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Grouted Anchors

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Content

Pumping station in Charlottenburg, Berlin, Germany
A sheet pile wall with grouted anchors, was created for the new main pumping station in Berlin-Charlottenburg.

Applications

Since its invention in 1958, the grouted anchor has provided an unobtrusive, cost-effective and time-saving solution. Excavation pits can be constructed without obstructive struts; piling walls and sheet pile walls can be anchored without problems. Grouted anchors can also be used to secure steep slopes, retaining walls and quay walls.

Excavation pit, Germany
Anchor drilling works were carried out using a KLEMM KR 806 for a water-impermeable and 12 m deep retaining structure, for a new residential and office building.

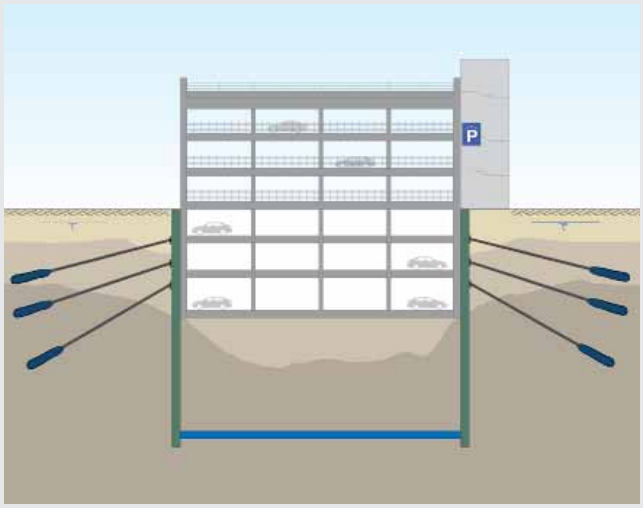

2115
2113

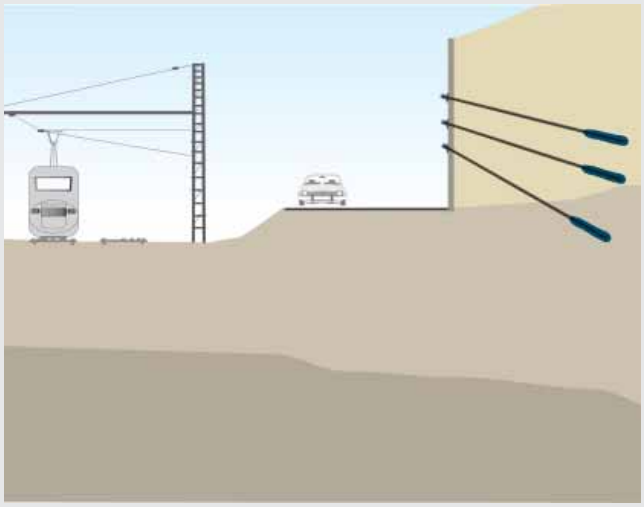
Excavation Pit

A retaining structure is used in situations where a sloped excavation pit is not possible due to space restrictions. In addition to the various retaining structures, the focus is on the grouted anchor: by absorbing the forces generated by the earth pressure, the grouted anchor prevents excavation pit walls from caving in, and consequently stops soil from shifting. As excavation pits are temporary construction measures, temporary anchors are used for a maximum life cycle of two years.

Slope Stabilization

In places where transport routes run through narrow valleys, over mountains or hilly terrain, or where commercial spaces are extended along slopes, cutting into the natural slope is necessary. Due to the limitation in terms of space, securing the slope often can't be achieved, without a retaining structure. In these cases, the terrain is secured by means of a retaining structure, which are further tied-back with permanent anchors to improve safety.





UpperNord Tower, Düsseldorf, Germany
To protect the vast excavation pit of the UpperNord Tower in Düsseldorf, around 5,300 m of anchors, with three to six strands and a drilling length of up to 24 m, were constructed. An anchor drilling rig type KR 806 from KLEMM Bohrtechnik GmbH was used for the anchor works, and a second layer of anchors was put in place to protect against pressing groundwater.

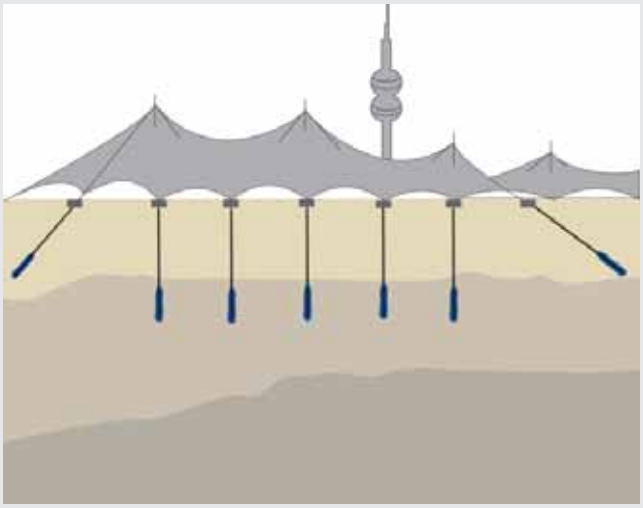
Mainz Ring Road, Mainz, Germany
In the course of the A60 freeway expansion of the Mainz Ring Road at Mainz-Hechtsheim, the freeway was lowered by 14 m and partly tunnelled whilst the traffic was still running. 26,000 temporary and 20,000 permanent anchors were installed as tie backs for the piling walls.

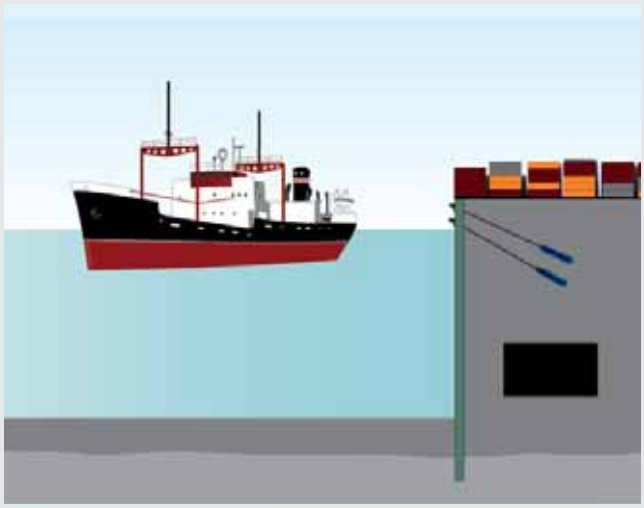
Foundation Tie Back

Building loads are generally applied to the construction soil as compressive forces on foundations. Tension anchors present an alternative for discharging tensile forces into the construction soil. These tensile forces are created in structures such as suspension bridges or tent-roof constructions of buildings, e.g. the Olympic Stadium in Munich. If foundations are tied-back by means of grouted anchors to discharge the tensile forces, the grouted anchors become a permanent part of the structure.

Bank Reinforcement

In harbors and piers on waterways, a sufficient water depth is required to enable ships to dock. In these areas, quay and bank walls are often tied-back with single bar permanent anchors. The required installation of grouted anchors from the water side presents a particular challenge in these situations. In these cases, the anchors are often created from work pontoons.





Small Olympic Hall, Munich, Germany
For the new Small Olympic Hall building, an excavation pit with 1,300 m² of tied-back MIP walls, 750 m² of king pile walls, and 820 m² of secant pile walls were created. The foundation had to be secured with 29 m long permanent strand anchors as part of the roof foundations of the adjacent indoor swimming pool protruded into the excavation pit. During the works, impeccable permanent anchors from Bauer, dating back to 1971, were excaveted.

Zerben Lock, Elbe-Havel Canal, Germany
In parallel with the existing Zerben lock between Magdeburg and Berlin, a new and larger lock basin was created, designed to accommodate the dimensions of modern European push barges. Bauer installed over 20,000 m² of partly tied-back sheet pile walls and 10,000 m² of excavated, reinforced diaphragm walls, as well as 930 uplift piles.

Methods

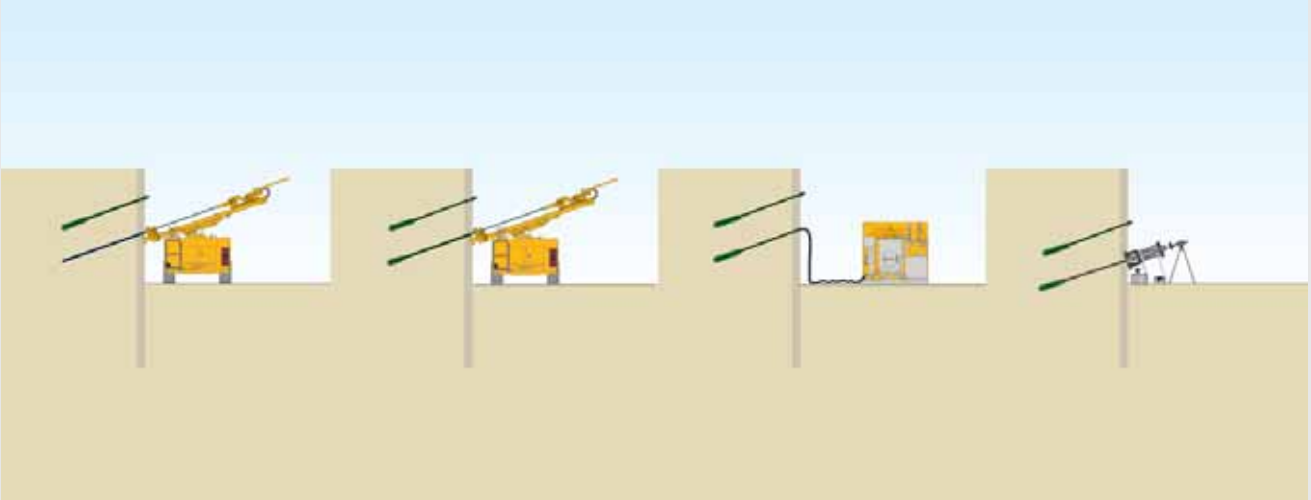
Different methods can be used in the manufacture of grouted anchors, depending on the requirement. As an option, grouted anchors can also be engineered as temporary or permanent anchors and as removable or staggered anchors. As required, grouted anchors can also be installed above groundwater or against pressing groundwater. The Bauer grouted anchor can also be used in all types of soil and rock.

Q6/Q7, Mannheim, Germany
For the Q6/Q7 inner-city shopping mall, 33,000 m of temporary anchors were constructed, including 27,700 m against pressing groundwater.


HITACHI
KLEMM

Anchor Drilling Works

The choice of the anchor drilling method needs to be aligned with the existing construction soil and the conditions of the respective site, such as neighboring buildings, groundwater or cramped spaces. Anchor drilling works are generally executed with rotary drilling, rotary percussive or inner and outer drill rods in double-head method. Auger or down-the-hole hammer drillings are possible in stable grounds. After completition of the bore, the anchoring tendon is installed in the bore hole and mortar is pressed into the area of the grout body directly afterwards. The drill rods are pulled out of the bore hole during this primary grouting process. The grout body is then cracked and multiple grouting is performed, via the post-grouting pipes attached to the anchoring tendon as necessary. After hardening of the grout body, the anchor head is installed, and the anchors are then subjected to a standard acceptance test and set to the necessary structural prestress loads.



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The bearing capacity of grouted anchors is determined by the geological conditions in the area of the grout bodies. In the case of non-cohesive soils – such as sand or gravel – primary grouting is usually sufficient. If the grout body is located in cohesive soils, such as silt or clay, the anchor is additionally post-grouted, which increases its load-bearing capacity by up to 30%.

Agnes-Pockels-Bogen, Munich, Germany
Works for a MIP wall with 8,000 m² and tie backs up to a depth of 20 m, were carried out for a new office complex on the fields of the former gas works, near the headquarters of the Munich City Utilities.

Embankment remediation, Vilseck, Germany
Around 42,000 m² of Mixed-in-Place ground improvement elements were created as individual barettes, for the remediation of a total of three railway embankments. To monitor displacements of the embankment, inclinometer pipes were fitted by using an anchor drilling rig.

Factory reconstruction, Germany
During the reconstruction of an operational factory, additional buildings were transferred into the construction soil via micropiles, with a length of up to 30 m. The works were completed over several stages using a small drilling rig.

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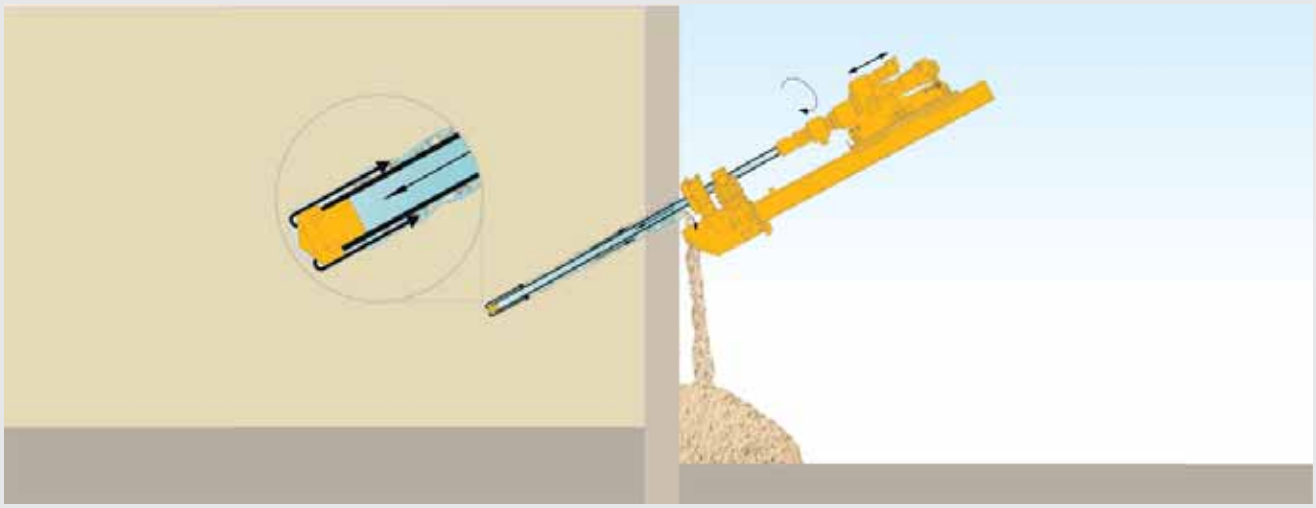
Anchor drilling works can be carried out using the following methods:

- **Rotary percussive drilling**
- **Double-head system**
- **Auger drilling**
- **Down-the-hole hammer drilling**

Railway line route, Diez, Germany
Near Diez in Rhineland-Palatinate, the adjacent railway line was expanded during operational breaks at Deutsche Bahn, and the necessary drilling levels were adjusted. Over a total of ten weekends, foundation piles, secant pile walls and tie backs were installed.

Rotary Percussive Drilling

The rotary percussive method is a highly productive drilling method which can be used in sand and gravel. In this case, the drill rod is locked with a drill bit at the lower end before start of drilling. The drill rod rotates and water is pumped through the interior of the drill rod to the drill bit, via the rotary swivel of the anchor drilling rig. At the same time, the hydraulic hammer strikes the top end of the drill rod, thereby supporting the action of breaking up the ground at the drill bit. The loosened soil is moved to the side and additionally transported to the initial drilling location, aided by the water-flush. Upon reaching the final depth, and prior to dismantling the drill rod, the drill bit is lost. The rotary method is used for low drilling resistance and, with increasing drilling resistance, the hammer mechanism of the hydraulic hammer will be switched on. Anchor drilling rigs with drill rod magazines could be used for rotary percussive drilling.



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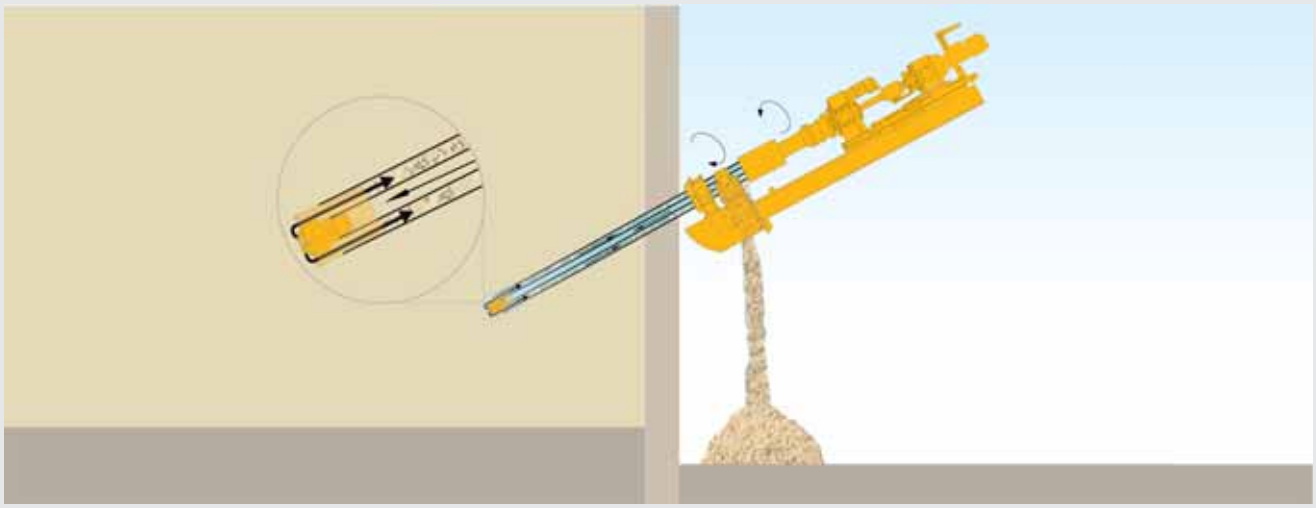
Advantages

- **Productive and cost-effective**
- **Use of single drill rods**
- **Hammer action supports drilling**

Dreiländergalerie, Weil am Rhein, Germany
Together with the Environment division of Bauer Resources, Bauer Spezialtiefbau created an excavation pit with a depth of up to 18 m, for the planned Dreiländergalerie shopping mall in Weil am Rhein. In addition to a Mixed-in-Place ground improvement wall and a secant pile wall, approx. 400 anchors were installed and around 220,000 t of excavation soil were moved.

Double-Head System

Overburden drilling with double-head system is suitable for all soils and rock. During the drilling process, an inner and outer drill rod with a drill bit fixed at the lower end of each rod is screwed into the ground. For rock drillings, a down-the-hole hammer is alternatively mounted to the inner drill rod. The outer drill rod is rotated by means of a rotary drive, while the inner drill rod is driven in the opposite direction by a hydraulic hammer. The air or water flushing is done via the inner drill rod, resulting in a controlled discharge of the drill spoil in the annular space between inner and outer drill rod. The inner drill rod must be removed before installing the anchoring tendon.



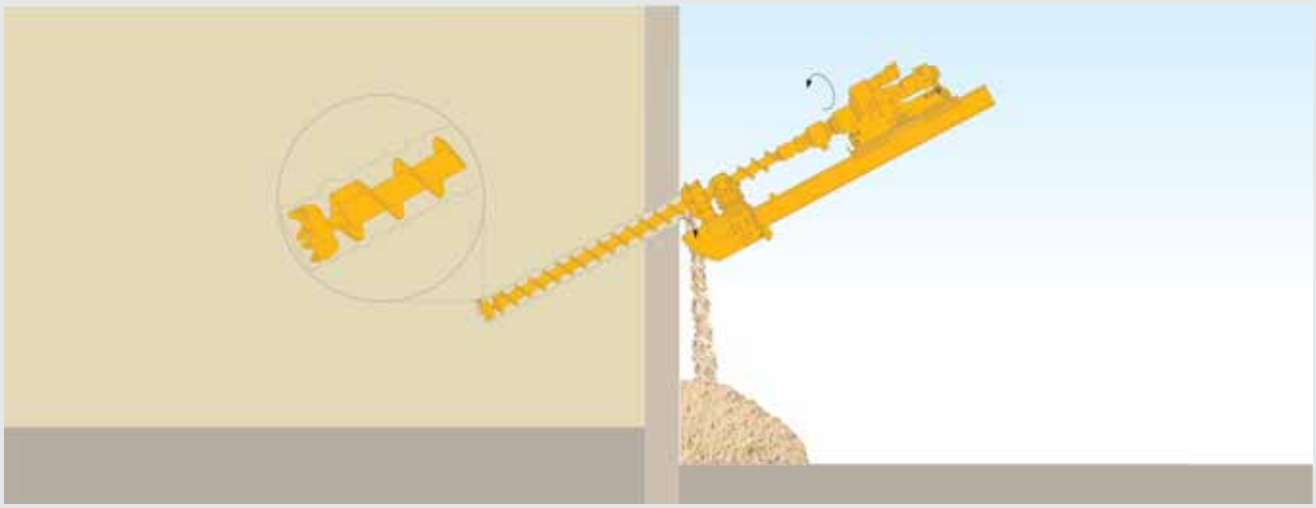
The double-head system is suitable for all types of ground, including rock, due to its two independent drill rods.

Christian Lorenz
Head of the Product Group Anchors

Ferdinand-Happ-Straße, Frankfurt am Main
To secure the up to 13 m deep excavation pit, the cut-off wall, with a depth of up to 20 m, was tied-back with around 470 stranded grouted anchors, in up to four layers. Two KR 806 from KLEMM Bohrtechnik GmbH were used to build the structure of around 8,000 linear meters.

Auger Drilling

Auger drilling uses a hydraulically powered rotary motor to rotate the auger rod. This loosens the soil with the drill bit and transports it to the mouth of the bore, via the auger. If a hollow stem auger is used, the soil discharge can be supported by air flushing. Depending on the strength and abrasiveness of the ground to be drilled, different drill bits are used, e.g. a 3-wing stage drill bit or a drill bit with round shank bit function. The drill bits create a clearance to reduce wear of the auger rods. After removal of the auger rod, the bore hole must be filled with mortar as quickly as possible, to prevent the bore hole from loosening or softening. The bore hole is filled using a grouting lance. Because the anchors are installed independently from the creation of the bore hole, auger drilling is a method that achieves a rapid construction progress.



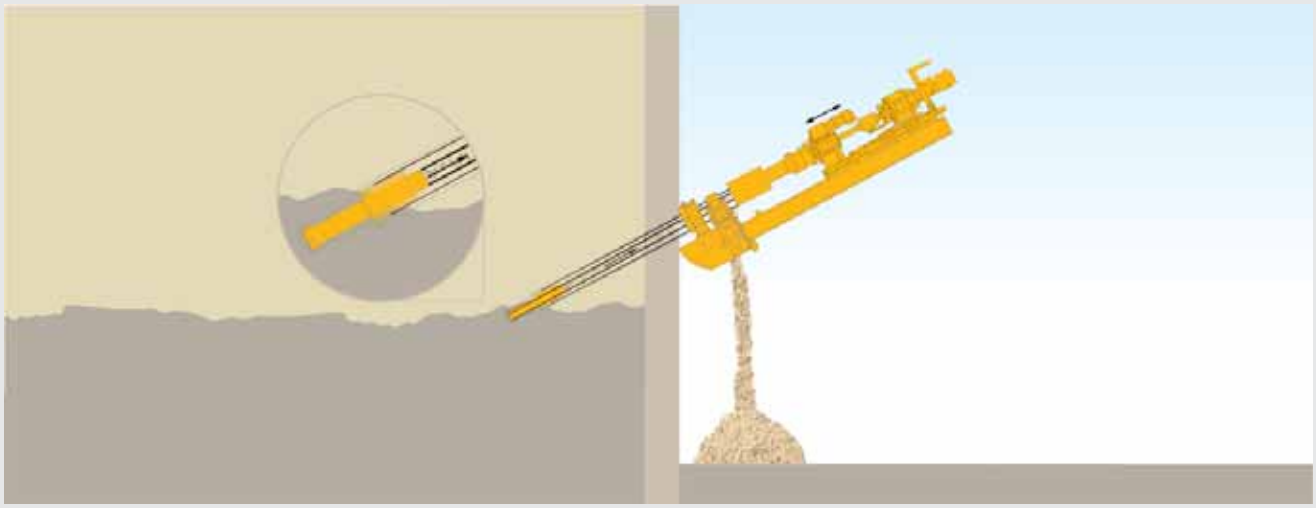
With the auger drilling method, anchors can be installed independently of the drilling process – an important aspect for the success of the project.

Arnim Schleeh
Site Manager

Logistics Center, Dettingen/Erms, Germany
A secant pile wall was created for the construction of a new logistics center. Permanent anchors, with anchor lengths of up to 13.5 m, were installed as tie backs.

Down-the-hole Hammer Drilling

Bores in bedrock can be drilled very efficiently using a wear-resistant and carbide-covered down-the-hole hammer drill bit. Compressed air is directed to the down-the-hole hammer through the rotating drill rod. The air serves as a driver, as well as a flushing agent to discharge drilling debris. The down-the-hole hammer always works at the deepest point of the drilling, which means the impact energy transferred to the drill bit acts directly on the rock to be loosened. The harder the rock, the greater the benefit of this process. The down-the-hole hammer can be combined with various drilling systems, such as the auger or double-head system. Alternatively, a water-driven down-the-hole hammer can be used and can offer additional benefits under certain conditions.



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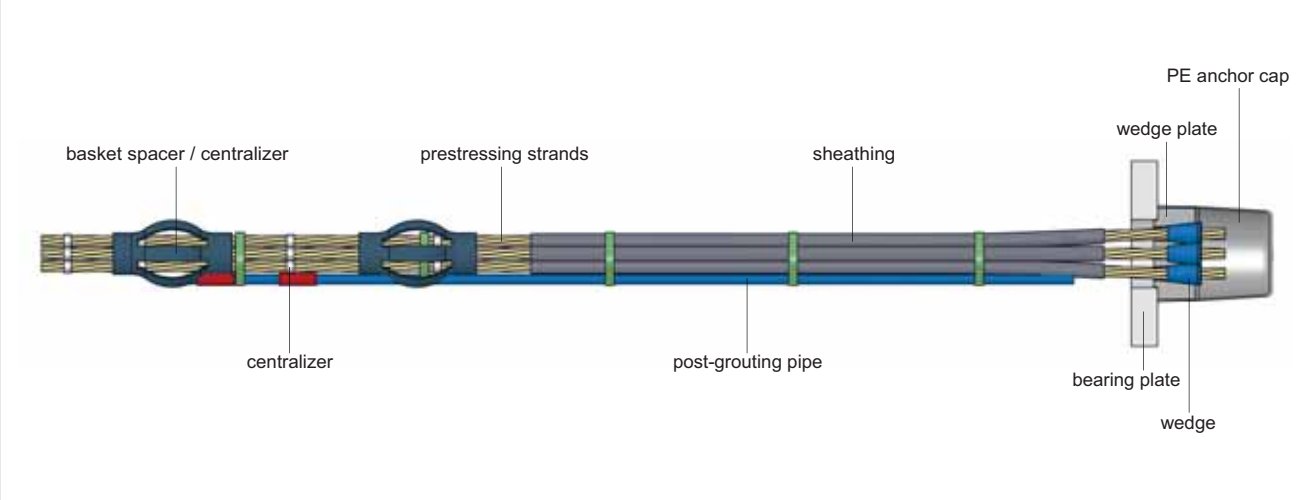
Drill bits

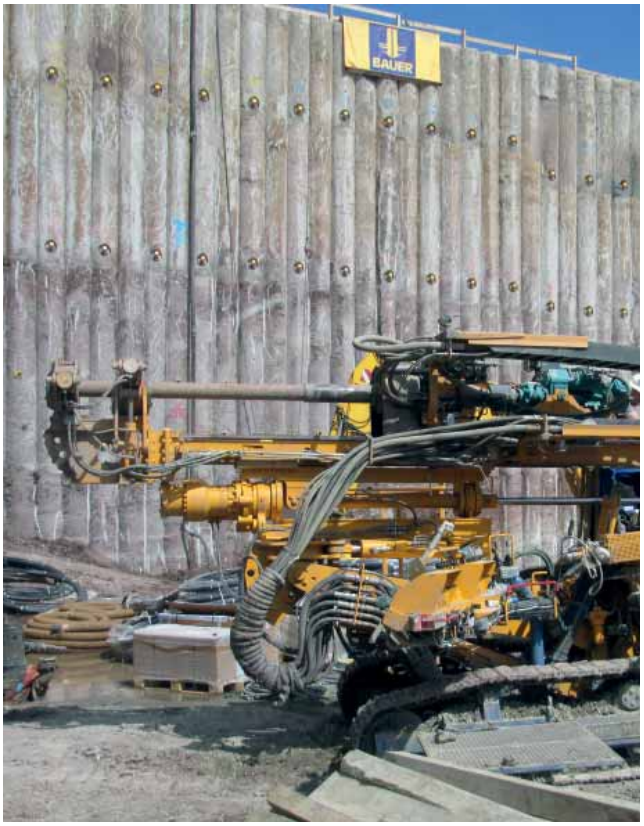
Various drill bit designs are available to suit the characteristics of the respective rock stone – such as strength, composition and abrasiveness. These can be combined with the down-the-hole hammer.

Excavation pit, Weilheim/Teck, Germany
For the new railroad between Wendlingen and Ulm, an excavation pit with soldier pile wall was constructed, in the area between Weilheim/Teck and Aichelberg along the new route. The retaining structure was secured with 499 temporary anchors.

Temporary Anchors

Temporary anchors serve to secure construction projects over a lifetime of a maximum of two years. They are generally constructed as stranded anchors, but can also be installed as single bar anchors. Prestressing strands with seven wires are employed. For quality reasons, these are exclusively factory-made. To protect against corrosion, the sections of the single strands are covered with PE sheaths and are factory-fitted with post-grouting pipes. The stranded anchors are supplied on rolls, stored in a space-saving manner on the site and installed in the bore hole, using an unwinding unit. Installation of the anchor heads and inspection of the anchors is done by in-company teams. Based on the installation situation, the respective anchor head structure is mounted on concrete abutments or connected to the wall as a welded structure. The load-bearing capacity of each anchor is determined by means of a standard load test – the anchor acceptance test – and recorded in a log. The yellow anchor cap identifies a finished anchor.





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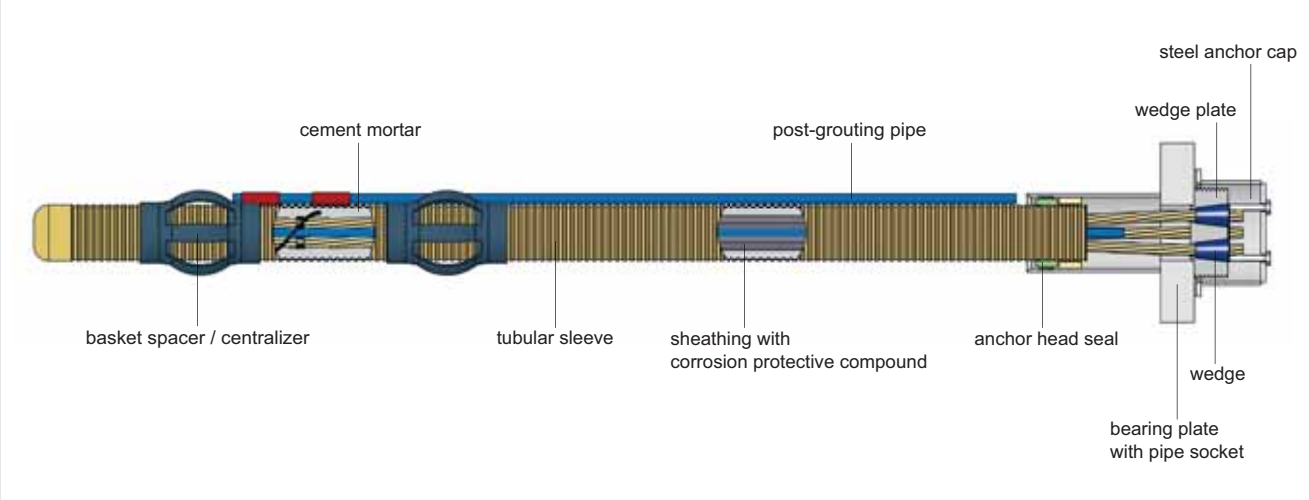
Possible prestressing strands

- **St1570/1770, 0.6“**
- **St1570/1770, 0.62“**
- **St1660/1860 0.6“**
- **St1660/1860 0.62“**

Automobile manufacturer, Germany
An excavation pit with 23 m high retaining walls, was constructed for the new plant of an automobile manufacturer. Temporary anchors with individual lengths of up to 33 m were installed in the area of the secant pile wall. The anchors were constructed with the double-head system and an air flushing system.

Permanent Anchors

Permanent anchors are grouted anchors for permanent use from two years and beyond and they become part of the structure. Prestressing strands or thread rods are used as base elements. Permanent anchors differ from temporary anchors by offering additional corrosion protection. For this purpose, the prestressing strands are greased with a plastic corrosion protection compound in the area of the free tendon lengths. The strand bundles are additionally protected over their entire length, with a common corrugated tube. These additional protective corrosion barriers result in larger drilling diameters that are created using an adapted drilling technique. The anchor head of the permanent anchor is also protected against corrosion and designed to allow re-inspection or re-tightening of the anchor at any stage. All cavities are filled with plastic corrosion protection compound. The anchoring tendon is filled with premium cement mortar inside the corrugated tube, and the load-bearing capacity of every anchor is determined by means of an anchor acceptance test. Permanent anchors are also subjected to a suitability test. Permanent strand anchors offer the same logistical benefits as Temporary strand anchors.



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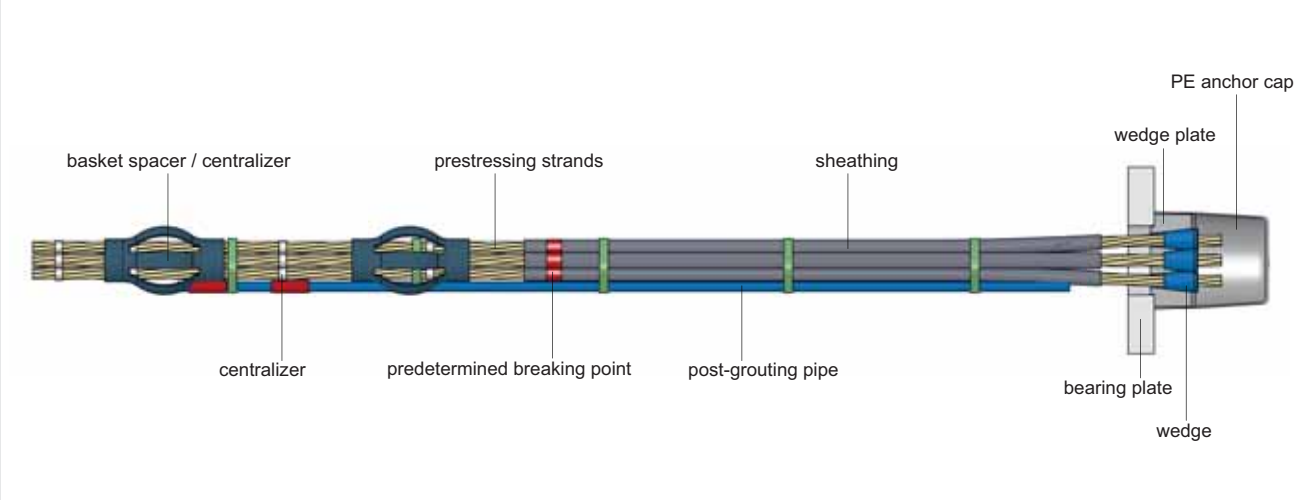
Installation

Plastic corrosion protection compound “Nontribos MP2” is pumped in below the wedge plate. Above the wedge plate and under the anchor cap, “Denso-Jet mixture” is filled. A special tool, such as a pipe cutter, a pump for the corrosion protection compound or a Denso boiler is required for installing the anchor head.

Boardinghouse Neuperlach, Munich, Germany
Bauer constructed an approx. 6,500 m² large building pit for a boardinghouse hotel in the Munich neighborhood of Neuperlach. A total of 65 bored piles were constructed and then tied-back with approx. 40 up to 11-strand anchors. In addition, the soldier piles, with wooden laggings and a MIP wall, were secured using 160 anchors, 40 of which were constructed as permanent strand anchors.

Removable Anchors

In some instances it may not be possible to have prestressing strands remaining in the neighboring construction soil. In these cases, grouted anchors can be constructed as removable anchors, which can be removed at the end of their lifetime. Installation and dismantling of these anchors is, however, associated with increased time and expenditure. Two different construction options are available, depending on the requirement: partly removable anchors, where only the free anchor length of the ground anchors is dismantled, and fully removable anchors, where the whole steel tendon is dismantled. With removable anchors, it is important to design the heights of the anchors' initial drilling positions in the retaining structure, to match the heights of the building within the excavation pit. Ideally, the anchors' initial drilling positions are located above the ceiling of the building and can then be removed from this level.



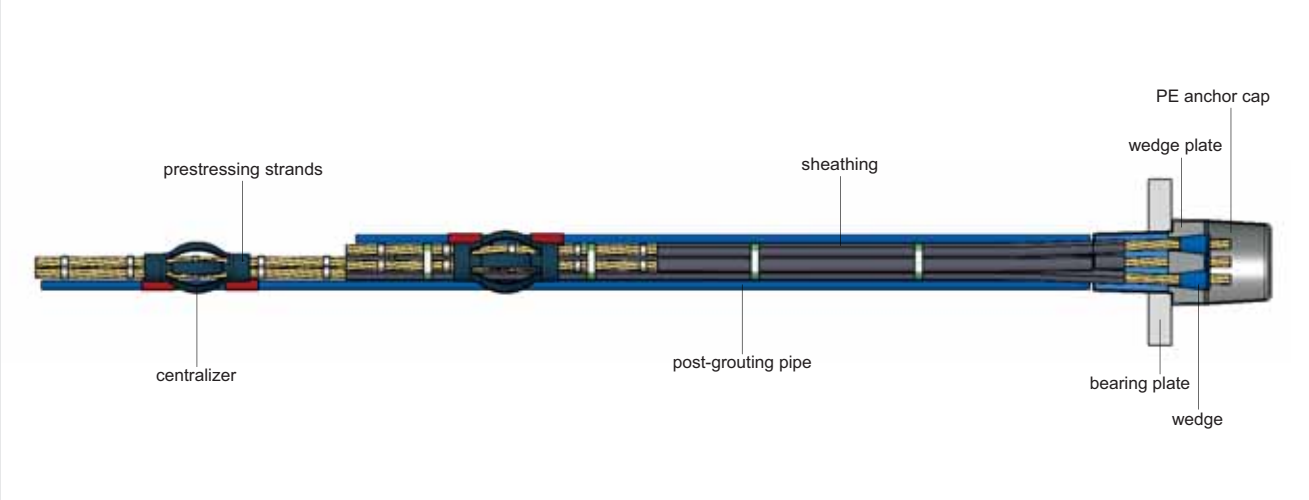
Depending on the client's requirements, partly removable and fully removable anchors are available. These can be removed depending on the planned lifetime.

Moritz Hahn
Project Manager

UpperNord Tower, Düsseldorf, Germany
In order to secure the impressive excavation pit of the UpperNord Tower, about a further 5,300 m of anchors with three to six strands and a drilling length of up to 24 m were constructed.

Staggered Anchors

In the case of bond type grouted anchors, an increase in the grout body length to more than 7 m, will only result in a slight increase of the anchor forces. With the Bauer staggered anchor, the anchor capacity can be significantly increased by installing two optimized part anchors in a bore. Dividing the anchor force over two grout bodies results in a very efficient power transmission of the anchor load into the ground. Bauer staggered anchors are tested in accordance with DIN standards, with both part anchors being tested at the same time, but independent of one another by means of two independently controllable hydraulic cylinders. Additionally, the displacements of the two part anchors are determined using two independent precision dial gauges. Staggered anchors can be used effectively in soils with a low load-bearing capacity.



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Sequence

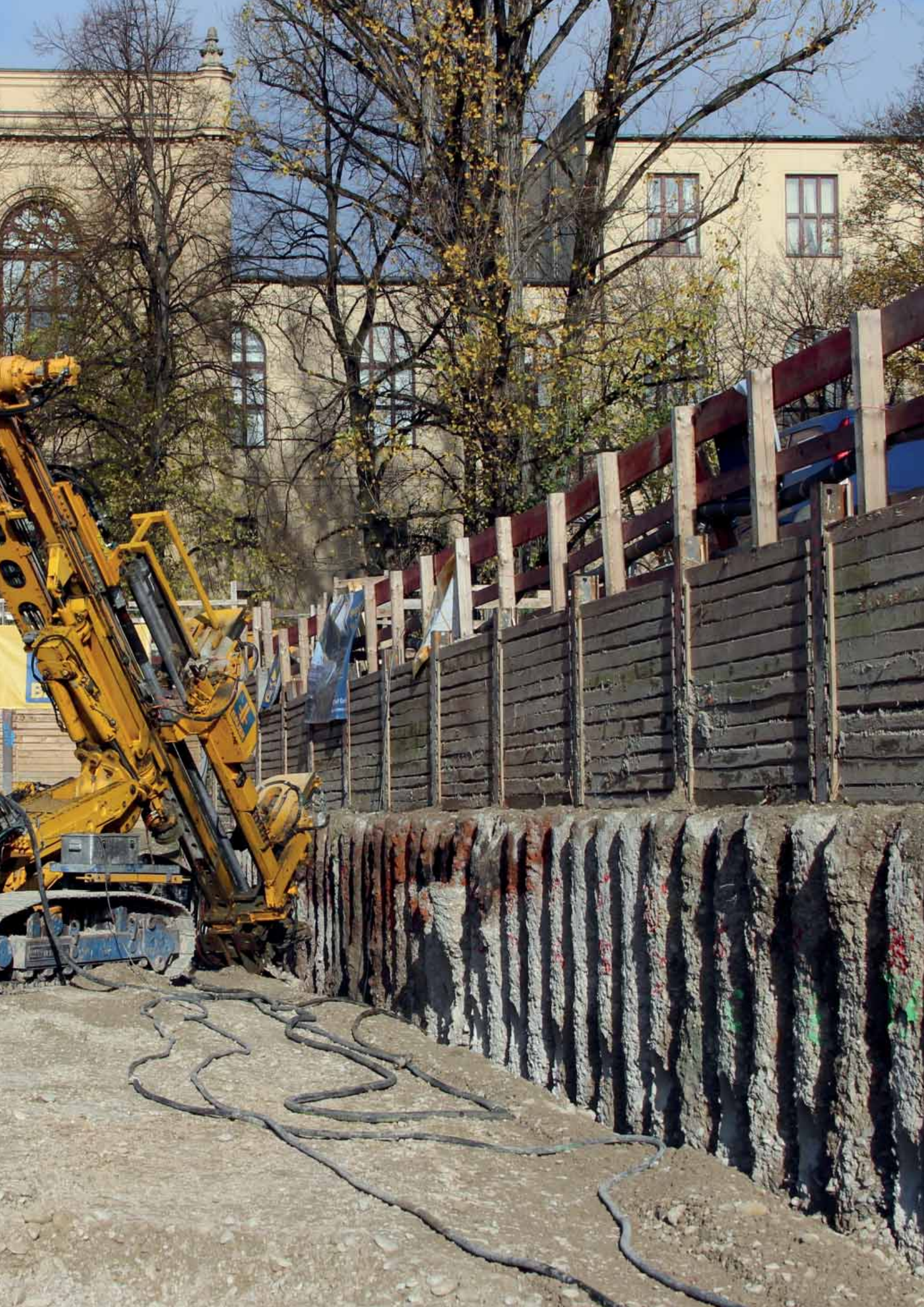
In the acceptance test, the shorter part anchor of the staggered anchor is always loaded up first to the test load. The longer part anchor is tested thereafter.

Underground car park, Ingelheim, Germany
For a two-story basement construction for an underground car park, a 3,200 m² MIP retaining structure, was installed. The retaining structure with a depth of approx. 9 m was secured with two anchor layers of 210 anchors, including 100 staggered anchors.

Project

A wealth of experience and qualified employees form the basis of our extensive range of construction services. We offer tailor-made solutions for every project and each individual challenge.

Multi-story car park, Munich, Germany
A multi-story car park was integrated into the road space around the Thomas-Wimmer-Ring in Munich. To secure the excavation pit, 6,500 m of temporary anchors were installed, in double-head method.



Excavation Pit, Germany

Several buildings with up to eight stories, are being developed for a new urban quarter with residential and office spaces. To provide the infrastructure for the buildings and for technical facilities and ancillary buildings, a three-story underground car park with around 800 parking spaces is being built. For this purpose, BAUER Spezialtiefbau GmbH was tasked with the construction of an excavation pit to a depth of 12 m. Due to the highly to very highly water-permeable gravel in the area, an watertight retaining structure was required. Engineering included sheet pile retaining walls, with tie backs for the greatest part of the pit, while a retaining structure consisting of MIP walls was envisaged along the adjacent train tracks. To secure the excavation pit, several layers of anchors were created with a KLEMM KR 806, and piles against uplift were constructed using the CFA method.

Anchor drilling works were done with a KLEMM KR 806 in double-head method.

A special feature of the construction site was its narrowness in parts. Moreover, the anchor works were carried out below groundwater level.

Christian Lorenz
Head of the Product Group
Anchors

Once the anchor drilling rig was set up at the start position, the actual drilling could begin.

The inner drill rod was removed from the bore hole with an excavator and placed in the drill rod box.

INFO

The double-head method

Because this method uses two drill rods for the drilling process, the annular space between inner and outer drill rod is flushed out, which eliminates the risk of uncontrolled soil discharge.

The anchor heads are installed after the finished anchor has hardened.

Individual anchors are constructed with several strands and in three layers.

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