A NEW DIMENSION FOR SOFT SOIL STABILIZATION

TITAN

Titan Geotechnical Systems (Pty) Ltd

TITAN

TITAN Drill- and Injection Anchors

Titan Drill- and Injection Anchors could also be used as piles or nails and are suitable for use as anchors, micro piles, soil nails, rock bolts or the reinforced soil method.

DIN 4125 "grouted anchors" Nov. 1990 applies for all stressed anchors which have a free (unbonded) length, and which take tensile forces only.

DIN 4128 "grouted piles" April 1983 applies for micro piles and soil nails which take loads on tension and compression and which are grouted over their entire length. Soil nails act like a frictional reinforcement (hooke) in reinforced concrete or like dowels or nails in timber construction taking shear loads.

This new anchoring technique *began in 1983 and is covered by patent nos. P 34 00 182 and P 38 28 335.*

A unique feature is the drill steel use as the tension- and/or compression member.

The principle of the TITAN Drill- and Injection Anchor is based on the combination of 7 ideas:

1. **Utilisation of a drill steel as an anchor**
   From the static point of view, a tube is superior to a solid rod of the same cross sectional area with respect to bending movement, shear resistance and surface bond/friction.

2. **Creation of an economically priced one-time use drill rod and drill bit**
   This technique eliminates two labour intensive elements required for anchor installations.
   They are: the insertion of the anchor itself and the removal of the drill rod and the casing. Consequently smaller drill rigs can be used, the amount of grout is reduced and substantial labour savings are achieved.

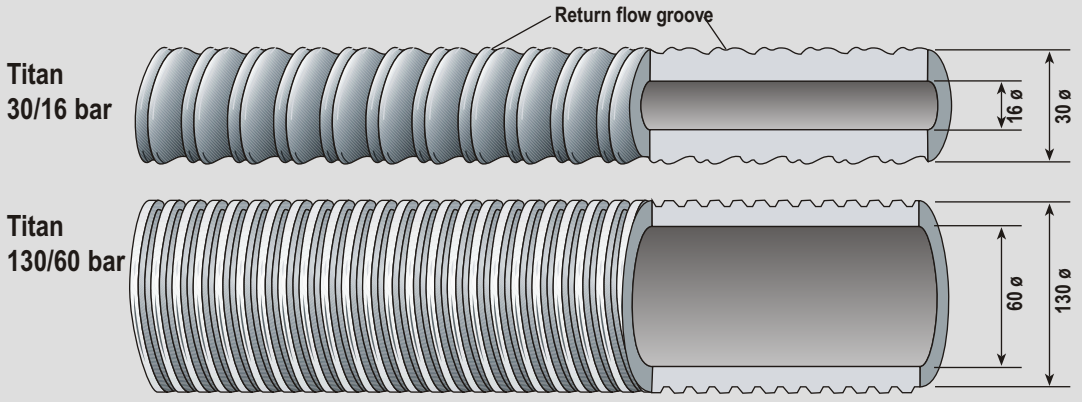
3. **Utilisation of the drill steel as grouting conduit for filling the annulus from the bottom-up**
   This guarantees a positive complete filling of the annulus as well as all fissures and cracks. This method is much easier than using additional tubes for grouting, air vents and post-grouting.

4. **High quality structural steel**
   The choice of a high quality structural steel offers high notch toughness > 39 J in comparison to high tensile rods or strands having > 15 J or glass fibre anchors. This steel is not affected by hydrogen embrittlement or by post rolling heat treatment. In addition, it offers high shear resistance.

5. **The use of a ferritic-austenitic stainless steel TITAN-INOX for permanent anchors with a life span of 50 years and more**
   This material (no. 14462) is equivalent to "double corrosion" DIN 50929 part 3 - likeliness of corrosion in construction parts and underwater construction. Working with this TITAN-INOX material is much easier than with the standard permanent anchors which are surrounded by grout in corrugated plastic tube, especially as far as extension (coupling) and the preparation for the anchor head are concerned.

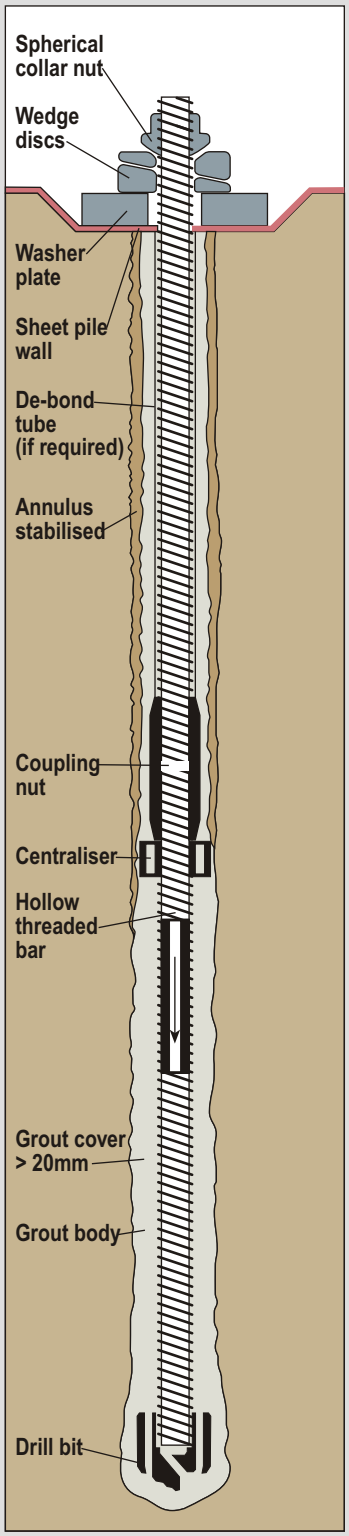
6. **The threads on the TITAN anchors are formed much like the ribs on a reinforcing bar fabricated according to DIN 488**
   The deep TITAN threads result in 2.4-times higher bond friction compared to standard drill steel coil-threads of R 32 (1-¼") or R 38 (1-½").

7. **Continuous threads guarantee the TITAN anchor can be cut or coupled anywhere along its length**
   Cutting, extending, pre-stressing and load releasing on the anchors are possible. A thread pitch of 6º eliminates the need for counter nuts at each coupling.

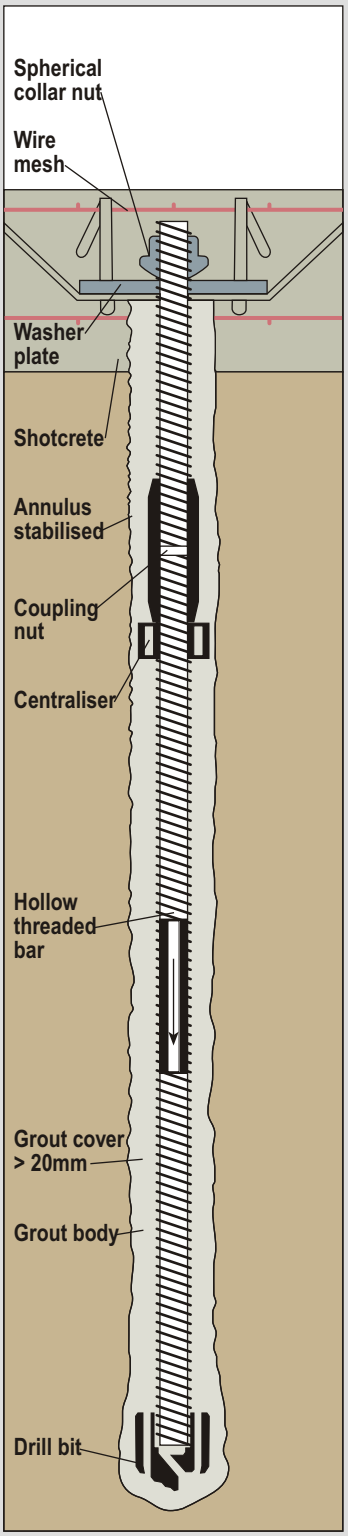


TITAN Injection Anchors

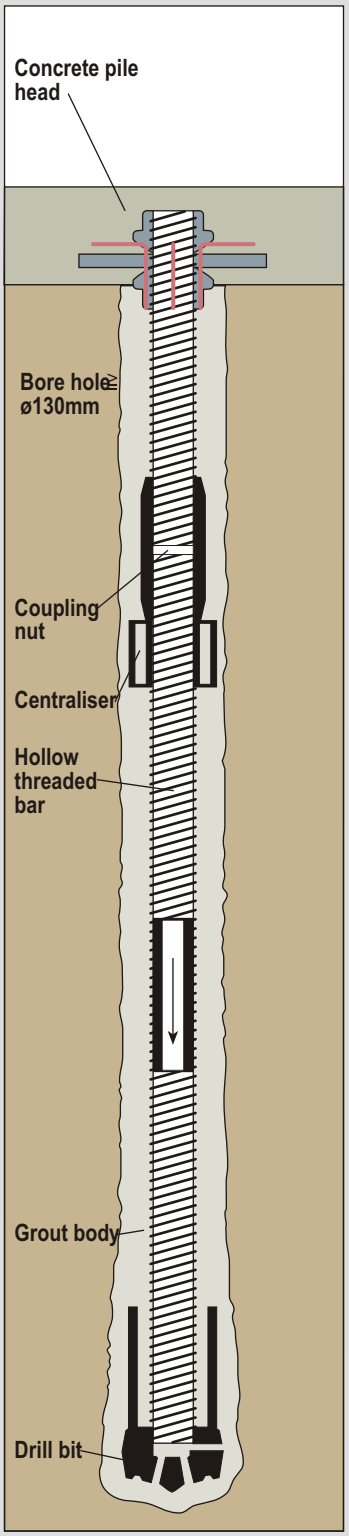
Anchor



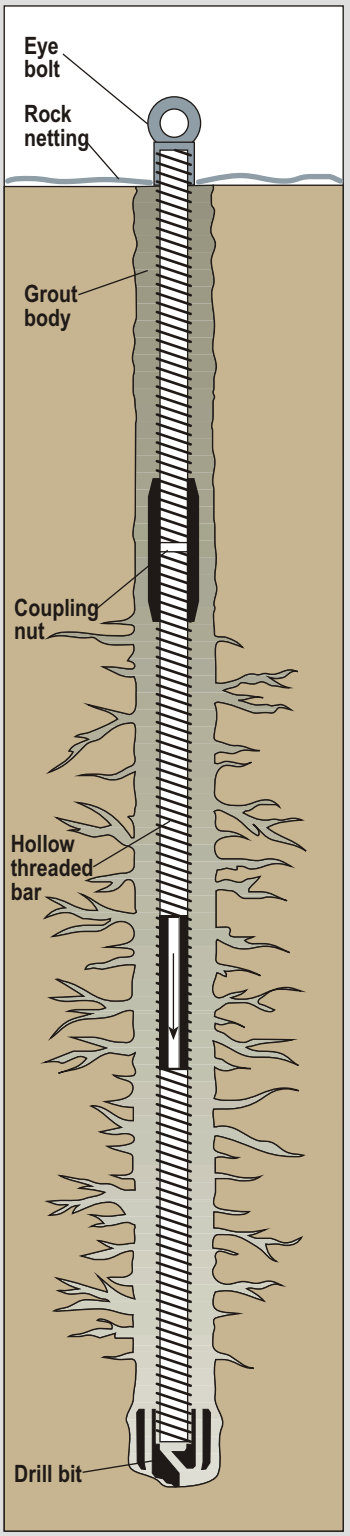
Soil Nail



Pile



Rock Bolt



Notes

The Difference in the Application for Soft Soil Stabilization

7 simple principles were realised in a standard application:

1. **Flushing and supporting fluid is simple cement grout**
   The fluid is simple cement grout with a water to cement ratio (W/C) of 0,4 to 0,7 (40 to 70 litres of water to 2 sacks = 100 kg of cement). Under a flushing pressure of 5 to 20 Bars the water is quickly absorbed by noncohesive soils leaving a cementituous surface which cures and stabilises the annulus. This method is also known when using supporting fluids for bored piles to DIN 4014.

2. **Controlled bulb and infiltration dowelling**
   All TITAN drill bits have a radial flushing hole, which can be used to control the size of the bulb of the grout body. Excavated grout bodies having an average diameter of 1,5 to 2,5 times the drill bit diameter confirm that radial flushing at 5 to 20 Bars pressure-reams the soil and also causes the grout to penetrate into the grain structure of the soil.

3. **Grouting pressures up to 60 bars**
   In an open bore hole, a grout pressure of up to 60 Bars can be achieved, because cementituous grout with a W/C ratio of 0,4 is pumped while the pile/anchor is constantly rotated with slowly increased grouting pressure. As with postgrouting the cured grout is cracked again by the rotation and the partly cured cement blocks move outwards and are wedged between the cured annulus and the rotating anchor/pile tube resulting in a natural packer. Since the TITAN method includes a similar effect to post grouting it eliminates this labour intensive portion of the job.

4. **Improved anchoring capacity and reduced settlement**
   Anchors, piles and soil nails are evaluated on their load and settlement characteristics taken from the load/settlement diagram. The calculated constant settlements are much less with the TITAN piles than with traditional bored piles or minipiles for identical soils under the same loads. The TITAN method grouted piles have much less settlements than traditionally installed ones (see load/settlement diagram). Shear deformations (soil friction) between soil and the grout body are important factors for uniform settlements.

5. **TITAN hollow anchor acts like a concrete vibrator**
   The vibrating TITAN hollow anchor acts like a concrete vibrator during the drilling and grouting process and consequently results in a homogeneous and compacted grout body.

6. **Minimum grout cover, maximum corrosion protection**
   The down-the-hole circular centralisers maintain directional stability during the drilling process, and centralise the TITAN anchors in the bore holes, thus achieving a minimum grout cover of 20mm around the pile/anchor.

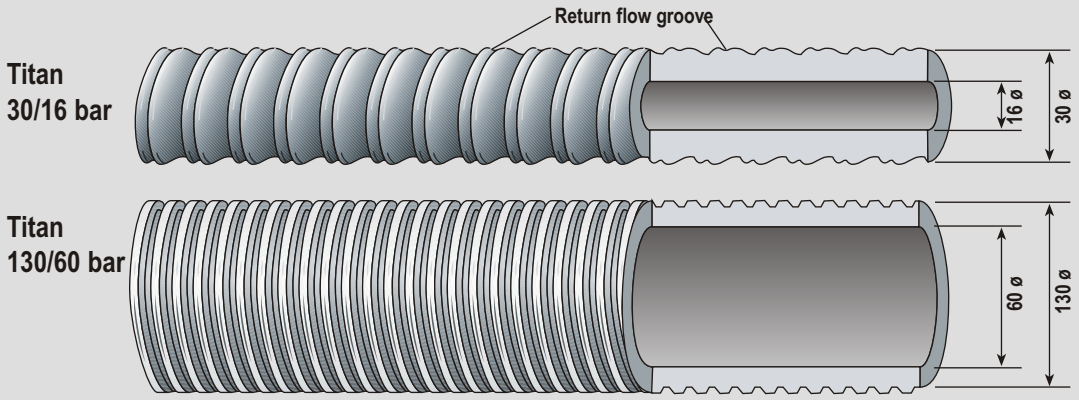
7. **A hollow soil nail creates a much higher shear resistance in the soil than a solid rod of the same cross sectional area**
   The stiffer a nail, the smaller the required shear movements needed to activate the normal force in the nail. TITAN Injection Anchors are 2 to 3 times stiffer than high tensile strands or bars under the same loads, since its cross section is larger. Prestressed TITAN anchors create much less movement in the soil than strands or bars under the same load conditions.

Notes

Technical Data

Product Specifications

Ischebeck Titan hollow bar type denotes external diameter of bar followed by its internal diameter. For example, a Titan 30/16 bar has an external diameter of 30mm and an internal diameter of 16mm.



Titan Bar Type	Unit	30/16	30/14	30/11	40/20	40/16	52/26	73/53	73/56	103/78	103/51	130/60
Nominal outside diameter	mm	30	30	30	40	40	52	73	73	103	103	130
Nominal inside diameter	mm	16	14	11	20	16	26	53	56	78	51	60
Ultimate load	kN	220	260	320	539	660	929	1160	1194	2282	3460	7940
Yield point	kN	180	220	260	430	525	730	970	785	1800	2750	5250
Yield Stress $T_{0.2}$	N/mm^2	470	610	580	590	590	550	590	550	570	500	550
Cross section (A)	mm^2	382	395	446	726	879	1337	1631	1414	3146	5501	9540
Weight	kg/m	2.7	2.9	3.3	5.6	7.0	10.0	12.3	11.1	24.9	43.4	75.0
Thread left/right hand	-	left	left	left	left	left	left/right	right	right	right	right	right
Lengths	m	3/4	3/4	2/3/4	3	3	3	3	6.25	3	3	3

The ultimate load of yield (or the corresponding load which occurs at a constant elongation of 0.2%) was tested by MPA, (The Material Testing Institute of the state of Northrhine Westfalia, Dortmund/Germany). This also applies to the cross sections. Above figures are valid for INOX anchors as well. The stresses mentioned were calculated from the load and cross section values of MPA.

Key Features

1. **Utilisation of a steel hollow bar as the tendon**
   From the static point of view, a hollow bar is superior to a solid rod of the same cross sectional area with respect to bending moment, shear resistance and surface bond/friction.

2. **Titan hollow bar is manufactured from high yield micro alloy high quality structural steel**
   This offers high notch toughness > 39J. This steel is not affected by hydrogen embrittlement or by stress crack corrosion.

3. **The threads on Titan hollow bars are formed much like the ribs on a reinforcing bar fabricated according to DIN 488**
   The deep Titan threads result in 2.4 times higher bond friction compared to standard drill steel coil-threads of R 32 (1 ¼") or R 38 (1 ½").

4. **Continuous threads guarantee the Titan bar can be cut or coupled anywhere along its length**
   Cutting, extending, pre-stressing and load releasing on the tendon are possible. A thread pitch of 6° eliminates the need for locking nuts at each coupling.

Technical Data

Sacrificial loss of steel on Titan hollow bars

			60 Years			120 Years		
Bar size	Cross section	Ground aggressivity	Diameter loss (mm)	Reduced area (mm²)	% Loss	Diameter loss (mm)	Reduced area (mm²)	% Loss
		Non	0.9	342	10.5	1.5	318	17.0
30/16	338mm²	Mild	1.5	318	17.0	2.5	278	27.0
		Aggressive	2.9	263	31.0	4.9	190	50.0
		Non	0.9	349	9.5	1.5	325	15.5
30/14	385mm²	Mild	1.5	325	15.5	2.5	287	25.4
		Aggressive	2.9	287	25.4	4.9	202	47.5
		Non	0.9	408	8.5	1.5	384	14.0
30/11	446mm²	Mild	1.5	384	14.0	2.5	346	22.5
		Aggressive	2.9	331	26.0	4.9	261	41.5
		Non	0.9	715	6.8	1.5	681	11.2
40/20	767mm²	Mild	1.5	681	11.2	2.5	626	18.4
		Aggressive	2.9	626	18.4	4.9	500	34.8
		Non	0.9	828	5.8	1.5	794	9.7
40/16	879mm²	Mild	1.5	794	9.7	2.5	739	16.0
		Aggressive	2.9	718	18.3	4.9	613	30.3
		Non	0.9	1271	5.0	1.5	1226	8.3
52/26	1337mm²	Mild	1.5	1226	8.3	2.5	1153	14.0
		Aggressive	2.9	1124	16.0	4.9	983	26.5
		Non	0.9	1533	6.0	1.5	1469	10.0
73/53	1631mm²	Mild	1.5	1469	9.9	2.5	1415	13.0
		Aggressive	2.9	1320	19.0	4.9	1112	32.0
		Non	0.9	2998	4.7	1.5	2904	7.7
103/78	3146mm²	Mild	1.5	2904	7.7	2.5	2750	12.6
		Aggressive	2.9	2688	14.6	4.9	2385	24.2
		Non	0.9	6145	2.3	1.5	6049	3.8
103/51	6290mm²	Mild	1.5	6049	3.8	2.5	5890	6.4
		Aggressive	2.9	5890	6.4	4.9	5516	12.3
		Non	0.9	10263	1.8	1.5	10141	2.9
130/60	10446mm²	Mild	1.5	10141	2.9	2.5	9940	4.8
		Aggressive	2.9	9940	4.8	4.9	9464	9.4

Notes