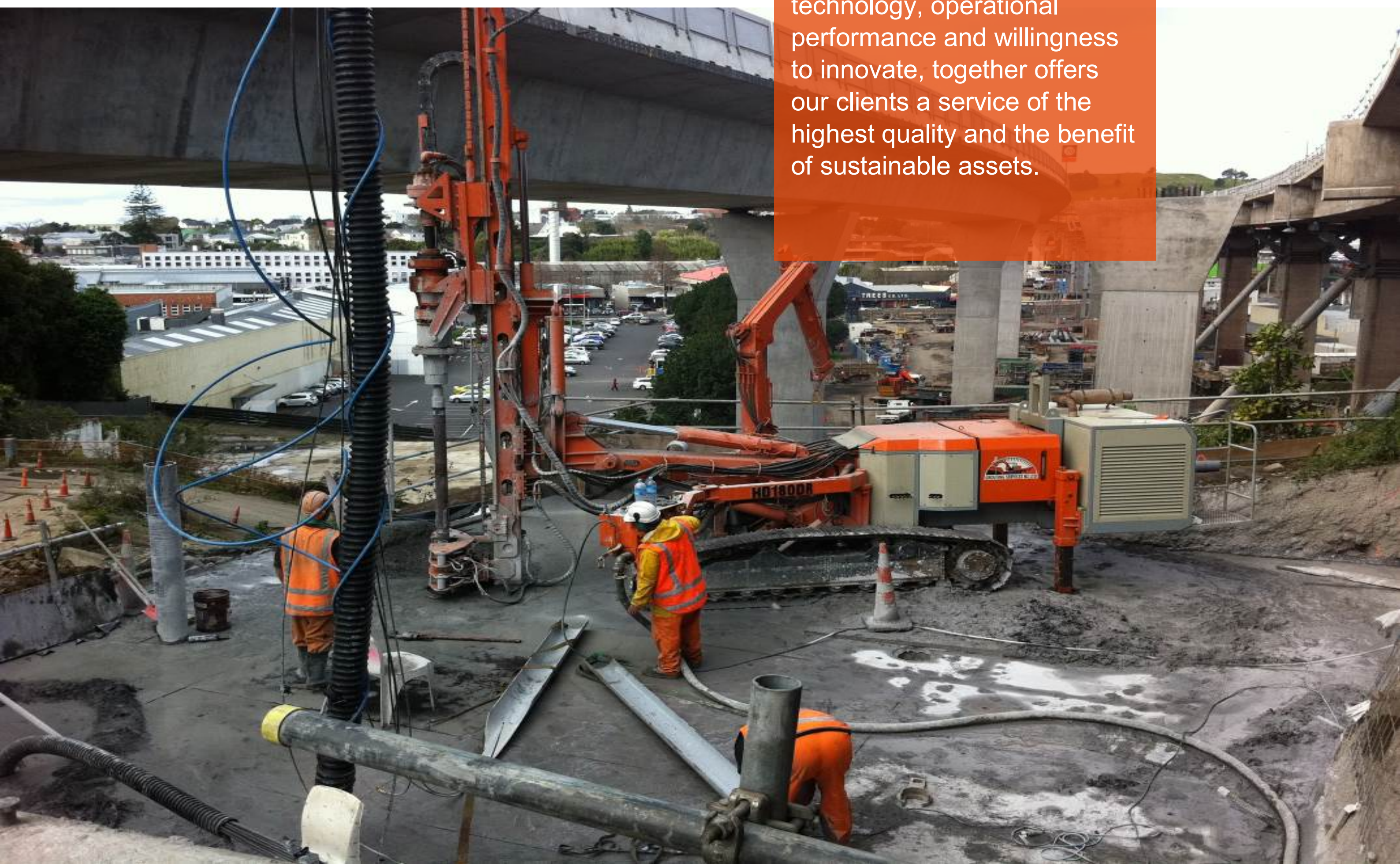
GROUND ANCHORING

GROUTING SERVICES

GROUND ANCHORING

Grouting Services provides a full range of specialist construction services in the fields of ground anchoring, soil nailing, post-tensioning, drilling and grouting. Our reputation as a construction company in New Zealand has been built on providing practical and cost effective solutions and we have the right mix of people, resources and expertise required to make your next project a success.

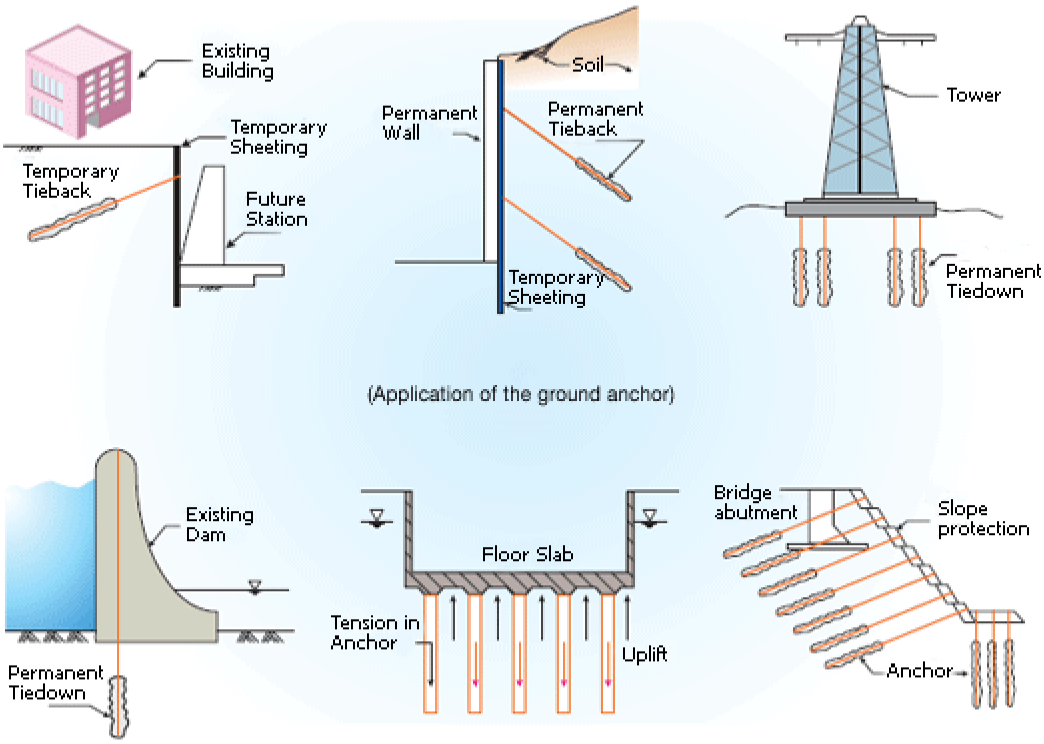
Over the years, a tradition of excellence in civil and structural engineering and construction has become one of our top priorities. Our continually developing technology, operational performance and willingness to innovate, together offers our clients a service of the highest quality and the benefit of sustainable assets.



GROUND ANCHORING

Grouting Services is the recognized leader in providing rock and soil anchoring solutions to the civil engineering and construction markets.

Ground anchors are effectively restraining devices used in many different types of structures including retaining walls, dams, wharves, bridge abutments and foundations for buildings. Ground anchors are stressed (active anchorage) to prevent structural movement and they typically transfer their load over a fixed length. These are commonly referred to as tension anchors and are suited for strong rock conditions. For anchors founded in soil or weak rock, load distributive compressive (and tension) anchors are used as they rely on the succession of small successive bond lengths rather than one unique longer bond length.

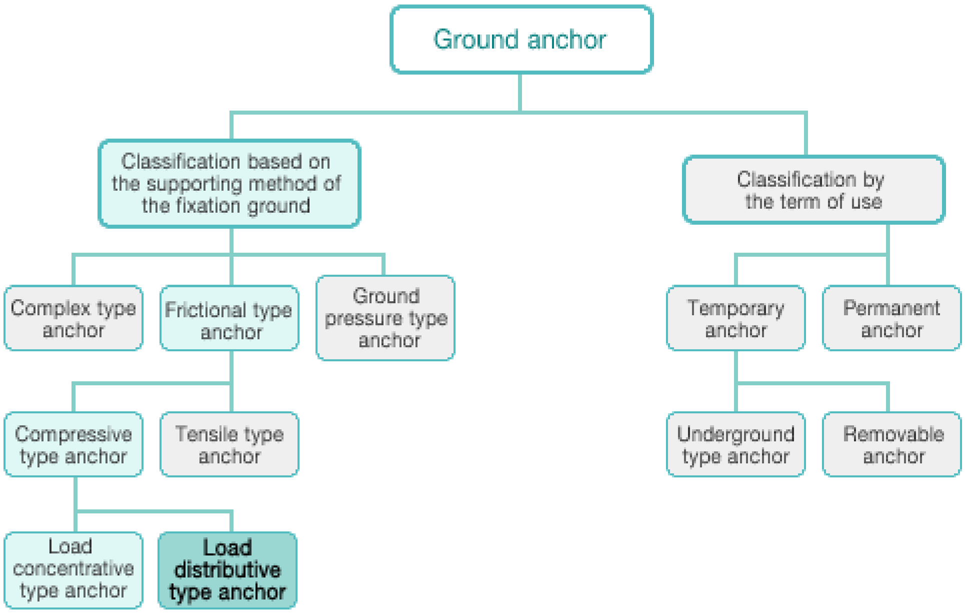


CLASSIFICATION OF GROUND ANCHORS

Ground anchors are classified according to their service life, purpose, installation procedures and method of load transfer from the anchor to the ground. An anchor with a service life greater than 24 months is generally considered permanent. Permanent anchors shall always have some type of corrosion protection system based on the service life of the structure, the known aggressivity of the environment and corrosive properties of the soil and consequences of tendon failure.

Also, anchors can be classified into frictional type anchors that are supported by the friction of the grout and the ground, ground pressure type anchors that acquire anchoring force with the passive resistance of the ground using ground pressure boards or piles, and complex type anchors that are a combination of the above two types, based on the supporting method of the fixation ground. Frictional type anchors can also be classified into tensile type anchors and compressive type anchors based on the load application method to the grout. Lastly, compressive type anchors can be classified into load concentrative type anchors and load distributive type anchors depending on the distribution of the load.

■ Classification of ground anchors



COMPARISON BY THE CHARACTERISTICS OF EACH ANCHOR TYPE

Load Concentrative Tension Type Anchor

When stress is applied to tension type anchor, load transfer occurs to bond length through adhesion of steel strand and grout. Due to load concentration, the parts of tension type anchor attached with steel strand and grout become unzipped and this leads to crack and load reduction. In addition, tension type anchor has the weakness of progressive debonding and time-dependent load reduction (creep) occurrence when friction of load concentration zone exceeds the extreme skin friction of the target ground. As shown by (Fig. A), tension at the earlier phase displays the state as of ①. Then, as the parts attached with steel strand and grout become unzipped, it changes into the state as of ②. The relatively concentrated skin friction of anchor becomes higher than the allowed value between ground and grout body to progress into the state as of ③. Accordingly, load reduction takes place. The drawbacks of tensile type anchors are that a progressive destruction occurs due to the jacking crack in the grout and creeps due to load concentration, greatly reducing the load. Therefore, as in the vicinity friction distribution graph(Figure A), the load transference distribution is as shown in curve 1) at the initial point when the load is applied, which changes into curve 3) due to the above mentioned reasons with the progress of time, reducing the load.

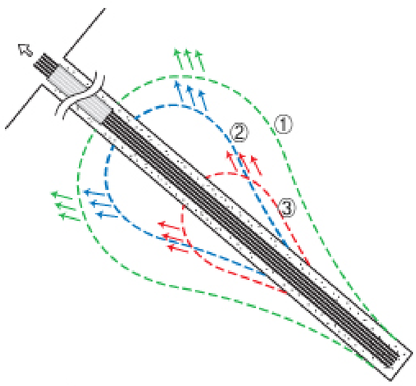


Fig. 1] Load Change Diagram

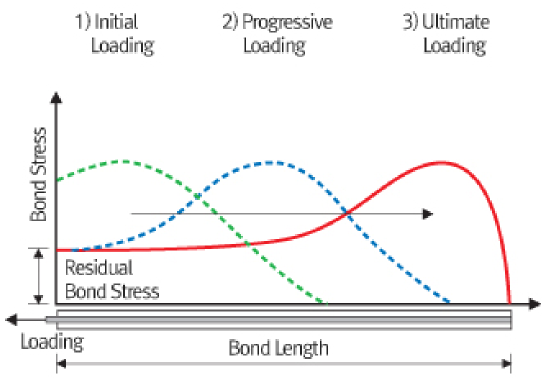


Fig. A] Load Distribution Graph

Load Concentrative Compression Type Anchor

Compression type anchors consist of an unbonded polyethylene (PE)-coated steel strand which transfers the jacking force / load directly to a structural element located at the distal end of the anchor. Unlike the tension type anchors, the grout body for compression type anchors is loaded in compression which is capable of securing much higher loads. However, due to the concentrative design of these anchors, the use of high-strength grout is frequently required to secure the jacking forces at the distal end. Also, it is often difficult to secure concentrative anchorage force in weak soils. Similar to the tension type anchors, compression type anchors are subject to the occurrence of progressive debonding and time-dependent load reduction (creep) as displayed in state ① as shown in (Fig. B). In this case the friction required to secure the concentrated load exceeds that of the skin friction for that zone. This effect causes grout debonding and loss of soil confinement pressure resulting in load reduction as displayed in states ②and③.

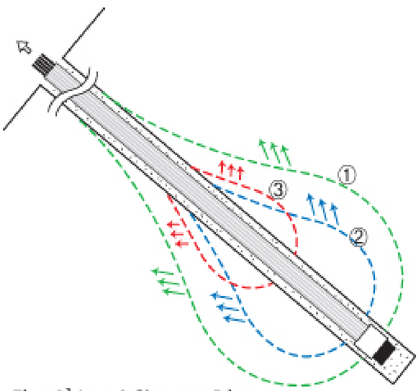


Fig. 2] Load Change Diagram

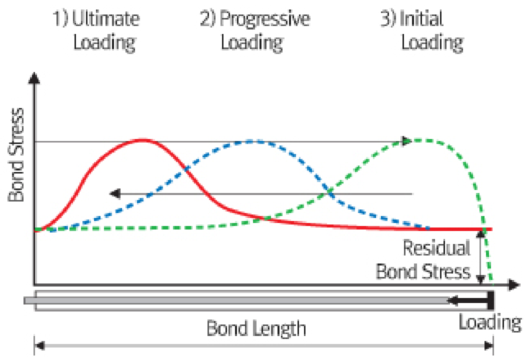


Fig. B] Load Distribution Graph

Load Distributive Tension / Compression Type Anchor

As discussed, high stresses from tension and conventional compression type anchors transfer concentrated loads to the soil and grout body which can become overstressed resulting in failure. Therefore, load distributive compression type anchors have been developed and are being used, which uniformly distribute the anchor load to the grout body and soil along the theoretical length of the bond zone. In addition the grout strength requirements are reduced as well as applied eccentricity. As a result high loads can be achieved even in normal soil condition. Recently, load distributive tension type anchors have been developed which are capable of securing stable loads in even relatively weak soils such as clay and silts. These anchors do not require high strength grout and have low eccentricity as well. The use of load distributive anchors results in a more uniform distribution of the anchor force to the soil as illustrated in figure C below. Therefore, load reduction and creep are minimized, enabling the anchor to maintain initial design load.

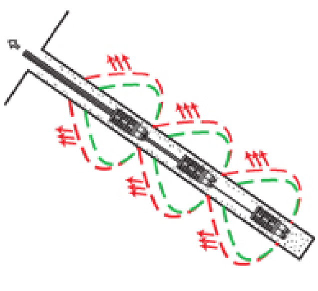


Fig. 3-1] Load Change Diagram

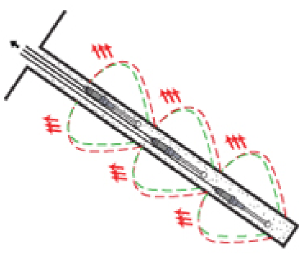


Fig. 3-2] Load Change Diagram

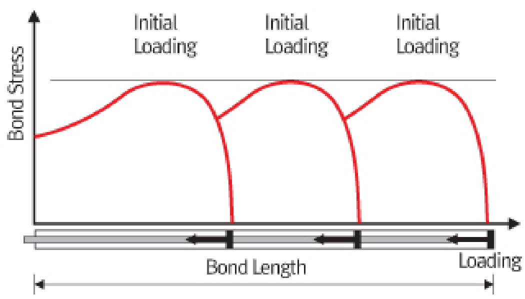


Fig. C] Load Distribution Graph

We design and construct both permanent and temporary anchors using either multi-strand or stress bar in accordance with internationally recognised codes that have been adopted in New Zealand which include; British Standard Code of practice for Ground Anchorages BS8081:1989, Execution of special geotechnical work – Ground Anchors BS EN 1537:2000, FIP Design and construction of prestressed ground anchorages April 1996 and US Federal Highway Administration Geotechnical Engineering Circular No. 4 Ground Anchors and Anchored Systems June 1999.

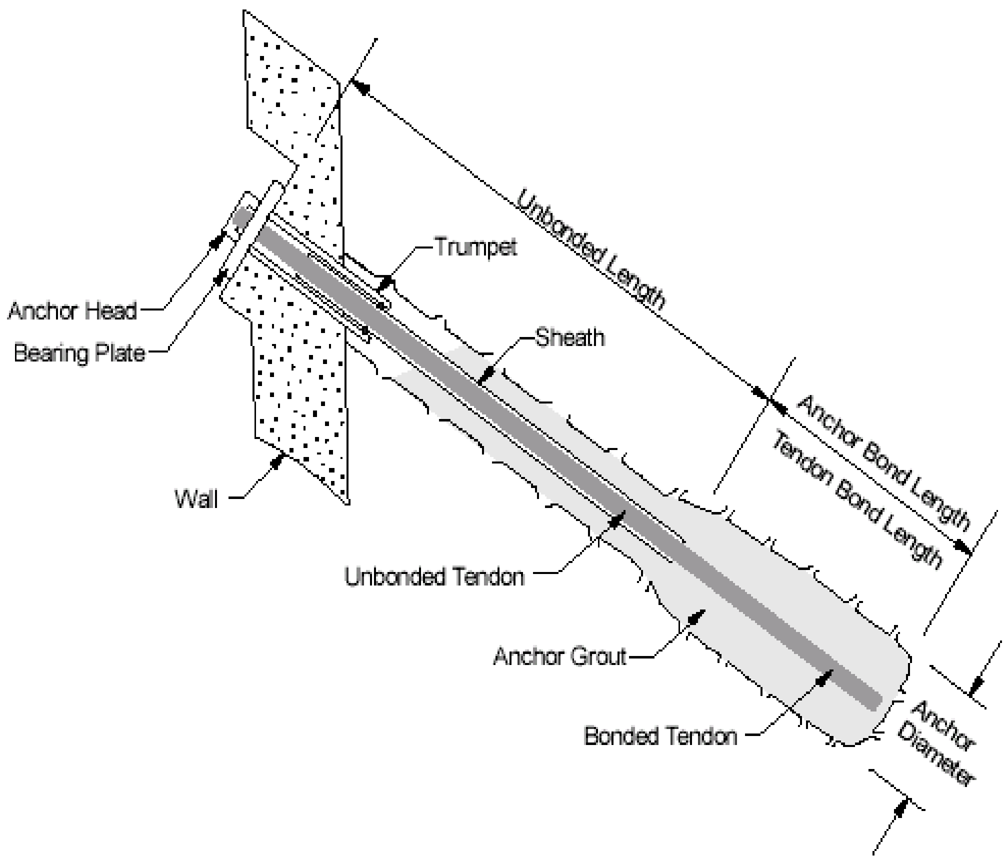
We have an extensive database of ground anchor testing and geotechnical ultimate bond ruptures in a wide range of materials nationwide. However, in any ground anchoring project, site specific geotechnical investigations for the construction of the ground anchors are critical to minimise the risk profile for all parties. Access to this information means we are better able to qualify potential drilling difficulties and any potential for loss of grout from the drill hole during the anchor installation.

For multi-strand anchors, the strands are run through our specialist greasing and sheathing machine. This machine parts the individual wires of the strands followed by immersion into a grease bath before completely encapsulating the strand in the outer sheathing to ensure no voids are present.

We utilise the technique of high-pressure (1000psi) post-grouting in weak compressible soils to significantly improve the bond capacity, and where required, fabric socks are used to ensure containment of grout within the drill hole thus ensuring full bond potential is realised.

COMPONENTS OF A GROUND ANCHOR

A ground anchor is used to transmit a tension force into the ground. They are installed in grout filled drill holes. The basic components of a ground anchor include the anchor head, free length (un-bonded) and the bond length (anchorage).



STRAND ANCHOR PROPERTIES

Pre-stressing strand comprising either 12.7mm or 15.2mm superstrands in accordance with ANZS4672 are common.

12.7mm strands have a nominal cross-sectional area of 100mm^2 and an ultimate tensile strength (UTS) of 186kN per strand. Maximum allowable load is typically 75% UTS.

15.2mm strands have a nominal cross-sectional area of 140mm^2 and an ultimate tensile strength (UTS) of 261kN per strand. Maximum allowable load is typically 75% UTS.

Strand Type				
Nominal diameter	d	(mm)	12.7/12.9	15.2/15.7
Nominal cross-section	Ap	(mm2)	100	140
Nominal mass	M	(kg/m)	0.78	1.1
Nominal yield strength	fp0.1k	(MPa)	1640	1640
Nominal tensile strength	fpk	(MPa)	1860	1860
Minimum breaking load	Fpk	(kN)	186	261
Young's modulus	E	(GPa)	195 (approx)	195 (approx)

Temporary Strand Anchors

For temporary anchors (working life up to 2 years) within the bond length a cement grout cover of at least 10mm thickness is considered to be sufficient to protect the tendon. Within the free length, it is imperative that air, water and corrosion promoting agents cannot reach the strand and this is normally achieved by the use of individually greased and sheathed strands.

It is important to note that temporary anchors installed within an aggressive ground environment should be fully encapsulated within corrugated ducting like a permanent anchor.

Permanent Strand Anchors

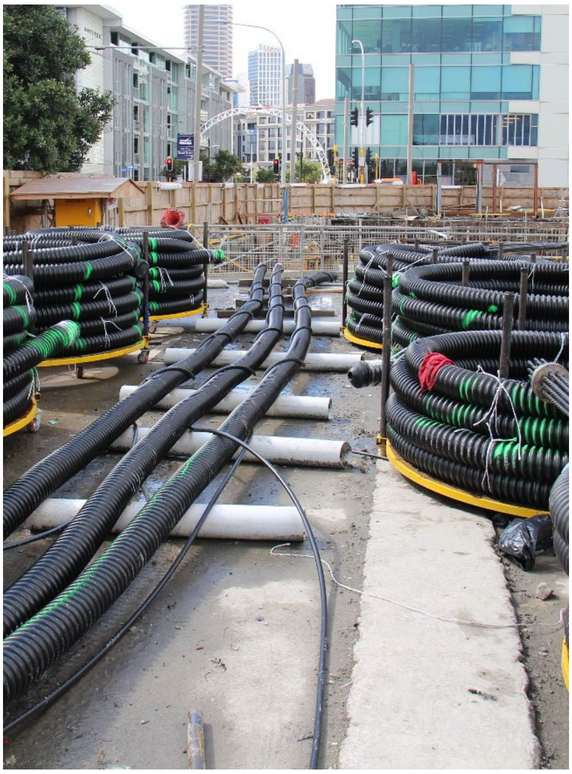
Permanent strand anchors fulfil their function for the duration of the working life of a structure and require comprehensive corrosion protection. They are equipped with watertight and thick-walled polyethylene encapsulation which acts as a barrier to corrosion. The tendons are greased and sheathed over the free length and the entire tendon installed in a single continuous single corrugated duct full length. The greased and sheathed free length provides the bond break mechanism so that no smooth pipe is required over the free length. The corrugated ducting, when combined with the internal installation grout, provides the double corrosion protection.

In some cases, additional levels of protection are required and this is achieved by providing an additional corrugated duct, normally confined to the bond length. It must be noted that two concentric layers of corrugated ducting has a significant cost implication to the project as a much larger drill hole diameter is required and due consideration should be given to this.

In a completely encapsulated bond length, the corrugations of the sheathing transfer the load to the surrounding grout in the borehole. In the free length, the load is transfer is prevented by the elongation of the strands within the greased sheathing.

A bearing plate and trumpet arrangement can be used at the anchor head, or, a proprietary anchorage can be selected but this must be cast-into reaction element. The corrugated ducting fits into the trumpet / anchorage and is filled with an anti-corrosion compound.

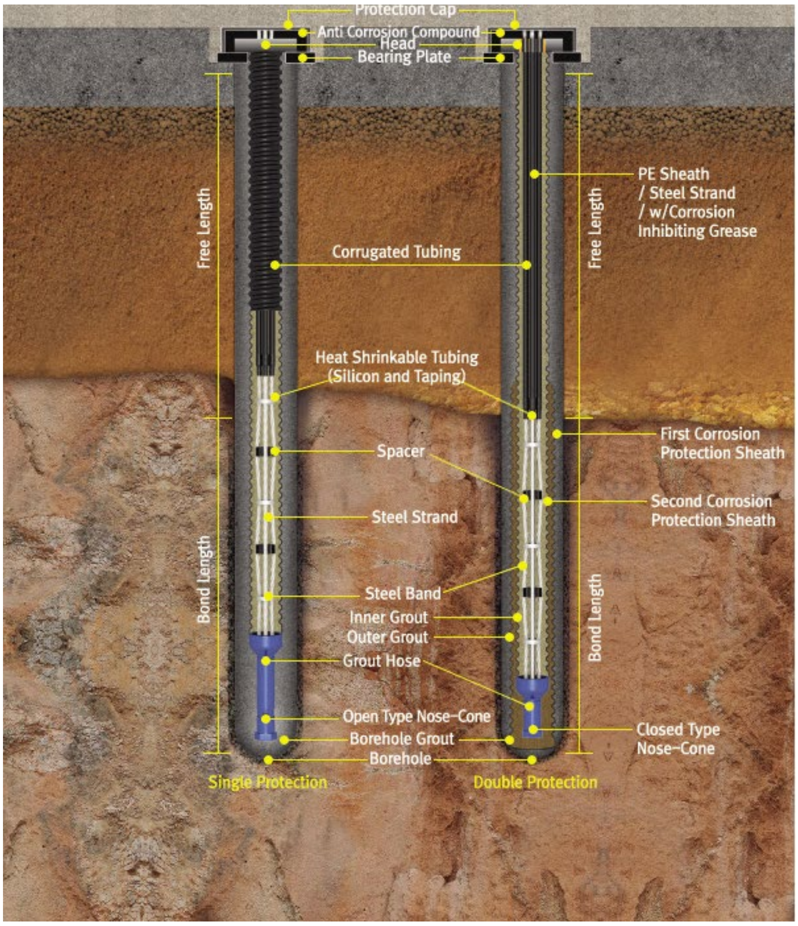
The bearing plate / anchorage is covered by a removable protective cap that is also filled with an anti-corrosion compound.



STRAND ANCHOR TENDON CONFIGURATIONS

Strand Size	No. Strands	Ultimate Capacity Breaking Load (1) kN	Borehole Diameter (2) Temporary Anchor mm	Borehole Diameter (2) Permanent Anchor mm	Permanent Anchor Sheath Size ID/OD (3) mm	Bearing Plate Size (typical) mm x mm x mm
15.2mm/15.7mm	2	512	100	125	50/65	200 x 200 x 32
	4	1024	100	125	65/85	200 x 200 x 36
	7	1792	100	150	80/105	300 x 300 x 50
	12	3072	150	175	100/130	350 x 350 x 60
	19	4864	165	215	125/160	400 x 400 x 70
	22	5632	165	215	125/160	450 x 450 x 80
	27	6912	180	215	150/188	500 x 500 x 80
	31	7936	180	260	150/188	500 x 500 x 90
	42	10752	225	315	175/230	600 x 600 x 100
	55	14080	250	315	200/260	700 x 700 x 120
	65	16640	260	315	200/260	700 x 700 x 140
	91	23296	310	350	250/270	900 x 900 x 160
12.7mm/12.9mm	2	372	100	125	50/65	200 x 200 x 32
	4	744	100	125	65/85	200 x 200 x 36
	7	1302	100	150	80/105	250 x 250 x 40
	12	2232	125	150	100/130	300 x 300 x 50
	19	3534	150	175	100/130	400 x 400 x 70
	31	5766	165	215	150/188	450 x 450 x 80
	42	7812	180	225	150/188	500 x 500 x 90
	61	11346	225	300	175/230	600 x 600 x 100

1. Ultimate capacity based on 15.2mm and 12.7mm strands with UTS of 261kN and 186kN per strand.
2. Borehole diameters may vary depending on ground conditions and sheathing sizes.
3. Corrugated ducting.



Permanent Type Ground Anchor

REMOVABLE ANCHOR TENDON CONFIGURATIONS

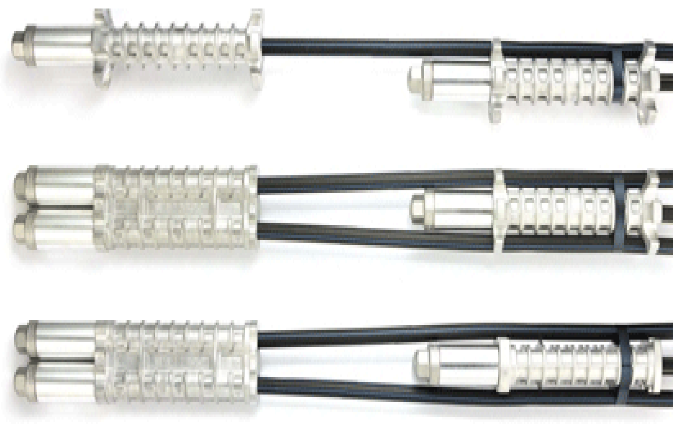
Strand Size	No. Strands	Ultimate Capacity Breaking Load, Tu (1) kN	Borehole Diameter (2) mm	Allowable Design Load, Ta kN	Remarks
15.2mm/15.7mm	3	783	150	470	
	4	1044	150	626	
	5	1305	150	783	Allowable design Load = 0.6Tu
	6	1566	160	940	
	7	1827	175	1096	Allowable lock-off Load = 0.7Tu
	8	2088	175	1253	
	9	2349	175	1409	Stressing Load = 0.75Tu
	10	2610	190	1566	
	11	2871	190	1723	
	12	3132	190	1879	

1. Ultimate capacity based on 15.2mm strands with UTS of 261kN per strand.
2. Borehole diameters may vary depending on ground conditions and selected anchor body.

Removable Type Ground Anchor

The SW-RCD anchor is a load distributive compression type removable anchor that offers a complete solution where anchorage systems required to be removed once they become redundant. Often city municipalities and the like, object to obstructions left in the ground beyond completion of construction for fear they will conflict with future developments or seek third party approval. The SW-RCD anchors are a cost effective solutions where the use of conventional tieback anchors are forbidden or discarded due to logistical and or practical site constraints. The entire steel strand can be quickly and easily removed or reengaged with limited site access. Simply rotate the strand to release the wedges which are fixed in the end of the anchor body and the entire steel strand is easily withdrawn through the PE sheath leaving the small aluminium anchor body.

The removal process is generally done by hand. In addition, allowing the steel strand to penetrate through the inside and be secured to the end of the anchor body, distributes the jacking force along the length of the anchor body which maximizes the effective cross-sectional area of the grout body. Since their initial development these anchors have been employed in numerous projects around the world providing lateral support to temporary sheeting and shoring conditions.



BAR ANCHOR PROPERTIES

Bar anchors typically consist of grade 1030 or Grade 550 steel tendons. The following table provides generic properties, but it should be noted that these do vary slightly depending on the manufacturer.

Grade 1030					
Diameter	Min. Break Load Fpk, (kN)	Mass (kg/m)	Area (mm2)	70% Force (kN)	Young's modulus (GPa)
26.5	569	4.56	552	398	170
32	828	6.66	804	580	170
36	1048	8.45	1018	734	170
40	1295	10.41	1257	906	170
50	2022	16.02	1965	1415	170
75	4311	33.2	4185	3018	205

Grade 550					
Diameter	Min. Break Load Fpk, (kN)	Mass (kg/m)	Area (mm2)	70% Force (kN)	Young's modulus (GPa)
20	188	2.47	314	131	205
25	270	3.85	491	189	205
32	442	6.31	804	309	205
40	691	9.86	1257	484	205
50	1080	15.4	1965	756	205

Temporary Bar Anchors

Anchors used in temporary applications do not require any form of protection. However, It is important to note that temporary anchors installed within an aggressive ground environment should include some form of protection that may include bar coating systems or full encapsulation within corrugated ducting like a permanent anchor.

Permanent Bar Anchors

In some instances, bar coating systems can also be used to provide protection to the steel bars. Galvanising and fusion epoxy coatings are typical. However, typically, permanent bar anchors use a double corrosion protection system to fully encapsulate the steel bars over their entire length. This system comprises cement grout injected into the annulus between the centralised steel bar and corrugated sheathing over the bonded and free lengths. The cement grout inside the corrugated sheathing acts as the first level of protection. The corrugated sheathing is impermeable to corrosive substances and acts as the second level of protection. This encapsulation must take place in a controlled factory environment.

In the bond length, the corrugations of the sheathing transfer the load to the surrounding grout in the borehole. In the free length, the load is transfer is prevented by fitting a smooth sheathing over the corrugated sheathing.

To accommodate elongation of the anchor during tensioning, a short section of the steel bar remains un-grouted beneath the bearing plate. A steel trumpet is welded to the bearing plate and fits over the free length sheathing to provide full encapsulation. The tube is filled with an anti-corrosion compound.

The bearing plate and termination nut are covered by a removable protective cap that is filled with an anti-corrosion compound.

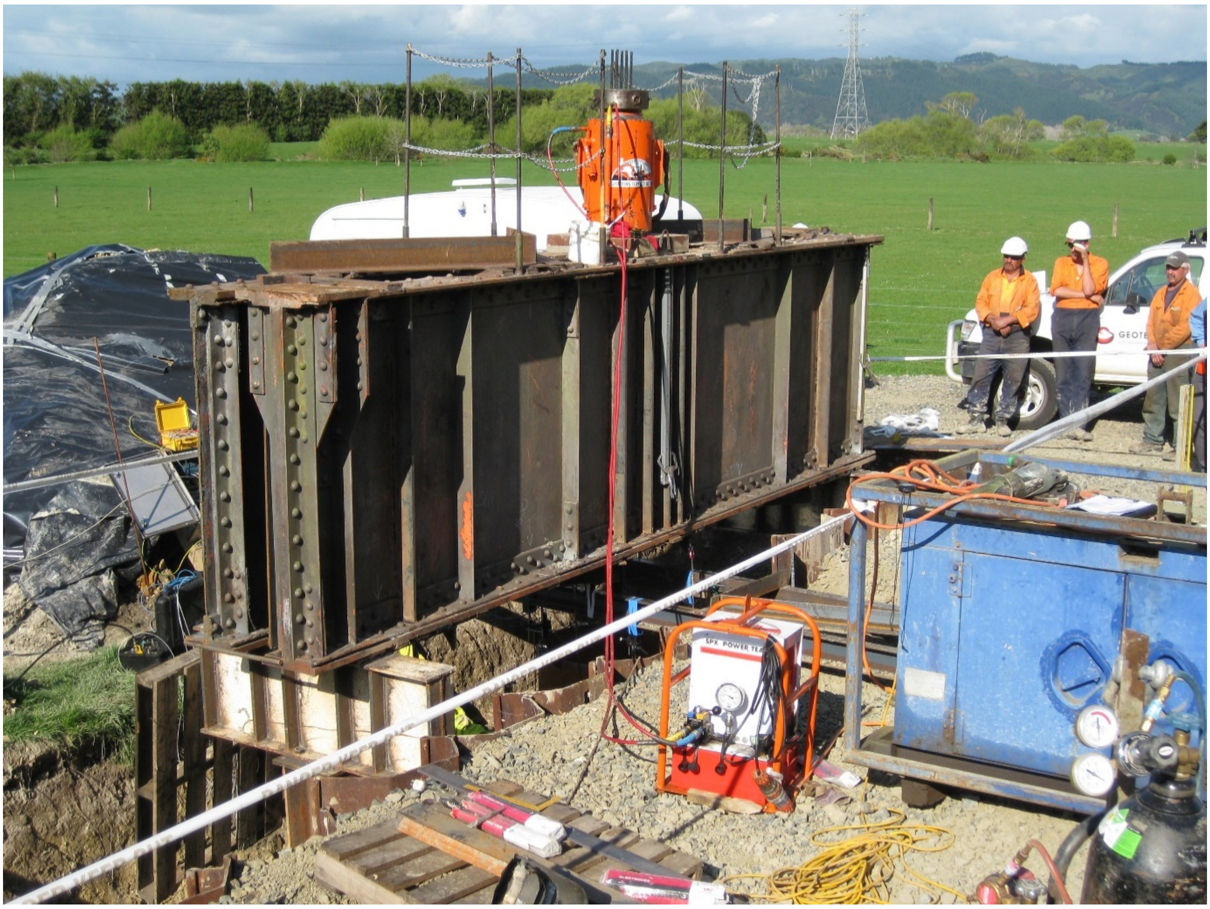
Where couplers are required, an anti-corrosion compound is applied to the bar and coupler and then covered with one or two layers of a heat-shrink sleeve. In the free length, an additional smooth tube is placed over the protected coupler to ensure movement during tensioning.

BAR ANCHOR TENDON CONFIGURATIONS

Bar Siza * nominal	No. Bars	Ultimate Capacity Breaking Load (1) kN	Borehole Diameter (2) Temporary Anchor mm	 Permanent Anchor mm	Permanent Anchor Sheath Size ID/OD (3) mm	Bearing Plate Size (typical) mm x mm x mm
Grade 1050*						
26.5	1	569	100	125	65/85	200 x 200 x 32
32	1	828	100	125	65/85	200 x 200 x 36
36	1	1048	150	150	80/105	250 x 250 x 50
40	1	1295	150	150	80/105	250 x 250 x 60
50	1	2022	150	175	100/130	300 x 300 x 60
75	1	4311	165	225	125/160	400 x 400 x 90
Grade 550*						
20	1	188	100	125	65/85	150 x 150 x 16
25	1	270	100	125	65/85	150 x 150 x 20
32	1	442	100	125	65/85	200 x 200 x 32
40	1	691	150	150	80/105	200 x 200 x 50
50	1	1080	150	175	100/130	250 x 250 x 50
63.5	1	2217	150	175	100/130	300 x 300 x 70

1. Ultimate capacity based on nominal grade and diameters shown.
2. Borehole diameters may vary depending on ground conditions and sheathing sizes.
3. Corrugated ducting.


HD180DR




SPX POWER TEAM
GROUTING SERVICES NZ LTD


VUKSICH & BORICH

Grouting Services NZ Limited

Grouting Services has been operating in New Zealand for over 40 years. In this time, they have established themselves as a leader in their sector and have earned the respect of their customers. Grouting Services is proudly New Zealand owned and operated.

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