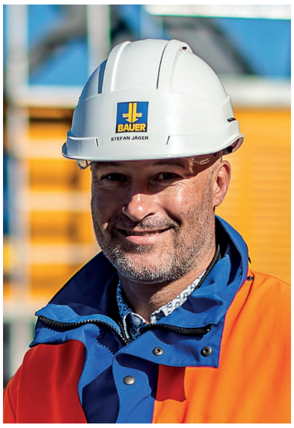
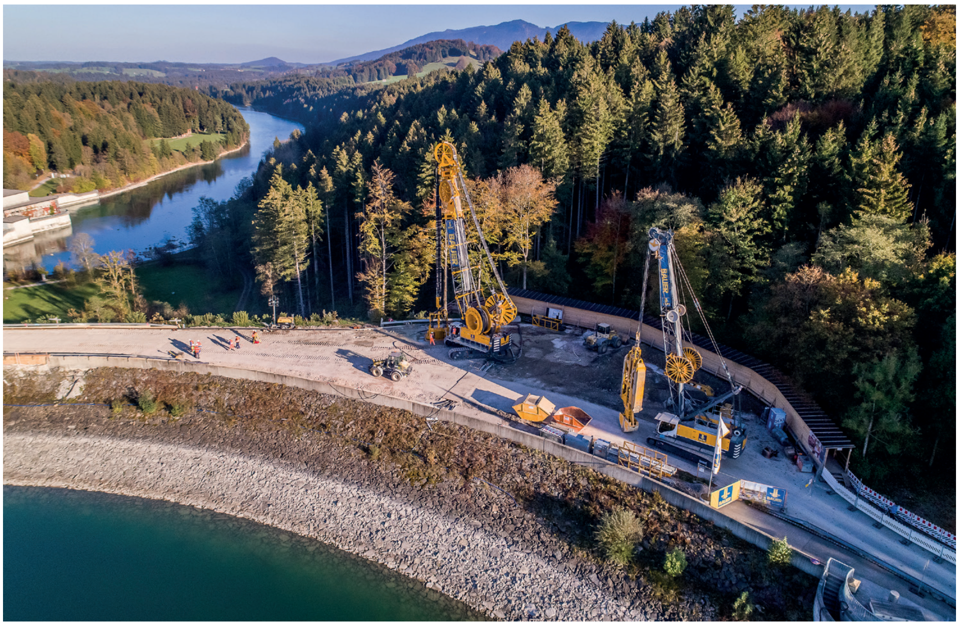
Cut-off wall construction

A new diaphragm cut-off wall has been constructed for the Rosshaupten Dam in Germany. Report by **Stefan Jaeger**, Tender Engineer at BAUER Spezialtiefbau GmbH



Above: **Stefan Jaeger**



Right: **Figure 1: Rosshaupten Dam during remediation**

Below from left to right:
Figure 2: Excavation of the trench with the supporting effect of a slurry made of bentonite and water

Figure 3: Two Bauer duty-cycle cranes of the types MC 96 (left) and MC 64 were used

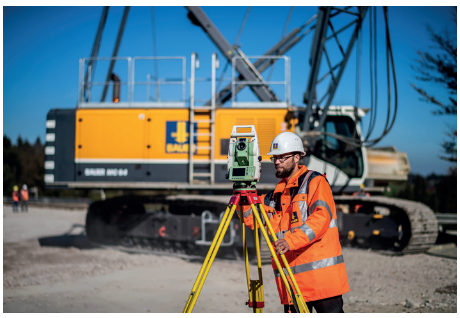
Figure 4: Using a tachymeter, the position of the aboveground section of the wire ropes was recorded three-dimensionally in space

WITH A SURFACE AREA of approximately 16km^2, the Forggensee in the Allgäu region is the fifth largest lake in Bavaria and the largest reservoir in Germany in terms of surface area. The structure has been in operation since 1954. In autum and winter, the lake releases water to the Lech river. In spring, it absorbs the water from melting snow and prevents flooding. To prepare the Rosshaupten Dam for the future, the power plant operator Uniper Kraftwerke GmbH commissioned BAUER Spezialtiefbau GmbH to renovate the inner seal of the dam (Figure 1).

The retaining structure is an earth fill dam approximately 40m high with a supporting body made of gravel and boulders and a centrally located sealing core made of material with a high cohesive content, such as loam and clay. Measurements had shown that individual crevices in the rock had become more and more aquiferous over the years, and that a downward current of the dam would be possible as a result. As part of the modernization scheme, the consultants and designers decided to renew the internal seal with a diaphragm wall that is 1m thick and approximately 70m deep. The diaphragm wall needed to be constructed from an extremely narrow dam crest. Additionally, the cut-off wall had to be embedded in the earth fill dam body as well as into the bedrock below and executed in a two-phase process.

Two-phase method

During execution, the trench was excavated with the supporting effect of a slurry made of bentonite and water (Figure 2). Then the slurry-stabilized trench was filled with the diaphragm wall building material from bottom to top in the contractor method. In the process, the stabilizing slurry was displaced upward and pumped away. Element by element, this resulted in a new internal seal made of so-called clay concrete or soil concrete often also known as plastic concrete.



The plastic concrete consisted of sand and gravel with a very small maximum grain size of only 8mm. A distinctive characteristic of the plastic concrete was the high percentage of clay, with approximately 350kg/m^3, and the far lower cement content of only approximately 80kg/m^3.

Cut-off wall construction and measurement technologies

The cut-off wall was executed in single-trench elements (Figure 3). At 3.2m, the length of each single trench corresponded to the width of the diaphragm walling grab and the trench cutter. To connect the individual trenches to a wall, the back-step method was applied. Two independent methods for surveying the trench during the excavation were used, which monitor each other. Inclinometers were installed both in the grab and in the trench cutter, which indicated initial reference points for the verticality deviation of the excavation tools. In addition, the CIS (Cutter Indication System) and GIS (Grab Inclination System) systems, developed by Bauer, were used. The inclination of the wire ropes to which the grab or cutter were attached provided information about their exact position in the trench. A tachymeter recorded the position of the aboveground section of the wire ropes three-dimensionally in space (Figure 4). The top 40m of the dam from the crown to the contact area of the dam was excavated using a BAUER DHG hydraulically operated diaphragm walling grab. A BAUER MC 64 duty-cycle crane was used as base machine (Figure 5).

Subsoil

The solid rock on which the Rosshaupten Dam was built is made up of alternating claystone and marlstone layers, permeated by bands of sandstone as well as coal in some places. The molasse layers often alternate at an interval of a few centimeters and there is rarely a layer that is several decimeters thick. Tectonic deformations have folded the layers of sedimentation stone almost vertically, frequently resulting in the formation of crevices. The undecomposed bedrock on the Rosshaupten Dam exhibits compressive strengths of between 8 and 85MN/m^2. Compressive strengths of approximately 35MN/m^2 had been measured in most solid cores from exploration drilling.

Right from top to bottom:
Figure 5: A BAUER MC 64 duty-cycle crane was used as a base machine for the hydraulic grab

Figure 6: Approx. 6200m² of diaphragm cut-off wall was embedded in the bedrock using the trench cutter

Figure 7: BAUER MC 96 base machine equipped with a turning device to rotate the BC 40 trench cutter on its own axis

Below: **Figure 8: View of the Rosshaupten Dam with its narrow dam crest**

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Challenges

The special challenges in Rosshaupten were multifaceted: half of the diaphragm cut-off wall totalling 13,000m^2 in size had to be embedded in the rock (figure 6), whilst at the same time only a very narrow dam crest was available as a working area. In addition, the diaphragm wall is not in the middle of the narrow dam crest, but instead is located toward the upstream face. This resulted in the available working surface on the dam crest being substantially reduced so that the diaphragm wall rigs could not be positioned to ride over the trench. However, the cut-off wall was produced without widening the crown of the dam: the base machine, a BAUER MC 96 (Figure 7) duty-cycle crane was equipped with the turnable BAUER HDS-T hose drum system, so that the BC 40 trench cutter could be rotated on its own axis. This made it possible to align the cutter parallel to the undercarriage even when the upper carriage of the duty-cycle crane was only partially pivoted. The diaphragm wall could only be executed in this special rig position (Figure 8).

Conclusion

The work on the diaphragm wall was tackled in a 24-hour operation cycle. Even during the winter months, work was not interrupted and it was possible to proceed according to schedule. The specialist foundation engineering work was completed in spring 2019. ●