



Slope stabilisation and soil nailing with TITAN micropiles

Temporary and permanent

TITAN micropile with
National Technical Approval

Slope stabilisation and soil nailing with TITAN micropiles

TITAN micropiles to National Technical Approval Z-34.14-209 for Slope stabilisation and soil nailing to EN 14490.

The challenge

Changes in the geometry of structures or slopes may lead to instability or proof difficult to verify their stability. There are a number of reasons that can influence this:

- Changes to the existing environment
- Weathering/erosion processes
- Redistribution of materials
- Additional loads
- Revised design codes
- Hydrological influences

Countermeasures

Conventional **retaining structures** resist earth pressures through self-weight, cantilever or anchorages that extend deep into the ground. TITAN micropiles according to EN 14199 can be used as tension piles for such anchorages (see our Anchorage brochure).

However, the principle of **soil nailing** using TITAN micropiles is to activate the subsoil by increasing the tensile and shear properties, with the installation of reinforcement into the in-situ soil mass. As a result the composite soil body maintains or increases the stability of the altered structure or slope geometry.

TITAN micropile – a soil nail as reinforcement

TITAN micropiles to DIBt approval Z-34.14-209 can be used as reinforcement/loadbearing tendons according to DIN 4084. Based on analysis, the micropile can be classed as a soil nail.

- The fundamental advantage of soil nailing over conventional retaining structures is that no additional excavation work is required behind the structure. Furthermore, no support measures (bored cast-in-place pile walls, sheet pile walls, etc.) are required prior to excavation.
- Soil nailing is mainly used for stabilising cuttings, unstable slopes/embankments and the refurbishment of retaining structures.
- When soil nails are used for excavation shoring, they are generally used together with a sprayed concrete facing.

Facing

Besides the composite body made up of soil plus reinforcement, soil nailing to EN 14490 generally requires a facing that has to be designed depending on the loads, subsoil conditions, batter and desired appearance. We distinguish between **hard, flexible and soft facings** as well as **designs without a facing**.

- **Hard facings** are rigidly connected to the nails and must be able to stabilise the embankment/wall together with the nails. They are mostly built in concrete (sprayed concrete, in situ or precast).
- **Flexible facings** support the subsoil between the reinforcing elements and provide protection against erosion. They are mostly in the form of steel or plastic nets/meshes.
- **Soft facings** are generally provided to protect against erosion and break-up of the surface. The tendons merely fix the facing and do not stabilise the embankment.
- **Designs without facings** are frequently used for shallow slopes and embankments, e.g. railway embankments and river-banks, where the stability of the embankment is assured by the soil nailing on its own and the vegetation is not disturbed.

Hard facing

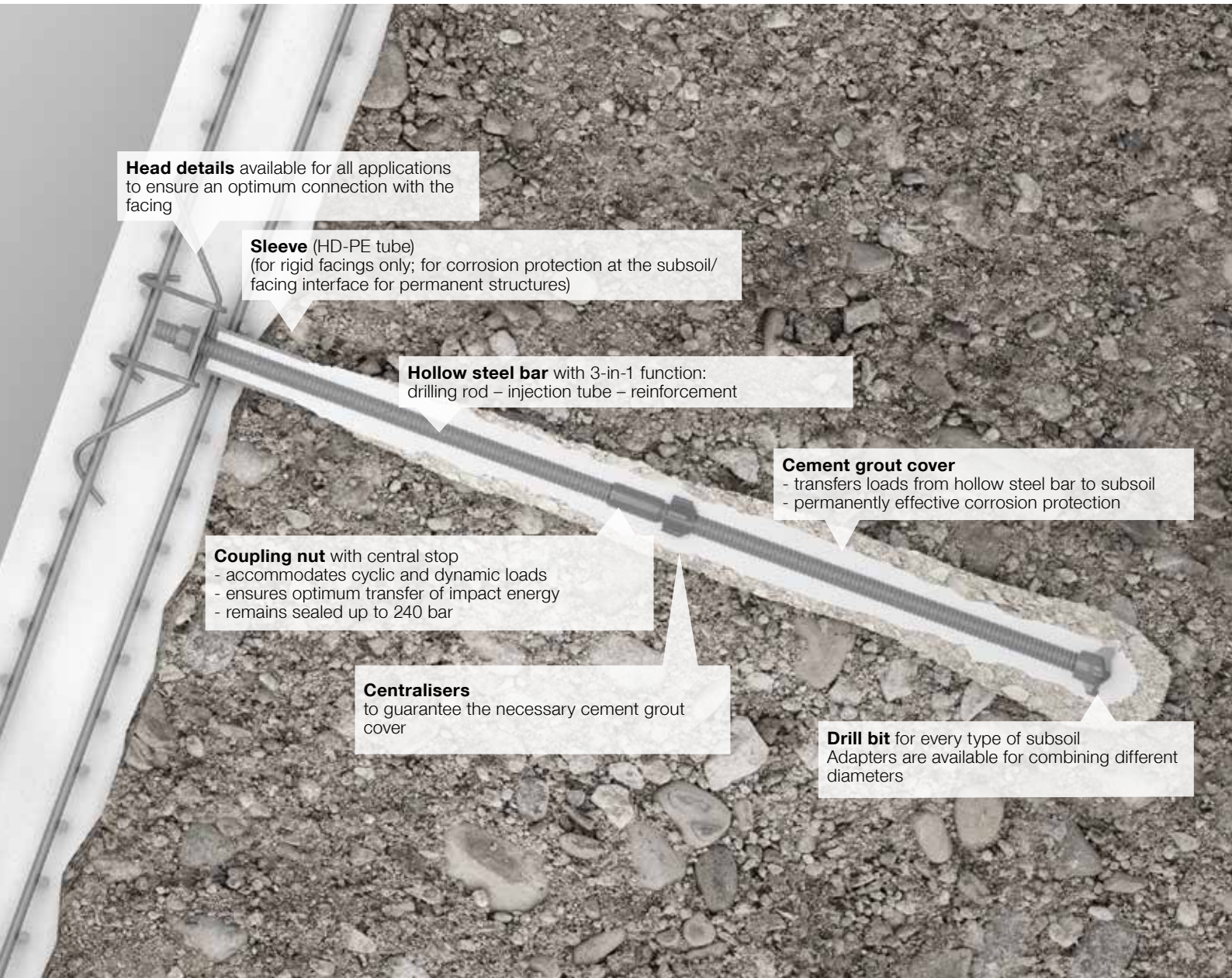
Sprayed concrete stabilisation secured with micropiles plus in situ concrete facing



Slope stabilisation without facing

Oldenburg–Wilhelmshaven railway line





Head details available for all applications to ensure an optimum connection with the facing

Sleeve (HD-PE tube)
(for rigid facings only; for corrosion protection at the subsoil/facing interface for permanent structures)

Hollow steel bar with 3-in-1 function:
drilling rod – injection tube – reinforcement

Cement grout cover
- transfers loads from hollow steel bar to subsoil
- permanently effective corrosion protection

Coupling nut with central stop
- accommodates cyclic and dynamic loads
- ensures optimum transfer of impact energy
- remains sealed up to 240 bar

Centralisers
to guarantee the necessary cement grout cover

Drill bit for every type of subsoil
Adapters are available for combining different diameters

Advantages for designers

- System has a National Technical Approval in Germany
- Versatile applications for difficult boundary conditions
- Suitable for all soils
- Low structural deformations without prestressing

Advantages for contractors

- One installation method for all types of applications
- Suitable for use in confined sites
- Fast production rates
- Unaffected by changing soil conditions

Advantages for clients

- Permanent corrosion protection
- Highly reliable installation method
- Avoids major interference with existing works
- Economic system

Benefits of the system: temporary or permanent without additional ribbed sheathing



The steel grade

The S460 NH fine-grain structural steel used for ISCHEBECK micropiles/soil nails complies with the requirements for steel tubes that are used as the reinforcement for soil nailing according to EN 14490.

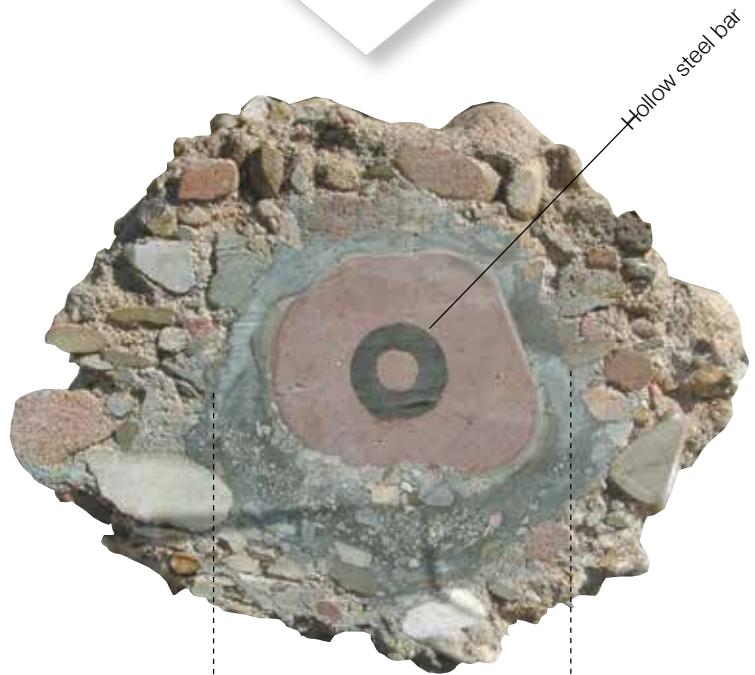
- Strain stiffness $f_{yk} < 600 \text{ N/mm}^2$ owing to the necessary composite action between loadbearing tendon and grout body
- Percentage total strain at maximum load (ductility): $A_{gt} > 5 \%$
- Complies with EN 10210 (hot-finished structural hollow sections of non-alloy and fine-grain steels)
- Notched impact energy (toughness): $Kv \geq 40 \text{ J}$ (at -20°C)

Permanent application

Effective encasement in cement grout provides permanent corrosion protection for construction projects with a design life > 2 years. The crack widths of $< 0.1\text{mm}$ which are necessary and required within the scope of the DIBt approval, have been verified.

The thread – optimum bond properties

For the DIBt approval, crack widths $< 0.1 \text{ mm}$ in the grout body were verified for the TITAN thread (reinforcing bar thread based on DIN 488 or EN 10080). According to the approval, apart from the minimum cement grout cover, no further corrosion protection measures are necessary.

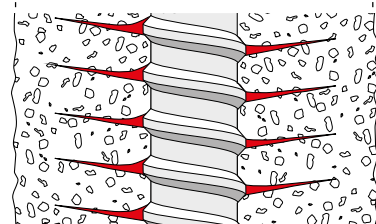


Permanent application

EN 14490 details very diverse options for protecting metal reinforcement against corrosion. The only two systems approved by the DIBt (German Institute of Building Technology) are:

1. A **cement grout cover** (provided a crack width of 0.1 mm is not exceeded)
2. The installation of a **ribbed sheathing** together with pressure grouting

Systems whose durability relies on a corrosion allowance in the region of the load transfer length (bonded length) are **not** permitted in Germany. The necessary cement grout cover is specified in the DIBt approval depending on the load.



Verified crack widths $s < 0.1 \text{ mm}$ when exploiting the steel stress to the full

Additional corrosion protection

Loadbearing tendons and pile head components can be supplied with additional factory-applied corrosion protection for special requirements. These include, highly aggressive soils, large joints and voids in the ground or where loadbearing tendons are exposed, especially the head details.



Hot-dip galvanising
to EN ISO 1461



DUPLEX protection Hot-dip galvanizing + powder coating + epoxy powder coating to DIN 55633



Stainless steel - INOX
Non-corroding stainless steel (grade 1.4462)

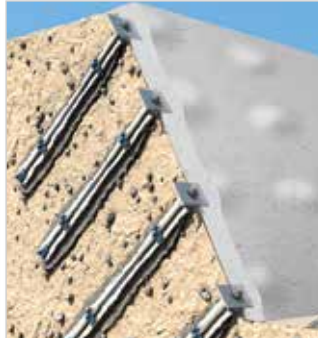
Range of applications

Applications for soil nailing to EN 14490 include the stabilisation of embankments, dams, cuttings, unstable slopes and tunnel entrances and the refurbishment of retaining walls.



Slope stabilisation

- Dams
- Cuttings
- Embankments
- Erosion protection
- Protective nets
- Avalanche protection



Anchoring sprayed concrete

- Excavations
- Retaining walls
- Tunnel portals
- Tunnel entrances
- Emergency stabilisation measures



Stabilising existing retaining walls

- Retaining walls
- Stone walls
- Concrete walls
- Crib walls



DRILL-DRAIN[®]

A supplementary application specifically for subsoil drainage in accordance with EN 14490 for slopes, embankments and retaining walls.

Advantages for installation

Installation can be carried out using small versatile drilling masts that can be fitted to a diverse range of base machines, that can reach almost every drilling position. Manually operated drills, fixed to scaffolding or tripods can be used where access for base machines is impossible.

The low noise and vibration generated during the installation is favourable in urban environments and on unstable slopes.



Slope and embankment stabilisation with mesh

Examples

In the future, there will be fewer “new” building measures. Instead, there will be more emphasis on working with the existing environment and stabilising and repairing structures/ earthworks. This will require small, versatile machinery and systems that will allow stabilisation techniques to be executed without disturbing the natural environment or requiring major earthworks.



Slope stabilisation with mesh
Embankment above Garmisch–Munich railway line near Wolfratshausen, Germany

One machine – many applications

Prior to the slope stabilisation work, the site had to be cleared and all vegetation removed. In addition, berms had to be constructed and drains installed.

Walking excavators are frequently used for such clearing and enabling works on slopes. Upon completion the drilling machines can be mounted to the excavators to install the TITAN soil nails. Alternatively light weight slope drilling rigs can be used for the soil nail installation.



Slope protection

After the loadbearing tendons have been installed, the slope protection, normally in the form of high-strength wire meshes (e.g. from Geobruigg, Trumer, Maccaferri, Krismer, etc.), are fixed to the slope with the manufacturers system plate and secured with a TITAN spherical collar nut.

All exposed steel components, especially the loadbearing tendon at the soil/air interface, should be hot-dip galvanised to protect against corrosion.



Examples of the system claw plates supplied by the mesh manufacturers, which are fixed using TITAN spherical collar nuts.

Hot-dip galvanised TITAN claw plates for securing “simple” hexagonal wire mesh.



Cutting stabilised with anchored mesh

Nuremberg–Hof railway line near Röslau
Rockfall protection for the tracks had to be installed with trains still running.



Laying the high-strength wire netting

The right plant for every application

A wide range of machinery is available to accommodate the most difficult and challenging drilling scenario's. To shorten construction programs and to limit road and rail closures, diverse types of machinery can be used simultaneously in confined and restricted sites.

Lower slope area

Drilling rig mounted on mini-excavator for work adjacent to the tracks, with railway operations temporarily suspended on one track.



Middle slope area

Drilling rig mounted on excavator with long telescopic boom positioned at the top of the slope to avoid heavy plant loads on the slope.



Upper slope area

Installing anchors from a drilling rig mounted on a walking excavator working on the slope.



Efficient site setup

In order to guarantee smooth and efficient project operations, the site set up should be planned to suit the site conditions.



Soil nail walls

Sprayed concrete anchored with micropiles

Permanent excavation shoring - Up to 9.0m high in the form of a soil nailed/ sprayed concrete wall for the construction of the Gut Hochreute Buddhist Centre at Immenstadt in Allgau.



A drilling system for all in situ soil conditions

The drilling method remains the same even with varying soil conditions. Simply the use of an alternative drill bit type or a different water cement ratio may be required.

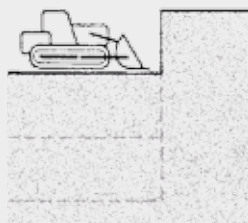


Exact alignment of the drilling rig at the drilling position.

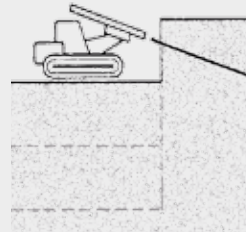


Staged excavation and soil nailing of the exposed section will depend on the stability of the in situ soil (normally between 1 – 2m). As soon as the soil nails and sprayed concrete facing of one section have cured excavation down to the next level can begin.

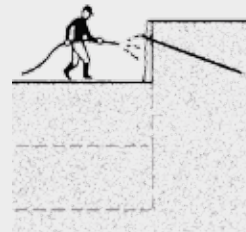
1. Staged excavation



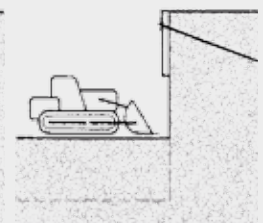
2. Installation of loadbearing tendons



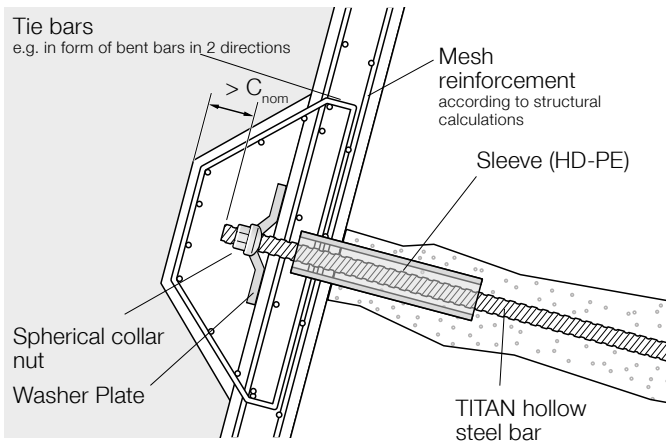
3. Reinforced sprayed concrete



4. Next excavation stage

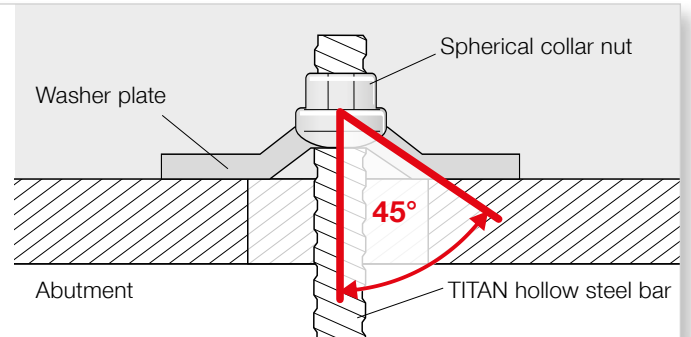


In the case of **stabilisation with permanent sprayed concrete**, two layers of reinforcement are normally required in the sprayed concrete facing. The end plate can be placed between the layers or on top. A punching analysis to EN 1992-1 must always be carried out, which means that tie bars might be necessary depending on the bearing pressure below the head. Head details are generally covered with a layer of reinforced sprayed concrete to provide permanent corrosion protection and protect against damage during further excavations.



End plate “bulge” for optimum load transfer

Loading tests have shown that the 45° “bulge” in the washer plate ensures an optimum load transfer and so deformations at service loads remain extremely small. Therefore, thinner plates are possible for the same bending.



Angle compensation



The shaped **TITAN washer plate** can compensate for angle differences of approx. 5° with respect to the abutment.

Differences in angle between soil nail and terrain of up to ± 36° can be compensated for by using the self-centring **TITAN angle adapter plate** (shown here with claw plate).

Other methods of angle compensation involve using a bed of grout.

Stabilising existing retaining walls

Refurbishment of a stone bridge over a gully below the Spitzingseestrasse in Bavaria. Due to increased traffic volume, erosion and washout, it became necessary to refurbish the entire structure. Voids in the backfill meant corrosion protection in the form duplex coating (hot-dip galvanising plus powder coating) was required for the horizontal anchorages, as a protective grout body could not be guaranteed for its entire length.



The **ISCHEBECK method** involves the loadbearing tendon being drilled directly with a sacrificial drill bit, whilst stabilising the borehole with a cement based flushing fluid. There is no time-consuming insertion and removal of temporary casings, which means much lighter machinery can be used.



TITAN hollow steel bars can be installed with excavator-mounted drilling rigs from the base of a structure or from the road above.

Drilling rigs can be mounted on elevating work platforms to reach otherwise inaccessible drilling positions.



The stone wall was initially temporarily secured by connecting the loadbearing tendons together with U-wailings to spread the load. TITAN washer plate and angle adaptor plate ensure compensation for different angles.



The second washer plate fixed between two spherical collar nuts was integrated into the reinforcement.



In the permanent, final condition, TITAN hollow steel bars anchor the structure in the ground and provide a structural connection between the new in situ concrete facing and the existing wall.



Stabilising a change in ground level

with a gabion wall facing, which is also anchored.



Soil nailing an existing retaining wall

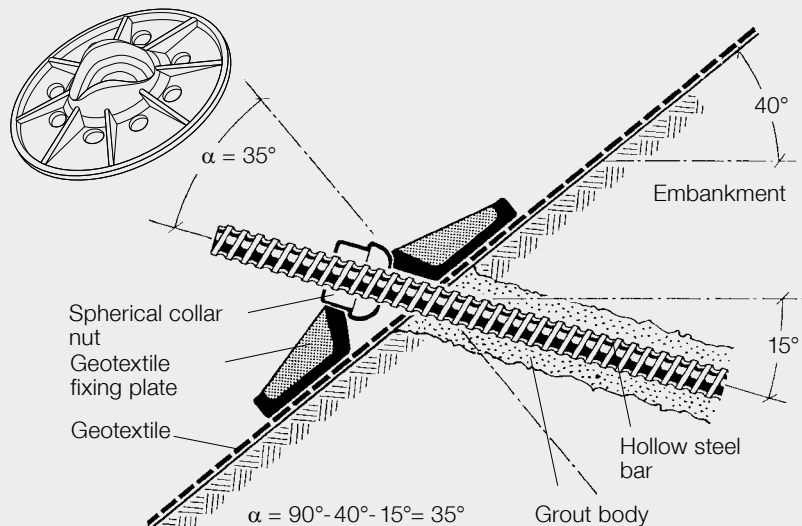
Soil nails installed from the river bed. The reinforcement to the sprayed concrete facing was in this case in the form of a net-like geotextile instead of steel bars.



Large load distribution plate

The TITAN geotextile fixing plate is ideal for use with geotextiles and rubble stone walls:

- **Rounded edges** = much less risk of damage to geotextiles or plastic sheeting
- **285 mm diameter** = low bearing pressures (ideal for thin stone walls, for instance)
- **Integral angle adaptor** = for differences in angles between pile axis and abutment of up to 36° in all directions
- **Galvanised** = permanent corrosion protection if left exposed



Railway embankment stabilisation

Many railway embankments are more than 100 years old. Information on to what extent a specified level of safety was considered or which criteria were placed on the selection of the fill material for the embankment and its compaction is frequently no longer available.

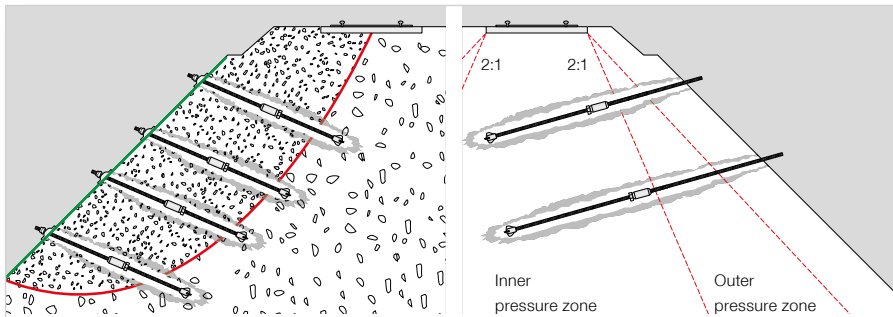
The effects of the weather and the washout of fine particles plus the fact that the track utilisation, the loads on the rails and train speeds have all increased mean that many railway

embankments no longer comply with modern safety standards. Permanent refurbishment and stabilisation measures are therefore required.

Besides the expected embankment failure problems, however, deconsolidation phenomena can also appear in embankments over the years. These lead to a more severe vibration behaviour of the embankment, which can have adverse effects on the fatigue strength of track installations and train

wheels.

The stabilisation measures required here, which are generally carried out while trains are still running, with closures kept to a minimum, involve drilling ISCHEBECK TITAN hollow steel bars down into loadbearing strata in the embankment, possibly even down into the in situ soil below the embankment in some cases.



Railway embankment stabilisation

- Owing to possible sliding/deformation of the embankment
- Loads transferred to loadbearing subsoil below the slip plane
- Normally with a partially flexible facing in the form of wire meshes

Railway embankment soil nailing

- For stabilising the embankment itself in order to reduce settlement and vibrations in the track area
- Frequently carried out without any head details, provided there are no erosion problems

Nets or geogrids laid as **additional erosion protection** are secured with a head detail consisting of plate plus spherical collar nut. However, if the measures involve merely "soil nailing" the embankment, then the loads are already transferred via bond into the soil and a head detail is unnecessary.

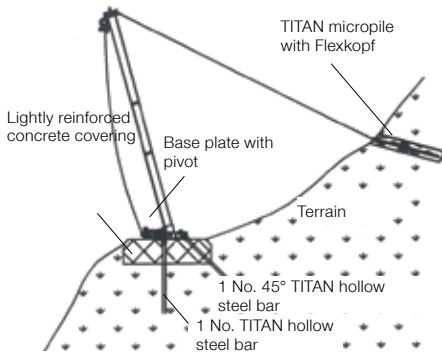


Stabilisation works are mostly carried out from the top or bottom of an embankment in order to prevent damaging natural vegetation that has grown over decades and to avoid placing additional loads on slopes that are sensitive anyway.

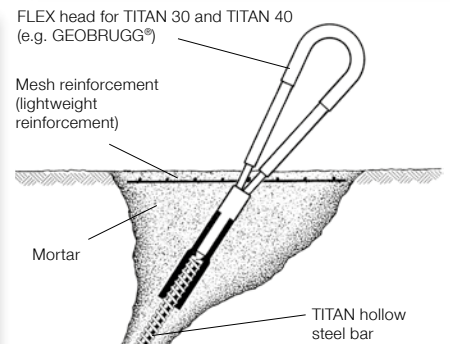
Rockfall/snow fencing

Besides embankment stabilisation and erosion protection with the help of anchored nets, roads, railway lines and buildings located at the base of slopes need fences to protect them against rockfalls or avalanches. Such fences must be designed depending on the potential impact loads of falling rocks and soil masses.

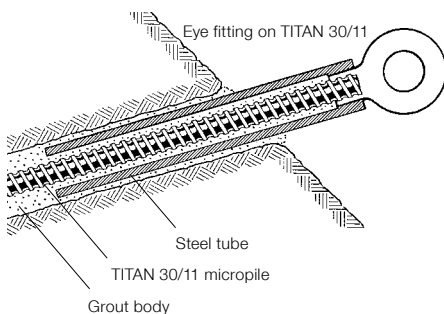
The pivoted base plates must be founded so that they cannot rotate and this is normally achieved by a pile trestle consisting of two axially loaded micropiles.



In addition, the fences are tied back with wire ropes parallel with and perpendicular to the direction of the fence. In order to prevent transferring shear forces to the micropiles, a flexible eye fitting (FLEX head, not part of the ISCHEBECK range of products) is often screwed onto the end of the TITAN micropile.



Alternatively, it is possible to use hot-dip galvanised eyes or TITAN ring nuts. A rigid steel tube is fitted to strengthen the hollow steel bar against shear forces.



Track barrier with protection against rockfall made from ISCHEBECK hollow steel bars fitted with eye bolts for hexagonal chain-link fencing.

Drainage of slope seepage water

Water in the soil can have an adverse effect on the stability as well as the sliding and creep behaviour of slopes, embankments and retaining structures. Besides draining the surface and the facing, which is normally achieved with channels, trenches, gutters and weepholes or drainage mats, it might also be necessary to provide subsoil drainage to EN 14490. The subsoil drainage collects and diverts slope seepage and formation water clear of the retaining structure, in the load transfer region of the structural anchorages.

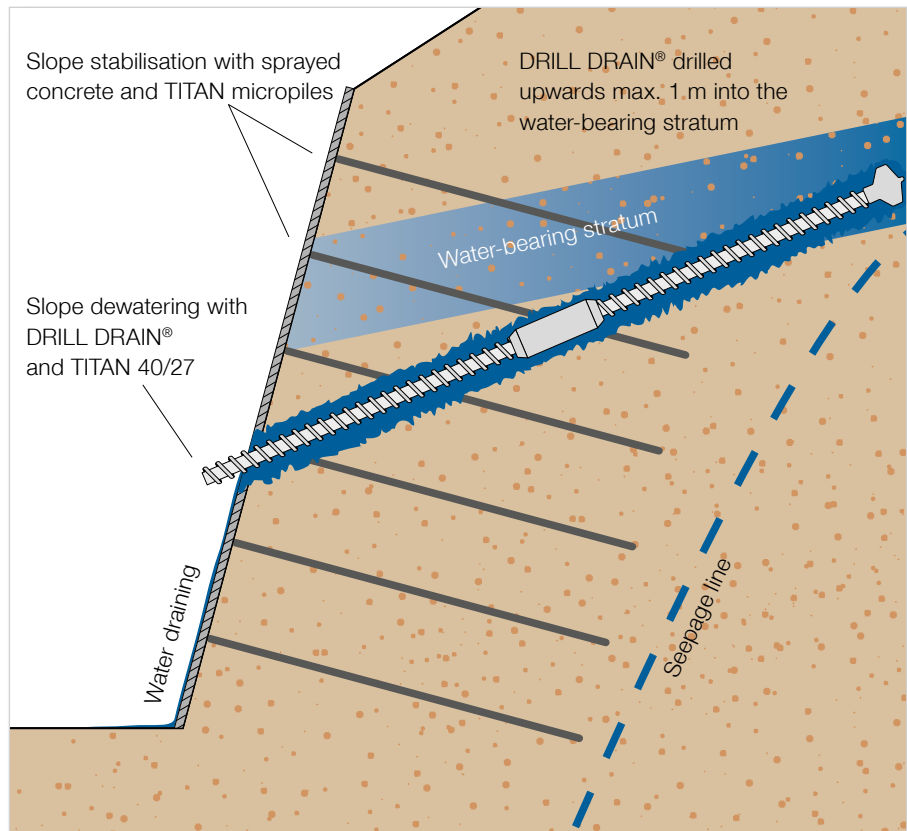
One economical option for such subsoil drainage is DRILL DRAIN, which is a directly drilled drainage in the form of TITAN 40/27 micropiles. These are installed in conjunction with a special filter material that, after it has cured, is permeable to water and air ($k_f \sim 10^{-4}$ m/s). Confined formation and perched water as well as excess pore water pressure in the soil are reduced by the DRILL DRAIN filter material and drained away unpressurised. The subsoil is relieved, the loads on the retaining structure are reduced and creep behaviour is diminished.

The system is:

- Self-drilling
- Not liable to scaling and a build-up of fine particle deposits
- Stable with respect to soil washout and piping, because the void created during drilling is filled completely with grout.
- The hollow steel bar functions as reinforcement for the DRILL DRAIN filter material.

For further information please refer to our DRILL DRAIN brochure.

Please contact us during the planning phase to discuss design options and installation limits.



Soil nailed wall with DRILL DRAIN®

Tyrol, Kappl

The slope seepage water draining from the drains at various heights can be clearly seen.

Fig.:

Shortly after installation and six years later



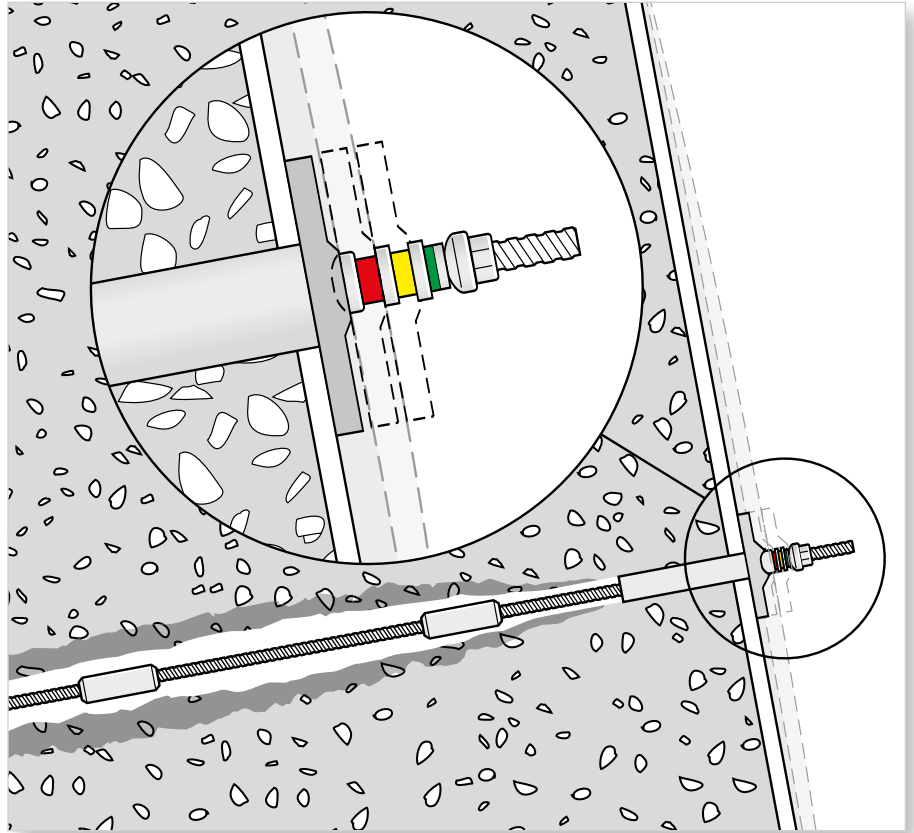
Fast identification of load increases

German Mining
Inspectorate (LOBA)
approval 18.24.6-28-4

ISCHEBECK
TITAN

The **load stage indicator (LSI)** is fitted to identify load increases and the associated deformations at an early stage. The LSI reveals load increases visually in three stages without the need for elaborate geodetic surveys.

- Three load stages
70 kN – 160 kN – 180 kN (TITAN 30/11)
200 kN – 300 kN – 400 kN (TITAN 40/16)
- Up to 30 mm deformation
- Can be checked visually at any time
- German Mining Inspectorate (LOBA) approval 18.24.6-28-4



Anchoring a retaining wall Damüls, Austria



Simple visual inspection of deformations without geodetic surveys

Design principles

Slope stabilisation and soil nailing:

Geotechnical category to EN 1997-1:

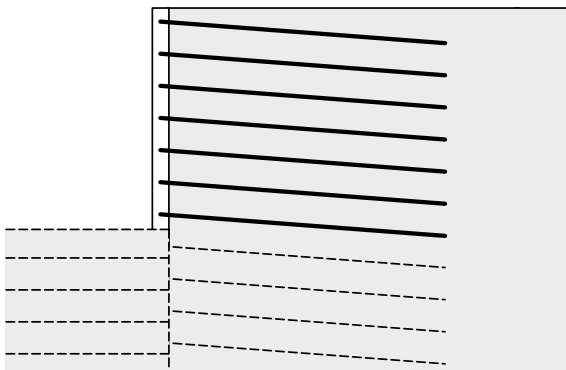
cat. 2 embankment heights generally up to 10 m

cat. 3 generally for > 10 m high

- where the soil has a distinct creep tendency
- when taking into account earthquakes
- where there are adjacent structures that are sensitive to displacements and settlement

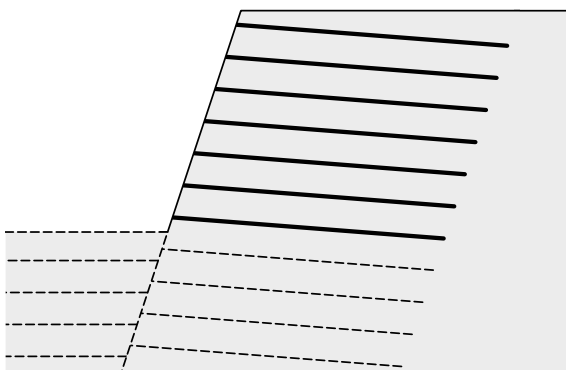
So far there is no harmonized European Standard for design and calculation of soil nailing. Design principles can be found i.e in EN 1997-1 (Eurocode 7: Geotechnical design – Part 1: General rules) and DIN 4084 (Soil – Calculation of embankment failure and overall stability of retaining structures), among others. Soil nails are installed according to EN 14490. However, analyses of the internal and external stability are required for all soil nailing design situations (walls or embankments).

We distinguish between **walls** and **slopes** when considering soil nailing.



Walls

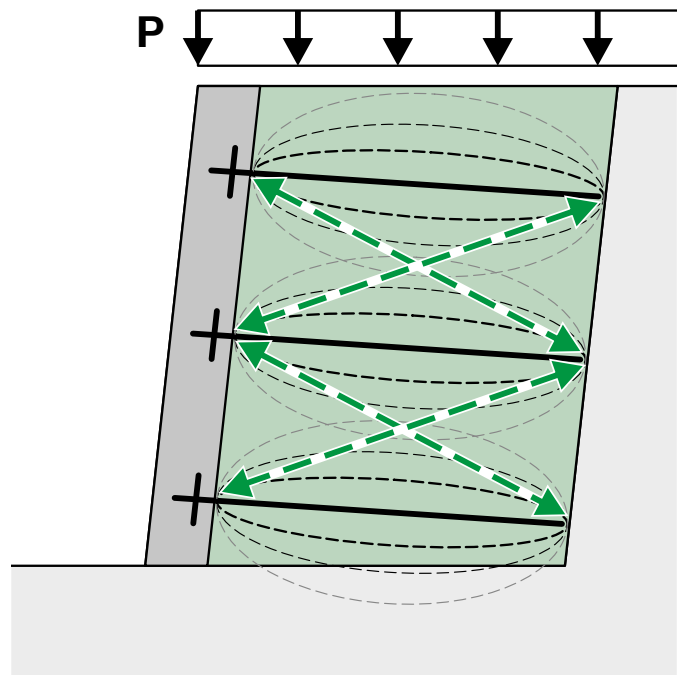
Steep cuttings with walls can be produced by excavating the soil in stages (angles of 70° to 90°). There is a structural connection between the reinforcement and the facing, which is normally of reinforced sprayed concrete. The design of such heavyweight structures is based on the approach that an active earth pressure acts on the rear wall of the structure, which is defined by the end of the loadbearing tendons.



Slopes

Embankments are less steep, which means that earth pressure problems tend to be less significant. Instead, it is more of a soil shear problem. The facing carries much lower loads depending on the soil conditions and external loads. It can therefore be built in a much lighter or more flexible form, e.g. with nets. Staggered soil nailing arrangements might therefore be advisable to avoid forming "lanes".

According to the Grundbau-Taschenbuch*, due to the composite action of soil nail walls, they behave monolithically when subjected to external loads, provided the soil nails are close enough together. For a structural analysis, this can be regarded as being similar to a vertical truss in which the soil nails/micropiles carry the tension loads and the intervening soil forms the diagonals in compression.



When **verifying the overall stability** of walls and slopes, it might be necessary to investigate the critical failure mechanisms, or rather their slip planes in the soil. To do this, it is necessary to consider, in particular, the respective form of construction, shape of the terrain, groundwater situation and magnitudes and positions of external loads. Slip planes can intercept or bypass all or some of the loadbearing tendons.

*Grundbau-Taschenbuch (foundations manual) Part 3 (3rd ed.); Ernst & Sohn, ed. Ulrich Smolczyk

The **external stability** concerns the behaviour of the entire monolithic body interacting with the subsoil and the applied loads. This requires the failure mechanisms shown below to be investigated according to EN 1997-1. Such work is usually carried out with the help of specialized software.

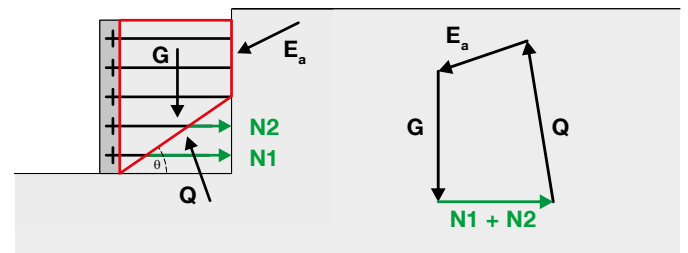
- Sliding along the base
- Overturning
- Bearing failure
- Rotational slip

Sliding along the base
Actions parallel with the base of the retaining structure are resisted by the frictional resistance at the base.

Overturning
Checking the position of the resultant of the forces acting at the base.

To check the **internal stability**, it is necessary to consider the equilibrium of the possible sliding masses of soil while varying the slip plane angle θ , which results in the soil nailing forces required. It is necessary to verify that tension members have an adequate margin of safety against material failure (component verification according to DIBt approval Z-34.14-209, TITAN Micropiles) and adequate pull-out resistance outside the sliding mass of soil. In accordance to EN 1997-1, the German Standard DIN 1054:2010-12 provides partial safety factors for the pull-out resistance of soil / rock nails.

BS-P	BS-T	BS-A	Partial safety factor g_a for pull-out resistance of soil or rock nails acc. to DIN 1054:2010, Tab. A 2.3:
1.40	1.30	1.20	



Bearing failure
The shear resistance of the soil in the area of the foundation is overcome and the subsoil is displaced laterally.

Rotational slip
A soil mass on an embankment slides as a result of the shear resistance of the soil being exceeded.

Rough assumptions for nailed walls with rigid facing

Depending on the stability of the subsoil, soil nail spacings in the horizontal and vertical directions are typically 0.7 to 2.0 m. Soil nail lengths depend on the subsoil and are usually in the order of magnitude of 0.5 to 0.7 times the height of the wall. (Much longer soil nails might be necessary on unstable slopes. Different lengths at different levels are advisable with high walls.)

Serviceability (to DIN 1054:2010, section 11.6)

In the case of at least medium-dense non-cohesive and at least firm cohesive soils, the partial safety factors for design situation BS-P in the limit state GEO-3 generally also include an adequate safety margin for the serviceability limit state.

It should be noted that due to the composite action, deformations of soil nailed walls are relatively small and according to the **Grundbau-Taschenbuch** are in the order of magnitude of 1–3% of the height of the wall. Soil nailed walls therefore can be counted among the low-deformation forms of construction.

From the soil mechanics point of view, more loadbearing tendons with a lower load-carrying capacity are advantageous because the composite action of the retaining structure increases with the density of the soil nailing.

Load tests

Static load tests to EN 14490 or in a similar way to anchors according to EN 1537 or micropiles to EN 14199.

The project specification must always lay down whether loading tests are to be carried out on **sacrificial soil nails** (preliminary test micropiles) prior to the construction measures or on **structural soil nails** (micropiles included in the final structure) during the construction work. It is also necessary to specify clearly the test procedure, test load and test criteria.



When **testing sacrificial soil nails**, it is essential to verify whether the chosen design is indeed effective in the given subsoil conditions. In addition, the required ultimate load-carrying capacity of the tension members in the subsoil and the various load transfer zones must be determined or confirmed. The soil nails are either tested to failure or up to a test load resulting from the design load and the safety factor γ_a for soil nail pull-out to EN 1997-1 (or DIN 1054) depending on the design situation ($P_p = F_d \cdot \gamma_a$). However, customary practice indicates that tests on sacrificial soil nails are the exception and, as a rule, only tests on structural soil nails are necessary for verifying adequate performance.



The following boundary conditions should be taken into account when **testing structural soil nails**:

Number of tests: geotech. cat. 2: 2%, but at least $n = 3$

geotech. cat. 3: 3%, but at least $n = 5$

Test load: $F_d \leq P_p \leq \gamma_a \cdot F_d$ ($P_p \leq 0.9 \cdot R_{M,k}$)

Test length: bonded length outside the sliding wedge of soil in undisplaced subsoil

Test procedure: at least 5 loading stages, normally in 1 cycle

Test criterion: creep coefficient $k_s \leq 2.0$ mm after at least 15 min holding time

It is essential to make sure that there is no transfer of force between the test soil nail and the facing.

Text for tenders

TITAN micropiles for anchoring sprayed concrete or embankments (sample extract)

Micropile, sprayed concrete anchorage, tension, TITAN 30/11, permanent

Micropile to EN 14199/DIBt Z-34.14-209 for anchoring sprayed concrete with a tension load design value $R_d = 183\text{kN}$. The loadbearing tendon is a hollow steel bar with 30mm O.D and 11mm I.D, and a continuous reinforcing thread according to DIN488, **made from EN 10210 grade S 460NH steel** ISCHEBECK TITAN 30/11.

Permanent application (> 2 years), corrosion protection is provided by means of a minimum of 30mm cement grout cover. Subsoil according to ground investigation report. The cement grout body is 90mm in diameter with centralisers spaced at every 3.0m (maximum). The pile head detail, including the HDPE tube shall be in accordance with the DIBt Z-34.14-209 approval and pile head detail drawing.

Length in m

Angle from the vertical in degrees

Installation by rotary percussive drilling without casing, with the hole stabilised during drilling, using a flushing fluid in the form of a cement slurry, $w/c = 0.4 - 0.7$. **Dynamic pressure grouting** from the bottom of the drill hole upwards using a cement slurry with a $w/c = 0.4 - 0.5$. Portland Cement to EN 197-1 will be used, taking into account exposure class. A pile log book should be kept for each pile according to EN 14199.

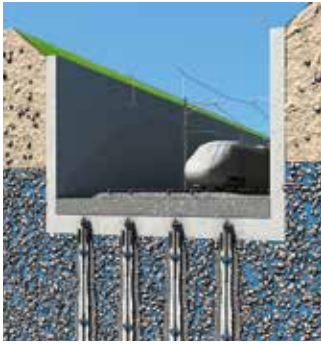
Additional cement requirement in kg/m:

Further information/items may be necessary regarding:

- Quantity of cement used and additional cement requirements
- Confined working conditions (height and width)
- Accessibility for drilling plant and position of starting point for drilling
- Whereabouts of cuttings/drilling fluid/cement suspension
- Special services and documentation
- Nature and scope of loading tests
- Homogeneous zones (description of subsoil)

ISCHEBECK specification texts can be very easily and expertly formulated and then downloaded in text, table or GAEB format ready for integrating into your own documents; simply go to <http://ischebeck.bauprofessor.de>, our online expert system. Our experts will be happy to advise you.



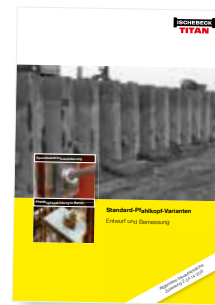
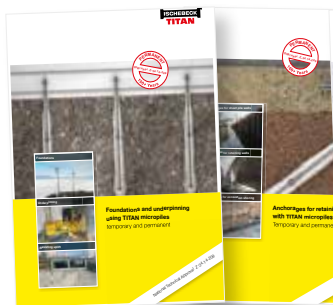


From foundations and uplift protection to anchorages and tunnelling – the TITAN system is ideal for many different applications.

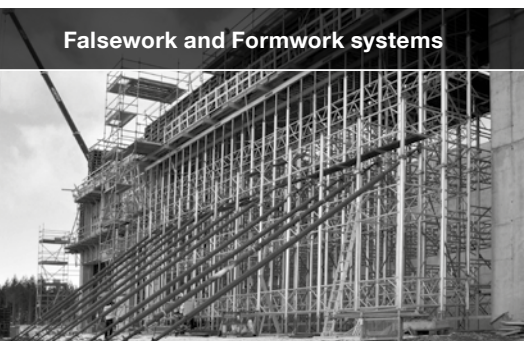


Please refer to our **TITAN Micropiles** brochure for general information and analyses.

Information on other potential applications can be found in our brochures on **Foundations/ Underpinning, Anchorages and Tunnelling**. Supplementary information on pile head details can be found in the brochure on **Standard Pile Head Details**.



The photos reproduced in this brochure represent momentary snapshots of work on building sites. It is therefore possible that certain facts and circumstances do not fully correspond to the technical (safety) requirements.



Falsework and Formwork systems

Trench lining systems

Geotechnical solutions

Certified Management-System to DIN EN ISO 9001 / 2008 ; Registry-No. DE-96-010



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