A new dimension for ground engineering from ISCHEBECK TITAN

- Self-drilling, caseless installation
- Suits all ground conditions
- Rapid, effective ground and structural stabilisation
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 stabilisation techniques.

Ischebeck Titan's ground engineering solutions utilise 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 stabilisation 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 stabilising structure.

Ischebeck Titan's ground engineering techniques provide solutions for anchor, soil nail, pile or rock bolt applications, with a wide variety of bar sizes, drill bits and accessories available to suit every requirement.

The versatility of the Ischebeck Titan 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 Ischebeck Titan's ground engineering solutions. Separate literature is available covering the various anchor, soil nail, pile and rock bolt applications.

Expert technical advice on product selection and scheme design is always available from the company's qualified engineers.

Production benefits
- Single caseless operation significantly improves productivity
- Suitable for difficult and restricted access situations
- Ability to use smaller drilling rigs reduces mobilisation costs

Geotechnical benefits
- Extremely low settlement characteristics - less than 5mm at working load
- Enhanced mechanical bond with surrounding ground
- 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
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.

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.

When each bar has been drilled to depth, it is withdrawn back up the mast and then redeployed in a reaming action to improve cuttings return and increase the scouring of the grout flush.

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.
Installation/grouting equipment

Installation equipment

**Hand held drill rigs**

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

**Titan bar diameter**
- 30/16 (left hand)
- 30/14
- 30/11

**Drilling equipment**
- Silver 303
- SIG PLB 291
- PB9
- Pneumatic rock drills 7/8 x 4” hex liner, 30 kgs left hand rotary percussion

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**Crawler mounted drill rigs**

Open access
- Restricted access
- Excavator mounted
- Masts

**Titan bar diameter**
- 30/16 (left hand)
- 30/14
- 30/11
- 40/20
- 40/16
- 52/26 (right hand)

**Drilling equipment**
- BBE 57
- Ingersol Rand LM 400
- Marini
- Morath HGB110
- Krupp HB 11a
- Boart Fleximaster HD160
- Pneumatic/hydraulic rotary percussive rock drills, male shank - R32, R38, T38, R55
Large crawler mounted drill rigs

Open access

Titan bar diameter
40/20 (left hand)
40/16
52/26 (right hand)
73/53
103/78
103/51
130/60

Drilling equipment
Klemm 802, 803
Krupp HB 40a, HB60a
Cassagrande C6, C9
Mustang

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
30/16 (left hand)
30/14
30/11

Grouting equipment
Injection technique requires:
- Grout station capable of mixing and pumping at the same time;
- Colloidal mixing tank and an agitating storage tank with capacity of 240 litres;
- Double or piston pump of approx 35l/min, such as Colmo 410 or Putzmister P13

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

Titan bar diameter
40/20 (left hand)
40/16
52/26 (right hand)
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 Hany 650 or Obermann VS100
Technical data

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 Railtrack and the Highways Agency. This research is detailed below.

Steel Characteristics
The steel utilised within the ground engineering products is a high quality, micro alloy structural steel which is high yield and not high tensile. It has similar properties in terms of corrosion to that used for both sheet piles and reinforcement bars.

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

Sacrificial allowance

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 categorised for ground aggressivity, with ranking values from non-aggressive to highly aggressive (it should be noted that there are no naturally occurring, highly aggressive soils in the UK).

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”.

The fire resistance of structural steel has been determined in accordance with BS476 Part 6:1987 and Tested in accordance with BS476 Part 6:1987. It is guaranteed at 1 hour fire rating.
## Technical data

### Table 1: Sacrificial loss of steel on Titan hollow bars

<table>
<thead>
<tr>
<th>Bar size</th>
<th>Cross section</th>
<th>Ground aggressivity</th>
<th>60 years</th>
<th>120 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Diameter loss (mm)</td>
<td>Reduced area (mm²)</td>
</tr>
<tr>
<td>Non</td>
<td>0.9</td>
<td>342</td>
<td>318</td>
<td>9.5</td>
</tr>
<tr>
<td>30/16</td>
<td>338 mm²</td>
<td>Mild</td>
<td>263</td>
<td>31.0</td>
</tr>
<tr>
<td>Aggressive</td>
<td>2.9</td>
<td></td>
<td>287</td>
<td>25.4</td>
</tr>
<tr>
<td>Non</td>
<td>0.9</td>
<td>349</td>
<td>318</td>
<td>17.0</td>
</tr>
<tr>
<td>30/14</td>
<td>385 mm²</td>
<td>Mild</td>
<td>263</td>
<td>31.0</td>
</tr>
<tr>
<td>Aggressive</td>
<td>2.9</td>
<td></td>
<td>287</td>
<td>25.4</td>
</tr>
<tr>
<td>Non</td>
<td>0.9</td>
<td>408</td>
<td>384</td>
<td>15.5</td>
</tr>
<tr>
<td>30/11</td>
<td>446 mm²</td>
<td>Mild</td>
<td>287</td>
<td>25.4</td>
</tr>
<tr>
<td>Aggressive</td>
<td>2.9</td>
<td></td>
<td>325</td>
<td>25.4</td>
</tr>
<tr>
<td>Non</td>
<td>0.9</td>
<td>384</td>
<td>384</td>
<td>15.5</td>
</tr>
<tr>
<td>40/20</td>
<td>767 mm²</td>
<td>Mild</td>
<td>681</td>
<td>11.2</td>
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<tr>
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<td></td>
<td>626</td>
<td>11.2</td>
</tr>
<tr>
<td>Non</td>
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<td>794</td>
<td>9.7</td>
</tr>
<tr>
<td>40/16</td>
<td>879 mm²</td>
<td>Mild</td>
<td>794</td>
<td>9.7</td>
</tr>
<tr>
<td>Aggressive</td>
<td>2.9</td>
<td></td>
<td>794</td>
<td>9.7</td>
</tr>
<tr>
<td>Non</td>
<td>0.9</td>
<td>1271</td>
<td>1226</td>
<td>8.3</td>
</tr>
<tr>
<td>52/26</td>
<td>1337 mm²</td>
<td>Mild</td>
<td>1226</td>
<td>8.3</td>
</tr>
<tr>
<td>Aggressive</td>
<td>2.9</td>
<td></td>
<td>1226</td>
<td>8.3</td>
</tr>
<tr>
<td>Non</td>
<td>0.9</td>
<td>1533</td>
<td>1533</td>
<td>8.3</td>
</tr>
<tr>
<td>73/53</td>
<td>1631 mm²</td>
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<td>1533</td>
<td>8.3</td>
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<tr>
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<td></td>
<td>1533</td>
<td>8.3</td>
</tr>
<tr>
<td>Non</td>
<td>0.9</td>
<td>2998</td>
<td>2998</td>
<td>8.3</td>
</tr>
<tr>
<td>103/78</td>
<td>3146 mm²</td>
<td>Mild</td>
<td>2998</td>
<td>8.3</td>
</tr>
<tr>
<td>Aggressive</td>
<td>2.9</td>
<td></td>
<td>2998</td>
<td>8.3</td>
</tr>
<tr>
<td>Non</td>
<td>0.9</td>
<td>6145</td>
<td>6145</td>
<td>8.3</td>
</tr>
<tr>
<td>103/51</td>
<td>6290 mm²</td>
<td>Mild</td>
<td>6145</td>
<td>8.3</td>
</tr>
<tr>
<td>Aggressive</td>
<td>2.9</td>
<td></td>
<td>6145</td>
<td>8.3</td>
</tr>
<tr>
<td>Non</td>
<td>0.9</td>
<td>10263</td>
<td>10263</td>
<td>8.3</td>
</tr>
<tr>
<td>130/60</td>
<td>10446 mm²</td>
<td>Mild</td>
<td>10263</td>
<td>8.3</td>
</tr>
<tr>
<td>Aggressive</td>
<td>2.9</td>
<td></td>
<td>10263</td>
<td>8.3</td>
</tr>
</tbody>
</table>
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.

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 maximum 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.
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.

F = 150kN = Allowable force

16% of all crack widths < 0.040m
50% of all crack widths < 0.075mm
84% of all crack widths < 0.100mm
Our commitment to providing you with the optimum in ground engineering solutions is illustrated by our investment in independent research programmes, 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 tendon pile confirm:

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

Principle testing at the testing institute for anchoring, rock and soil mechanics at the University of Munich
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.

<table>
<thead>
<tr>
<th>Titan bar type</th>
<th>Unit</th>
<th>30/16</th>
<th>30/14</th>
<th>30/11</th>
<th>40/20</th>
<th>40/16</th>
<th>52/26</th>
<th>73/53</th>
<th>73/56</th>
<th>103/78</th>
<th>103/51</th>
<th>130/60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal outside dia mm</td>
<td></td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>40</td>
<td>40</td>
<td>52</td>
<td>73</td>
<td>73</td>
<td>103</td>
<td>103</td>
<td>130</td>
</tr>
<tr>
<td>Nominal inside dia mm</td>
<td></td>
<td>16</td>
<td>14</td>
<td>11</td>
<td>20</td>
<td>16</td>
<td>26</td>
<td>53</td>
<td>56</td>
<td>78</td>
<td>51</td>
<td>60</td>
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<tr>
<td>Ultimate load kN</td>
<td></td>
<td>220</td>
<td>260</td>
<td>320</td>
<td>539</td>
<td>660</td>
<td>929</td>
<td>1160</td>
<td>1194</td>
<td>2282</td>
<td>3460</td>
<td>7940</td>
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<tr>
<td>Yield point kN</td>
<td></td>
<td>180</td>
<td>220</td>
<td>260</td>
<td>430</td>
<td>525</td>
<td>730</td>
<td>970</td>
<td>785</td>
<td>1800</td>
<td>2750</td>
<td>5250</td>
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<tr>
<td>Yield Stress $T_{0.2}$ N/mm²</td>
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<td>470</td>
<td>610</td>
<td>580</td>
<td>590</td>
<td>590</td>
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<td>590</td>
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<td>570</td>
<td>500</td>
<td>550</td>
</tr>
<tr>
<td>Cross section (A) mm²</td>
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<td>382</td>
<td>395</td>
<td>446</td>
<td>726</td>
<td>879</td>
<td>1337</td>
<td>1631</td>
<td>1414</td>
<td>3146</td>
<td>5501</td>
<td>9540</td>
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<tr>
<td>Weight kg/m</td>
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<td>2.9</td>
<td>3.3</td>
<td>5.6</td>
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<td>10.0</td>
<td>12.3</td>
<td>11.1</td>
<td>24.9</td>
<td>43.4</td>
<td>75.0</td>
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<tr>
<td>Thread left/right hand</td>
<td></td>
<td>left</td>
<td>left</td>
<td>left</td>
<td>left</td>
<td>left</td>
<td>left</td>
<td>left</td>
<td>right</td>
<td>right</td>
<td>right</td>
<td>right</td>
</tr>
<tr>
<td>Lengths m</td>
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<td>3/4</td>
<td>2/3/4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>6.25</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

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. **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 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.** The deep Titan threads result in 2.4 times higher bond friction compared to standard drill steel coil-threads of R 32 (1/4") or R 38 (1/2")

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.
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.

Combi-Coat: A combination of hot dipped galvanised and a blue epoxy paint finish gives the bar additional protection for aggressive conditions. Used in conjunction with galvanised accessories. Available in 30/11 and 40/16.

Inox: A feritic-austenitic steel (inox duplex), material no. 1.4462. Used for extremely aggressive environments. Available in 30/11 and 40/16.

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, centralising 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 drill 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 - Pneumatic rotary percussive drilling rig
R55 - Hydraulic hammer drilling rigs
Ground Anchors - Hull
- Environment agency flood protection scheme
- 650No. ground anchors
- Ischebeck Titan 30/11 (20m) and 40/16 (25m) bar
- All black mild steel bar
- Installed by 13T excavator working underneath itself
- Sacrificial thickness
- Crack width limitation
- 50 year design life

Soil Nails - Brighton Marina
- Coastal protection scheme
- Approximately 600No. soil nails
- Ischebeck Titan 30/11 black bar
- 75mm hardened clay drill bit used to drill chalk
- 25 - 30 soil nails installed per day (150 - 180m)
- Installed by abseil team
- 120 year design life

Mini-Piles - University of Strathclyde
- Creation of new mezzanine floor within existing building
- 33No. 9m long micropiles drilled through boulder clay
- Ischebeck Titan 30/11 black bar
- 150kN working load per pile to support new 254 x 254 x 73 universal columns
- 3No. piles at close centres giving small pile cap (865 x 950 x 500dp)
- Limited access and headroom
- Minimal excavation and disruption

Rock Bolts - Reston Cutting
- Reston Cutting stabilisation, East Coast Mainline
- 148No. 3m crest anchors installed in 1m lengths using couplings
- Ischebeck Titan 30/11 black bar
- 4250m² of chain-link rock-fall mesh
- Integral eye bolt allowed 3-way connection for cable stays
- Anchors installed by hand through 2m of mixed overburden into rock
- Anchor fully bonded in cement grout for full service life
Ischebeck Titan Group

Founded in Germany over 120 years ago Ischebeck is renowned internationally for its aluminium formwork and false work systems, trench support systems and ground engineering products.

Ischebeck NZ Ltd

The company operates from headquarters located in the Auckland

Product Availability

Substantial stocks of equipment are available ex-stock from the company’s Onehunga distribution site, with most items available nationwide on a 48-hour delivery.

Technical Support

We will participate in concept stage development. Providing input on applications, production rates, budget design and costings. Active for on site support, particularly for new users. We can provide guidance on industry special European and national standards.

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