

**■ Marine Structures****Reference Details:**

Owner State of Saxony,
Saxonian State Ministry for the Environment and
Agriculture, Plauen,
Germany +++ **Main
Contractor and
General
Contractor** Contractor
Ed.Züblin AG,
Chemnitz, Germany
+++

Subcontractor INSOND
GmbH, Spezialtiefbau,
Neumarkt am
Wallersee, Austria +++

Design
Arbeitsgemeinschaft für
Ingenieurleistungen
Instandsetzung
Talsperre Muldenberg
(JV ITM), consisting of
KUBENS
Ingenieurgesellschaft
mbH, SPIEKERMANN
GmbH & Co.,
Ingenieurbüro Dr.Linse
and HPI Hydroprojekt
Ingenieurgesellschaft
mbH, Germany

DSI Units DSI Austria /
DSI Technical Services,
Germany

DSI Services
Manufacture and
delivery of 19
permanent DYWIDAG
Strand Anchors with
3x7=21 strands Ø15.3
mm, anchor length 42 m
with accessories;



Rehabilitation works on the Muldenberg Dam using 19 permanent DYWIDAG Rock Anchors consisting of 21 strands Ø15.3 mm and in lengths of 42 m

Rehabilitation of the Muldenberg Dam, Vogtland, Saxony, Germany

The Muldenberg Dam is located in the upper Vogtland in Saxony and was built as a rubble masonry gravity dam between 1920 and 1925. Since its completion, it has served as a drinking water supply reservoir, as a low water elevation of the Zwickauer Mulde and provides flood protection for the surrounding area.

Inspection and calculations revealed extensive damage to the masonry after 75 years of operation and inadequate stability for the load cases of temperature strain, ice pressure and earthquakes. To ensure stability, the installation of 19 permanent rock anchors with a working load of 2,500kN and a length of 42m was required in the spillway.

The following processes had to be carried out, before the permanent anchors were installed:

- Drilling of the Ø146 mm pilot holes: The continuously cored pilot holes were drilled at an angle of up to 2° from the vertical line within the specified maximum deviation of 1%. This high accuracy requirement could only be met by using the proper alignment tube and stabilizers in the drill string.
 - Widening of the pilot holes and measurement: After curing the grout, the Ø146mm pilot holes were redrilled using a winged chisel and the borehole inclinations determined with an inclinometer. The deviations were less than 1% (20-30 cm in the deepest boreholes - about 45 m).
 - Enlargement of the pilot holes and testing using water pressure: The pilot holes were enlarged to a diameter of 245mm using a down-the-hole hammer. Subsequently, the water pressure tests (so-called W/P tests) were carried out in 3 m sections with double packers in the anchorage and wall areas. For permeabilities of more than 1 Lugeon (i.e. water quantities in liters per minute and meter applying a pressure of 10 bar), the steps of hardening, drilling and a new W/P test had to be repeated. Since water losses could be up to 20 times the allowable rate nearly all the holes had to be regouted and redrilled.
- Details:**
- The drill cores revealed graywacke quartzite placed in cement grout in the masonry and clay slate type phyllite and quartzite in the subsoil. The distance between the drill holes and the existing inspection gallery about 15m below the drill rig was only 30-40cm.
- Improvement of the subsoil and rubble masonry using cement grout: While the rocky subsoil was grouted with pressures up to 10 bar, the backfilling of the rubble masonry was carried out without applying any pressure, using simple packers in stipulated grouting section lengths (packer grades).

A total of 19 permanent DYWIDAG Strand Anchors with 21 strands Ø15.3 mm ($A = 140\text{mm}^2$), St 1570/1770 N/mm² had to be manufactured. Originally, the microwax corrosion protected individual strands were to be prefabricated at the Elsbethen works and subsequently brought to an on site assembly building (45 x 5m) to be assembled into anchors.

However, in order to keep site work to a minimum and to facilitate the use of standard parts, the following procedure was used:

Technical supervision;
Rental of technical
equipment

- Manufacture of complete 7-strand permanent standard anchors including primary injection of the bond length at the Elsbethen works, Austria;
- Transport of the 7-strand anchors to the job with adequate storage at a stipulated site;
- Assembly of three 7-strand individual anchors into one 21-strand permanent anchor and fixing of the head connection template and a temporary buckling protection to the transition point between bond length and free length;
- Manufacture of all anchor head components for the incorporation of 3x7=21 strands at the Elsbethen works, Austria.

Another important step was to install the anchors from the storage site directly into the drill hole via the dam crest, using a mobile crane with an adequate boom length. A 200t crane was used for the installation of the first 3 anchors. A suitability test according to DIN 4125 was successfully performed on these structural anchors. For the installation of the remaining 16 anchors a 400t crane with a hook clearance of 120m was used because its long boom made movement unnecessary. As a result, the time-consuming transport of the anchors to the spillway with a possible intermediate storage and the lowering of the anchors via a deflector by means of a crane or winch could be saved.

All anchors were installed in boreholes that were partly filled with water. They were suspended from their anchor heads and grouted in the borehole from bottom to top. The "interior grouting" of the bond length was eliminated, because it had been pregrouted in the shop. After the cement grout had partly cured, the anchor head components were repositioned and the remaining hollow spaces grouted. Special emphasis was put on the fact that the emerging of the individual strands from their respective micro wax filled sheathing at the transition point to the wedge anchorage takes place in a closed sealed chamber which is also filled with micro wax. Thus, there are no contact surfaces between the corrosion protective compound and cement grout.

After the grout had cured for 28 days, a suitability test or load testing was carried out on the anchors, using a jack type HOZ 4000 with a stressing chair. The maximum anchor test load of 3,750 kN corresponded to 150% of the working load. The elongation of the strands was measured with a precision clock frequency gauge with continuous display. As a result, the repositioning of traditional bar clock frequency gauges was not required because the elongation was limited to approximately 200mm.

A software program developed by the Chairman of the soil mechanics and foundation engineering/geotechnics Department of the technical university of Cottbus was used to prepare the stressing procedures including the required force/time displacement lines. The working load of the anchors was specified at 70% (1,750 kN). In 2006, after completion of the remaining rehabilitation works, the anchors will be restressed to the final specified working load of 2,500kN. The entire construction project was subjected to a quality assurance system. All companies involved prepared operating and quality plans that could only be implemented after approval by the client. Specific job planning and the constructive cooperation between the special heavy civil engineering companies and the DSI personnel led to the successful completion of this unusual geotechnical construction project.