DSI
Ground Anchor-Systems



SANDVIK



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About us

Driving underground operations

Sandvik Ground Support is the global leader in providing cutting-edge support solutions for mining and tunneling. In addition, we are a key player in pioneering system solutions for specialized foundation engineering. We operate in over 70 countries and employ approximately 3,000 professionals, including engineers and technical specialists with deep expertise in geotechnics and underground construction. With a comprehensive and market-leading portfolio that includes everything from micropiles and rock anchors to state-of-the-art injection systems and high-performance resin cartridges, we provide robust and reliable support for excavation sites, slope stabilizatin, tunnel structures, and mines. Our mission is to help customers advance their projects – both underground and above ground – by ensuring maximum safety, efficiency, and progress. While other suppliers offer standardized products, we leverage our extensive experience to develop project-specific solutions, meticulously designed to address unique challenges. These solutions are crafted, refined, and tailored in close collaboration with our customers to ensure they meet the highest industry standards and specific project requirements.

Accredited to the internationally recognized ISO 9001:2015 standard and backed by world-class production facilities and rigorous internal quality assurance, we consistently meet even the most demanding delivery timelines and order volumes – all while upholding the highest levels of quality, precision, and safety. Our global logistics network ensures reliable and on-time deliveries, with customized solutions to meet diverse customer needs. Thanks to our continuous production and 24/7 availability, we enable seamless construction site operations, minimizing downtime and maximizing productivity. Our highly skilled team of experts, strategically positioned across all key markets, offers in-depth technical support, precise recommendations, and expert consultation. Whether on-site, through remote assistance, or via specialized training and rigorous testing, our dedicated team is committed to overcoming challenges, optimizing performance, and driving projects to successful completion.
We are your trusted partner in strengthening your company, empowering your teams, and enhancing their capabilities. With our expertise and innovation, we help you tackle the complexities of foundation engineering – both today and in the future.







Reinforcing progress

Humanity would not be where it is today without construction. Every structure, every building, and every piece of infrastructure must be built on a solid foundation. Every excavation and cut must be properly secured, and with the increasing frequency of extreme weather events, the need for slope stabilization has never been greater.
At Sandvik Ground Support, we stand as a trusted and experienced partner, offering solutions that secure progress for both our customers and society. We are your:

— **Cost-efficient partner**
From tailored solutions that meet your exact requirements to seamless on-site implementation – our motto is: everything from a single source. We design the best product, optimize its application, and leverage global expertise to find the most effective solution for your construction site.

— **Honest and transparent partner**
Our tested, proven, and certified systems undergo continuous internal and external quality monitoring – ensuring the highest level of reliability and project success.

— **Reliable partner**
With our robust global supply chains, we minimize delays and ensure smooth project execution. Should conditions change during implementation, we work alongside you to develop alternative solutions, ensuring your project reaches a successful conclusion.

— **Efficient partner**
By integrating the latest technologies and innovations, we enhance your productivity and performance – enabling faster and more cost-effective project completion.

— **Experienced partner**
With the assurance of having direct access to the expertise and long-standing experience of our specialists, even the most complex challenges can be overcome.

With our products and services, we don't just reinforce the ground – we strengthen your team, drive your success, and support you in overcoming challenges on the construction site and beyond.

We make the shift through engineering

Proven system solutions

As a trusted partner in specialized foundation engineering, our products and systems are successfully integrated into countless projects worldwide. Wherever we operate, our expertise and reliability add measurable value to operations, accelerate construction progress, and contribute to the economic growth of cities, regions, and countries.
Our system solutions cover the full spectrum of geotechnical applications – ranging from solid-bar micropiles and strand anchors to self-drilling hollow-bar systems. Additionally, we offer state-of-the-art innovations, such as the AT – Pipe Pile System, alongside a diverse portfolio of injection systems – ensuring an optimal solution for every challenge.
Backed by our highly skilled team of engineers, we have the expertise to master even the most complex applications and challenges. When required, we design and develop customized solutions that precisely align with project-specific demands. Furthermore, we provide comprehensive training programs and on-site assembly supervision, ensuring seamless integration and optimal system performance.
Today, as cities expand underground and construction projects become increasingly ambitious, we continuously evolve – leveraging cutting-edge technologies to support our partners in building safer and more sustainable infrastructure.
Working side by side with you, we help drive progress – safely, efficiently, and with a long-term vision.





Manufacturing competence

Sandvik Ground Support manufactures products and system solutions for mining, tunneling, and geotechnical applications in 45 regional production facilities worldwide. With a workforce of over 3,000 employees, we manage highly sophisticated and logistically demanding systems on a global scale. Our combination of international expertise and strong local presence enables us to provide superior service while reducing delivery times for our customers.
Outstanding examples of our cutting-edge, fully automated production clusters include the global DSI Hollow Bar Competence Center in Pasching, Austria, and the Global Competence Center for Injection Technology and Resin Cartridges in Mikołów, Poland. In Austria, load-bearing elements of the DSI Hollow Bar System are produced, with the portfolio ranging from the R32 series (hollow bars with a nominal diameter of Ø 32 mm and round threads) to the T76 series (hollow bars with a nominal diameter of Ø 76 mm and trapezoidal threads).

Each year, up to 22,500 tons of raw material are processed into over 5.6 million meters of hollow bar components.
Our production process is reinforced by a comprehensive quality assurance system and an in-house research & development (R&D) division, ensuring continuous product innovation and optimization. In Poland, seven fully automated production lines are dedicated to manufacturing injection and cartridge systems.
By integrating production with a dedicated R&D department and an advanced testing facility, we offer customer-specific solutions that maximize innovation, efficiency, and output. Annually, we produce over 20,000 tons of injection resin and manufacture more than 20 million resin cartridges.
For products we do not manufacture in-house, we rely on a network of trusted, long-standing partners who adhere to the same rigorous quality standards and testing protocols – ensuring reliability, consistency, and excellence across our entire supply chain.



Quality management

At Sandvik Ground Support, safety and quality are our top priorities and the foundation of everything we do. To ensure that quality-related requirements are met across all areas – from development to application—our production facilities are certified according to ISO 9001. Regular internal and external audits not only verify compliance with existing standards but also actively drive the continuous improvement and evolution of our quality management system.

Quality is not a one-time goal – it is an ongoing process. This philosophy aligns with one of the core principles of total quality management (TQM): continuous improvement and rigorous evaluation. We are committed to TQM on a global scale and operate in accordance with its three fundamental principles:

— **Total**
Full integration of all employees in the quality management process, ensuring that every individual contributes to the production of our high-performance products and systems.

— **Quality**
A customer-centric approach, where all business activities are aligned with client requirements and expectations.

— **Management**
A leadership philosophy based on participation, teamwork, and accountability, fostering a culture where management leads by example at all levels. Ensuring the highest quality standards requires a highly skilled team of experienced experts, supported by state-of-the-art tools and equipment. The Competence Center of Sandvik Ground Support Austria is equipped with advanced testing technology, including:

— **High-performance horizontal tensile testing machine – DSI Hotz 3000/250 (max. 3,000 kN, sample length: 3 m)**
This machine enables static tensile tests on bars and combined tensile-slip tests on systems with diameters up to 63.5 mm, ensuring compliance with the highest industry standards.

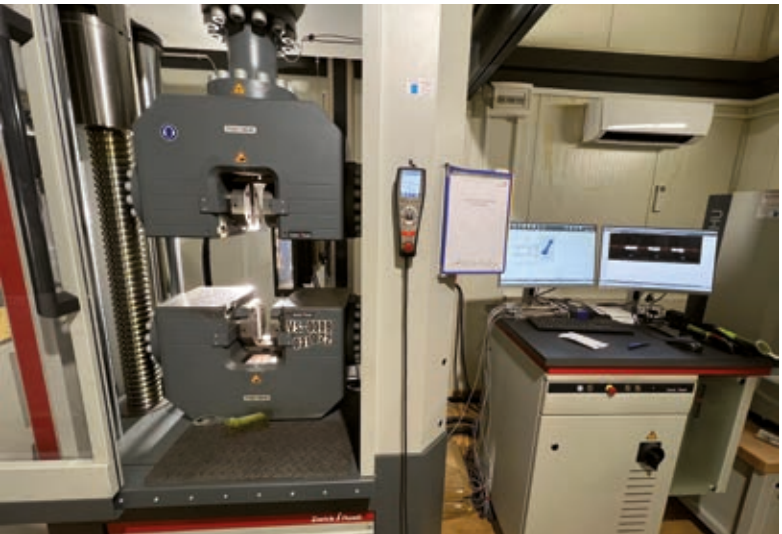
— **Vertical tensile testing machine – Zwick/Roell Z1200 (max. 1,200 kN)**
This machine is primarily used for in-process quality control and features an optical strain measurement system to determine stress-strain-curves during static tensile tests.

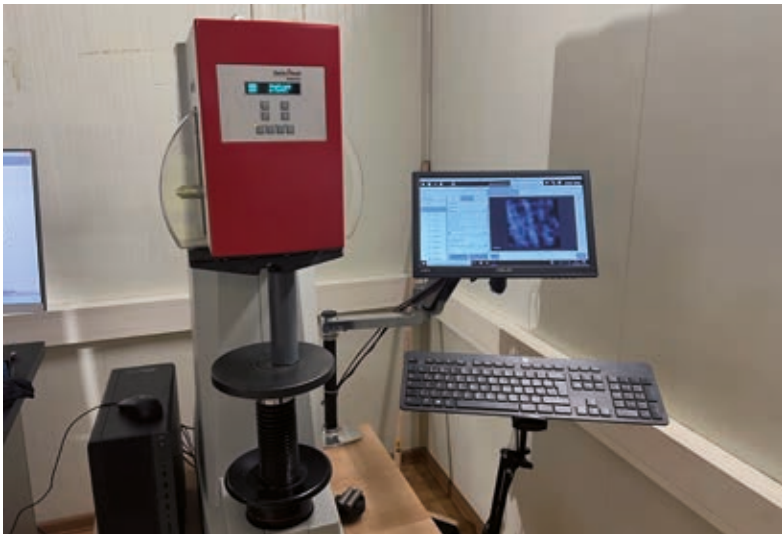
— **Universal hardness tester – Zwick/Roell ZHU250CL (HRC, HV, HB)**
This device enables non-destructive hardness testing, ensuring material quality across a wide range of materials. It can also perform hardness tests on small components such as cast nuts, ensuring precision and reliability.

— **Surface profile measurement device – Marsurf PCV**
To verify compliance with tolerance specifications for thread forms in bars and accessories, the device scans the thread and automatically compares it with the required reference values.

— **Comprehensive selection of field equipment for anchor tensioning and tensile testing**
Our testing capabilities extend beyond the laboratory to in-situ applications. We conduct standardized pile, nail, and anchor tests, as well as project-specific quality controls and field trials for new product developments.

Sandvik Ground Support collaborates globally with leading universities, private research institutions, and certified testing facilities in the fields of research and development, continuous quality monitoring, certification processes, and on-site construction testing. With this extensive expertise, we can offer customized support for on-site quality control, specialized inspection tools for various products, and in-situ testing solutions upon request.





System description

In geotechnical engineering, three primary elements are distinguished: soil nails, micropiles, and grouted anchors. Soil nails and micropiles are classified as passive systems, whereas grouted anchors are prestressed after installation and set to a defined load.
Passive systems, such as soil nails and micropiles, become ”activated” through soil displacement or settlement. In contrast, prestressed systems introduce a force into the structure in advance, thereby mitigating deformation before external loads act on the system. Only when the prestressing force (approximately equal to the lock-off load) is exceeded does additional deformation occur.

A grouted anchor primarily consists of three key sections:

— Anchor head
— Free length (unbonded zone)
— Bond length (grouted zone)

The prestressing force is transferred into the structure through the anchor head. The anchor, in turn, transmits the load into the ground via the bond length. The required bond length depends on the load-bearing capacity and stiffness of the soil or rock. The free length serves as the transmission zone, allowing the force to travel from the anchor head to the bonded section. The total anchor length is determined based on ensuring that the applied load is effectively transferred into competent, load-bearing ground layers.





Key specifications

— Load-bearing elements typically consist of one or multiple steel components
— Steel components include solid bars, hollow bars, or prestressing steel strands
— Solid bars are available in various steel grades and diameters
— Hollow bars come in different diameters and load-bearing capacities
— Prestressing steel strands are offered in two different steel grades and diameters
— Grouted anchors can consist of up to 22 strands (or more)
— Installation is carried out in cased drilled boreholes, suitable for all soil conditions (uncased drilling is possible in stable ground)
— Compliance with national and international approvals
— Proven system with decades of reliable performance

Key advantages

— Installation in all orientations (both downward and upward)
— Suitable for confined spaces, enabling use in restricted construction areas
— Economically and technically optimized system selection based on soil conditions, anchor length, and project-specific requirements
— Cost-efficient design through the availability of various steel grades, diameters, and corrosion protection systems
— High precision during drilling due to the use of cased boreholes
— Targeted load transfer into deeper, load-bearing soil or rock layers
— Prevention of excessive deformation by applying prestressing force in advance
— 100 % system verification through the prestressing process

Quality control

Sandvik Ground Support provides comprehensive services covering the design, engineering, and planning of all systems, as well as quality management, construction supervision, and on-site support (including anchor testing, tensioning, and inspection).
To meet the ever-growing demands and requirements of modern specialized foundation engineering, Sandvik Ground Support has implemented Total Quality Management (TQM) principles in its quality assurance processes.
For our customers, quality means safety and reliability. Our primary objective is to ensure product quality and safety throughout the entire manufacturing and distribution process.



Applications

Grouted anchors are used for anchoring retaining walls, slope stabilization, and excavation support. Depending on the intended service life, they are categorized into the following systems:

— **Temporary grouted anchors**
Temporary grouted anchors are installed without corrosion protection and are designed for a planned service life of up to two years. However, depending on environmental conditions, their actual lifespan may be shorter. These anchors are primarily used for excavation support, where the construction duration is precisely estimated. The steel elements remain embedded in the ground after use, without obstructing future utilization of the anchored soil.

— **Temporary grouted anchors with extended service life ("semi-permanent anchors")**
Temporary grouted anchors with an extended service life are typically used for excavation support, particularly when the completion of construction cannot be guaranteed within the service life of a standard, non-corrosion-protected anchor.
To extend their durability (typically up to seven years), the free length is provided with corrosion protection.
This is achieved by filling the annular space between the steel tendon and its sheath with grease or a similar protective material. Additionally, the anchor head is sealed or filled with grease to further enhance protection.

— **Permanent grouted anchors**
Permanent grouted anchors are installed with comprehensive corrosion protection, usually double corrosion protection (DCP), ensuring a planned service life of more than two years, often exceeding 50 years. The corrosion protection measures are tailored to the expected lifespan, the structural safety classification, and the corrosivity of the ground conditions. These anchors are primarily used for anchoring retaining walls and stabilizing slopes in long-term applications.

— **Fully removable grouted anchors**
Removable anchors are used whenever the anchoring system needs to be dismantled after the completion of the construction project. There are three different removal stages for grouted anchors:

- Anchor relaxation
  In this process, the entire grouted anchor remains in the ground, but it is relieved of tension. While the steel tendon remains embedded, it is no longer under stress. This minimizes any structural impact, allowing for safe removal or cutting during future construction activities. Although steel elements remain in the ground, they are deactivated, posing no immediate risks.
- Removal of the free length
  In this method, the steel tendon is relaxed and severed at the transition between the free length and the bonded section. The free length is completely removed, while the bonded section remains in place. This approach significantly reduces the amount of steel left in the ground, making future excavation or construction easier. However, some steel components still remain embedded in the soil.
- Fully removable anchors
  Fully removable anchors are designed so that the entire steel tendon can be extracted after being relaxed. This ensures that no steel elements remain in the ground after dismantling. Various removal systems are available, depending on project-specific requirements (see chapter: "fully removable grouted anchors" for further details).

Removable anchors can be temporary, semi-permanent, or, in rare cases, permanent, depending on the project's needs.

Design

The loads acting on the anchors and the required prestressing forces are determined using static or geomechanical models. Based on these calculated loads, the anchor design is carried out. In addition to verifying the overall stability of the structure and ensuring safety in case of individual anchor failure, the following checks must be performed for each anchor:

— Verification in the Ultimate Limit State (ULS – GZT):
  - Verification of internal load-bearing capacity (failure of the steel tendon)
  - Verification of external load-bearing capacity (failure of the bond between the grout body and the soil)
— Verification in the Serviceability Limit State (SLS – GZG):
  If the prestressing force is lower than the applied load in the SLS, a deformation analysis must be conducted.

The determination of the internal load-bearing capacity of the anchor is explained in the following section according to the Austrian National Annex to EN 1997.

Maximum test and lock-off load

The maximum test load for anchors is specified in EN ISO 22477-5 (section 6.5) and must not exceed:

$$P_p \le \min \begin{cases} 0.80 \cdot f_{uk} \cdot A_{nom} \\ 0.95 \cdot f_{yk} \cdot A_{nom} \end{cases}$$

The Austrian National Annex ÖN B 1997-1-1 (section 4.6.2.2) specifies the maximum test loads as follows:

$$P_p \le \min \begin{cases} 0.80 \cdot f_{uk} \cdot A_{nom} \\ 0.90 \cdot f_{yk} \cdot A_{nom} \end{cases}$$

According to EN 1992-1-1 (section 5.10.2.1, item 2), over-stressing is permitted up to the same values specified in EN ISO 22477-5 (95 % of f_{yk}), provided that the tensioning jack ensures a measurement uncertainty of less than ±5 % of the test load. If this condition is not met, the following applies:

$$P_p \le \min \begin{cases} 0.80 \cdot f_{uk} \cdot A_{nom} \\ 0.90 \cdot f_{yk} \cdot A_{nom} \end{cases}$$

According to EN 1992-1-1 (section 5.10.3), the maximum residual force in the tendon after the tensioning process P_{m0} must not exceed the following values:

$$P_{m0} \le \min \begin{cases} 0.75 \cdot f_{uk} \cdot A_{nom} \\ 0.90 \cdot f_{yk} \cdot A_{nom} \end{cases}$$

The utilization level in prestressed concrete construction is generally higher than in geotechnical applications. According to OEN B 1997-1-1 (section 4.6.2.6), the lock-off load P_0 must not exceed the characteristic anchor load P_k:

$$P_0 \le P_k$$

Assuming that the design resistance of the anchor (R_d) corresponds to the design value of the anchor load (P_d), the design load (P_d) is defined by the following formula:

$$P_d = P_k \cdot \gamma_E \rightarrow P_k = \frac{P_d}{\gamma_E} \quad \text{that leads to:} \quad P_0 = \frac{R_d}{\gamma_E}$$

Thus, the maximum lock-off load is determined under the assumption of $\gamma_E = 1.35$ using the following equations:

$$P_0 \le \begin{cases} \dfrac{0.82 \cdot R_e}{\gamma_E} = 0.60 \cdot R_e \text{ for CC 1 and CC 2} \\ \dfrac{0.72 \cdot R_e}{\gamma_E} = 0.53 \cdot R_e \text{ for CC 3} \end{cases}$$

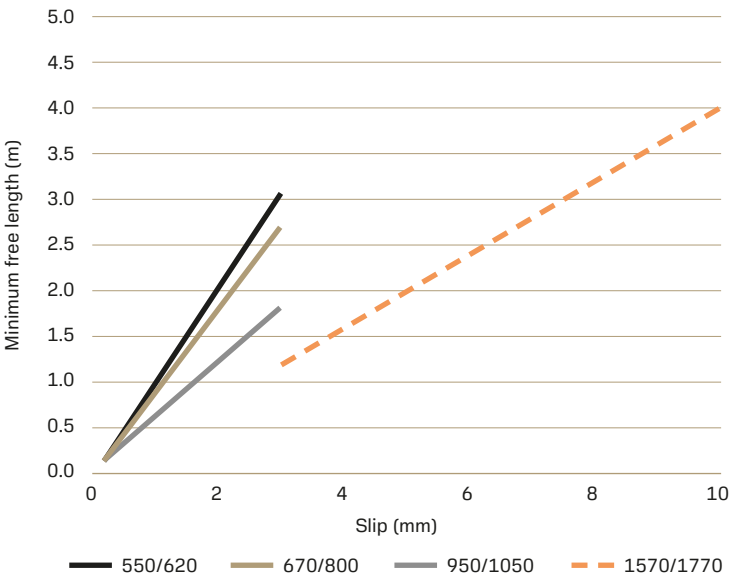
To maximize the utilization of anchors (lock-off load P_0), different free steel lengths are required depending on the steel grade. The free tendon length necessary for full anchor utilization depends on the following factors:

— Slip of the anchorage system (approx. 1 mm for threaded bars, approx. 5 mm for pre-wedged strands, approx. 10 mm for conventional strands) and
— Steel grade of the load-bearing tendon, particularly the ratio of tensile strength to yield strength

Legend:

P_p = (max) test load
P_0 = (max) lock-off load
P_{m0} = force after tensioning
P_d = design value of anchor load
P_k = characteristic value of anchor load
f_{uk} = ultimate tensile strength
f_{yk} = yeld stress at 0.1 % permanent strain (for prestressing steel) or at 0.2 % permanent strain (for rebar)
A_{nom} = nominal cross section
R_d = design value of the resistance of the anchor
R_e = characteristic yield strength of the tenson at 0.1 % permanent strain (for prestressing steel) or at 0.2 % permanent strain (for rebar)
γ_E = partial safety factor for loads (acc. table 10)

Minimum free length for full anchor utilization



For bars, a free anchor length of less than two meters is already sufficient to reach the maximum permissible lock-off load.
For strand anchors, a free length of approximately four meters is required.

Verification for the ultimate limit state (ULS)

The following inequalities must be satisfied:

$$P_d \le R_{a,d} \le R_{t,d}$$

with $R_{t,d} = \frac{R_e}{\gamma_S \cdot \eta}$ evalues for the damage consequence classes results in:

	CC 1 and CC 2	CC 3
$R_{t,d} =$	$\frac{R_e}{1.15}$	$\frac{R_e}{1.33}$
$P_d =$	$\frac{P_p}{1.10}$	$\frac{P_p}{1.25}$
$P_p =$	$\frac{R_e}{1.15} \cdot 1.10 \approx 0.95 \cdot R_e$	$\frac{R_e}{1.33} \cdot 1.25 \approx 0.95 \cdot R_e$

Legend:
$R_{a,d}$ = Design value of the pull out resistance
$R_{t,d}$ = Design value of the material resistance of the tension member
γ_S = Partial safety factor for reinforcement and PT-bars

Since, according to OEN B 1997-1-1, the maximum test load is limited to 90 % R_e, the following applies:

	CC 1 and CC 2	CC 3
$R_{t,d} =$	$\frac{R_e}{1.15}$	$\frac{R_e}{1.33}$
$P_d =$	$\frac{P_p}{1.10} = \frac{0.9 \cdot R_e}{1.10} = \frac{R_e}{1.23}$	$\frac{P_p}{1.25} = \frac{0.9 \cdot R_e}{1.25} = \frac{R_e}{1.39}$

Thus, the maximum permissible design resistance for an anchor in consequence classes CC 1 and CC 2 is 81 % of the yield load, while in CC 3, it is 72 % of the yield force.

$$P_d \le \min \begin{cases} \frac{P_p}{\gamma_a} \approx 0.82 \cdot R_e \text{ for CC 1 and CC 2} \\ \qquad\qquad\; 0.72 \cdot R_e \text{ for CC 3} \\ \frac{R_e}{\gamma_S \cdot \eta} \approx 0.87 \cdot R_e \text{ for CC 1 and CC 2} \\ \qquad\qquad\; 0.75 \cdot R_e \text{ for CC 3} \end{cases}$$

Table 10
Partial safety factors for loads (γ_E) for ground anchors and micropiles

Load Period	Condition	Symbol	Value BS 1	Value BS 2	Value BS 3
Permanent	Unfavourable	γ_G	1.35	1.35	1.00
	Favourable	γ_G	1.00	1.00	1.00
Variable	Unfavourable	γ_Q	1.50	1.50	1.00
	Favourable	γ_Q	0	0	0
Floating	Destabilizing	γ_G	1.10	1.10	1.00

Table 13
Partial safety factors for resistances against pullout of grouted anchors, grouted piles, and nails (γ_R) for all design situations

Resistance	Symbol	CC 1 and CC 2	CC 3
Grout anchors	γ_a	1.10	1.25
Micropiles	$\gamma_{s,t}$	1.40	1.60
Nails	$\gamma_{n,t}$	1.40	1.60

Table 14
Factor η depending on failure consequence categories

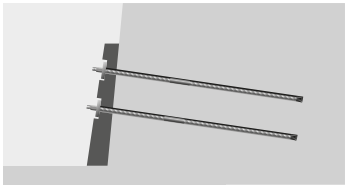
Resistance	Symbol	CC 1 and CC 2	CC 3
Grout anchors	η	1.00	1.15
Micropiles	η	1.30	1.50
Nails	η	1.30	1.50

Note: By introducing the factor η, it is ensured that all steel tension members are designed to withstand not only the design load P_d but also the required test forces.

Note:
All shown tables are cited from OEN B 1997-1-1:21

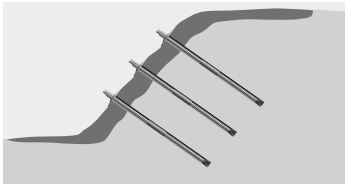
Application areas

DSI grouted anchors are used in a wide range of geotechnical applications. Fundamentally, they are employed wherever deformations need to be prevented or minimized. Overall, grouted anchors offer a versatile solution for enhancing the stability and safety of various structures and infrastructure projects, particularly in scenarios where conventional anchoring methods are insufficient due to soil conditions, groundwater levels, or other influencing factors, or where deformation-sensitive areas require specialized solutions.
Key application areas include, but are not limited to:



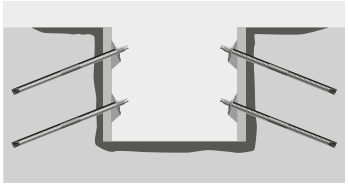
— **Anchoring of retaining walls**
Grouted anchors are used to stabilize and secure retaining walls, especially in areas with sloped terrain or unstable soil conditions. They help prevent wall displacement and improve overall structural integrity.





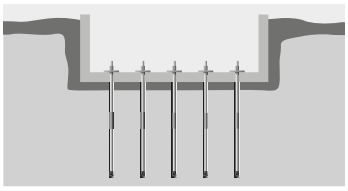
— **Slope stabilization and anchoring**
Grouted anchors are used to secure and stabilize slopes, preventing landslides and slope failures.
They enhance soil retention and reinforce terrain in geologically challenging areas.





— **Retaining and anchoring of excavations and cuts**
Grouted anchors are used in excavations and other earthworks to stabilize sidewalls and prevent soil movement or material intrusion into the construction pit.
They ensure structural safety and maintain the integrity of deep excavations.

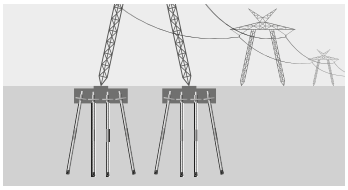




— **Uplift protection for foundations in groundwater**
In areas with high groundwater levels, grouted anchors are used to prevent foundation uplift and ensure structural stability. They counteract buoyant forces and enhance the foundation's load-bearing capacity.

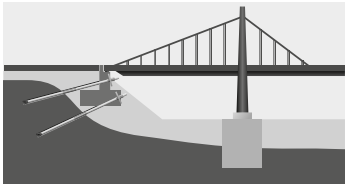






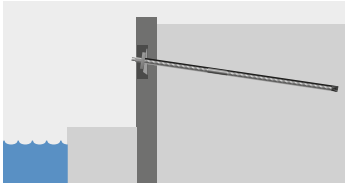
— **Tensile anchoring of infrastructure structures**
Grouted anchors are used to secure infrastructure structures such as wind turbines, power transmission towers, and bridge piers, enhancing their stability against tensile forces and external loads.





— **Anchoring of bridges and abutments**
Grouted anchors are used to enhance the stability of bridges and their abutments by securely fastening them to the ground, minimizing movement, and ensuring long-term structural integrity.





— **Harbor structures**
Grouted anchors are used in port facilities to securely anchor quay walls, docks, and other maritime structures, enhancing their stability and resistance to environmental forces such as tides and soil movement.






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System components

Steel tendon

The following types of steel load-bearing elements are suitable for grouted anchors, depending on structural and project requirements:

— **Hollow bar with continuous thread ribs (”hollow bar anchor”)**
Hollow bars feature a continuous external thread and are available in diameters ranging from 32 mm to 103 mm. By adjusting wall thickness, the required load-bearing capacities can be optimized to suit specific project needs. The hollow core design allows for simultaneous drilling and grouting, making these anchors highly effective in difficult soil conditions.

— **Seven-wire strand (”strand anchor”)**
Strand anchors consist of multiple strands grouped together to provide high tensile resistance. Strands are available in two different diameters (0.60" and 0.62") and are offered in two high-strength steel grades (Y 1570/1770 and Y 1680/1860). A nearly unlimited number of strands can be combined into a single anchor to achieve the required load capacity. Typically, strand anchors are configured with 2 to 15 strands, balancing strength and flexibility for various geotechnical applications.

— **Solid threaded bar (”bar anchor”)**
Solid bar anchors feature a continuous external thread, enabling secure load transfer along the entire length. Available in three different high-strength steel grades (S 500/550, S 670/800, S 950/1050). A range of diameters from 18 mm to 75 mm is available, allowing for characteristic resistance values exceeding 3,500 kN. The continuous thread profile ensures easy adjustability and secure attachment to anchoring components.

Anchor head

The end anchorage system differs significantly between bar/hollow bar anchors and strand anchors, each optimized for efficient force transfer and long-term stability.

Anchor head for bar and hollow bar anchors

— Anchor plate with cone and spherical nut (alternative: anchor plate and anchor nut)
— If required: sealing tube, welded to the anchor plate
— Comprehensive corrosion protection system (Internal cap, sealing between the sealing tube and load-bearing element to prevent environmental exposure)
— Corrosion protection (compound to safeguard against degradation)
— Protective cap

Anchor head for strand anchors

— Bearing plate for distributing forces effectively
— If required: sealing tube welded to the bearing plate
— Wedge plate (anchor block) with anchoring wedges, ensuring a secure fixation of the strands
— Advanced corrosion protection system (internal cap, sealing between the sealing tube and load-bearing element to prevent ingress of moisture or contaminants)
— Corrosion protection compound for extended durability
— Protective cap

Additional optional components, such as angle compensation plates, load cells, and stress-relief rings, can be integrated to enhance monitoring and long-term performance.



Coupling joint

Coupling joints are used exclusively for solid bar and hollow bar anchor systems. In contrast, strand anchors always consist of a continuous steel load-bearing element, ensuring uninterrupted force transmission. The coupling joint consists of:

— A coupler with a continuous internal thread, designed to meet or exceed the actual load capacity of the anchor bar
— Twist-locking mechanisms to ensure stability and prevent unwanted movement, including:
  - Adhesive bonding of the coupling joint, or
  - Grub screws for additional mechanical fixation, or
  - Locknuts to maintain a secure connection
— Optional corrosion protection features to extend service life and enhance durability in challenging environments.

Couplers should ideally be positioned in the transition zone between the bonded length and the free-stressing length, ensuring optimal performance. If a coupling joint is required in the free-stressing length, it must be designed to avoid any obstruction during tensioning operations. Coupling joints should be avoided within the bonded length whenever possible to ensure an uninterrupted transfer of forces. By carefully selecting the appropriate anchoring system and ensuring precise installation, grouted anchors provide exceptional performance, longevity, and reliability in diverse geotechnical applications.

Hybridanker-plate





Hybridanker-plates are made from UHPFRC (Ultra-High Performance Fiber-Reinforced Concrete) and serve as load-bearing plates for transferring anchoring forces into the ground. Their load-bearing capacity has been validated through both theoretical calculations and experimental testing. These plates hold a European approval, ensuring compliance with industry standards.
Advantages of Hybridanker-plates compared to conventional steel anchor plates are among others:

- Exceptional durability and high resistance to corrosion, ensuring long-term performance
- Flexible geometry, allowing for customized shapes and designs
- Lightweight construction, significantly reducing installation complexity and transportation costs
- Angle compensation of up to 30° with a single plate, offering increased adaptability
- Custom-engineered solutions to meet specific project requirements
- Integrated threaded inserts for anchor caps, available in standard steel or stainless steel
- Provisions for grouting and venting pipes, facilitating an efficient installation process
- Embedded PE pipes for corrosion protection systems, enhancing durability in challenging environments

By combining high-performance materials with innovative engineering, hybrid anchor plates provide a superior alternative to traditional steel plates, offering greater longevity, flexibility, and efficiency in geotechnical applications.





System accessories

DSI provides a comprehensive range of accessories for the installation, grouting, and tensioning of grouted anchors.
The product portfolio includes, but is not limited to:

— **Installation aids**
Tools and components to facilitate proper anchor placement
— **Grouting adapters**
Specialized fittings for efficient and precise grout injection
— **Tensioning accessories**
Equipment designed for controlled and reliable anchor tensioning
— **Measurement systems and data acquisition**
Advanced monitoring solutions for real-time load measurement and performance tracking
— **And more ...**
A variety of additional accessories tailored to meet specific project requirements

By offering a complete accessory portfolio, DSI ensures efficient, safe, and high-quality execution of anchoring systems across various geotechnical applications.



Hollow core cylinder
(several load capacities and strokes)



Accessory for tensioning of strand anchors
(resetplate and tensioning anchorage)



Hydraulic pump and manometer



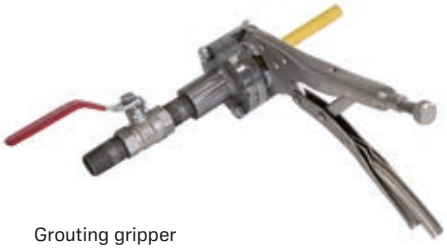
Tensioning accessories for bar anchors
(load distribution plate and tensioning chair)



Tube cutter
(for cutting the corrugated sheathing of DCP strand anchors in the borehole)



Inner cap



Grouting gripper

Technical data

DSI grouted anchors are available with a variety of steel load-bearing elements and different steel grades to meet diverse geotechnical requirements. These include:

— **Solid thread bar**
- Reinforcement grade: S 500/550, S 550/620 and S 555/700
- High strength reinforcement grade: S 670/800
- Post tensioning grade: S 835/1035, S 950/1050

— **Hollow bar**
- Outer diameter: 32 to 103 mm
- Wall thickness: 5.05 to 14.3 mm

— **Strands**
- Steel grade: Y 1570/1770 and Y 1680/1860
- Nominal diameter 0.60" (A = 140 mm²) and 0.62" (A = 150 mm²)

Mechanical properties

Steel grade	**Symbol**	**Reinforcement S 500/550**	**Reinforcement S 550/620**	**Reinforcement S 555/700**
Diameter range	$Ø_s$	12-75 mm	12-75 mm	57.5-63.5 mm
Yield strength	R_e (f_{yk})	500 N/mm²	550 N/mm²	555 N/mm²
Ultimate strength	R_m (f_{tk})	550 N/mm²	620 N/mm²	700 N/mm²
Ratio	$(R_m/R_e)_k$	≥ 1.08	≥ 1.08	≥ 1.08
Elongation at maximum load	A_{gt}	≥ 5.0 %	≥ 5.0 %	≥ 5.0 %
Resistance of fatigue at an upper stress of $0.6 \cdot R_e$ and up to N = $2 \cdot 10^6$ load cycles	$2 \cdot \sigma_A$	$Ø_s$ = 20-32 mm: 120 N/mm² $Ø_s$ = 40-75 mm: 100 N/mm²	$Ø_s$ = 20-32 mm: 120 N/mm² $Ø_s$ = 40-75 mm: 100 N/mm²	100 N/mm²

Steel grade	**Symbol**	**High strength reinforcement S 670/800**	**PT-bar S 950/1050**	**PT-bar S 835/1035**
Diameter range	$Ø_s$	18-75 mm	18-47 mm	57-75 mm
Yield strength	R_e (f_{yk})	670 N/mm²	835 N/mm²	950 N/mm²
Ultimate strength	R_m (f_{tk})	800 N/mm²	1,035 N/mm²	1,050 N/mm²
Ratio	$(R_m/R_e)_k$	≥ 1.10	—	—
Elongation at maximum load	A_{gt}	≥ 5.0 %	≥ 5.0 %	≥ 4.0 %
Resistance of fatigue at an upper stress of $0.7 \cdot R_e$ and up to N = $2 \cdot 10^6$ load cycles	$2 \cdot \sigma_A$	$Ø_s$ = 18-43 mm: 150 N/mm² $Ø_s$ = 50-63.5 mm: 120 N/mm² $Ø_s$ = 75 mm: 100 N/mm²	$Ø_s$ = 18-32 mm: 180 N/mm² $Ø_s$ = 36-40 mm: 137 N/mm² $Ø_s$ = 47 mm: n. a. [1]	—

1) n. a. = not available.

Steel grade	**Symbol**	**Hollow bar 28Mn6**	**PT-strands Y 1570/1770**	**PT-strands Y 1570/1770**
Diameter range	$Ø_s$	32-76 mm	0.60" bzw. 0.62"	0.60" bzw. 0.62"
Yield strength	R_e (f_{yk})	510-640 N/mm²	1,500 N/mm²	1,600 N/mm²
Ultimate strength	R_m (f_{tk})	620-835 N/mm²	1,770 N/mm²	1,860 N/mm²
Ratio	$(R_m/R_e)_k$	≥ 1.15	—	—
Elongation at maximum load	A_{gt}	≥ 5.0 %	≥ 3.5 %	≥ 3.5 %
Resistance of fatigue at an upper stress of $0.7 \cdot R_e$ and up to N = $2 \cdot 10^6$ load cycles	$2 \cdot \sigma_A$	190 N/mm²	171 N/mm² [1]	171 N/mm² [1]

1) Calculated based on the Wöhler Curve specified in the approvals.

Technical data of individual tendons: solid thread bar

Steel grade	Nominal diameter $Ø_s$	Nominal cross section A_s	Nominal weight g_{nom}	Yield load F_{tk}	Maximum load F_{tk}	Max. test load $P_{p,max.}$ min $(0.9 \cdot F_{yk}; 0.8 \cdot F_{tk})$	Max. lock-off load $P_{0,max.}$ min $(0.85 \cdot F_{yk}; 0.75 \cdot F_{tk})$
S 500/550	16 mm	201 mm²	1.58 kg/m	100 kN	110 kN	88 kN	82 kN
	20 mm	314 mm²	2.46 kg/m	160 kN	175 kN	140 kN	131 kN
	25 mm	491 mm²	3.85 kg/m	245 kN	270 kN	216 kN	202 kN
	28 mm	616 mm²	4.84 kg/m	310 kN	340 kN	272 kN	255 kN
	32 mm	804 mm²	6.31 kg/m	405 kN	440 kN	352 kN	330 kN
	36 mm	1,018 mm²	7.99 kg/m	510 kN	560 kN	448 kN	420 kN
	40 mm	1,257 mm²	9.87 kg/m	630 kN	690 kN	552 kN	517 kN
	43 mm	1,452 mm²	11.4 kg/m	726 kN	799 kN	639 kN	599 kN
	50 mm	1,963 mm²	15.41 kg/m	980 kN	1,080 kN	864 kN	810 kN
	57.5 mm	2,597 mm²	20.39 kg/m	1,299 kN	1,428 kN	1,142 kN	1,071 kN
	63.5 mm	3,167 mm²	24.86 kg/m	1,584 kN	1,742 kN	1,393 kN	1,306 kN
	75 mm	4,418 mm²	34.68 kg/m	2,209 kN	2,430 kN	1,944 kN	1,822 kN
S 550/620	16 mm	201 mm²	1.58 kg/m	110 kN	124 kN	99 kN	93 kN
	20 mm	314 mm²	2.46 kg/m	172 kN	194 kN	154 kN	145 kN
	25 mm	491 mm²	3.85 kg/m	270 kN	304 kN	243 kN	228 kN
	28 mm	616 mm²	4.84 kg/m	339 kN	382 kN	305 kN	286 kN
	32 mm	804 mm²	6.13 kg/m	442 kN	499 kN	397 kN	374 kN
	36 mm	1,018 mm²	7.99 kg/m	559 kN	631 kN	503 kN	473 kN
	40 mm	1,257 mm²	9.87 kg/m	691 kN	779 kN	621 kN	584 kN
	43 mm	1,452 mm²	11.4 kg/m	798 kN	900 kN	718 kN	675 kN
	50 mm	1,963 mm²	15.41 kg/m	1,080 kN	1,217 kN	972 kN	912 kN
	57.5 mm	2,597 mm²	20.39 kg/m	1,428 kN	1,610 kN	1,285 kN	1,207 kN
	63.5 mm	3,167 mm²	24.86 kg/m	1,742 kN	1,963 kN	1,567 kN	1,472 kN
	75 mm	4,418 mm²	34.68 kg/m	2,430 kN	2,739 kN	2,187 kN	2,054 kN
S 670/800	18 mm	254 mm²	1.99 kg/m	170 kN	204 kN	153 kN	144 kN
	22 mm	380 mm²	2.98 kg/m	255 kN	304 kN	229 kN	216 kN
	25 mm	491 mm²	3.85 kg/m	329 kN	393 kN	296 kN	279 kN
	28 mm	616 mm²	4.84 kg/m	413 kN	491 kN	371 kN	351 kN
	30 mm	707 mm²	5.55 kg/m	474 kN	565 kN	426 kN	402 kN
	35 mm	962 mm²	7.55 kg/m	645 kN	770 kN	580 kN	548 kN
	43 mm	1,452 mm²	11.4 kg/m	973 kN	1,162 kN	875 kN	827 kN
	50 mm	1,963 mm²	15.41 kg/m	1,315 kN	1,570 kN	1,183 kN	1,117 kN
	57.5 mm	2,597 mm²	20.39 kg/m	1,740 kN	2,077 kN	1,566 kN	1,479 kN
	63.5 mm	3,167 mm²	24.86 kg/m	2,122 kN	2,534 kN	1,909 kN	1,803 kN
	75 mm	4,418 mm²	34.68 kg/m	2,960 kN	3,534 kN	2,664 kN	2,516 kN
S 950/1050	18 mm	241 mm²	1.96 kg/m	230 kN	255 kN	204 kN	191 kN
	26.5 mm	551 mm²	4.48 kg/m	525 kN	580 kN	464 kN	435 kN
	32 mm	804 mm²	6.53 kg/m	760 kN	845 kN	676 kN	633 kN
	36 mm	1,020 mm²	8.27 kg/m	960 kN	1,070 kN	856 kN	802 kN
	40 mm	1,257 mm²	10.21 kg/m	1,190 kN	1,320 kN	1,056 kN	990 kN
	47 mm	1,735 mm²	14.1 kg/m	1,650 kN	1,820 kN	1,456 kN	1,365 kN
S 835/1035	57 mm	2,581 mm²	20.95 kg/m	2,155 kN	2,671 kN	1,939 kN	1,831 kN
	65 mm	3,331 mm²	27.1 kg/m	2,780 kN	3,447 kN	2,502 kN	2,363 kN
	75 mm	4,418 mm²	35.9 kg/m	3,690 kN	4,572 kN	3,321 kN	3,136 kN

Hollow bar

Type	Nominal diameter $Ø_s$	Nominal cross section A_{nom}	Nominal weight g_{nom}	Yield load F_{yk}	Maximum load F_{uk}	Max. test load $P_{p,max.}$ min $(0.9 \cdot F_{yk}; 0.8 \cdot F_{tk})$	Max. lock-off load $P_{0,max.}$ min $(0.85 \cdot F_{yk}; 0.75 \cdot F_{tk})$
R32-250	32 mm	370 mm²	2.9 kg/m	190 kN	250 kN	171 kN	161 kN
R32-280		410 mm²	3.2 kg/m	220 kN	280 kN	198 kN	187 kN
R32-320		470 mm²	3.7 kg/m	250 kN	320 kN	225 kN	212 kN
R32-360		510 mm²	4.0 kg/m	280 kN	360 kN	252 kN	238 kN
R32-400		560 mm²	4.4 kg/m	330 kN	400 kN	297 kN	280 kN
R38-420	38 mm	660 mm²	5.15 kg/m	350 kN	420 kN	315 kN	297 kN
R38-500		750 mm²	5.85 kg/m	400 kN	500 kN	360 kN	340 kN
R38-550		800 mm²	6.25 kg/m	450 kN	550 kN	405 kN	382 kN
R51-550	51 mm	890 mm²	6.95 kg/m	450 kN	550 kN	405 kN	382 kN
R51-660		970 mm²	7.65 kg/m	540 kN	660 kN	486 kN	459 kN
R51-800		1,150 mm²	9.0 kg/m	640 kN	800 kN	576 kN	544 kN
R51-925		1,275 mm²	10.0 kg/m	740 kN	925 kN	666 kN	629 kN
T76-1300	76 mm	1,590 mm²	12.5 kg/m	1,000 kN	1,300 kN	900 kN	850 kN
T76-1650		1,975 mm²	15.5 kg/m	1,200 kN	1,650 kN	1,080 kN	1,020 kN
T76-1900		2,360 mm²	18.5 kg/m	1,500 kN	1,900 kN	1,350 kN	1,275 kN



DSI strand anchors

	Steel grade 1570/1770				Steel grade 1680/1860			
No. of strands 15.3 mm/ 140 mm²	**Char. max. load** F_{uk}	**Char. load at 0.1 % elongation** $F_{p0.1k}$	**Char. anchor capacity** $F_{yk} = F_{p0.1k}/\gamma_s$	**Max. test load** $P_{p,max.}$	**Char. max. load** F_{uk}	**Char. load at 0.1 % elongation** $F_{p0.1k}$	**Char. anchor capacity** $F_{yk} = F_{p0.1k}/\gamma_s$	**Max. test load** $P_{p,max.}$
2	496 kN	436 kN	379 kN	392 kN	520 kN	458 kN	398 kN	412 kN
3	744 kN	654 kN	569 kN	588 kN	780 kN	687 kN	597 kN	618 kN
4	992 kN	872 kN	758 kN	784 kN	1,040 kN	916 kN	796 kN	824 kN
5	1,240 kN	1,090 kN	948 kN	980 kN	1,300 kN	1,145 kN	995 kN	1,030 kN
6	1,488 kN	1,308 kN	1,137 kN	1,176 kN	1,560 kN	1,374 kN	1,194 kN	1,236 kN
7	1,736 kN	1,526 kN	1,327 kN	1,372 kN	1,820 kN	1,603 kN	1,393 kN	1,442 kN
8	1,984 kN	1,744 kN	1,516 kN	1,568 kN	2,080 kN	1,832 kN	1,592 kN	1,648 kN
9	2,232 kN	1,962 kN	1,706 kN	1,764 kN	2,340 kN	2,061 kN	1,791 kN	1,854 kN
10	2,480 kN	2,180 kN	1,895 kN	1,960 kN	2,600 kN	2,290 kN	1,990 kN	2,060 kN
11	2,728 kN	2,398 kN	2,085 kN	2,156 kN	2,860 kN	2,519 kN	2,189 kN	2,266 kN
12	2,976 kN	2,616 kN	2,274 kN	2,352 kN	3,120 kN	2,748 kN	2,388 kN	2,472 kN
13	3,224 kN	2,834 kN	2,464 kN	2,548 kN	3,380 kN	2,977 kN	2,587 kN	2,678 kN
14	3,472 kN	3,052 kN	2,653 kN	2,744 kN	3,640 kN	3,206 kN	2,786 kN	2,884 kN
15	3,720 kN	3,270 kN	2,843 kN	2,940 kN	3,900 kN	3,435 kN	2,985 kN	3,090 kN

	Steel grade 1570/1770				Steel grade 1680/1860			
No. of strands 15.7 mm/ 150 mm²	**Char. max. load** F_{uk}	**Char. load at 0.1 % elongation** $F_{p0.1k}$	**Char. anchor capacity** $F_{yk} = F_{p0.1k}/\gamma_s$	**Max. test load** $P_{p,max.}$	**Char. max. load** F_{uk}	**Char. load at 0.1 % elongation** $F_{p0.1k}$	**Char. anchor capacity** $F_{yk} = F_{p0.1k}/\gamma_s$	**Max. test load** $P_{p,max.}$
2	532 kN	468 kN	407 kN	421 kN	558 kN	492 kN	428 kN	443 kN
3	798 kN	702 kN	611 kN	632 kN	837 kN	738 kN	642 kN	665 kN
4	1,064 kN	936 kN	814 kN	842 kN	1,116 kN	984 kN	856 kN	886 kN
5	1,330 kN	1,170 kN	1,018 kN	1,053 kN	1,395 kN	1,230 kN	1,070 kN	1,108 kN
6	1,596 kN	1,404 kN	1,221 kN	1,263 kN	1,674 kN	1,476 kN	1,284 kN	1,329 kN
7	1,862 kN	1,638 kN	1,425 kN	1,474 kN	1,953 kN	1,722 kN	1,498 kN	1,551 kN
8	2,128 kN	1,872 kN	1,628 kN	1,684 kN	2,232 kN	1,968 kN	1,712 kN	1,772 kN
9	2,394 kN	2,106 kN	1,832 kN	1,895 kN	2,511 kN	2,214 kN	1,926 kN	1,994 kN
10	2,660 kN	2,340 kN	2,035 kN	2,105 kN	2,790 kN	2,460 kN	2,140 kN	2,215 kN
11	2,926 kN	2,574 kN	2,239 kN	2,316 kN	3,069 kN	2,706 kN	2,354 kN	2,437 kN
12	3,192 kN	2,808 kN	2,442 kN	2,526 kN	3,348 kN	2,952 kN	2,568 kN	2,658 kN
13	3,458 kN	3,042 kN	2,646 kN	2,737 kN	3,627 kN	3,198 kN	2,782 kN	2,880 kN
14	3,724 kN	3,276 kN	2,849 kN	2,947 kN	3,906 kN	3,444 kN	2,996 kN	3,101 kN
15	3,990 kN	3,510 kN	3,053 kN	3,158 kN	4,185 kN	3,690 kN	3,210 kN	3,323 kN

Solid thread bar anchors

General

For solid bar anchors, the steel load-bearing element consists of a solid bar with continuous thread ribs. This type of anchor is available in three different steel grades (refer to technical data for details). A solid bar anchor is composed of the following key elements:

— **Bond length/anchorage length**
In the bond length, the load-bearing element is fitted with spacers to ensure precise centering within the borehole. This centering guarantees uniform encapsulation with grout, optimizing load transfer efficiency and structural integrity.

— **Coupling connection**
A coupling joint should ideally be positioned at the transition between the anchorage length and the free steel length to maintain uniform stress distribution. Couplers should be avoided within the anchorage length, as potential slippage within the coupler and its blocking effect could lead to excessive cracking in the surrounding structure and uneven distribution of bond stresses, compromising anchor performance.
When placing couplers in the free steel length, it must be ensured that the coupling joint remains freely movable during tensioning and that the elongation path is verified throughout the tensioning process to prevent any restrictions that could hinder proper force application.

— **Free length/free steel length**
It must be ensured that no bond forms between the grouted body and the steel load-bearing element within this section. The elongation path should be continuously monitored during tensioning to guarantee unobstructed movement.

— **Anchor head**
The anchor head of a solid bar anchor consists of an anchor plate with a conical bore and a welded steel pipe fitting, providing a secure anchoring interface. A nut, preferably a spherical seat nut, ensures optimal centric load transmission, even in cases of slight misalignment during installation. The anchor head is also equipped with a comprehensive corrosion protection system, ensuring long-term durability and resistance to environmental degradation.

Corrosion protection

Depending on the planned service life, the following corrosion protection measures are implemented for the individual anchor components:

	Temporary anchor	**Semi-permanent anchor**	**Permanent anchor**
Planned service life time	< 2 years	2-7 years	> 2 years
Bond length	— Grout cover ≥ 10 mm	— Grout cover ≥ 10 mm	— Corrugated sheeting with inner cement grout ≥ 5 mm sealed with grouting cap — Outer grout cover ≥ 10 mm
Coupler in transition bond to free length	— Grout cover	— Grout cover	— Two layer heat shrink sleeve
Coupler in free length	— Coupler tube sealed with heat shrink sleeve	— Steel elements covered with corrosion compound — Coupler tube sealed with heat shrink sleeve	— Steel elements covered with corrosion compound — Coupler tube sealed with heat shrink sleeve
Free bar length	— Smooth PE sheeting, sealed with tape	— Threadbar covered with corrosion compound — Smooth PE sheeting sealed with heat shrink sleeve	— Corrugated sheeting with inner cement grout ≥ 5 mm — Additional smooth PE sheeting sealed with tape
Anchor head	— No sealing between steel tube and smooth sheeting — Anchor head covered with corrosion compound	— Sealing between steel tube and smooth sheeting — Bar heavily covered with corrosion compound — Anchor head covered with corrosion compound — Steel or plastic protection cap, installed tight	— Anchor plate and tube hot-dipped galvanized — Sealing between steel tube and smooth sheeting — Inner cap installed tight and remaining space filled with corrosion compound — Steel protective cap

Properties

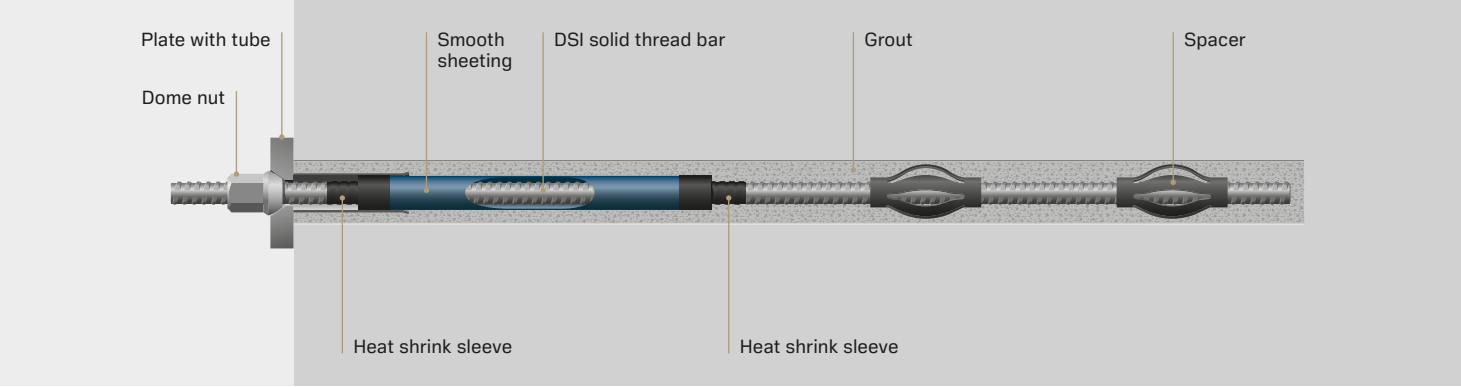
Solid bar anchors can be manufactured in lengths of up to 15 m in a single piece due to transport constraints. For longer lengths, special transportation is required, making it more practical and cost-effective to join bars using coupling joints.
When using prestressing steel bars, it is important to note that the material is sensitive to heat exposure and corrosion. While surface rust (flash rust) is acceptable, it should be removed prior to installation. Additionally, welding or cutting with a grinder must not be performed near prestressing steel bars unless adequate protective measures are in place to prevent damage.

Advantages of solid bar anchors compared to strand anchors:

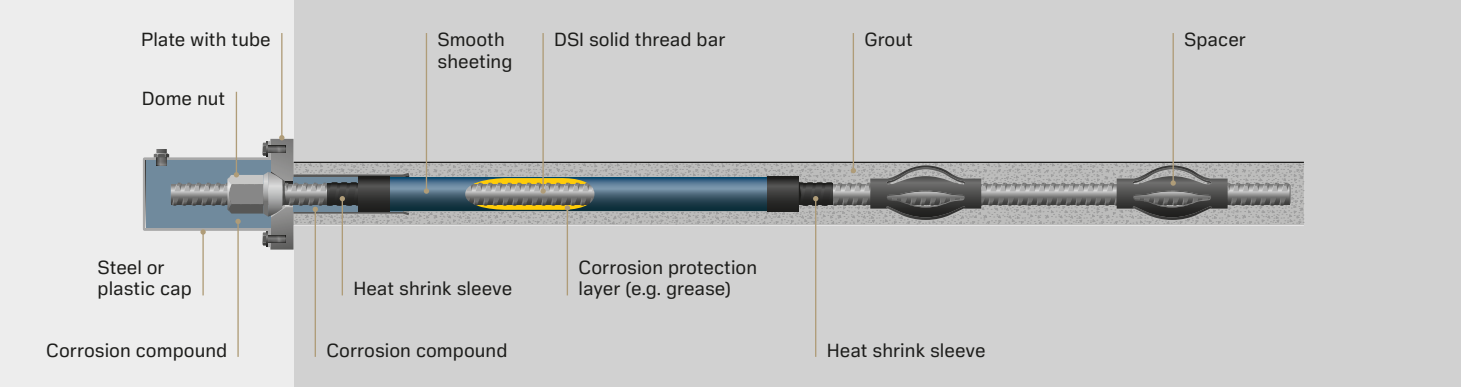
- Simpler and more cost-effective anchor head design
- Minimal slip during tensioning, allowing for shorter anchor lengths
- Incremental retensioning and detensioning possible if sufficient bar length is available
- Easy handling during installation and tensioning
- Factory-applied double corrosion protection available
- Wide selection of bar diameters and steel grades

These advantages make solid bar anchors a highly efficient and durable anchoring solution in various geotechnical applications.

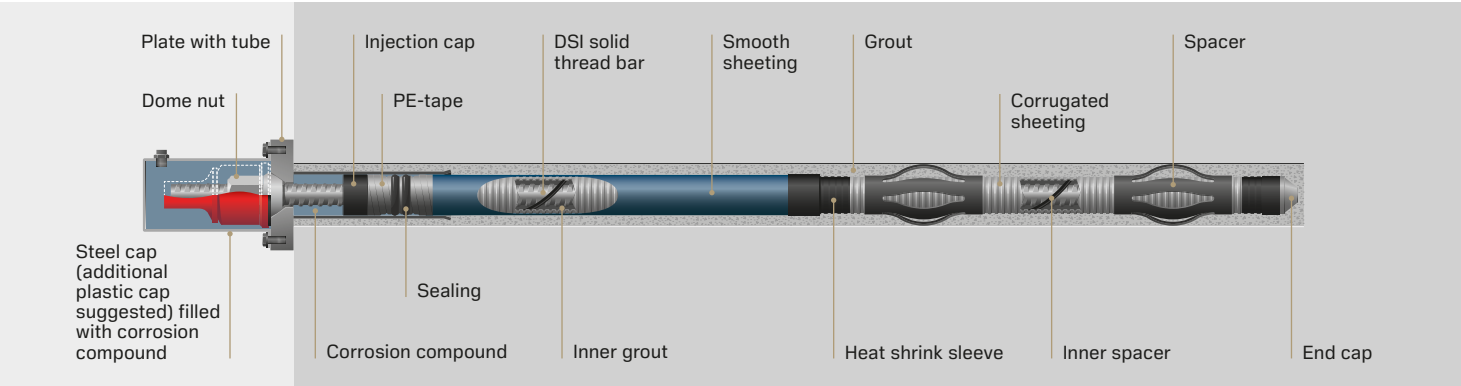
Temporary anchor (standard corrosion protection (SCP))



Semi-permanent anchor

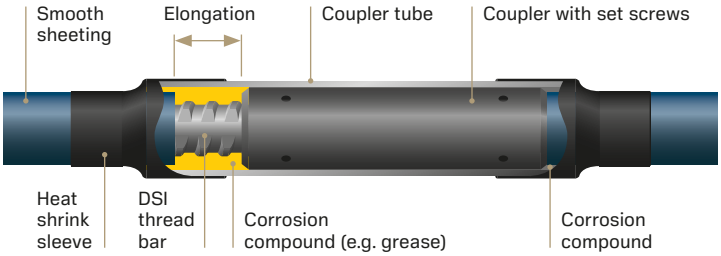


Permanent anchor (with double corrosion protection (DCP))

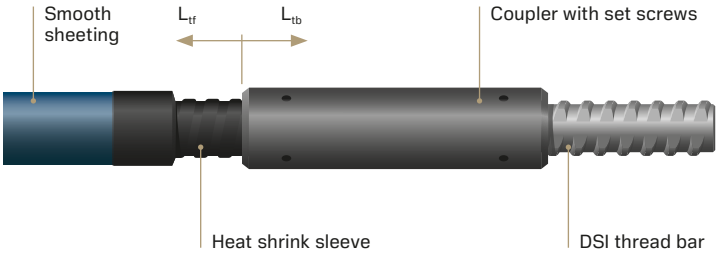


Coupler joint for temporary (SCP) and semi permanent anchors

At L_{tf}

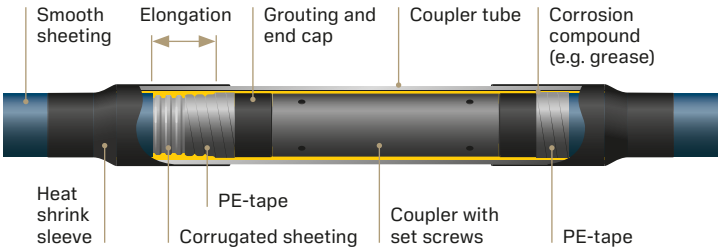


At transition zone between L_{tb} and L_{tf}

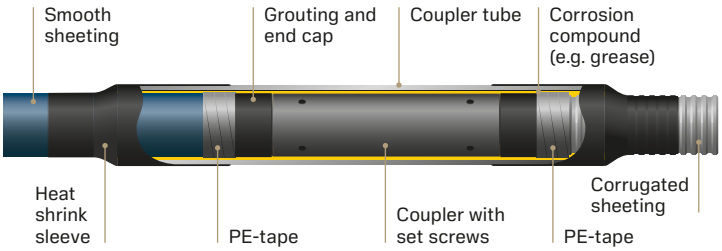


Coupler joint for permanent anchors (DCP)

At L_{tf}



At transition zone between L_{tb} and L_{tf}

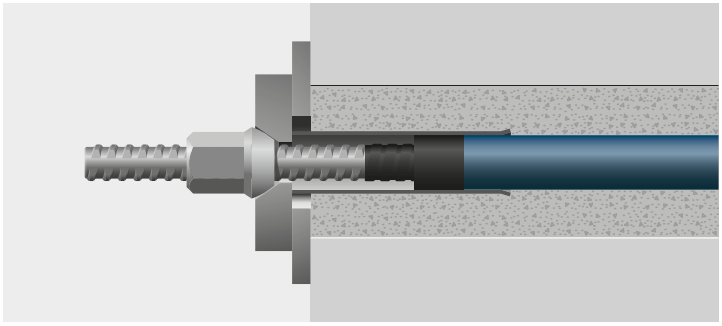


— In transition zone between free length L_{tf}/bond length L_{tb}: coupler joint with two layer heat shrink sleeve

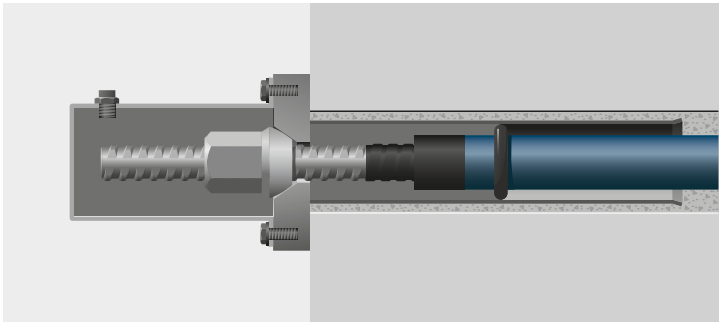
— In bond length L_{tb}: avoid coupler joints! If necessary: coupler joint with two layer heat shrink sleeve

Anchor head layouts

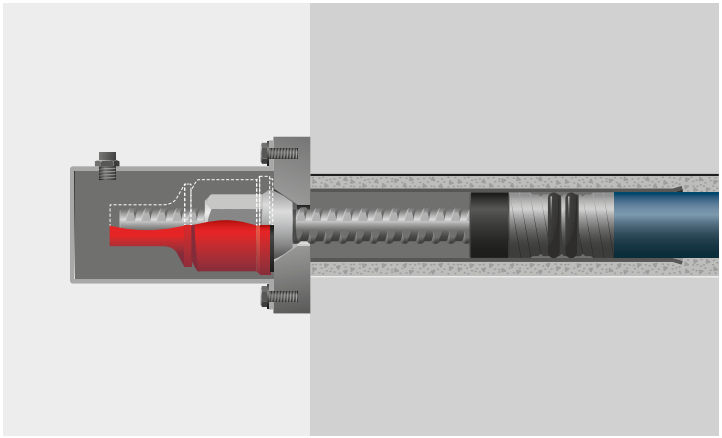
Temporary
(support over larger drill hole or distance using a base plate)



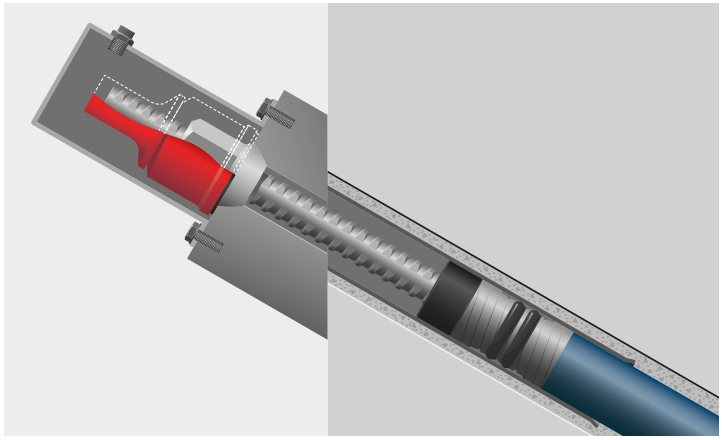
Semi-permanent, fully grouted



Permanent



Permanent with Hybridanker-plate





Hollow bar anchors

General

Hollow bars are installed as self-drilling systems using rotary-percussive methods with a sacrificial drill bit. Following drilling, the borehole is grouted through the hollow bar and injection ports in the drill bit. This method, which does not require casing during installation, allows for high drilling performance but introduces specific system requirements:

— Grouting without external grout tubes
— Ensuring the free movement of bars and couplings in the unbonded length after drilling (e.g., the sleeve separating the bar from the grout must not be damaged during drilling)
— The coupling connection must not obstruct the tensioning process
— Regrouting is only possible to a limited extent and requires specialized grouting couplers

Hollow bar anchors consist of the following components:

— **Drill bit**
The (sacrificial) drill bit not only breaks and removes the drilled material but also serves as a flushing and injection aid.
The flushing and grout material exits through designated injection ports in the drill bit and flows upward from the bottom of the borehole.

— **Bond length/anchorage length**
In the bonded section, the load-bearing bar is equipped with spacers to ensure central alignment within the borehole and uniform encapsulation by the grout.

— **Coupling connection**
Ideally, a coupling should be located at the transition between the anchorage length and the free steel length. Couplings within the anchorage zone should be avoided, as slippage or potential blockage can result in significant cracking or an uneven stress distribution in the bonded length. When positioned in the free length, it must be ensured that the coupling allows for free movement during tensioning and does not impede the process (verify elongation during tensioning!).

— **Unbonded length/free steel length**
It is crucial to prevent any bonding between the grout and the steel load-bearing element in this section (verify elongation during tensioning!).

— **Anchor head**
In hollow bar anchors, the anchor head consists of an anchor plate (either with a conical bore or a domed plate), a nut (preferably a spherical collar nut to ensure axial loading even with slight misalignments), and the appropriate corrosion protection.

Corrosion protection

Depending on the planned service life, the following corrosion protection measures are implemented for the individual anchor components:

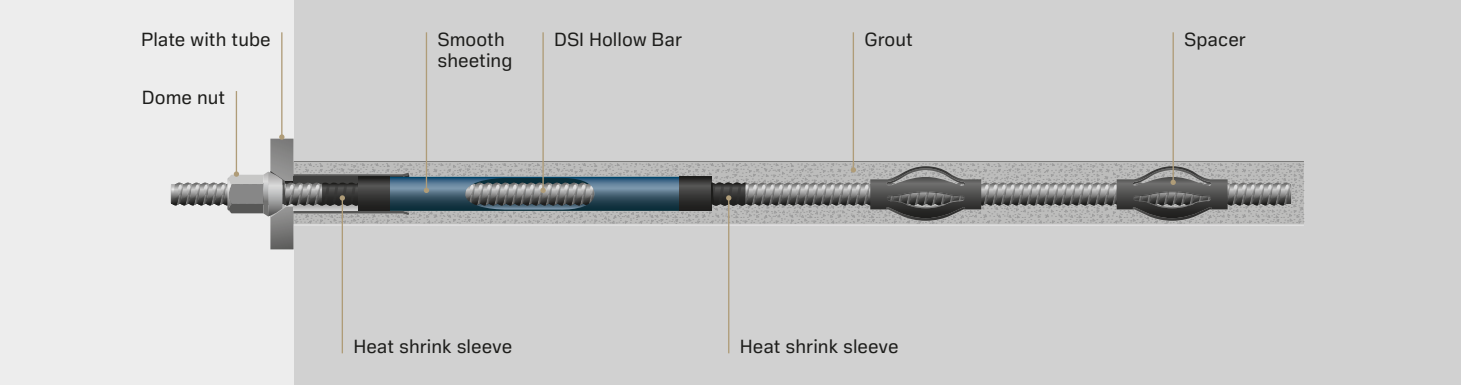
	Temporary anchor	**Semi-permanent anchor**	**Permanent anchor**
Planned service life time	< 2 years	2-7 years	> 2 years
Bond length	— Grout cover ≥ 10 mm	— Grout cover ≥ 10 mm	— Corrugated sheeting with inner cement grout ≥ 5 mm sealed with grouting cap — Outer grout cover ≥ 10 mm
Coupler in transition bond to free length	— Grout cover	— Grout cover	— Two layer heat shrink sleeve
Coupler in free length	— Coupler tube sealed with heat shrink sleeve	— Steel elements covered with corrosion compound — Coupler tube sealed with heat shrink sleeve	— Steel elements covered with corrosion compound — Coupler tube sealed with heat shrink sleeve
Free bar length	— Smooth PE sheeting, sealed with tape	— Threadbar covered with corrosion compound — Smooth PE sheeting sealed with heat shrink sleeve	— Corrugated sheeting with inner cement grout ≥ 5 mm — Additional smooth PE sheeting sealed with tape
Anchor head	— No sealing between steel tube and smooth sheeting — Anchor head covered with corrosion compound	— Sealing between steel tube and smooth sheeting — Bar heavily covered with corrosion compound — Anchor head covered with corrosion compound — Steel or plastic protection cap, installed tight	— Anchor plate and tube hot-dipped galvanized — Sealing between steel tube and smooth sheeting — Inner cap installed tight and remaining space filled with corrosion compound — Steel protective cap

Properties

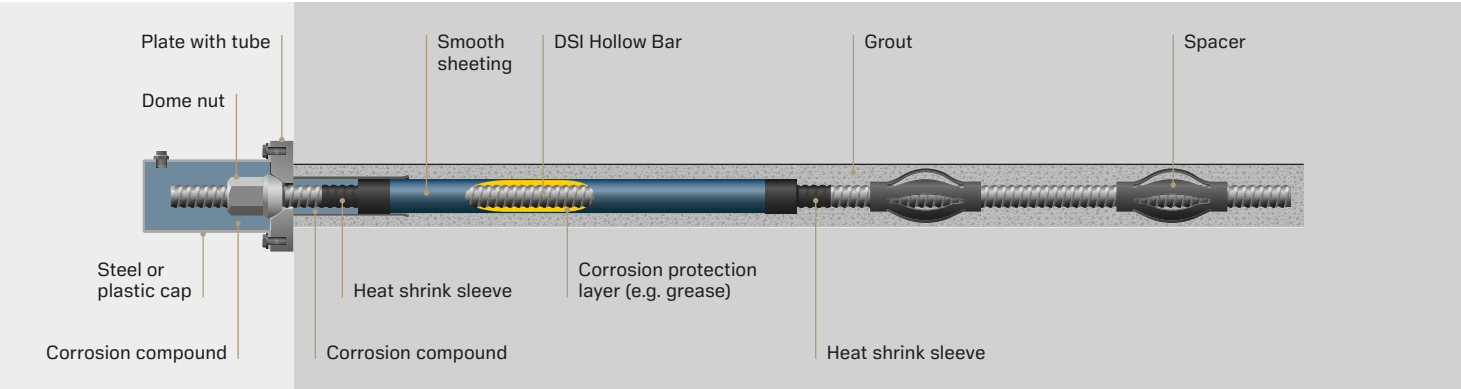
Hollow bar anchors are manufactured in lengths of 3 and 4 meters and transported to the construction site. As a result, the bond length is limited to 4 meters. Compared to conventional solid bar anchors, hollow bar anchors offer the following advantages:

— Fast and optimized self-drilling installation
— Installation possible using walking excavators or small drilling rigs
— Rapid availability due to standardized lengths
— Fully automated installation possible

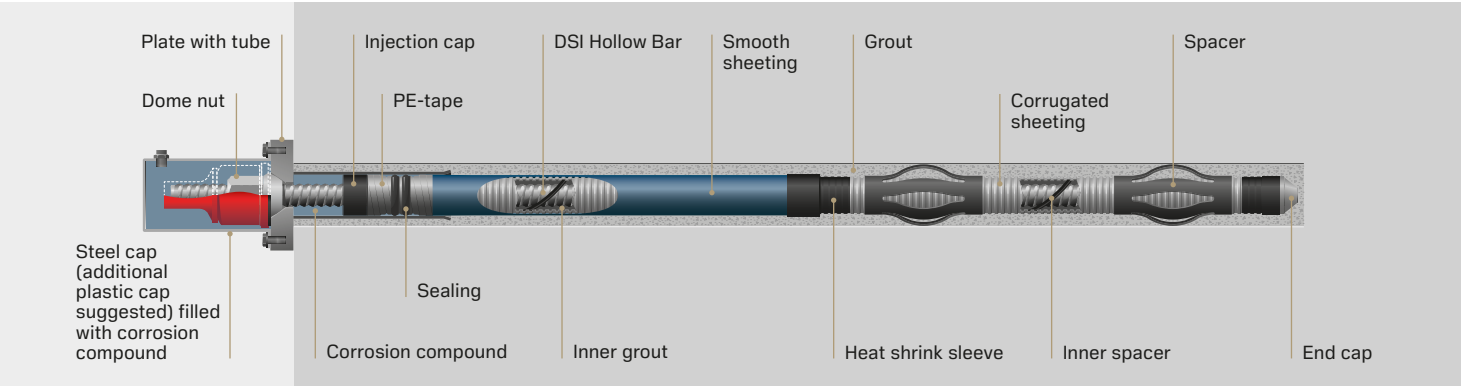
Temporary anchor (standard corrosion protection (SCP))



Semi-permanent anchor

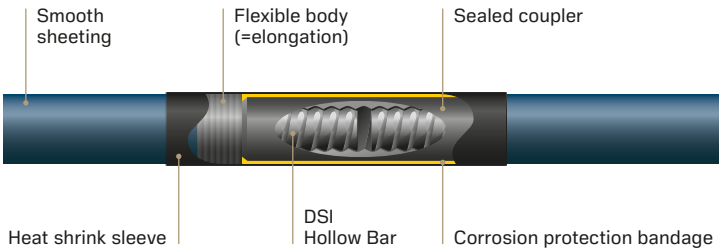


Permanent anchor (with double corrosion protection (DCP))

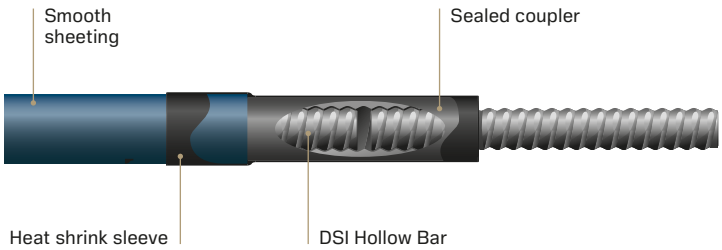


Coupler joint for temporary (SCP) and semi permanent anchors

At L_{tf}

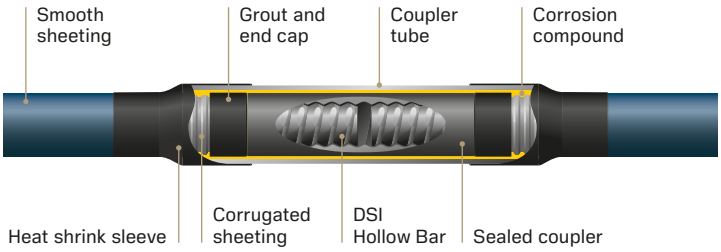


At transition zone between L_{tb} and L_{tf}

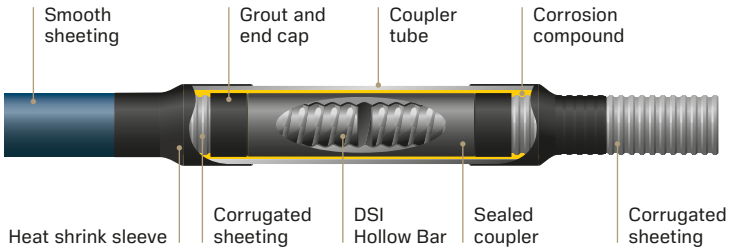


Coupler connection for permanent anchors (DCP)

At L_{tf}

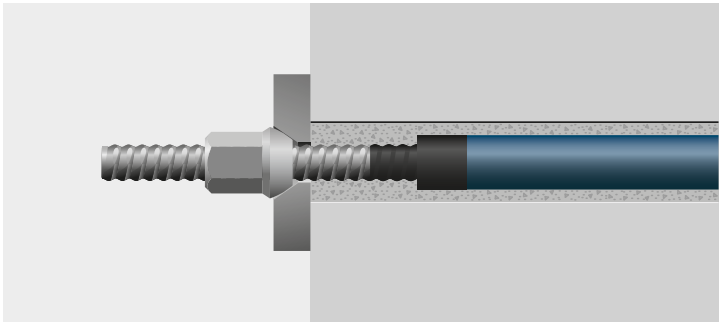


At transition zone between L_{tb} and L_{tf}

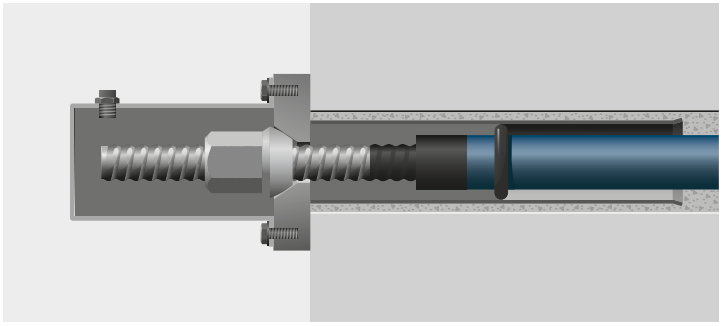


Anchor head layouts

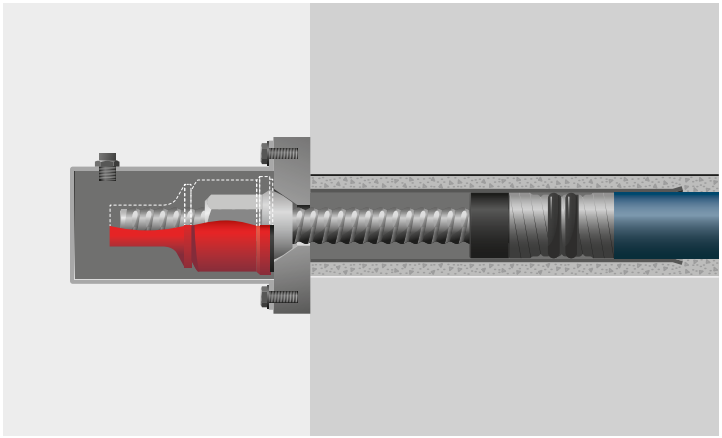
Temporary



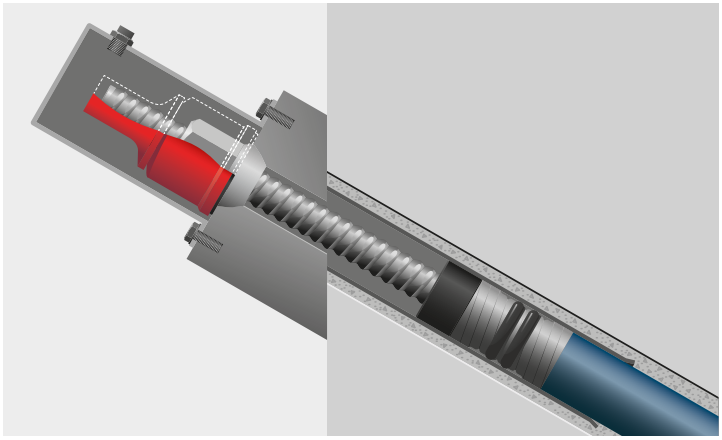
Semi-permanent, fully grouted



Permanent



Permanent with Hybridanker-plate







Strand anchors

General

In strand anchors, the load-bearing elements consist of prestressing steel strands. Each strand is made up of seven smooth, cold-drawn wires – six wires helically wound around a central core wire. There are two available diameters and two different steel grades (see technical data for details). Strand anchors are composed of the following parts:

— **Bond length/anchorage length**
In the bonded section, the load-bearing strand is equipped with spacers to ensure central alignment within the borehole and uniform encapsulation with grout.

— **Unbonded length/free steel length**
It is essential to ensure that no bond forms between the grout body and the steel tendon in this section (verify elongation during the tensioning process!).

— **Anchor head**
In strand anchors, the anchor head consists of an anchor plate with a welded steel pipe sleeve, a wedge plate, wedges, and the appropriate corrosion protection.

Corrosion protection

Depending on the planned service life, the following corrosion protection measures are implemented for the individual anchor components:

	Tempory anchor	**Semi-permanent anchor**	**Permanent anchor**
Intended service life	< 2 years	2-7 years	> 2 years
Bond length	— Grout cover ≥ 10 mm	— Grout cover ≥ 10 mm	— Strands in PE-pipe with inner grout cover ≥ 5 mm, sealed with end cap — Grout cover ≥ 10 mm
Free length	— Individual sheathing of the strands with a smooth PE (polyethylene) tube — End sealing using PE adhesive tape or heat shrink sleeve	— Individual sheathing of the strands with a smooth PE (polyethylene) tube filled with corrosion protection compound — End sealing using PE adhesive tape or heat-shrink tubing	— Individual sheathing of the strands with a smooth PE (polyethylene) tube filled with corrosion protection compound — End sealing using sealing compound and heat shrink tubing — The PE corrugated sheath is extended, ensuring an internal grout cover of ≥ 5 mm
Anchor head	— PE transition sleeves between the anchorage plate and individual strands — Anchor head coated with corrosion protection compound, protected by corrosion protection tape or a cover cap	— PE transition sleeves between the anchorage plate and individual strands — Protective cap filled with corrosion protection compound or anchor head wrapped in multiple layers of corrosion protection tape	— Anchor plate and sealing pipe hot-dip galvanized — Sealing ring between the steel pipe and corrugated sheath — Inner protective cap, tightly fitted and remaining gap filled with corrosion protection compound — Outer protective cap made of steel

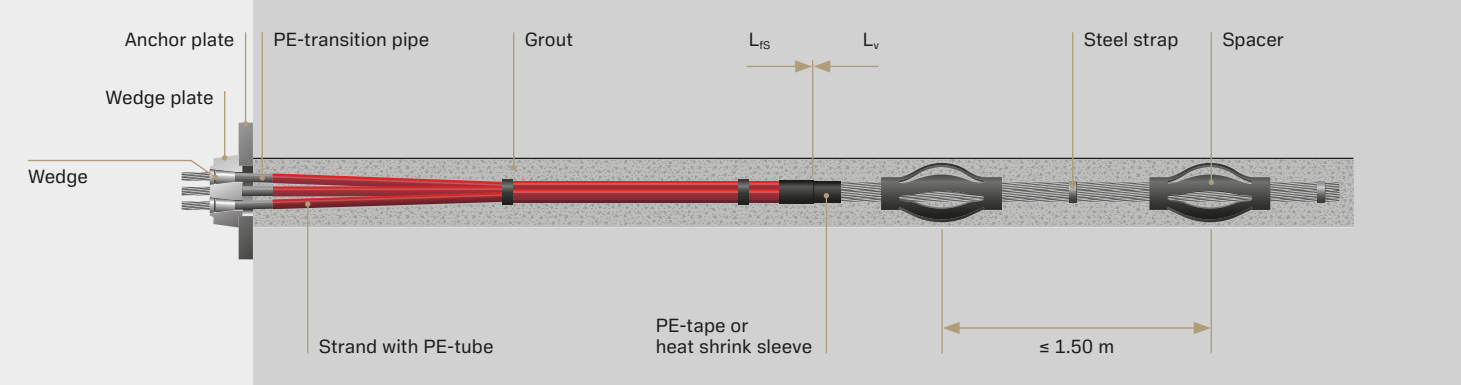
Properties

Strand anchors can be manufactured in nearly any length without the need for couplings. Anchor lengths of up to 150 meters are not uncommon. Due to the elongation (slip) that occurs during tensioning, a practical minimum anchor length of approximately 10 to 15 meters is recommended for economic efficiency. After production, the anchors are coiled and delivered either loosely or on reels. For uncoiling and installation on site, the use of a payoff reel is strongly recommended. When using strand anchors, it is important to note that prestressing steel strands are sensitive to heat and corrosion. Light surface rust (flash rust) is acceptable but should be removed prior to installation.

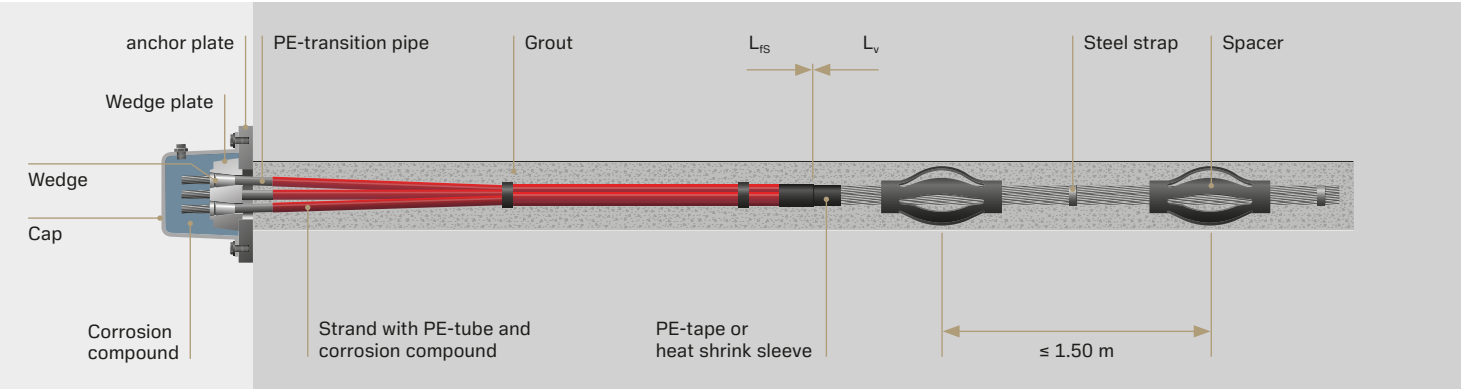
Under no circumstances should welding or cutting with a grinder be performed near the strands without adequate protection. Compared to solid bar anchors, strand anchors offer the following advantages:

— Cost-effective load-bearing elements
— No couplings required, even for very long anchors
— Simple sizing by selecting the appropriate number of strands
— High load capacities achievable
— Fast installation (especially for long anchors)
— Minimal space requirements due to the flexible load-bearing element

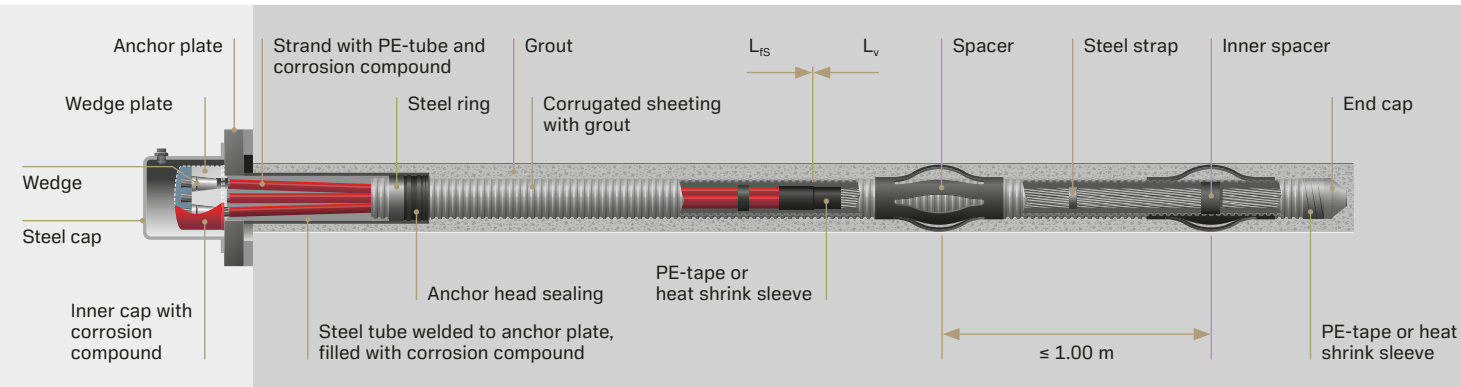
Temporary anchor



Semi-permanent anchor

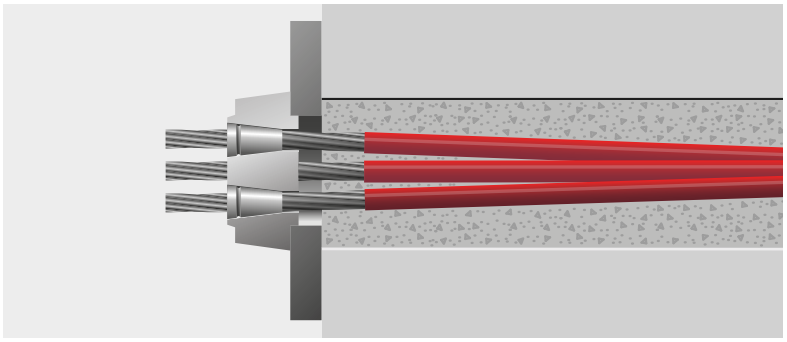


Permanent anchor

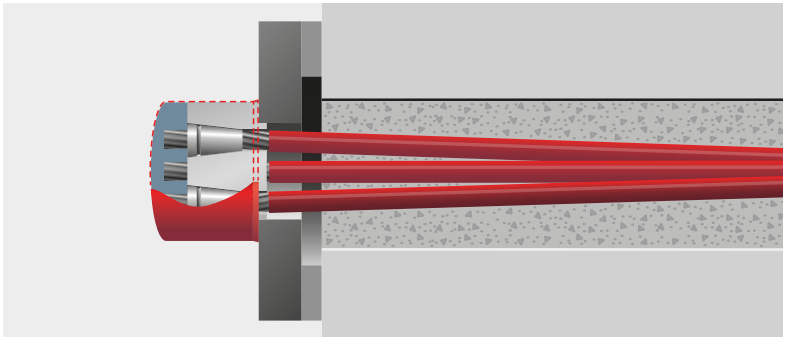


Anchor head layouts

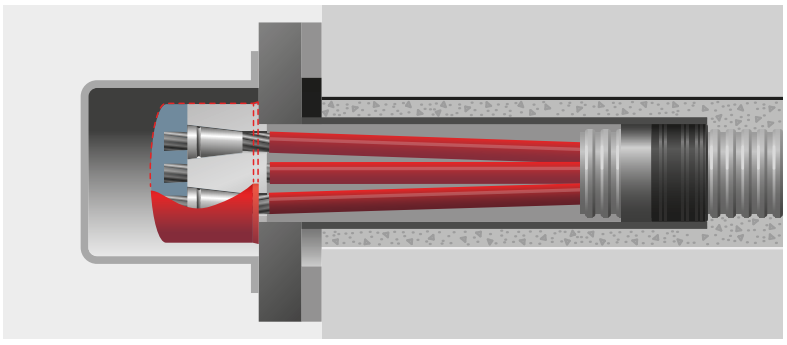
Temporary



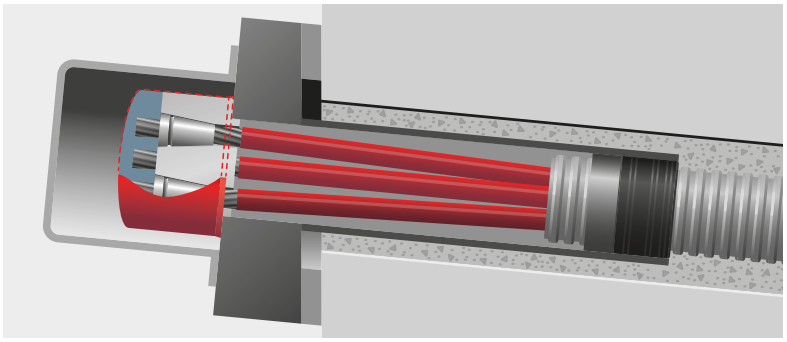
Semi-permanent



Permanent



Permanent with Hybridanker-plate



Removeable anchors

Removable anchors are used for temporary structures that are to be dismantled after construction is completed. A typical application is the support of an inner-city excavation pit using grouted anchors installed into a neighboring property. To avoid affecting the long-term usability of the adjacent land, these anchors are usually removed after the pit is backfilled. Depending on the agreement with the neighboring property owner, several scenarios are possible:

— **Left in place as installed**
If the anchors do not interfere with the use of the neighboring property, they may be left in the ground as originally installed. This is the most cost-effective option for the developer, but it requires consent from the neighboring party. However, if construction activities occur in the future, the presence of pre-tensioned anchors may pose challenges and safety concerns due to their stored energy.

— **Anchor de-tensioning**
To reduce risks for future works, the anchor may be de-tensioned while remaining in the ground. In this case, the steel tendon is no longer under stress and can be safely cut if needed.

— **Partial removal of the anchor**
In a partial removal, only the free anchor length is extracted. This is typically achieved by mechanically weakening the tendon at the transition between the free length and the bonded zone (e.g., inductively), or by integrating a detachable coupling (e.g., a threaded sleeve). As a result, most of the steel tendon is removed, and only the bonded section remains in the ground.

— **Complete removal of the anchor**
If the entire anchor is to be removed, the bonded section must also be destroyed, or a coupling element must be installed at the deepest point of the anchor to transfer the load via a compression body into the soil (e.g., compression pipe anchors). Destruction of the grout bond can be achieved either mechanically using a pull-out cone or by means of a pyrotechnic device (which generates pressure to break the bond). Due to increasing urban density and the need for reliable, process-safe solutions, fully removable anchors are now commonly used. De-tensioning is only used when removal is not feasible.

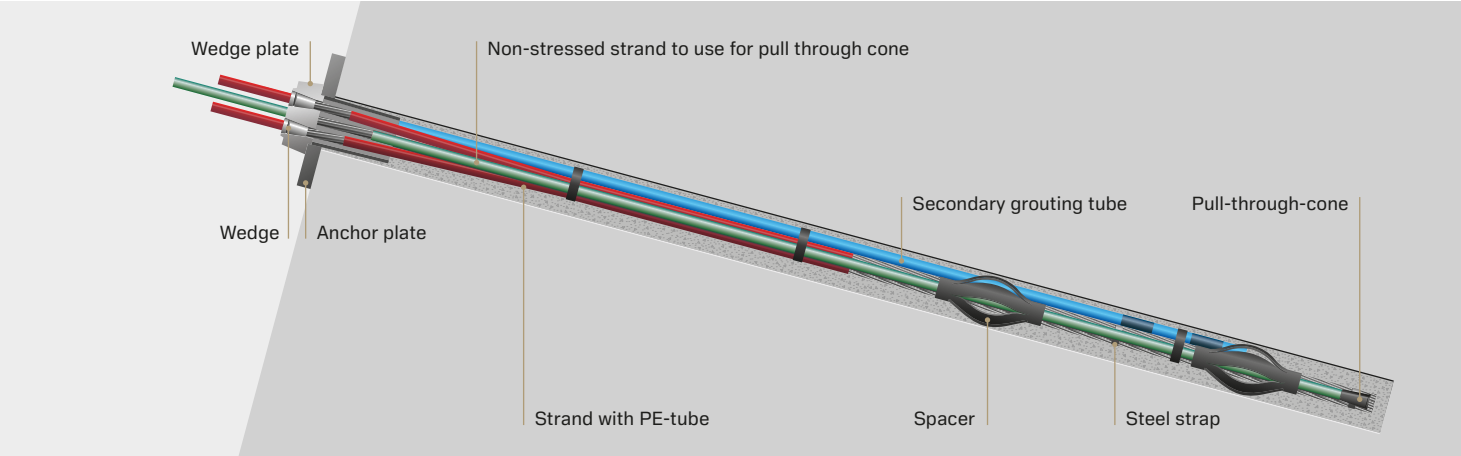
A fully removable anchor means the tendon is entirely extracted, while components such as the grout body or plastic sheathing may remain in the ground. These residual elements are environmentally harmless and do not restrict future use of the soil.

Nonetheless, due to environmental factors, installation errors, or other conditions, it is possible that some anchors remain in the ground despite being designed for full removability.
Any potential impact from these residual tendons must be assessed and managed based on the local conditions.

DSI strand anchors – fully removable with pull-through-cone

DSI fully removable strand anchors with pull-through-cones are used as temporary anchors (optionally with extended corrosion protection). The tension member can be completely removed along its entire length, without compromising load capacity.
A dedicated pull strand is factory-installed along the full length of the steel tendon. This strand is centrally aligned and connected at the lower end to a special pull-through-cone. To ensure easy identification, the pull strand is manufactured approximately 10-20 cm longer than the tensioned strands. In this anchor system, the pull strand has a diameter of 0.62", while the load-carrying strands have a diameter of 0.60".
The pull strand is non-load-bearing and remains unstressed and unanchored during the service life of the anchor. It only becomes active during removal. At that point, it is pulled back using a single-strand jack to approximately 1 meter below the anchor plate. The pull-through-cone at the soil-side end then breaks up the hardened grout body, effectively releasing the bond of the tensioned strands embedded within.
Subsequently, the tension strands can also be freed individually (“free-pull”) from any remaining bond and fully extracted using a single-strand jack, a multi-strand jack, or other suitable removal equipment.

Removeable anchor with pull-through-cone



DSI PyroDebond

In the past, fully removable anchors were sometimes dismantled by explosively destroying the grout body using explosives (e.g., detonating cord). However, this approach involved significant administrative effort to obtain the necessary permits for blasting – particularly in urban or built-up areas. Today, rock-breaking cartridges using pyrotechnic charges are already successfully used for the controlled destruction of large boulders. These systems generate a gas volume that, when confined, produces a high internal pressure, sufficient to fracture rock masses.

Unlike explosives, pyrotechnic systems operate at a lower reaction velocity:

— Commercial explosives: 2,000 to 8,600 m/s
— Pyrotechnic charges: 630 to 1,000 m/s

In addition to fewer regulatory requirements, a key advantage of using pyrotechnics is that they do not produce a detonation wave, making them safer and more suitable for use in sensitive environments, such as inner-city areas.



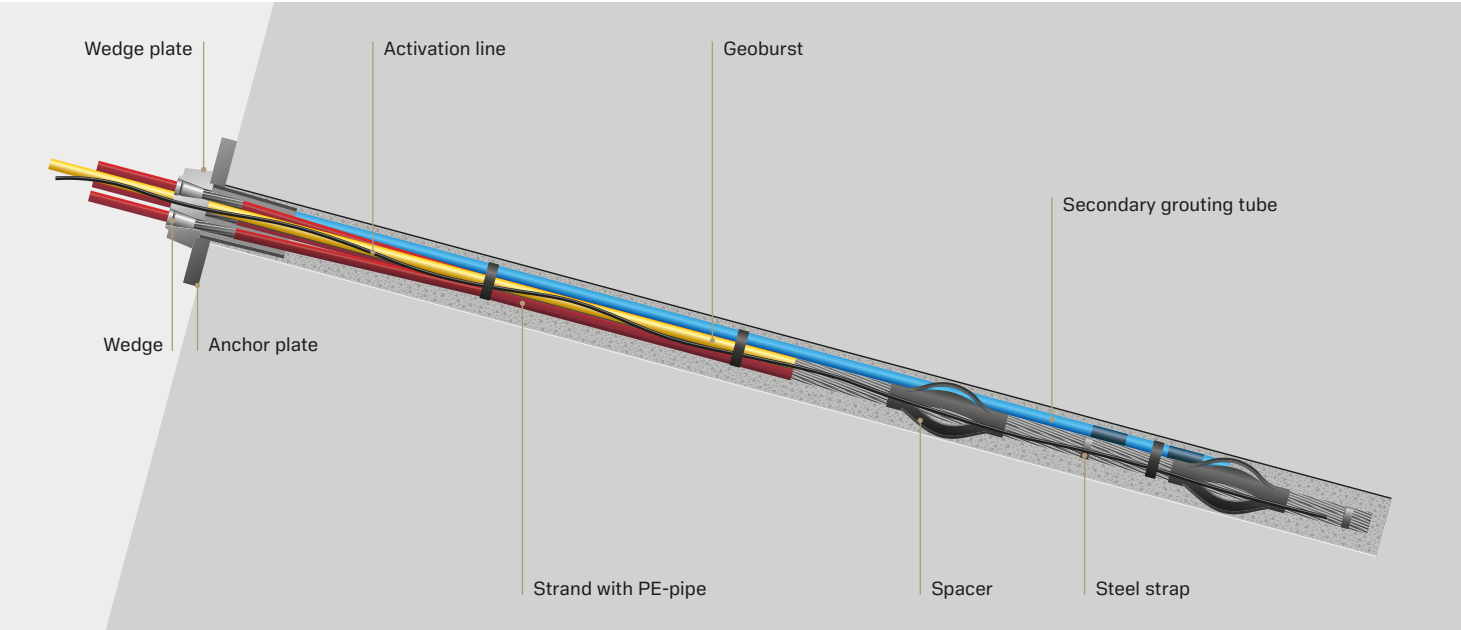
Structure of the PyroDebond System
The basic setup corresponds to that of a temporary or semi-permanent strand anchor. Additionally, in the bond zone, a burst tube (a pipe containing the pyrotechnic charge) is centrally installed and connected to the surface via an ignition cable. This cable is used to initiate the charge during anchor removal, thereby destroying the grout body and breaking the bond.

Function of the rock-breaking cartridge
Explosives are defined as materials intended to release energy through deliberately triggered chemical reactions in such a way that solid bodies can be fractured. However, the shockwaves generated by explosives are highly undesirable in urban environments, where they can cause damage to surrounding buildings and infrastructure during anchor removal.
In contrast, pyrotechnic charges (such as rock-breaking cartridges) cannot be triggered arbitrarily. When ignited without confinement, only the igniter reacts, and no full reaction of the pyrotechnic powder occurs.
The main component of the “DSI Geoburst” pyrotechnic charge is a CE-certified propellant based on nitrocellulose (NC). These powders are rigorously tested to ensure they cannot detonate. A secondary component, ammonium nitrate, improves the oxygen balance of the reaction, reducing the toxicity of the exhaust gases. The reaction velocity ranges between 630-1,000 m/s, which is comparable to the speed of a rifle bullet.
The required safety distance depends on the specific site conditions and must be determined by a trained operator.

Rock-breaking cartridges, in their original packaging, are classified as category 1.4 S, similar to sporting or hunting ammunition. Transport can be carried out using a regular passenger car or truck. For storage, a lockable cabinet or secured storage room is sufficient. Access must be restricted to authorized personnel, and protection against unauthorized access (e.g., children) must be ensured.

Installation and removal of the PyroDebond Anchor
The installation procedure is the same as for standard temporary strand anchors, with a few additional considerations:
Installation checklist:
— Check the resistance of the ignition cap before and after installation to confirm functionality
— This measurement must be performed with a voltage-free meter and should yield 3 Ohms
— Secure storage of the ignition cable in the anchor head area

Removal procedure:
— Clean the anchor head and the ignition unit
— Initiate the pyrotechnic charge using trained and authorized personnel, following all safety regulations and distance requirements
— Free the individual strands from any remaining partial bond (“free-pull”)
— Remove the anchor using a winch, excavator, or manually
— If necessary, cut the strands during the removal process



Anchor installation



Tensioning of anchor



Anchor prior removal



Anchor removal





Transport, storage, and installation

The installation of grout anchors is always tailored to the specific application and construction site. Below is an overview of general guidelines and recommendations for transport, storage, and installation. Detailed, project-specific instructions are available upon request.

Transport

When transporting grout anchor systems, the following must be observed:

— The systems must not be thrown or dropped.
— Damage to bars, strands, or corrosion protection (particularly coatings or plastic sheathing for DCP systems) must be avoided.
— Use the factory-installed lifting loops when loading and unloading.
— On-site transport should be carried out by hand, over the shoulder, or using carrying straps.
— When transporting with a crane hook, ensure sufficient support points are used.
— The systems must be protected against corrosion in accordance with the applicable requirements.



Storage

The following rules apply to the proper storage of grout anchors:

— Systems must be stored off the ground and free from contamination.
— A temporary corrosion protection must be ensured (e.g., by covering or storing under a roof).
— Support points must be free of sharp edges to avoid damage to the corrosion protection. The distance between supports should be short enough to prevent harmful sagging due to self-weight.
— Systems must be stacked only to the extent that no deformation occurs due to their own weight. Special care must be taken with strand anchors to ensure that the unfilled corrugated sheathing is not crushed.





Installation

Grout anchors are installed either self-drilling or into pre-drilled boreholes. Pre-drilled boreholes are typically drilled with casing. Only in very stable or rocky ground conditions can drilling be done without casing. During installation, the following must be ensured that:

— The corrosion protection remains undamaged.
— Required (spring basket) spacers are installed at the specified intervals before installation.
— Coupling joints are assembled before or during installation in accordance with the specifications (adhesive quantity, locking torque, securing screws, etc.).
— Temporary protective transport measures are removed.
— Grouting pipes are mounted and secured.
— The borehole is filled from the lowest point upward.
— Grouting parameters (volume, pressure, etc.) are recorded.
— Re-grouting is carried out if necessary, after the appropriate curing time.
— The anchor head is constructed according to the specified requirements.
— Continuous corrosion protection is ensured throughout the anchor.
— Quality assurance is documented comprehensively throughout the transport, storage, and installation process.













Equipment

Hydraulic hollow-piston jacks are used for the tensioning of DSI solid bar systems. Two design variants are available:

— Metal version made of steel or aluminum
— Version made of carbon fiber reinforced plastic (CFRP)

The metal version offers greater robustness. Potential operating errors (e.g. eccentric loading, dropping the jack, etc.) are usually less critical than with CFRP models. However, due to their low weight, CFRP jacks are now used primarily. The weight reduction is 60 % or more.



Portable hollow-piston cylinders in lightweight CFRP design

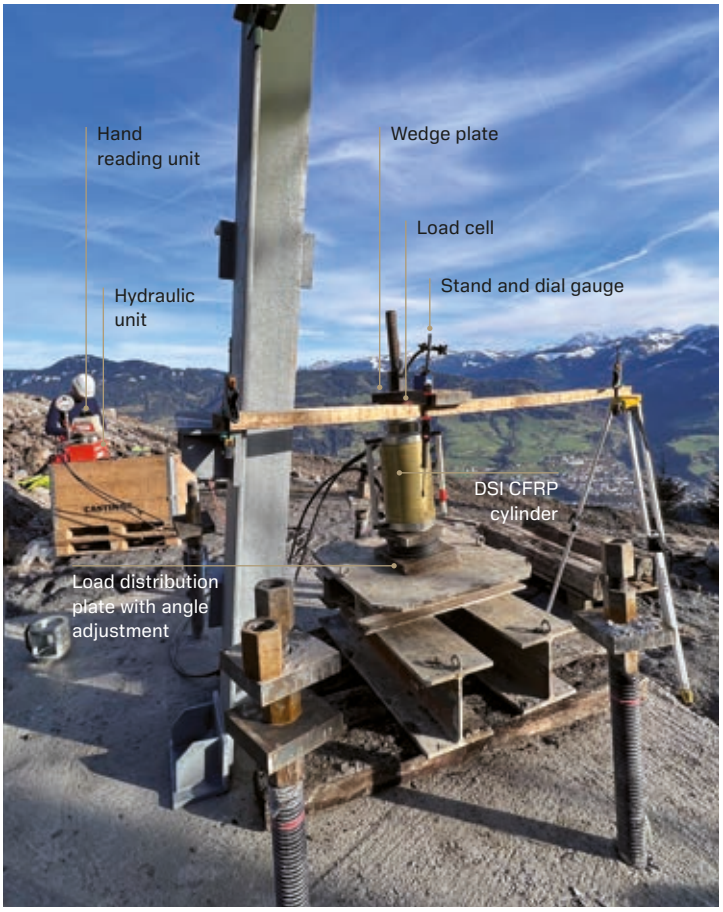
Lightweight CFRP hollow-piston cylinders ensure simple, fast, and efficient positioning and handling. In most cases, no lifting equipment is required for transport or assembly. These cylinders are primarily used in bridge construction, prestressed concrete, and geotechnical engineering.
The cylinders are available in standard versions with pressing forces ranging from 80 t to 500 t. Especially in geotechnical applications, the lightweight CFRP cylinders offer a significant advantage. The most commonly used device for this purpose weighs only 25 kg and provides a performance capacity of 120 t. External grout cylinders and tensioning chairs for tendon and ground anchors can be connected to CFRP hollow-piston cylinders. With minimal effort, they are used for quick tensioning and testing of bar and strand anchors.

Key features:
— Easy to operate and universally applicable
— Significant reduction in physical strain on personnel
— Hydraulic retraction for fast piston return
— Overload protection and pressure relief valve to prevent damage due to overpressure
— High-quality wiper rings on the piston rod prevent the ingress of dirt particles
— Impact protection through aramid sheathing
— Corrosion resistance thanks to premium materials and high-tech coating
— Operating pressure: 700 bar
— Available in standard and custom sizes

Accessories

To ensure optimal use of the CFRP hollow-piston cylinders, we also offer a wide range of accessories. These have been developed in collaboration with our specialists – by professionals, for professionals. Among the available items are:

Accessory	Description
Bushing	For tensioning and testing of strand anchors
Centralizing device	For tensioning and testing of bar systems
Tension chair	With or without screwing chair
Hand pump	Hydraulic unit powered by hand for tensioning a cylinder
Hydraulic power unit	Electric hydraulic pumps for tensioning the cylinder
Hydraulic wedge unit	For hydraulic pre-wedging in strand systems to reduce slip
Load cell	Analog or digital readout of the applied force
Stand and dial gauge	Dial gauges for measuring deformations and devices for mounting/fixation



DSI CFRP hollow-piston cylinder (compression load: 80 to 500 t, pressure: 700 bar)

Type	Load	Jack stroke	Inner diameter	Weight	Dimensions (Ø and height)	Piston area
80 t	897 kN	100 mm	90 mm	17 kg	190 x 280 mm	115.4 cm²
100 t	1,018 kN	150 mm	90 mm	24 kg	212 x 328 mm	144.1 cm²
125 t	1,264 kN	180 mm	90 mm	29 kg	224 x 362 mm	180.6 cm²
140 t	1,438 kN	250 mm	105 mm	40 kg	251 x 448 mm	200.9 cm²
180 t	1,829 kN	250 mm	110 mm	52 kg	276 x 441 mm	261.3 cm²
200 t	2,006 kN	250 mm	130 mm	68 kg	312 x 463 mm	286.6 cm²
250 t	2,511 kN	250 mm	130 mm	83 kg	334 x 490 mm	358.7 cm²
320 t	3,208 kN	300 mm	150 mm	120 kg	387 x 548 mm	458.0 cm²
360 t	3,609 kN	250 mm	150 mm	102 kg	376 x 481 mm	515.7 cm²
420 t	4,219 kN	250 mm	110 mm	113 kg	380 x 506 mm	602.7 cm²
480 t	4,821 kN	150 mm	140 mm	117 kg	563 x 412 mm	688.8 cm²
500 t	5,000 kN	360 mm	180 mm	217 kg	456 x 653 mm	724.3 cm²

Measuring and testing equipment

Load cell (LC)

Load cells are used for short-term or permanent measurement and monitoring of anchor forces.
The LC is installed under the anchor nut, usually between two plates, and connected to an analog or digital readout device.
Wireless solutions for reading the load are also available and are primarily used in hard-to-access areas.

Key features
- Load cell for nominal loads from 800 kN to 10,000 kN
- The nominal load corresponds to the sustained (permanent) load
- 30 % overload capacity for short durations
- Elastic element made of stainless steel
- Suitable for use in aggressive environments (e.g., acid- or chloride-containing areas such as road tunnels or bridge undersides)
- Protection class IP 68
- Integrated temperature sensor
- Integrated signal amplifier
- Resistant to long cable lengths and electrical interference
- Measurement signal output in V and mV/V
- Automatic identification of the load cell via integrated memory (stores location, cell number, installation date, etc.)
- Durable, UV-, acid-, and oil-resistant signal cables
- Long-lasting, waterproof Lemo connector
- Optional surge protection
- Flexible cable lengths between the load cell and readout device





Portable readout device for all LCs with mobile app support

A highly popular solution for reading force data from LCs is a portable readout adapter with smartphone connectivity.
A dedicated mobile app allows users to read and store various data.

Key features

— Display of load cell force and cell temperature
— Display of the KMD serial number
— Display of user-entered information, such as cell ID, construction site, etc.
— Force resolution: 1 kN
— Temperature resolution: 0.5 °C
— Operating temperature: -25 °C to +50 °C
— Powered via smartphone battery
— Weight: < 2 kg
— Housing made of high-impact resistant plastic
  - Airtight
  - Shockproof
  - Break-resistant
  - Waterproof (IP67)
  - Sand- and dust-proof
  - Acid-resistant
  - Pressure-resistant
— Display of a graph of measurement values
— Storage of measurement values
— Option to export measurements as a CSV file

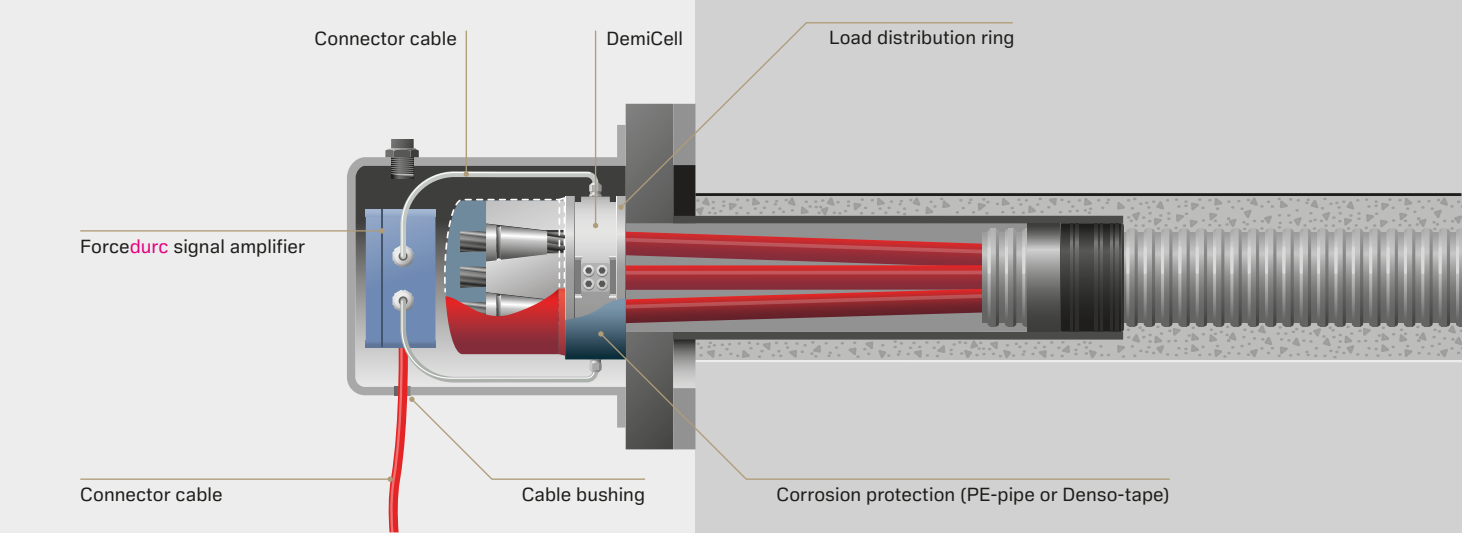


DemiCell (DC)

While permanent grout anchors are designed for a service life of 100 years or more, load measuring devices typically reach the end of their lifespan much earlier. For this reason, replaceable load cells are increasingly being requested.
At the same time, split load measuring devices allow for retrofitting into existing systems. However, this requires that the tendons have sufficient elongation capacity, or that relieving rings have been installed which can be removed.
DemiCells can either be read remotely via a monitoring system or locally using a portable readout device.

The DemiCell split load cell offers, for the first time, a combination of a simple, robust solution for force measurement with the ability to replace or retrofit the unit – all while maintaining minimal dimensions.
In addition to the features of standard KMDs, the DemiCell offers the following benefits:

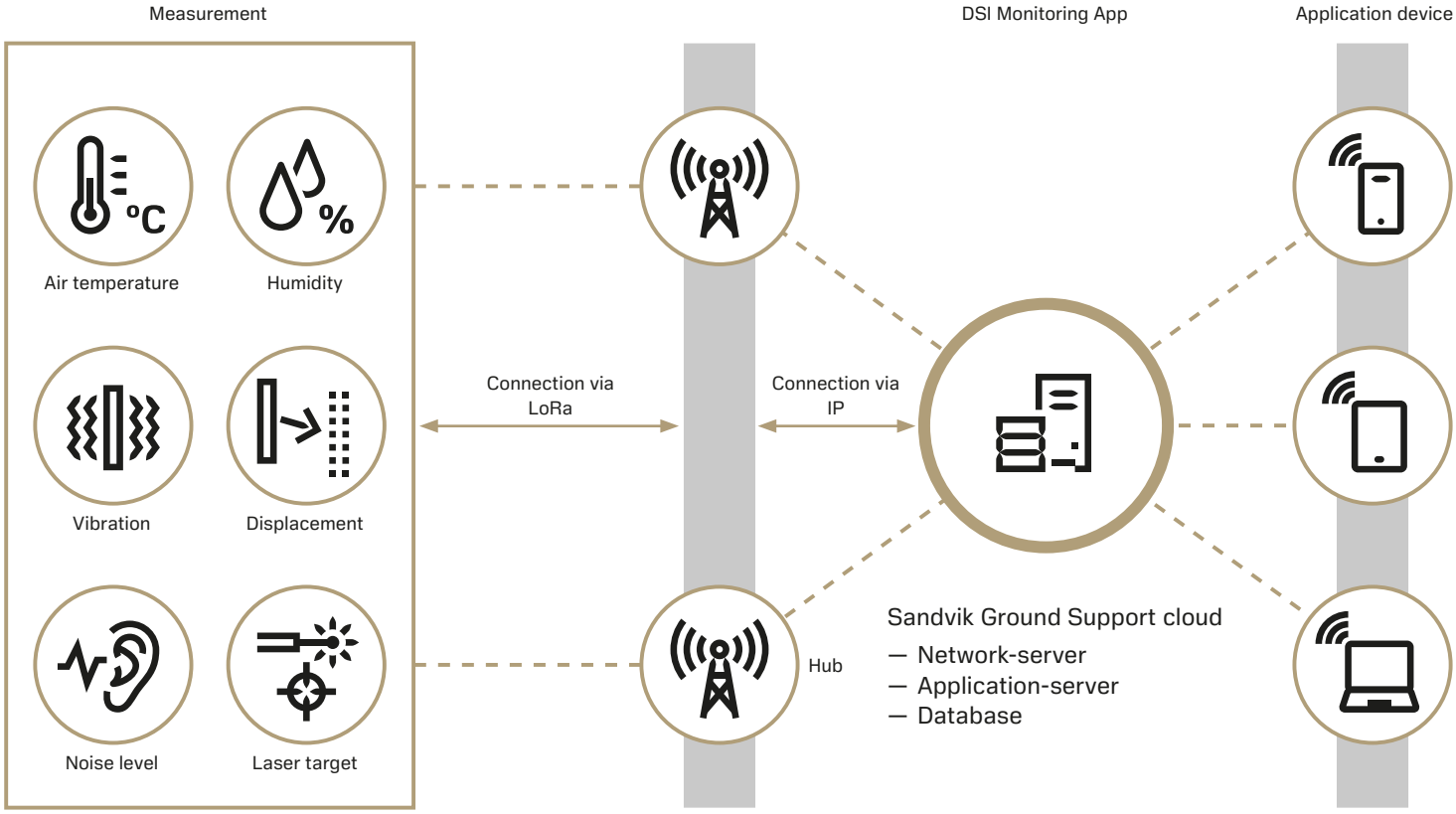
— Two-part design allows for replacement
— Load distribution rings included
— Minimum installation height of just 15 mm possible
— Replacement can be carried out during a lifting test
— Protected against mechanical impact by an external anchor cap



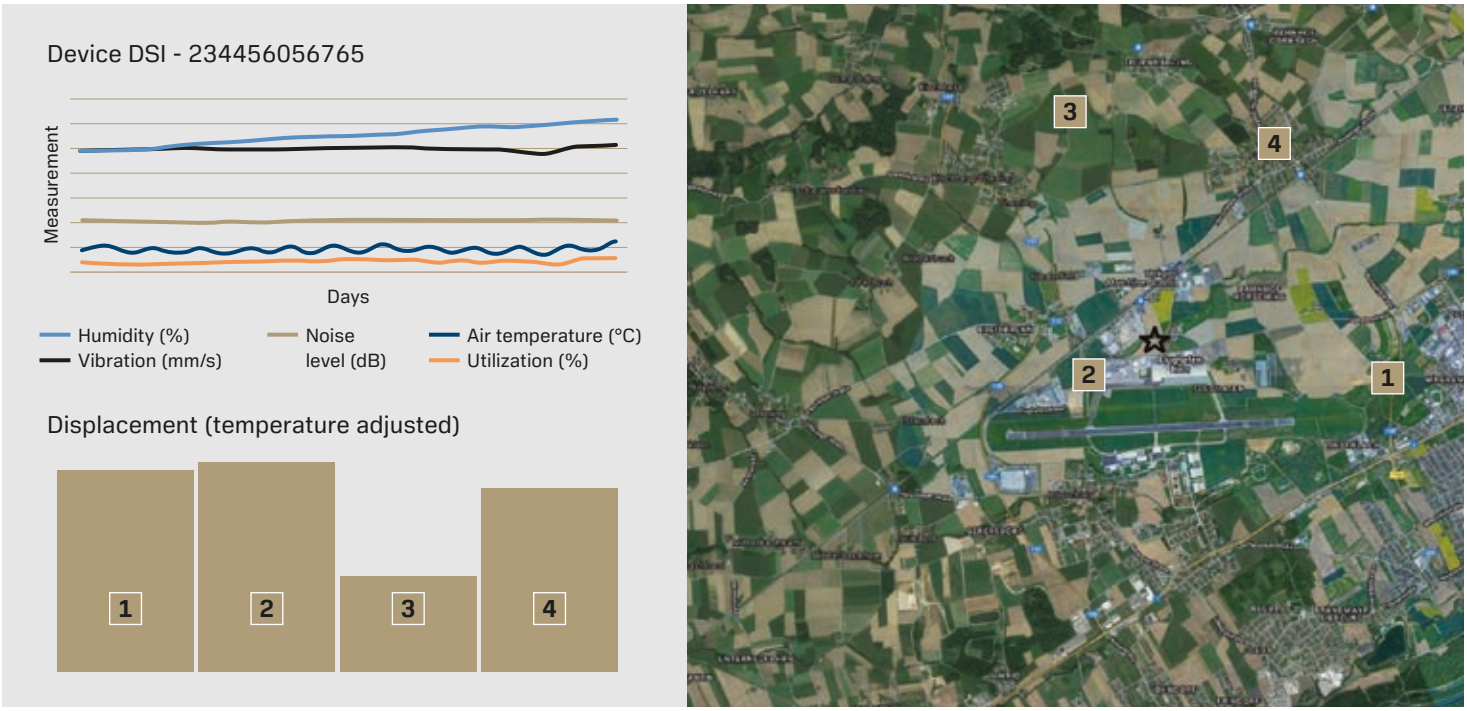




DSI monitoring applications (data transmission)



Georeferenced visualisation



Further references

Norm	Description
DIN 8061: 2016	Unplasticized polyvinyl chloride (PVC-U) pipes – General quality requirements, testing
DIN 8062: 2009	Unplasticized polyvinyl chloride (PVC-U) pipes – Dimensions
DIN 8074: 2011	Polyethylene (PE) – Pipes PE 80, PE 100 – Dimensions
DIN 8075: 2018	Polyethylene (PE) – Pipes PE 80, PE 100 – General quality requirements, testing
EAD 160004-00-0301: 2016	European Assessment Document for post-tensioning kits for prestressing of structures
ETAG 013:2002	Guideline for European Technical Approval of post tensioning kits for prestressing of structures
ISO 15835-1: 2018	Steels for the requirement of concrete – Reinforcement couplers for mechanical splices of bars – Part 1: Requirements
ISO 15835-2: 2018	Steels for the requirement of concrete – Reinforcement couplers for mechanical splices of bars – Part 2: Test methods
ÖNORM B 1997-1-1: 2021	Eurocode 7: Geotechnical design – Part 1: General rules – National specifications concerning ÖNORM EN 1997-1 and national supplements
ÖNORM B 1997-1-3: 2015	Eurocode 7: Geotechnical design – Part 1-3: Pile foundations
ÖNORM B 4456: 2021	Geotechnic – Durability of anchorages
ÖNORM B 4707: 2017	Steel for the reinforcement of concrete – Requirements, classification and testing
ÖNORM B 4758: 2014	Prestressing steel – Requirements, classification and conformity assessment
ÖNORM EN 10025-2: 2019	Hot rolled products of structural steels Part 2: Technical delivery conditions for non-alloy structural steels
ÖNORM EN 10083-3: 2006	Steels for quenching and tempering – Part 3: Technical delivery conditions for alloy steels
ÖNORM EN 10216-1:2014	Seamless steel tubes for pressure purposes – Technical delivery conditions – Part 1: Non-alloy steel tubes with specified room temperature properties
ÖNORM EN 10217-1:2019	Welded steel tubes for pressure purposes – Technical delivery conditions Part 1: Electric welded and submerged arc welded non-alloy steel tubes with specified room temperature properties
ÖNORM EN 12501-1: 2003	Protection of metallic materials against corrosion – Corrosion likelihood in soil Part 1: General
ÖNORM EN 12501-2: 2003	Protection of metallic materials against corrosion – Corrosion likelihood in soil Part 2: Low alloyed and non alloyed ferrous materials
ÖNORM EN 14199: 2016	Execution of special geotechnical works – Micropiles
ÖNORM EN 14490: 2010	Execution of special geotechnical works – Soil nailing

Norm	Description
ÖNORM EN 1537: 2015	Execution of special geotechnical works – Ground anchors
ÖNORM EN 1990: 2020	Eurocode – Basis of structural and geotechnical design
ÖNORM EN 1992-1-1: 2018	Eurocode 2: Design of concrete structures Part 1-1: General rules and rules for buildings
ÖNORM EN 1997-1:2014	Eurocode 7: Geotechnical design Part 1: General rules
ÖNORM EN 206:2017	Concrete – Specification, performance, production, and conformity
ÖNORM EN 445:2008	Grout for prestressing tendons – Test methods
ÖNORM EN 446:2008	Grout for prestressing tendons – Grouting procedures
ÖNORM EN 447:2017	Grout for prestressing tendons – Basic requirements
ÖNORM EN ISO 1461: 2022	Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods
ÖNORM EN ISO 17855-1: 2015	Plastics – Polyethylene (PE) moulding and extrusion materials Part 1: Designation system and basis for specifications
ÖNORM EN ISO 22477-1: 2019	Geotechnical investigation and testing – Testing of geotechnical structures Part 1: Testing of piles: static compression load testing
ÖNORM EN ISO 22477-2: 2022	Geotechnical investigation and testing – Testing of geotechnical structures Part 2: Testing of piles: static tension load testing
ÖNORM EN ISO 22477-5: 2019	Geotechnical investigation and testing – Testing of geotechnical structures Part 5: Testing of grouted anchors
ÖNORM EN ISO 683-1:2018	Heat-treatable steels, alloy steels and free-cutting steels Part 1: Non-alloy steels for quenching and tempering
ÖNORM EN ISO 9001: 2015	Quality management systems – Requirements
RVS 08.22.01: 2013	Grouted anchors, nails and grouted piles subjected to tension (GPT)
ÖNORM EN 13438	Paints and varnishes – Powder organic coatings for hot dip galvanised or sherardised steel products for construction purposes
ÖNORM EN 15773	Industrial application of powder organic coatings to hot dip galvanized or sherardized steel articles (duplex systems) — Specifications, recommendations and guidelines
ASTM A153	Standard specification for zinc coating (hot dip) on Iron and steel hardware
ASTM A775	Standard specification for epoxy-coated steel reinforcing bars

All dimensions, weights, quantities, and specifications are those applicable at the time of this publication and may be amended from time to time. Please contact your local representative for final confirmation of any key specifications.

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