BA - ANCHOR SYSTEM
Non-penetrative fastening technology for reinforcement of concrete inner shells and in-tunnel installations
BA-ANCHOR
The patented BA-anchor is a rigid PVC shell with flange factory-welded onto a PVC tunnel waterproofing membrane, and allows connection to a non-penetrative flexible seal. The sealing layer is not penetrated by the anchor, but led around the anchor with the same material as the seal, thus maintaining the seal’s tightness and integrity. To ensure that the BA-anchor meets the highest quality standards, it is tested in the laboratory and in various tunnels. The tensile and shear force transmissions of the anchor are optimal. Initially, the non-penetrative BA-anchor was deployed in the branch line and service bay in Kohlfirst tunnel N4, and has since been applied successfully in tunnel construction worldwide.

APPLICATIONS
The BA-Anchor system is used in tunnels and gallery construction wherever flawless sealing against groundwater is needed, even in instances of high water pressure. On the other hand, where the use of a formwork is not needed such as in rapid changes in cross sections, short tunnels, and in the production of drainage seals on excavation pits.

ADVANTAGES
° The BA-anchor system enables fast, safe installation of a single-sided reinforcement framework to protect shotcrete structures.

° The BA-anchor provides an excellent distribution of force through the rigid PVC shell.

° Because the sealing layer is not interrupted, as in a conventional anchor system, the anchor rod is protected against corrosion.

° The installation is quick and easy.

![Diagram of BA-Anchor System](image)
LAYERS STRUCTURE IN BA-ANCHOR

1. Drill hole D=32 mm
2. Anchor grout (BA-anchor (resin)
3. Anchor M16, rigid PVC
4. Anchor rod M16, St III
5. Shotcrete leveling layer
6. Drainage mat
7. Geomembrane PVC-soft
8. Link PVC-rigid/PVC-soft
9. Welding PVC-soft/PVC-soft
10. Fastening point D=12 mm perforated
11. Anchor spider D=14 mm perforated
12. Spacer for e=30 mm
13. Reinforcement shotcrete
14. Shotcrete/in-situ concrete
15. Fastener for geomembrane
BA-ANCHOR SYSTEM IN PRACTICE

SHOTCRETE INNER SHELL

- Flexible, non-penetrative seal
- Safer shotcrete order
- High tensile strength of the anchor
- Perfect corrosion protection
- No perforation for sealing

COMPOSITE ARCH

- Exterior and interior vaults are activated together against mountain, and if necessary against water pressure.
- Tensile-and shear-resistant connection exterior/interior vaults
- Flexible, durable sealing
- Corrosion-resistant anchor

SHEAR PROTECTION

- Shear-safe connection of the protective layer at outer seals
- Reduction in the required thickness of the protective layer

FORMWORK ASSEMBLY

- Single-sided formwork assembly without support and without penetrating the seal
- Non-penetrative anchor assembly for lifting anchor
1. DRILL HOLE
- Drill hole according to anchor length for normal anchor M16/200: 32 mm L = 200 mm
- Inspect shotcrete and rock strength (drilling dust, sample anchor)

2. CLEANING OF DRILL HOLE
- Clean the drill hole first with pressurized water and compressed air.
- Check for water in the drill hole. Water must not be present in the drill hole. Moisture on the drill hole is not problematic.

DRAIN
- Remove drilling dust.
- Rinse with high-pressure water.
- Blow out drill hole with compressed air.
- Remove standing water with compressed air.

3. BA-ANCHOR GROUT
- Prior to injection ensure there is no water in the drill hole.
- Fill the drill hole to about 1/2 of the drill hole depth with BA-anchor grout.
4. INSERTING THE BA-ANCHOR/WELDING
- Carefully screw in the BA-anchor prior to curing of the anchor grout until the flange rests on the threaded tunnel geomembrane (avoid air pockets).
- Clean the welded tunnel waterproofing membranes of sand, oil, grease, etc.

5. SCREWING IN THE M16 THREADED ROD
- The welded nut has a safety stop at 190 mm.
- Carefully hand-screw plastic thread.
- Insert with power assist into the pressure pitch.

6. TESTING THE TRACTION
Test equipment:
- Support plate
- Mount plate with screws
- Press with double cylinder
- Manometer
- Hand pump
## SPECIFICATIONS OF STANDARD ANCHORS-BA 16/200 PVC

### BA-anchor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchor diameter</td>
<td>mm</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Anchor length</td>
<td>mm</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Shell diameter</td>
<td>mm</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Shell length</td>
<td>mm</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Drill hole diameter</td>
<td>mm</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Steel quality</td>
<td></td>
<td>8.8</td>
<td></td>
</tr>
<tr>
<td>Working load</td>
<td>kN</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

### Anchor shell with flange

<table>
<thead>
<tr>
<th>Material</th>
<th>Density</th>
<th>Yield stress</th>
<th>Elongation at yield</th>
<th>Breakdown voltage</th>
<th>Elongation at break</th>
<th>Pull-E-module</th>
<th>Bend-E-module</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC-U (PVC-rigid)</td>
<td>g/cm³</td>
<td>Mpa</td>
<td>%</td>
<td>Mpa</td>
<td>%</td>
<td>Mpa</td>
<td>Mpa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.37</td>
<td></td>
<td>52</td>
<td>3.5</td>
<td>31</td>
<td>22</td>
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</tbody>
</table>

### Adhesive mortar epoxy

<table>
<thead>
<tr>
<th>Material</th>
<th>Density</th>
<th>Compressive strength</th>
<th>Tensile strength</th>
<th>Torsion strength</th>
<th>Adhesion to concrete</th>
<th>Pull-E-module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epoxy resin</td>
<td>g/cm³</td>
<td>Mpa</td>
<td>Mpa</td>
<td>Mpa</td>
<td>Crushed concrete</td>
<td>Mpa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.65</td>
<td>60</td>
<td>15</td>
<td></td>
<td>5,000</td>
</tr>
</tbody>
</table>

### Plastic cartridges for BA-anchor resin

<table>
<thead>
<tr>
<th>Material</th>
<th>Density</th>
<th>Compressive strength</th>
<th>Adhesion to concrete</th>
<th>Dynamic-E-module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyester resin</td>
<td>g/cm³</td>
<td>Mpa</td>
<td>Crushed concrete</td>
<td>Mpa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.0</td>
<td></td>
<td>15,000</td>
</tr>
</tbody>
</table>

NOTE

The BA-anchor is also available in a version with FPO material.
STANDARD BA-ANCHOR 16/200 PVC AND MOUNTING ACCESSORIES

STANDARD ANCHOR BA 16/200 PVC

ANCHOR GROUT/ANCHOR RESIN

ANCHOR ROD

ANCHOR PLATES FIXING POINT

NOTE: Also available for all other dimensions
SPECIAL TYPES OF BA-ANCHORS

BA 10/75 PVC
Metric 10 mm thread for light loads

BA 20/200 PVC
Metric 10 mm thread for medium loads

BA 24/500 PVC
Metric 24 mm thread for heavy loads

BA 30/500 PVC
Metric 30 mm thread for very heavy loads
SPECIAL TYPES OF BA-ANCHORS

BA-anchor from left to right:
BA-twin anchor, BA 16/200 PVC
BA-anchor with viscous epoxy resin
BA-anchor 16/200 PVC (standard anchor)

NOTE:
BA-anchors can be produced in different countries, if necessary.
The delivery time for special productions is 6-8 weeks.
BENCHMARK TESTS

Pull-out test, performed on BA-anchors in non-reinforced shotcrete

1st Test
BA-anchor with epoxy resin
Embedment depth anchor steel: 190 mm

<table>
<thead>
<tr>
<th>Results:</th>
<th>Pull-out strength after 8 days</th>
<th>Pull-out strength after 32 days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>110 kN</td>
<td>&gt;120 kN</td>
</tr>
<tr>
<td></td>
<td>Until fracture of the shotcrete</td>
<td>Until fracture of the shotcrete</td>
</tr>
</tbody>
</table>

2nd Test
BA-anchor fixed anchor with fiber-reinforced mortar
Embedment depth anchor steel: 190 mm

<table>
<thead>
<tr>
<th>Results:</th>
<th>Pull-out strength after 8 days</th>
<th>Pull-out strength after 32 days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>65 kN</td>
<td>95 kN</td>
</tr>
<tr>
<td></td>
<td>Until the breaking of rigid PVC shell</td>
<td>Until the breaking of rigid PVC shell</td>
</tr>
</tbody>
</table>

REMARKS:

These results originated from tests and cannot be viewed as maximum pull-out strength for other projects. The results serve as a rough guide. The theoretical stripping force was set at 30 kN/anchor. Each project requires pull-out tests under local conditions. It has proven effective to test every tenth anchor with 30 kN stripping forces.

The number of offsetting BA-anchors, depends on the requirement at 0.3-1 per piece/m2. The rigidity of the reinforcement net as well as the flatness of the substrate determine this number. The stability of a self-supporting shotcrete inner shell is always the responsibility of the design engineer.
BENCHMARK TESTS

LOESCHBERG BASE TUNNEL

ALPTRANSIT

Test of HIGH LOAD ANCHOR

Engineers and Examiners at work

Anchor shell BA 30/300

Offset in rock anchor shell with anchor rod

Test equipment with hydraulic device up to 700 bar

NOTE: Detailed documentation is available upon request.
APPLICATION: TUNNEL KOHLFIRST, FLURLINGEN (CH)

TUNNEL KOHLFIRST, FLURLINGEN
General view of the tunnel
Branch 5 gauge lines, vaulted with shotcrete (self-supported)

BA-ANCHOR
Mounting with drill mount

BA-ANCHOR
Attached reinforcement spider anchor is only necessary in network sections shorter than 8 mm.

BA-ANCHOR mounted
Afterwards the shotcrete layer gets applied with a thickness of 30 cm.
Vaults with BA-anchor for receiving the shotcrete. In the tunnel, the Jungfrau-Railway, the overhead line was mounted with BA-anchor.
APPLICATION: TUNNEL MROZOVKA; PRAGUE (CZ)

Installation of BA-anchor for assembly of the reinforcement and special anchor plates in the vaults

**BA-anchor** built-in
for installation of reinforcement and anchor plate

**Special anchor plate** in the vault mounted on anchor rods of BA-anchor 20/300 FPO

**Special anchor plates** in the vault
4 pcs. BA-anchor 20/300 FPO produced as a special grade, according to the engineer
APPLICATIONS:

TUNNEL ZIMMERBERG-ZURICH, ZUGANGSTOLLEN, ZERMATT, TUNNEL SCHOENBUHL-BERN (CH)

TUNNEL ZIMMERBERG LOS 101, ZUERICH

BA-anchor to accommodate the reinforcement in the upper wall area and as an additional support of the formwork

ZUGANGSTOLLEN, ZERMATT

Anchor assembly with spider for small network sections

TUNNEL SCHOENBUHL, BERN

Anchoring the ceiling support with BA-anchor 20/200 PVC
BA-ANCHOR TENDER SPECIFICATION

1. BA-anchor drilling and shifting
Deliver and offset BA-anchor type:_________ with internal thread and anchor rod M________steel III, including drilling the blind holes circa ________cm deep in the outside vault. Deliver and press the anchor grout or the anchor resin brand type:_________incl.
Screw the BA-anchor into the blind hole. Connect the sealing membranes to the tunnel film by sealing technicians.

2. BA-anchor connection to tunnel film
Weld the BA-anchor membrane with the tunnel foil using simple seam welding incl. of any cleaning work BA-anchor type:_________.

3. BA-anchor drilling, Moving and connection to the tunnel film
Deliver and move the BA-anchor type:_________ with internal thread anchor rod for M________steel III, incl. drilling blind holes circa_________cm deep into the outer vaults. Deliver and press in the anchor grout or the anchor resin brand type:_________incl.
Screw in the BA-anchor in the blind hole and connect the sealing membrane by simple seam welding to the tunnel film.

4. BA-anchor mounting assistant for reinforcement
4.1 Deliver the on-site mounting anchor rod to BA-anchor type:_________
4.2 Deliver the on-site mounting spider anchor to BA-anchor type:_________
4.3 Deliver the on-site mounting of net holders to BA-anchor type:_________

5. Surcharges for Pro. 1-3
5.1 Surcharges for cutting the protective layer for the flange and welding with underlying sealing foil
5.2 Closing and adding the protective layer in the flange of the anchor shell