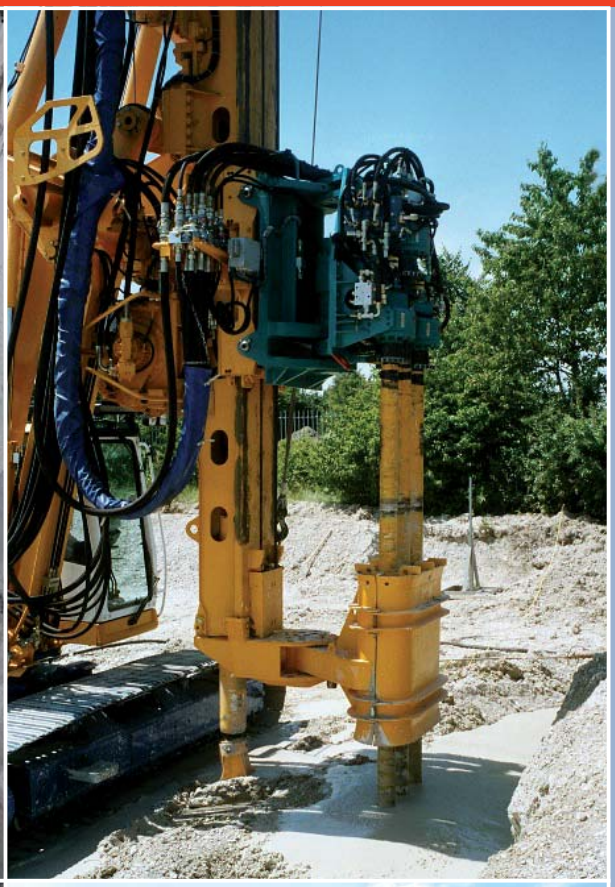
SMW

Soil Mixing Wall – System

03/2012



BAUER

The SMW-System

Mixing self-hardening slurry in-situ with native soil (SMW) is a cost-effective technique for the construction of walls for groundwater control (cut-off walls), walls for excavation support (retaining walls) as well as for ground improvement.

For walls with shallow depths (typically 6 to 15 m) the Bauer Soil Mixing Wall Method (SMW) has been developed. The soil is loosened and immediately mixed with a self-hardening suspension by three adjacent slightly overlapping augers and mixing paddles.

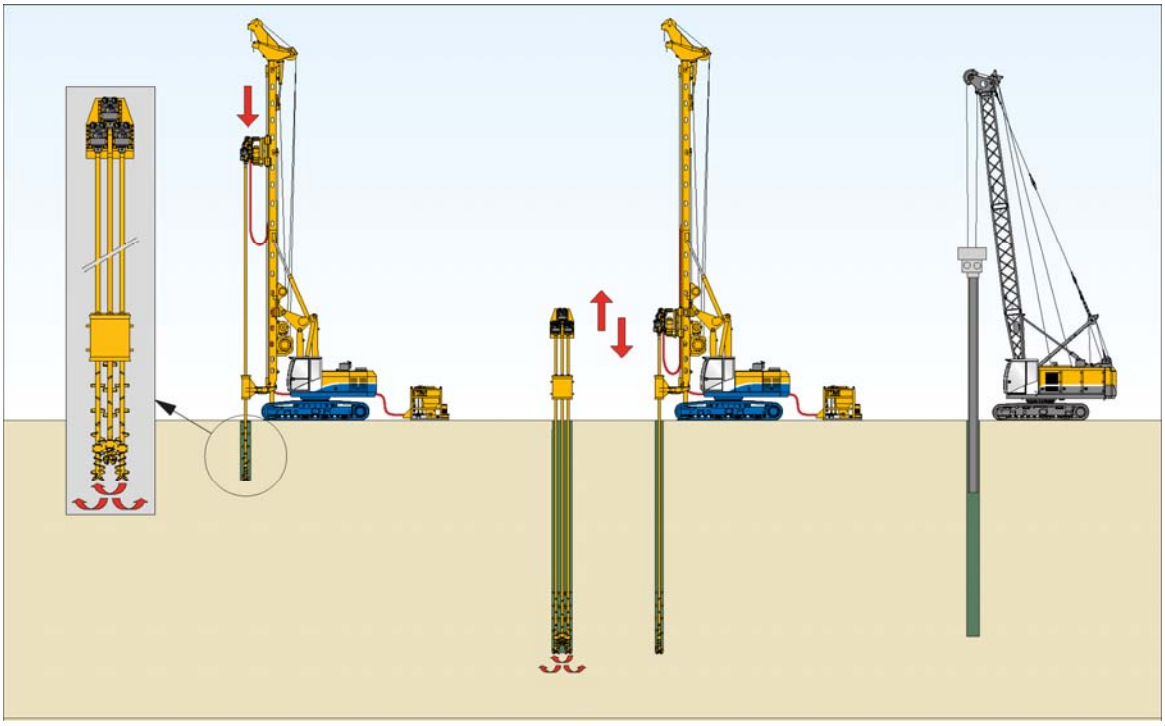
By loosening, conveying and mixing of the soil, minimum friction between rods and mixed soil is ensured. Therefore, it is possible to construct walls effectively rigs with medium power supply.

At the same time a very homogeneous soil-cement mixture can be ensured in order to achieve a good quality of the wall.

Main advantages of the method are:

- Small to medium size rigs can be used
- The in-situ soil is used as a construction material
- Very little generation of spoil (important factor in contaminated areas)
- No vibrations induced during construction (SMW can be used in immediate vicinity to buildings)

Construction sequence



Step 1: Excavation of a guide trench for collecting surplus slurry (trench width corresponding to diameter of mixing tool, depth approx. 50 cm) and align mixing tool with centreline of wall.

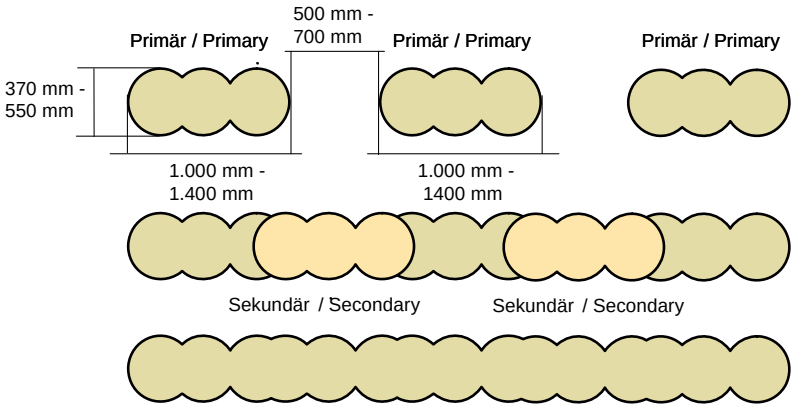
Step 2: Drill mixing tool into the ground in a continuous operation and concurrently inject self-hardening slurry. The two outer mixing paddles are rotated in opposite direction. The rate of penetration of the mixing tool and the volume of slurry delivered by the pump are controlled in such a way that no surplus slurry appears on the surface.

Step 3: After reaching the predetermined design depth, the mixing tool is withdrawn whilst the mixing paddles continue to be rotated. The volume of slurry injected during the withdrawal phase is equal to the displacement volume of the mixing tool.

Step 4: During the construction of a continuous wall, individual wall panels are installed in an alternating sequence of primary and secondary panels.

Step 5: Reinforcing elements required for structural purposes can be inserted into the completed soil mixing wall.
a) Insertion of sheet pile wall elements or steel stanchions into the not fully hardened wall. The spacing between individual stanchions is dependent on the characteristic strength of the hardened wall (arching effect) and the intensity of static loading.
b) Alternative: Installation of cast-in-situ bored piles in the hardened wall. The spacing between individual piles is dependent on the characteristic strength of the hardened wall (arching effect).

Sequence of wall construction



A continuous wall is formed in a series of overlapping primary and secondary panels. Overcutting into fresh adjacent panels is called „fresh-in-fresh method“.
The width of the secondary SMW panels results from the width of the used mixing tools.

Productivity factors

	favourable conditions	Unfavourable conditions
Soil structure	uniform soil structure	layered soil structure
Soil type	loose to medium dense gravelly sand, silty sand	dense to very dense soil, cobbles and boulders embedded in soil, stiff or hard soil, cohesive or organic soil (reduction of the final strength)
Site geometry	long, straight wall sections	irregular wall layout
Wall depth	wall depth > 6 - 10 m	wall depth < 5 m (influence of non-productive periods such as moving, setting-up)

The SMW process is a technique with wide-ranging applications. In order to avoid economical and technical problems during the construction of the wall and also quality-related problems on the completed wall, the following process-specific limitations should be taken into account:

- Capacity to drill in rocky types of soil or in soils containing cobbles and boulders
- Reduction in the strength of the completed wall in cohesive or organic soils.

Rate of production

Recommended rates of production favourable conditions: 20 - 24 m² per hour
unfavourable conditions 12 - 15 m² per hour

(Net production per m² of completed wall including overlaps and in-situ mixing)
When determining the theoretical total production it is recommended to apply a utilization rate ranging from 65 – 80 %

Personnel
1 operator SMW-rig
1 mixing plant operator
1 foreman
(1 helper)

Slurry

Components

The slurry mix used in the construction of SMW panels consists normally of:

- Cement OPC or blast furnace cement CEM III/B 32,5 (typical)
- Bentonite Standard bentonite
- Additives (plasticizer, retarder or polymer additions) optional
- Admixtures (fly ash) optional

Mix proportions and consumption values

The mix design is governed by various factors:

Application:

- Cut-off wall (permeability, strength, plasticity, erosion stability)
- Retaining wall (strength, permeability, plasticity of fresh mix - as precondition for the installation of reinforcement)

Soil properties:

Particle size distribution, grain size, fines content, organic content, relative density, porosity, groundwater level, groundwater chemistry

The mix design should always - especially in unknown conditions - be determined by suitability tests prior to the start of construction.

The following tables give values for an initial design of the mix proportions. They should be used for reference only. They have to be confirmed by suitability tests.

Binder slurry (typical predesign values)

	Cut-off wall	Retaining wall
Cement	250 - 450 kg/m³ slurry	750 – 1.200 kg/m³ slurry
Bentonite	30 – 50 kg/m³ slurry	15 – 30 kg/m³ slurry
w/c ratio	2,0 - 4,0	0,5 - 1,0

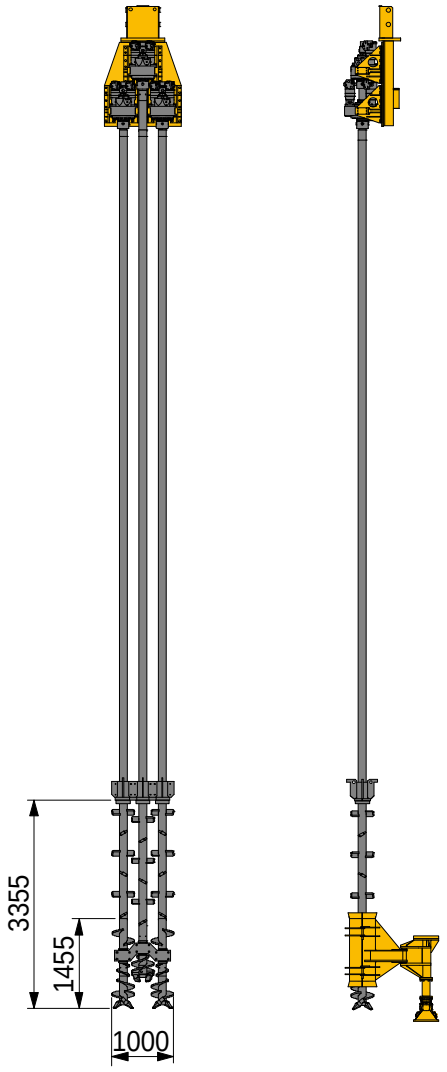
Wall characteristics (typical predesign values)

	Cut-off wall	Retaining wall
Compressive strength q_u	0,5 - 2 MPa	5 - 15 MPa
Permeability kf	ca. 1 x 10^{-8} m/sec	
Cement content in soil	100 - 200 kg/m³ soil	200 - 450 kg/m³ soil

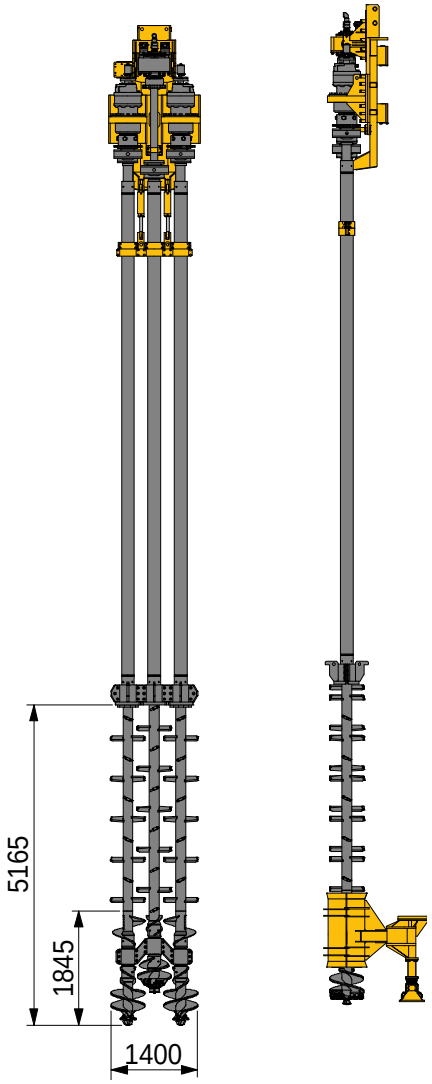
SMW-Mixing units

The SMW mixing units are available in two dimensions: (**SMW 370** and **SMW 550**).
Wall thickness of 370 mm or 550 mm can be reached.

SMW 370



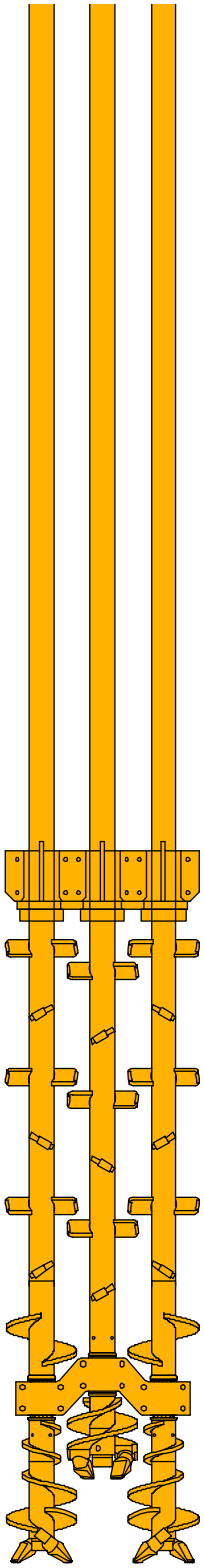
SMW 550



Technical data:	**Rotary drives:**
Type	**SMW 370**
Manufacturer	**EURODRILL**
2 Rotary drives (outer)	
Speed (max.)	50 rpm
Torque (max.)	23.6 kNm
1 Rotary drive (central)	
Speed (max.)	68 rpm
Torque (max.)	14 kNm

Technical data:	**Rotary drives:**
Type	**SMW 550**
Manufacturer	**EURODRILL**
2 Rotary drives (outer)	
Speed (max.)	25 rpm
Torque (max.)	51 kNm
1 Rotary drive (central)	
Speed (max.)	64 rpm
Torque (max.)	19 kNm

In the SMW method the soil is loosened and mixed with self hardening slurry with three slightly overlapping augers and mixing paddles.
A SMW-mixing unit consists of four sections:



Section 4:

The rods end with a simple tube extension. This ensures the required depth of the panel, without the building up of friction.

Section 3:

The mixing area is located right above the augers (Section 2). Counter-rotating and overlapping of the paddles ensures a homogeneous mixing over the whole panel area.

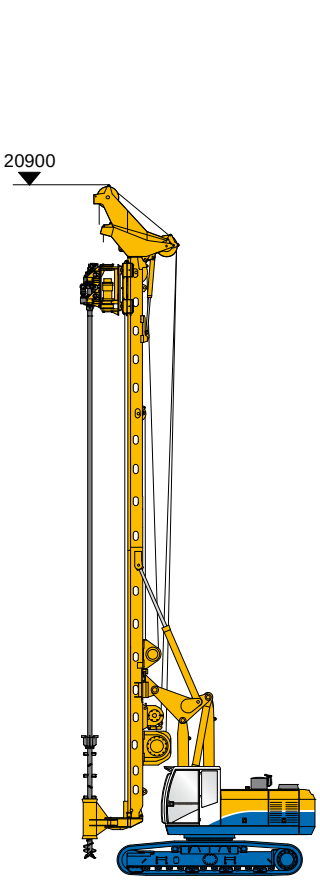
Section 2:

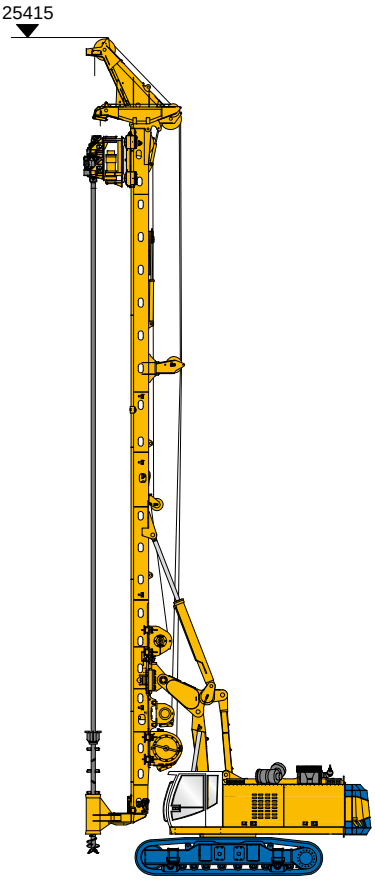
Short augers above the central pilots are moving the loosened soil and the slurry upwards, to ease the loosening process. The auger flights of the outer strings are smaller in the starter area of the inner auger to prevent collision of the three augers.

Section 1:

The soil is loosened at the bottom of each auger with two cutting edges and a central pilot bit. The outer augers are rotating in opposite direction. The starter of the central auger is placed at a slightly higher position. While cutting the soil, slurry is pumped into the soil through radial nozzles at the bottom of the augers.

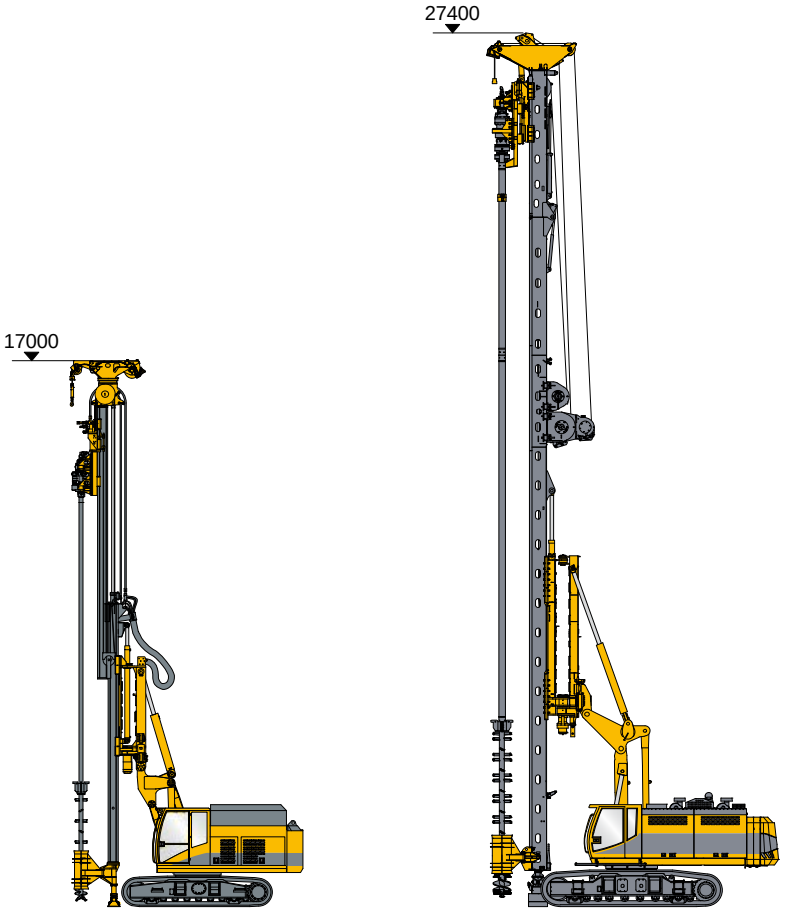
Base carrier (BG-series)





	BG 18 / BG 20	BG 24 / BG 28
SMW-unit (recommended)	**SMW 370**	**SMW 370 / SMW 550**
Panel depth (approx.)	**13 m - 14,5 m**	**15,5 m - 18 m**
Installed power	**186 kW - 205 kW**	**261 kW - 313 kW**
Crowd pull	**200 kN - 260 kN**	**330 kN**
Overall height	**19,1 m - 20,9 m**	**21,8 m - 25,4 m**
Operating weight (approx.)	**53 t - 60 t**	**60 t - 90 t**

Base carrier (RG-series)



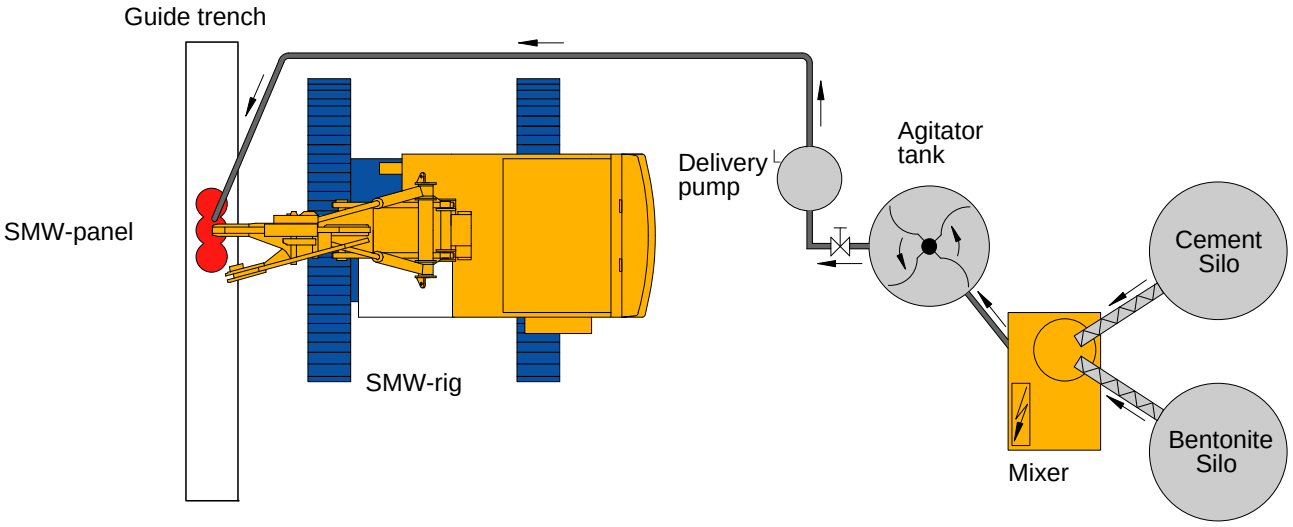
	RG 14 T	RG 16 T	RG 19 T
SMW-unit (recommended)	SMW 370	SMW 370 / SMW 550	SMW 370 / SMW 550
Panel depth (approx.)	10,6 m	11,5 m	14,6 m
Installed power	311 kW	570 kW	570 kW
Crowd pull	170 kN	200 kN	200 kN
Overall height	18,3 m	21,5 m	24,7 m
Operating weight (approx.)	48,5 t	60 t	70 t

	RG 21 T	RG 18 S / RG 22 S	RG 25 S
SMW-unit (recommended)	SMW 370 / SMW 550	SMW 370 / SMW 550	SMW 370 / SMW 550
Panel depth (approx.)	17,1 m	17,5 – 20,0 m	20,0 m
Installed power	570 kW	570 kW	570 kW
Crowd pull	260 kN	400 kN	530 kN
Overall height	27,6 m	22,1 – 26,03 m	29,4 m
Operating weight (approx.)	82,7 t	79 – 80 t	98 t

Additional equipment

		kW (ca.)	
Slurry mixing station	minimum capacity 20 m³/h (e.g. batch mixer MAT SCC 20 or bigger)	30	
Delivery pump	frequency controlled slurry pump with remote control, capacity depends on volume of panel and speed of mixing.(typically: 200 - 400 l/min, 12 – 15 bar, for instance EP 12-400 or EP 12-600)	18,5	
Agitator tank	approx.3 - 5 m³ (as buffer for cement slurry)	2,2	
Silos	for cement and bentonite with screw conveyors	2 x 5	
Hydraulic backhoe	for excavation of guide trench, maintenance of working platform, handling of backflow	50	
Hoses	for conveying cement or bentonite slurry from the agitator to the rig. Typically 1,5” or 2” rubber hose (length to suit site requirements)		
Service crane and vibrator	for inserting universal beams into the panel of retaining wall. Size of crane depends on length and weight of beams and vibrator use	60	optional
	Steel plates or excavator support mats if working platform is not able to support the weight of the rig		recom-mended

Schematic site installation



Quality control

Prior to construction:

Suitability test to determine mix design. Material testing in accordance with QA plan.

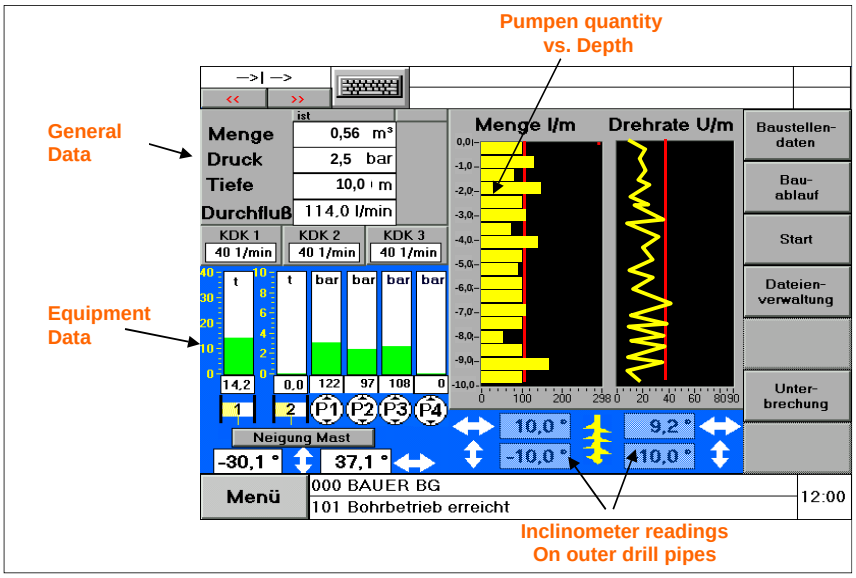
During construction:

Geometric checks of individual panel positions

Slurry tests in accordance with QA plan

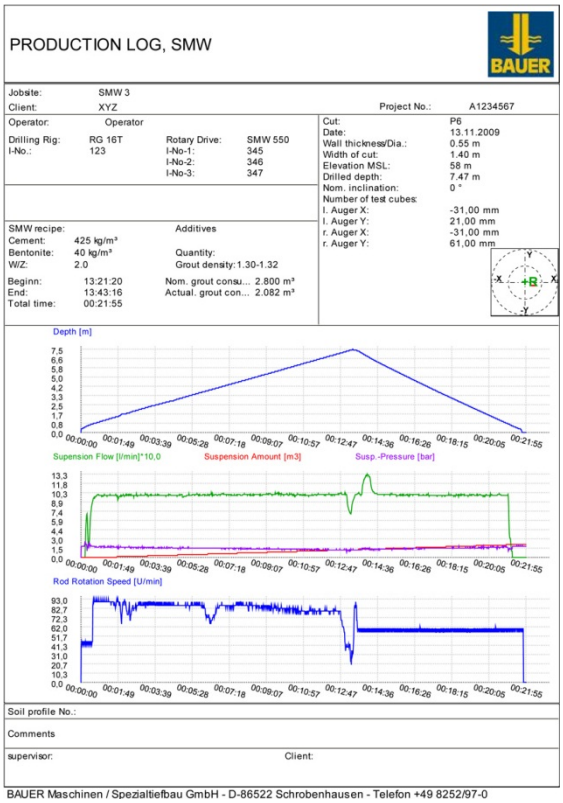
Control of production parameters displayed on the monitor of the rig operator:

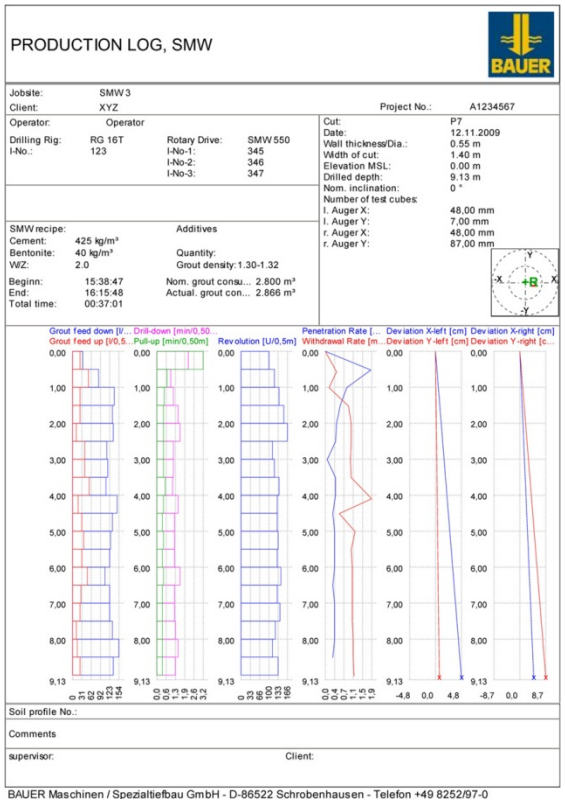
- Depth
- Volume
- Slurry pressure
- Pumped volume v. time
- Pumped volume v. depth
- Inclination
- Speed of mixing tool



Documentation:

All production parameters are monitored recorded and stored inside the rig throughout the construction process and can be printed out in the form of a quality assurance record for each individual panel.





Site examples

Retaining wall with RG, Sydney, Australia

Cut-off wall with BG, Oberhausen, Germany

Excavated SMW retaining wall, Sydney, Australia

Exposed test shaft, Sydney, Australia

BAUER Maschinen GmbH
BAUER-Straße 1
D-86529 Schrobenhausen
Tel. +49 (0)8252/97-0
Fax +49 (0)8252/97-1135
e-mail: BMA@bauer.de
www.bauer.de