A new dimension for ground engineering from

ISCHEBECK TITAN

- **IBO: Injection Boring**
- **Dynamic pressure grouted, casing free one step installation**
- **Suits all ground conditions**
- **Rapid, effective ground and structural stabilization (ground improvement)**

CON-TECH SYSTEMS Ltd.

CTS/TITAN IBO (Injection Bore) System

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Devised by Ernst Ischebeck in 1983, Ischebeck Titan's ground engineering solutions provide engineers in the construction and civil engineering industries with a new dimension in structural and geotechnical reinforcement, retention and stabilization techniques.

CTS/TITAN IBO (Injection BOre) ground engineering solutions utilize a hollow steel bar, which has a continuous thread running along its external wall. A suitable drill bit is fitted to the end of the bar to penetrate the structure or material requiring stabilization and a drill rig is used to install the bar into the desired position. Grout is injected through the hollow bar and ejected from apertures in the drill bit. Pressure then forces the grout back along the outside of the bar to form a strong, monolithic stabilizing structure.

CTS/TITAN IBO ground engineering techniques provide solutions for anchor, soil nail, pile, rock bolt or ground improvement applications, with a wide variety of bar sizes, drill bits and accessories available to suit every requirement.

The versatility of the CTS/TITAN IBO solution is evident in the number and variety of projects on which it has been used, often providing a more economic, efficient and effective alternative to traditional construction and engineering methods.

This brochure details the principles and techniques employed in CTS/TITAN IBO ground engineering solutions. Separate literature is available covering the various anchor, soil nail,micro pile and rock bolt applications.

Expert technical advice on product selection and scheme design is always available from Con-Tech System's qualified engineers.

Production benefits

- Single step casing free operation significantly improves productivity
- Suitable for difficult and restricted access situations
- Ability to use smaller drilling rigs reduces mobilization costs

Geotechnical benefits

- Extremely low settlement characteristics - less than 5 mm at working load
- Enhanced mechanical bond with surrounding ground (ground improvement)
- Minimal disturbance during installation

Material benefits

- No requirement for double corrosion protection in permanent works
- On site fabrication provides design flexibility
- Wide variety of drill bits to suit different ground conditions.

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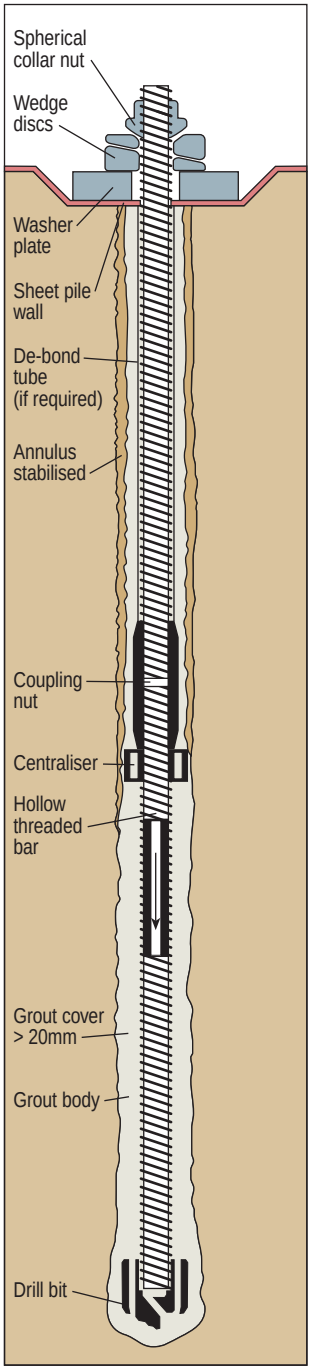
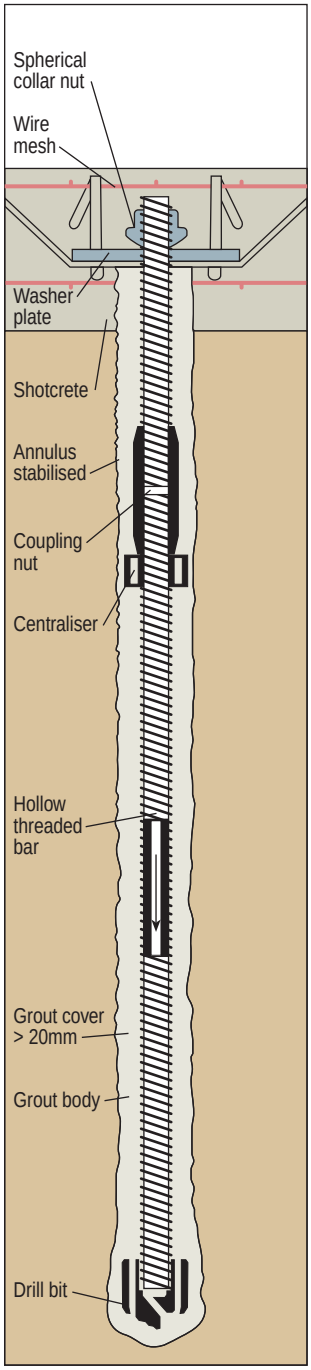
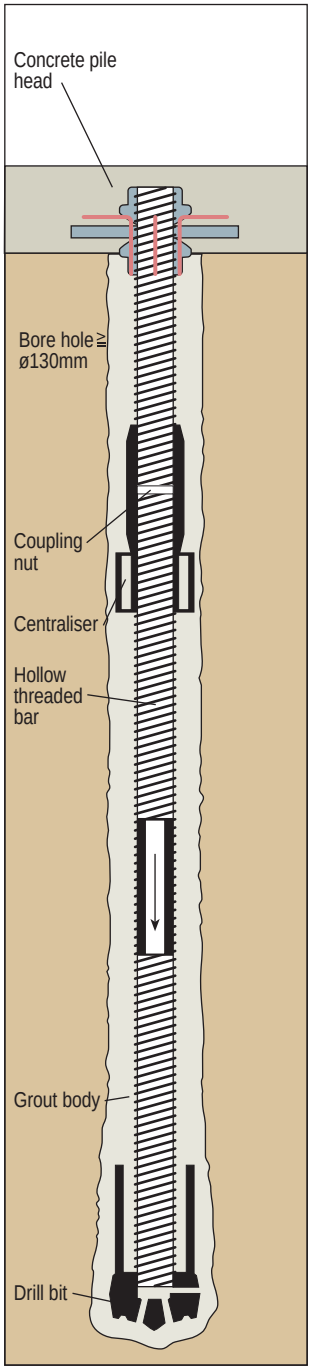
Anchor



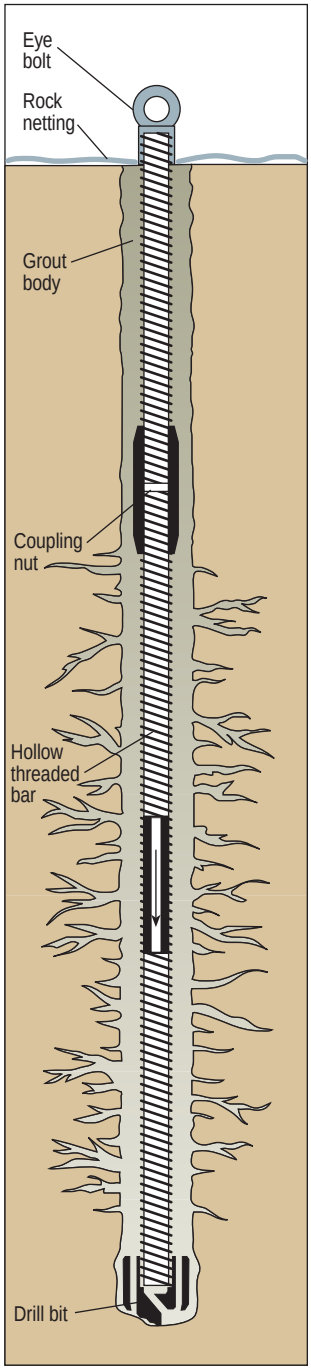
Soil Nail



Pile



Rock Bolt



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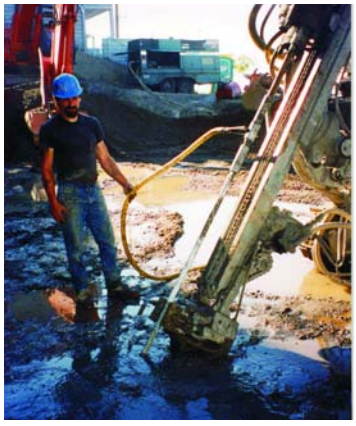
The Ischebeck Titan solution uses the hollow threaded bar as a conduit for either air, water or grout flushing mediums. The medium used is dependent on the ground conditions encountered. For example: Rock would normally require air or water whereas soft or collapsing ground would require grout.

Grout Flushing
The density of the grout is varied depending on the ground conditions; the greater the need to support the annulus, the thicker the grout required. Typically a W/C ratio of between 0.7 and 0.4 would be used.

The flushing head transmits the rotary and percussive forces from the drilling machine to the drill bit, whilst allowing continuous pumping of the flushing medium through the hollow Titan bar.



The flushing medium leaves the apertures of the drill bit under pressure, creating a continuous low pressure scouring action against the sides of the drill hole. This action exposes the harder parts of the hole whilst flushing and removing the softer parts to the surface.

When each bar has been drilled to depth, it is withdrawn back up the mast and then redrilled in a reaming action to improve cuttings return and increase the scouring of the grout flush.

Scouring creates a very rough, irregular shaped grout body with a much greater mechanical connection to the soil, providing greater pull-out resistance and lower settlement characteristics.

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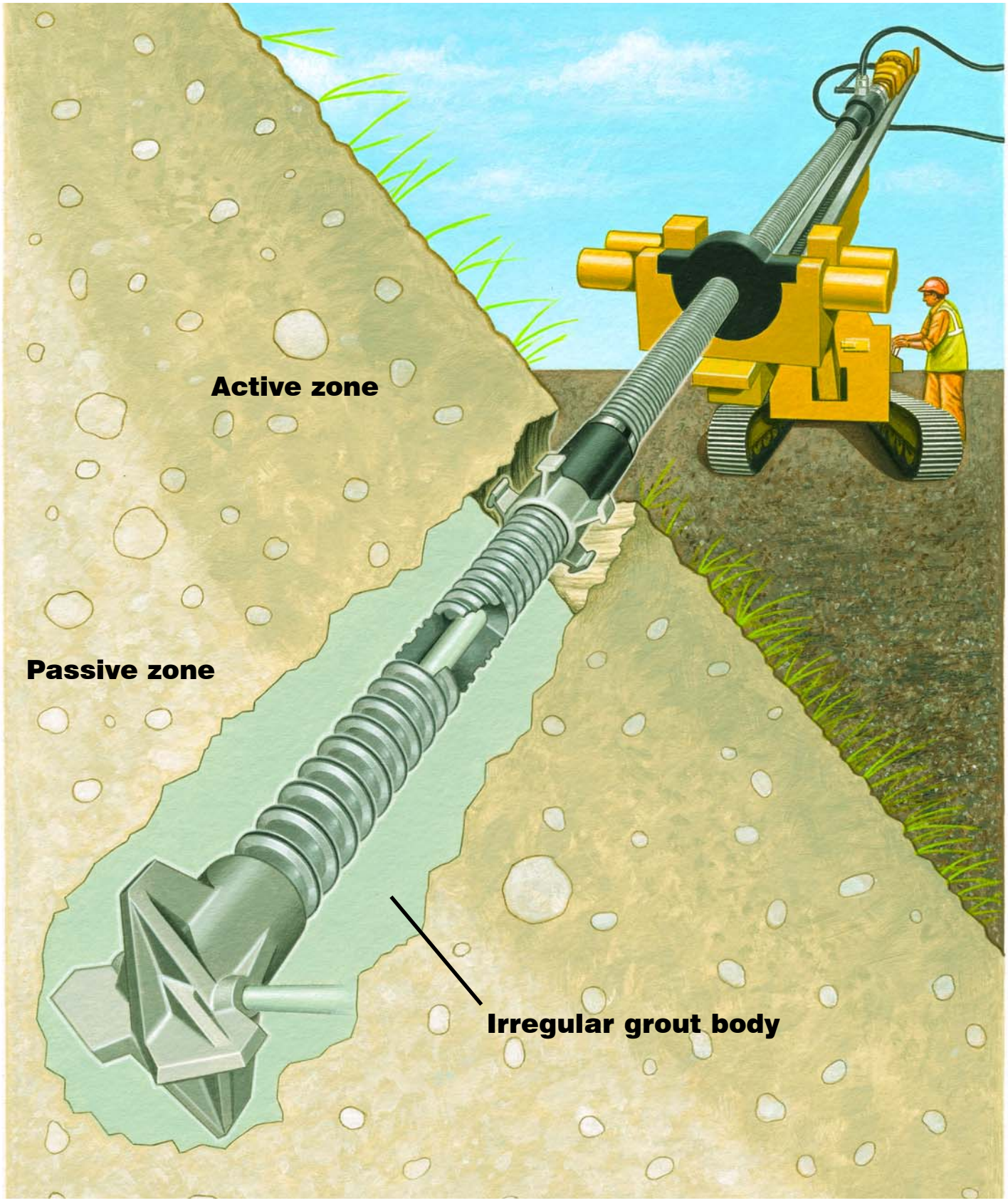

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Installation equipment

Hand held drill rigs

Limited drill bit diameter and limited installed length, depending on ground conditions.

Titan bar diameter

30/16
30/14
30/11

Drilling equipment

TEI Rock Drill
Hand rotary percussion

The result of using good equipment

Crawler mounted drill rigs

Open access
Restricted access
Excavator mounted
Masts

Titan bar diameter

30/16	40/20
30/14	40/16
30/11	52/26

Drilling equipment

Ingersol Rand LM 400
TEI Rock Drill
Morath HGB110
Boart Fleximaster HD160
Pneumatic/hydraulic rotary percussive male shank - R32, R38, T38, T45, R55

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Large crawler mounted drill rigs

Open access

Titan bar diameter

40/20
40/16
52/26
73/53
103/78
103/51
130/60

Drilling equipment

Klemm 802, 803
Krupp HB 40a, HB60a
Cassagrande C6, C9
TEI Rock Drill
Hydraulic rotary percussive heads
2500Nm torque min., male shank -
R55, C64, H55, H112

Grouting equipment

Grout consumption approx 20 kg/m
Ordinary Portland cement dependent on drill bit size and ground conditions.

Titan bar diameter for 20kg/m

30/16
30/14
30/11

Grouting equipment

Injection technique requires:- Grout station capable of mixing and pumping at the same time; Colloidal mixer and an agitating storage tank with capacity of 240 litre; Moyno, piston or plunger pump of approx 35l/min, such as Obermann plunger pumps.

Grout consumption approx. 40 kg/m
Ordinary Portland cement dependent on drill bit size and ground conditions.

Titan bar diameter for 40kg/m

40/20
40/16
52/26
73/53
103/78
103/51
130/60

Grouting equipment

As above but higher capacity of 100l/min at up to 100 bar, such as Obermann VS100, VS110

Sacrificial Steel Allowance

ISCHEBECK TITAN®

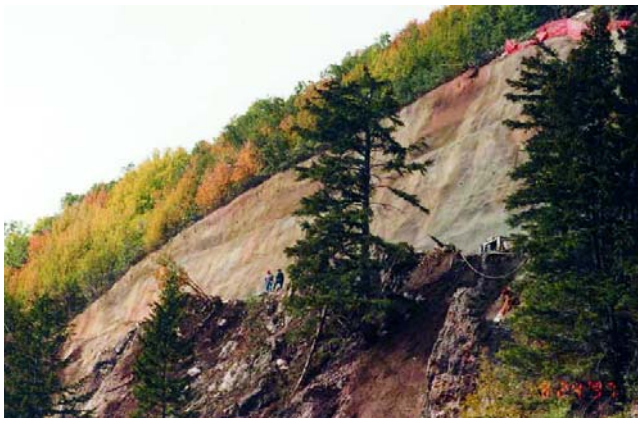
Service life

Ischebeck Titan injection ground engineering products provide a service life in excess of 120 years based on research which has been accepted by both, the UK Railway and Highways Agencies. This research is detailed below.

Steel Characteristics

The steel utilized within the ground engineering products is a high quality, micro alloy structural steel with relatively high yield and tensile capacity. It has similar properties in terms of corrosion to that used for both sheet piles and reinforcement bars. It is vert ductile.

This high yield steel has a low carbon content and as a result is not susceptible to stress corrosion cracking or hydrogen embrittlement.



Sacrificial Steel allowance

The UK Highways Agency Design Manual for Roads and Bridges incorporates section HA68/94 - Design Methods for the Reinforcement of Highway Slopes by Reinforced Soil and Soil Nailing Techniques.

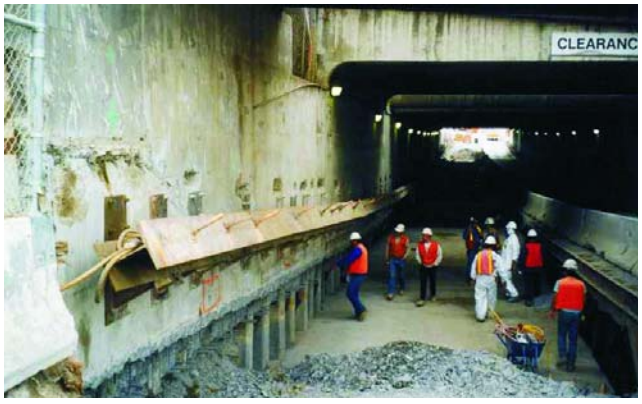
Appendix C of this document is entitled *Corrosion of Metallic Reinforcement and Soil Nails*, and refers to Transport Research Laboratory Research Report 380 (1993) - The Development of Specifications for Soil Nailing; R T Murray TRL RR380 sets out the parameters by which soil can be categorized for

ground aggressivity, with ranking values from non-aggressive to highly aggressive.

The report produces the expected loss of sacrificial thickness of metal over elapsed time. In Table 1 opposite, this data has been applied to the cross sectional area of Ischebeck Titan bar sizes to give an expected loss of steel strength over 60 and 120 year periods. This only applies to the steel buried in the ground with no other protective measures taken.

Section 4.3 of TRL RR380 suggests that “the grout surrounding the nail could be regarded as enhancing the soil environment so that the requirements for sacrificial allowances may be reduced. One strategy, for example, would be to regard the soil as falling within the adjacent lower category of aggressiveness”.

In the USA the Utah Department of Transportation and the Federal Highway Administration (FHWA) approved the use of the sacrificial steel method for a soil nail retaining wall in the Provo Canyon.



Sacrificial Steel Loss Technical Data

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Table 1: Sacrificial loss of steel on Titan hollow bars

			60 years			120 years		
Bar size	Cross section	Ground aggressivity	Diameter loss (mm)	Reduced area (mm^2)	% loss	Diameter loss (mm)	Reduced area (mm^2)	% loss
		Non	0.9	342	10.5	1.5	318	17.0
30/16	338mm^2	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	385mm^2	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	446mm^2	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	767mm^2	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	879mm^2	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	1337mm^2	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	1631mm^2	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	3146mm^2	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	6290mm^2	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	10446mm^2	Mild	1.5	10141	2.9	2.5	9940	4.8
		Aggressive	2.9	9940	4.8	4.9	9464	9.4

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Cement grout

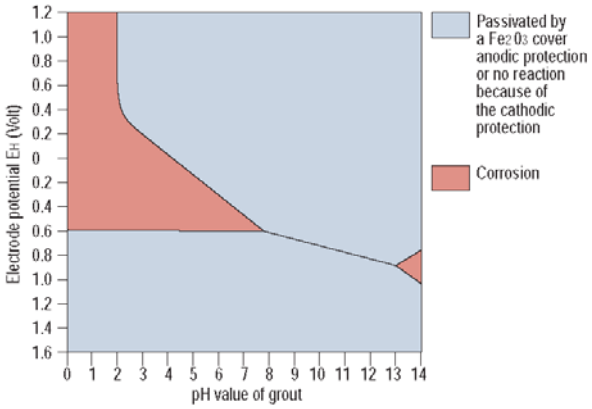
Hydrated cement provides an alkaline environment in the region of pH 12.6 - 13. When steel is encased within such an environment, chemical as well as physical corrosion protection is provided. This is due to the fact that a steel surface remains electrically passivated by the alkali environment, resisting carbonation, which would allow aggressive anions to ingress and attack the steel (see also “Extreme corrosive conditions” below).

The adjacent diagram illustrates why cement grout within this pH value provides an active corrosion protection.

Crack width limitation

Unlike rope threads, the Ischebeck Titan thread is coarse, widely spaced and has a groove taken out of the crown. This induces controlled cracking of the grout along the length of the bar.

Corrosion is likely to occur initially where the bar intersects a crack. Therefore, the smaller the crack width the lower the risk of corrosion. British Standard guidelines propose that crack widths of <0.1mm are acceptable in a cementitious protective barrier.



Shear friction tests, in conjunction with crack width measurements, have been carried out on the Titan thread. The results have shown that the frequency of cracking within a grout body can be controlled to such an extent that the crack widths stay well below the permitted 0.1mm.

Identical tests have also been carried out using hollow rope threaded bars. However, the crack width was over 0.2mm above the permitted 0.1mm and, therefore, the grout cannot be considered as an acceptable cementitious protective barrier.

This has been determined by extensive testing and research carried out by the LGA Geotechnical Institute, University of Munich.

Extreme corrosive conditions

To qualify for class I corrosion protection (as per PTI recommendations) in extreme corrosive conditions, TITAN bars can be manufactured out of “INOX” steel (see page 14). They can also be protected by epoxy coating, metallizing or combi-coating.

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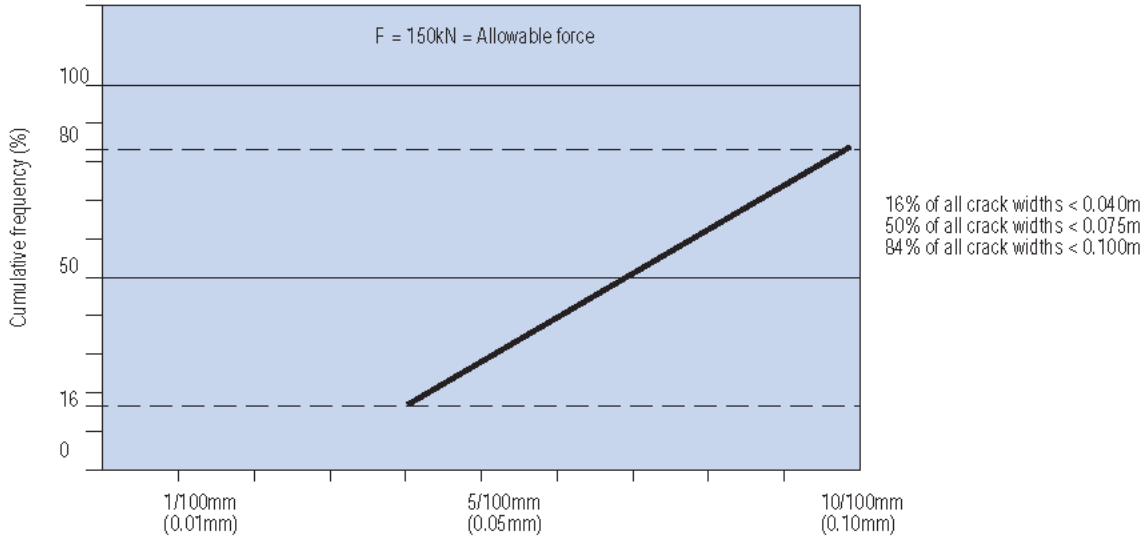
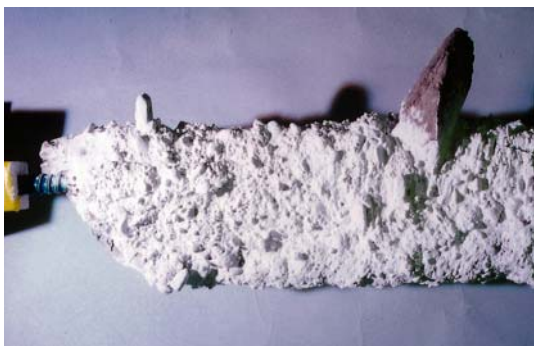
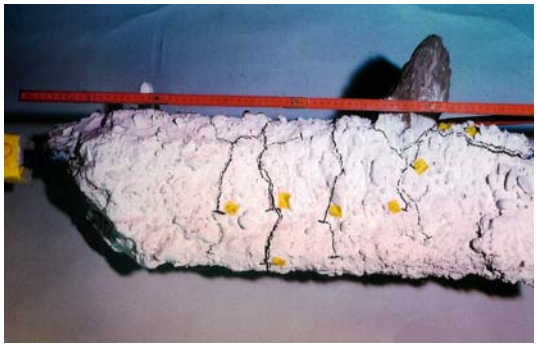
LGA Test 1997

Summary of test 1250/MU/2800/523 dt 29/07/97

Subject of test:	Titan 30/11 within an excavated OPC grout body
Purpose of test:	To determine the number and dimension of the cracks in the grout body during stressing of the anchor tendon to 125% of its SWL.
Result of test:	Cracks, which were not visible to the human eye, were induced along the entire length of the grout body. Every crack measured less than 0.10mm.
Explanation:	The drilling and flushing method used causes scouring of the drill hole. The softer parts of the drill hole are flushed out and the harder parts are exposed. Final pressure grouting creates the strongest possible mechanical connection at the grout/ground interface. The unique thread on the Titan anchor bar has a groove on the crown which is designed to encourage the backflow of cuttings and flushing fluid during drilling. The roughness of this thread produces the strongest possible mechanical connection at the grout/tendon interface. Scientific examination of the grout body revealed that the spacing of the hairline cracks corresponded with the spacing of the threads on the Titan anchor bar.
Conclusion:	At the SWL of 150kN and with all cracking limited to less than 0.10mm the grout body provides complete corrosion protection.







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Research & Development

Our commitment to providing you with the optimum in ground engineering solutions is illustrated by our investment in independent research programs, which enable us to develop and refine the performance and quality of our products for a wide variety of ground conditions.

Excavated grout bodies of a Titan micro pile, soil nail or anchor confirm:

- Grout body has enhanced diameter
- Irregular grout body generates extremely high soil friction
- Continuous and homogeneous grout cover without contamination
- Ground improvement

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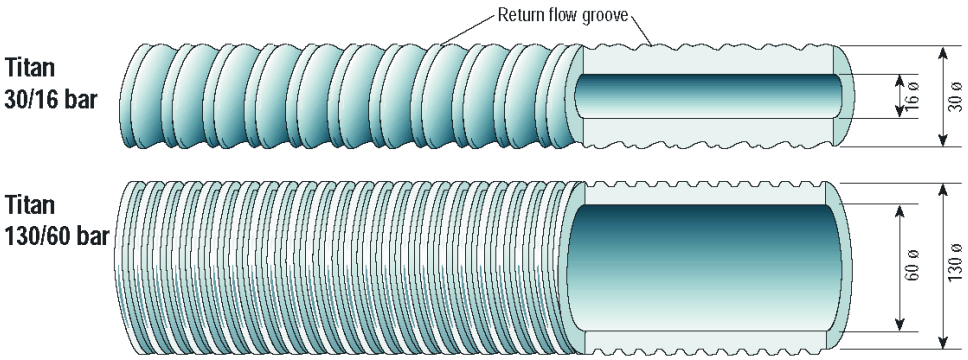
Product specifications

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 dia	mm	30	30	30	40	40	52	73	73	103	103	130
Nominal inside dia	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/mm²	470	610	580	590	590	550	590	550	570	500	550
Cross section (A)	mm²	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 or 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 at 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. **Utilization 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 offering** high notch toughness > 39J. This steel is not affected by hydrogen embrittlement or by stress crack corrosion.

3. **The threads on Titan hollow bar are formed much like the ribs on a reinforcing bar fabricated according to DIN 488 & ASTM-A 615.** The deep Titan threads result in 2.4 times higher bond friction compared to standard drill steel coil-threads of R 32 (1¼") or R 38 (1½")

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

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Hollow bar

Sizes:
A comprehensive selection of Ischebeck Titan hollow bar is available in sizes 30/16 to 130/60 and with ultimate capacity of 220kN to 7900kN. See product specifications and table on page 13 for details.

Finishes:
Black: This high quality, low carbon content, high yield hollow steel bar is suitable for the majority of applications where normal environmental conditions are present.

Epoxy Coated, Metallized or Galvanized: Additional protection for aggressive conditions; used in conjunction with correspondingly coated accessories. For class I corrosion protection.

Inox (a stainless steel): A feritic-austenitic steel (inox duplex), material no. 1.4462. Used for extremely aggressive environments.

Accessories

Ischebeck Titan offers a wide variety of accessories to complement the entire hollow bar range, providing the flexibility to install the bar in different ground conditions with different drilling equipment to suit different applications. The comprehensive range of accessories includes coupling nuts, centralizing spacers, washer plates, adaptor bits, wedge discs, collar nuts and many more ancillary items.

Drill bits

Soft soil

Hardened clay drill bit	75mm to 280mm

Medium rock

Button drill bit	42mm to 70mm
Cross cut drill bit	90mm to 175mm

Hard rock

Carbide button drill bit	90mm to 180mm
Carbide cross cut bit	46mm to 70mm

Flushing heads

Various types are available to suit different bar sizes and drilling rigs:-

S22 - Handheld rock drill with a hexagonal female shank

R32/R38/T38/T45 - Pneumatic rotary percussive drilling rig

R55 - Hydraulic hammer drilling rigs

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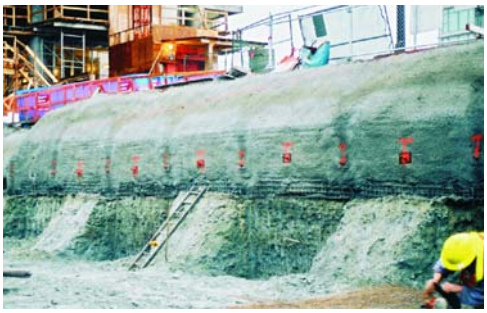

Tie-Backs - Harbor Green Shoring Vancouver

- Excavation Shoring
- CTS/TITAN 30/16 & 40/20
- Temporary anchors
- Corrosion protection through grout body
- Owner: ASPAC Developments
  Contractor: Southwest Contracting

Tie-Backs - Slide Stabilization in Ocean Side near San Diego

- Stabilization of residential area
- CTS/TITAN 40/20
- Owner: Home Owner Association
  Contractor: Condon Johnson

Soil Nails - Slope Stabilization Provo Canyon

- Slope stabilization repair after conventionally nailed wall failed
- CTS/TITAN 40/16 permanent soil nails
- Corrosion protection through grout body
- Sacrificial steel allowance, use approved by UDOT and FHWA
- Owner: UDOT
  Contractor: Obayashi

Micro Piles - Louisville

- Foundations for power house
- Low headroom
- Karst ground
- CTS/TITAN 103/78 micro piles
- Corrosion protection through grout body
- Owner: Kentucky Power
  Contractor: Morris Shea Bridge Co.

Contact

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T-Wall Repair, CTS/TITAN 103 Micropiles
Contractor: Hayward Baker; Owner: CALTRANS

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