BAUER
Silicate Gel LWS

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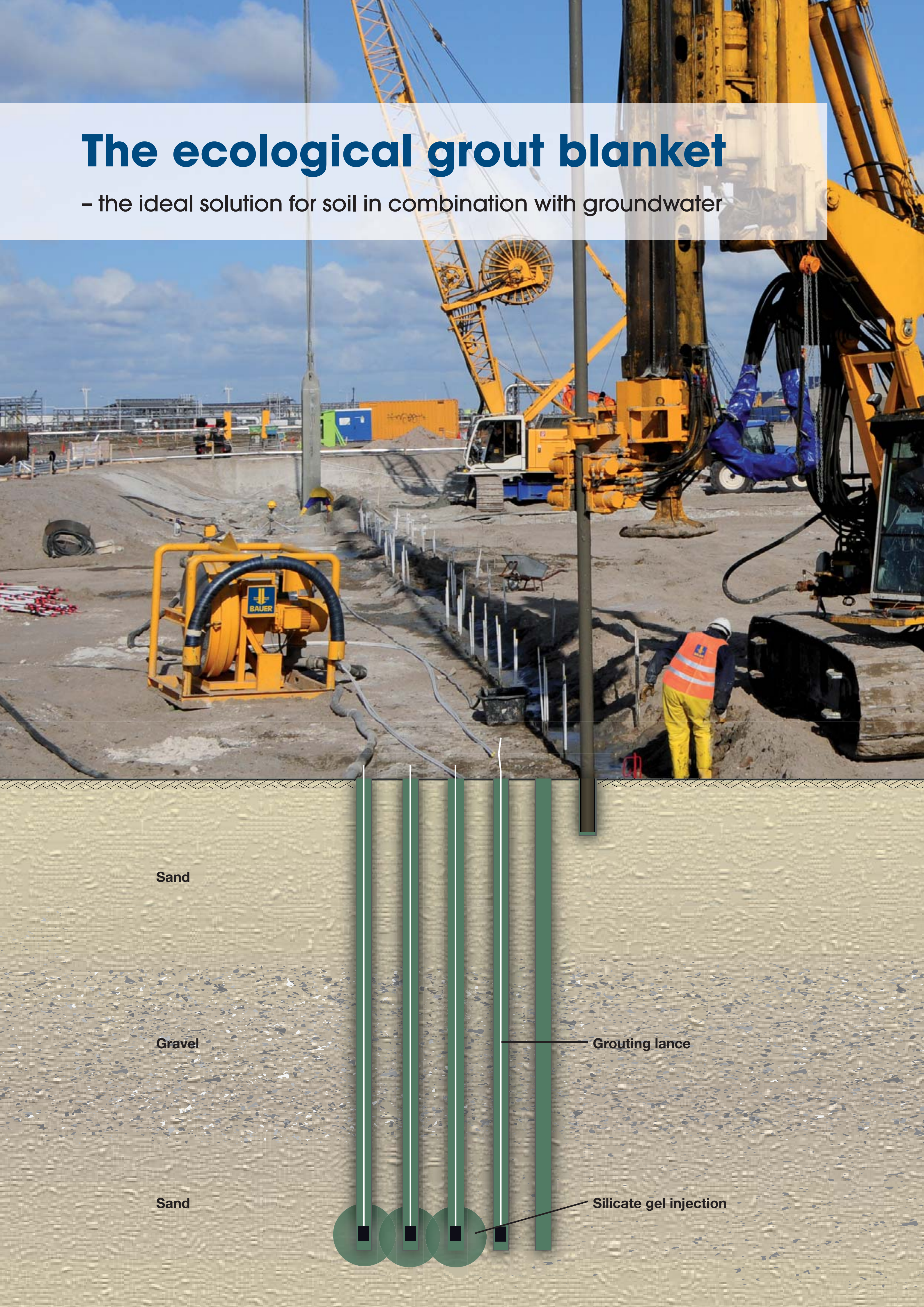
The ecological grout blanket

– the ideal solution for soil in combination with groundwater



Grouting with soft silicate gel containing sodium aluminate as a hardener is a construction engineering technique in use all over the world. BAUER Spezialtiefbau GmbH has already executed more than 350,000 m² of base sealing using such materials, at a variety of different depths, with great success. However, regulatory restrictions on its use have made it necessary to enhance this technology.

We have therefore now focused much more closely on aspects of environmental compatibility and economical use of resources. We had to come up with innovative solutions in order to ensure sustainability. As part of this approach, we paid particular attention to the issues of energy balance and CO_2 reduction.

Having obtained general regulatory approval for the Bauer Silicate Gel LWS, we have now succeeded in bringing to market a grouting product for executing base seals which represents a true milestone in many respects. This innovative product is far superior to other base sealing techniques in terms of environmental sustainability, without losing out on robustness or reliability – the key features of soft gel injection.

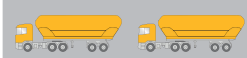
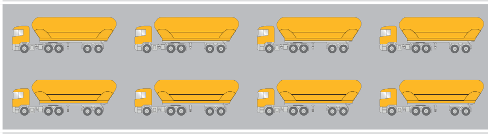
Using Bauer Silicate Gel LWS eliminates many of the problems associated with base sealing by the jet grouting method, such as loosening of the ground by introducing air into it, entailing a change in soil layer density, reduction in load-bearing of the uplift elements and alterations to the structural system.

Although the jet grouting method and associated quality assurance has been greatly enhanced over the last 15 years, it has not been possible to improve its deficiencies in terms of environmental compatibility and energy efficiency – such as relatively high transport volumes – due to the intrinsic nature of the system. The new Bauer Silicate Gel LWS, on the other hand, is an eco-friendly product that uses valuable resources sparingly. It therefore more than meets the demands of sustainable foundation engineering.

Environmental compatibility

The way to achieve ecologically sound, sustainable foundation engineering

A number of studies have been carried out to assess the environmental impact of injection grouting. The main focus to date has been on emissions of hydroxides and secondary compounds into the groundwater. The following table sets out all the key parameters in assessing environmental impact, including CO_2 emissions and transport volumes, in relation to Bauer Silicate Gel LWS. The alternative presented by way of comparison is the jet grouting method.

	Bauer Silicate Gel LWS	Jet grouting
pH value	Grout pH ≤ 10	Grout pH 14
Alkalis	Alkali contamination ≤ **0.9 kg/m³**	Alkali contamination ≤ **11.2 kg/m³**
Chromate	No contamination	Contamination by cement
CO_2 balance	**CO_2 emissions: approx. 76 kg CO_2/m²** **Power consumption: approx. 144 kWh/m²**	**CO_2 emissions: approx. 590 kg CO_2/m²** **Power consumption: approx. 860 kWh/m²**
	with 5,000 m² grout blanket - 384 t CO_2 - 720 MWh **or:** **Power consumption of approx. 178 4-person households per year**	with 5,000 m² grout blanket - 3,000 t CO_2 - 4,300 MWh **or:** **Power consumption of approx. 1,060 4-person households per year**
Transportation delivery (binding agent)		
Outbound transport (return)		

Advantages of using Bauer Silicate Gel LWS

Low emissions and **fast working** are the main advantages of the Bauer Silicate Gel LWS grout blanket.

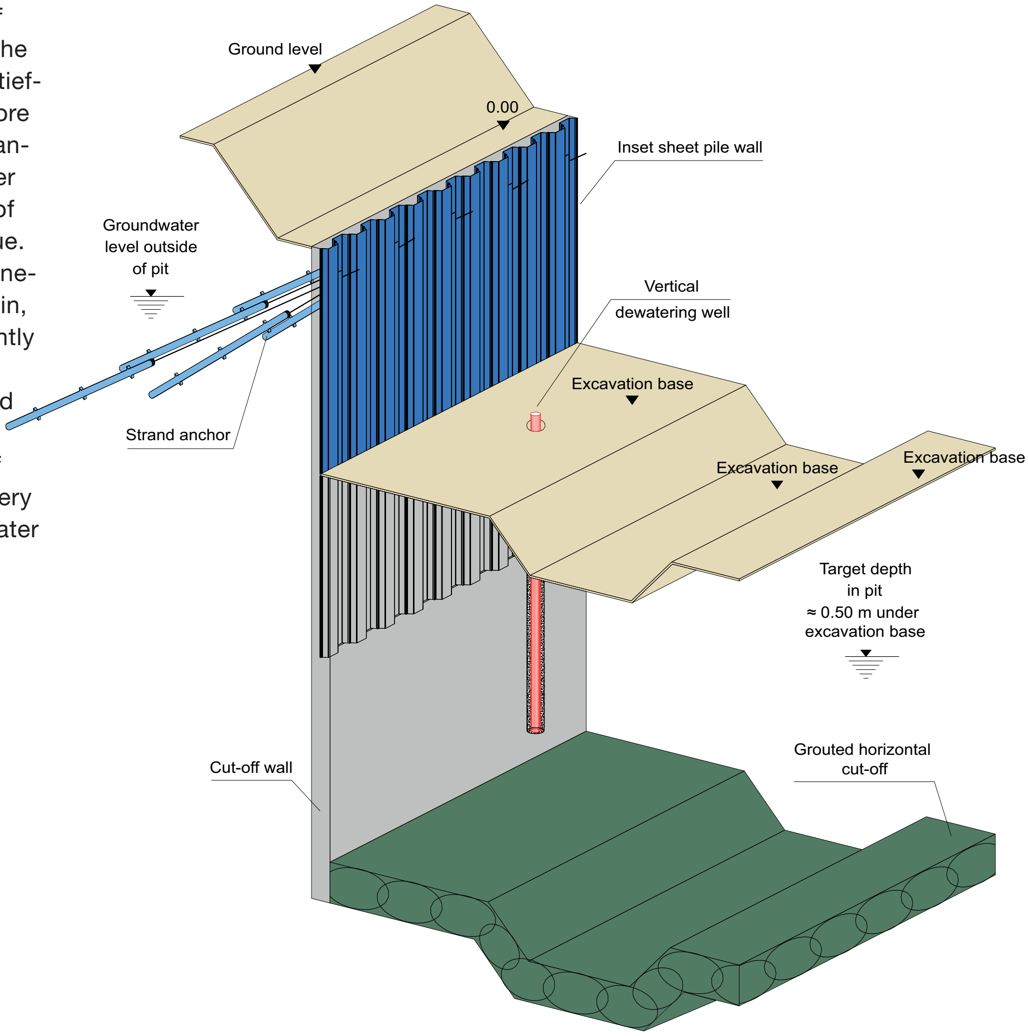
The highly productive vibration technique used to install the grouting lances enables daily rates of 500 to 1,800 m per machine to be achieved, subject to the ground and other site conditions.

Silenced mixing/pumping containers minimize noise and so enable grouting to be carried out in daytime and night shifts.

The small number of material transports greatly reduces impact on local residents.

System safety

Since the introduction of the technique back in the 1970s, BAUER Spezialtiefbau GmbH has executed more than 350,000 m² of grout blankets using silicate gel all over the world. This is evidence of the reliability of the technique. It has proved particularly beneficial in the area around Berlin, where the soil is predominantly sandy. That ideal suitability is impressively demonstrated by the technique's fulfilment of high demands in terms of leak-tightness, and by the very small volumes of residual water it produces.



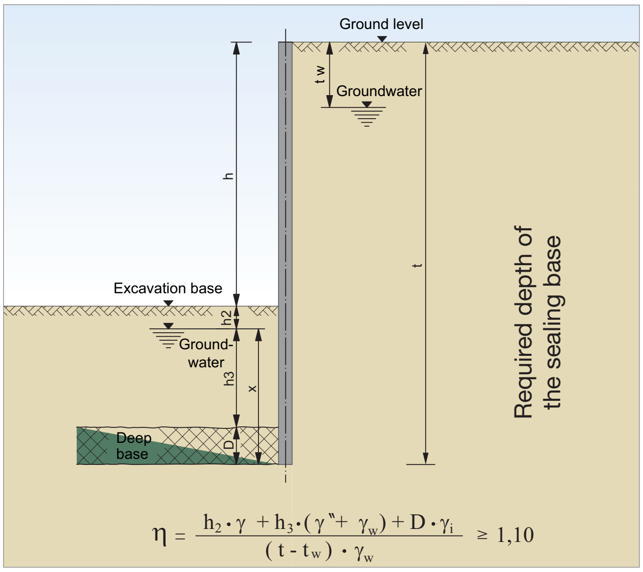
Technical advantages and dynamic adaptation

- Depending on their size, **artificial and natural obstacles** are surrounded and incorporated into the grout blanket.
- The "fresh-in-fresh" grouting (in daytime and night shift operation) results in a **very small number of joints.**
- **Lengthy breaks in work** (such as at weekends) between two working areas **are no problem.**
- **Allowance can be made for geometric irregularities**, such as corners or underpasses.
- By arranging additional points or carrying out regrouting, **dynamic adaptation** to work breaks or obstacles can be systematically **planned and implemented.**
- **Verticality measurements** during or after installation of the grouting lances **form the basis for dynamic planning** of the numbers of grouting lances and to plan any required increase in grouting volume per point.
- A second injection lance can be installed **as an option in order to enhance the redundancy** of the overall system.

Bauer Silicate Gel LWS

Process description

In order to produce a water-tight pit, the groundwater inflow must be limited by a largely water-impermeable vertical encapsulation and – if there is no socketing into a dense soil layer – additionally by a horizontal barrier layer.

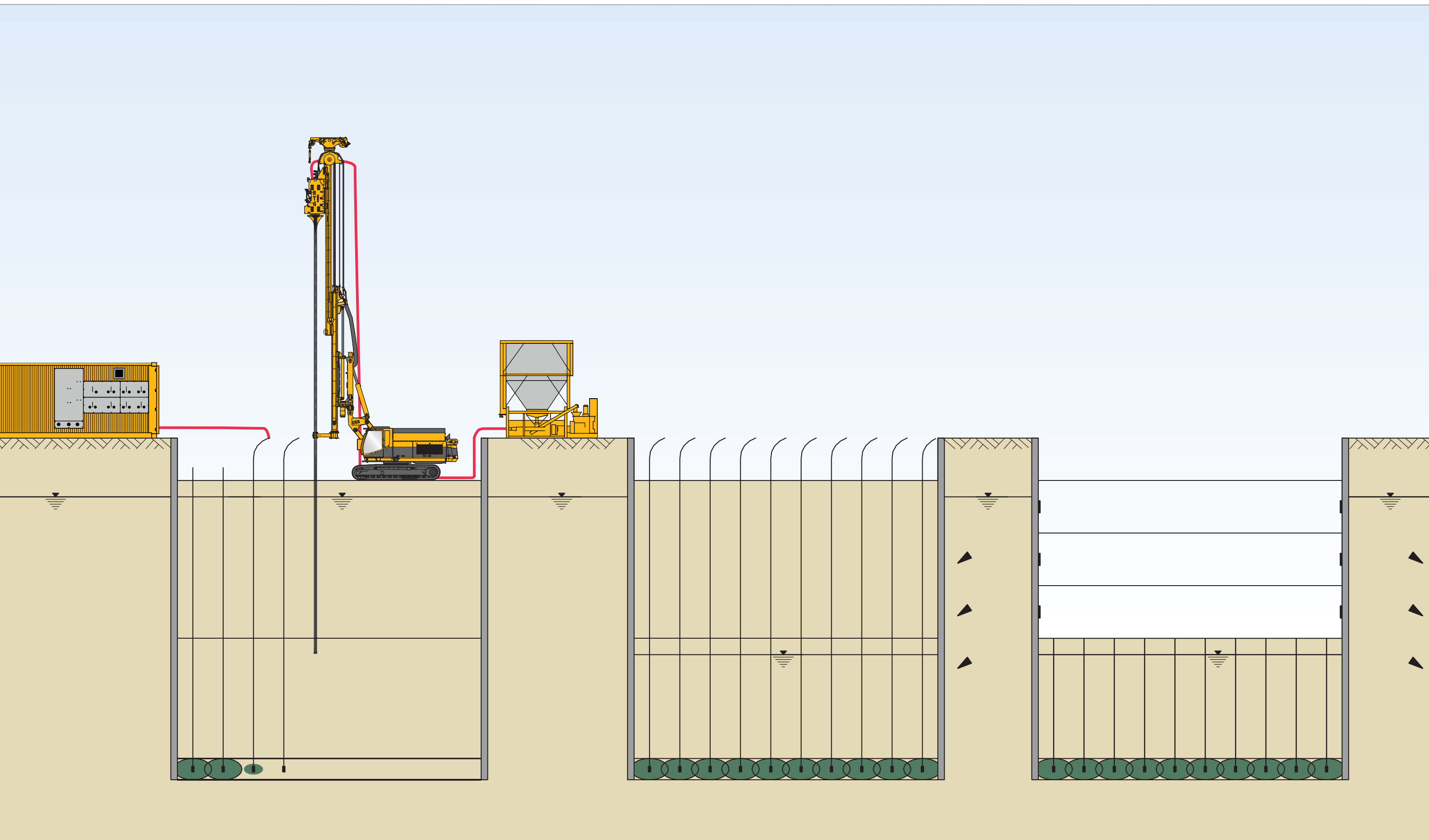


Term
Permeation grouting is a process of injection into pores. DIN EN 12715 gives the following definition: “Permeation grouting is the replacement (displacement) of pore water or gas in the porous medium by grouting under pressure low enough to prevent deformation.”

Static function
Grout blankets usually have to perform no structural function based on a specified material strength. The location is at a depth below the pit base which is safe against uplift. In verifying safety against uplift, the grout blanket is assumed to be completely sealed, with a notional membrane at the planned bottom plane of the blanket. For geotechnical analysis, the uplift forces acting on the bottom plane of the blanket are set against the forces from the soil and groundwater acting above the blanket.

Sequence of operations

A grout blanket is produced by drilling/vibration and injection (compaction). In the first step, injection lances are installed in drilling/vibration holes supported by suspension. Once the supporting medium has hardened, in a second step the grout is injected into the ground by way of valve bodies at the base point of the lances.



Installation technique
The holes in the ground needed to install the lances are made by drilling or vibration, depending on the ground and site conditions (such as existing structures). The basic principle is that a casing is sunk to the required depth with a drill rig located above the groundwater level.

During extraction, the bore hole is filled with a stabilizing suspension. Then the injection lances are installed by hand, with the exact depth of the valve body being controlled by way of the head point of the lance using rotary lasers.

Drilling
In this variant the suspension pumped to the bit at the drill rods assists the loosening and conveying process through the soil layers being penetrated. The returning slurry is captured and re-used after desanding.

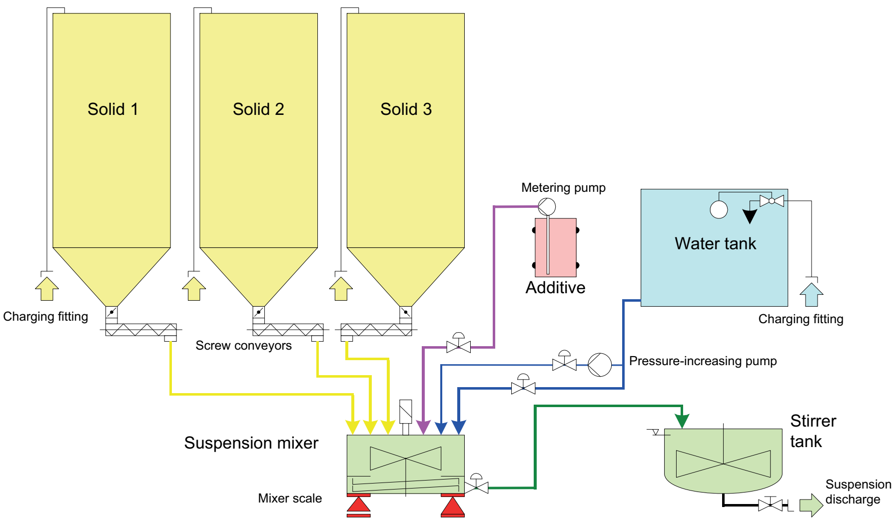
This technique is applied primarily in very dense soils or where there are artificial obstacles.

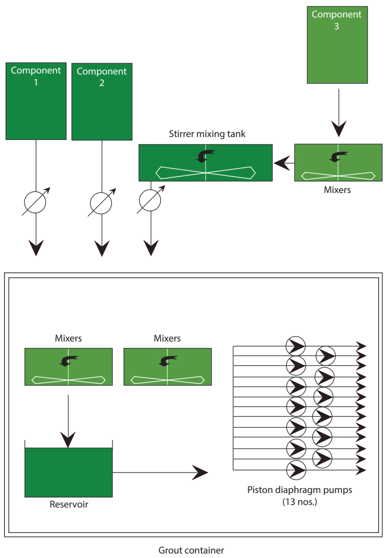
Vibration
In this process a casing is inserted into the soil by displacing the soil layers using a vibrator or rotary drive assisted by a percussion mechanism.

The highly productive technique causes little vibration when used in suitable ground, and so can also be deployed close to sensitive built structures.

Grouting technique
Grouting can begin when the supporting suspension in the drilling/vibration hole is of sufficient strength to prevent the flow-by of the LWS solution. In a mixing/pumping container the base components are precisely dosed, mixed, and stored for a limited period of time. Then as many as 13 grouting lances are injected in one pass.

Thanks to the encapsulation of the complete mixing and grouting system, the grouting work can also be carried out in city centre environments, and in day and night operations.





Quality assurance

In permeation grouting the water in the soil is displaced by the grout and the pores are sealed by gelling. In the process, a pre-calculated volume is grouted and the grouting parameters (pressure, flow rate and injection quantity) are measured and recorded. The materials to be used, the sequence of works and the rheological properties of the silicate gel are specified dependent on the ground, the depth of the grouting horizon and the geometric conditions on-site.

Detailed planning is the basis for quality assurance parameters. These are used to adapt the standard quality assurance plan to the project-specific conditions. The quality assurance plan details all the measures, with assessment criteria.

These include:
- Checking the drilling depth
- Verticality monitoring requirements
- Scope and criteria for suspension checking
- Depth of the valves
- Grouting parameters, documentation and evaluation
- Incoming materials inspection

The works are dynamically adapted to any deviation from the plan. This may suddenly become necessary, for example, in the event of tolerances being exceeded or if obstacles are detected. The required measures, such as the arrangement of additional points or a change in grout quantity, are then integrated directly into the ongoing works.

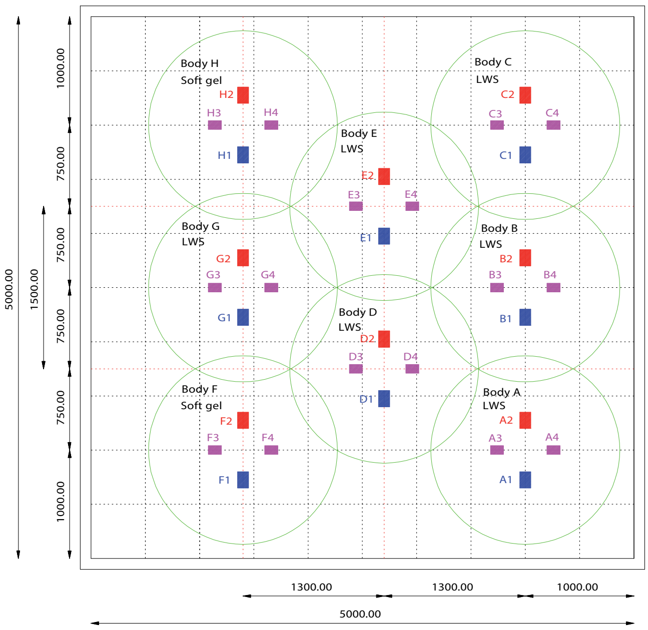
Patents and approval

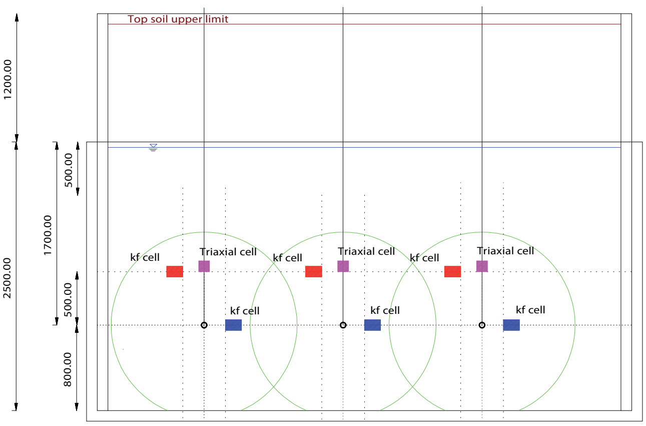
Bauer Silicate Gel LWS is an innovative development by BAUER Spezialtiefbau GmbH. A number of patents have already been registered in respect of it, and it has been granted general regulatory approval. Various tests by independent bodies have affirmed the product's environmental compatibility.

Research project

A number of trials have been conducted as part of a Bauer research and development project.

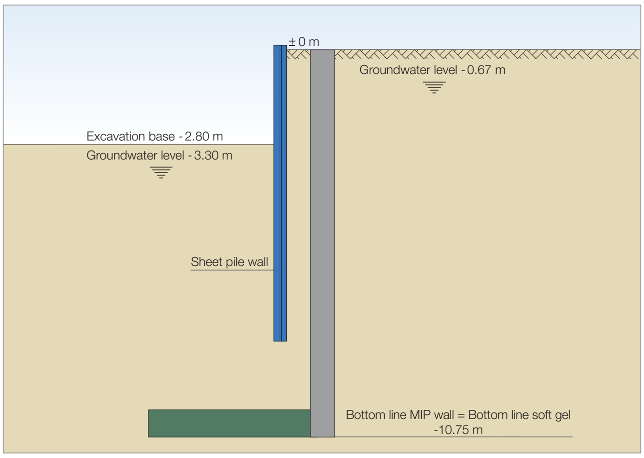
The goals of the grouting trials were to optimize the material composition and to verify and document the flow of the LWS solution in sands. After installing the grouting lances and filling in the test pit layer by layer, the Silicate Gel LWS was injected at a depth of just a few meters. All soil and grouting parameters were documented, and the grouting bodies were manually exposed, measured and analyzed with regard to their strength and permeability.

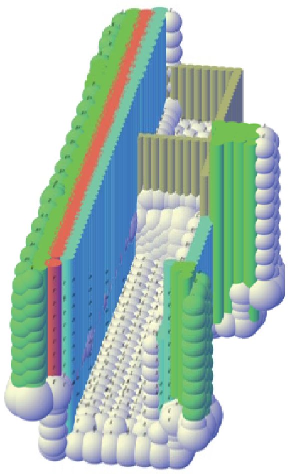




Bauer Silicate Gel LWS in use

Berlin: New build CHN
In “Chausseestrasse”, in the district “Berlin Mitte”, the German Federal Building and Planning Office is constructing a new building complex on the site of the former Stadium of World Youth. In 2007 BAUER Spezialtiefbau GmbH was contracted to carry out the CHN trough excavation pit. Over an area of 6,200 m², a Bauer Silicate Gel LWS blanket was installed at a depth down to 14 m below planum. Mixed-in-Place (MIP) cut-off walls and/or retaining walls as well as sheet pile walls were constructed to enclose the excavation pit.





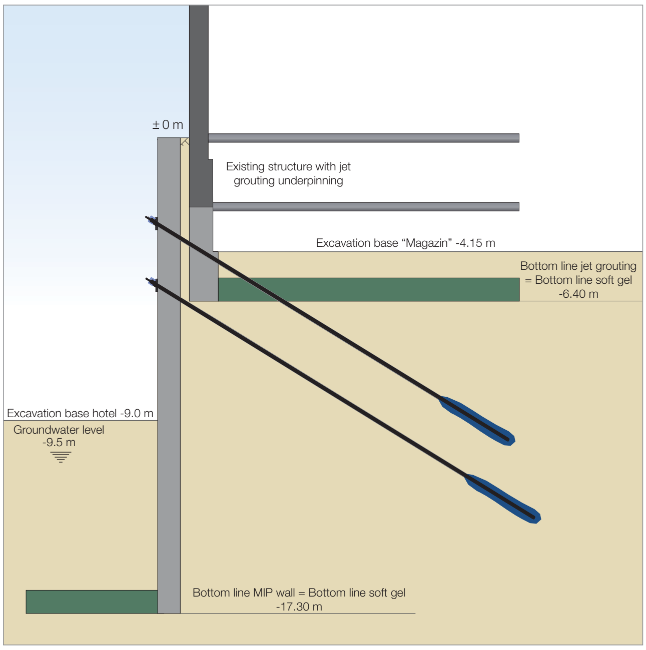
Wolfsburg, VW AG, Multiple die press
An excavation pit with a depth of 9.50 m was required for a new multiple die press to produce wheels. The pit was retained with already existing and newly constructed bored pile walls, jet grouting walls and diaphragm walls, as well as horizontally sealed with a soft gel base.

The greatest challenge was to execute all construction methods while production in hall 11 was ongoing. Furthermore, several foundations of neighboring excavation pits with different depths had to be included in the new pit. The various structural components of the pit were also sealed with an eco-soft gel base LWS.

An amount of 0.4 l/s/1,000 m² of residual water was achieved at the groundwater table drawdown in the trough. Thus the volume was significantly below the contractually required figure of 1.5 l/s/1,000 m².

Berlin, New construction Titanic Hotel
In the existing structures of the listed facades of "Französische Str. 30" a five-star hotel was constructed for the Turkish hotel chain "Titanic Hotel". The cramped access roads as well as the small-scale excavation pit in front of the neighboring buildings which were up to 30 m high posed specific challenges to all parties involved.

For the two basements an excavation pit of 9 m depth with 7 m groundwater level drawdown was required. The excavation pit was executed with a strutted and/or tied-back Mixed-in-Place wall with a horizontal eco-soft gel LWS. The base area of both partial excavation pits is 1,700 m².



A special feature was the two-layered tie-back of the retaining wall below groundwater which penetrated in parts the soft gel base. During the construction of the grout pipes with valves, the drill deviations were determined and at a subsequent stage they were used for calculating the grout volumes in the soft gel visualisation. At a water-wetted area of 4,000 m² a residual water volume of 1.4 l/s/1,000 m² was achieved. Thus, the construction pit could be handed over with a total tightness being below the figures required by the authorities.

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