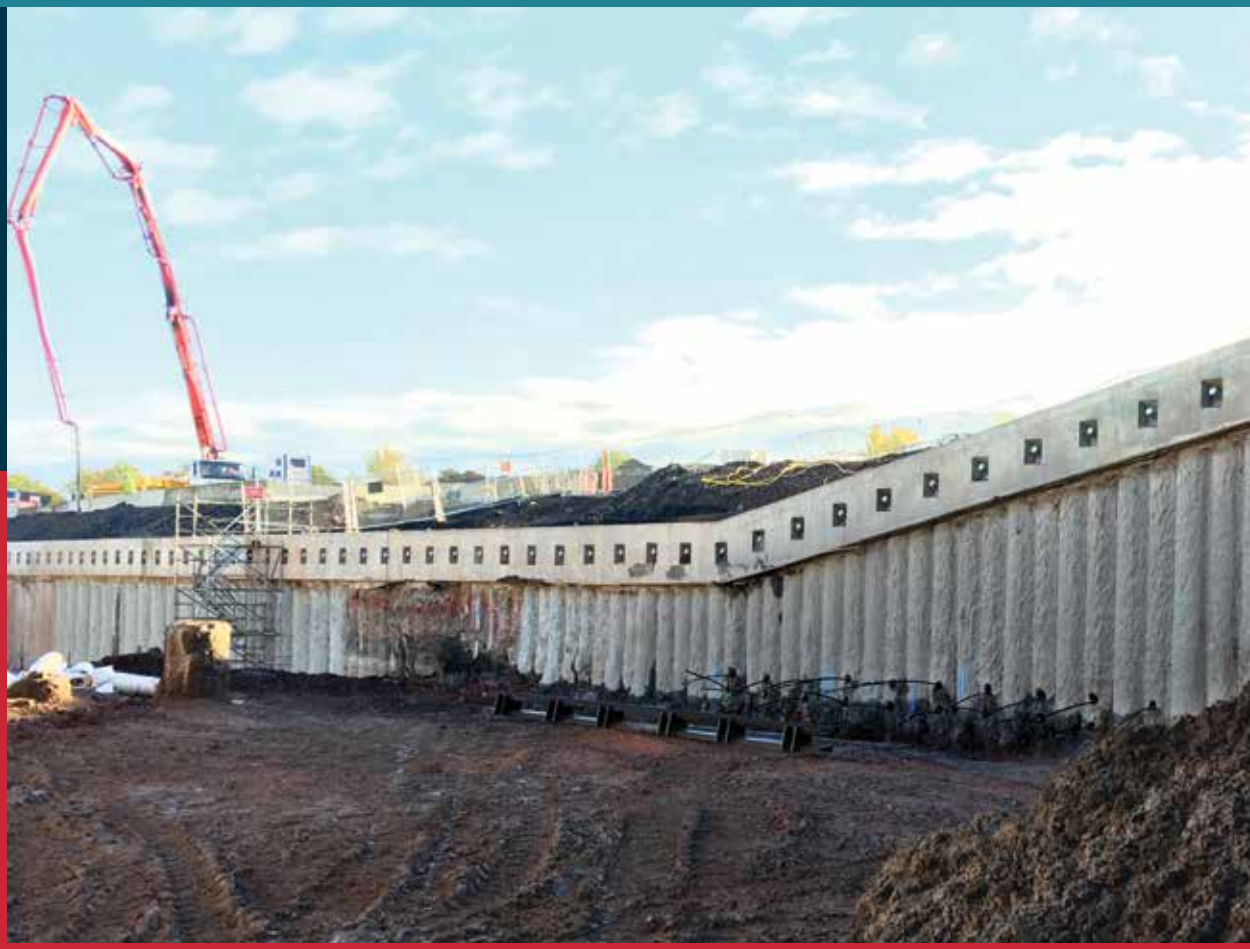
DYWIDAG

WE MAKE INFRASTRUCTURE
SAFER, STRONGER, AND SMARTER.

ANCHOR SYSTEMS




JCB
JCB
JCB

Contents

About us

DYWIDAG Ltd are a specialist geotechnical systems supplier with expert technical knowledge and longstanding experience in pre-stressed anchoring systems.

Anchors are used throughout infrastructure development to provide restraint for a range of structures from hydro-electric dams to sheet pile walls. The anchoring systems developed by DYWIDAG Ltd lead the industry in this specialist construction application.

Our comprehensive approach allows us to provide our customers with technical advise based on the requirements and characteristics of the whole solution rather than the individual components. By providing a specialist elemental technical service, we can provide advice and guidance on how changes can be made to increase the technical or economical efficiencies within the solution provided.

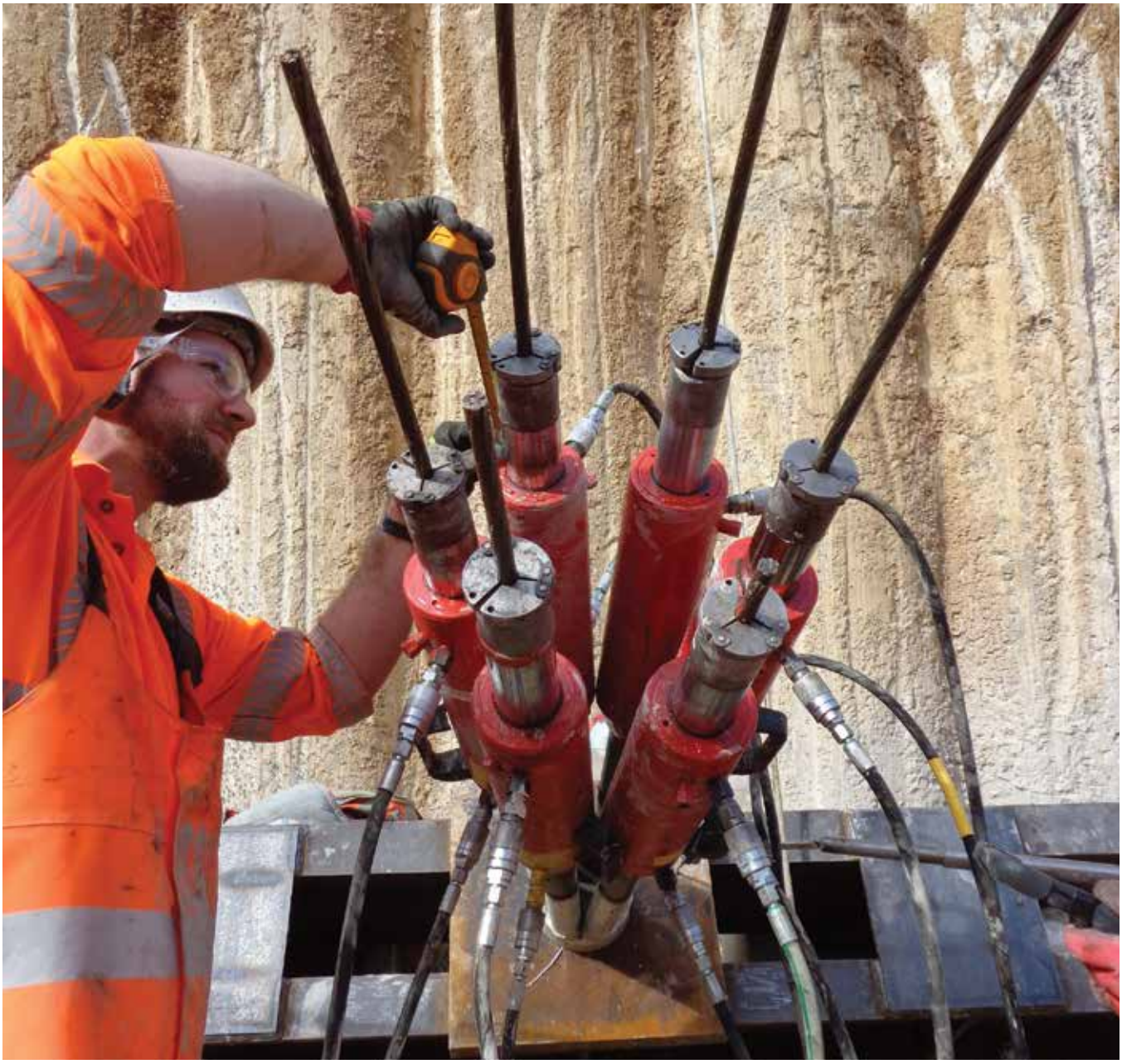
DYWIDAG Ltd was established in 1967 and has provided both products and technical advice to the UK's geotechnical drilling contractors and engineers ever since.

By drawing on our experience, not only in anchoring systems but also slope stabilisation, micro piling and rock bolting, we have have a reputation in line with our core values of:

- Technical Expertise & Advice
- High Quality Products
- Professional & Customer Focused Service
- Prompt & Efficient Deliveries

DYWIDAG Ltd is a globally aligned organisation with the ability to draw on experience from around the worldand therefore, we also understand the sensitivities and differing demands of local markets and therefore we aim to live up to our motto:

Local Presence – Global Competence



Anchoring Systems

Basic Concept

Ground anchors are defined as a pre-stressed element which actively contribute to the stability of the structure throughout its design life. Unlike passive elements the performance of the anchor is critical to the stability of the structure.

Force is applied to the surface of the wall or slab by pre-stressing the anchor using a stressing jack to elongate the tendon, once the necessary load has been established, the anchor is “locked off” at the head. From this moment onwards the anchor will be applying a compressive load to the structure to arrest movement.

To prevent load from being transferred into unsuitable material and to ensure sufficient elongation of the tendon is possible, the tendon is de-bonded from the ground between the structure and the load-bearing strata. Upon reaching the desired depth, the tendon is directly bonded to the ground. This forms the two fundamental elements of the ground anchor, the free length and the bond length.

Critical characteristics of ground anchors are:

- Length (Free & Bond Lengths)
- Diameter
- Tensile Capacity
- Relaxation Rate
- Installation Angle
- Corrosion Protection

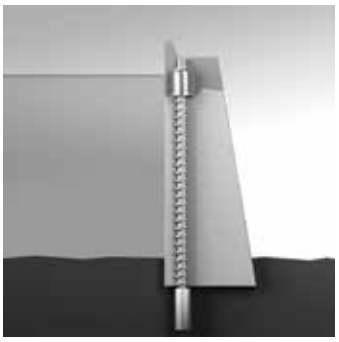
As the quality of available space for development reduces, the requirements for ground anchors increase, and the challenges facing ground anchoring change. In addition to our conventional systems, we have developed specialist anchoring products for:

- Anchors in poor soil conditions
- Removable anchors for use in urban environments
- Cuttable anchors that can be left in the ground following their use without causing an obstruction to future development

All ground anchors must be tested and their capabilities proven before they can be commissioned. Therefore, we have a dedicated team of specialist technicians that supply stressing and testing services as well as a large range of bespoke equipment for hire.







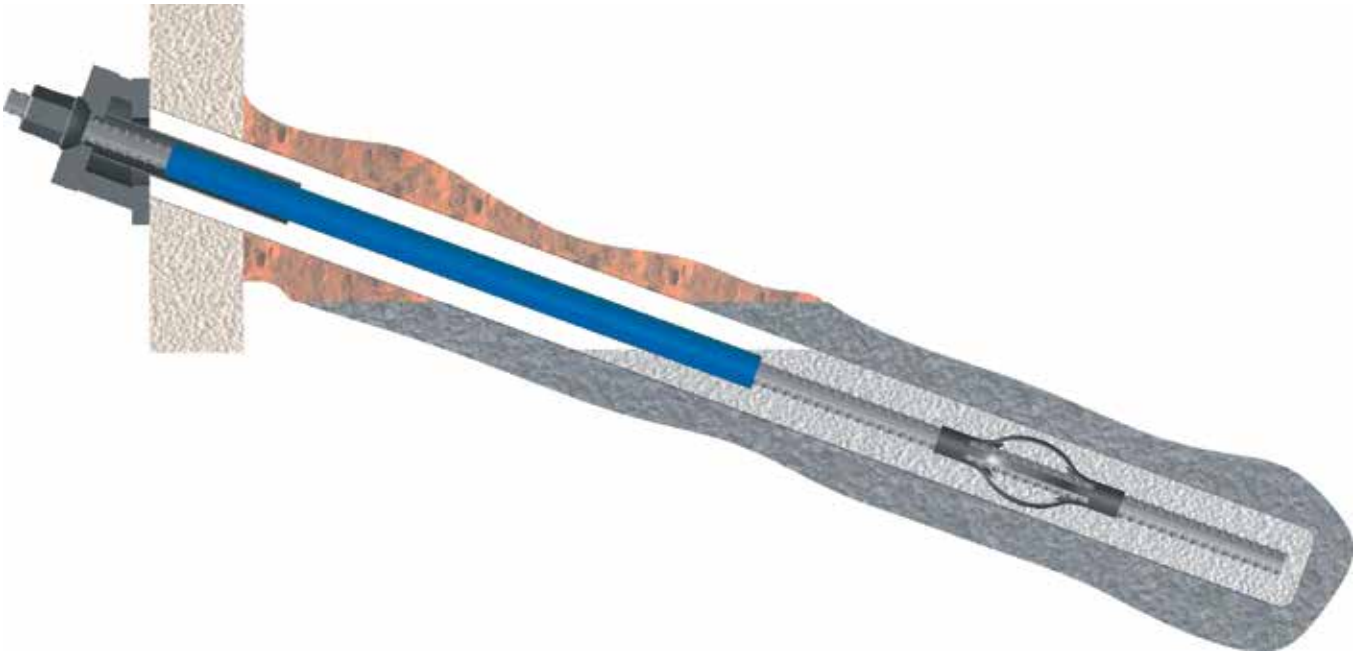


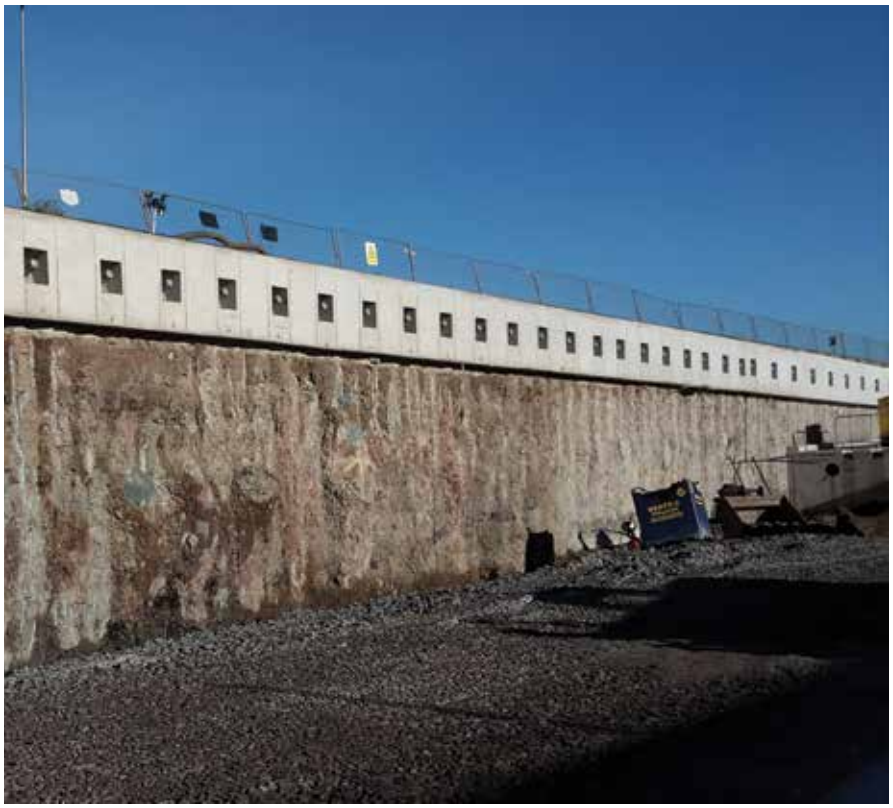
DYWIDAG Bar Anchors

Basic Concept

Bar Anchors are formed from a solid steel threadbar which can be installed in coupled sections to achieve the desired design depth. Bar anchors are the simplest type of anchor with a long history of use. The modular nature of the bar anchor system means that installation, although sometimes challenging due to the length of the individual bars, is straightforward. In an unrestricted working area, individual bar lengths of up to 12m can be installed. In areas of restricted access, bar lengths can be tailored to meet the site specific requirements of the project.

We have a range of Threadbar systems suitable for use in anchoring applications. This ensures that an economic choice of tendon can be made. The main consideration is available space vs load capacity.





DYWIDAG Bar Anchors

DYWIDAG Gewi

DYWIDAG Gewi Steel High Yield Threadbar is a high tensile alloy steel bar which features a coarse left-hand thread over its full length. The system is proven worldwide and offers versatility in a range of applications.

Manufactured in accordance with the German Certificate of Approval (Deutsches Institut für Bautechnik), the system also offers general conformance with BS 4449 : 2005 (Steel for the Reinforcement of Concrete).

The minimum specified characteristic yield strength is 500 N/mm^2 for bar diameters 16 - 50mm and 555 N/mm^2 for the 57.5 - 63.5mm diameter bar.

16 - 50mm bars can be welded using appropriate industry practices relative to the carbon content of the steel. Welding off the higher grade 63.5mm diameter bar is also acceptable with additional measures.

The most common sizes of DYWIDAG Gewi bar used in ground anchoring applications are 28 - 63.5mm. The DYWIDAG Gewi product comes with a full range of accessories including domed nuts, full strength couplers, bearing plates, steel protection caps and spacers.

Modulus of Elasticity

- E = 205,000 N/mm^2 +/- 5%
- Stock Lengths
  - All bar diameters 12.0m. Tolerances +/- 100mm. Special lengths up to 18.0m are available to order.

All bar diameters can be cut to length to suit customer requirements or supplied bent to BS 8666 : 2000.

DYWIDAG Gewi Plus

DYWIDAG Ltd has developed the DYWIDAG Gewi Plus systems to meet the challenges set by restrictions in construction space and higher demands on load capacities of steel elements.

DYWIDAG Gewi Plus offers an increase in strength compared to traditional DYWIDAG Gewi Threadbars. DYWIDAG Gewi Plus has a yield strength of 670 N/mm^2 – an increase of 34% and an ultimate strength of 800N/mm^2 – an increase of 45%.

In instances where construction tolerances within a concrete column, precast segment or borehole are tight, the increased strength offered by DYWIDAG Gewi Plus can allow for bar sizes to be reduced subsequently, allowing for concrete cover requirements to be met or borehole sizes to become smaller.

Compared to DYWIDAG Gewi, DYWIDAG Gewi Plus can reduce the cross sectional area of steel required in a ground anchor pile or rock bolt by up to 25% due to the increased strength.

Despite the high strength, DYWIDAG Gewi Plus is not sensitive to stress crack corrosion and hydrogen induced embrittlement.

The robust DYWIDAG Gewi Plus thread is specially designed for rough site conditions. The right-hand thread over the full length offers the possibility to fix and couple the bars at any point.

DYWIDAG Gewi Plus is fully integrated in the ISO 9001 quality assurance system of DYWIDAG Ltd.

Prestressing Steel

DYWIDAG Prestressing Steel Threadbar is a high tensile alloy steel bar which features a coarse right-hand thread over its full length. The system is proven worldwide and offers versatility in a range of applications.

Manufactured in accordance with the German Certificate of Approval (Deutsches Institut für Bautechnik), the system also offers general conformance with BS 4486 : High Tensile Steel Bars for Prestressing of Concrete.

During the steel making process, the threadbars are hot rolled, quenched and tempered, followed by cold working and further tempering, to achieve the necessary performance.

DYWIDAG Prestressing Steel Threadbars, 15mm - 75mm Ø, are suitable for all static loading applications. Additionally, for post-tensioning and dynamic applications, DYWIDAG Prestressing Steel Threadbars 26.5mm - 40mm Ø, offer a fatigue resistance in excess of 2 million load cycles over a tensile range of 630 - 682N/mm^2 as specified in the European Technical Approval No. ETA - 05/0123 and ETAG 013. Stress relaxation when loaded to 70% fpu is less than 3.5% over a 1000 hour period in accordance with BS4486.

The low relaxation characteristics combined with the high strength offered by prestressing steel make it ideal for anchoring applications.

DYWIDAG Bar Anchors

Threadbar Data

DYWIDAG Gewi Threadbar

Nominal Diameter	Steel Grade	Ultimate Strength	Yield Strength	Design Resistance (BS8081)	Cross-Sectional Area	Diameter Over Threads	Thread Pitch	Weight
[mm]	[N/mm²]	[kN]	[kN]	[kN]	[mm²]	[mm]	[mm]	[kg/m]
16		121	101	88	201	18	8	1.58
20		188	157	137	314	23	10	2.47
25		295	246	214	491	28	12.5	3.85
28		370	308	268	616	32	14	4.83
32	500 / 600	482	402	350	804	36	16	6.31
36		612	510	443	1,020	40	18	7.99
40		754	629	547	1,257	45	20	9.86
50		1,178	982	854	1,963	55	26	15.41
57.5		1,818	1,441	1253	2,597	63	20	20.38
63.5	555 / 700	2,217	1,758	1529	3,167	69	21	24.66
75	500 / 600	2,651	2,209	1921	4,418	82	24	34.68

DYWIDAG Gewi Plus Threadbar

Nominal Diameter	Steel Grade	Ultimate Strength	Yield Strength	Design Resistance (BS8081)	Cross-Sectional Area	Diameter Over Threads	Thread Pitch	Weight
[mm]	[N/mm²]	[kN]	[kN]	[kN]	[mm²]	[mm]	[mm]	[kg/m]
18		203	170	148	254	21	8	2.00
22		304	255	222	380	25	8	2.98
25		393	329	286	491	28	10	3.85
28		493	413	359	616	32	11	4.83
30		566	474	412	707	34	11	5.55
35	670 / 800	770	645	561	962	40	14	7.55
43		1,162	973	846	1,452	48	17	11.40
50		1,570	1,315	1143	1,963	56	18	15.40
57.5		2,078	1,740	1513	2,597	63	20	20.38
63.5		2,534	2,122	1845	3,167	69	21	24.86
75		3,534	2,960	2574	4,418	82	24	34.68

Prestressing Steel Threadbar

Nominal Diameter	Steel Grade	Ultimate Strength f_{pu}	0.1% (a) Proof Strength	Design Resistance (BS8081)	Cross-Sectional Area	Diameter Over Threads	Thread Pitch	Weight
[mm]	[N/mm²]	[kN]	[kN]	[kN]	[mm²]	[mm]	[mm]	[kg/m]
15	900/1100	195	159	138	177	17	10	2.00
20		345	283	246	314	23	10	2.56
26.5		579	525	456	551	30	13	4.48
32		845	760	661	804	36	16	6.53
36	950/1050	1,070	960	835	1,020	40	18	8.27
40		1,320	1,190	1,035	1,257	45	20	10.21
47		1,822	1,650	1,435	1,735	52	21	14.10
57		2,671	2,155	1,874	2,581	64	21	20.95
65	835/1035	3,447	2,780	2,417	3,331	71	23	27.10
75		4,572	3,690	3,209	4,418	82	24	35.90

DYWIDAG Bar Anchors

Accessories

DYWIDAG Gewi Accessories

Nominal Diameter	Static Coupler		Lock Nut		Hexagonal Nut		Domed Nut		Eye Nut WLL 2t	
										
	Dia.	Length	AF	Length	AF	Length	AF	Length	Width	Height
[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
16	32	90	32	30	32	40	27	33	62	87
20	36	105	32	40	36	45	36	42	66	96
25	40	115	41	40	41	50	41	45	71	106
28	45	125	41	45	46	55	41	54	76	112
32	52	140	50	50	55	60	46	57	95	135
36	60	150	55	55	60	65	N/A	N/A	100	140
40	65	160	65	70	65	70	60	70	105	155
50	80	200	80	85	80	85	80	85	120	185
57.5	102	230	90	80	90	100	90	100	130	230
63.5	102	260	100	115	100	115	100	115	140	235
75	108	240	100	80	100	100	100	120	140	250

DYWIDAG Gewi Plus Accessories

Nominal Diameter	Static Coupler		Lock Nut		Hexagonal Nut		Domed Nut		Eye Nut WLL 2t	
	Dia.	Length	AF	Length	AF	Length	AF	Length	Width	Height
[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
18	36	100			36	45	32	35	66	96
22	40	110			41	50	36	45	71	106
25	45	120			46	55	41	50	76	116
28	50	140	46	53	50	60	46	55	80	125
30	55	150	50	60	55	65	50	60	85	140
35	65	120	55	65	65	70	60	70	105	155
43	80	200	70	80	80	90	70	85	120	190
50	90	210	80	90	80	100	80	100	130	200
57.5	102	250	90	100	90	120	90	115	130	230
63.5	114	300	100	105	100	145	100	125	140	230
75	108	250	100	120	100	130	120	150	140	250

Prestressing Steel Accessories

Nominal Diameter	Static Coupler		Lock Nut		Hexagonal Nut		Domed Nut		Eye Nut WLL 2t	
	Dia.	Length	AF	Length	AF	Length	AF	Length	Width	Height
[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
15	36	100								95
20	40	110								121
26.5	50	170	36	22	46	80	50	75	76	141
32	60	200	41	22	55	90	60	90	95	165
36	68	210	46	25	60	110	65	100	100	190
40	70	245	50	25	70	120	70	115	110	210
47	83	270	60	30	80	140	80	135	120	240
57	95	240	85	40	90	120			130	230
65	106	260	90	40	100	130			140	250
75	114	290	105	50	105	145			145	270

DYWIDAG Strand Anchors

Basic Concept

Strand anchors are assembled from flexible steel wire strand. These anchors are made to order and are installed in one continuous length.

Strand anchors are most commonly used when anchor lengths exceed 20m or when access restrictions prevent solid threadbars from being used.

Strand anchors are supplied to site coiled with a grouted bond length. Strand anchors can be unwound directly into a borehole; this is particularly useful when working in tunnels or basements.

Strand anchors also provide a solution when anchor capacities exceed the strength of the threadbar ranges available. Each 15.2mm compact strand has an ultimate load of 300kN and multiple strands can be incorporated into an anchor. The maximum number of strands used is only dictated by the stressing equipment available to the installer, and capacities of up to 8,000kN have been achieved to date.

In a conventional strand anchor, all of the strands begin and end at the same point.

Strand offers more challenges when it comes to stressing the ground anchor due to its increased elongation under load when compared to solid threadbar.

Instead of a thread and a nut, a head block and series of wedges are used to lock off the anchor.

DYWIDAG Strand Anchor Capacity

No. Strands	Ultimate Strength	0.1 Proof Strength	Design Resistance (BS8081)	Tendon Cross Sectional Area
	[kN]	[kN]	[kN]	[mm^2]
1	300	255	222	165
2	600	510	443	330
3	900	765	665	495
4	1,200	1,020	887	660
5	1,500	1,275	1,109	825
6	1,800	1,530	1,330	990
7	2,100	1,785	1,552	1,155
8	2,400	2,040	1,774	1,320
9	2,700	2,295	1,996	1,485
10	3,000	2,550	2,217	1,650
11	3,300	2,805	2,439	1,815
12	3,600	3,060	2,661	1,980

DYWIDAG Strand Anchors

Multi-Stage Strand Anchors

Basic Concept

The multi-stage strand anchor has been developed from the need to achieve greater anchor loads in poor ground conditions. It offers uniform distribution of load over the full bond length in addition to efficient utilisation of the in-situ ground strength.

Conventional ground anchors are limited to a maximum fixed length of 10m
(BS 8081); extending the conventional fixed length will not produce a gain in load carrying capacity, because any higher loading would induce progressive de-bonding from the proximal end of the fixed anchor length due to stress concentration.

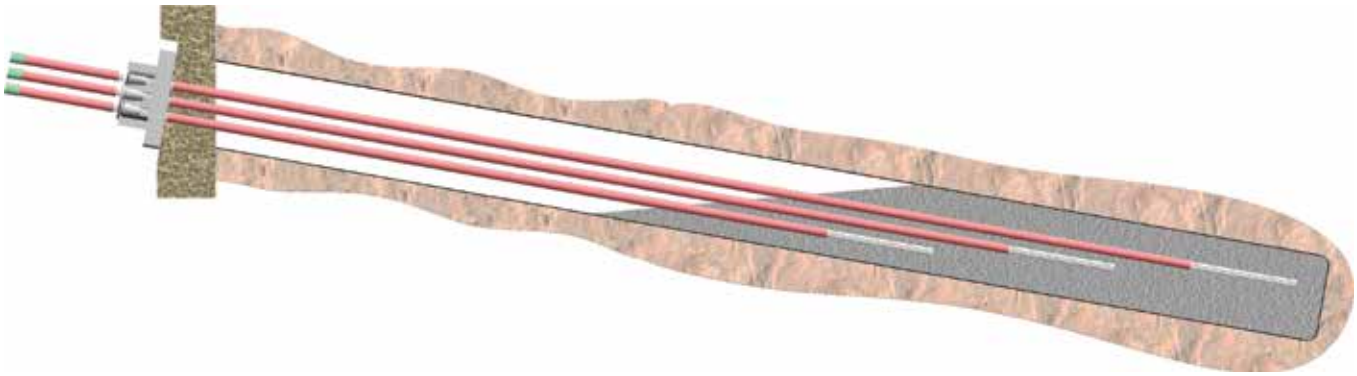
The multi-stage anchor accommodates any uneven distribution of load by employing individually staged bond lengths along the fixed length. It provides the solution where ground conditions dictate a fixed anchor length greater than that achievable with a conventional anchor. Multi-staging enables the fixed length to be increased in proportion to the number/ length of stages. Through efficient distribution of load over the entire fixed anchor length, the multi-stage anchor is able to develop proportionately higher loads than conventional anchors.

The technique of staging individual bond lengths within the fixed anchor length, ensures an even distribution of load.

Individual bond lengths, in conjunction with the borehole diameter, are matched to the soil strength. Typical bond lengths range from 2 to 4.5m; in general, bond lengths within this range offer the most efficient distribution of load, but longer bond lengths are available to suit particular ground conditions.

Bond stress performance is enhanced along the tendon/grout interface by noding of the strands.

Fixed length extension is matched to the extension characteristics of the soil.



Multi-Stage Strand Anchor Capacity

No. Strands	Ultimate Strength	0.1 Proof Strength	Design Resistance (BS8081)	Tendon Cross Sectional Area
	[kN]	[kN]	[kN]	[mm²]
1	300	255	222	165
2	600	510	443	330
3	900	765	665	495
4	1,200	1,020	887	660
5	1,500	1,275	1,109	825
6	1,800	1,530	1,330	990
7	2,100	1,785	1,552	1,155
8	2,400	2,040	1,774	1,320
9	2,700	2,295	1,996	1,485
10	3,000	2,550	2,217	1,650
11	3,300	2,805	2,439	1,815
12	3,600	3,060	2,661	1,980

Double Corrosion Protection

Basic Concept

BS8081 defines permanent anchors as installations with lifespans in excess of 2 years. In order to achieve this status, sufficient corrosion protection needs to be provided. To ensure durability throughout the working life of each anchor, double corrosion protection needs to be provided. Double corrosion protection (DCP) is defined in BS8081 and consists of factory pre-grouted encapsulation of the bar within a corrugated plastic sheath.

DYWIDAG DCP Anchors are capable of providing consistent performance for 120 years. The specialist coupler and head assembly details ensure that a consistent double corrosion protection is provided for the full anchor length.

DCP head details are fully enclosed and incorporate a steel protection cap for the anchor head which is filled with a water resistant grease. Depending on maintenance requirements over the anchor lifespan, the stressing length can be left long to permit regular lift-off tests. For longer stressing lengths, a longer protection cap can also be provided.

Borehole grout is not recognised by current anchor standards (BS8081 or EN1537) as a corrosion protection barrier due to its susceptibility to contamination and potential inconsistency.

DYWIDAG Bar Anchor Sheathing System

Dia.	Ribbed Ø	Smooth Ø	Coupler Ø
[mm]	[mm]	[mm]	[mm]
Gewi			
16 - 25	50	55	70
28 - 40	65	70	83
50	80	86	117
57.5 - 63.5	100	107	144
Gewi Plus			
25	50	55	70
30 - 35	65	70	83
43 -50	80	86	117
57.5 - 63.5	100	107	142 / 144
75	110	125	144

DYWIDAG Strand Anchor Sheathing System

No. Strands	Sheating Ø	Duct/Borehole Ø
	[mm]	[mm]
1 - 4	90	125
5 - 9	125	170
10 - 15	160	200
16 - 19	160	200
20 - 21	160	240

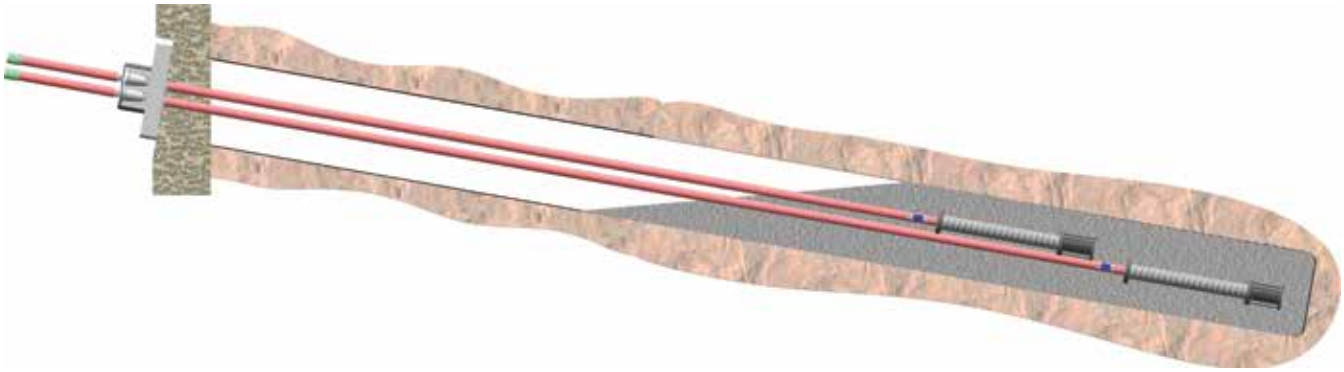
DYWIDAG Removable Strand Anchors

Basic Concept

DYWIDAG removable strand anchors are based on a multi-stage anchor with a compression unit at the distal end of each stage. The full length of the anchor, other than the compression unit, is de-bonded. When the anchor is stressed, the compression unit reacts against the underside of the grout column, putting it into compression: hence the term “compression unit”.

At the base of each compression unit is a rupture point formed from a strand fixing with a known failure load. Stressing the anchor in excess of that failure load causes the strand to break free of the compression unit. It can be removed, leaving only the small compression unit in the ground.

The demand for these anchors in urban areas is increasing, based on the limited easement restrictions imposed by adjacent landowners and the potential for tunneling below urban environments. Removable strand anchors can be supplied to a variety of specifications and can be used for excavation support as an alternative to propping. Anchoring provides the necessary support to excavations, but without reducing the working space or available headroom on site.



GFRP Cuttable Anchors

Basic Concept

When temporary anchors are installed into ground that has potential for future development, an alternative solution to the removable anchor system is the cuttable anchor. Glass Fiber Reinforced Polymer bar has been used for passive systems such as rock bolts and soil nails for some time; however, as a material which is easily cut, it can provide specific qualities desirable temporary pre-stressed systems too.

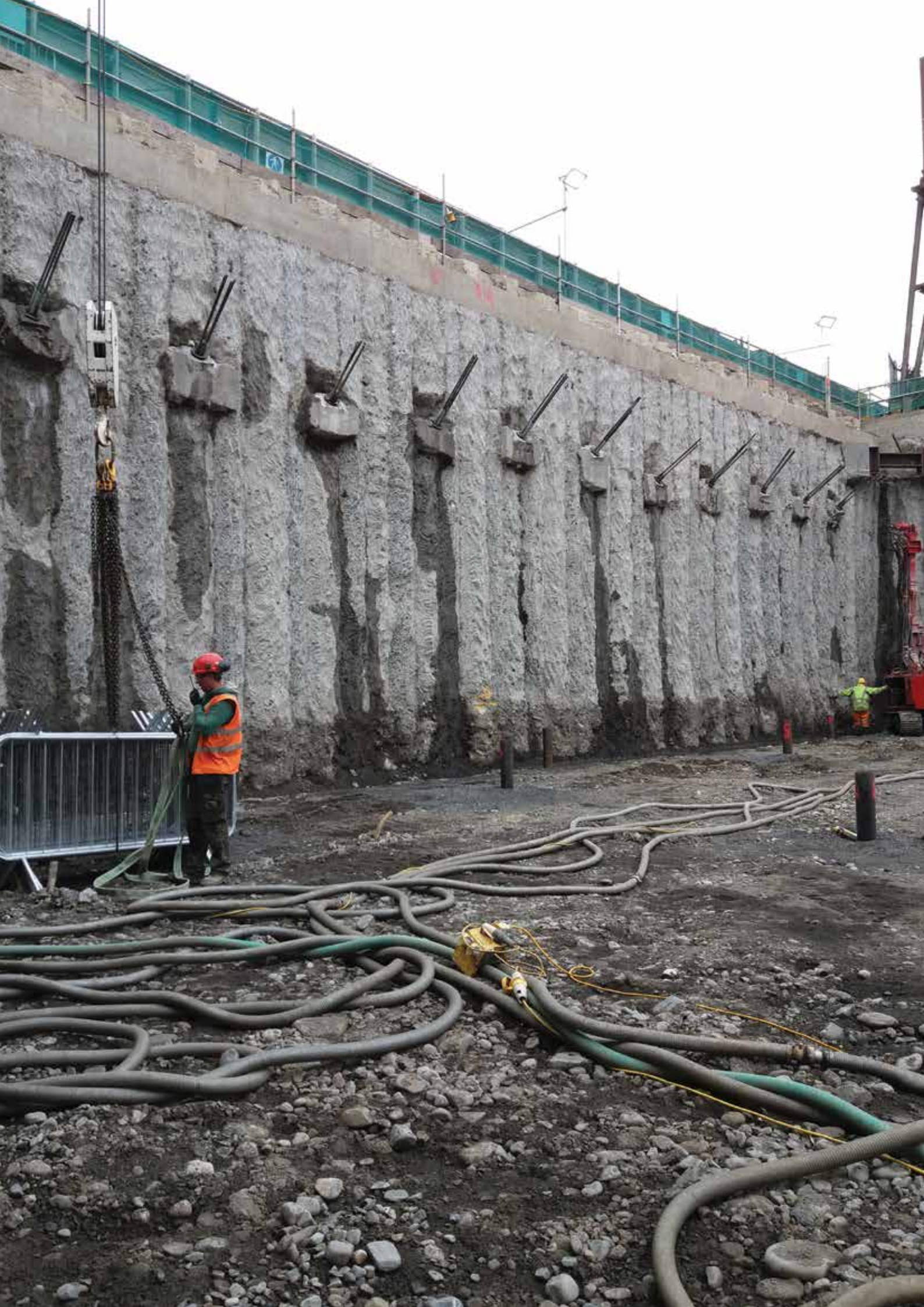
GFRP can take large tensile forces and so lends itself to ground anchoring however due to the materials reduced shear strength compared to steel, the full strength of the bar can not be utilised as the thread form is the limiting element in the system. To compensate for this, several bars form the anchor and combined at the head plate to form a cluster of bars within the anchor.

GFRP anchors are most efficient if they are installed in a single section as the use of couplers will further reduce the load capacity of the bar. GFRP Anchors are light weight and easily lifted into position.

Following their use, these anchors can be de-stressed and left in place. The anchor head can be removed and the bars cut off at the head. If the anchor tendons are encountered below ground at a later date they will be easily cut by an excavator or Tunnel Boring Machine without causing and damage to infrastructure above ground or causing delay to the progression of the tunnel.

GFRP Cuttable Bar Anchor Capacity

No. Bars	Bar Diameter	Ultimate Strength	Cum. Tendon Cross Sectional Area	Cum. Tendon Cross Sectional Area
	[mm]	[kN]	[mm^2]	[mm^2]
1	32	320	165	165
2	32	640	330	330
3	32	960	495	495
4	32	1,280	660	660
5	32	1,600	825	825



Anchor Stressing and Testing Services

Basic Concept

On-site testing ensures the performance of the DYWIDAG Anchoring System. This demonstrates both the quality and adequacy of the proposed design. Depending on the application, the appropriate test method should be chosen. Some tests may be more rigorous and are therefore conducted on sacrificial trial elements, installed as replicas of the working tendons.

The testing of ground anchors generally involves three categories of tests:

Investigation Tests

- Conducted on trial anchors and tested to failure
- They identify the pullout resistance and thus allow for choosing a design load from the anchored structure.
- To ensure that the anchor is bonded into the strata in an adequate distance from the structure to assure its stability.

Suitability Tests

- Conducted on either sacrificial or working anchors to provide a data reference against which the working anchors can be measured.
- To document the ability to resist a proof load
- To assess creep rate or load loss
- To assess apparent free length parameters (the elastic part of the anchor)

Acceptability Tests

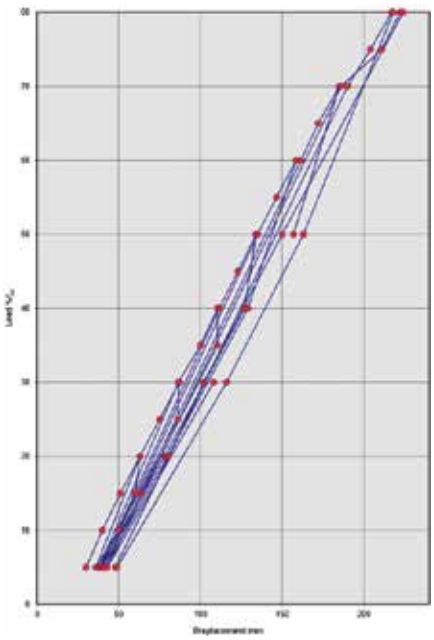
- Conducted on working anchors to ensure construction methods and safety.
- To document the ability to resist a proof load
- To assess creep rate or load loss
- To assess apparent free length parameters

Each test is conducted via loading and unloading cycles and increments up to a known load using a stressing jack. These are tailored to suit the respective test method chosen and capacity of the structural tendon.

On completion of the test, if specific tolerances are met, the anchor can be locked off at a known load. This becomes the datum for any future monitoring.

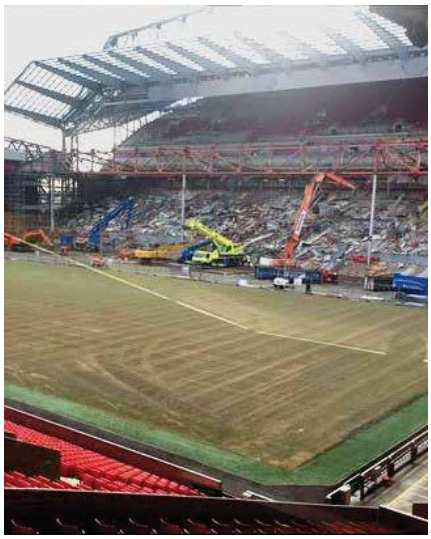
Testing and monitoring features economic advantages during the Service life of the tendon. With information gained from in-situ tests and trials, an optimised assessment of the construction design may be possible. Monitoring and regular inspection increase the service life of both the tendon and therefore the entire retaining structure, as defects or damage can be detected at an early stage.

More information is given in the relevant Codes and Standards BS8081 : 2015.




DYWIDAG

Liverpool FC, Main Stand Anfield – 75mm Permanent Bar Anchors



Owner Liverpool FC, Great Britain +++ **General Contractor** Adana Construction & CAN Geotechnical, Great Britain +++
Engineers Jacobs, Great Britain

Unit DYWIDAG Ltd , Great Britain
Services Technical Advice, Material Supply and Stressing & Testing Services
Products supplied 75mm DYWIDAG DCP Prestressing Steel Ground Anchors

Edinburgh Tram Way – 40mm Permanent Bar Anchors

Owner Transport for Edinburgh, Great Britain +++ **General Contractor** Albion Drilling, Great Britain +++
Engineers Parsons Brinckerhoff & Halcrow, Great Britain

Unit DYWIDAG Ltd , Great Britain
Services Material Supply, Stressing & Testing Equipment Hire
Products 40mm Prestressing Steel, DYWIDAG DCP Bar Anchors

Bank Street Canary Wharf – Permanent Strand Anchors

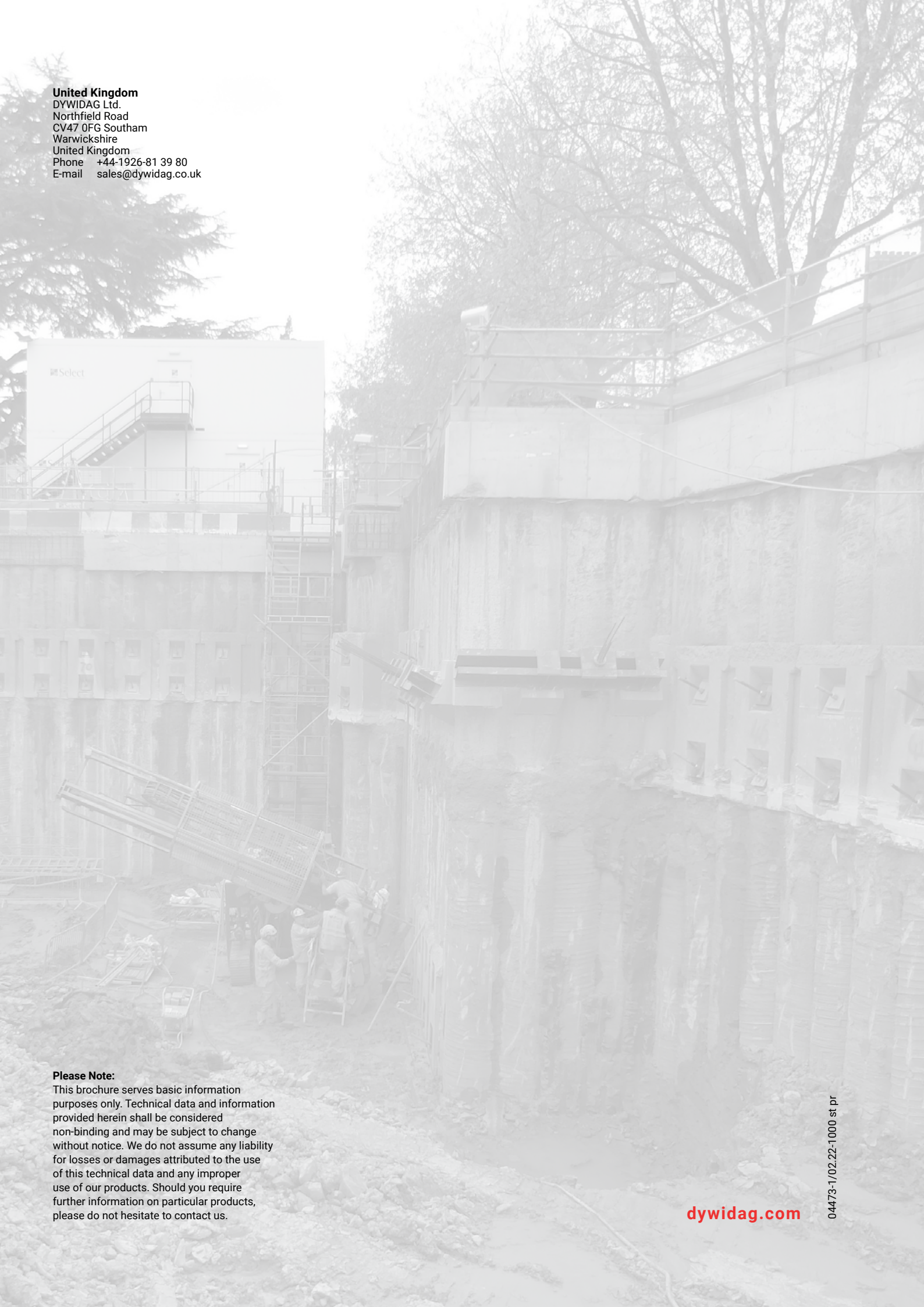
Owner Canary Wharf Group, Great Britain +++ **General Contractor** Bachy Soletanche, Great Britain

Unit DYWIDAG Ltd, Great Britain
Services Material Supply, Stressing and Testing
Products 150 permanent, double corrosion protected DYWIDAG Strand Anchors with 5 strands

Trinity Business School, Dublin – GFRP Temporary Cuttable Anchors

Owner Trinity College, Dublin, Great Britain +++ **General Contractor** BAM Building & PJ Edwards, Great Britain +++
Anchor Designer ARUP, Great Britain

Unit DYWIDAG Ltd, Great Britain
Services Material Supply
Products 3 Bar GFRP Temporary Bar Anchors



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