors can easily be coiled to fit on trucks and are well suited for installation where work space is limited.

Advantages

- Little space required during transport, storage and installation when coiled in the factory
- Sturdiness against damage ensured through flexibility
- Double corrosion protection is supplied for permanent anchors
- Easy installation due to relatively low weight
- Practically no limitation of the working load due to an optional number of strands
- Consistent high quality product due to internal supervision of production
- Each strand is opened, coated with corrosion inhibitor, then closed and inserted in individual sheaths prefilled with corrosion inhibitor
- Pre-fabricated in the factory, minimising assembly time and labour costs on the job site.





DYWIDAG Multistrand Anchor System

DYWIDAG Multistrand Anchor - Double Corrosion Protection (DCP)
DCP Anchors are used for permanent applications in aggressive or uncertain environments.

Corrugated polyethylene (PE) sheathing covers both the bond and free stressing lengths. The bottom of the sheathing is sealed with an end cap, the top fits inside a grease-filled steel pipe that is welded to the underside of the plate.

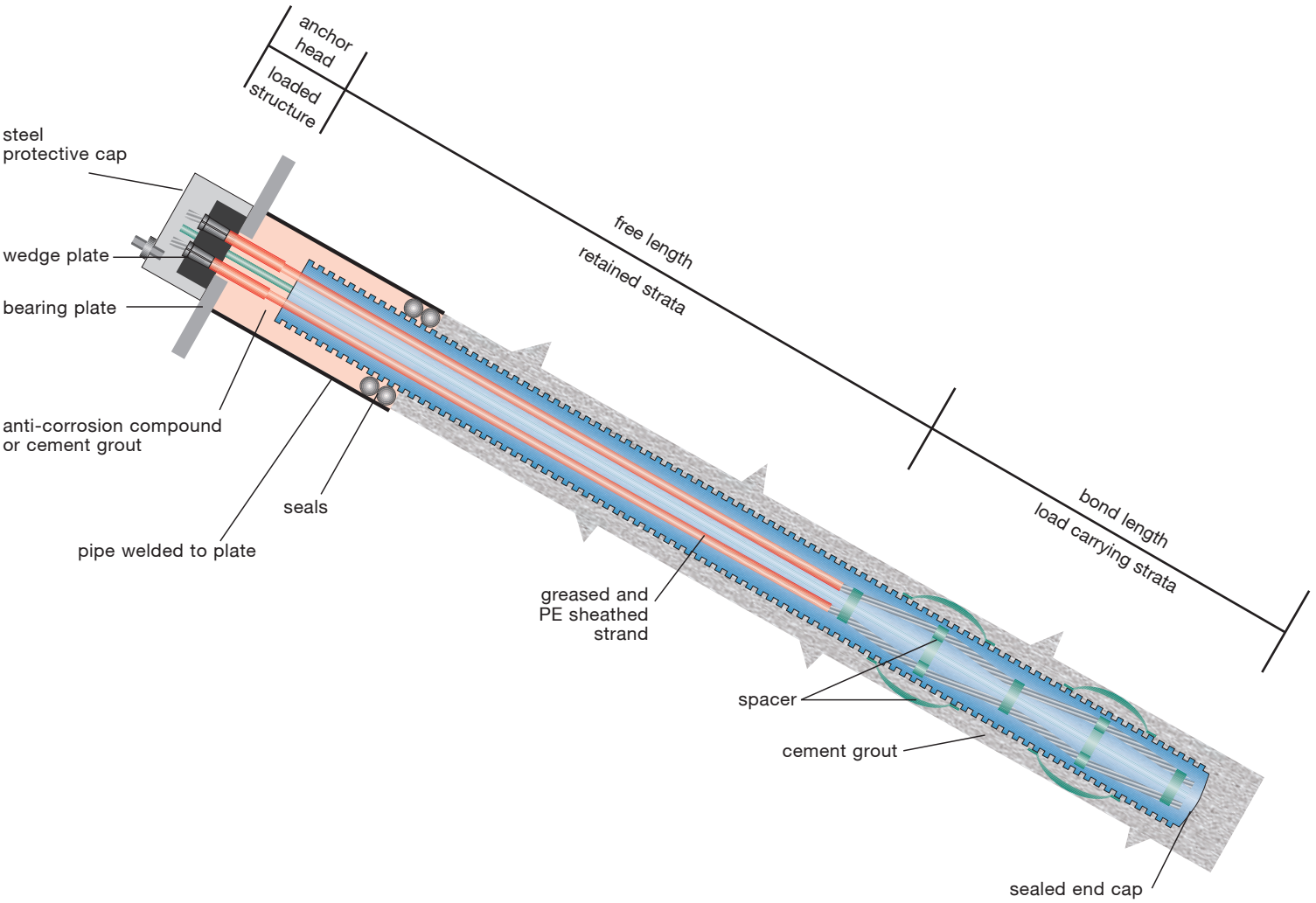
Within the bond length, the strands are bare and separated by installing internal spacers to ensure bond to the surrounding grout. Within the free stressing length, each strand is greased and individually sheathed in order to ensure that it is free from the surrounding grout to allow for tensioning of the anchor. This is achieved in the factory by opening every individual wire of a single strand, passing them through a hot-grease chamber, closing the strand by re-winding it and finally inserting the greased strand into a grease-filled PE tube. This ensures that there is no void and therefore no corrosion ingress.

The anchor head consists of a bearing plate that transfers the anchor loads to the rock or structure, a wedge plate with tapered holes and 3-part wedges that grip onto the strands. During tensioning the strands are pulled simultaneously with a multistrand hydraulic jack, resulting in the strands stretching within the free length.

When the desired load is achieved, the wedges are pushed against the wedge plate, the tensioning jack is released and the wedges grip on the strands as they are drawn into the tapered wedge plate holes.

Hot-dipped galvanised steel protective caps are placed over the wedge plates after tensioning.

All DYWIDAG multistrand jacks are self-centering by bearing directly on a locating ring that is machined on the wedge plates. This is to prevent wire breakage due to misalignment and also reduces wedge seating losses.



DYWIDAG Multistrand Anchor Properties and Dimensions

Super Grade Strand					
Number of Strands	4	7	12	15	19
Area (mm^2)	572	1,001	1,716	2,145	2,717
Weight (kg/m)	4.49	7.85	13.46	16.83	21.32
Yield (kN)	820	1,435	2,430	3,075	3,895
UTS (kN)	1,000	1,750	3,000	3,750	4,750

Extra High Tensile Strand					
Number of Strands	4	7	12	15	19
Area (mm^2)	572	1,001	1,716	2,145	2,717
Weight (kg/m)	4.49	7.85	13.46	16.83	21.32
Yield (kN)	856	1,498	2,568	3,210	4,066
UTS (kN)	1,044	1,827	3,132	3,915	4,359

Note: Other strand quantities available upon request.

DYWIDAG Multistrand Anchor Hardware

Number of Strands		4	7	12	15	19
Bearing Plate	W (mm)	230	230	290	340	390
	T (mm)	32	32	36	36	40
Pipe Sleeve	OD (mm)	102	102	114	114	140
	L (mm)	350	350	450	550	550
Corrugated Sheathing	OD (mm)	65	85	96	96	125

DYWIDAG Multistrand Anchor Equipment

Tensioning of DYWIDAG Multistrand Anchors

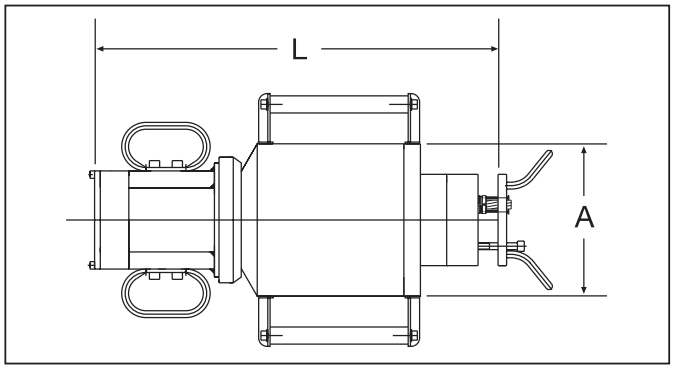
All jacks are calibrated with their respective pressure gauges.
For installation and stressing efficiency, most DYWIDAG jacks for multistrand anchors are equipped with internal strand guide tubes and automatic strand gripping and releasing devices.

These features make jack installation a fast, one-step operation with small wedge seating loss.

For safety, all jacks feature a check valve which holds the pressure in the unlikely event of hydraulic failure.
For reliability, the jacks are equipped with a special plate for seating all wedges simultaneously.

DYWIDAG Strand Anchor Jacks





Jack 1,500 kN

Jack Type	Length L	O. D. A	Stroke	Piston Area	Capacity	Weight
	(mm)	(mm)	(mm)	(cm^2)	(kN)	(kg)
1,100 Mp	720	267	150	235.6	1,200	81
1,500 Mp	870	336	250	302.4	1,500	125
HOZ 3,000	1,200	385	250	508.9	3,053	400
HOZ 5,000	1,462	482	250	894.6	4,200	600

Strand: Super Grade and extra High Tensile

No. of strands	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1,100 Mp	●	●	●	○	○	○															
1,500 Mp	○	○	○	●	●	●															
HOZ 3,000							●	●	●	●	●										
HOZ 5,000												●	●	●	●	●	●	●	●	●	●

● Standard ○ Optional

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