DYWIDAG-SYSTEMS INTERNATIONAL

DYWI® Drill Hollow Bar System

Content

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The DYWI® Drill Hollow Bar is a fully threaded self-drilling anchorage system which can be simultaneously drilled and grouted into loose or collapsing soils and brittle rock without the need for a casing. Furthermore, the bar features a left-hand thread for standard rotary percussive drilling.

Manufactured from high grade steel tubing to EN 10083-1, DYWI® Drill Hollow Bar is cold rolled to form standard rope thread or "T" thread profiles. The DYWI® Drill rolling process refines the grain structure of the steel, increasing the yield strength and producing a robust drill steel suitable for a range of drilling and grouting applications.

The DYWI® Drill Hollow Bar System includes a full range of drill bits, adaptor sleeves, couplers, nuts and bearing plates. In addition, thanks to a wide range of DYWI® Drill injection adaptors and drill tooling, the hollow bar can be used with many types of drilling equipment.

Key features of the DYWI® Drill Hollow Bar System are:

No Casing Required

Bars can be drilled into loose or collapsing soils without the need for a casing to support the borehole.

Simultaneous Drill and Grout Installation

Grout is injected at all points of the borehole as drilling is advanced, permeating the local strata for increased bond performance and producing bulbing between the strata and the hollow bar in the softer sections of the soil.

Rotary Percussive Drilling

This drilling technique is highly efficient, ensures fast progress of drilling as well as good directional stability of the drill string and helps to consolidate the grout within the borehole.

Fully Threaded Rod Sections

Continuous thread ensures that rods can be cut and coupled or extended at any point.

High Strength Threads

Both the rope threads and "T" threads provide a strong and robust thread, ideal for rotary percussive (drifter) drilling as well as ensuring a high level of bond with the borehole grout.

Self-Drilling System

Thanks to their self-drilling function, bars can be drilled into most ground conditions for tension, compression or alternating load applications and can also be used as an injection conduit.

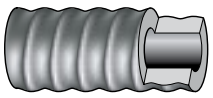
Bar/Grout bond

Restricted access soil nailing

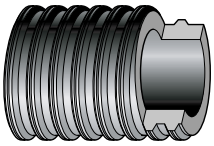
DYWI® Drill Hollow Bar soil nails, top bar galvanized, for slope stabilization

DYWI® Drill Technical Data

DYWI® Drill Rope Thread (R)



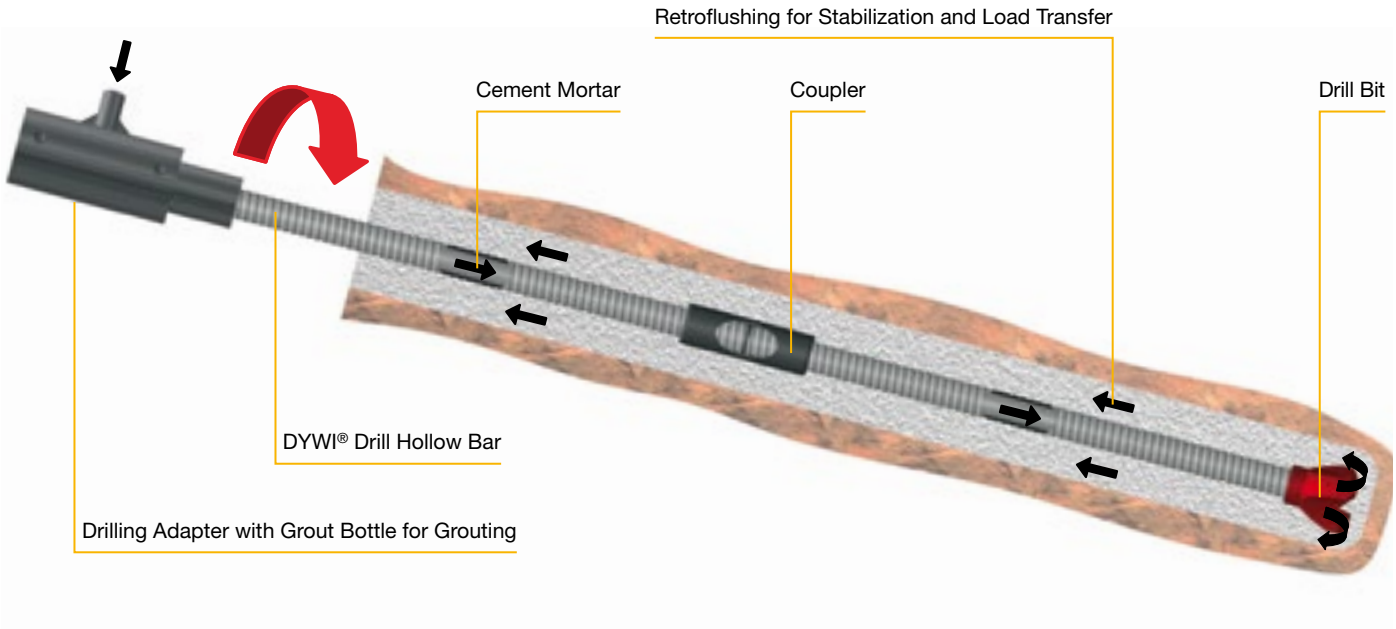
DYWI® Drill "T" Thread



- Bar Finishes: Plain or Galvanized to EN 1461

E Value:

- Strain at Ultimate Load
- Fractile Value of Strain



Technical Data

Type	Cross-sectional area A [mm²]	Load at yield F_{yk} [kN]	Ultimate load F_{tk} [kN]	Weight [kg/m]	Approval
R32-210 (R32L)	340	160	210	2.65	○ × △
R32-250	370	190	250	2.90	○ × △
R32-280 (R32N)	410	220	280	3.20	○ × △
R32-320	470	250	320	3.70	○ × △
R32-360 (R32S)	510	280	360	4.00	○ × △
R32-400	560	330	400	4.40	○ × △
R38-420	660	350	420	5.15	○ × △
R38-500 (R38N)	750	400	500	5.85	○ × △
R38-550	800	450	550	6.25	○ × △
R51-550 (R51L)	890	450	550	6.95	○ × △
R51-660	970	540	660	7.65	○ × △
R51-800 (R51N)	1,150	640	800	9.00	○ × △
T76-1200 (T76L)	1,610	1,000	1,200	12.60	
T76-1600 (T76N)	1,990	1,200	1,600	15.60	
T76-1900 (T76S)	2,360	1,500	1,900	18.50	

Lengths of delivery L = 2/3/4/6m

○ Germany: Z-14.4-674 & Z-34.13-208
× Austria: BMVIT-327.120/0010-IV/ST2/2012
△ Europe: ETA-12/0603

Additional Information

German Approval DIBt Z-14.4-674 und Z-34.13-208 / Austrian Approval BMVIT-327.120/0010-IV/ST2/2012 / European Approval ETA-12/0603

Drill Bits, Couplers and Nuts

Tri Crescent Bit

- Hardened drill bit complete with side scallops
- Universal bit for a range of ground conditions
- 45° forward flush
- Uses: cohesive soils, mixed fills, chalk, marl and softer sedimentary rocks
- SPT 0-50
- Thread: R32 Ø 51 mm

Button Bit, Small Ø

- Flat face, hardened button bit
- Full face prevents snatching/ grabbing in broken ground
- 30° forward flush
- Uses: intermediate soils, soft mudstones
- SPT 0-55
- Thread: R32 Ø 51 mm

Button Bit, Large Ø

- Flat face, hardened button bit
- Full face prevents snatching/ grabbing in broken ground
- 30° forward flush
- Uses: intermediate soils, soft mudstones
- SPT 0-55
- Thread: R51 Øs 100, 115 mm

Tri Crescent Bit with T/C Blades

- Tungsten Carbide bladed tri crescent drill bit complete with side scallops
- Universal drill bit for a range of ground conditions
- 45° forward flush
- Uses: denser gravels, sedimentary rocks
- SPT 0-60
- Thread: R32 Ø 51 mm

Carbide Button Bit, Small Ø

- Flat face
- Full face carbide for broken rock or harder ground
- 30° forward flush
- Uses: fractured ground, broken rock, medium rock
- UCS 80 MN/mm²
- Thread: R25, R32, R38 Øs 42, 51, 76, 90 mm

Carbide Button Bit, Large Ø

- Flat face, Tungsten Carbide button bit
- Full face carbide for broken ground or abrasive rock
- 30° forward flush
- Uses: fractured ground, schists, abrasive sandstone, rubble, broken rock
- UCS 80 MN/mm²
- Thread: R51 Øs 100, 115 mm

Drop Center Blade Bit

- Drop center hardened blade drill bit with hardened buttons in the center
- 30° forward flush and side flush
- Uses: granular soils, chalk, marl and softer sedimentary rocks
- SPT 0-55
- Thread: R38 Øs 76, 90 mm

Drop Center Blade Bit, T/C Blades

- Drop center Tungsten Carbide blade drill bit with hardened buttons in the center
- 30° forward flush and side flush
- Uses: Dense Gravels, Limestone, Schists
- UCS 70 MN/mm²
- Thread: R32, R38 Øs 76, 90 mm

Drop Center Button Bit

- Drop center hardened button bit, complete with side scallops for increased drilling efficiency
- 30° forward flush
- Uses: intermediate or granular soils, soft mudstones
- SPT 0-55
- Thread: R51 Ø 115 mm

Two Stage Retroflush Bit

- Cross cut drill bit complete with retrac blades
- Cast body with induction hardened cutting faces
- Retroflush and side flush
- Uses: cohesive soils and mixed fills
- SPT 0-50
- Thread: R32, R38, R51, T76, Øs 76, 100, 110, 130, 150, 200, 300 mm

Carbide Chisel Cross Cut Bit

- Heavy duty cross cut drill bit with Tungsten Carbide chisels
- Suitable for hard drilling
- Center and 30° forward flush
- Uses: strong rock, hard seams, concrete obstructions
- UCS 100 MN/mm²
- Thread: R32 Ø 51 mm

Carbide Drop Center Button Bit

- Drop center Tungsten Carbide button bit, complete with side scallops for increased drilling efficiency
- 30° forward flush
- Uses: dense gravels, fractured ground, schists, rubble, broken rock
- UCS 80 MN/mm²
- Thread: R51, T76 Øs 115 mm, 130 mm

Drill Bit Adaptor Sleeves

R25/R32

R32/R38

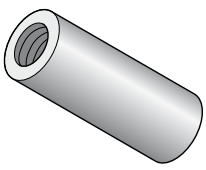
R38/R51

R51/T76

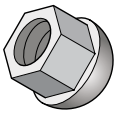
CRC Retroflush drill bits for loose soils, sands, gravels or mixed fills with clay

T76 ESS-D 130 drill bit for rock sockets, also for drilling through (soft) secant piles

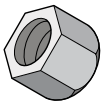
Couplers and Nuts



Coupler with Central Threadstop



Domed Nut



Nut with Convex Seat

DYWI® Drill Hollow Bar Installation

Crawler mounted drill boom for simultaneous drill & grout soil nails

Rotary percussive top hammer (hydraulic)

Excavator mounted drill boom, installing top bar galvanized soil nails

The DYWI® Drill Hollow Bar offers high rates of installation, as drilling and grouting can be combined as a single cycle. To achieve these benefits, it is important that the correct equipment is selected to ensure efficient drilling.

Drilling Technique

The three main drilling functions are:

- Rotation: 120-150 RPM. This is the key drilling function to ensure the full diameter of the borehole is cut as drilling advances
- Percussion: 300-600 BPM, for directional stability and drilling efficiency
- Fine Feed: Feed pressures should be regulated to match the achievable drilling rate

Rotary percussive top hammer (drifter)

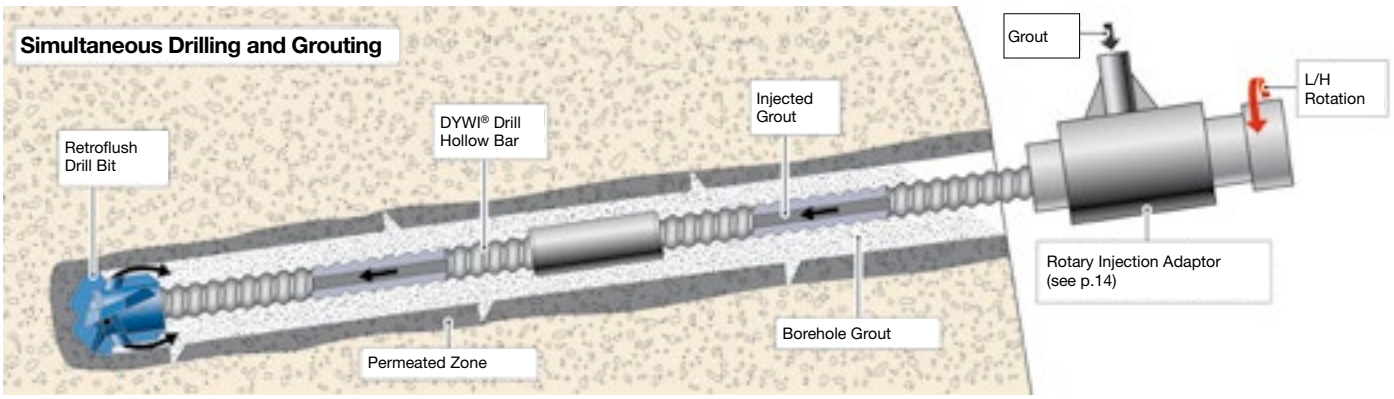
This is the essential piece of equipment for hollow bar drilling. Rotary percussive drilling ensures efficient drilling in most ground conditions, provides good directional stability for the drilled bar and helps consolidate the placed grout. The hammer should have sufficient torque and rotation speed.

Simultaneous Drilling and Grouting

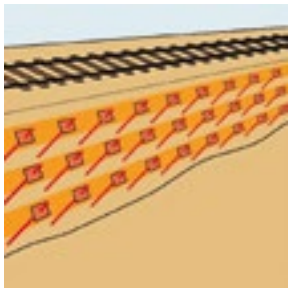
This technique ensures grout is placed at all points of the borehole as drilling is advanced, permeating the local soil strata and producing bulbing in the softer sections of the borehole.

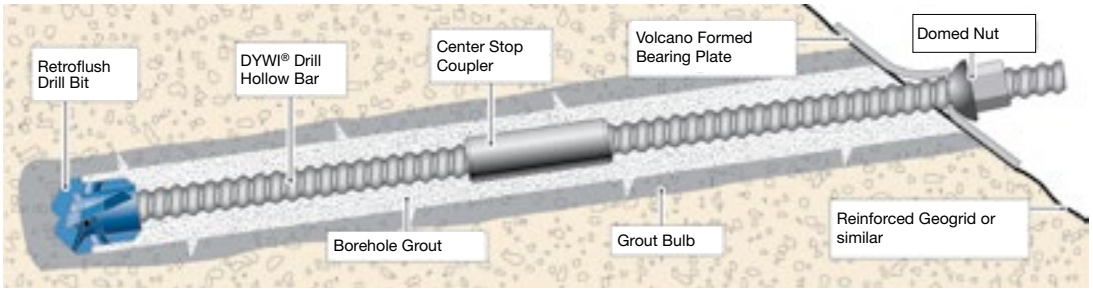
Reaming of the bottom rod section at full depth will further enhance bond performance, as the ground strength is typically highest at this point, due to overburden pressure.

Long reach excavator for restricted access drilling



Soil Nails - Hollow Bar System





DYWI® Drill Hollow Bar soil nails are ideal for loose or collapsing soils as they can be installed without the need for a casing. The system is used for mixed fills, granular material and loose overburden. The DYWI® Drill hollow bar system allows drilling and grouting to be combined as a single operation and complies fully with EN 14490 (European standard for soil nails).

Soil nails are typically classified as lightly loaded (30-150 kN), passive installations. The fully bonded feature enables the loose wedge at the surface to be tied into the deeper stable zone. Soil nails are normally regarded as low risk installations, with an element of redundancy existing in the stabilized face.

The design of soil nailed faces should incorporate a diamond grid layout to ensure efficient distribution of the reinforcement. Suitable drainage must be incorporated within the nailed face to prevent build up of water within the slope. This would lead to uncontrolled loads at the facing at a later stage.

Corrosion Protection

The durability of soil nails is dependent on the working load, the aggressivity levels of the soil and surrounding environment, and the planned lifespan of the structure.

Sacrificial Corrosion Allowance

This technique calculates the loss of section over the lifespan, in order to assess the residual strength of the bar and its ability to fulfill the loading requirement of the soil nail.

Top Bar Galvanization

The most practical solution for drilled-in hollow bars, providing additional protection at the soil/air interface (on top of sacrificial corrosion allowance).

Fully Galvanized Systems

Extra corrosion protection over the full nail length if the full nail length is in fill material or where corrosion potential is higher. The galvanizing of all DYWI® Drill hollow bars is in accordance with EN 1461.

Soil nailed gabions at the toe of a slope

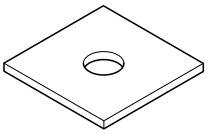
Excavator mounted drill boom for versatile positioning of the soil nail

Drill platform mounted on telescopic forklift

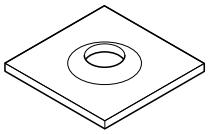
DYWI® Drill Galvanized hollow bar soil nails for railway cutting widening

Soil Nails - Bearing Plates and Facings

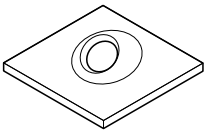
Bearing plates are used primarily to secure facings, such as a reinforced geogrid, steel fabric or shotcrete. There is also an element of face confinement provided, in conjunction with the retention effect of the fully bonded nail in the wedge zone. Centers for and lengths of soil nails should be defined by modelling the stability of the face first and then the stability of the overall slope. Nails should be arranged on a diamond grid.



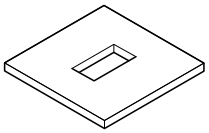
Flat Plate
0-15°
(Domed Nut)



Formed Plate
0-25°
(Domed Nut)



Vulkano Plate
0-35°
(Domed Nut)



Slotted Plate
Up to 50°
(Articulation Boss)

Angle compensation between the bearing plate and the soil nail must be addressed to ensure full seating of the plate against the face. For flatter slopes (25° to 30°), the amount of angle compensation is significant and can be up to 50°. See left for angle compensation options.

Facings for slope faces should be selected on the basis of slope angle, phi value, surcharge at crest and lifespan. Reinforced geogrids offer a practical solution for most slopes up to 55°; above this, angle facings with structural stiffness to resist bulging are required, i.e. panel systems or shotcrete. Alternatively, a tensioned mesh may be used in certain applications.

Soil nailed slope with crib wall facing

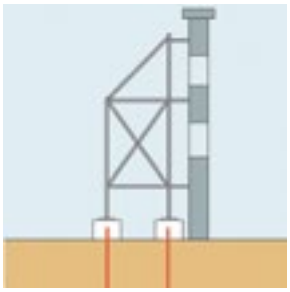
Flexible reinforced geogrid, with volcano bearing plates for angle compensation

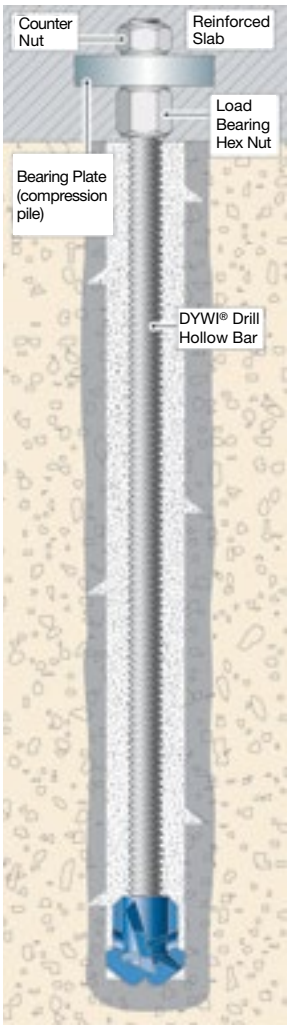
Benched face stabilised with DYWI® Drill soil nails

Steep cut slope with shotcrete facing for structural stiffness to resist bulging

Plating up, using pneumatic box wrench

Micropiles





DYWI® Drill Hollow Bar Micropiles can be installed into areas of restricted access or within the close proximity of buildings. Thanks to the fully threaded system, the micropile can be extended and grouted in areas where the founding level is deeper than expected.

The percussive drilling method ensures minimal disturbance compared to driven piling systems, enabling the foundations of old structures or buildings to be upgraded without damage. Pile stiffness can be increased by placing a steel tube over the top 2m of bar and grouting the annulus.

Applications for DYWI® Drill injection piles, in accordance with EN 14199, include: retained facade bases, foundation upgrades, pylon bases, wind turbines, refurbishment of old structures and gantry bases for rail electrification.

DYWI® Drill T76 micropiles with in-situ steel tube over top 2m

Raking micropiles for bridge pier upgrades

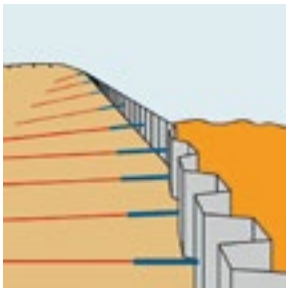
Long stroke drill boom for deep micropiles

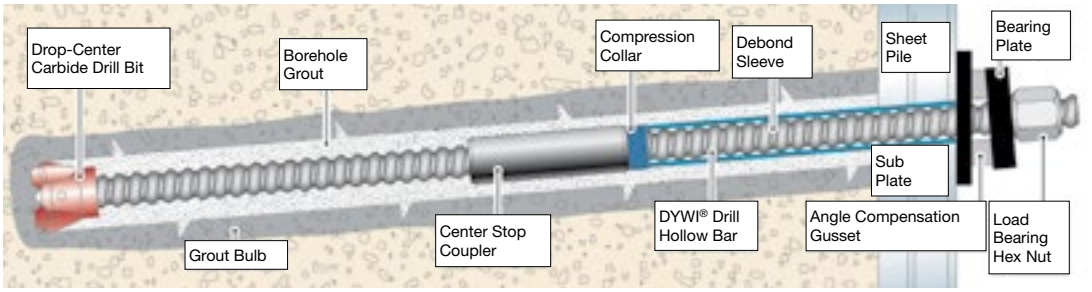
Base slab reinforcement using micropiles

Grout injection behind sheet piles

Micropiles for retained facade frame bases

Ground Anchors





DYWI® Drill Injection Anchors are used extensively in temporary works, as the anchor can be readily drilled into a range of difficult ground conditions or collapsing soils without the need for a casing. The bond stress of both Rope thread and "T" thread bars is high and compares favourably with reinforcing bars of similar diameter (this has been proved by tests carried out by the Technical University of Munich).

The DYWI® Drill free length system incorporates a special debond sleeve and compression collar so that the self-drilled anchors remain debonded in the free length for stressing.

The stressing operation and acceptance tests ensure that each anchor is fully tested and that additional extension will not occur during its service life.

Irrespective of threadform, hollow bar systems are only suitable as temporary anchors. The high impact energy during rotary percussive drilling prevents the use of an adequate corrosion protection system approved by the building authorities. However, corrosion protection is mandatory for stressed (active) permanent anchors, in accordance with the design standards for permanent anchors (EN 1537).

DYWI® Drill free length system for temporary anchors

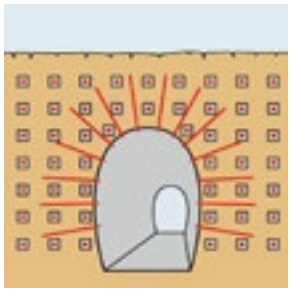
Drilling through a secant piled wall

4m long T76 bars for 32 m deep anchors, sheet pile tie-back

Hollow bar drilling from a floating barge for sheet pile tie back

Sheet pile tiebacks using large diameter hollow bars

Rock Bolts



Self-drilled hollow bars are used for rock bolting and grouting in softer rocks where there is loose ground or sections prone to collapse. Slope faces with highly weathered or broken rock can be stabilised using DYWI® Drill hollow bar rock bolts in conjunction with rock fall netting. Rock bolts can also be used for rock pinning and rock dowel applications where localized reinforcing of the rock face is required.

Rock bolts are typically classified as lightly loaded, fully bonded (passive) installations, for low risk applications. They are used for stabilizing external slope faces where the surface has become highly weathered or where there is a potential for surface slips.

Drilling options include air or water flush, followed by grout injection (known as subsequent grouting). Alternatively, the simultaneous drill and grout technique can be used for softer ground.

For roped access applications, suitable drill rigs include: trolley mounted “A” frame rigs, scaffold mounted drill booms, crane baskets or telescopic fork lift drill platforms.

Applications for DYWI® Drill hollow bar rock bolts include: slope stabilization, rock fall netting, catch fences, tunnel portal stabilization or avalanche protection barriers. The speed of installation, combined with the facility to grout through the core of the bar, make the hollow bar a popular choice for rock bolting in remote locations or difficult drilling conditions.

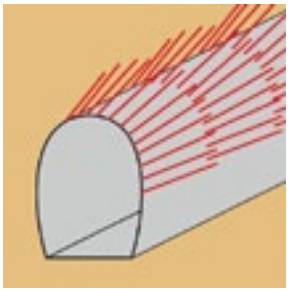
DYWI® Drill rock bolts for anchoring of rock fall netting

Hollow bar rock bolts for stabilization of a weathered face

Stabilization of tunnel portal with hollow bar rock bolts

Scaffold mounted hydraulic drill boom for rock bolting

Tunneling Applications



Stabilisation of Tunnel Portals

DYWI® Drill hollow bars are used extensively for the stabilization of tunnel portals. The ability of self-drilled hollow bars to accommodate a range of different ground conditions make them a popular choice for tunneling works.

Spiling

Spiles are used to form a protective canopy for tunneling in areas of loose ground. When using DYWI® Drill Hollow Bars as spiles, the bar can be drilled into place using rotary percussion and then grouted through the hollow core to consolidate the heading.

Mining Applications

In mining applications, hollow bars are used for the bolting of pillars, the injection of resins or waterproofing agents as well as for general reinforcement applications.

DYWI® Drill hollow bar spiles for the stabilization of a launch adit for a TBM

Drilling of hollow bar rock bolts in variable ground

Self-drilled hollow bars for the stabilization of a tunnel portal and approach cutting

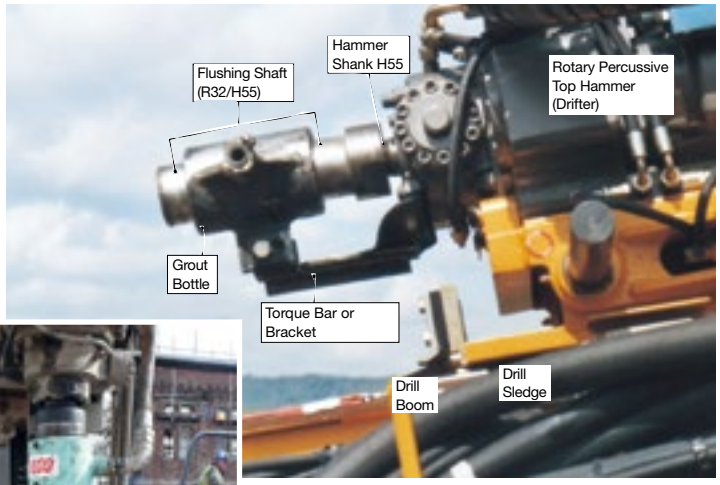
Hollow bar spiles installed through a lattice girder

DYWI® Drill Injection Adaptors

DYWI® Drill Injection Adaptors enable grout to be pumped into the bore of a rotating bar during drilling, ensuring the hollow bar is simultaneously grouted as drilling advances. The injection adaptor is a three component unit consisting of a flushing shaft, grout bottle and a seal kit.

For the connection between the hammer shank and the hollow bar, the selection of the correct injection flushing shaft within the injection adaptor unit is important. This will ensure the connection is sufficiently strong to endure the demands of rotary percussive drilling and withstand any temporary misalignment if obstructions are encountered during drilling.

Tightening of the flushing shaft onto the hammer shank, lock-up, is essential to ensure that this joint remains tight during drilling and does not release during rod changes. The seals within the grout bottle should be greased approx. every 20 minutes.

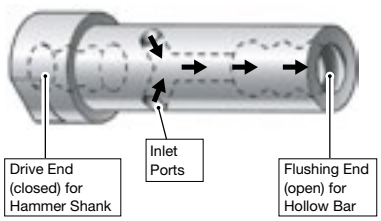


Torque bar location & float position of grout bottle

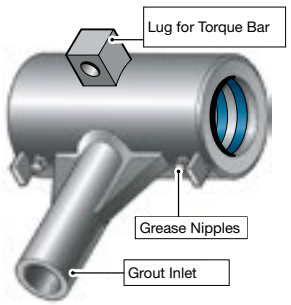
Heavy duty injection adaptor (H112/T76)

Greasing of seal tracks (H64/R51 adaptor)

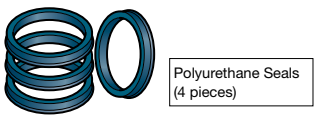
Flushing Shaft



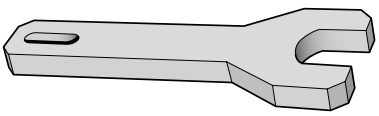
Grout Bottle



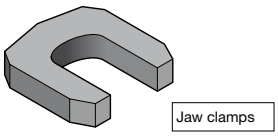
Seal Kit



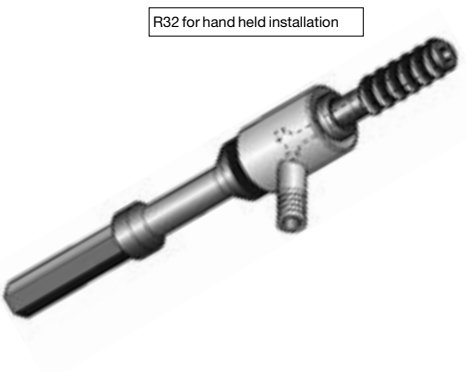
Drill Spanner (drill boom)



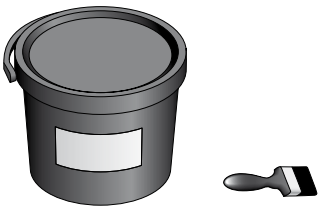
C Spanner



Rotary Injection Adaptor

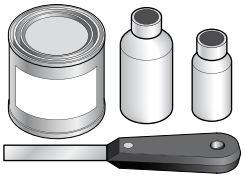


Thread Sealant



TF15, Teflon grease

Thread Lock Kit



Jet Lok

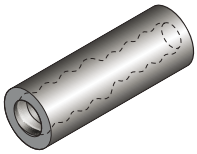
Drill Tooling

Drilling equipment often has to be adapted at short notice to accommodate unforeseen conditions. The DYWI® Drill tool range offers the driller the flexibility to make changes, ensuring limited down time and efficient drilling.

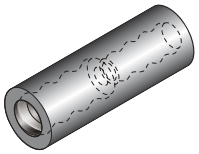
In addition to the tool range, drill spanners are supplied for lock-up of the flushing shaft on the shank adaptor and torque wrenches for the seating of bearing plates on the slope face, by torquing up the nut.

Rotary percussive drilling for DYWI® Drill soil nails

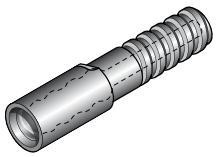
Reducing Coupler



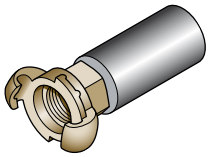
Reducing Coupler, complete with center bridge



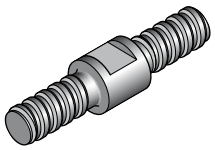
Box/Pin Adaptor (hollow)



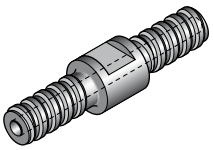
Grout Injection Coupler (for subsequent grouting)



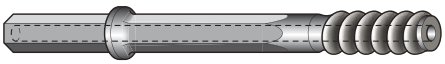
Pin/Pin Adaptor (solid)



Pin/Pin Adaptor (hollow)

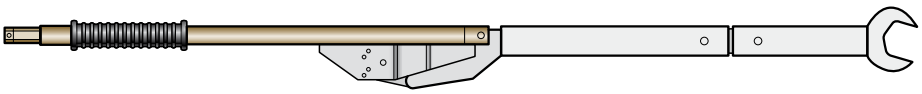


Air Flush Shank



R25, hand held installation

Torque Wrench



Torque Wrench for uniform seating of bearing plates on slope faces (torque is applied to the domed hex nut, retaining the bearing plate)

Long reach excavators with hydraulic powered drill booms for soil nailing

Top down construction using hollow bar soil nails and shotcrete

Grouting

The grout injection technique used for the installation of DYWI® Drill Hollow Bar is dependent on the type of drilling and the respective application. The most popular method is simultaneous drill and grout. This method ensures that all points of the borehole are homogeneously grouted as drilling is advanced.

For simultaneous drilling and grouting, pressure requirements are not high (up to 7 bar), but constant supply is necessary to ensure that grout circulates within the borehole during drilling. For granular soils, a small return of grout at the mouth of the borehole is all that is required; for cohesive soils, greater flush is necessary.

Grout pump with colloidal mixing unit

Grout Pumps

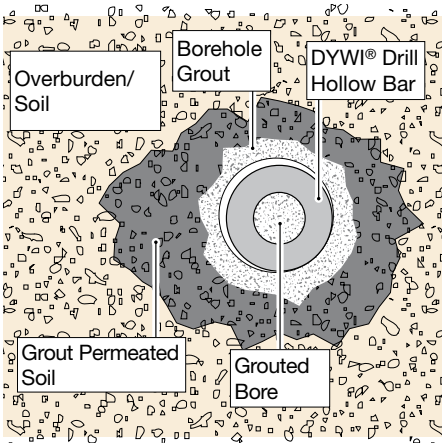
These units typically comprise of a mixer and a pump. The choice of grout pump is dependent upon the application; Colcrete Colloidal mixing pumps, Hani, Putzmeister or Turbosol are all suitable. The key requirement is full mixing of the grout and a steady pumping pressure.

Typical Grouting Volumes

DYWI® Drill Hollow Bar	Drill Bit Ø (mm)	Grout (kg/m)	Drill Bit Ø (mm)	Grout (kg/m)
R32	75	30-40	100	32-42
R38	110	32-42	130	35-45
R51	115	35-45	150	38-48
T76	130	38-48	200	40-50

Grout consumption is dependent on:

- a) Amount of flush used - simultaneous drill and grout is a part flush/part injection technique
- b) Ground being drilled - granular soils or fractured ground with voids will result in increased grout take
- c) Rate of drilling advance



Typical section of grouted DYWI® Drill Hollow Bar

Grout Mixes

- a) 0.40 w/c ratio (water: cement ratio) = 40 liters water: 100kg cement
- b) 0.45 w/c ratio (water: cement ratio) = 45 liters water: 100kg cement

Grout Yields

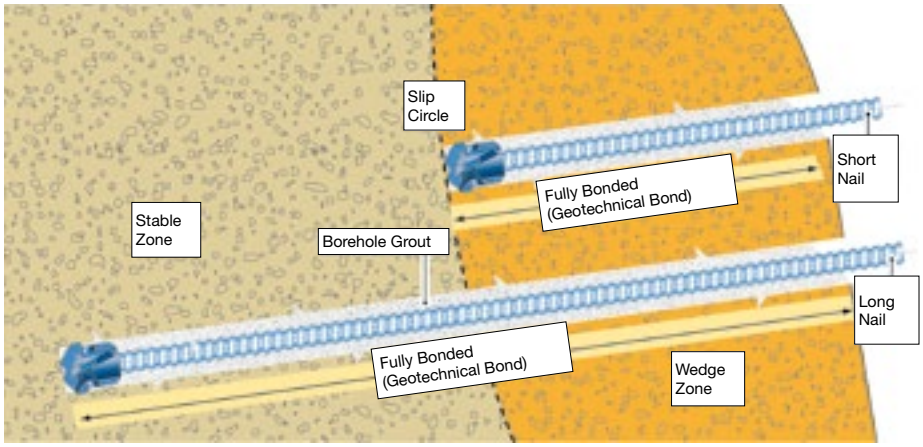
- a) One 25kg bag of cement, mixed at 0.40 w/c cement ratio, will give 17.5 liters of grout
- b) Four 25kg bags of cement, mixed at 0.40 w/c cement ratio, will give 70 liters of grout

Grouted soil nails on shotcrete face

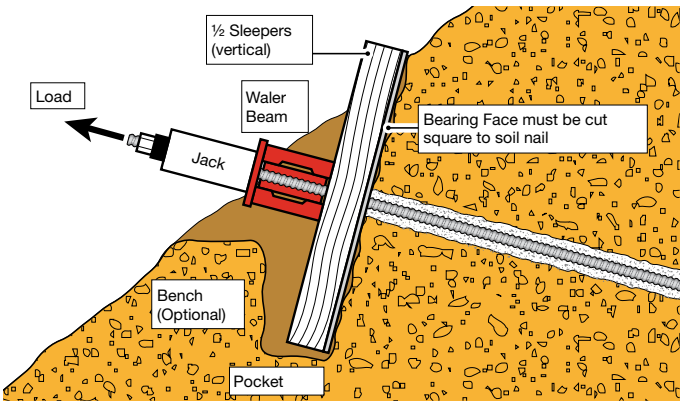
Soil Nail Testing - Long Nail/Short Nail System

Simultaneous drill and grout installation produces a fully grouted (therefore fully bonded) soil nail. Grout is placed in the wedge as well as the stable zone during drilling, therefore, any test must incorporate a mechanism for discounting load generated in the wedge zone from the overall test load. The long nail/short nail testing method is the most effective solution.

Note: The use of debonded free lengths will debond the bar, but will not debond the borehole grout from the soil in the critical wedge zone.



Long Nail/Short Nail testing



Typical excavated pocket for soil nail testing

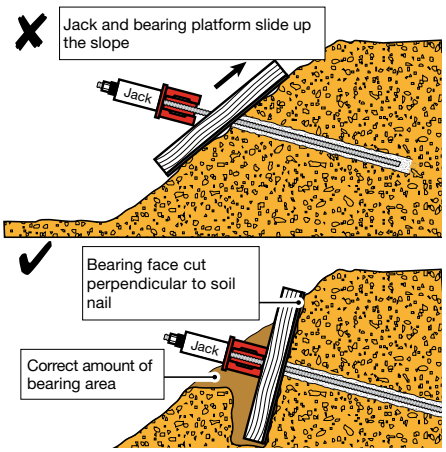
Long Nail/Short Nail testing system for fully grouted hollow bar soil nails

Ground Anchor Testing

The free length system employed for self-drilled hollow bars (see CHB 133) features debonded bars with partially bonded couplers (smooth wall). It is important to appreciate the influence of friction generated at the coupler locations, as this will affect extension readings. Therefore, acceptance criteria based on theoretical free length extensions will be erroneous for self-drilled hollow bar systems. The most effective test method is a maintained load displacement test in accordance with EN1537, Test Method 1 (Section E2).

Micropile Testing

The test set up varies according to the load characteristic of the pile. Tension Micropiles are relatively straightforward to test using bearing plates and a testing beam. Compression Micropiles are much more difficult to test as the pile stiffness at the head needs to be ensured, in order to avoid axial misalignment as the load is applied. Failure to provide lateral restraint or stiffening at the pile head will result in poor load testing.



1,500kN jack for T76 temporary anchors

Heavy duty spreader beam for micropile tension test

Stabilization of a tunnel portal using DYWI® Drill Hollow Bar Anchors, Ø32mm – Thuringia, Germany

Slope stabilization using DYWI® Drill Hollow Bar Anchors at the Rock of Gibraltar

Slope stabilization following a rock fall – Carinthia, Austria

Installation of DYWI® Drill Hollow Bar Anchors at the Garden of Eden project in Great Britain

Stabilization of a trough structure using DYWI® Drill Hollow Bar Anchors, Ø 38mm – Reno, Nevada, USA

Installation of 67,000m of DYWI® Drill Hollow Bar Anchors, Ø 25mm – Valik Tunnel near Pilzen, Czech Republic

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