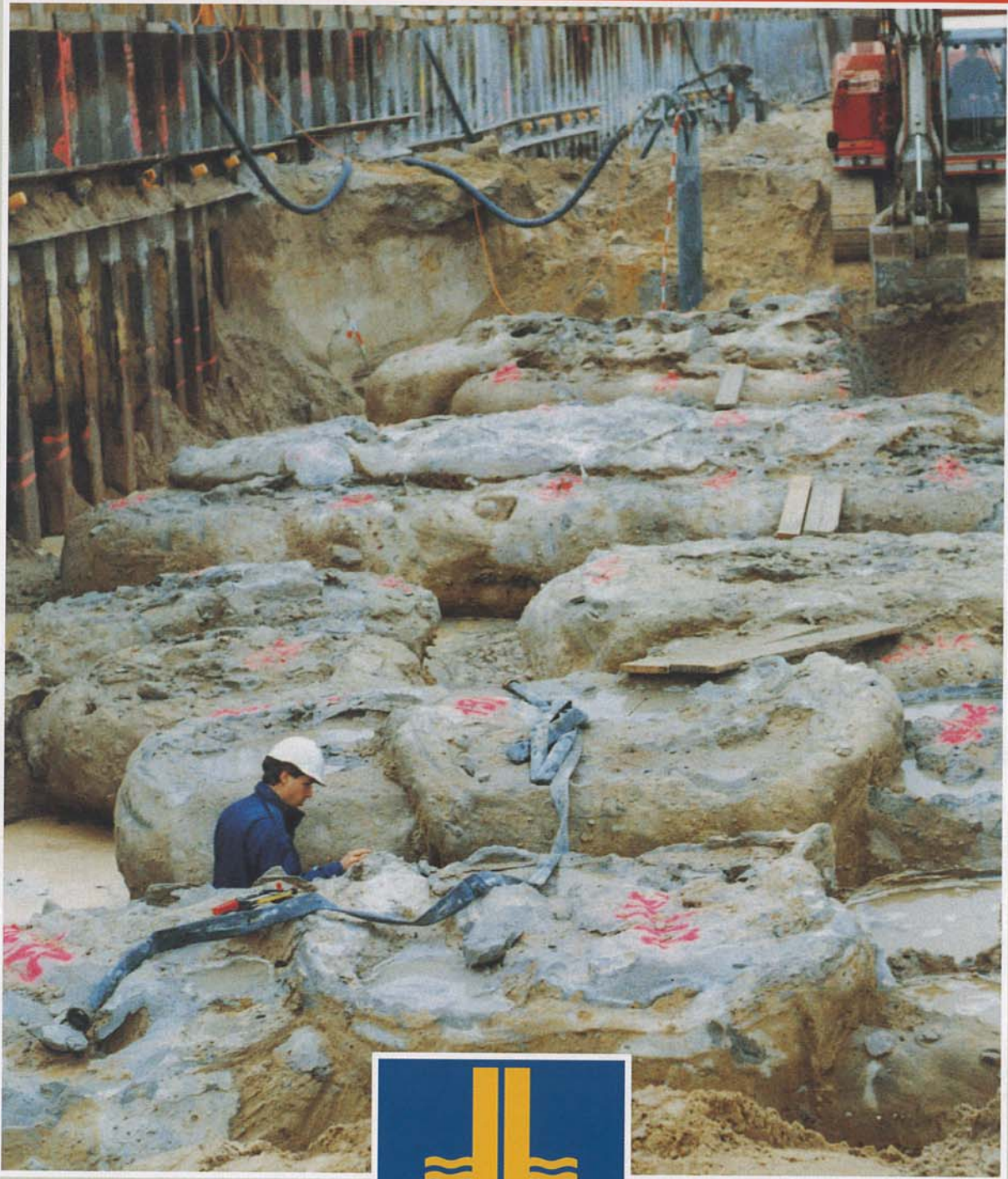


The BAUER Jet Grouting Technique



The BAUER Jet Grouting Technique

The jet grouting technique is known in the market under various terms and trade names. The process was first introduced under the terms 'high pressure grouting' and 'jet grouting'. For the BAUER technique, Bauer holds the "General Building Approval Certificate" issued by the German Institute of Construction Technology of Berlin.

The first jet grouting contract in Germany was carried out at the end of the seventies - in 1983, BAUER carried out underpinning by jet grouting for the first time in Munich and, since then, has gained extensive experience on numerous projects. By developing and improving the process in-house, it has progressively become a more controllable and more economical technique.

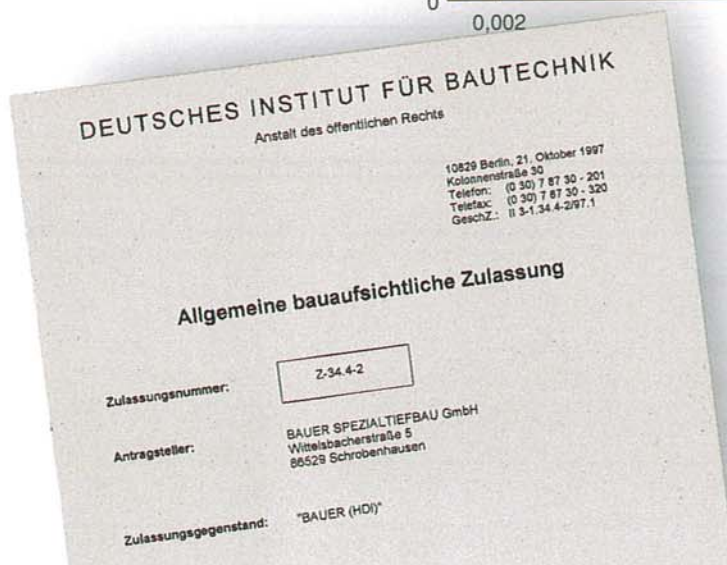
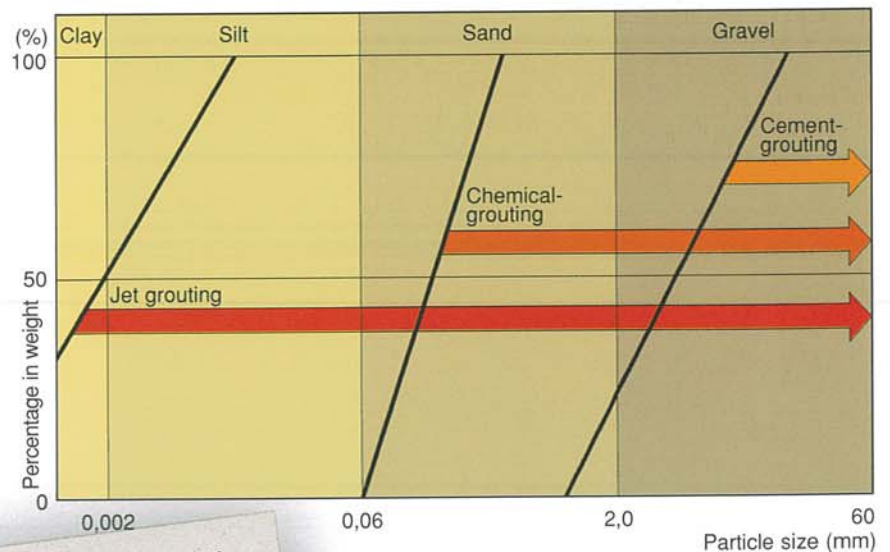
As the jet grouting technique is not specified by a DIN standard, any contractor using this process, will work in accordance with an approved certificate issued to their individual company. This outlines the constraints for the application of the technique. The operating parameters are determined by the site-specific conditions.

The main areas of application for jet grouting are:

- underpinning
- base slabs as horizontal cut-offs
- vertical cut-off walls
- ground improvement
- fissure grouting
- gap grouting
- protective hoods for tunnel drives
- deep foundations



Limits of application for cement, chemical and jet grouting techniques



Frontpage:
Test columns for
horizontal cut-off slab

Quality Assurance

Jet grouting is one of the most involved and demanding techniques in specialist geotechnical engineering. The product of the jet grouting process - a composite mass of solidified soil of predetermined shape and size at any depth - must be reliably fit for its intended purpose and cannot be seen during its construction.

Quality Assurance relies, therefore, on the continuous monitoring of all conceivable aspects of the production process.

The principles of Quality Assurance are specified in our Corporate Management Manual in the form of operational and works procedures. For complex and technically demanding construction processes individual QA plans are prepared and implemented.

Determining and verifying operating parameters

The operating parameters used are empirically based on exhaustive assessment of a wealth of in-house experience. Diameters and quality of construction are verified either by excavating grout columns or by indirect sensing techniques, particularly for greater depths. The operating parameters are recorded in daily reports, column record sheets and jet grouting



data reports. The density of the fresh grout is continuously monitored at the mixing plant. For accurate monitoring of all relevant jet grouting operations - such as drilling depth, injection pressures, grout volume, rotation and withdrawal speed and column diameter - the electronic data recording system (Medef), developed in-house by Bauer, is also available. (below)



During the construction of a jet grouted base slab, setting out of the grout column positions is, as a rule, carried out by an electronic positioning system. A rotating laser controls the drilling depths. An inclinometer probe can



be used to monitor the verticality of the boreholes. Test cores are used to verify the compressive strength of the jet grouted columns.

VMVA Verband der Materialprüfungsämter e.V.

Zertifikat

Die Betonprüfstelle W

Firma Bauer
Spezialtiefbau GmbH
Wittelsbacherstraße 5
86529 Schrobenhausen

entspricht den Anforderungen
der DIN 1045
und wird im Verzeichnis der

VMVA - Betonprüfstellen W
unter der Nummer
VMVA-BPW-1314-98-B1
geführt



Berlin, den 03.04.1998
Gültig vom 01.01.1998 bis 31.12.2000

Dr.-Ing. Ges.
Verband der Mat.

Baustofflabor / Prüfstelle E + W

Bestimmung der einaxialen Druckfestigkeit
nach DIN 1048 - Teil 5

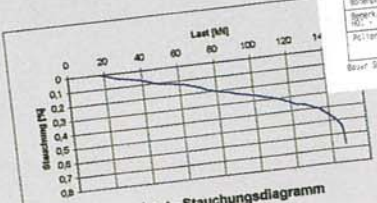
Prüfprotokoll

Auftragsgeber: H. Gügel / NL - TD
Baustelle: BV Dresden * Mik 5 *
Herstellung: 06.05.1998
Prüfung: 02.08.1998
Labornummer: 8107
Art der Probe: HDI - Bohrkern
Entnahmort: Bohrung 5 Pfahl A 45 Achse B 5 / NN 107,00
Probenalter: 27

Probenangaben

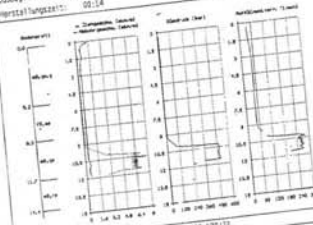
Labornummer:	8107
Höhe (mm):	100
Fläche (mm²):	8645
Durchmesser (mm):	92
Rohdichte (kg/cm³):	2.19
Gewicht (kg):	1.45

Probennummer	Bruchlast [kN]	Festigkeit f_{cd} [N/mm²]
8107	148,00	22,3



Herstellungsprotokoll HDI

Bestell-Nr.: Berlin 8-28 Baugruben
Auftraggeber: H. Gügel / NL - TD
Geräteeinsatz: Werkzeug / Fließschicht
Bohrgerät: 800/100
T-Nr.: 800000
Höhe (mm): 11-500
Tiefe (mm): 116000
Gestänge Durchmesser: 89 mm
Verfahren: DL
Bohrsystem: 18/10
Bohrrohr: 18/10
Innentemperaturzeit: 02:14
Auftrags-Nr.: 11200200
Säulen-Nr.: 211
Neigung: 90°
Datum: 12.07.1998
Bohrtiefe (mm): 11-500
Säulendurchmesser (mm): 11-92
Lagerbohrung: 1-500
Satz: -
Satz: -
Satz: -
Satz: -



Bohrprofil gemäß Aufschußabrechnung Nr.: 830.125/12
Bauer Spezialtiefbau GmbH 86529 Schrobenhausen Tel. 1852/91-0

Method

Phase 1: Drilling

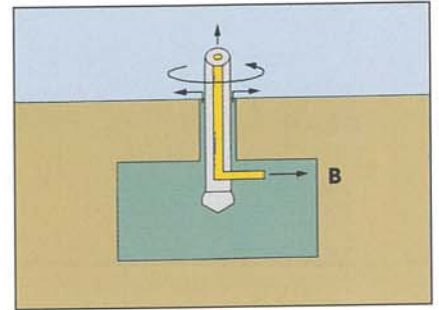
The jet grouting drill string is drilled into the ground by rotary drilling assisted by flushing with either water or grout. The diameter of the bore is enlarged in order to maintain a sufficiently large annulus around the drill rod to enable drilling sludge and excess grout to be discharged to the surface.

Phase 2: Jetting

From the nozzle assembly or "monitor" at the lower end of the drill rod, a high pressure fluid jet is expelled with great speed through a very fine nozzle-

le. The fluid jet of either water or cementitious grout, which can also be surrounded by a concentric collar of compressed air in order to concentrate the jet, cuts into the soil and breaks down the soil structure around the borehole to a specific distance from the nozzle. The eroded soil is displaced and simultaneously mixed in situ with the cementitious grout and partially flushed out to the surface through the annulus between drill rod and pre-bored hole. The waste slurry can be treated with the use of modern desanding plants, regenerated and partially re-used. These savings reduce the cost of off-site disposal.

We differentiate between four different process variants:



1. High pressure cutting with cementitious grout (B):

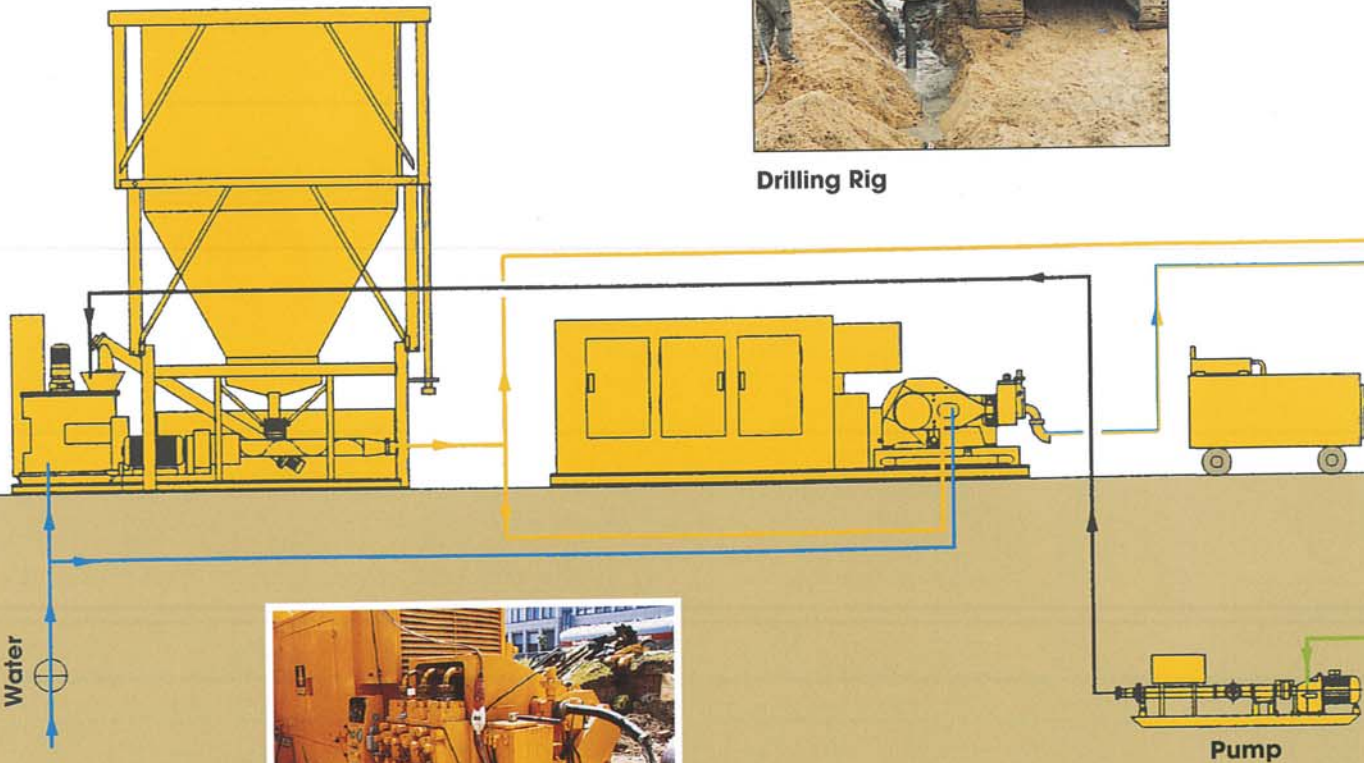
This system utilises a single cementitious grout jet to break down the soil structure and to mix the soil particles with the cementitious grout.



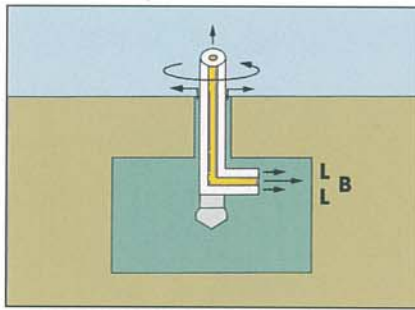
Mixing Unit with transportable silo



Drilling Rig

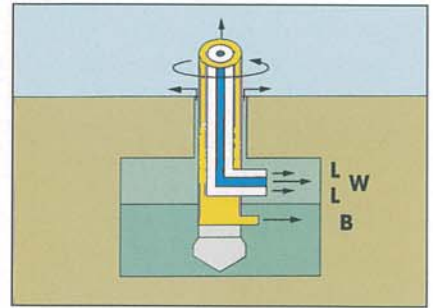


Jet Grouting Pump

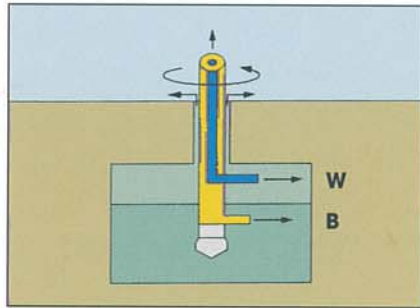


2. High pressure cutting with cementitious grout surrounded by a concentric collar of compressed air (BL): This system utilizes a single cementitious grout jet surrounded by a concentric collar of compressed air. This variant requires a concentric or dual tube drill stem assembly, which provides two separate supply lines, one for compressed air and one for the cementitious grout.

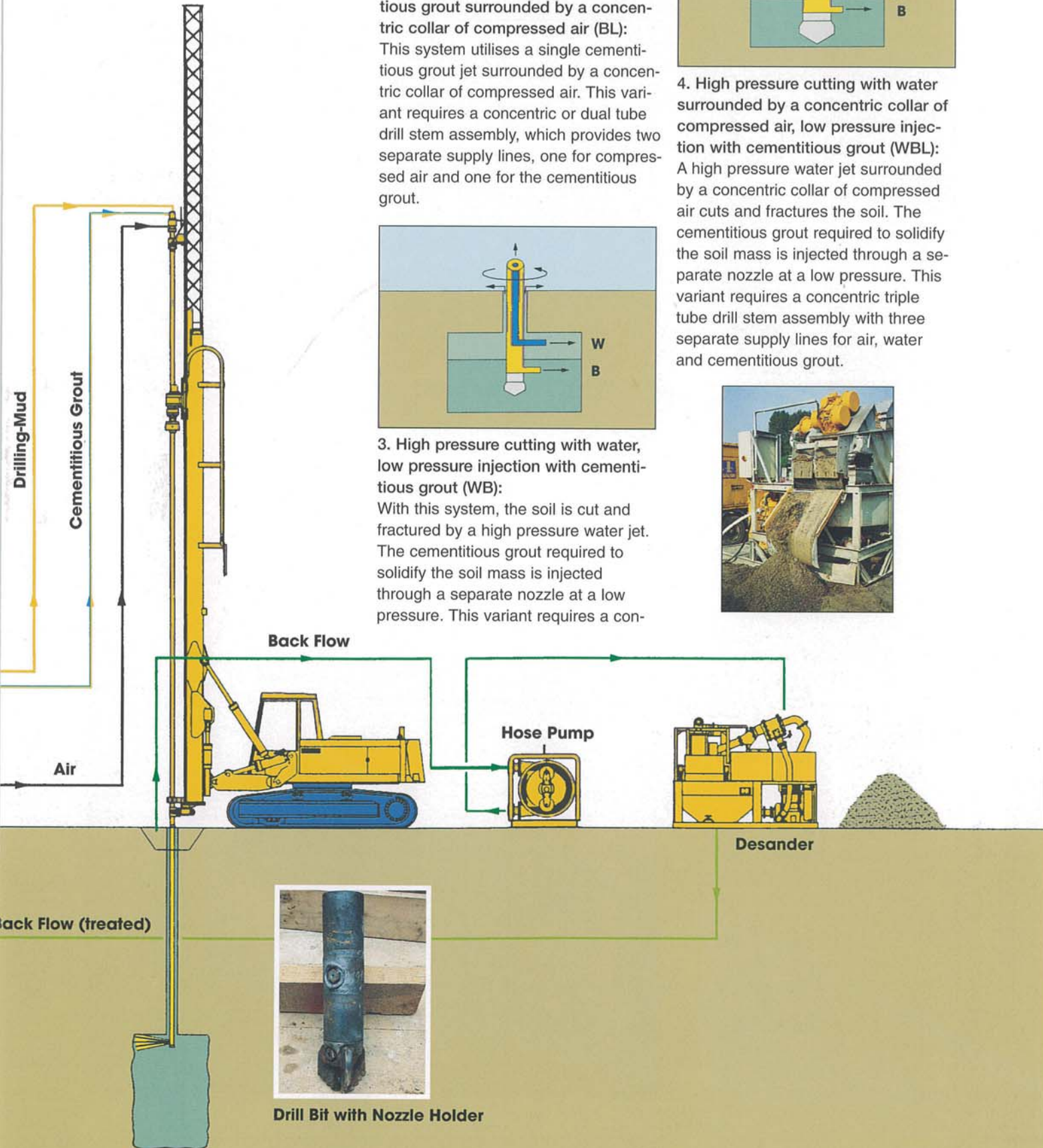
centric dual tube drill stem assembly with two separate supply lines, one for water and one for the cementitious grout.



4. High pressure cutting with water surrounded by a concentric collar of compressed air, low pressure injection with cementitious grout (WBL): A high pressure water jet surrounded by a concentric collar of compressed air cuts and fractures the soil. The cementitious grout required to solidify the soil mass is injected through a separate nozzle at a low pressure. This variant requires a concentric triple tube drill stem assembly with three separate supply lines for air, water and cementitious grout.



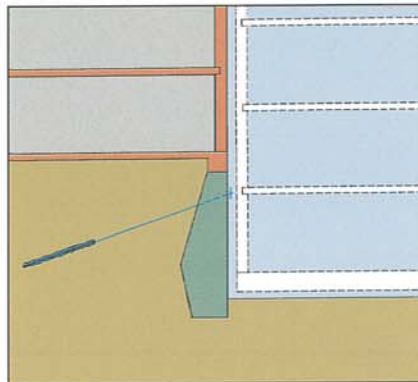
3. High pressure cutting with water, low pressure injection with cementitious grout (WB): With this system, the soil is cut and fractured by a high pressure water jet. The cementitious grout required to solidify the soil mass is injected through a separate nozzle at a low pressure. This variant requires a con-



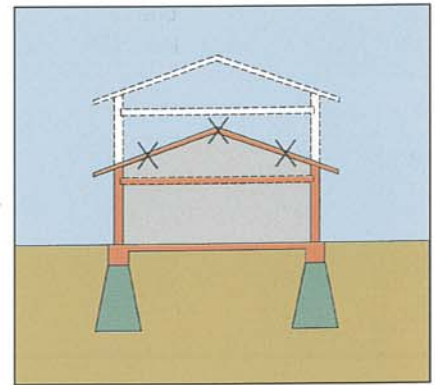
Drill Bit with Nozzle Holder

Applications

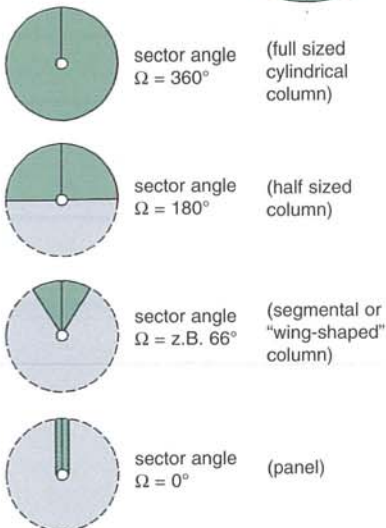
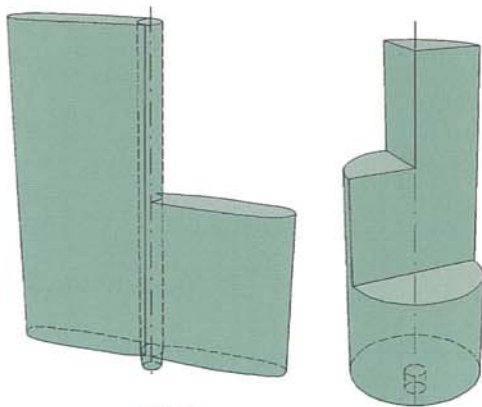
Jet grouting can be used to construct both vertical and horizontal structurals and groundwater cut-off elements. Vertical elements are primarily employed for underpinning, foundation construction for deep excavations and gap closures. Horizontal elements include deep as well as high lying base slabs to provide horizontal cut-offs and base stabilisation, and protective hoods or screens for tunnel drives. By adapting operating parameters such as drill stem rotation and withdrawal rates,



Underpinning to retain ground adjacent to an excavation

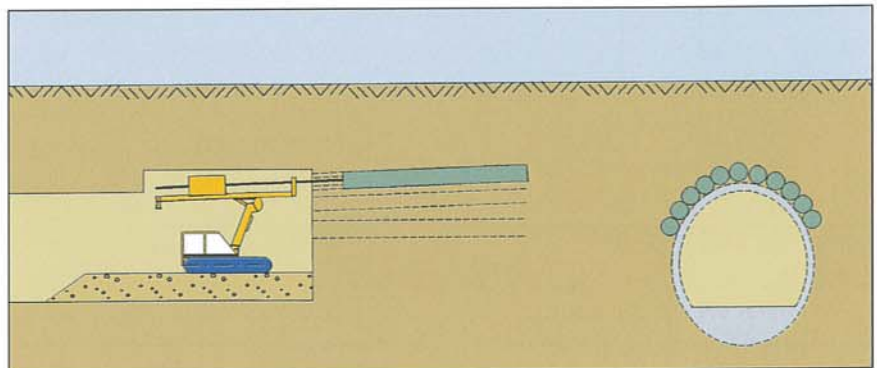


Underpinning to upgrade strip foundations



different shapes and sizes of jet grout elements can be produced for differing applications, ranging from full sized cylindrical columns, half sized columns and 'wing-shaped' segmental columns to panels.

Bauer operate an extensive range of specialist equipment for drilling the boreholes required for jet grouting, ranging from a 30 m long drill mast which allows drilling to great depths in a single pass without having to add drill tubes, to compact mini rigs for drilling in confined basement areas.



Protective hood or screen for tunnel drives

Underpinning

The most frequent application of jet grouting today involves the underpinning of buildings to facilitate a new basement excavation on an adjacent site without the loss of building space.

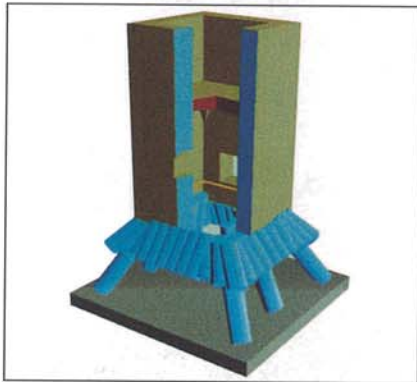
In this application, jet grouting replaces previously much used hand-dug underpinning methods and other more traditional grouting techniques suitable for certain soil types.



Advantages of Jet Grouting:

- Small deformations / good load bearing characteristics
- Provides a direct load bearing connection to existing foundations elements
- Underpinning possible to considerable depths
- Suitable in almost all soil types and below groundwater tables

Minimum dimensions of a block of jet grouting required for underpinning are determined by structural analysis. A grout column layout drawing is also prepared in the course of precontract planning.



Underpinning to upgrade existing foundations

Jet grouting is also an ideal method for upgrading existing strip foundations of buildings which are being changed to different usage, refurbished or enlarged by an additional storey. Historic buildings, in particular, are strengthened by this technique. This work is often carried out from inside existing basements. With the use of relatively small borehole diameters (approx. 150 mm), extensive foundation elements can be constructed, whilst any interference with the substance of the historic building is kept to the absolute minimum.

Horizontal cut-offs

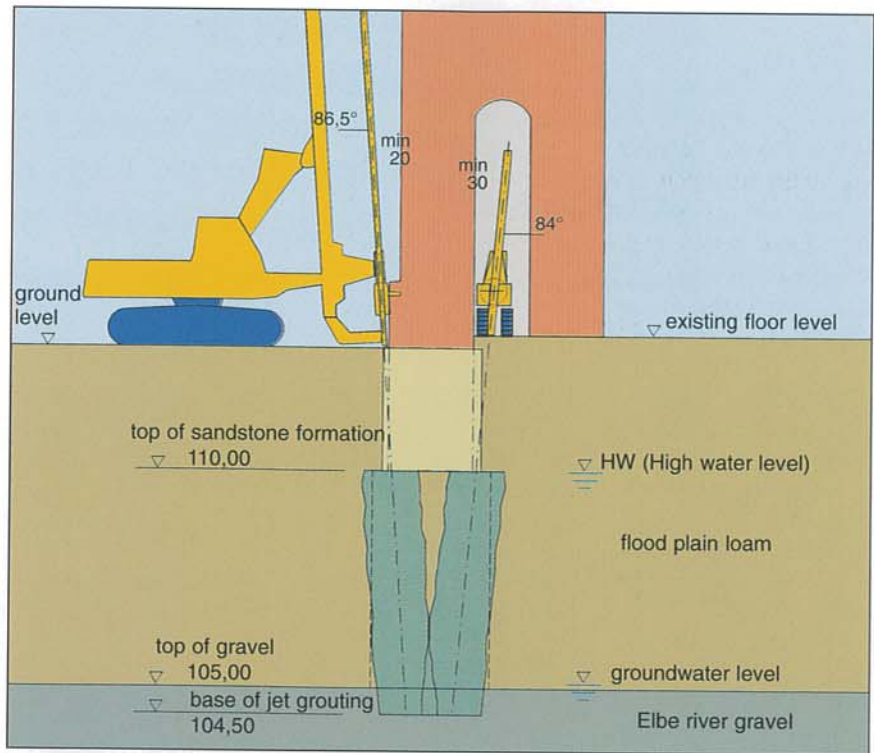
Jet grouting can be used to construct deep as well as high lying anchored base slabs to provide horizontal cut-offs and base stabilisation for deep excavations.

Deep base slab cut-off:

The weight of the overlying soil alone provides adequate safety against hydraulic uplift.

High base slab cut-off:

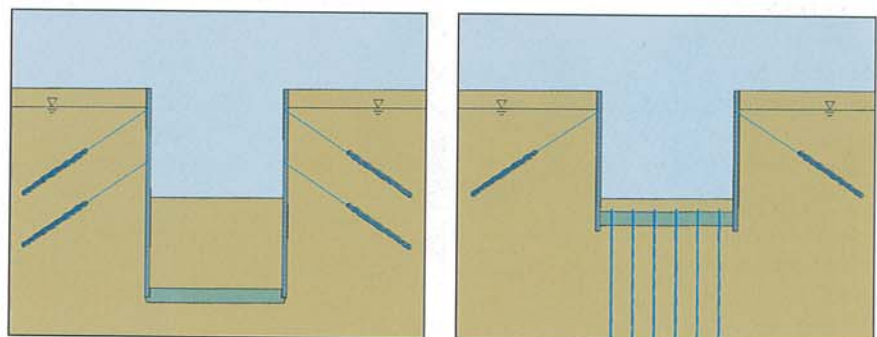
Hydraulic uplift forces are carried by vertical tension elements, such as tension piles or anchors. A high lying jet grouted base slab has the added advantage of being able to provide a strut for the retaining walls.



Underpinning in restricted conditions



Anchored jet grouted base slab





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