Titan Soil Nails from ISCHEBECK TITAN

- Economic embankment reinforcement
- Unlimited service life
- Suit all soil conditions

Titan Soil Nails from ISCHEBECK TITAN

Soil nailing is an efficient, effective and economical method of earth reinforcement, which allows a controlled improvement of the natural stability of the soil.

Titan soil nails provide friction, shear and tension strength in loose materials, combining all into a new monolithic structure.

Soil nailing consists of 3 basic elements:

1. Existing soils or weathered rock.

2. Titan rotary grouted, self drilling soil nails.

3. Surface treatment with reinforced shotcrete, geotextile mesh or tensioned wire nets on slopes to 70 degrees.

Titan soil nails are installed by simultaneous drilling and grouting, which enhances the diameter of the grout body and maximises shear value at the grout/ground interface.

Correct design of the nail positioning grid across an embankment and soil nail lengths, results in a monolithic structure capable of supporting required loads.

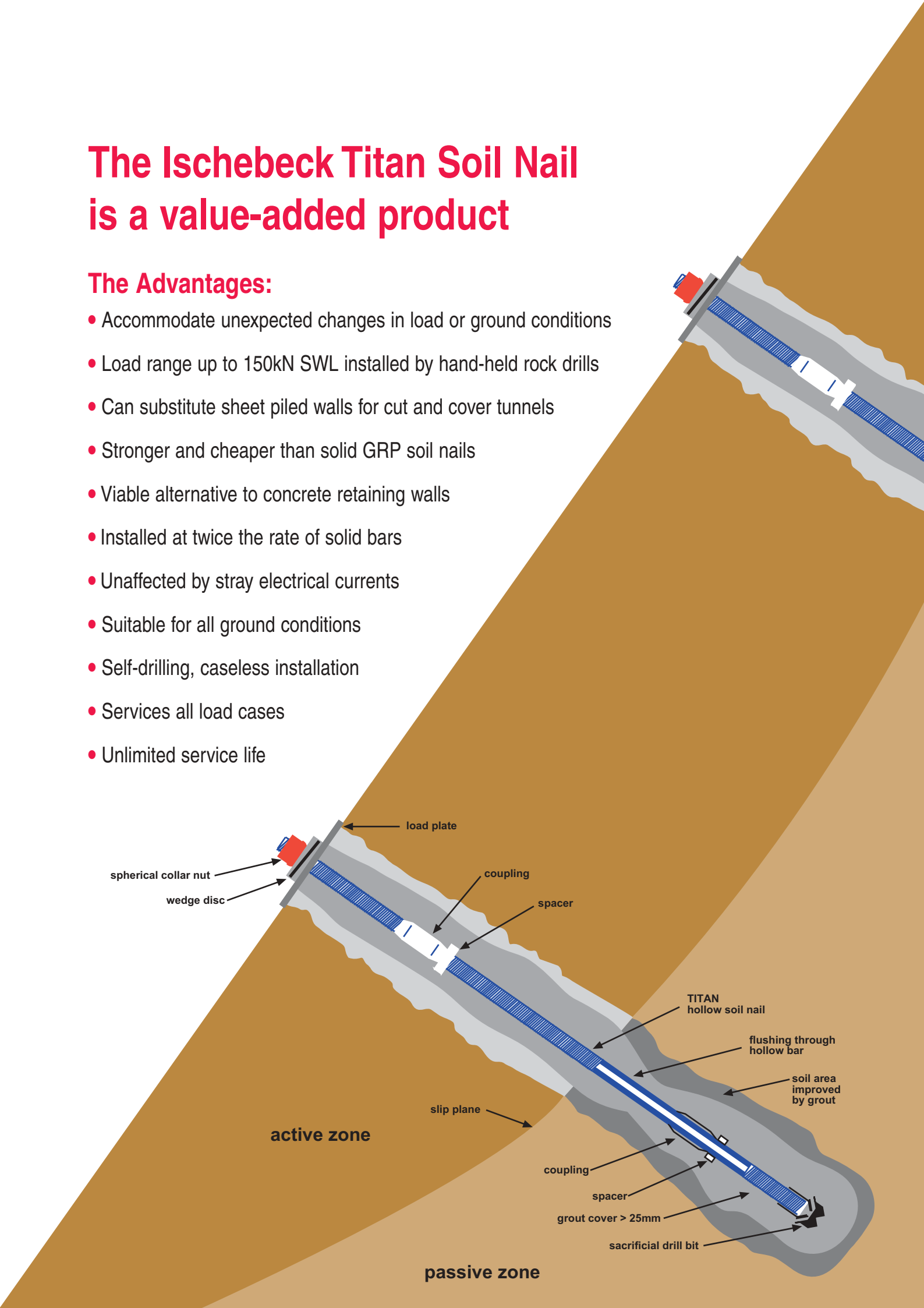
Advantages of soil nailing

- Installation is practically free from vibration.
- Drill rigs can install soil nails at all angles.
- As there is no requirement to case line the drill hole, most drill rigs installing Titan soil nails are smaller and can cope well with slopes and confined spaces.
- Soil nailing offers the opportunity to produce an environmentally friendly but technically safe “green wall” solution, often less expensive than traditional back anchored retaining walls.

The Ischebeck Titan Soil Nail is a value-added product

The Advantages:

- Accommodate unexpected changes in load or ground conditions
- Load range up to 150kN SWL installed by hand-held rock drills
- Can substitute sheet piled walls for cut and cover tunnels
- Stronger and cheaper than solid GRP soil nails
- Viable alternative to concrete retaining walls
- Installed at twice the rate of solid bars
- Unaffected by stray electrical currents
- Suitable for all ground conditions
- Self-drilling, caseless installation
- Services all load cases
- Unlimited service life



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CTRL 430

Some 375No. 6m long 30/60 soil nails were installed on CTRL 430, part of the Channel Tunnel Rail Link Phase 1. The soil nails were used as part of a temporary works scheme in Ashford in order to construct a new bridge abutment adjacent to the existing railway. The cutting had an overall length of 60m and was 6.2m high. A gunite finish was used to retain the 70° batter. The soil nails were successfully tested to 75kN:-

- 60 metre cutting, 70° batter
- Gunite Finish
- 375No. 6 metre soil nails
- Soil nails tested to 75kN

Avon Ring Road

The Avon Ring Road design and build contract required a new cutting to be constructed within the mudstone experienced on site. The cutting was stabilised by installing over 200No. 30/16 black soil nails. Due to difficult access, the soil nails were installed by a fork lift mounted drill rig. The soil nails were designed to meet the 120 year design life required by the highways agency:-

- Fork lift mounted drilling rig
- 200No. 30/16 black soil nails
- 120 year design life

Embankment stabilisation

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Bugbrooke Embankment

Bugbrooke Embankment emergency works saw the installation of some 250No. 8m long 30/16 soil nails within three days of establishing on site. The 30/16 black soil nails had a design life of 60 years and a nominal working load of 20kN. The self drilling caseless operation allowed the train speed restriction to be lifted at the earliest opportunity:-

- 250No. 8m soil nails
- 60 year design life
- 3 day installation programme minimises rail closure

Leighton Buzzard

This section of embankment forms part of the West Coast Main Line. A combination of 30/11, 30/14, 30/16 and 40/20 soil nails was installed to allow for a sacrificial thickness loss due to the soil conditions being considered as mildly aggressive. The various soil nail types were dependent on the load criteria and predicted loss of section over the required design life of 60 years:-

- 60 year design life
- Aggressive soil conditions
- Soil nails work in conjunction with gabion walls

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Copenhagen Metro

The Copenhagen Metro cut and cover tunnel involved the excavation of a 12 metre deep cutting through flinty till. Soil nails were selected as the preferred method of stabilisation, replacing sheet piling due to the difficult ground conditions, efficiency and cost effectiveness:-

- Cut and cover tunnel
- Cost effective replacement for sheet piling
- Installation rate of 350 metres per day, per rig
- Maximum deformation of only 15 mm

Road widening schemes

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M1 Junction 21A

Part of a major design and build carriageway widening scheme at junction 21A of the M1, required stabilisation of a new cutting in stiff clay. Contractors used 6m and 2m long soil nails to stabilise the embankment:-

- 2m long soil nails tested to 50kN
- Soil nails stabilise cutting and secure facing elements for 'green' finish
- Highways Agency approved 60 year design life

A465

The A465 connects the M4 to Merthyr Tydfil. At Aberdulais a section of retaining wall required stabilisation and a combination of reinforced soil and 330No. 11m 30/16 soil nails was used. The soil nails were installed in silt stone using a 70mm button type drill bit. The black 30/16 soil nails had a design life of 120 years:-

- Combination of soil nails and reinforced earth
- 120 year design life

A2/M2 Widening Scheme

Due to inconsistent ground conditions experienced on site, 30/16 soil nails were installed at various locations throughout the works as an alternative design to either reinforced earth structures or sheet piled retaining walls. All soil nail schemes had Highways Agency approval for both temporary and permanent works (120 year design life):-

- Alternative to reinforced earth and sheet piling
- Highways agency approved for 120 year design life

Creating space for site development

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Liversedge

Used in conjunction with a 150mm thick gabion wall filled with Yorkshire stone, soil nails provided the viable alternative to ordinary reinforced concrete retaining walls and provided a free-draining, aesthetically pleasing finish, as well as maximising the floor area available for development:-

- Soil nails as an alternative to reinforced concrete retaining wall
- 800No. 30/16 soil nails installed as excavation progressed
- 120 year design life
- 150mm thick gabion mattress
- Factory floor space was doubled

Ballylumford Power Station

The United Kingdom's largest soil nail and shotcrete retaining wall was used to double the size of this electricity generating plant in Northern Ireland. After cutting back a natural slope comprising clay, large basalt bolders and cobbles, contractors exploited the outstanding performance characteristics of Titan soil nails to drill into these difficult ground conditions and stabilise the embankment

- 1400No. soil nails of between 9m and 18m
- 70mm carbide bits
- 120 year design life

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Titan self drilling, self grouting hollow soil nails to DIN 21521

The concept of soil nails can be compared to timber technology whereby two planks of wood are joined by nails. The nails develop tension forces, preventing the planks being pulled apart. The nails resist shear forces between the two planks, preventing them from sliding.

To guarantee the maximum shear value at the grout/ground interface the Titan soil nail is installed by simultaneous drilling and grouting. Thereby enhancing the diameter of the grout body.

The dynamic rotary pressure grouting process penetrates into loose material at the grout/ground interface, dramatically increasing skin friction. This produces an enhanced grout body, giving a pull-out value equivalent to twice the drill bit diameter in non-cohesive soils.

Bottom up pressure grouting through the hollow Titan soil nail, fills all fissures and voids on the way to the surface. The rotary percussive drilling action improves the grout strength similar to a concrete vibrating poker.

All the benefits above combine to produce the most effective method of mobilising the maximum strength available in the ground.

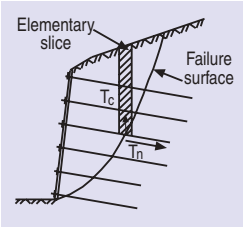
Soil nails differ from grouted piles (DIN 4128), which act independently, and ground anchors, which transfer loads via walls or walings. Soil nails are installed in a grid pattern, in the active zone intersecting the perceived slip circle and penetrating the passive zone. Soil nails are unstressed until ground movement takes place. When movement occurs the shear and tension values in the grouted soil nail are activated.

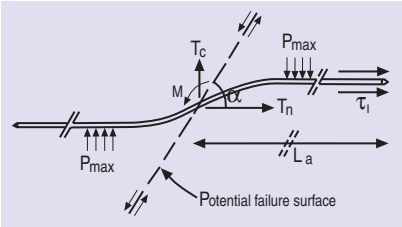
Titan soil nails can take up tension and shear forces as well as bending moments. The friction value of the soil determines the grid spacing of the soil nails. Correct design of the grid and soil nail lengths results in a monolithic structure capable of supporting required loads.

According to the calculations from the French "Clouterre", four criteria (C) for stability have to be fulfilled:-

C1 Staying within the acceptable tension values in the soil nail comprising of normal force, shear force and bending movement.
C2 Surface friction in the limit areas of the grout/ground interface and that of the grout/soil nail tendon interface.
C3 Lateral force (effective drill hole diam.) of grout body to the soil.
C4 Mass law of soils.

There are now computer programmes available to assist in the calculation of soil nail forces, lengths, spacing and inclination.





FAILURE CRITERIA

① Nail: $\left|\frac{M}{M_r}\right| + \left(\frac{Tn}{R_n}\right)^2 + \left(\frac{Tc}{R_c}\right)^2 \leqslant 1$

② Lateral Friction: $T_n \leqslant \pi \cdot Bl_a \cdot \tau_e$

③ Lateral Pressure: $\rho \leqslant \rho_e$

④ Soil: $\tau \leqslant c + \sigma \tan \phi$

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There are 3 general rules for the calculation and installation of soil nails:-

In the United Kingdom, soil nailing with Titan soil nails is approved by the Highways Agency, Railtrack, Ministry of Defence, the Environment Agency, British Waterways and many of the top consulting engineering practices. In Germany Titan soil nails correspond to DIN 21521.

In all calculations there is an active zone, which may come loose by pre-deformation and a passive zone, which is static. Both zones are separated by a slip plane, which is considered for calculation as curved or straight.

Very often the slip plane is due to nature, e.g. water containing boundary layers or back filled slopes.

1. Soil nails must penetrate beyond the slip plane into the passive zone typically for 4-5 metres.
2. The spacing of the soil nails, horizontally and vertically, must be directly related to the strength of the soil. Extra soil nails should be installed at the edge of any surface being stabilised.
3. Soil nailing should commence immediately after excavation. Any delay increases the chance of the unrestrained ground relaxing. Early soil nail installation ensures the maximum holding power.

Calculation

length of nails	0.5 to 0.7 x wall height but not less than 6.0 m
capacity of nails	50 to 250 kN/m^2
density of nails	0.5 to 2.0 per m^2
amount of reinforcement	1.5 to 6.0 kg/m^3
nail forces	50 to 100 kN (in special applications up to 300 kN)
inclination of nails	0 to 30 degrees
deformation of nailed walls	1.50% x wall height

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Numeric modelling of TITAN soil nails and rock bolts for the finite element (FE) calculation

$$C_{nail} = \frac{1+\sin\varphi}{2\cos\varphi} \cdot P$$

$$P = \frac{F}{a \cdot b}$$

P = density of nail
F (Tn) = nail force
a, b = designed grid pattern of nails
φ = angle of friction
C = cohesion between 2 finite elements
$C_{remainder}$ = remaining cohesion of soil/rock

With FE-calculations, nails or bolts are designed by changing the cohesion or by inserting a tension element (truss) in the area to be nailed/bolted. The expansion stiffness of the tension element (truss) is derived from nail/bolt tests (0.5 m long). For three-dimensional FE-calculations the modelling of the cohesion shows suitable results. For two-dimensional FE-calculations the modelling of the expansion stiffness is more suitable.

As nails and bolts are only activated by deformation, it is assumed that prior to any movement of rock/soil mass only the self cohesion of the mass is active. When the strength of the soil is exceeded, the friction changes with increasing plastic elongation for the sum: $C_{remainder}$ (which is the cohesion remaining in soil or rock) plus the cohesive effect from C_{nail}. The cohesive effect depends on the quality of the soil and the mechanical strength of the nail/bolt itself. The nails/bolts are calculated in a simple way based on the thesis of Wullschlager ("A composite material model for the system anchoring" published by the institute of Soil Mechanic and Rock Mechanic of the University Fridericana in Karlsruhe/Germany, paper no. 1 1 2, 1088).

conservative calculation	**calculating including remaining cohesion of soil/rock**	
loose soil C_{nail} = 39 kN/m²	loose soil = >$C_{remainder}$ + C_{nail}	= 39.0 kN/m²
highly weathered rock (V4 - V5) C_{nail} = 43 kN/m²	highly weathered rock (V4 - V5) = >$C_{remainder}$ + C_{nail}	= 55.5 kN/m²
moderately weathered rock (V2 - V3) C_{nail} = 51 kN/m²	moderately weathered rock (V2 - V3) = >$C_{remainder}$ + C_{nail}	= 81.0 kN/m²

This approach is valid for loose materials but over designed for sound rock.

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TITAN

Ischebeck Titan Group

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

Ischebeck Titan Ltd

The company operates from headquarters centrally located in the heart of the UK.

Product Availability

Substantial stocks of equipment are available ex-stock from the company's strategically located 4-acre distribution site, with most items available nationwide on a 48-hour delivery. Products are available for both hire and outright purchase.

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 specific european and national standards.

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