

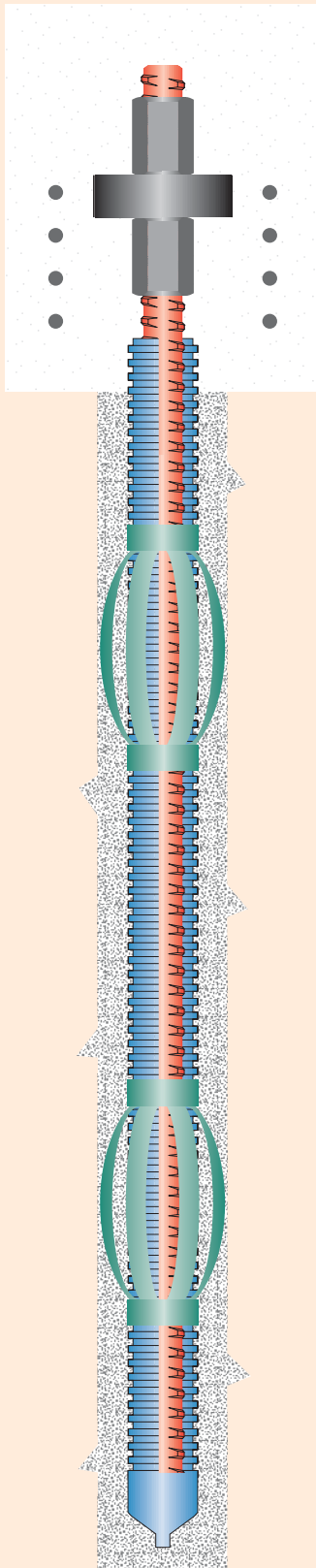


DYWIDAG Geotechnical Product Range





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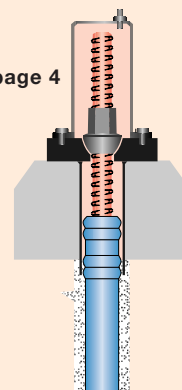
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DYWIDAG Ductile Iron Piles

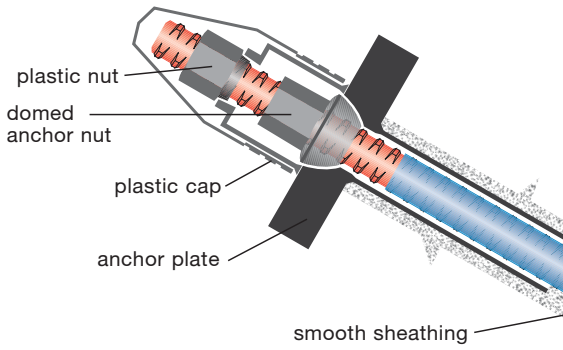
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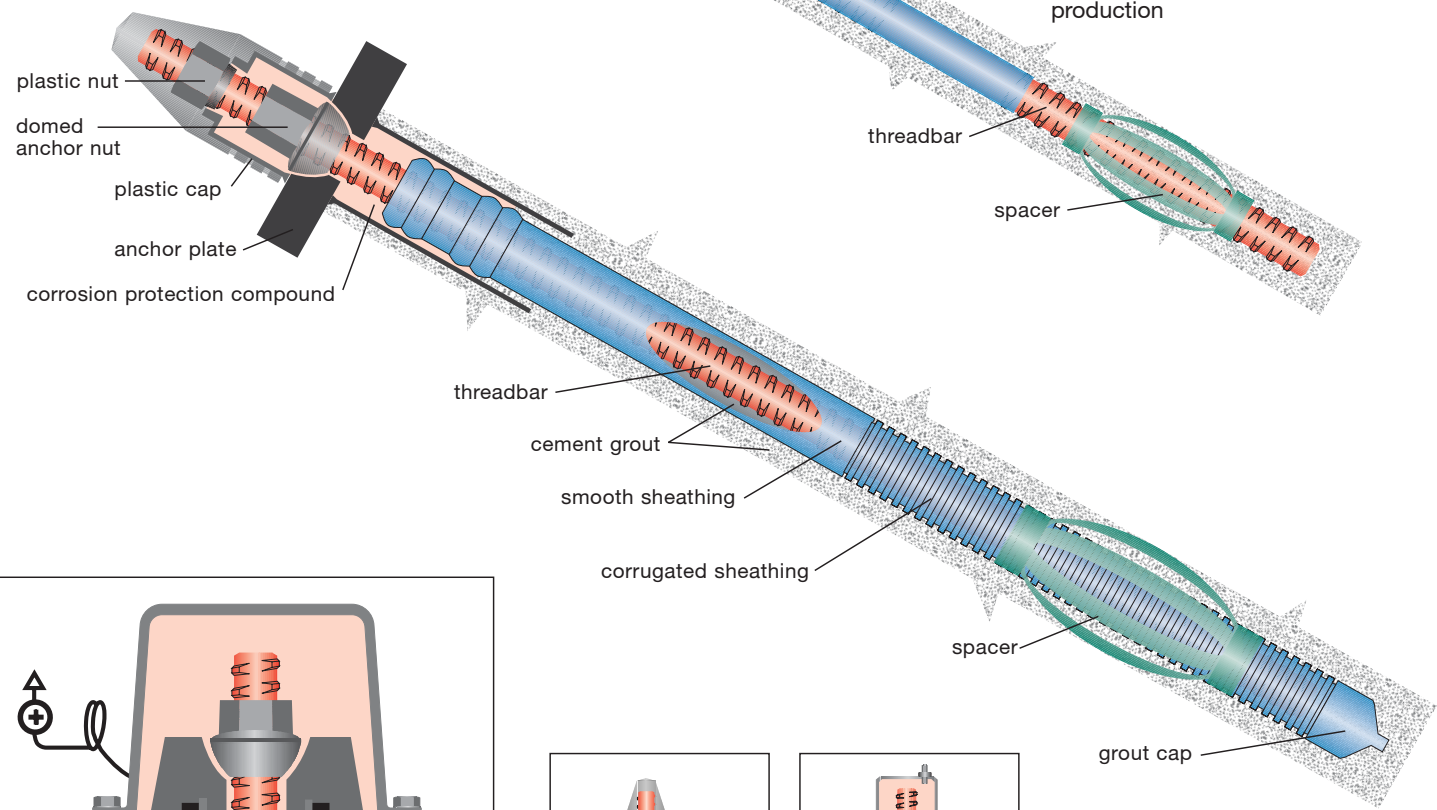


DYWIDAG Threadbar Anchors

Temporary Anchor

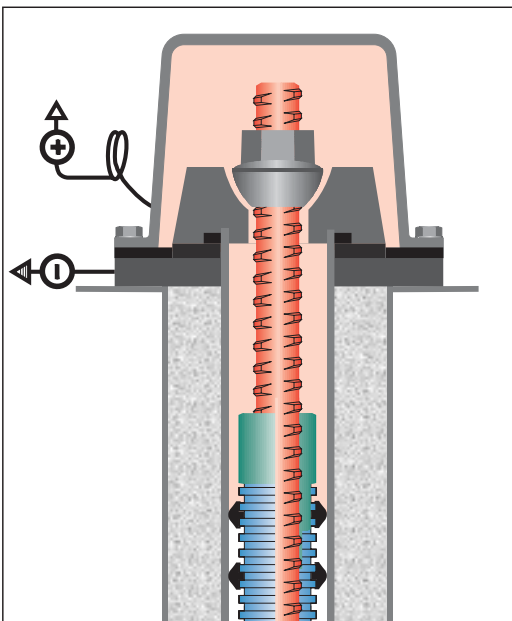


Permanent (DCP) Anchor

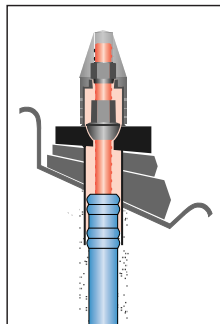


Advantages and Characteristics

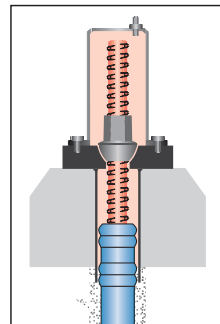
- Easy system handling
- Simple restressing and destressing through threaded anchorage
- Permanent corrosion protection possible
- Easy removal of temporary anchors through threaded sleeves
- Flexibility in transport lengths by using couplers
- High shear bonding between THREADBAR® and cement grout
- High stiffness when installed overhead
- Adjustment of angle through wedge washer and bearing plates
- Quality assurance through internal and external supervision of production



Anchor head for electrically isolated bar anchors



Adjustment of angle through bearing and wedge washer

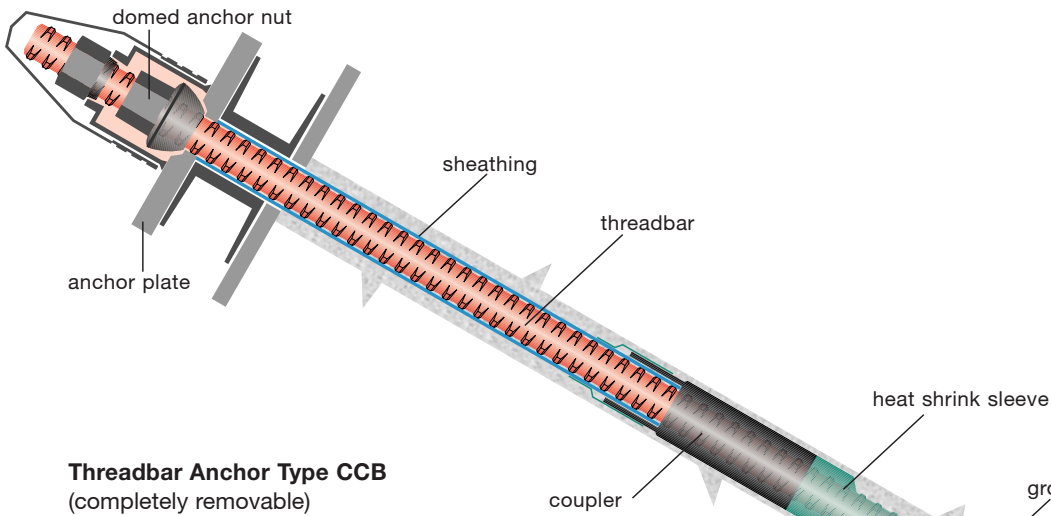


Anchor head concrete or steel support

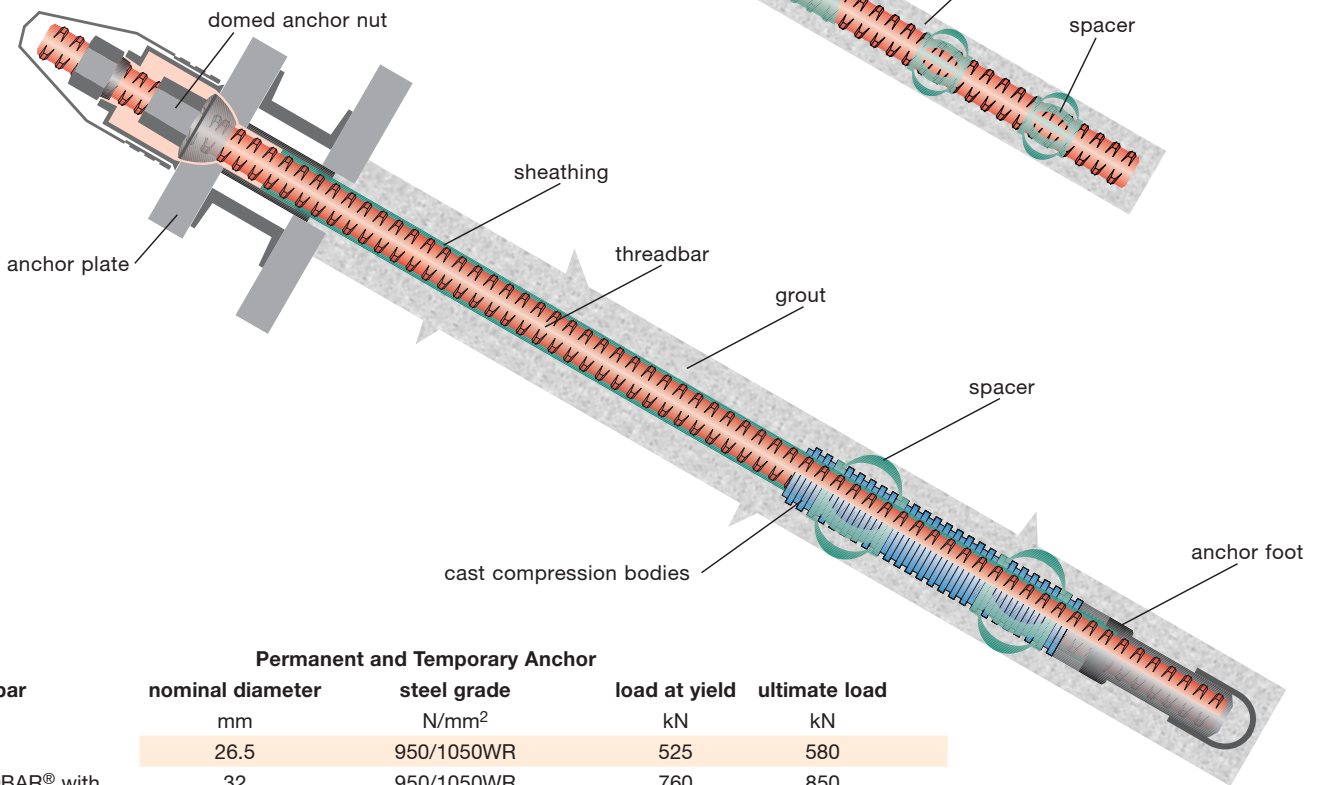
Approval Z-20.1-17
 see: www.dywidag-systems.com
 (downloads – approvals – Germany – Geotechnical Systems)

Removable Threadbar Anchors

Threadbar Anchor Type WG (partially removable)



Threadbar Anchor Type CCB (completely removable)



Permanent and Temporary Anchor

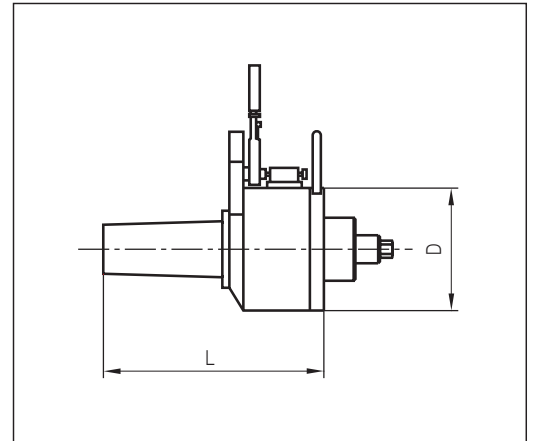
type of bar	nominal diameter	steel grade	load at yield	ultimate load
	mm	N/mm ²	kN	kN
THREADBAR® with right-hand thread	26.5	950/1050WR	525	580
	32	950/1050WR	760	850
	36	950/1050WR	960	1,070
	40	950/1050WR	1,190	1,320
	47	950/1050WR	1,648	1,822
GEWI®Plus bar with right-hand thread	30	670/800	474	565
	35	670/800	645	770
	43	670/800	973	1,162
	57.5	670/800	1,740	2,077
	63.5	670/800	2,122	2,534
GEWI® bar with left-hand thread	40	500/550	628	691
	50	500/550	982	1,080
	63.5	555/700	1,758	2,217

DYWIDAG Threadbar Anchors – Equipment

DYWIDAG Threadbar Jacks



Jack 600 kN Series 04 through 1100 kN Series 03/04



► Technical Data

jack type	length L	diameter D	stroke	piston area	weight
	mm	mm	mm	cm ²	kg
600 kN Series 04	401	190	50	132.5	36
600 kN Series 05	456	190	100	132.5	44
1100 kN Series 01	494	267	50	235.6	46
1100 kN Series 03/04	594	267	150	235.6	54
2000 kN	880	325	150	361.3	210

other jacks on request

Hydraulic Pumps



► Technical Data

pump type	max. operating pressure	capacity oil volume	effective oil amount	weight	dimensions L x W x H
	bar	l/min	l	kg	mm
77-193 A	600	3.0	10.0	63	420/380/450
R 3.0 V	600	3.0	13.0	98	600/390/750

Hydraulic Pumps are delivered without oil filling

Hydraulic pump, type 77 – 193 A

DYWIDAG Systems to rebuild cruise ship pier

Reconstruction of cruise ship pier in Basseterre, St. Kitts, West Indies



View of the new cruise ship pier



Installation of
DYWIDAG Micropiles
Ø 57 mm, between
37 and 42 m long



i **Owner** St. Christopher Air and Sea Ports Authority, Basseterre, St. Kitts, West Indies +++ **Engineer** Novaport Ltd., Halifax, Canada +++ **General Contractor** Island Dredging Ltd., Kingston, Jamaica +++ **Piling Contractor** DSI Canada, Western Division, Surrey, BC, Canada

DSI Services Supply, drilling, installation and grouting of fully bonded DYWIDAG Micropiles Ø 57 mm (21 pcs. vertical micropiles on approach piers and 20 pcs. battered on 3 dolphins) with a compression and tension capacity of 790 kN; Rental of equipment and technical assistance

First South Korea application of DYWIDAG Pre-Grouted Anchor System to prevent slide

Hongchon Road No. 36, Gangwon Province, South Korea



Stressing of the anchor with DYWIDAG Jack

Slopes secured with DYWIDAG Threadbar Anchors



Top and right: Stabilized slopes with DYWIDAG Threadbar Anchors

i **Owner** Hongchon Road Maintenance Office, Gangwon Province, South Korea +++ **Contractor** Dongseo Construction Co., Ltd., Chunchon City, Gangwon Province, South Korea +++ **Engineering** Kukil Construction & Engineering, Hongchonkun, Gangwon Province, South Korea

DSI Services Supply of 123 pcs. DYWIDAG Threadbar Anchors, length 10.5 and 15.5 m, bonded length 5 m, free length 5 and 10 m; Technical support

DYWIDAG Permanent Threadbar Anchors secure new electronuclear accelerator

Electronuclear accelerator for the European Organisation for Nuclear Research (CERN), Geneva, Switzerland



Cavern excavations

i **Owner** Centre Européen pour la Recherche Nucléaire (CERN), Geneva, Switzerland +++
General Contractor Dragados, Spain / Seli, Italy

DSI Services Supply of DYWIDAG Anchors made of steel 835/1030, \varnothing 36 mm, l = 15 m; Technical job-site assistance, implementation of load tests and partial implementation of stressing operations; Rental of stressing equipment

DYWIDAG Threadbar Anchors prevent uplift of new Copenhagen Opera

Construction of Opera House in Copenhagen, Denmark



Location in line with Marble Church and Amalienborg Castle

i **Owner** A. P. Moller Foundation (Maersk), Copenhagen, Denmark, as a gift to the city of Copenhagen +++
Designer Henning Larsen, Copenhagen, Denmark +++
General Contractor E. Pihl & Son A/S, Copenhagen, Denmark +++
Subcontractor Züblin Spezialtiefbau GmbH, Stuttgart, Germany +++
Engineering Rambøll A/S, Copenhagen, Denmark

DSI Services Supply of 820 Double Corrosion Protected Uplift Prevention Anchors \varnothing 36 mm, ranging in length between 15-20 m; Technical support by DSI Licencee AAGE Christensen A/S, Copenhagen, Denmark

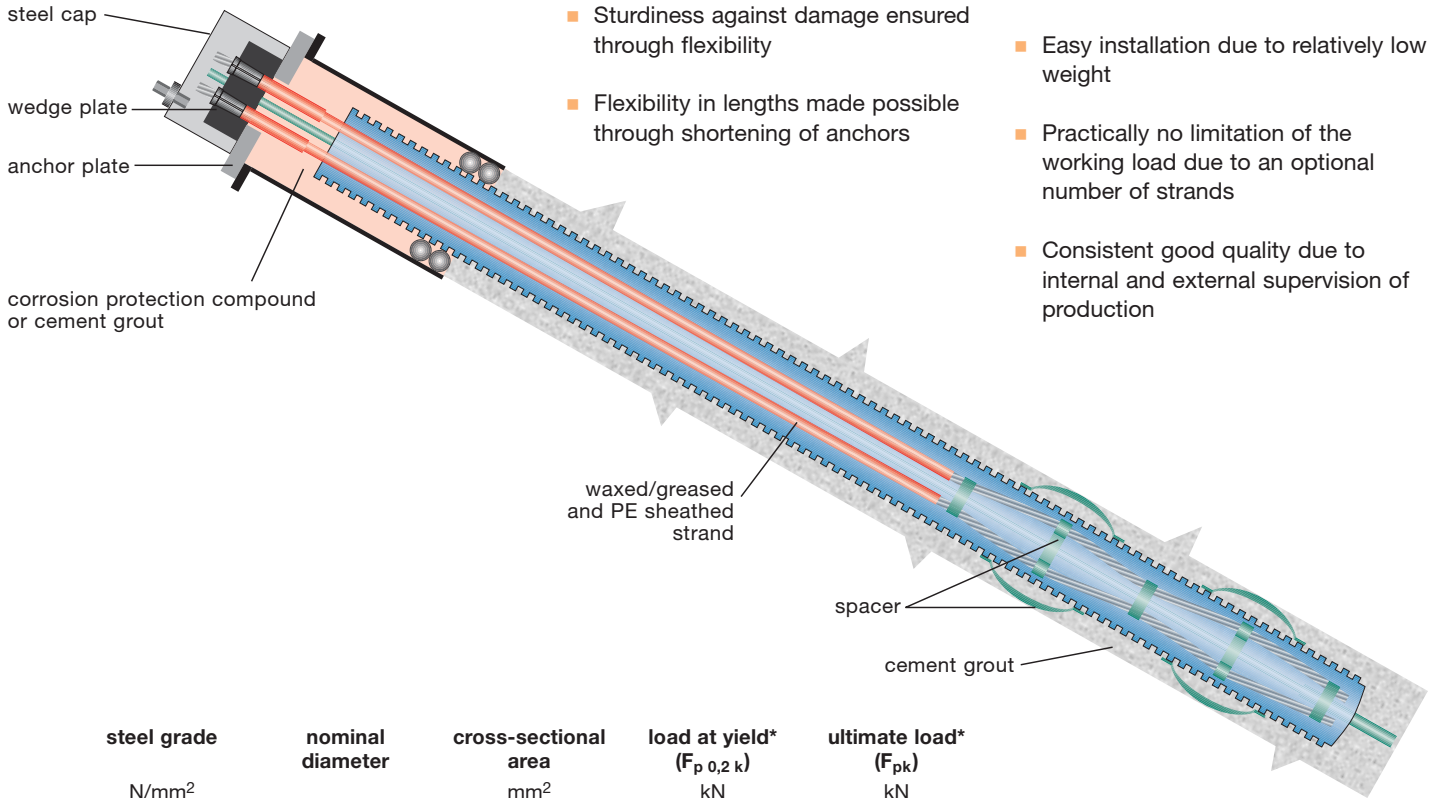


DYWIDAG Strand Anchor System

Permanent (DCP) Anchor acc. to DIN 4125

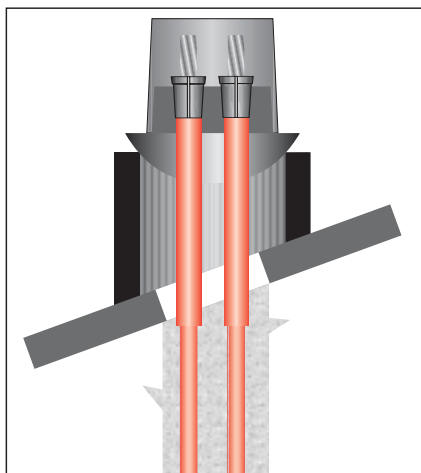
Advantages and Characteristics

- Large transport lengths avoid splices
- Need little space during transport, storage and installation
- Sturdiness against damage ensured through flexibility
- Flexibility in lengths made possible through shortening of anchors
- Double corrosion protection can be supplied for permanent anchors
- Permanent testability of the corrosion protection possible through electric isolation
- Easy installation due to relatively low weight
- Practically no limitation of the working load due to an optional number of strands
- Consistent good quality due to internal and external supervision of production

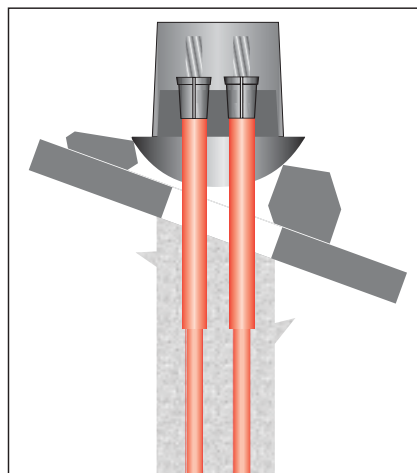


steel grade	nominal diameter	cross-sectional area	load at yield* ($F_{p,0.2k}$)	ultimate load* (F_{pk})
N/mm ²		mm ²	kN	kN
1570/1770	0.6"	140	220	248
1570/1770	0.62"	150	236	266
1670/1860	0.6"	140	234	260
1670/1860	0.62"	150	251	279

* per strand



Adjustment of angle by spherical disc and steel tube

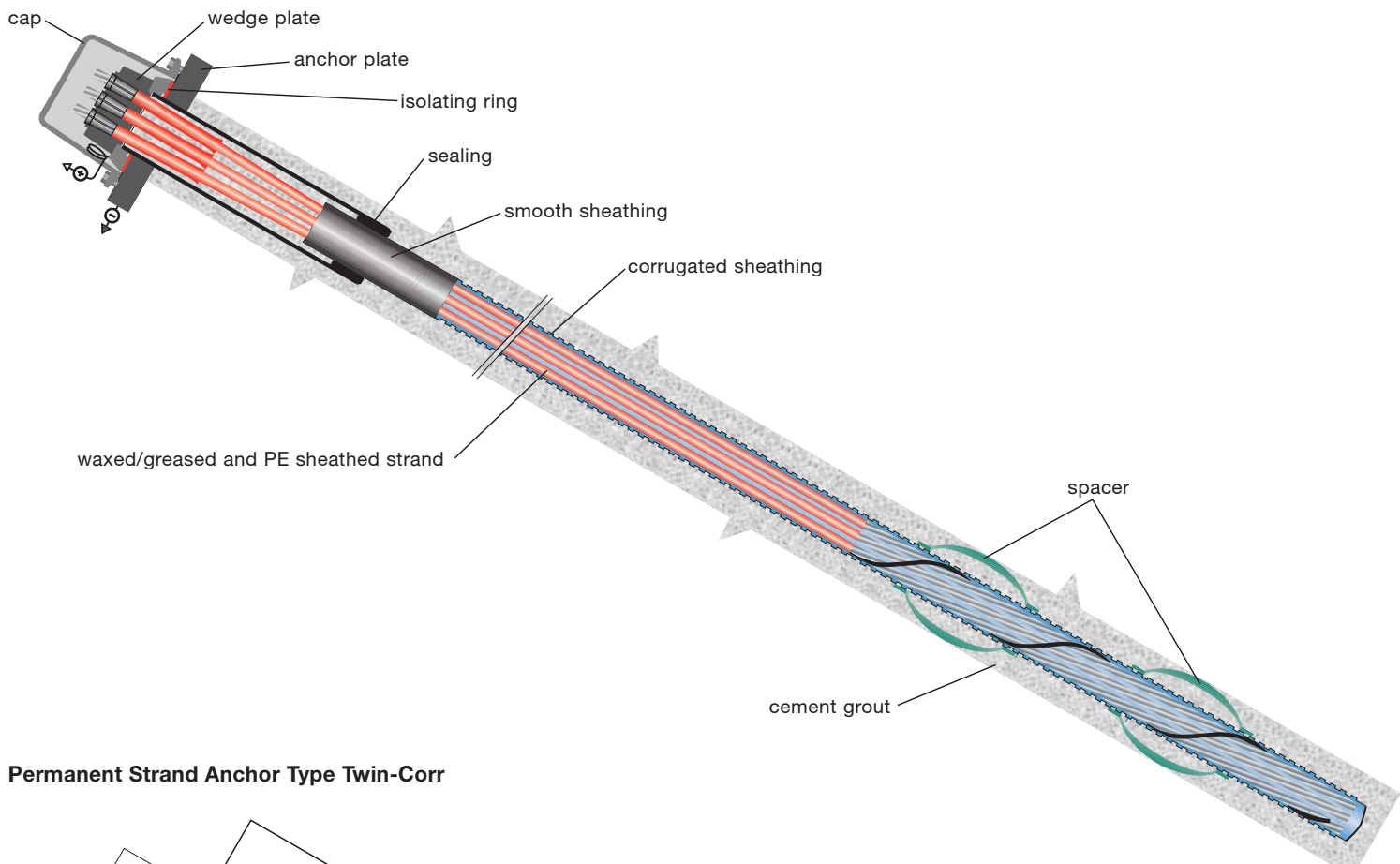


Adjustment of angle by spherical disc and wedge plate

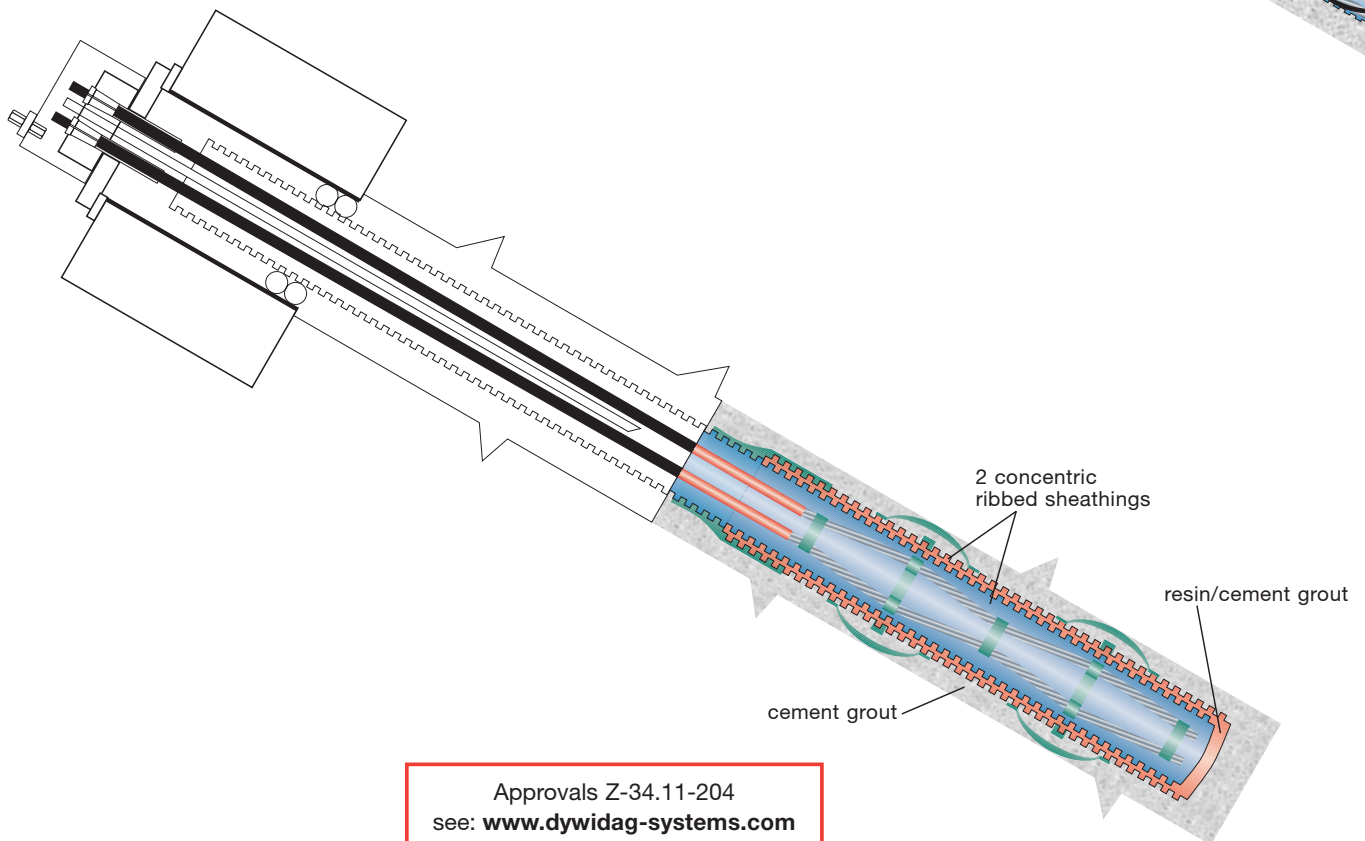
Approvals Z-20.1-15 and Z-34.11-204
 see: www.dywidag-systems.com
 (downloads – approvals – Germany – Geotechnical Systems)

DYWIDAG Strand Anchors acc. to EN 1537

Electrically Isolated Permanent Strand Anchor



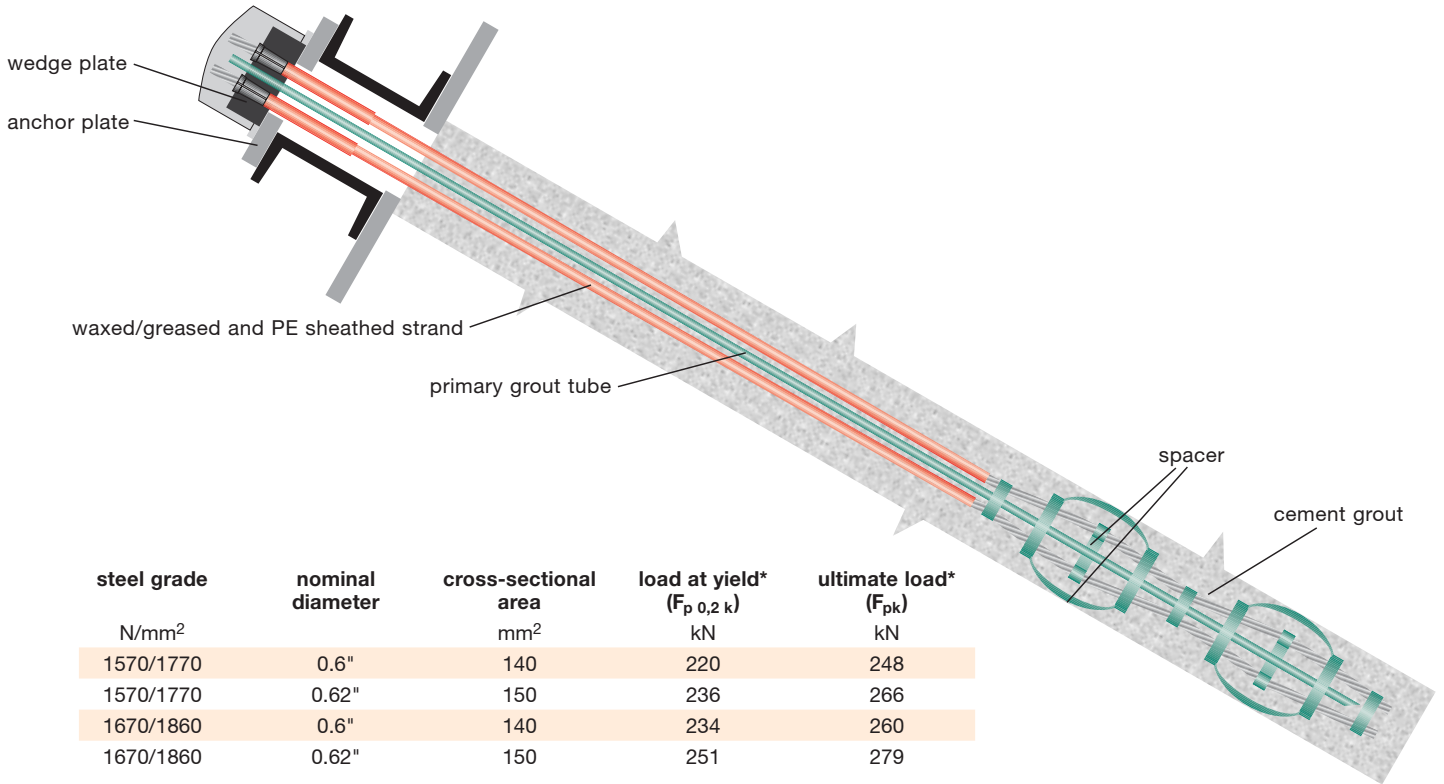
Permanent Strand Anchor Type Twin-Corr



Approvals Z-34.11-204
see: www.dywidag-systems.com
(downloads – approvals – Germany –
Geotechnical Systems)

Temporary Strand Anchors

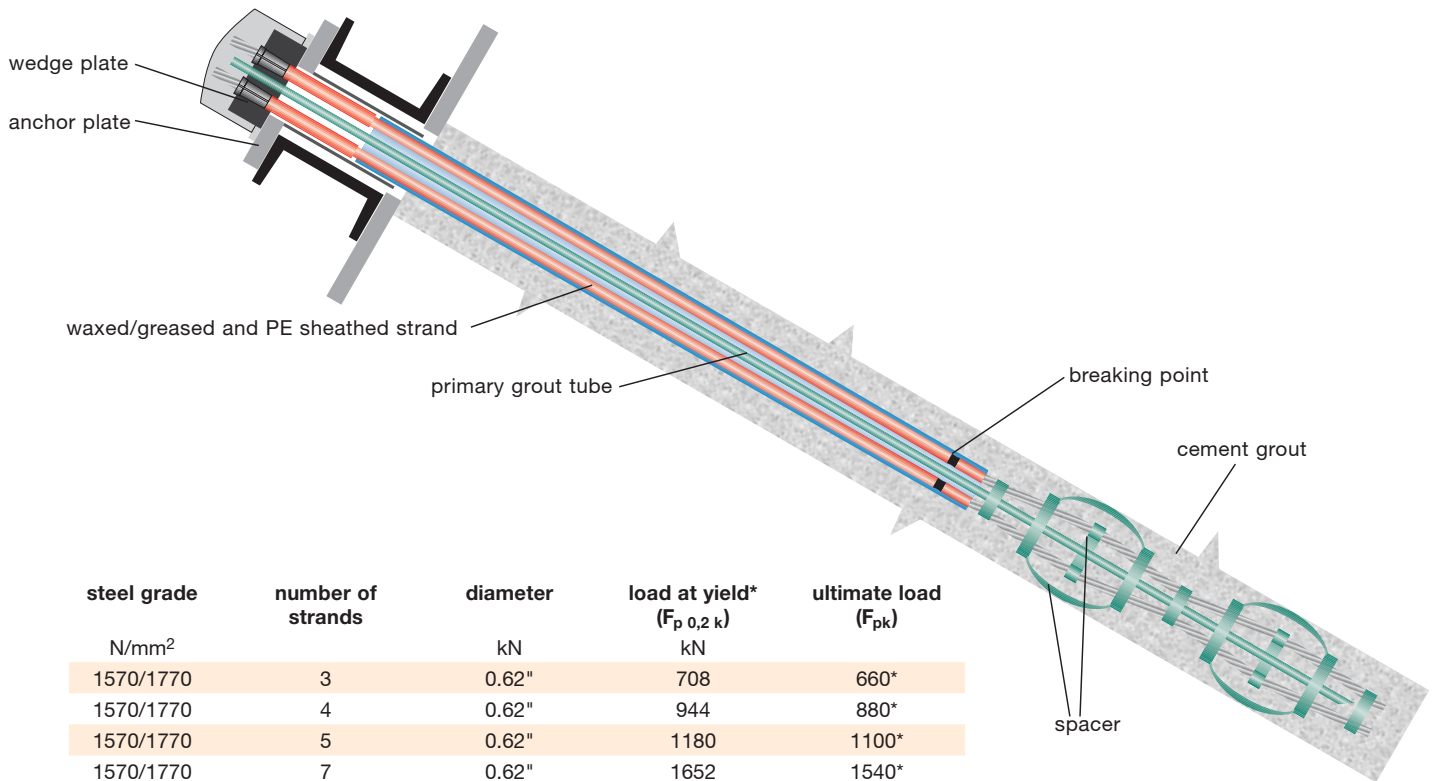
Temporary Anchor



steel grade	nominal diameter	cross-sectional area	load at yield* ($F_{p 0,2 k}$)	ultimate load* (F_{pk})
N/mm ²		mm ²	kN	kN
1570/1770	0.6"	140	220	248
1570/1770	0.62"	150	236	266
1670/1860	0.6"	140	234	260
1670/1860	0.62"	150	251	279

* per strand

Removable Strand Anchors for free length with predetermined breaking point

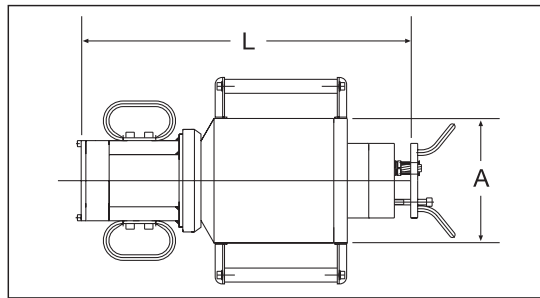


steel grade	number of strands	diameter	load at yield* ($F_{p 0,2 k}$)	ultimate load (F_{pk})
N/mm ²		kN	kN	
1570/1770	3	0.62"	708	660*
1570/1770	4	0.62"	944	880*
1570/1770	5	0.62"	1180	1100*
1570/1770	7	0.62"	1652	1540*

* load at point of rupture

DYWIDAG Strand Anchors – Equipment

DYWIDAG Strand Anchor Jacks



Prestressing Jack 1500 kN

► Technical Data

jack types	length L	O. D. A	stroke	piston area	capacity	weight
	mm	mm	mm	cm ²	kN	kg
1100 kN	720	267	150	235.6	1200	81
1500 kN	870	336	250	302.4	1500	125
2600 kN	785	370	250	549.8	2749	330
HOZ 3000	1200	385	250	508.9	3053	400
HOZ 5400	1462	482	250	894.6	5367	600

strand 0.6 and 0.62" St 1570/1770 St 1670/1860

No. of strands	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1100 kN	●	●	●	●	●	○															
1500 kN	○	○	○	●	●	●															
2600 kN						●	●	●	●	●											
HOZ 3000							●	●	●	●	●										
HOZ 5400													●	●	●	●	●	●	●	●	●

● Standard ○ Optional

Hydraulic Pumps



Hydraulic Pump, Type R 6.4



Hydraulic Pump, Type 77 – 193 A

jacks	1100 kN	1500 kN	2600 kN	HOZ 3000 HOZ 5400
pumps				
77-193 A	●	●		
R 3.0 V	●	●		
R 6.4			●	●

► Technical Data

pump type	max. operating pressure	capacity oil volume	effective oil amount	weight	dimensions L x W x H
	bar	l/min	l	kg	mm
77-193 A	600	3.0	10.0	63	420/380/450
R 3.0 V	600	3.0	13.0	98	600/390/750
R 6.4	600	6.4	70.0	310	1400/700/1100

Hydraulic Pumps are delivered without oil filling

DYWIDAG Permanent Strand Anchors for seismic upgrade of an apartment building in Peru

Kontiki Apartment Building, Playa Punta Hermosa, Lima, Peru



Prestressing tests performed on the anchors



Lengthening of anchors with couplers of type R

i **Client** The Wiese Family, Miroquesada, Lima, Peru +++ **Main Contractor** Augusto Cánepa Ingenieros, Lima, Peru +++ **Consulting Engineers** Gallegos Casabonne Arango Ingenieros Civiles S.A.C., Lima, Peru

DSI Services Supply, preparation, assembly, testing and prestressing of 32 permanent DYWIDAG Strand Anchors with double corrosion protection in sizes 3 up to 12-0.6" and of 3 tendons with 12 greased, sheathed strands \varnothing 0.6".

Seven Mile Dam – Successful completion of test anchor program with 90-0.6" anchors, length 98 m

Seven Mile Dam, Southern BC, Canada



i **Owner** BC Hydro, Burnaby, BC, Canada +++ **Engineer** BC Hydro, Burnaby, BC, Canada +++ **General Contractor** Peter Kiewit & Son, Richmond, BC, Canada

DSI Services Supply of restressable DYWIDAG 90-0.6" Strand Anchors with Double Corrosion Protection 3 pcs. about 98 m long; Rental of 2,000 t jack and technical assistance for installation, testing and stressing



DYWIDAG Permanent Strand Anchors for seismic upgrade of a quay wall

EPC marine dock for the Q-Chem project, Mesaieed, Qatar



Tensioning of the DYWIDAG Multistrand Anchors

Drilling work



i **Owner** Qatar Chemicals Company Ltd., Doha, Qatar +++ **General Contractor** AMCON Project Management, Doha, Qatar +++ **Subcontractor** Swissboring Overseas Corp. Ltd., Dubai, U. A. E.

DSI Services Supply of all anchor components and required equipment for the fabrication and stressing of 100 double corrosion protected DYWIDAG Strand Anchors, 12 x 0,62", with a length of 40 m each; Supervision of anchor fabrication and installation as well as testing and stressing of the anchors

DYWIDAG Anchors prove to be best solution for dam upgrades

Forth River Dams upgrades, Tasmania, Australia



Paloona Dam



Devils Gate Dam

i **Client** Hydro Tasmania, Hobart, Australia +++ **General Contractor** Hazell Bros. Civil Contracting Pty. Ltd., Hobart, Australia +++ **Subcontractor** Mulligan Drilling Pty. Ltd. Rockridge, Australia +++ **Engineering** Hydro Tasmania, Hobart, Australia +++ **Consulting Engineers** Hydro Tasmania, Hobart, Australia

DSI Services Supply of 30 t of \varnothing 36 mm and \varnothing 40 mm epoxy-coated DYWIDAG Threadbars® and accessory for permanent passive rock bolts. Supply of 10 pcs. DYWIDAG Permanent Strand Anchors 8 x 0,6"; Rental of tensioning equipment and field supervision during installation and stressing

Use of DYWIDAG Permanent Strand Anchors on permafrost – Grossglockner in the Austrian Alps

Stabilization of the Erzherzog Johann Hütte at a height of 3,454 m on Mount Grossglockner



View on the Erzherzog Johann Hütte on mount Grossglockner



Tensioning of the DYWIDAG Strand Anchors



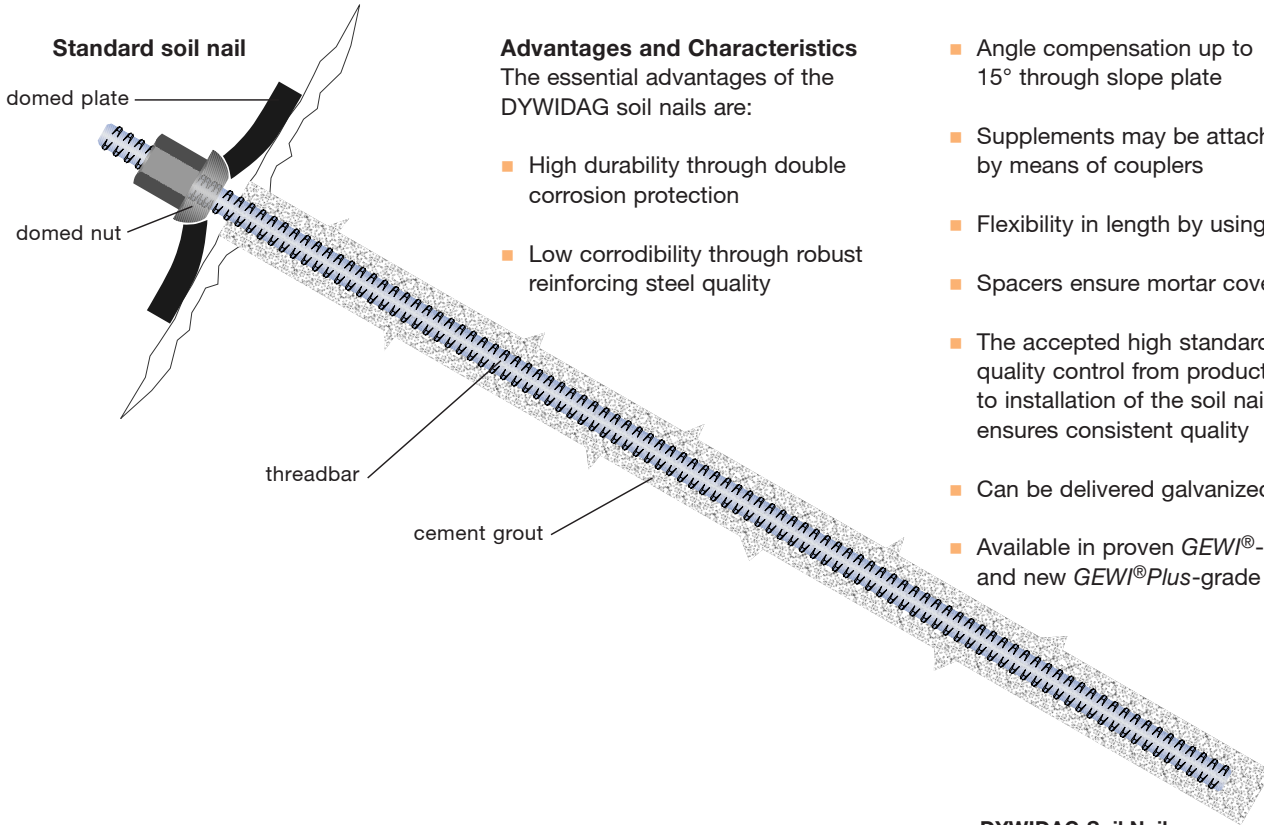
DYWIDAG Strand Anchor after installation

i **Owner** Austrian Alpine Club, Vienna, Austria +++ **General Contractor** Horst Felbermayr GesmbH, FST Spezialtiefbau, Salzburg, Austria +++ **Design Consultant and Authority inviting the tender** Engineering Office Bmst. Ing. Gerhard Schimek, Spittal/Drau, Austria +++ **Subsoil Expert** Civil engineers Garber - Dalmatiner, Graz, Austria

DSI Services Supply of DYWIDAG Permanent Strand Anchors 5 x 0.6", service load 550 kN and GEWI® Piles Ø 40 mm, incl. technical assistance

DYWIDAG Soil Nails

Standard soil nail

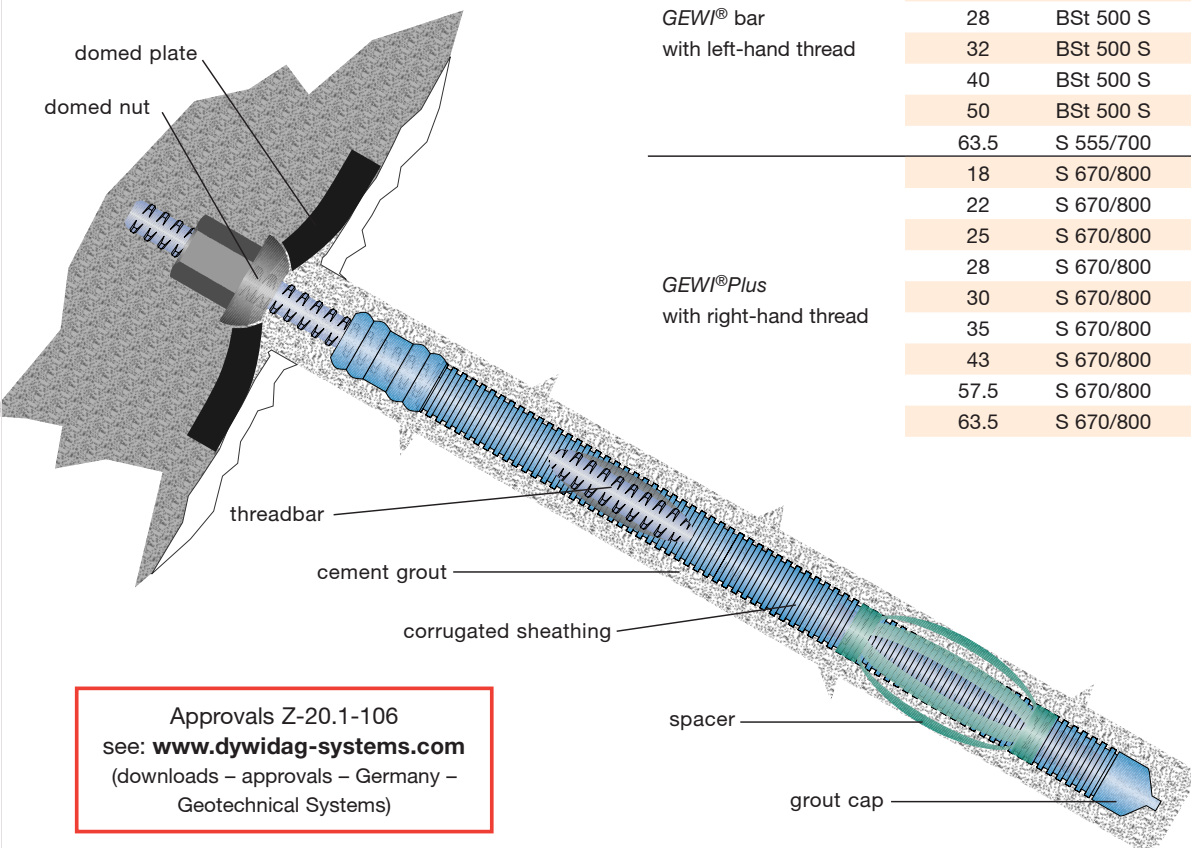


Advantages and Characteristics

The essential advantages of the DYWIDAG soil nails are:

- High durability through double corrosion protection
- Low corrodibility through robust reinforcing steel quality
- Angle compensation up to 15° through slope plate
- Supplements may be attached by means of couplers
- Flexibility in length by using couplers
- Spacers ensure mortar cover
- The accepted high standard of quality control from production stage to installation of the soil nails ensures consistent quality
- Can be delivered galvanized
- Available in proven GEWI®-grade and new GEWI®Plus-grade

DCP-soil nail



DYWIDAG Soil Nail

steel grade	nominal diameter	steel grade	cross-sectional area A	load at yield	ultimate load
	mm	N/mm ²	mm ²	kN	kN
GEWI® bar with left-hand thread	16	BSt 500 S	201	101	111
	20	BSt 500 S	314	157	173
	25	BSt 500 S	491	246	270
	28	BSt 500 S	616	308	339
	32	BSt 500 S	804	402	442
	40	BSt 500 S	1,257	628	691
GEWI®Plus with right-hand thread	50	BSt 500 S	1,963	982	1,080
	63.5	S 555/700	3,167	1,758	2,217
	18	S 670/800	254	170	204
	22	S 670/800	380	255	304
	25	S 670/800	491	329	393
	28	S 670/800	616	413	493
	30	S 670/800	707	474	565
	35	S 670/800	962	645	770
	43	S 670/800	1,452	973	1,162
	57.5	S 670/800	2,597	1,740	2,077
63.5	S 670/800	3,167	2,122	2,534	

Approvals Z-20.1-106
 see: www.dywidag-systems.com
 (downloads – approvals – Germany – Geotechnical Systems)

The Eden project built with DYWIDAG Soil Nails and Ground Anchors

In the last two years a 60 m deep former china clay pit just outside St. Austell in Cornwall was transformed into a unique 21st century Biosphere



On the upper levels, drill platforms were mounted to hydraulic telescopic arms.

i Owner The Eden Project +++ Main contractor JV McAlpine +++ Geotechnical engineer John Grimes Partner +++
Geotechnical subcontractor Saxton Deep Drillers
DSI Services Supply of 2,000 GEWI® bolts and DYWI® Drill anchors, 50 DSI permanent ground anchors and 40 temporary DYWIDAG Soil Nails

GEWI® Steel Soil Nails stabilize slopes on the Rock of Gibraltar

Slope stabilization for decommissioned rainwater catchment system, Gibraltar, Spain



i Owner British Ministry of Defence, London, England +++ Main Contractor Edmund Nuttall, Camberley, Surrey, England +++ Consultant Gifford and Partners, Chester, England +++ Alternative Design Donaldson Associates, Uttoxeter, England
DSI Services Supply of 8,200 galvanized DYWIDAG Soil Nails



Drill platform in use

Retaining walls at Dallas/Fort Worth International Airport secured with DYWIDAG Soil Nails



i **Owner** Dallas/Fort Worth Airport, TX, USA +++ **Contractor** Craig Olden, Inc., Little Elm, TX, USA +++ **Installed by** Craig Olden, Inc., Little Elm, TX, USA

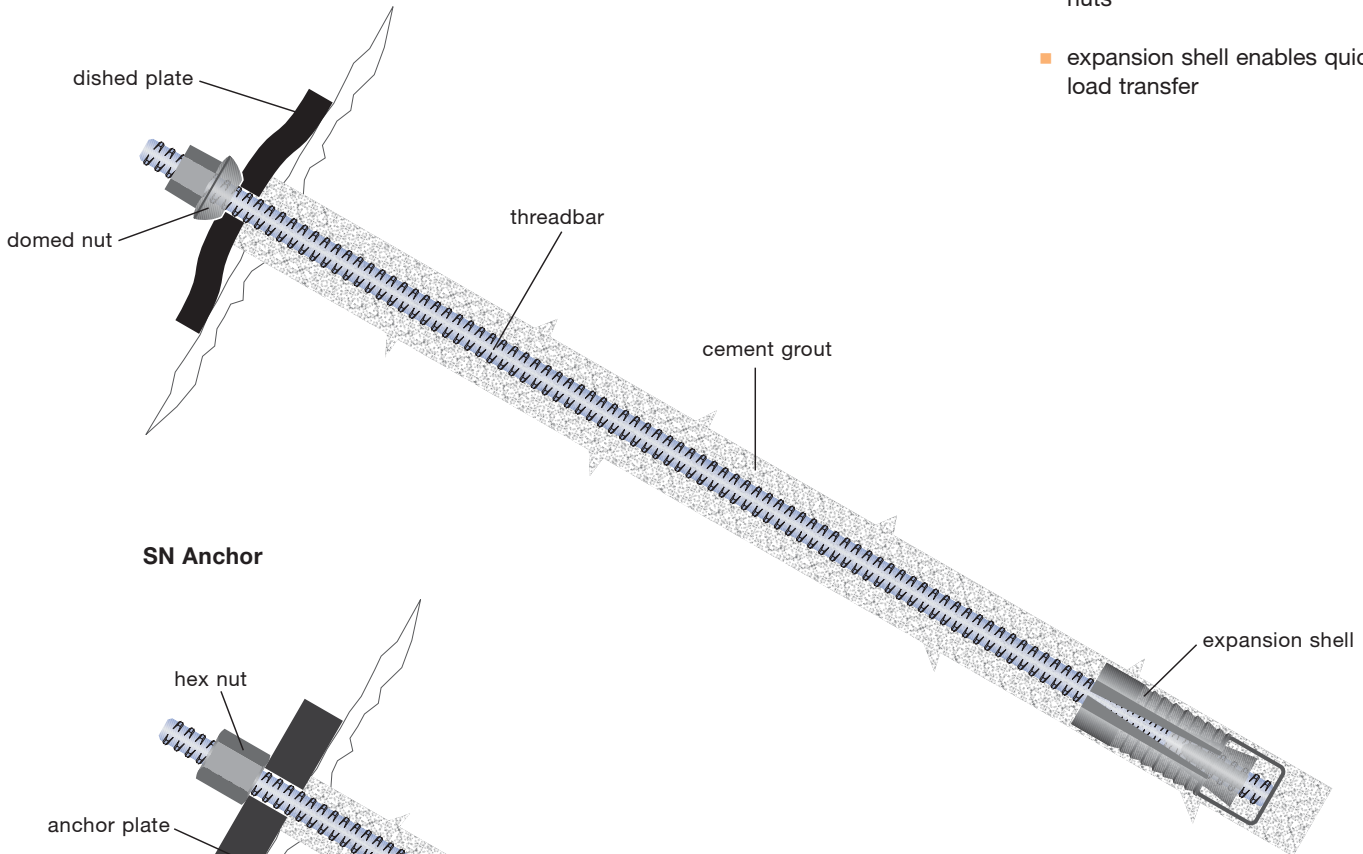
DSI Services Supply of 650 DYWIDAG Soil Nails, \varnothing 25 mm, total length about 5,000 m

DYWIDAG Rock Bolts

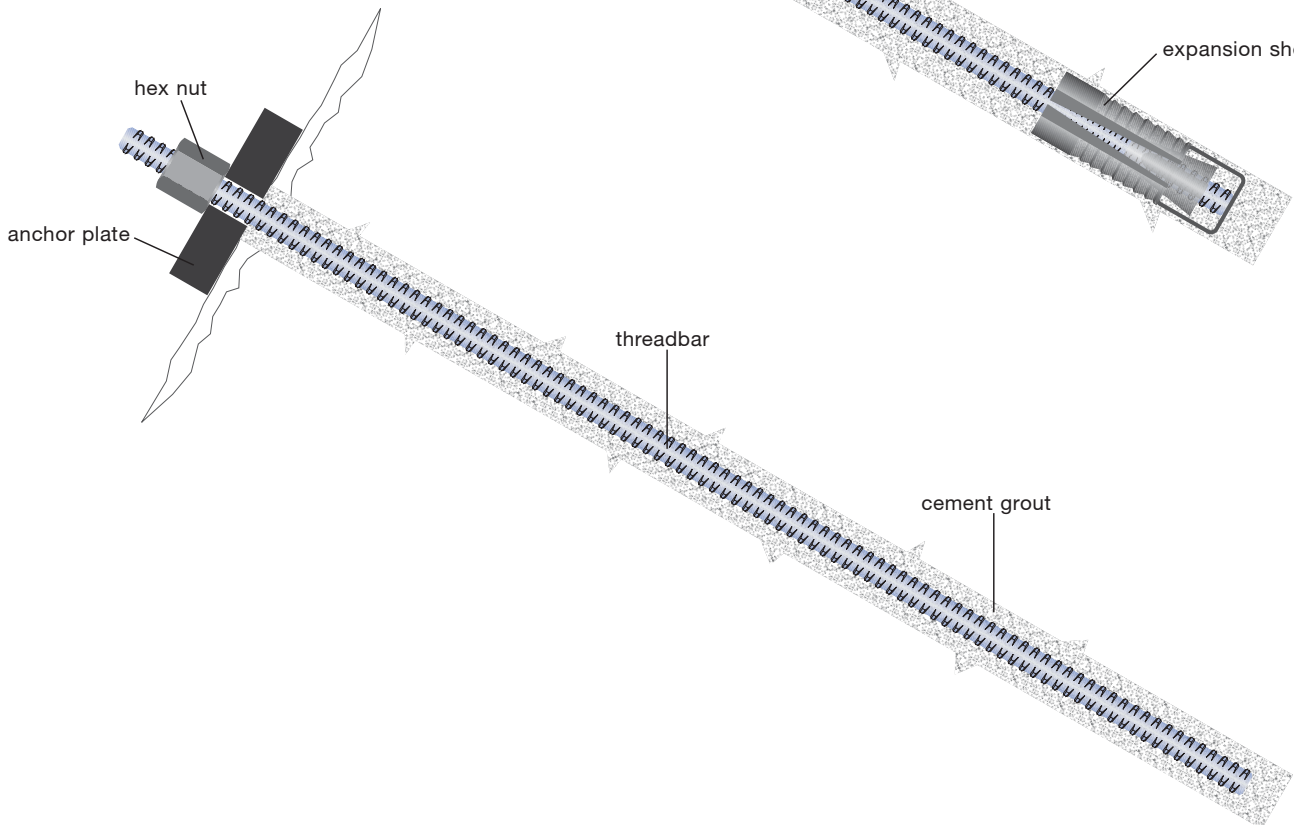
Advantages and Characteristics

- high loads with small borehole diameters
- continuous bar thread allows cutting at any point, length adaptation on site, easy to order and to store
- coarse thread, insensitive to rough handling
- high bond along the bar length for anchoring into resin or cement mortar
- good mixing of resin cartridges through the thread ribs
- restressing possible
- angle compensation through dished plates, spherical seats or domed nuts
- expansion shell enables quick load transfer

Expansion Shell Bolt (with or without cement grout)

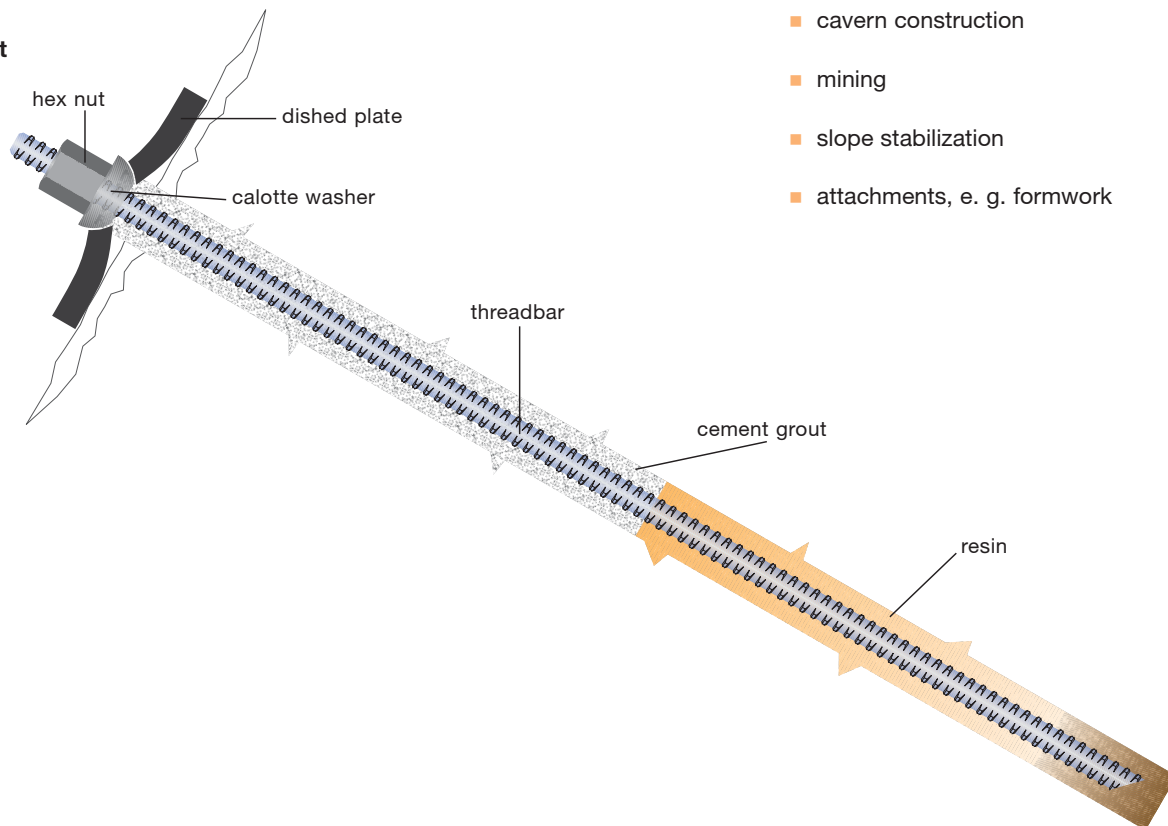


SN Anchor



DYWIDAG Rock Bolts

Resin Bolt



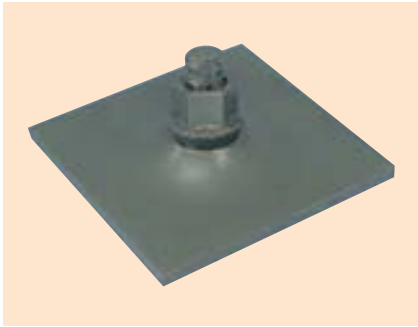
Fields of Application

- tunnel and shaft construction
- cavern construction
- mining
- slope stabilization
- attachments, e. g. formwork

type of bar	nominal diameter	steel grade	max. diameter over ribs	cross-sectional area A	load at yield	ultimate load
	mm	N/mm ²	mm	mm ²	kN	kN
GEWI® bar with left-hand thread	16	500/550	18	201	101	111
	20	500/550	23	314	157	173
	25	500/550	28	491	246	270
	28	500/550	32	616	308	339
	32	500/550	36	804	402	442
GEWI®Plus bar with right-hand thread	18	670/800	21	254	170	204
	22	670/800	25	380	255	304
	25	670/800	28	491	329	393
	28	670/800	32	616	413	493
	30	670/800	34	707	474	565
GEWI® bar with right-hand thread	16	450/700	18	207	93	145
THREADBAR® with right-hand thread	15	900/1100	18	177	159	195
	26.5	950/1050WR	31	552	525	580
	32	950/1050WR	36	804	760	850

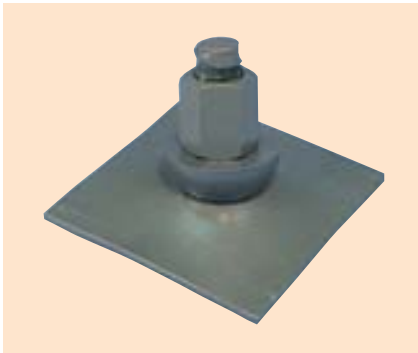
DYWIDAG Rock Bolts – Anchorages

Anchorage with domed nut and dished plate



steel grade	nominal diameter	order No. plate	plate dimensions	order No. nut
N/mm ²	mm		mm	
450/700	16	16 W 2134	80 x 80 x 10	16 W 2014
500/550	16	16 T 2079	120 x 120 x 5	16 T 2056
500/550	20	20 T 2182	150 x 150 x 8	20 T 2044
500/550	25	25 T 2182	150 x 150 x 8	25 T 2044
500/550	28	28 T 2182	150 x 150 x 10	28 T 2044
500/550	32	32 T 2182	180 x 180 x 12	32 T 2044
670/800	18	18 TR 2182	150 x 150 x 10	18 TR 2001
670/800	22	22 TR 2182	150 x 150 x 10	22 TR 2001
670/800	25	25 TR 2182	200 x 200 x 12	25 TR 2001
670/800	28	28 TR 2182	200 x 200 x 12	28 TR 2001
670/800	30	30 TR 2182	200 x 200 x 12	30 TR 2001

Anchorage with hexagon nut, spherical seat and dished plate



steel grade	nominal diameter	order No. plate	plate dimensions	order No. nut	order No. spherical seat
N/mm ²	mm		mm		
500/550	16	16 T 2131	150 x 150 x 8	16 T 2002	16 T 2130
500/550	20	20 T 2131	150 x 150 x 8	20 T 2002	20 T 2130
500/550	25	25 T 2131	180 x 180 x 8	25 T 2002	25 T 2130
500/550	28	28 T 2131	200 x 200 x 10	28 T 2002	28 T 2130
500/550	32	32 T 2131	200 x 200 x 12	32 T 2002	32 T 2130
900/1100	15	15 F 2131	150 x 150 x 8	15 F 2002	15 F 2130

further plate dimensions available on request

Anchorage for rock bolts with steel grade St 950/1050



steel grade	nominal diameter	order No. plate	plate dimensions	order No. nut
N/mm ²	mm		mm	
950/1050	26.5	26 WR 2011	150 x 150 x 35	26 WR 2001
950/1050	32	32 WR 2011	180 x 180 x 40	32 WR 2001

DYWIDAG Rock Bolts – Accessories

Expansion Shells

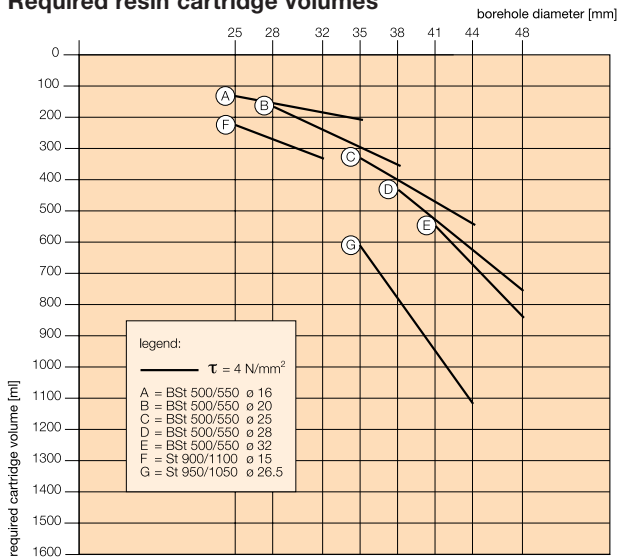


borehole diameter mm	type DSI	for bar sizes												rock quality	length of cone mm			
		15F	16T	16W	18TR	20T	20W	22TR	25T	25TR	26WR	28T	28TR			30TR	32T	
33/37	2128	●	●		●												hard	35
34/38	2184	●		●	●												potassium	50
34/38	2185			●													medium hard	65
34/38	2135	●	●		●												hard	35
39/46	2117	●	●		●	●											hard	50
44/47	2185				●		●	●									potassium	85
43/48	2136	●	●		●	●		●									hard	47
50/58	2137	●	●		●	●		●	●	●	●	●	●	●	●		hard	50
59/60	2221								●	●	●	●	●	●	●		hard	65

Expansion shells for TR-grade bars on request only



Required resin cartridge volumes



Selection criteria

Selection Criteria for Rock Bolts

underground	expansion shell	resin	cement grout
usable in cleft ground conditions	limited	limited	yes
required strength of rock	30 N/mm ²	low	low
suited for wet borehole	yes	limited	yes
application technique			
corrosion protection	yes*	yes	yes
fast loading	yes	yes	no
stressing	yes	yes**	no
suited for advance through blasting	limited	yes	yes
sensible to deviations of the borehole diameter	yes	yes	no

* expansion shell anchor with cement grout injection, ** if free length is guaranteed

DYWIDAG Rock Bolts – Installation and Stressing Equipment

Installation

Spinning Adapter to spin the bolts into resin cartridges by electrical or air-driven drilling machines



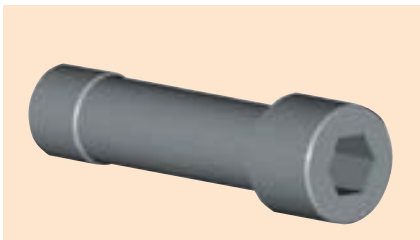
Impact Wrench



Stressing

Hydraulic Jack HOZ 250/50 for stressing and testing of rock bolts with hexagon nut and spherical seat

Tensioner suitable for electric or pneumatic impact wrenches

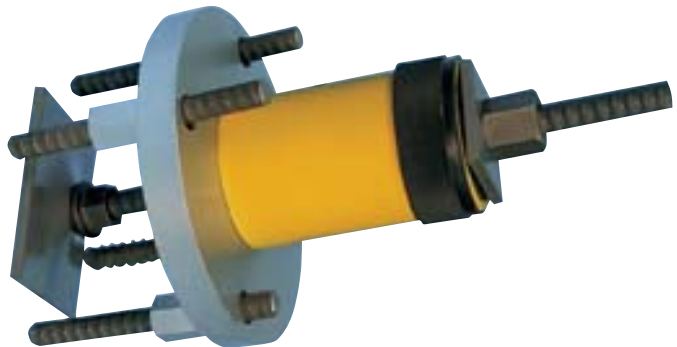


Hydraulic Jack HOZ 250/50

► Technical Data of the HOZ 250/50

dimensions	mm	600 x 400 x 200
capacity	kN	250
stroke	mm	50
pressure	bar	500
weight	kg	15

Universal Stressing Setup for stressing of rock bolts whose axes do not lie normal to the rock face, a hollow cylinder jack equipped with an adjustable chair is used to ensure perfect alignment and load transmission.



Universal Stressing Setup

Applications for DYWIDAG Rock Bolts



i **Project** Stabilization of the rockfall at the B99 Katschberg federal road, Carinthia, Austria +++ **Owner** Authority of the Carinthian State Government, Klagenfurt, Carinthia, Austria +++ **Design** Engineering Office Dr. Ernst Garber – Dr. Joerg Dalmatiner, Villach + Graz, Austria

DSI Services Technical assistance and deliver of DYWIDAG rock bolts, rental of technical equipment

i **Project** Paramatta Rail Link Tunnel in NSW, Australia +++ **Owner** State Rail Authority, Rail Infrastructure Corporation and NSW Government, Australia +++ **Main Contractor** Thies Hochtief Joint Venture, Sydney, Australia +++ **Consulting Engineers** Gutteridge Haskins & Davey Pty Ltd., Sydney, Australia; Parsons Brinkerhoff Australia Pty Ltd., Sydney, Australia
DSI Services Supply of 50,000 rock bolts, resins and accessories, Supply of 500 steeling sets



i **Project** Nancy Creek Tunnel, Atlanta, Georgia, USA +++ **Owner** City of Atlanta, Georgia, USA +++ **Design Engineer** Jordan Jones & Goulding, Atlanta, Georgia, USA +++ **General Contractor** Nancy Creek Constructors, Atlanta, Georgia, USA

DSI Services Supply of DYWIDAG rock bolts; Pull testing and on-site technical assistance

Applications for DYWIDAG Rock Bolts



i **Project** Lesotho Highlands Project, Lesotho, South Africa
+++ **Owner** Lesotho Highlands Development Authority (LHDA) +++
Design Lesotho Highlands Contractors, a JV consisting of: Spie Batignolles, Balfour & Beatty Ltd., Campenon Bernard SGE, LTA Ltd. and Ed. Züblin AG

DSI Services 320,000 pieces of hot dip galvanized rock bolts \varnothing 25 mm

i **Project** Eastside Reservoir, Riverside County, CA, USA +++
Owner Metropolitan Water District of Southern California (MWDSC)
+++ **Design** Ebasco Team, a JV consisting of: Black & Veatch and Woodward-Clyde
DSI Services 8,000 m of rock bolts \varnothing 26.5 mm, prestressing and testing equipment, technical assistance on site



i **Project** Fort Regent Cavern, St. Helier, Jersey, UK
+++ **Owner** Public Services Department of the States of Jersey +++ **Design** GEO-Engineering (Jersey)

DSI Services 4,000 pieces of epoxy-coated rock bolts \varnothing 25 mm GEWI® and \varnothing 26.5 mm THREADBAR®

Innovative solution using DYWIDAG Rock Bolts for cavern construction in India

Baglihar Hydro Electric Power Station, Jammu & Kashmir, India



Underground installation team; Small picture: Stressing operation with local jacks using a stressing chair

Position of the concrete dam with foundation for cable cranes

i **Owner** Jaiprakash Industries Limited, New Delhi, India +++ **General Contractor** Jaiprakash Industries Limited, New Delhi, India +++
Consultant Lahmeyer International GmbH, Bad Vilbel, Germany
DSI Services Supply of a total of 7,720 DYWIDAG Rock Bolts in single section lengths between 6 and 10 meters; Technical support

DYWIDAG Rock Bolts for roof support in German salt mines



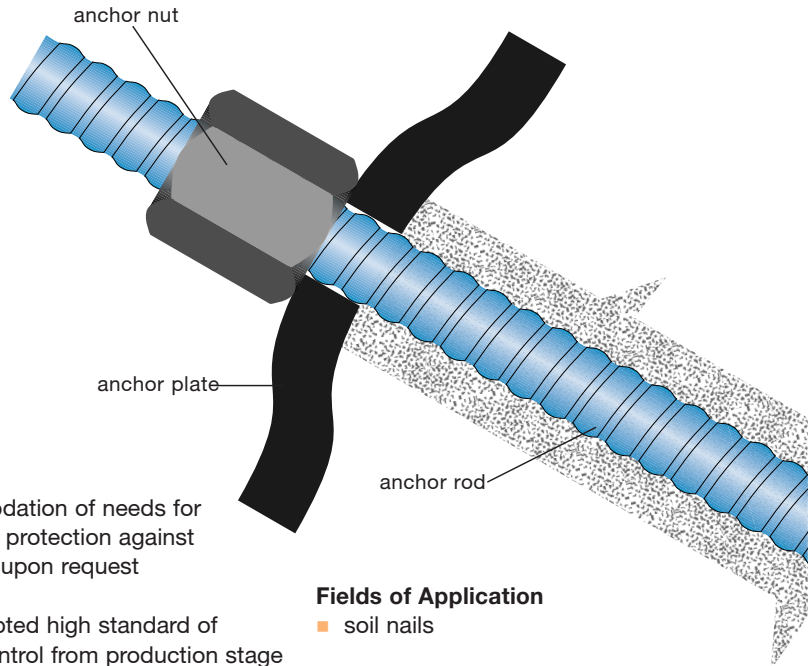
i **Owner** Kali & Salz AG, Kassel, Germany
DSI Services 1 million DYWIDAG Rock Bolts per year \varnothing 16 mm, steel grade 450/700 with expansion shells

DYWI® Drill Hollow Bar System

Advantages and Characteristics

The main advantages of the DYWI® Drill Hollow Bar are:

- Fast drilling and placing due to drilling, anchor installation and grouting in a single operation
- Neither separate anchor installation nor removal of casing and drill rods
- Similar installation methods for all ground conditions
- Choice of drill bits for different ground conditions
- The hollow core not only serves for flushing with air or water during drilling, but also for grouting the anchor tendon
- Flexibility in length by using couplers
- Ability to work with small drill rigs without casing in restricted headroom conditions
- Accommodation of needs for enhanced protection against corrosion upon request
- The accepted high standard of quality control from production stage to installation of the DYWI® Drill Hollow Bar Anchors ensures consistent quality



Fields of Application

- soil nails
- micro piles
- temporary anchors

Technical Data	Unit	R25N	R32L	R32N	R32S	R38N	R51L	R51N	T76N	T76S
Outer diameter	mm	25	32	32	32	38	51	51	76	76
Average inner diameter	mm	14	22	18,5	15	19	36	33	51	45
Average cross sectional area	mm ²	290	340	430	520	770	890	1070	2120	2750
Ultimate load *1	kN	200	220	280	360	500	550	800	1600	1900
Yield load *1	kN	150	180	230	280	400	450	630	1200	1500
Average tensile strength *1	N/mm ²	690	650	650	690	650	620	750	750	690
Average yield strength *1	N/mm ²	520	530	530	540	520	510	590	570	550
Weight	kg/m	2.3	2.7	3.4	4.1	6.1	7.0	8.4	16.7	22.0
Thread standard	-	ISO 10208				ISO 1720			T76 *2	
Steel grade	-	Acc. to EN 10083-1								
Delivery lengths	-	1 m, 2 m, 3 m, 4 m, 6 m								

*1 The ultimate load and yield load capacity are measured values. The tensile-/yield strengths are calculated average values.

*2 Internal standard



Approval Z-34.13-208
 see: www.dywidag-systems.com
 (downloads – approvals – Germany –
 Geotechnical Systems)

DYWI Drill® Hollow Bar System



Connecting the drill bit



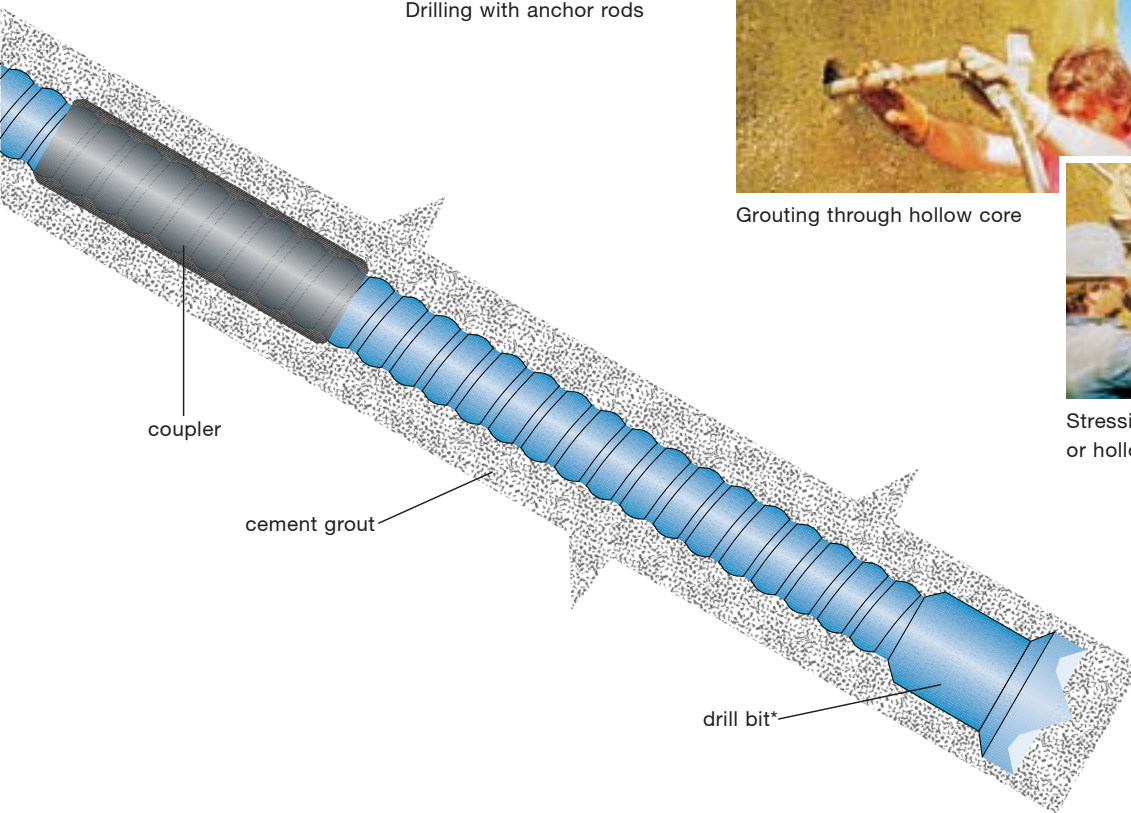
Drilling with anchor rods



Grouting through hollow core



Stressing the anchor by torque wrench or hollow cylinders



* various drill bits for different ground conditions available



DYWI® Drill Hollow Bars used to stabilize a steep cutting on the UK's first toll road

Birmingham Northern Relief Road, West Midlands, Birmingham, England



i **Client** Midland Expressway Ltd., Birmingham, England +++ **General Contractor** CAMBBA, Birmingham, England +++ **Specialist Installer** South Western Mining & Tunnelling Ltd., Nanstallon, Cornwall, England +++ **Consulting Engineers** Arup Atkins, Birmingham, England

DSI Services Supply of 1,000 Permanent R32 DYWI® Drill Hollow Bar Soil Nails (7.5 m to 9.0 m long); Soil nail testing by specialist DSI personnel

Shotcrete excavation wall secured with DYWI® Drill Hollow Bolt Anchors

Brantford General Hospital, Brantford, Ontario, Canada

i **Owner** Brantford General Hospital, Brantford, Ontario, Canada +++ **General Contractor** Bondfield Construction, Concord, Ontario, Canada +++ **Consulting Engineers** Carruthers & Wallace Limited, Toronto, Ontario, Canada +++ **Contractor for foundations** HC Matcon Inc., Ayr, Ontario, Canada +++ **Engineer for foundations** Isherwood Associates Ltd., Mississauga, Ontario, Canada

DSI Services Supply of 12,000 m DYWI® Drill Hollow Bar Soil Nails for the shotcrete wall



17,000 m DYWI® Drill Hollow Bar Anchors deep beneath Downtown London

The North Downs Tunnel is the first part of the railway tunnel which connects the British Channel with King's Cross Station in downtown London.



The North Downs Tunnel portal

i **Owner** Channel Tunnel Rail Link +++ **Contractor** Eurolink, consisting of: Miller, GTM, Dumez and Beton Monierbau +++ **Operator** Union Railways / UK +++
Consulting engineers Rail Link Engineering, consisting of: Ove Arup, Halcrow and Bechtel +++ **Engineering** Eurolink
DSI Services Supply of 17,000 m DYWI® Drill Hollow Bar Anchors
Leasing of stressing and testing equipment



The drill platforms were fixed to telescopic arms on the upper levels

DYWI® Drill Hollow Bar Anchors meet new geological and geotechnical challenges



- i** **DSI Services**
Supply of
- 10,800 m DYWI® Drill Hollow Bar Anchors type R32N
 - 14,517 m DYWI® Drill Hollow Bar Anchors type R32S
 - 700 m double corrosion protected rock anchors
 - 2,310 m GEWI® rock bolts
 - 3,500 m DYWI® Drill Hollow Bar Anchors type R51N
 - 600 m temporary strand anchors with 4 strands

Slope stabilization with DYWI® Drill Hollow Bar Anchors R51N in Lefkopetra-Veria-Kouloura Tunnel

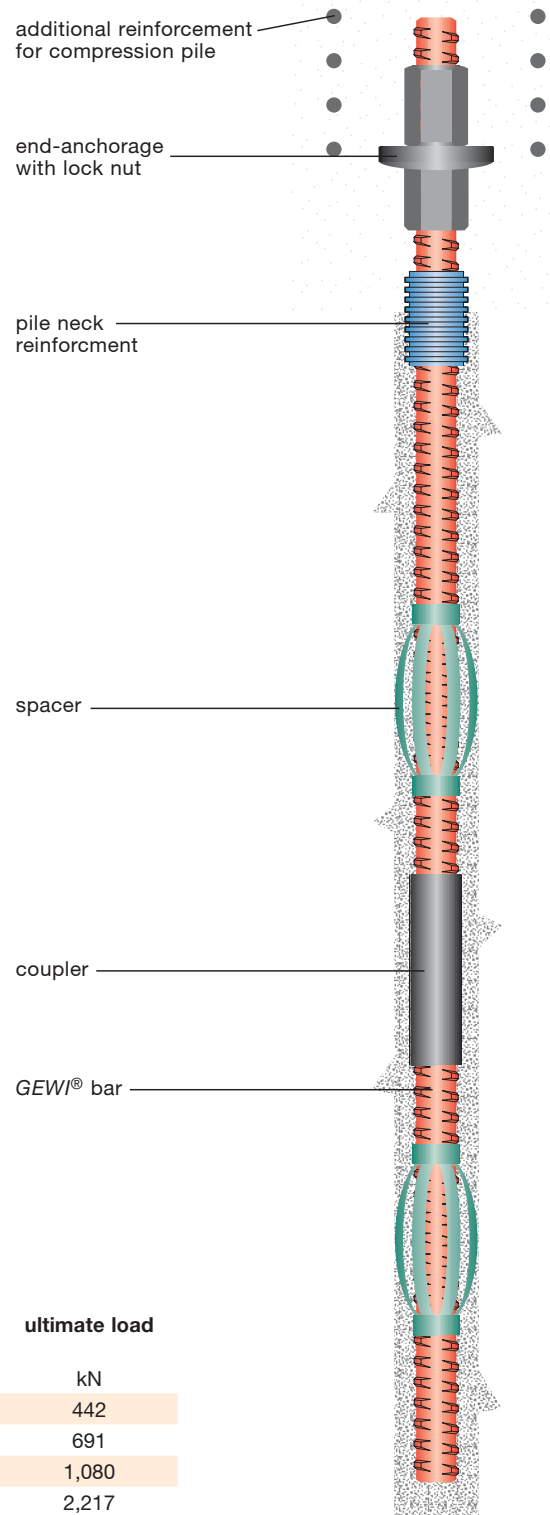
GEWI® Pile

Advantages and Characteristics

The DYWIDAG GEWI® Pile is a drilled micropile with a steel core made of the GEWI® Bar with hot-rolled, continuous thread deformations on both sides, the so-called coarse GEWI® Thread. The steel core is sheathed by cement grout which acts both as corrosion protection and load transfer into the soil or rock.

- Robust coarse thread remains threadable even when dirty or damaged
- can be cut off and spliced at any given point
- excellent load transfer into concrete structures by means of anchoring elements
- a small drill hole diameter allows economic drilling equipment
- tensile, compression and alternating loads can be transferred to the same extent
- the coarse GEWI® Thread guarantees maximum bond between steel and cement grout
- the stress-strain curve of the GEWI® Bar shows high ductility
- continuing settlements can be stopped by preloaded GEWI® Piles
- load transfer into the soil is optimized by the post-grouting system
- Double Corrosion Protected Piles can be used in aggressive media such as seawater or water leaking from dump sites.

GEWI® Pile with single corrosion protection



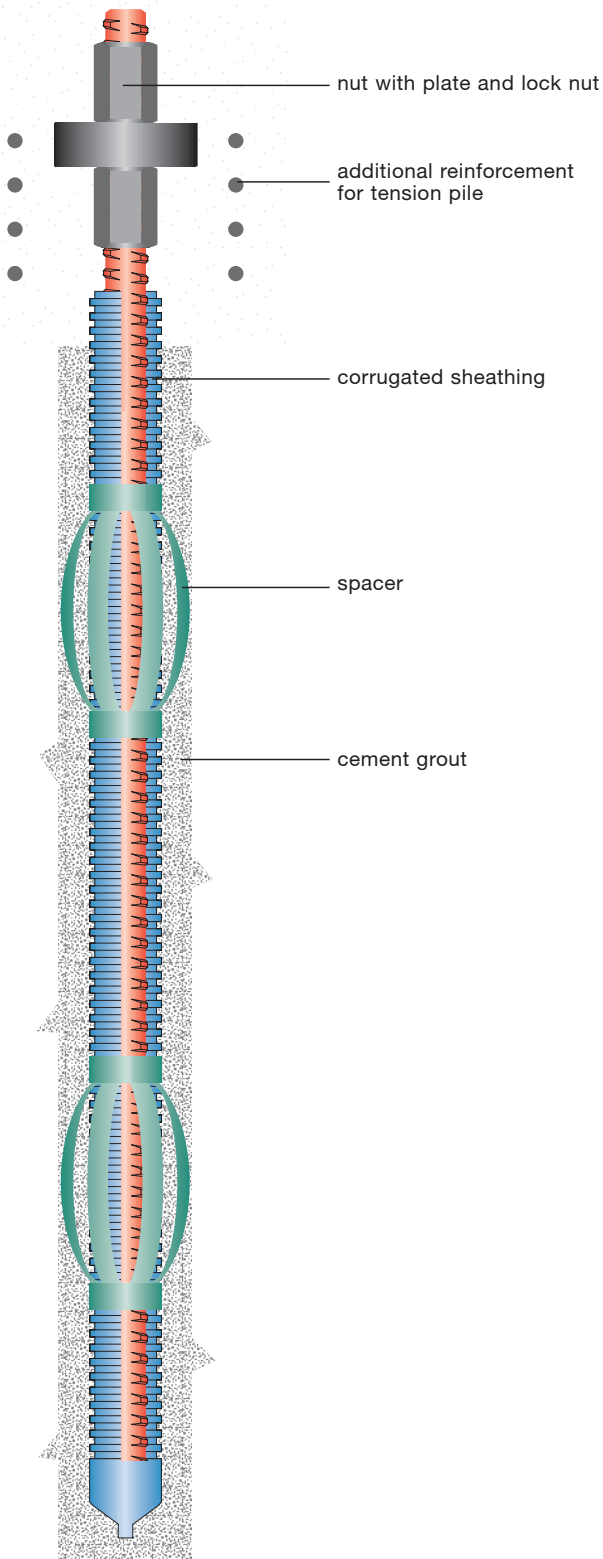
GEWI® and GEWI®Plus Pile

	nom. diameter	steel grade	cross sectional area	yield load	ultimate load
	mm	N/mm ²	mm ²	kN	kN
GEWI® bar with left-hand thread	32	500/550	804	402	442
	40	500/550	1,257	628	691
	50	500/550	1,963	982	1,080
	63.5	555/700	3,167	1758	2,217
GEWI®Plus bar with right-hand thread	28	670/800	616	413	493
	30	670/800	707	474	565
	35	670/800	962	645	770
	43	670/800	1,452	973	1,162
	57.5	670/800	2,597	1,740	2,077
	63.5	670/800	3,167	2,122	2,534

Approvals Z-32.1-2 and Z-32.1-9
see: www.dywidag-systems.com
(downloads – approvals – Germany – Geotechnical Systems)

GEWI® Pile – Equipment

GEWI® Pile with double corrosion protection



Equipment

Hydraulic pumps

► Technical Data

pump type	flow rate of oil	operating pressure max.	tank volume	weight	dimensions L x W x H
	l/min	MPa	l	kg	mm
R 0.9	0.9	70	7	35	455/300/635
CT 2E-W-S	1.2	70	4	26	420/320/450



hydraulic pump CT 2E-W-S



hydraulic pump R 0.9

GEWI® Torque Equipment

	Standard	Plarad
pump type		
R 0.9	●	
CT 2 E-W-S		●
pump		
GEWI® Ø mm	32, 40, 50	63.5



torque equipment type Plarad



torque equipment type Standard

GEWI® Multi Bar Pile

diameter	cross sectional area	load at yield	ultimate load
mm	mm ²	kN	kN
3 x 32	2412	1206	1327
1 x 40. 1 x 50	3220	1610	1771
3 x 40	3770	1885	2074
2 x 50	3927	1963	2160
2 x 40. 1 x 50	4477	2238	2462
1 x 40. 2 x 50	5184	2592	2851
3 x 50	5890	2945	3240

DYWIDAG-Technology provides additional seismic event stability for Terminal Building

Vancouver International Airport Domestic Terminal Building, Canada



View on the Vancouver Airport Tower, Canada

i **Owner** Vancouver International Airport Authority, BC, Canada +++ **General Contractor** Ledcor Industries Ltd., Vancouver, BC, Canada +++ **Structural Design** Read Jones Christoffersen Ltd., Vancouver, BC, Canada +++ **Geotechnical Engineers** Macleod Geotechnical Ltd., North Vancouver, BC, Canada +++ **Piling Contractor** Kani Foundation Technologies, Richmond, BC, Canada

DSI Services Supply of 330 GEWI® Piles with double corrosion protection, total length 18 m; Technical support; Rental of testing equipment

Testing GEWI® Piles in compression using adjacent GEWI® Piles for reaction piles



Detail view of GEWI® Pile head (compression/tension)

DYWIDAG GEWI® Piles stabilize major Scottish railway realignment

East Coast Main Line, Dolphingstone, Scotland

i **Client** Railtrack, UK +++ **Main Contractor** Edmund Nuttall Ltd., Camberley, England +++ **Joint Venture Contractor** Ritches, Kilsyth, Scotland +++ **Consulting Engineers** Donaldson Associates, Glasgow, Scotland +++ **Geological Analyst** Dalgleish Associates, Scotland

DSI Services 39.000 m GEWI® Pile \varnothing 40 mm, incl. 6.600 couplers; Supply of a series S.03 1,100 kN Hydraulic Jack and Power Pump for stressing test piles



View of the 1.6 km long track section

DYWIDAG GEWI® Piles after installation



GEWI® Piles for foundation upgrade in Aluminum Smelter

VAW Kurri Kurri Pty. Ltd. Aluminum Smelter, Kurri Kurri, NSW, Australia



Detail view of **GEWI®** Pile head (compression)

i **Owner** VAW Kurri Kurri Pty. Ltd. Aluminum Smelter, Kurri Kurri, Australia +++ **General Contractor** Civilbuild Pty. Ltd., Carrington, Australia +++ **Engineering** Lindsay & Dynan Pty. Ltd., Broadmeadow, Australia

DSI services Supply of 54 **GEWI®** Piles \varnothing 32 mm with accessories; Technical support and training of the contractor's crew; Supply of testing equipment; Performance of compression tests and rental of grouting equipment

Uplift **GEWI®** Piles for underground parking structure

i **Project** Untere Stadt Parking Structure, School and Sports Facility, Hall in Tyrol, Austria +++

Owner Stadtgemeinde Hall (municipality of Hall), Tyrol, Stadtwerke Hall GesmbH (municipal utilities) +++ **Design** Stadtbauamt (Town Planning Dept.) Hall / Teindl Geotechnik Consult

DSI Services Supply of 800 **GEWI®** Piles and 120 DYWIDAG Strand Anchors incl. testing of anchors, technical assistance with respect to design and execution

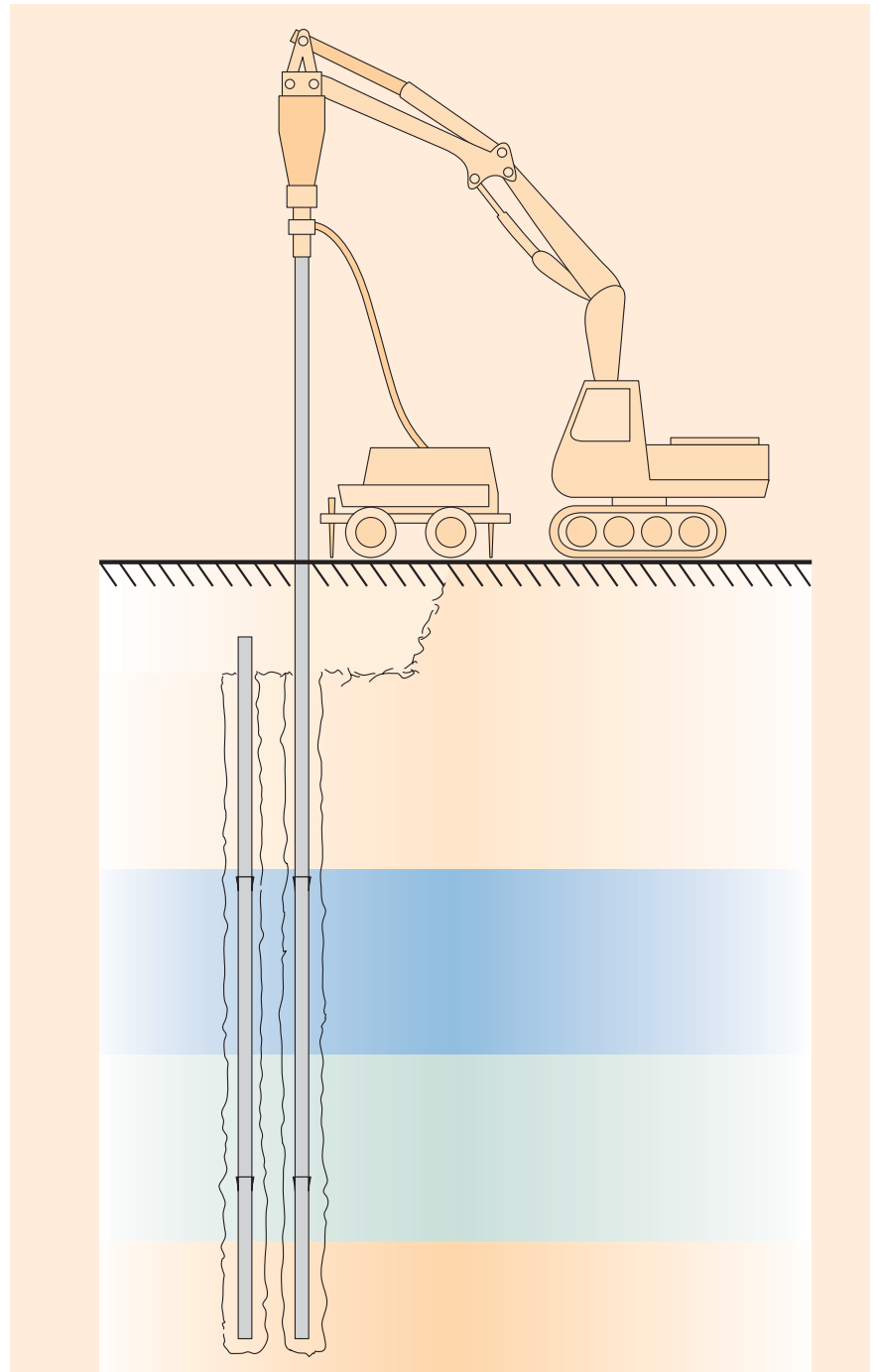
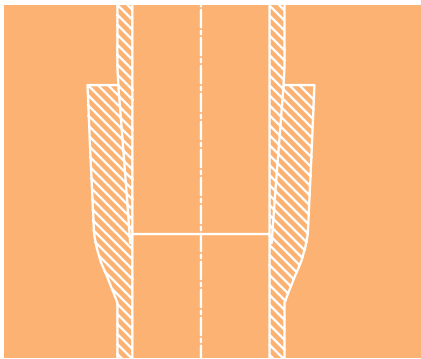


DYWIDAG Ductile Iron Piles

Advantages and Characteristics

The pile system consists of driven ductile centrifugally cast pipes with conical couplers. Depending on the soil conditions, the ductile cast iron piles will be used as peak pressure or frictional piles.

- very fast and almost vibrationless pile production
- control of load capacity through correlation with driving rate
- can be used as permanent pile
- easy adaption of the pile length to different soil conditions
- no waste cuttings
- no reworking of the pile heads necessary
- light and easily moveable equipment allows pile production under limited space conditions
- small site equipment enables fast use



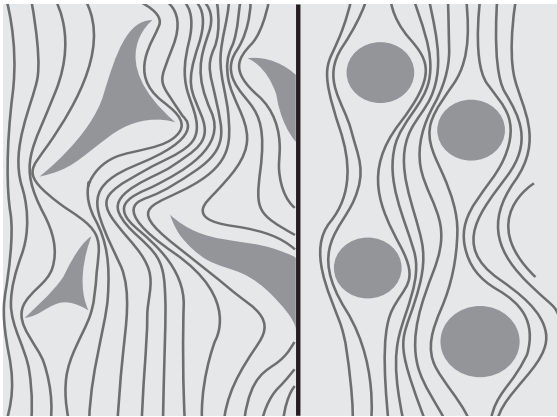
Interior load capacity of the DYWIDAG Ductile iron pile acc. to approval by DIBt (German Institute for Structural Engineering)

type of pile	exterior diameter	wall thickness	cast iron cross section	concrete cross section	load capacity cast iron	load capacity concrete B25	load capacity pile
Ø x s	mm	mm	cm ² *	cm ²	kN*	kN	kN
118 x 7.5	118.00	7.50	20.55	83.32	438	69	507
118 x 9.0	118.00	9.00	25.33	78.54	540	65	605
118 x 10.6	118.00	10.60	30.26	73.59	646	61	707
170 x 9.0	170.00	9.00	37.58	181.46	800	151	951
170 x 10.6	170.00	10.60	45.14	173.90	962	144	1,106

* considering the corrosion rate

Approval Z-34.25-202
 see: www.dywidag-systems.com
 (downloads – approvals – Germany –
 Geotechnical Systems)

DYWIDAG Ductile Iron Piles

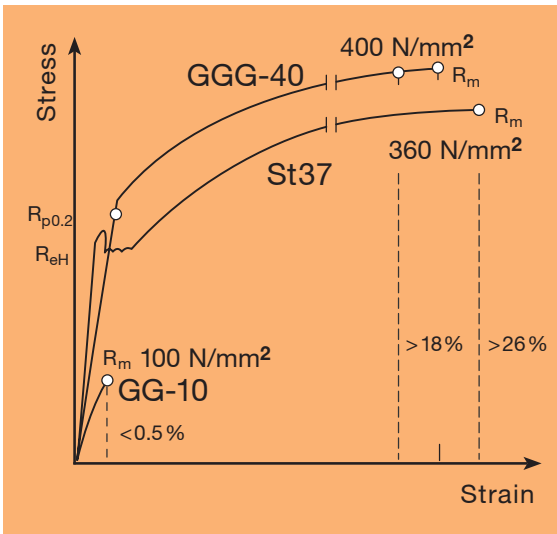


Course of the Strain Lines:

Cast iron with lamellar graphite (gray cast iron = GG)
 Cast iron with spheroidal graphite (ductile cast iron = GGG)

Cast Iron with Spheroidal Graphite (GGG)

In the melted cast iron mass graphite is converted from a tapered lamellar shape (gray cast iron) into a spheroidal shape (ductile cast iron). Thus the mechanical characteristics are significantly changed, strength is increased and the material becomes more ductile.

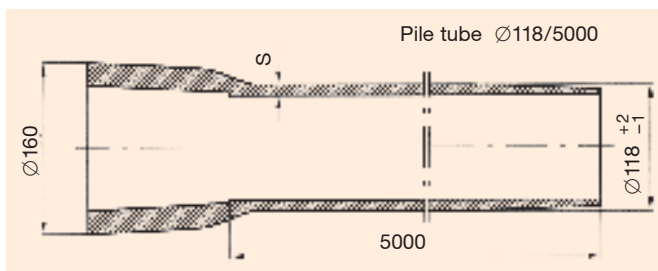


Relation of the Work Lines:

GG-ST37-GGG

R_m , tensile strength	min. 420 N/mm ²	Brinell hardness	max. 230 HB
$R_{p0.2}$, 0.2% - elongation limit	min. 300 N/mm ²	Joung modulus of electricity	160,000 N/mm ²
elongation at maximum load	min. 10%	density	7.05 g/cm ³

Ø 118	
nom. S	weight
7.5	105kg ± 7kg
9.0	123kg ± 7kg
10.6	142kg ± 7kg

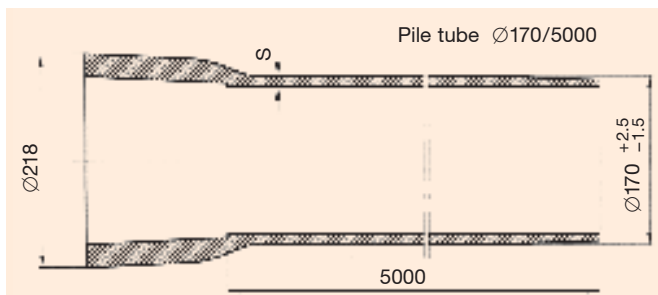


Pile Production

The piles are produced using-rapid per-cussion hammers. The first pipe length is fitted with a ram shoe and driven into the soil. The subsequent pipe lengths are driven into the conical couplers of the pile driven before.

The final pile length will be determined based on the penetration resistance.

Ø 170	
nom. S	weight
9.0	186kg ± 10kg



Applications for DYWIDAG Ductile Iron Piles



i **Project** Sports Facility Linz, Austria +++ **Client** Structural analysis: Kirsch-Muchitsch & Partner +++ **Owner** Town of Linz
DSI Services 1,200 m of Ø 170 mm grouted DYWIDAG Ductile iron piles; foundation of pillars 10 m.



i **Project** Residential Building Complex Unterrohr, Kremsmünster, Austria
DSI Services 2,000 m of Ø 118 mm ungrouted DYWIDAG Ductile iron piles.



i **Project** Construction Site for Approval Tests, Bischofshofen, Austria
DSI Services ungrouted DYWIDAG Ductile iron piles



i **Project** Budenheim near Mainz, Germany
DSI Services Performance test for grouted test piles Ø 118 x 9 mm



Austria

DYWIDAG-SYSTEMS
INTERNATIONAL GMBH
Alfred-Wagner-Strasse 1
4061 Pasching/Linz, Austria
Phone +43-7229-61 04 90
Fax +43-7229-61 04 980
E-mail: dsi-a@dywidag-systems.at
www.dywidag-systems.at

Belgium and Luxembourg

DYWIDAG-SYSTEMS
INTERNATIONAL N.V.
Industrieweg 25
3190 Boortmeerbeek, Belgium
Phone +32-16-60 77 60
Fax +32-16-60 77 66
E-mail: info@dywidag.be

France

DSI-Artéon
Avenue du Bicentenaire
ZI Dagneux-BP 50053
01122 Montluel Cedex, France
Phone +33-4-78 79 27 82
Fax +33-4-78 79 01 56
E-mail: dsi.france@dywidag.fr
www.dywidag-systems.fr

Germany

DYWIDAG-SYSTEMS
INTERNATIONAL GMBH
Schuetzenstrasse 20
14641 Nauen, Germany
Phone +49 3321 44 18 32
Fax +49 3321 44 18 18
E-mail: suspa@dywidag-systems.com

DYWIDAG-SYSTEMS
INTERNATIONAL GMBH
Max-Planck-Ring 1
40764 Langenfeld, Germany
Phone +49 2173 79 02 0
Fax +49 2173 79 02 20
E-mail: suspa@dywidag-systems.com
www.suspa-dsi.de

DYWIDAG-SYSTEMS
INTERNATIONAL GMBH
Germanenstrasse 8
86343 Koenigsbrunn, Germany
Phone +49 8231 96 07 0
Fax +49 8231 96 07 40
E-mail: geotechnik@dywidag-systems.com

DYWIDAG-SYSTEMS
INTERNATIONAL GMBH
Siemensstrasse 8
85716 Unterschleissheim, Germany
Phone +49-89-30 90 50-100
Fax +49-89-30 90 50-120
E-mail: dsihv@dywidag-systems.com
www.dywidag-systems.com

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Italy

DYWIT S.P.A.
Via Grandi, 64
20017 Mazzo di Rho (Milano), Italy
Phone +39-02-93 46 87 1
Fax +39-02-93 46 87 301
E-mail: info@dywit.it

Netherlands

DYWIDAG-SYSTEMS
INTERNATIONAL B.V.
Veilingweg 2
5301 KM Zaltbommel, Netherlands
Phone +31-418-57 89 22
Fax +31-418-51 30 12
E-mail: email@dsi-nl.nl
www.dsi-nl.nl

Norway

DYWIDAG-SYSTEMS
INTERNATIONAL A/S
Industrieveien 7A
1483 Skytta, Norway
Phone +47-67-06 15 60
Fax +47-67-06 15 59
E-mail: manager@dsi-dywidag.no

Portugal

DYWIDAG-SYSTEMS
INTERNATIONAL LDA
Rua do Polo Sul
Lote 1.01.1.1 - 2B
1990-273 Lisbon, Portugal
Phone +351-21-89 22 890
Fax +351-21-89 22 899
E-mail: dsi.lisboa@dywidag.pt

Spain

DYWIDAG SISTEMAS
CONSTRUCTIVOS, S.A.
Avenida de la Industria, 4
Pol. Ind. La Cantuena
28947 Fuenlabrada (MADRID), Spain
Phone +34-91-642 20 72
Fax +34-91-642 27 10
E-mail: dywidag@dywidag-sistemas.com
www.dywidag-sistemas.com

United Kingdom

DYWIDAG-SYSTEMS
INTERNATIONAL LTD.
Northfield Road
Southam, Warwickshire
CV47 0FG, Great Britain
Phone +44-1926-81 39 80
Fax +44-1926-81 38 17
E-mail: sales@dywidag.co.uk
www.dywidag-systems.com/uk

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