

DYWI® Drill Hollow Bar System

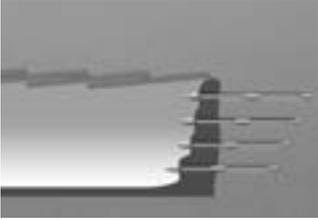


DYWI® Drill Hollow Bar System

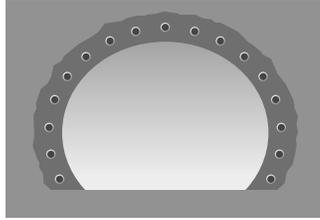
Fields of Application

Underground

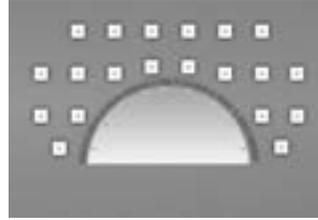
Face Bolting



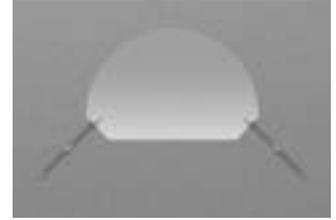
Injection Works



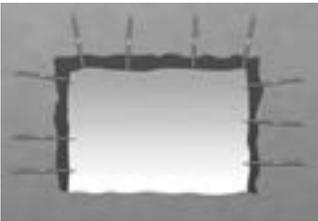
Portal Stabilization



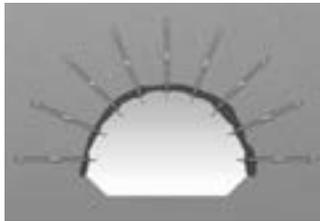
Footwall Stabilization



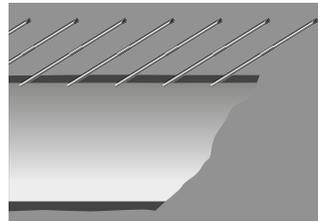
Roof and Rib Bolting



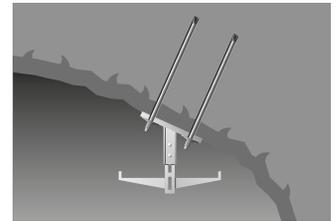
Radial Bolting



Forepoling

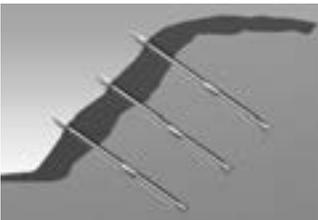


Utility Hangers

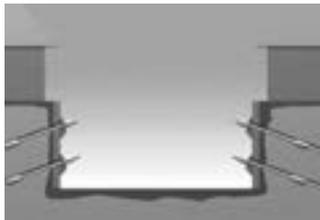


Civil Engineering

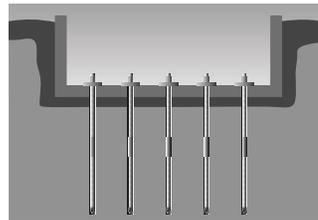
Slope Stabilization



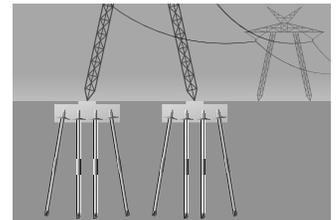
Tie Back Anchorage



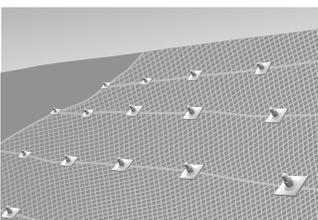
Uplift Control



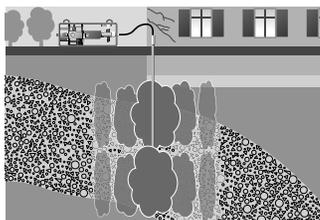
Pile Foundation



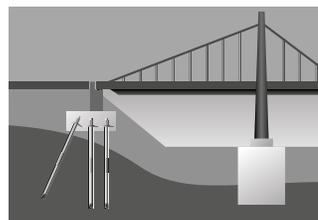
Rock Fall Protection



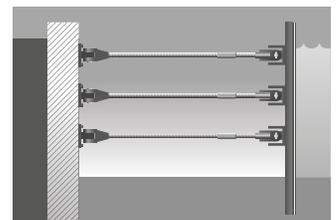
Ground Consolidation



Abutments



Tie Rods



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Introduction

The DYWI® Drill Hollow Bar System is a self-drilling ground control solution used for Underground applications and in Civil Engineering. Underground, it can be used for bolting, foot piles, face stabilization, as forepoling element for pre-support, or as a lance for injection works.

The DYWI® Drill Hollow Bar System also features a wide range of applications in Civil Engineering such as rock and soil nails, micropiles, or ground anchors. The system features an “all in one” tool for drilling, flushing, post- or simultaneous grouting, and finally the load-carrying member itself.

Installations in weak ground and unstable borehole conditions represent no difficulty and are ideal for the application of the DYWI® Drill Hollow Bar System. DSI Underground has long-term experience in the design, development, manufacturing, testing, and distribution of the DYWI® Drill Hollow Bar System.

System Solution



System Description

- Self-drilling ground control solution
- Preferably used under unstable borehole conditions
- Self-drilling installation without casing using a lost drill bit
- Installation with standard rotary or rotary-percussive drilling machines
- Hollow bar with continuous left-hand, cold-rolled outside thread utilized as drill rod during installation
- Easy extension of hollow bars using couplings
- Grouting can either be performed during drilling with a rotary injection adapter or after the drilling operation
- Threaded profile allows an ideal bond between the hollow bar and the grouting medium

Main Advantages

- Fast and safe self-drilling installation
- Trouble-free application in unstable boreholes
- Easy and similar operating principle using on-site personnel and standard drilling machinery
- Drilling, installation, and optional grouting in a single operational step
- Proven installation process in difficult ground conditions
- Sound and efficient alternative compared to time-consuming cased drilling installation methods and products
- Same installation principle for all applications and ground conditions
- Minimization of ground disturbance
- Drill bit designs and diameters can be adjusted to different and varying ground conditions
- Minor space requirements for installation
- Functional adjustment of required lengths using couplings
- Broad range of hollow bar load capacity classes allows basic dimensioning and adaptation of design
- Robust system and high-strength thread designed for the demands of the construction industry
- High level of quality control measures among all levels of design and manufacturing

Quality Assurance

DSI Underground's comprehensive services include the conception, design, planning and installation of its systems as well as quality management and on-site supervision.

To satisfy your requirements and needs, DSI Underground has implemented a quality assurance process for the

DYWI® Drill Hollow Bar System in accordance with the principles of total quality management.

Quality means safety and reliability for our customers. Our aim is to provide product quality and safety through the entire manufacturing and distribution process.

**QUALITY
SAFETY
RELIABILITY**

Quality Assurance Process



System Components

Basic Elements

- Hollow bar
 - Used as drill rod during installation
 - Suitable for simultaneous or subsequent grouting
 - Tension or compression member
- Coupling
 - Continuous inside thread with middle stop or center bridge
 - Controlled drilling energy transmission
 - Full load bearing capacity
- Drill bit
 - One drill bit per installed unit
 - Different diameters and designs
 - Hardened and carbide insert versions
 - Optimized for various ground conditions

Design Examples



System Components

Anchorage and Foundation Constructions

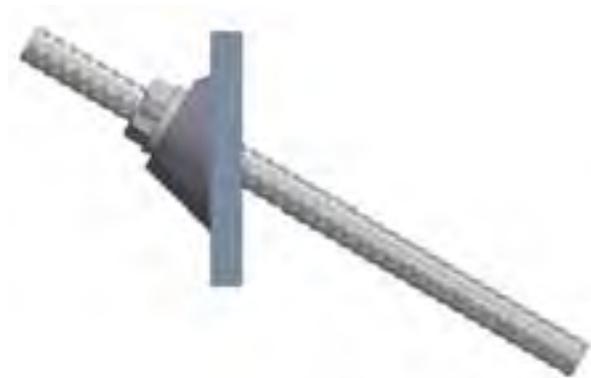
- Nut
 - Hex or domed version
 - Weldable square nut
 - Different designs and dimensions available
- Plate
 - Flat or domed
 - Plate design adjusted to system demands
 - Various solutions for angle compensations and special plate designs available

Design Examples

Nail Head with Domed Plate



Anchor Head with Angle Compensation



Micropile Head (Compression Pile)



Reverse Anchor Head



System Accessories

- Structural elements
 - S-D expansion bolt
 - Expansion shell
 - Yielding anchor head
 - Lock nut
 - Eye nut and loop nut
 - Bail nut
 - Reverse anchor head
 - Lock coupling
 - Angle compensation disk
 - Sleeve for free length
 - Protective cap
- Drilling, grouting, and monitoring
 - Bayonet connector
 - Injection adapter
 - Rotary injection adapter
 - Grout mixing pump
 - DYWI® Inject Systems
 - Sealing coupling
- Post-injection coupling
 - Drill bit adapter
 - Rock drilling equipment
 - Centralizer
 - Injection flow-pressure meter
 - Pull testing equipment
 - Drill rod wrench
 - Tensioning tool

Rock and Soil Nail

Basic Concept

Soil nailing is a construction technique generally used for the stabilization of naturally unstable slopes or securing of over-steepened existing slopes, as well as the stabilization of retaining walls or embankments. For Underground applications, soil nails are also referred to as rock nails or bolts.

The basic concept of a soil or rock nail is based on the installation of longitudinal reinforcement elements into the ground. Hence, this load-bearing

system significantly differs from ground anchors (actively tensioned) and tensile piles, as the nail is installed un-tensioned (passive system). Consequently, nails increase the load-bearing capacity of the entire structure and act as a group of elements, withstanding tensile and shear forces acting on the nails. The center-to-center distance of nails must be chosen as such they are able to act as a complete nailing system. Prior to nail installation, the excavation face is generally

supported by shotcrete, precast concrete elements, mesh, or geotextiles. The design of a nail head construction depends on the application and the intended lifetime of the structure.

Conventional nail systems consisting of solid threaded bars are installed into pre-drilled holes and subsequently grouted. DYWI® Drill rock and soil nails are installed self-drilling, and are either grouted simultaneously during drilling or afterwards.

Schematic Drawing

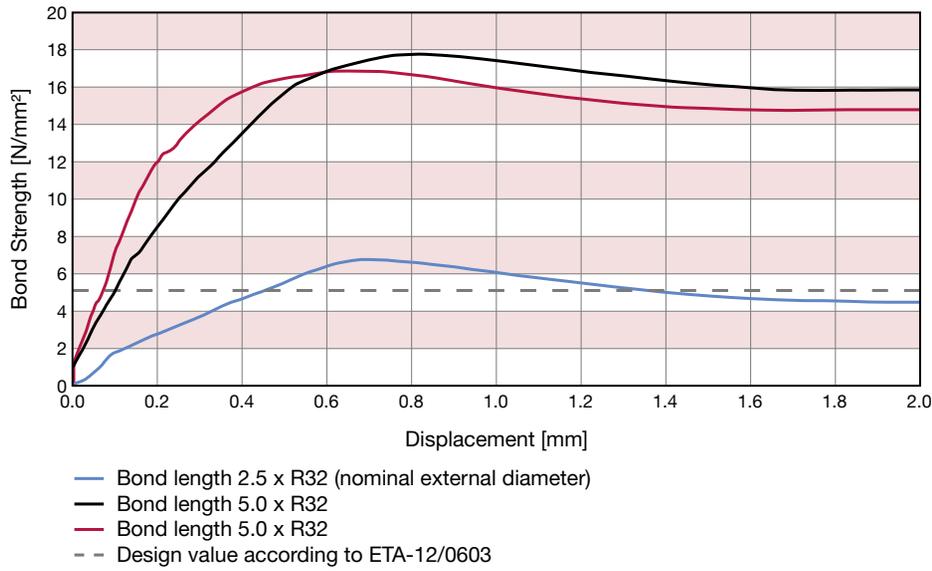


Approvals

- European Technical Approval (ETA)
- National technical approval in Austria (BmVIT)
- National technical approval in Germany (DIBt)
- German approval for Underground application
- National technical approval in Poland (IBDiM)
- Project-specific application

Rock and Soil Nail

Bonding Characteristics DYWI® Drill R32-400



Applications



Ground Anchor

Basic Concept

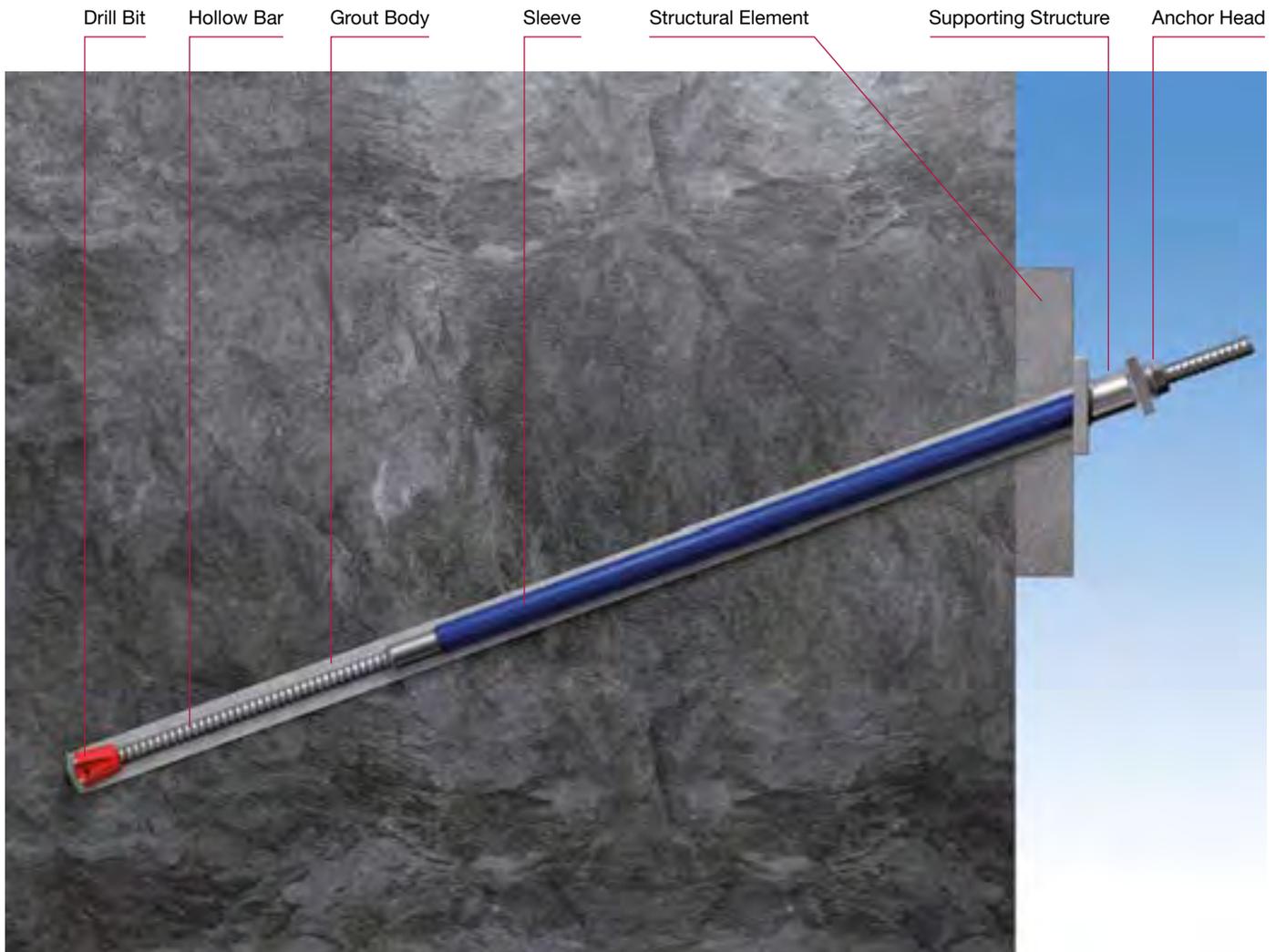
In Civil Engineering, ground anchors are elements which are actively tensioned to support structures. Due to the active tensioning of the system, anticipated deformations are minimized or entirely eliminated. Fields of applications are either temporary – such as excavation pits and retaining walls – or permanent, e.g. tie backs or masts.

By definition, ground anchors consist of the following three system components:

- Bond length: the anchor is set in the borehole using cement grout (mortar), and is able to transfer the forces to the load-bearing soil via bond and skin friction
- Unbonded (or free) length: the tendon is uncoupled from the borehole wall using a sheathing (sleeve) which is sealed towards the coupling or hollow bar; the unbonded portion can freely extend and tension can be applied to the anchor system
- Anchor head: transfers the anchor force to the substructure (e.g. precast concrete elements) that needs to be anchored

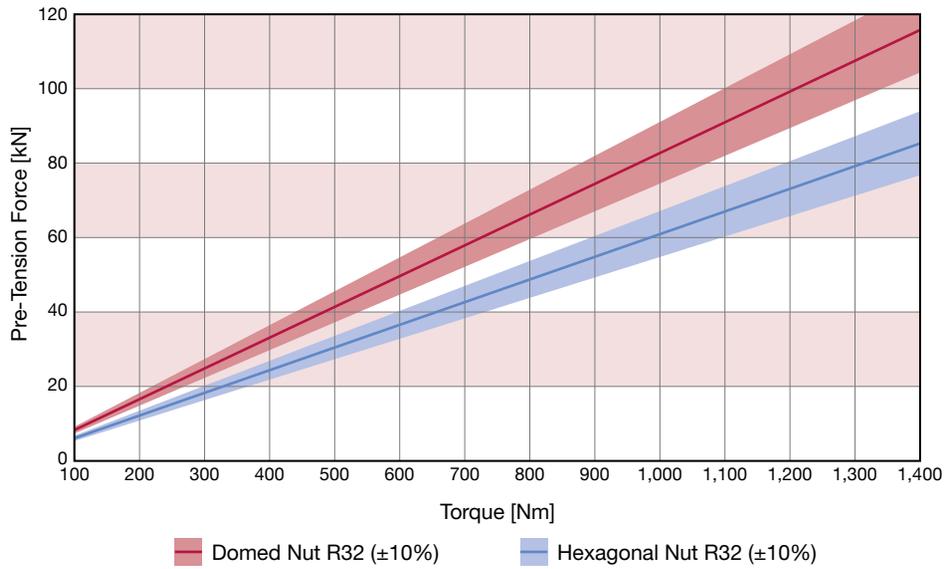
Strand or solid bar ground anchor systems are installed into cased, pre-drilled holes and subsequently grouted. DYWI® Drill ground anchors are installed self-drilling with a pre-mounted sleeve attached to the drill string during installation.

Schematic Drawing



Ground Anchor

Torque-Tension Diagram DYWI® Drill Hollow Bar Type R32-280



Domed Nut R32



Hexagonal Nut R32

Applications



Self-Drilling (S-D) Expansion Bolt



Micropile

Basic Concept

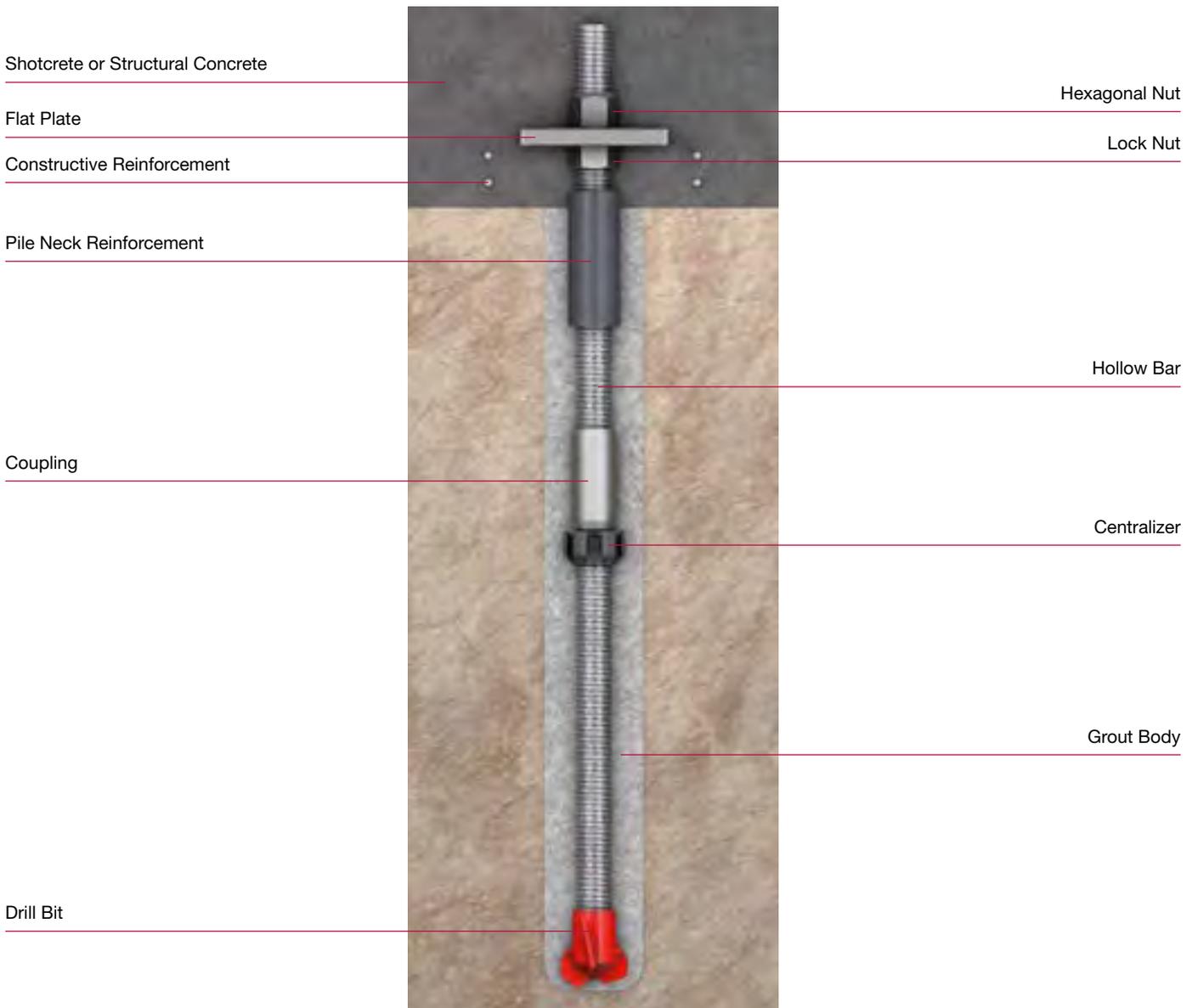
Pile foundation systems either consist of single piles (monopiles) or a group of piles which are connected to each other by a pile cap structure. Micropiles are typically used for underpinning civil structures, especially under limited space conditions or time constraints. By definition, micropiles consist of tubular steel elements with an outer

diameter range of approx. 60 - 200 [mm] (2.5 - 8.0 [in]). In general, micropiles act as a passive foundation system.

DYWI® Drill micropiles are installed self-drilling, typically using a large-diameter drill bit. Installation is accomplished with rotary or rotary-percussive drilling equipment, depending on the ground

conditions and intended installation length. Filling/grouting of the borehole is either performed simultaneously while drilling or afterwards. The grout serves as bonding medium which transfers the forces to the soil in terms of skin friction. A larger grout coverage also enhances the corrosion protection of the system.

Schematic Drawing (Tension Pile)

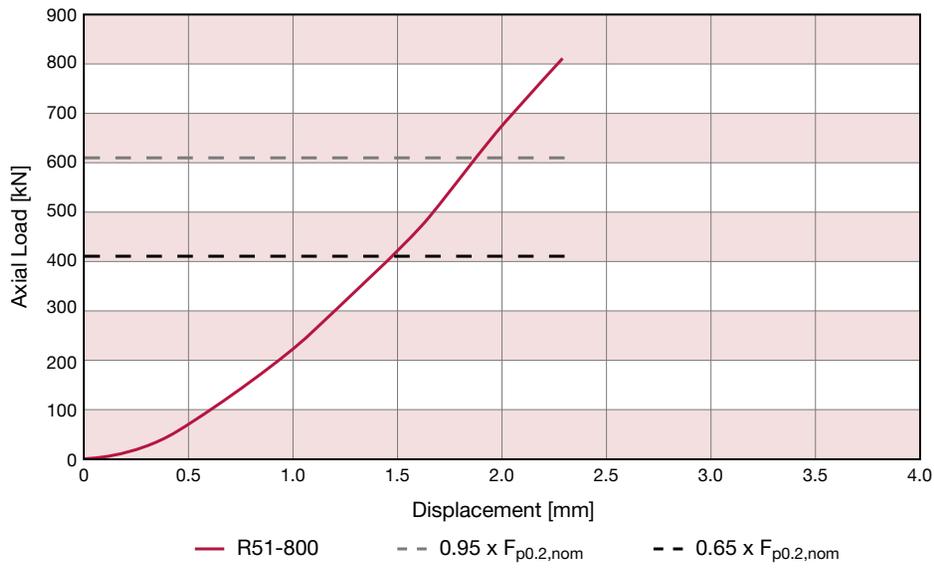


Approvals

- National technical approval in Austria (BmVIT)
- National technical approval in Poland (IBDiM)
- Project-specific

Micropile

Load Transfer Testing (ETAG 013)



Applications



Spile and Injection Lance

Basic Concept

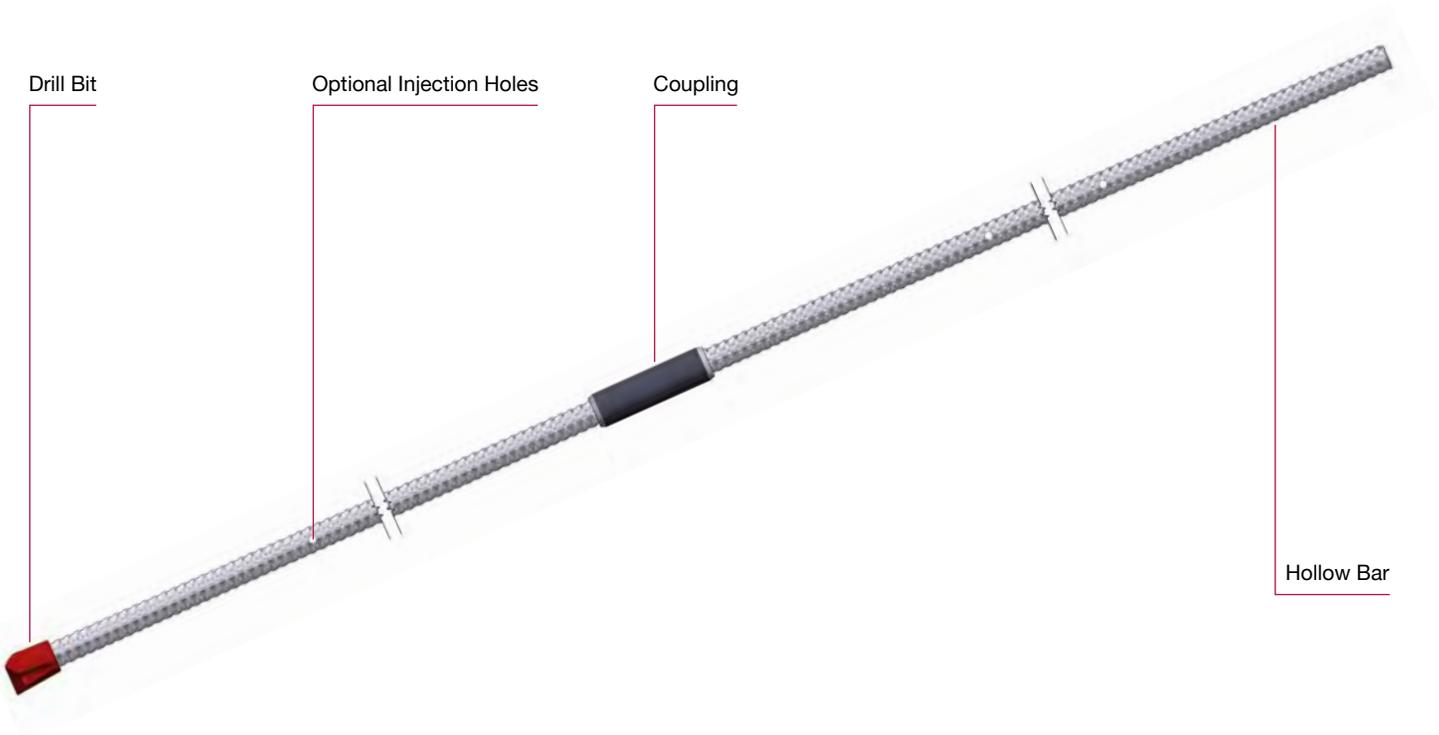
Spiles are used as temporary pre-support elements for the stabilization of the working area in tunnel headings. They are installed in the crown and sidewall area of a tunnel, to ensure the stability of the perimeter of the open span until the primary lining is installed.

Injection lances are used for the targeted transport of a cement or resin based injection medium to the designated injection area.

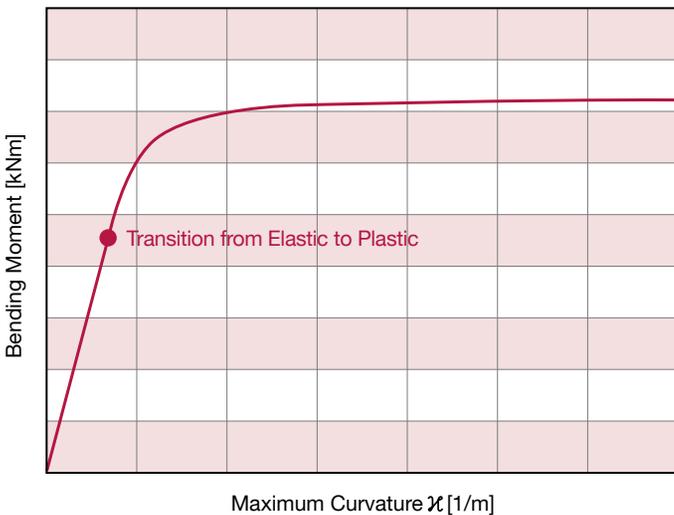
In difficult ground and in case of unstable boreholes, DYWI® Drill spiles and injection

lances are a preferred solution to ensure a safe and fast installation procedure. Self-drilling spiles and injection lances allow the use of default Underground drilling machinery (jumbos); threaded hollow bars enable a durable and easy connection to any injection hose system.

Schematic Drawing



Bending Tests



Spile and Injection Lance

Applications



Specifications

SI Units

Technical Data Series R32

Characteristic Value / Type ¹⁾	Symbol	Unit	R32-210	R32-250	R32-280	R32-320	R32-360	R32-400
Nominal external diameter	$D_{e,nom}$	[mm]	32					
Actual external diameter	D_e	[mm]	31.1					
Average internal diameter ²⁾	D_i	[mm]	21.0	20.0	18.5	16.5	15.0	12.5
Nominal cross-sectional area ³⁾	S_0	[mm ²]	340	370	410	470	510	560
Nominal weight ⁴⁾	m	[kg/m]	2.65	2.90	3.20	3.70	4.00	4.40
Specific rib area	f_R	[-]	0.13					
Nominal yield load ⁵⁾	$F_{p0.2,nom}$	[kN]	160	190	220	250	280	330
Nominal ultimate load ⁵⁾	$F_{m,nom}$	[kN]	210	250	280	320	360	400
Yield strength ⁶⁾	$R_{p0.2}$	[N/mm ²]	470	510	540	530	550	590
Ultimate strength ⁶⁾	R_m	[N/mm ²]	620	680	680	680	710	710
$R_m/R_{p0.2}$ ⁷⁾	-	[-]	≥ 1.15					
Ultimate load strain ⁷⁾	A_{gt}	[%]	≥ 5.0					
Fatigue strength $2 \cdot \sigma_a$ ⁸⁾	-	[N/mm ²]	190					
Bond strength ⁹⁾	τ_{ak}	[N/mm ²]	5.1					

Technical Data Series R38

Characteristic Value / Type ¹⁾	Symbol	Unit	R38-420	R38-500	R38-550
Nominal external diameter	$D_{e,nom}$	[mm]	38		
Actual external diameter	D_e	[mm]	37.8		
Average internal diameter ²⁾	D_i	[mm]	21.5	19.0	17.0
Nominal cross-sectional area ³⁾	S_0	[mm ²]	660	750	800
Nominal weight ⁴⁾	m	[kg/m]	5.15	5.85	6.25
Specific rib area	f_R	[-]	0.13		
Nominal yield load ⁵⁾	$F_{p0.2,nom}$	[kN]	350	400	450
Nominal ultimate load ⁵⁾	$F_{m,nom}$	[kN]	420	500	550
Yield strength ⁶⁾	$R_{p0.2}$	[N/mm ²]	530	530	560
Ultimate strength ⁶⁾	R_m	[N/mm ²]	640	670	690
$R_m/R_{p0.2}$ ⁷⁾	-	[-]	≥ 1.15		
Ultimate load strain ⁷⁾	A_{gt}	[%]	≥ 5.0		
Fatigue strength $2 \cdot \sigma_a$ ⁸⁾	-	[N/mm ²]	190		
Bond strength ⁹⁾	τ_{ak}	[N/mm ²]	5.1		

Technical Data Series R51

Characteristic Value / Type ¹⁾	Symbol	Unit	R51-550	R51-660	R51-800	R51-950
Nominal external diameter	$D_{e,nom}$	[mm]	51			
Actual external diameter	D_e	[mm]	49.8			
Average internal diameter ²⁾	D_i	[mm]	34.5	33.0	29.0	26.0
Nominal cross-sectional area ³⁾	S_0	[mm ²]	890	970	1,150	1,225
Nominal weight ⁴⁾	m	[kg/m]	6.95	7.65	9.00	9.60
Specific rib area	f_R	[-]	0.13			
Nominal yield load ⁵⁾	$F_{p0.2,nom}$	[kN]	450	540	640	780
Nominal ultimate load ⁵⁾	$F_{m,nom}$	[kN]	550	660	800	950
Yield strength ⁶⁾	$R_{p0.2}$	[N/mm ²]	510	560	560	640
Ultimate strength ⁶⁾	R_m	[N/mm ²]	620	680	700	770
$R_m/R_{p0.2}$ ⁷⁾	-	[-]	≥ 1.15			
Ultimate load strain ⁷⁾	A_{gt}	[%]	≥ 5.0			
Fatigue strength $2 \cdot \sigma_a$ ⁸⁾	-	[N/mm ²]	190			
Bond strength ⁹⁾	τ_{ak}	[N/mm ²]	5.1			

Specifications

SI Units

Technical Data Series T76

Characteristic Value / Type ¹⁾	Symbol	Unit	T76-1300	T76-1650	T76-1900
Nominal external diameter	$D_{e,nom}$	[mm]		76	
Actual external diameter	D_e	[mm]	74.6		75.6
Average internal diameter ²⁾	D_i	[mm]	56.0	52.0	47.0
Nominal cross-sectional area ³⁾	S_0	[mm ²]	1,590	1,975	2,360
Nominal weight ⁴⁾	m	[kg/m]	12.5	15.5	18.5
Specific rib area	f_R	[-]	0.20		0.24
Nominal yield load ⁵⁾	$F_{p0.2,nom}$	[kN]	1,000	1,200	1,500
Nominal ultimate load ⁵⁾	$F_{m,nom}$	[kN]	1,300	1,650	1,900
Yield strength ⁶⁾	$R_{p0.2}$	[N/mm ²]	630	610	640
Ultimate strength ⁶⁾	R_m	[N/mm ²]	820	840	810
$R_m/R_{p0.2}$ ⁷⁾	-	[-]		≥ 1.15	
Ultimate load strain ⁷⁾	A_{gt}	[%]		≥ 5.0	

1) Status: 2016-04, all values are subject to change

2) Calculated from the actual external diameter, the average thread height, and the nominal cross-sectional area, rounded

3) Calculated from the nominal weight $S_0 = 10^3 \times m / 7.85$

4) Deviation: -3% to +9%

5) Characteristic value (5%-fractile)

6) Calculated from the nominal load and the nominal cross-sectional area, rounded

7) Characteristic value (10%-fractile)

8) Values are determined at an upper force $F_{up} = 0.7 \times F_{p0.2,nom}$ and 2 million load cycles

9) Characteristic values, determined by pull-out tests using mortar with a prism compressive strength ≥ 55 [N/mm²]

Modulus of elasticity $E = 205,000$ [N/mm²]



Specifications

US Customary Units

Technical Data Series R32

Characteristic Value / Type ¹⁾	Symbol	Unit	R32-210	R32-250	R32-280	R32-320	R32-360	R32-400
Nominal external diameter	D _{e,nom}	[in]	1.26					
Actual external diameter	D _e	[in]	1.22					
Average internal diameter ²⁾	D _i	[in]	0.83	0.79	0.73	0.65	0.59	0.49
Nominal cross-sectional area ³⁾	S ₀	[in ²]	0.53	0.57	0.64	0.73	0.79	0.87
Nominal weight ⁴⁾	m	[lb/ft]	1.78	1.95	2.15	2.49	2.69	2.96
Specific rib area	f _R	[-]	0.13					
Nominal yield load ⁵⁾	F _{p0.2,nom}	[kip]	36	43	49	56	63	74
Nominal ultimate load ⁵⁾	F _{m,nom}	[kip]	47	56	63	72	81	90
Yield strength ⁶⁾	R _{p0.2}	[ksi]	68	74	78	77	80	86
Ultimate strength ⁶⁾	R _m	[ksi]	90	99	99	99	103	103
R _m /R _{p0.2} ⁷⁾	-	[-]	≥ 1.15					
Ultimate load strain ⁷⁾	A _{gt}	[%]	≥ 5.0					
Fatigue strength 2·σ _a ⁸⁾	-	[ksi]	28					
Bond strength ⁹⁾	τ _{ak}	[ksi]	0.7					

Technical Data Series R38

Characteristic Value / Type ¹⁾	Symbol	Unit	R38-420	R38-500	R38-550
Nominal external diameter	D _{e,nom}	[in]	1.50		
Actual external diameter	D _e	[in]	1.49		
Average internal diameter ²⁾	D _i	[in]	0.85	0.75	0.67
Nominal cross-sectional area ³⁾	S ₀	[in ²]	1.02	1.16	1.24
Nominal weight ⁴⁾	m	[lb/ft]	3.46	3.93	4.20
Specific rib area	f _R	[-]	0.13		
Nominal yield load ⁵⁾	F _{p0.2,nom}	[kip]	79	90	101
Nominal ultimate load ⁵⁾	F _{m,nom}	[kip]	94	112	124
Yield strength ⁶⁾	R _{p0.2}	[ksi]	77	77	81
Ultimate strength ⁶⁾	R _m	[ksi]	93	97	100
R _m /R _{p0.2} ⁷⁾	-	[-]	≥ 1.15		
Ultimate load strain ⁷⁾	A _{gt}	[%]	≥ 5.0		
Fatigue strength 2·σ _a ⁸⁾	-	[ksi]	28		
Bond strength ⁹⁾	τ _{ak}	[ksi]	0.7		

Technical Data Series R51

Characteristic Value / Type ¹⁾	Symbol	Unit	R51-550	R51-660	R51-800	R51-950
Nominal external diameter	D _{e,nom}	[in]	2.01			
Actual external diameter	D _e	[in]	1.96			
Average internal diameter ²⁾	D _i	[in]	1.36	1.30	1.14	1.02
Nominal cross-sectional area ³⁾	S ₀	[in ²]	1.38	1.50	1.78	1.90
Nominal weight ⁴⁾	m	[lb/ft]	4.67	5.14	6.05	6.45
Specific rib area	f _R	[-]	0.13			
Nominal yield load ⁵⁾	F _{p0.2,nom}	[kip]	101	121	144	175
Nominal ultimate load ⁵⁾	F _{m,nom}	[kip]	124	148	180	214
Yield strength ⁶⁾	R _{p0.2}	[ksi]	74	81	81	93
Ultimate strength ⁶⁾	R _m	[ksi]	90	99	102	112
R _m /R _{p0.2} ⁷⁾	-	[-]	≥ 1.15			
Ultimate load strain ⁷⁾	A _{gt}	[%]	≥ 5.0			
Fatigue strength 2·σ _a ⁸⁾	-	[ksi]	28			
Bond strength ⁹⁾	τ _{ak}	[ksi]	0.7			

Specifications

US Customary Units

Technical Data Series T76

Characteristic Value / Type ¹⁾	Symbol	Unit	T76-1300	T76-1650	T76-1900
Nominal external diameter	$D_{e,nom}$	[in]		3.0	
Actual external diameter	D_e	[in]	2.94		2.98
Average internal diameter ²⁾	D_i	[in]	2.20	2.05	1.85
Nominal cross-sectional area ³⁾	S_0	[in ²]	2.46	3.06	3.66
Nominal weight ⁴⁾	m	[lb/ft]	8.40	10.42	12.43
Specific rib area	f_R	[-]	0.20		0.24
Nominal yield load ⁵⁾	$F_{p0.2,nom}$	[kip]	225	270	337
Nominal ultimate load ⁵⁾	$F_{m,nom}$	[kip]	292	371	427
Yield strength ⁶⁾	$R_{p0.2}$	[ksi]	91	88	93
Ultimate strength ⁶⁾	R_m	[ksi]	119	122	117
$R_m/R_{p0.2}$ ⁷⁾	-	[-]		≥ 1.15	
Ultimate load strain ⁷⁾	A_{gt}	[%]		≥ 5.0	

1) Status: 2016-04, all values are subject to change

2) Calculated from the actual external diameter, the average thread height, and the nominal cross-sectional area, rounded

3) Calculated from the nominal weight

4) Deviation: -3% to +9%

5) Characteristic value (5%-fractile)

6) Calculated from the nominal load and the nominal cross-sectional area, rounded

7) Characteristic value (10%-fractile)

8) Values are determined at an upper force $F_{up} = 0.7 \times F_{p0.2,nom}$ and 2 million load cycles

9) Characteristic values, determined by pull-out tests using mortar with a prism compressive strength ≥ 8 [ksi]

Modulus of elasticity $E = 29,700$ [ksi]



Corrosion Protection

Definitions, Principle, and Protection

Introduction

By definition, corrosion is the reaction of a material with its ambient environment, causing a measurable change in the material (e.g. rust) which can lead to function impairment of a component or system. From a practical standpoint, a complete corrosion protection cannot be achieved.

Therefore, applied protective methods are directed towards a reduction of the corrosion attack and the respective damages to the reinforcement or ground control elements during their intended lifetime.

Corrosion refers to the entire system, e.g. reinforcement element, grout body, ground, and corrosion media, and is expressed in terms of two main mechanisms of action: "corrosion of concrete" and "corrosion of the reinforcement in the concrete".

Corrosion of Concrete

This principle applies for grout and cement mortar. Three main factors of concrete corrosion are pH-value, presence of oxygen, and ion concentration.

Concrete damage on the surface is a first requirement for the penetration of harmful substances as far as the reinforcement in the concrete is located.

Subsequently, the corrosion of reinforcing elements reduces the strength of the structure. Dense and impenetrable concrete is more protected against corrosion than a porous one.

Corrosion of the Reinforcement in the Concrete

In properly fabricated reinforced concrete structures, reinforcement elements are generally not subjected to corrosion. Hence, if an adequate gas and water permeability of the concrete through cracks occurs, air containing carbon dioxide, sulfides, or corrosive water

in general can be transferred to the reinforcement, causing steel corrosion to start.

For civil applications, where a proper and complete cement stone or grout cover cannot be guaranteed in many

cases, the sacrificial corrosion principle is a recommended tool for the design of ground control systems with an extended working life. Hence, a cement stone coverage and respective carbonation generally helps to reduce the corrosion rate.



Blank



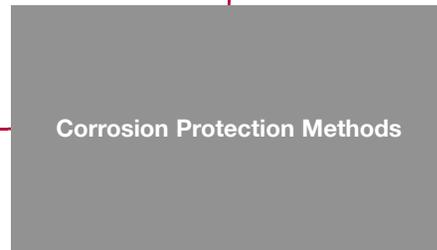
Sacrificial
Corrosion
Protection



Hot-Dip Galvanizing



Double Corrosion Protection



Corrosion Protection Methods



Duplex Coating



Cement Stone Coverage

Corrosion Protection

Corrosion Protection Methods

The selection of the optimal corrosion protection method(s) depends on the corrosion potential of the environment, and the type as well as the intended service life of the structure. The load-bearing element, transition zone between borehole and surface, and the head construction must be assessed separately.

Corrosion protection methods are divided into two main groups. The first one is called active, and comprises all

influencing methods which eliminate or reduce the corrosion reaction. A common example for active corrosion protection is encapsulation with concrete. The second one is passive corrosion protection, including methods to produce a protective layer on corrosion endangered parts, for example duplex coating systems.

A preferred and recommend active corrosion protection method is the sacrificial corrosion design principle,

which is based on corrosion rates of blank and galvanized steel depending on the corrosive environment and the expected lifetime, without considering cement stone encapsulation. Double corrosion protection (e.g. factory-made grouted corrugated sheathing) is not used for self-drilling applications; duplex type coatings can be damaged by the self-drilling installation process.

Sacrificial Corrosion Protection

- Definition of corrosion rates (sacrificial corrosion), depending on ground conditions and other influencing factors
- Element design in accordance with an increase of cross-section due to corrosion over the intended service life
- The system inherent encapsulation with cement mortar or grout is not considered
- Blank or galvanized ground control elements – galvanization leads to a delay of the corrosion start and to an increased service life
- Hot-dip galvanizing: preferred method for load-bearing system components in accordance with ISO 1461 or national standards
- Corrosion protection of head constructions must be considered separately

Working Life According to European Standards and Approvals

Working Life in Years ¹⁾	Steel ²⁾	Corrosion in [mm] for different Corrosion Loads ³⁾		
		Low	Medium	High
2	Blank	0	0	0.2
	Hot-dip galvanized	0	0	0.1
7	Blank	0.2	0.2	0.5
	Hot-dip galvanized	0	0.1	0.4
30	Blank	0.3	0.6	–
	Hot-dip galvanized	0.1	0.4	–
50	Blank	0.5	1.0	–
	Hot-dip galvanized	0.3	0.7	–

1) A working life up to 100 years can be considered in accordance with EN 1993-5

2) Typically applied average zinc layer thickness: ≥ 85 [µm] in accordance with ISO 1461

3) According to ETA-12/0603. EN 14490 and EN 14199 also define classes of ground aggressiveness and corrosion rates for achieving the intended working life; Low, medium, and high corrosion loads are defined in EN 12501-2

Double Corrosion Protection

- Factory-made corrugated sheathing with controlled crack width
- Not applicable for self-drilling installation
- Installation into pre-drilled boreholes and post-injection

Duplex Coating

- Painting or powder coating of a previously galvanized element
- Protective layer can be destroyed during the self-drilling installation process
- Coating thickness depending on the application

Cement Stone Coverage

- Encapsulation of load-bearing elements
- Carbonation reduces the influence of corrosive environments
- Guaranteed full encapsulation and limitation of crack development required for a successful application of this method

Drill Bits

Introduction

The drilling performance is affected by the choice of the proper drill bit, which mainly depends on the hardness and abrasiveness of the ground, the drilling method, borehole diameter, and borehole length.

Furthermore, the drill bit and therefore the borehole diameter depend on the application (e.g. rock or soil nails, micropiles, etc.). A key issue during the self-drilling installation procedure is to minimize the impact on the surrounding soil or rock by optimizing drilling rates and the applied energy.

For example in mixed fill type soils, drill bit types typically used are two-stage

retro flush drill bits, arc-shaped drill bits, or cross drill bits.

Ground such as clays, loams, soft slate, or clayey silt is removed in terms of cutting and scraping. For these soil types, two-stage flush drill bits, arc-shaped drill bits, and cross drill bits are typically used.

In harder soil or rock, the use of percussive energy plays a more dominant role. In this case, button drill bits, cross drill bits, or arc-shaped drill bits are typically used in combination with carbide inserts.



Application Range

Designation	Ground Properties		Drill Bit Type ¹⁾									
	Description	Examples	Two-Stage R-Flush and RS-Flush	Arc-Shaped Button, Hardened	Arc-Shaped Button, Carbide Inserts	Arc-Shaped, Hardened	Arc-Shaped, Carbide Inserts	Cross, Hardened	Cross, Carbide Inserts	Button, Hardened	Button, Carbide Inserts	
Alluvium	Humus and organic layers	Top soil or flowing ground, possibly water-bearing										
	Peat and sludge		X	(X)		(X)			X			
	Gravel, sand, silt and clay mixtures	Sedimentary fills, fault zone material										
Sands	Non-cohesive and cohesive sand, gravel, and mixtures with small clay contents	Easily removable soil Mixed fills	X	(X)	(X)	X			X			
Cohesive soils	Mixtures of sand, gravel, silt and clay	Average removable soil Mixed fills	(X)	X	X	X	(X)	X	(X)			
Gravel	Soils with a higher gravel content of larger sizes	Difficult removable soil Riverbeds		(X)	X	(X)	X	(X)	X			
Soft rock	Jointed, brittle, weathered	Average removable rock			X	(X)	X		X	X	X	
	Conglomerate	Limestone, schist										
Hard rock	Higher abrasiveness and/or compressive strength, less fractured	Difficult removable rock Volcanic rock, hard sandstone, concrete					(X)		(X)	(X)	X	

¹⁾ Indications are general guidelines, and depend on on-site conditions. Borehole diameter and drilling length influence drill bit selection. "X" markings show standard applications, "(X)" markings possible combinations

Drill Bits

Portfolio

- Successful installation performance depends on selecting the adequate drill bit
- Large drill bit portfolio for various ground conditions
- Selection of optionally used centralizers must be accomplished dependent on the drill bit diameter
- Optimized in regards to installation parameters such as cutting ability and drilling performance
- Adjusted to the requirements of Civil Engineering as well as for Underground applications
- Further information regarding drill bit design and selection are included in a separate leaflet on drill bits for the DYWI® Drill Hollow Bar System

Diameter ¹⁾		Thread	Drill Bit Type									
[mm]	[in]		Two-Stage R-Flush (Retro-Flush), Hardened	Two-Stage RS-Flush (Retro & Side Flush), Hardened	Arc-Shaped Button, Hardened	Arc-Shaped Button, Carbide Inserts	Arc-Shaped, Hardened	Arc-Shaped, Carbide Inserts	Cross, Hardened	Cross, Carbide Inserts	Button, Hardened	Button, Carbide Inserts
51	2.0	R32					X	X	X	X	X	X
		R38										
		R51										
		T76										
76	3.0	R32		X	X	X	X	X	X	X	X	X
		R38			X	X	X		X	X	X	X
		R51			X	X					X	X
		T76										
90	3.5	R32			X	X						
		R38			X	X			X	X	X	X
		R51			X	X						
		T76										
100	3.9	R32		X								
		R38		X							X	X
		R51							X	X	X	X
		T76										
115	4.5	R32										
		R38			X	X			X	X	X	X
		R51			X	X			X	X	X	X
		T76										
130	5.1	R32										
		R38		X								
		R51			X						X	
		T76			X	X			X	X	X	X
150	5.9	R32										
		R38										
		R51		X								
		T76	X		X	X			X		X	X
200	7.9	R32										
		R38										
		R51										
		T76	X						X			

1) X-marked fields indicate standard drill bit types, other dimensions available on request

Self-Drilling Installation

Self-drilling installation may be accomplished either manually or semi-automated, depending on the available drilling machinery.

The DYWI® Drill Hollow Bar System offers high rates of installation, as drilling and grouting can be combined into one single operational procedure.

Selection of the proper drilling machinery is key to ensure efficient and sound drilling.



Installation Parameters

Self-drilling installation is accomplished using either rotary or rotary-percussive drilling machines. Depending on the

application, the ground conditions, the DYWI® Drill type as well as the final installation length, the main drilling

parameters which are listed and described in the following have to be adjusted accordingly.

Rotation Speed

The rotation speed is controlled by the rotation motor used. While Underground rotation motors of (hydraulic) rock drills run on higher rotation rates and the final installed element length is normally short, experience from Civil Engineering applications has shown that rates in the range of 120 - 150 [rpm] provide sound results.

Torque

The recommended maximum torque for the installation of the DYWI® Drill Hollow Bar System has been determined for different types and feed ratios. These values have been determined numerically with a safety factor of 0.7 with regards to the yield load.

Percussion

Different types of rock drilling equipment feature a wide range of percussion rates. In general, the same percussion rate as for default “smooth rock/soil drilling” using drill steel and multiple-use drill bits should be applied. For directional stability and drilling efficiency in Civil Engineering, percussion rates of 300 to 600 [bpm] have shown good results.

Feed

The recommended maximum feed range for installation depending on the DYWI® Drill type and the applied torque is shown in the following diagram.

For shorter installation lengths required for Underground applications, adjustment of the feed rate is not as critical as in Civil Engineering, where the stability

and accuracy of the drill string are key features. Here, the feed pressure should be adjusted so that it matches the achievable smooth drilling rate.

Self-Drilling Installation

Grouting

Grout mixing pumps used for injection of the DYWI® Drill Hollow Bar System typically comprise of a mixing and a pumping unit. Those injection pumps must feature a complete mixing of the grout and a steady pumping pressure. For simultaneous drilling and grouting, pressure requirements are not high (< 7 [bar] / 100 [psi]), hence a constant supply rate is required to ensure that the grout circulates within the borehole during drilling. The grouting pressure must be customized to respective and machine capacity.

For example, the required pressure is higher for long ground anchors than for short bolts.

The consumption of injection medium mainly depends on:

- Amount and type of flushing medium
 - Air, water, water-air mixture, or grout
 - Simultaneous drilling and grouting is a combined flushing and injection technique

- Ground conditions
 - Non-binding soils or fractured rock result in an increased consumption of injection media
- Water-cement ratio
 - Generally between 0.35 and 0.70

Besides the common self-drilling installation feature, grouting may either be performed while drilling with a rotary injection adapter or after the drilling operation. This subsequent grouting procedure is accomplished with a conical push adapter or a threaded coupling connector. In case given ground conditions require further improvement, multiple injections using post-injection couplings further enhance the grouting performance. Additional injection holes drilled into hollow bars may also support grout distribution along the entire element length; however, they reduce the load-bearing capacity of the hollow bar.



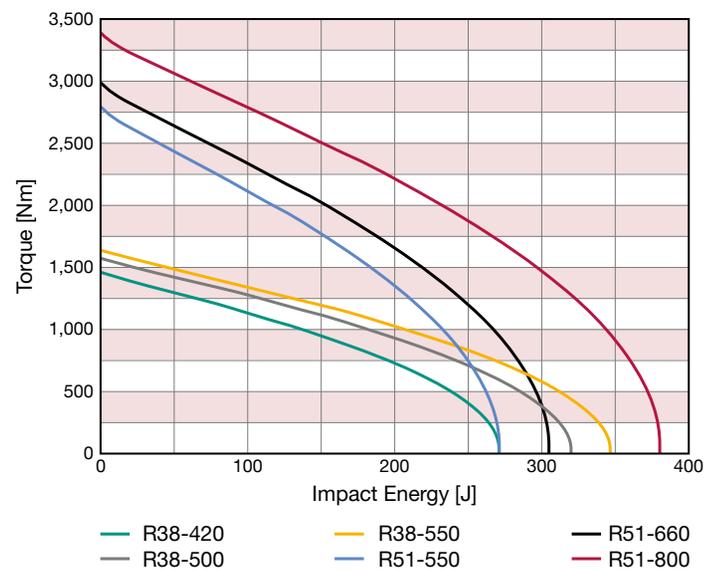
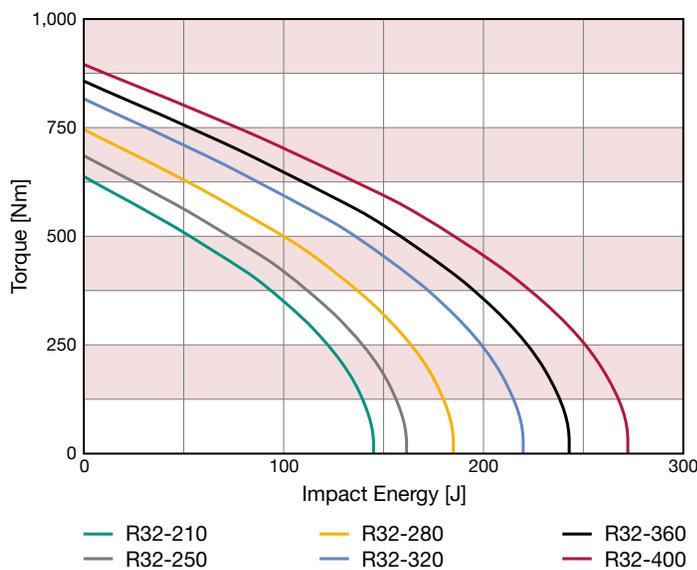
Simultaneous Drilling and Grouting

This technique ensures that the grout is properly and uniformly distributed over the entire installation length as drilling advances, and has shown proper results in ground types where a cement grout bulb around the hollow bar cannot be

properly established by post injection grouting. Grout which replaces water or air as a flushing medium is injected into the drill string over a rotary injection adapter; it permeates the ground concurrently with the installation and

forms bulbs for increased bond strength. For granular soils, a small return of grout at the collar of the borehole is required, for cohesive soils, larger grouting/flushing amounts may be necessary.

Recommended Pairs of Impact Energy and Torque



Self-Drilling Installation



Simultaneous Drilling and Grouting

- Assembly of the DYWI® Drill Hollow Bar System and connection to the rotary injection adapter



- Rotary self-drilling installation and simultaneous grouting



- Optional extension using couplings



- De-coupling from the rotary injection adapter



- Assembly of anchorage or head construction (plate and nut), depending on the application



Drilling and Subsequent Grouting

- Assembly of the DYWI® Drill Hollow Bar System and connection to the rock drill



- Rotary percussive self-drilling installation without casing: single-use drill bit and hollow bar drill steel, water or air-water mixture flushing



- Optional extension using couplings



- De-coupling from the drilling machinery; subsequent grouting using an injection adapter



Testing and Monitoring

Introduction

On-site testing ensures proper functioning and allows to proof the performance of the installed DYWI® Drill Hollow Bar System. Depending on the application, an appropriate test method must be selected. Tests are carried out on trial elements. Those trial elements should be prepared and installed as performed during the construction process.

For example, testing of ground anchors involves three general testing types for quality control purposes:

- Investigation tests
 - Conducted on trial anchors installed prior to the main works
 - Investigation tests provide information on the expected performance of working anchors, suitability of design, and levels of safety

- Suitability tests
 - Conducted on ground anchors identical to the working anchors
 - Data provides a reference against which the performance of the working anchors can be measured
- Acceptance tests
 - May be applied to all working anchors
 - Test loading demonstrates the ground anchor's ability to withstand a load exceeding its working load

For micropiles as well as rock and soil nails, investigation tests and suitability tests are the preferred testing types. In the course of investigation tests, the ultimate load resistance at the ground-grout interface and the characteristics of the system in the working load range are determined. Suitability tests confirm a particular design in comparable ground conditions by test loading.

Pull-out tests are the default on-site testing procedure for ground anchors, soil nails, and bolts. Depending on the loading mechanism (tensile, compressive, or alternating), micropiles are tested either by pull-out tests and/or static load tests. Spiles and injection lances are generally not tested in-situ.

Testing and monitoring features economic advantages during the product service life cycle. With the information from in-situ tests at hand, an optimization of the construction design may be possible. Monitoring and regular inspection increase the service life of both the used product and the entire structure, because structural damages or imperfections of construction can be detected at an early stage.

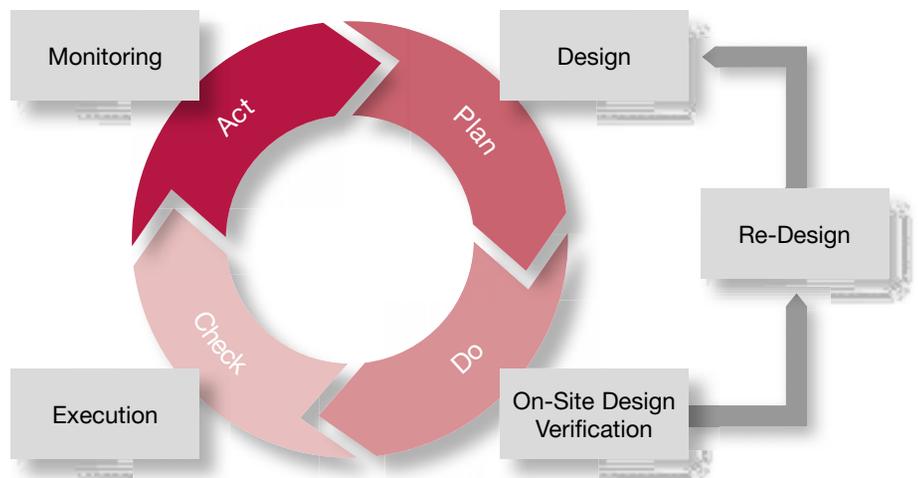
Pull-Out Tests

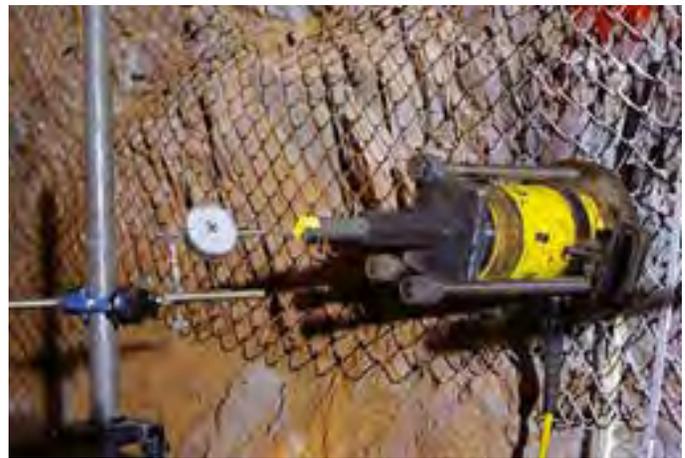
A pull-out (or simply pull) test measures the characteristics and the performance of the load transfer mechanism of the installed DYWI® Drill Hollow Bar System. Pull tests can be conducted on actual lengths (soil nails) or on short encapsulated samples.

At the excess length of the installed hollow bar, a tensile load is applied by using a hydraulic tension jack with a load measurement system. A hydraulic hollow core cylinder and a press chair as bearing on the soil or rock surface are connected to the hollow bar with a pull adapter and fixing nut. Tensile loading is applied over the extension of the hollow core cylinder. During pull-out tests, force and displacement of the hollow bar must be measured and recorded.

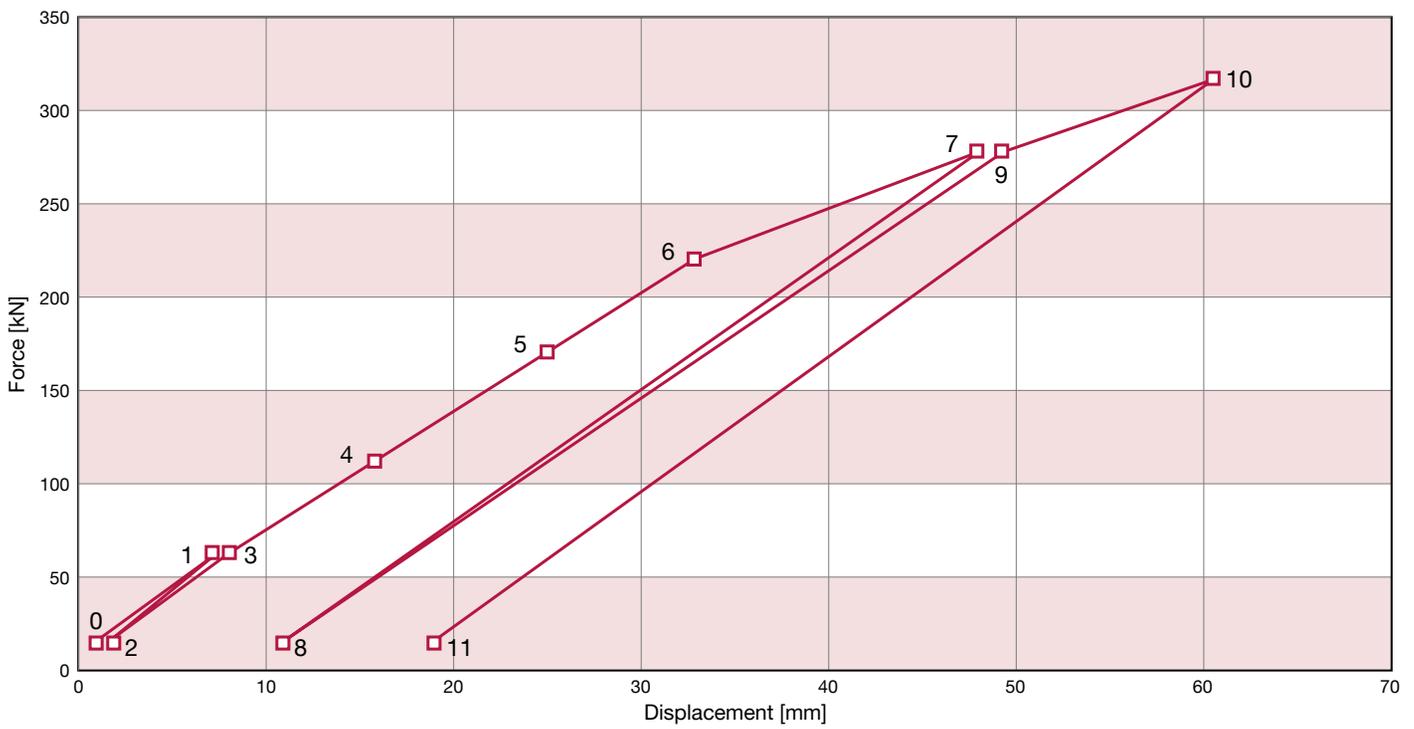
In general, pull test equipment includes the following main parts:

- Tension adapter, pull rod, and fixing nut
- Press chair (bearing element)
- Hydraulic system: hollow core cylinder and pump
- Load and displacement measurement systems





In-Situ Pull Testing (DIN 21521-2): Load-Displacement Diagram R32-360 with DYWI® Inject SILO 8044-M



Further References

- EN 1461: Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods
- EN 12501-1: Protection of metallic materials against corrosion – Corrosion likelihood in soil – Part 1: General
- EN 12501-2: Protection of metallic materials against corrosion – Corrosion likelihood in soil – Part 2: Low alloyed and non alloyed ferrous materials
- EN 13438: Paints and varnishes – Powder organic coatings for galvanized or sherardised steel products for construction purposes
- EN 14199: Execution of special geotechnical works – Micropiles
- EN 14490: Execution of special geotechnical works – Soil nailing
- EN 15773: Industrial application of powder organic coatings to hot dip galvanized or sherardized steel articles [duplex systems] – Specifications, recommendations and guidelines
- ASTM A153: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- ASTM A-775: Standard Specification for Epoxy-Coated Steel Reinforcing Bars
- ASTM A-934: Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
- ASTM D4435: Standard Test Method for Rock Bolt Anchor Pull Test
- DIN 21521-2: Rock bolts for mining and tunnel support; general specifications for steel-bolts; tests, testing methods
- ISRM: Suggested Methods for Rockbolt Testing
- Hollow Bar Soil Nails – Pullout Test Program. FHWA-CFL/TD-10-001. 2010
- European Technical Approval (ETA) as self-drilling rock and soil nail for temporary and permanent application: ETA-12/0603
- Approval for application as soil nail for temporary and semi-permanent application by the Austrian Federal Ministry of Transport, Innovation and Technology, Vienna, GZ: BMVIT-327.120/0012-IV/ST2/2015
- Approval for application as micropile for temporary and semi-permanent application by the Austrian Federal Ministry of Transport, Innovation and Technology, Vienna, GZ: BMVIT-327.120/0030-IV/IVS2/2015
- Designs and dimensions of system components as well as primary material specifications are included in DSI Underground's system brochures and approvals



System Accessories

DSI Underground provides a wide range of modular system accessories, which complete the premium quality series of the DYWI® Drill Hollow Bar System.

System accessories are essential for a safe and successful product performance. Typical system accessories can be used as structural load-bearing elements and for drilling, grouting, and monitoring.

Local support and short-term availability is provided by local competence centers – DSI Underground is THE SOLUTION PROVIDER.

- Yielding anchor head
- Angle compensation disks
- Reverse anchor head
- Protective caps
- Anchorage and foundation elements



- Bayonet connector



- Post-injection coupling



- Sleeves



- Utility nuts



- Injection flow-pressure meter



- Grout mixing pump



- Post-injection adapter
- Rotary injection adapter



System Accessories

- Drill rod wrench
- Rock drilling equipment

- Pull testing equipment

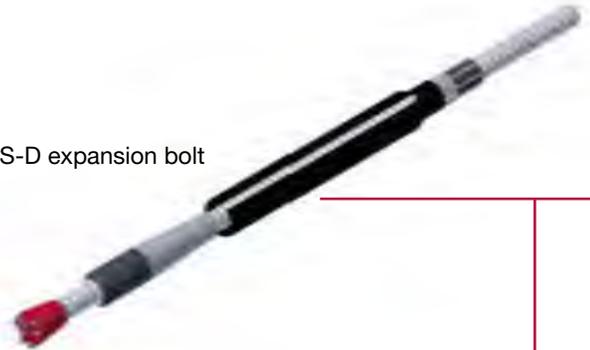
- Sealing coupling



- Lock coupling

- S-D expansion bolt

- Expansion shell



- Centralizer



- Drill bit adapters



- Drill bits



S-D Expansion Bolt

Introduction

In the past decade, various so-called “one-step” bolting systems have been developed. This is a result of steadily increasing requirements on installation procedures and the ensuing higher need for self-drilling bolts. The self-drilling bolt product family has now been extended by an expansion shell element for the DYWI® Drill Hollow Bar System.

This innovative DYWI® Drill S-D (self-drilling) expansion bolt is used both for Underground applications and in Civil Engineering. The key factor for the success of this combination bolt type

is the use of the long-term proven DYWI® Drill principle with a robust and innovative expansion element.

The DYWI® Drill S-D expansion bolt is installed self-drilling; borehole drilling and bolt installation are accomplished in one operational step. The system’s adaptability to changing ground conditions is an important feature. Immediately after the self-drilling installation, an activation of the expansion element leads to an instant load-bearing capacity. The DYWI® Drill S-D expansion bolt can be optionally tensioned following the fixation of

plate and nut. Subsequent grouting, de-coupled from the actual installation procedure, permits further optimization of installation cycle times.

One important application in Civil Engineering is the use in excavation pits, where the construction process requires an immediate load-bearing capacity. Underground, face support (face bolts) and longer vertical bolts (large-span support in caverns) are typical application examples for this type of self-drilling combination bolt.



System Description

- Expansion bolt: mechanically anchored and fully grouted
- Self-drilling installation based on the principle of the DYWI® Drill Hollow Bar System
- Hollow bar with continuous cold-rolled left-hand outside thread utilized as drill rod during installation
- Rotary-percussive installation using standard Underground drilling machines
- Conventional or automated installation
- Immediate load-bearing capacity via the mechanical end anchorage
- Subsequent optional grouting feature
- Flexible application range from 210 to 800 [kN] (47 - 180 [kip]): R32-210 to R51-800
- Utilization of several subsequently aligned extension expansion elements allows a higher load-bearing capacity even in weak ground

System Components

- Drill bit
 - Single-use drill bits in different diameters and designs
 - Hardened or carbide inserts
- S-D expansion element
 - Standard diameters: R32, R38, and R51
 - R38 and R51: several coupled extension expansion elements can be used
- Hollow bar R32, R38, or R51
- Plate
 - Different designs and dimensions available on request
- Nut
- Drive adapter
 - Couplings in different versions

S-D Expansion Bolt R38-076 with two Coupled Expansion Elements



S-D Expansion Bolt

Main Advantages

- Immediate load-bearing capacity after installation and activation of the expansion element
- Ability to maintain load-bearing capacity even when undergoing large deformations
- Improved drilling accuracy thanks to the directional guidance of the self-drilling expansion element
- Cycle time reduction due to the de-coupling of the grouting procedure from installation
- Tough system components
- Safe, easy, and reproducible installation procedure

Ready-For-Use S-D Expansion Bolt R32-051



Installation Procedure

- Assembly and connection of the drive adapter to the rock drill
- Rotary percussive self-drilling installation (counterclockwise rotation) without casing: single-use drill bit and hollow bar drill steel, water or air-water mixture flushing
- Optional extension using couplings
- Activation of the expansion element after the final drilling depth has been reached: withdrawal of the rock drill with hammer strokes
- De-coupling of the drive adapter
- Fixation and assembly of the anchorage (plate and nut)
- Optional de-coupled grouting



Expansion Shell

Introduction

Bolts with a variable free length ensure a pre-tensioning of the anchor and thus an active force transmission.

The DYWI® Drill expansion shell anchor is installed into pre-drilled boreholes. Immediate load-bearing capacity is achieved by an activation of the expansion shell.

The injection of the annular gap between the DYWI® Drill Hollow Bar tension member and the borehole using cement grout or DYWI® Inject Systems is accomplished in a second working step.

Main Advantages

- Simple handling and optimized installation time
- Immediate loading-bearing capacity
- Unproblematic installation in aquiferous boreholes
- The choice of the appropriate DYWI® Drill Hollow Bar ensures the optimum anchor force
- Continuous DYWI® Drill Hollow Bar thread allows flexible length adjustments and posterior extension on site
- Available for series R32, R38, and R51



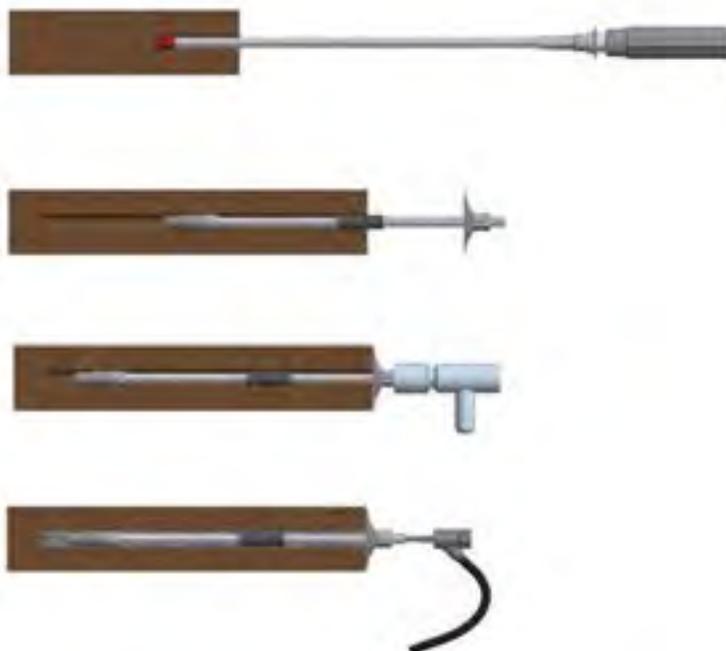
Specifications

Characteristic Value / Type	Symbol	Unit	SK-R32-048	SK-R38-068	SK-R51-078
Nominal external diameter	$D_{e, nom}$	[mm]	48	68	78
		[in]	1.9	2.7	3.1
Length	L	[mm]	170	186	230
		[in]	6.7	7.3	9.1
Nominal weight	m	[kg]	1.8	4.0	7.8
		[lb]	4.0	8.8	17.2
Required borehole diameter	D_b	[mm]	52 - 58	72 - 78	90 - 95
		[in]	2.0 - 2.3	2.8 - 3.1	3.5 - 3.7
Nominal load-bearing capacity ¹⁾	$F_{m, nom}$	[kN]	230	400	630
		[kip]	52	90	142

1) Determined in the course of laboratory pull tests in model rock mass (concrete)

Installation Procedure

- Drilling of a borehole in accordance with the specifications, approx. 150 [mm] (6 [in]) longer than the expansion shell anchor when installed
- Insertion of the assembled expansion shell anchor into the borehole – shell must fit into the borehole tightly
- Pre-tensioning via impact screw driver or adequate driver tool
- Optional post grouting after installation



Yielding Anchor Head

Introduction

The DYWI® Drill yielding anchor head plus integrated free (de-bonded) length is used for applications in squeezing and loose ground. Installation is accomplished either self-drilling or in a pre-drilled borehole; the bond length is grouted.

Main Advantages

- Controlled accommodation of large deformations
- Adjustable to given ground conditions
- Constant high yielding force level
- Tough and durable design
- German approval for Underground application
- Simple and secure manipulation of pre-assembled components

Design Example DYWI® Drill Yielding Anchor

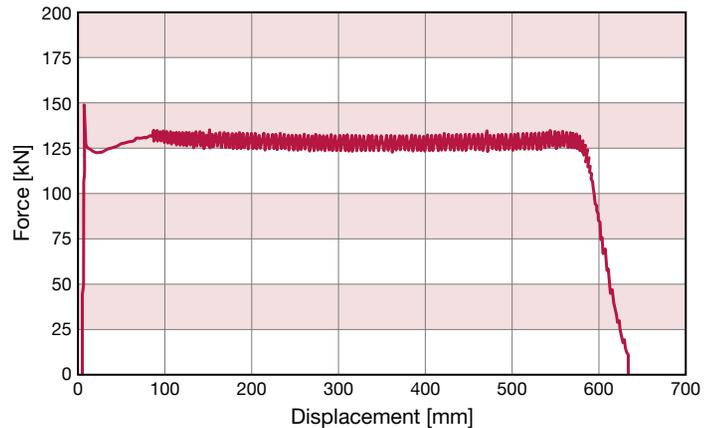


Specifications

Characteristic Value / Type	Unit	R32-GK 150-L ¹⁾
Yield force	[kN]	130 - 150
	[kip]	29 - 34
Yield length	[mm]	Up to 600
	[in]	Up to 23.6

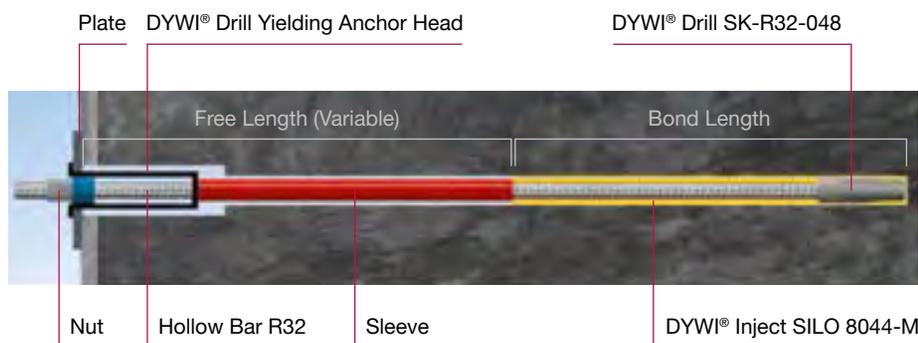
1) Recommended default DYWI® Drill type: R32-360

Yielding Characteristics

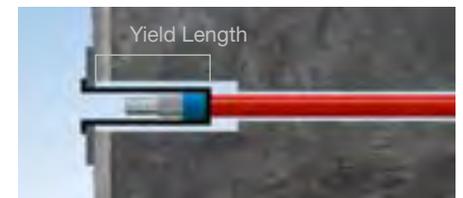


Basic Concept

Installation Principle



Working Mechanism



- Load transfer
 - Bond length: grouted, preferably in combination with an expansion shell
 - Anchorage: plate and yielding anchor head
- Working mechanism
 - Ground deformations result in an elongation of the hollow bar in the free length
 - Induced controlled yielding of the head construction
- Yielding anchor head
 - Discrete component
 - Absorbing mechanism based on a cylinder with integrated piston
 - Defined force-displacement characteristics
 - Adjustable to project-specific requirements

Lock Coupling

Introduction

When using standard couplings for installation, couplings inside the borehole may loosen due to hammer strokes applied in the course of drill string extension. There may be no external signs for this failure.

Faulty installation may be caused by worn out coupling adapters, damaged

or missing clamping jaws, or loose couplings if non system-conform components have been used.

The DYWI® Drill lock coupling prevents a loosening of couplings inside the borehole – the hollow bar is installed continuously in one piece.

Main Advantages

- The DYWI® Drill lock coupling does not detach itself during a clockwise rotation of the drill string
- Trouble-free extension or de-coupling of the drill string
- Suitable for free length sections
- Controlled removal of defined hollow bar sections by the selective use of standard couplings and lock couplings



System Description

The standard coupling is replaced by a DYWI® Drill lock coupling. During the counterclockwise rotation of the drill string, the inside locking mechanism (toothed gear with radial and longitudinal teeth) cuts transverse ribs onto the hollow bar. Thus, the hollow bar coupling is locked against clockwise rotation and loosening.

Specifications

- Available for series R32, R38, and R51
- Designed for highest load-bearing capacities
 - R32-400
 - R38-550
 - R51-800
- Optionally available with a one-sided or double locking mechanism

Technical Features

- Handling during installation is the same as for standard couplings
- The DYWI® Drill lock coupling permits rotary-percussive installation (counterclockwise) and locks the coupling during clockwise rotation of the drill string



Sealing Coupling

Introduction

Due to the design of conventional couplings for standard applications, absolute leak tightness of the couplings cannot be warranted when applying standard flushing pressures.

The DYWI® Drill sealing coupling allows an optimized installation procedure with regards to the leak tightness of the drill string. This advantage is significant for simultaneous drilling and injection operations.

Main Advantages

- Targeted and safe injection of the flushing and/or injection medium
- DYWI® Drill sealing couplings ensure leak tightness when applying standard flushing pressures
- Easy application; same operating principle as for standard couplings



System Description

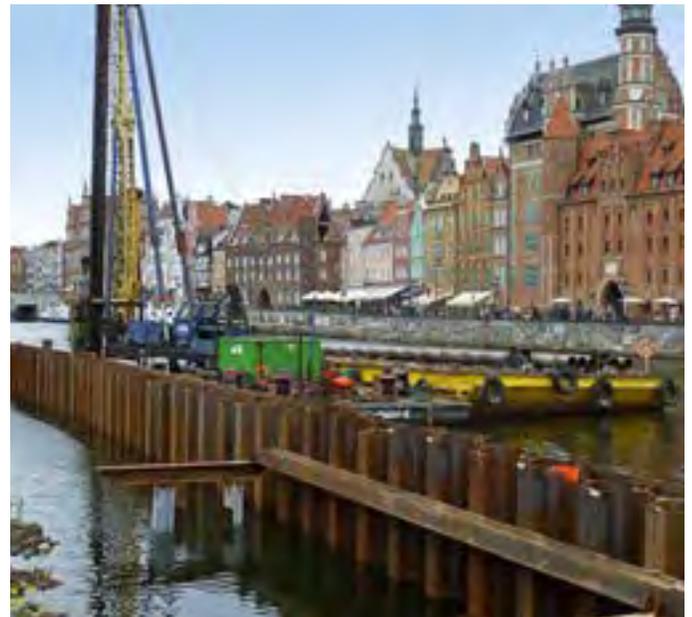
The standard coupling is replaced by a DYWI® Drill sealing coupling. Upon establishment of a proper and tight connection, the pre-installed centered sealing ring ensures a tight fitting between the chamfered surfaces of two hollow bars. During installation and injection, the DYWI® Drill sealing coupling ensures a tight connection under default working pressures.

Specifications

- Available for series R32, R38, R51, and T76
- Designed for highest load-bearing capacities
 - R32-400
 - R38-550
 - R51-800
 - T76-1900

Technical Features

- Handling during installation is the same as for standard couplings
- A sealing ring inside the coupling and chamfered hollow bar ends ensures optimum leak tightness



Post-Injection Coupling

Introduction

By default, the annular gap between hollow bar and ground is grouted via the outlet port at the drill bit to achieve improved load transmission.

The DYWI® Drill post-injection coupling allows the targeted post-injection through

the cleaned inner hole of the hollow bar using different injection media.

These injections can be carried out for ground improvement, sealing, or compensating grouting.

Main Advantages

- Application in all ground types
- No partial loss of drilling and cooling medium during installation
- Controlled and targeted post-injection of the ground
- Adjustable rated opening pressure



System Description

The standard coupling is replaced by a DYWI® Drill post-injection coupling. This special coupling type allows targeted multiple injections through circumferentially aligned injection holes with valves. Valve opening pressures can be adapted on customer request.

Specifications

- Available for series R32, R38, R51, and T76
- Designed for highest load-bearing capacities
 - R32-400
 - R38-550
 - R51-800
 - T76-1900
- Adjustable rated valve opening pressure: from 8 to 20 [bar] (115 to 290 [psi])

Technical Features

- Handling during installation is the same as for standard couplings
- The load-bearing capacity of the system (hollow bar - coupling) remains completely intact
- Multiple injections can be accomplished through valves with injection holes

Installation Procedure

- Assembly of the DYWI® Drill Hollow Bar System and connection to the rotary injection adapter
 - Note: self-drilling installation and subsequent grouting is also possible
 - Rotary self-drilling installation and simultaneous grouting
 - Primary injection process through the drill bit
 - Extension of hollow bars with DYWI® Drill post-injection couplings
 - Post-injection and final assembly
 - Flushing of the injection channel (inside of the hollow bar) with water using a plastic hose shortly after the installation is completed
 - Short curing time primary injection, depending on the grout mixture used (generally 12 to 18 hours)
 - Post-injection with an injection adapter through the DYWI® Drill post-injection couplings
- with a pressure exceeding 8 [bar] (115 [psi])
- Maximum injection pressure depending on application and ground conditions
 - Repetition of working steps in case a consecutive injection process is required
 - Preparation of the head construction, if required



Utility Nuts

Loop and Eye Nut

- Eye nut: heavy duty version
- Loop nut: standard version
- Utility hangers
- Fixation of ropes and mats
- Anchorage of mesh and geogrid



Bail Nut

- Light utility hangers
- Mounting of instrumentation tools



Anchorage Elements

Sleeves

- De-bonding
- Free length(s)
- Additional corrosion protection
- Micropiles: pile neck reinforcement
- Steel and plastic versions available



Protective Caps

- Temporary corrosion protection
- Construction walls where shotcrete is not used for sealing
- Protection of personnel when head constructions are exposed to walkways
- Steel and plastic versions available



Anchorage Elements

Angle Compensation Disks

- Secure anchorage even when undergoing large inclinations
- Standard application in combination with domed nuts
- Standard version for hollow bar series R32 and R38



Reverse Anchor Head

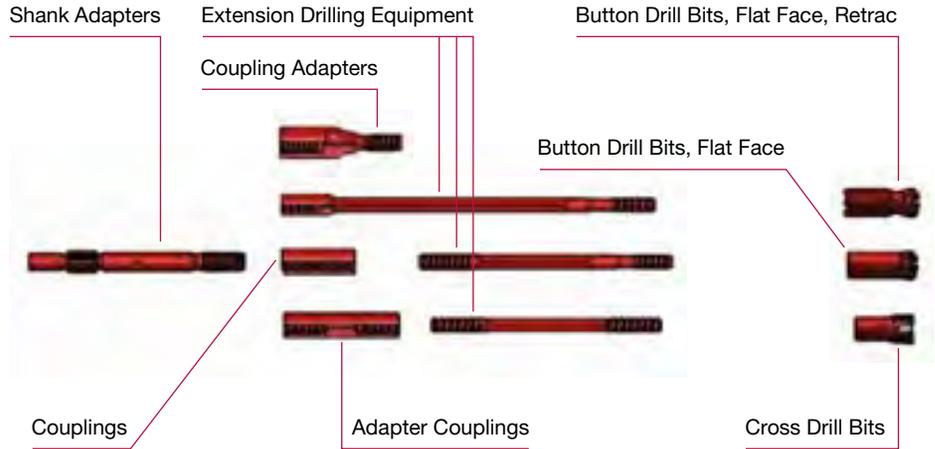
- Sheet piles
- Tie-back anchorage
- Limited space conditions



Rock Drilling Equipment

System Components

- Shank adapters
- Couplings
- Adapter couplings
- Extension drilling equipment
- Coupling adapters
- Drill bits
 - Drill bits in either flat face or retrac design
 - Cross drill bits



Drill Bit Adapters

- Connection of hollow bar and drill bit threads of different diameters
- Large drill bit portfolio for diameter ranges outside standard versions
- Controlled transmission of the drilling energy from the hollow bar onto the drill bit



Drill Rod Wrench and Tensioning Tool

- Tough design
- Various lengths and wrench sizes

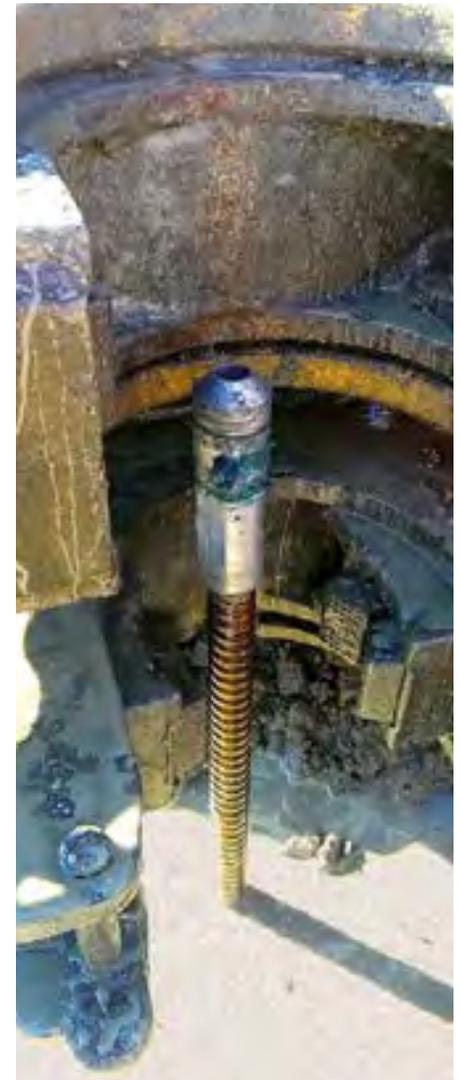


Rock Drilling Equipment

Bayonet Connector

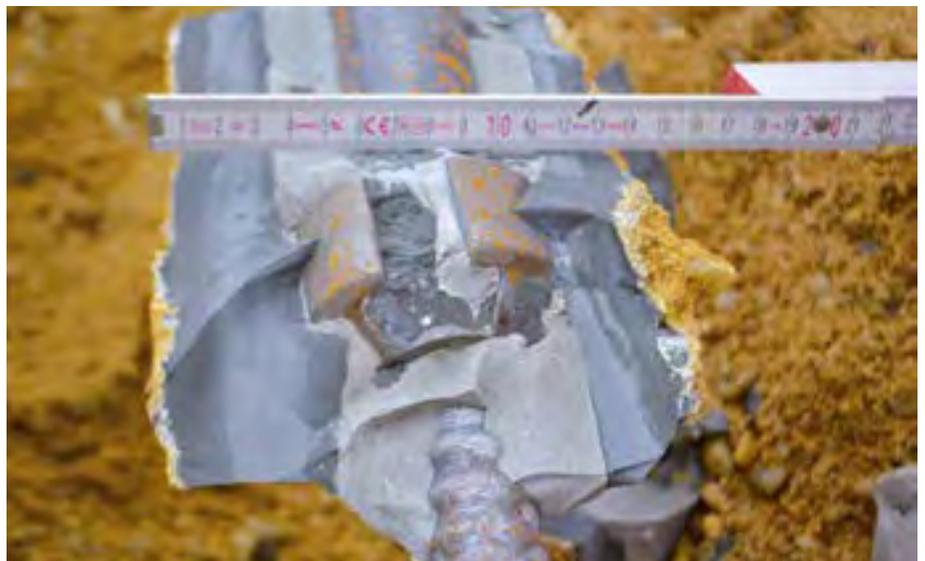
The bayonet connector is a sealed, easy-to-remove connection between hollow bars used for self-drilling installation. It consists of two parts: adapter and coupling. A bayonet connector efficiently transfers the total impact energy and torque from the hydraulic drifter or rotary head onto the hollow bar drill string. Defined hollow bar sections can be easily removed once drilling has been completed.

- Sealed connection for micropile installation
- Easy to disconnect
- Removal of defined hollow bar sections
- Transfer of the drilling energies nearly without any loss



Centralizers

- Centralization of DYWI® Drill Hollow Bars inside the borehole
- Increased directional installation accuracy
- Optimum grout cover
- Available for series R32, R38, R51, and T76



Injection Adapters

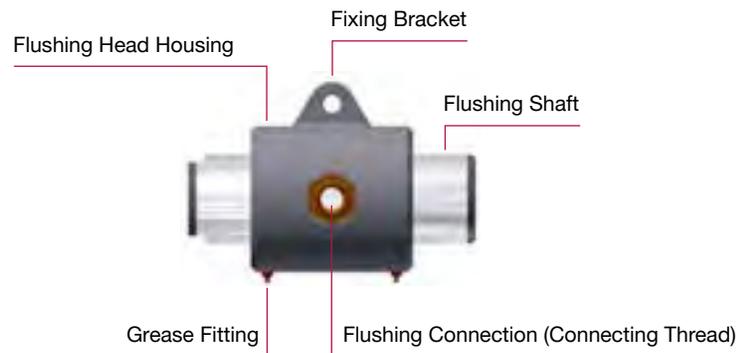
Rotary Injection Adapter

System Components

- Flushing head housing
- Flushing shaft with connecting thread for the hollow bar and the shank adapter
- Gasket and wiper (internal)
- Fixing bracket with connection thread for the injection hose
- Grease fitting
- Dampening rubber

Main Advantages

- Simultaneous drilling and grouting ensures an ideal bond with the loose rock or soil
- Penetration of the injection material into the surrounding ground
- Ground improvement and homogeneous distribution of the injection material



Injection Adapter

- Different versions for cement grout or resin injection
- Conical push adapters or threaded adapter couplings
- Various grout hose connections available on request



Grout Mixing Pump

Introduction

DSI MAI® grout mixing pumps have been developed for extremely challenging Underground conditions. They have been successfully used around the world in Tunneling and Civil Engineering, for

example for the shoring of slopes, hill sides, and building excavations.

The proven and delivery technology is suitable for:

- Injection and grouting works
- Re-injection
- Drillhole filling
- Backfilling

Main Advantages

- Tough design and galvanized pump casing
- Low empty weight
- Simple operation and maintenance due to modular design
- Low start-up and cleaning times
- Low filling and overall height
- High delivery rate at continuous pressure
- Variable discharge
- All-purpose equipment



Injection Flow-Pressure Meter

Introduction

The revolutionary injection flow-pressure meter DSI MAI® LOG400 permits an

exact and comprehensible documentation of ground improvement

as well as a control system for specified injection termination criteria.

System Description

Flow rates and injection pressures are recorded separately for each injection borehole. The manipulation-proof digital data recording is operated via a user-friendly and simple touch-screen terminal. The easy handling and the integrated software, which allows the input of the working data into spreadsheet calculation program, are a benefit for each job site.

System Components

- Flow meter
- Pressure transmitter
- Operating and analysis unit
- Data transfer via compact flash card or USB
- Tripod
- Technical documentation
- User manual
- Software package







Austria

DSI Underground Austria GmbH
Alfred-Wagner-Strasse 1
4061 Pasching/Linz
Austria
Phone +43-7229-610 49 0
Fax +43-7229-610 49 80
E-mail office@dywidag-systems.at



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