Innovative techniques for the rehabilitation of Bautzen dam

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Wir planen das Ganze

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1. General

The Landestalsperrenverwaltung (LTV) (dam authority of Saxony) is responsible for planning, building, operation, monitoring and maintenance of water, local dams, water reservoirs and flood control reservoirs including the subordinate facilities. The facilities of the LTV ensure mainly flood protection; supply the water for drinking and industrial water but also the regulation of the discharges. The LTV of the Free State of Saxony is thus responsible for 69 main dams and reservoirs with altogether 52 pre- dams (sub reservoirs), approx. 50 km of artificial ditches, approx. 60 km tunnels, 2973 km running waters 1st order, 118 km border water, 652 km of flood protection dikes, 195 weirs, 77 ground sills, 192 sluices and 45 dike gaps.

2. Problem definition

The Talsperrenmeisterei Spree as a regional part of the LTV prosecutes among other things the industrial water dam in Bautzen (Bautzen dam, Fig. 1). Apart from the flood protection and its function for fishery and recreation it ensures in particular water supply for the flow or filling of unused gaps in brown coal mines at the lower course of the Spree. The Bautzen dam provides an annual average of 36,3 x 10^6 m³ water. In order to be able to guarantee the important supply functions, the Bautzen dam was taken out of operation for renewals, which should have lasted from January 2000 until January 2001. In the summer 1999 the civil engineers Salveter GmbH was assigned the engineer-moderate handling, which designated a re-impoundment of the reservoir already at the 01. November 2000.

The project was divided into 12 subprojects, in order to tender the water level dependent and water level independent work out separately and to work on them later.

The target could be achieved. At the time of the printing (July 2001) the TS Bautzen was in a test impoundment to check the efficiency of the water-level depending work. The entire procedure is presented later and with this the reorganisation of the asphalt concrete sealing will be described more detailed.

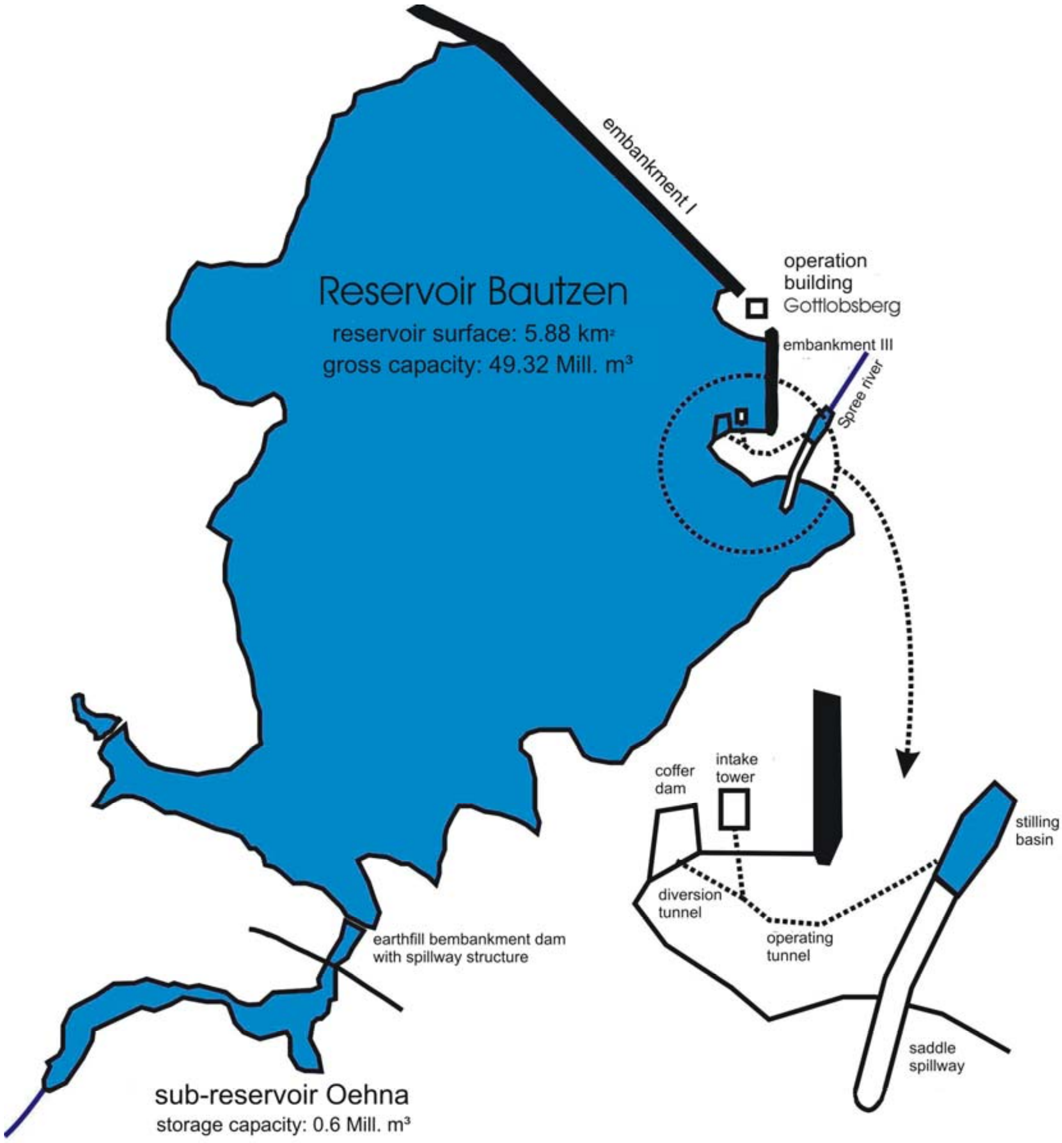

Figure 1: Bautzen dam

3. Damages

After 25 years of operation the dam had developed technological problems (originated from the building phase) to damage and had to be reorganised:

Asphalt concrete sealing

- Missing gripping between the two sealing sheets with damp blistering and resulting from this progressive destruction of the impervious layers from the lower surface.

- missing gripping on the construction seam and resulting from this openings of joints. The surface cracks in the construction seam, which are running in the slope inclination lines led to the penetration of water into the interface between the double layer sealing. With that the destruction of the asphalt concrete sealing had been accelerated.

Concrete buildings

- Alkali-aggregate-reaction (AAR) in the concrete of the stilling basin as well as the wave wall on the dam crest. The volume increase occurrence caused cracks, which are some centimetres of width,

- depth of carbonation of up to 1,5 cm with corroded reinforcement because the concrete surface was too thin (intake tower of secondary dams and Bridge abutment of the spillway).

4. Reorganisation scope

Besides extensive works for temporary structures and flood protection during the construction works the following main works were necessary:

- milling off approx. 37.000 m² old asphalt concrete sealing, and to fabricate a new homogenous asphalt concrete sealing,

- coating of approx. 650 m² intake tower shaft,

- build in approx. 700 m² shotcrete on the concrete structure of the intake tower of the secondary dam to protect the concrete structure,

- renew approx. 2.000 m wave (protection) wall made of prefabricated concrete including the foundation base beam,

- fabricate approx. 3.000 m³ watertight in situ (site-placed) concrete.

Subprojects

The timetable of the works for the planned subprojects, described below is shown together with the water level in figure 2.

Subproject 1 “water bypass“
The approaching water could have been turned aside by a temporarily opened diversion tunnel during construction period. This was necessary because

- the intake tower with bottom outlets had to be taken out of operation, because of the coating works at the intake tower shaft.

The tunnel itself had to be protected by shut off unit, using a cofferdam with slop logs, because:

- Below the minimum operating water level in the diversion tunnel a concrete seal, which had a diameter of 4.5 m and was 10 m long, had to be milled out

- and the reservoir had to be re-impounded before the re-seal of the diversion tunnel was finished.

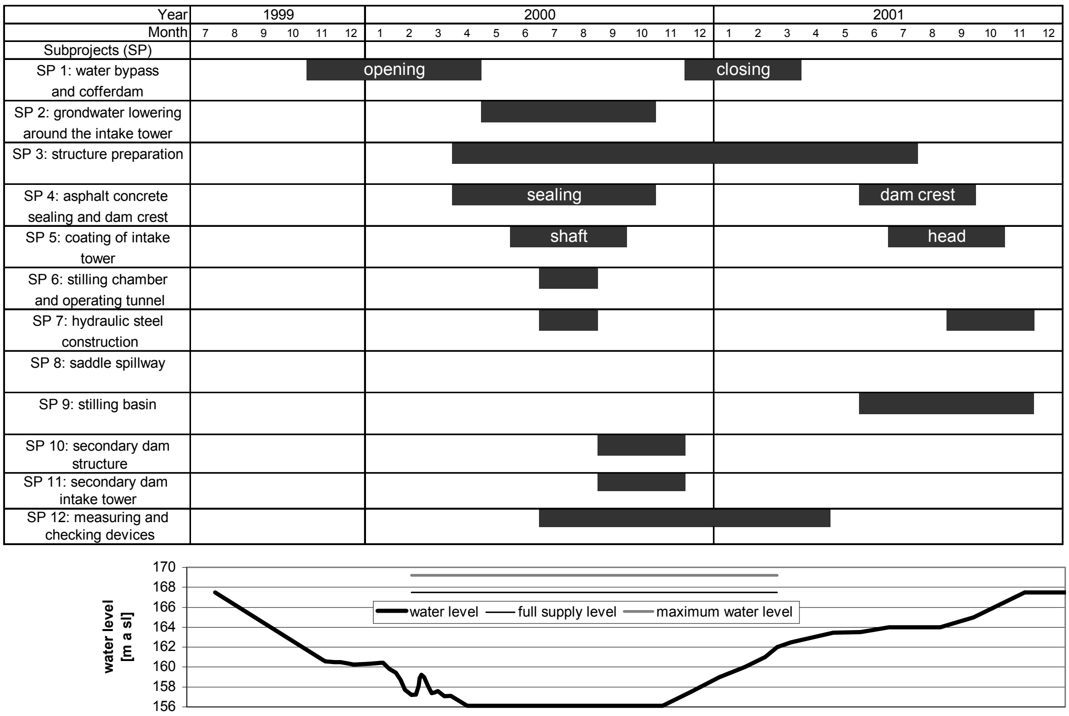

Figure 2: Timetable of works

Subproject 2 “groundwater lowering work around the intake tower“
The intake tower was protected with a sheet pile wall against a maximum computed two-year flood. The water at the intake tower was lowered until 6 m below the minimum operating water level.

Subproject 3 “construction preparation“
Among other things extensive safety works for cable and measurement equipment have been made.

Subproject 4 “asphalt concrete sealing and dam crest“
This work will be described later in chapter 4

Subproject 5 “ intake tower “
The concrete of the intake tower was protected from the very beginning against aggressive reservoir water using a glass fibre reinforced plastic coating. This coating had

been damaged over the years and was replaced by a new coating system, which is made of liquid plastic.

Subproject 6 “stilling chamber and operating tunnel“
Rehabilitation work on the concrete has been done there partly.

Subproject 7 “hydraulic steel construction“
With the reorganisation of the intake tower some hydraulic steel structures have been renewed or added.

Subproject 8 “saddle spillway“
The concrete construction the saddle spillway shows only little damages. A reorganisation is planned in future.

Subproject 9 “stilling basin“
This concrete construction was due to alkali silicic acid expansion very strongly damaged. It was partly demolished and new erected.

Subproject 10 “pre- dam structure“
The slopes and the downstream drainage on the toe of the dam were repaired.

Subproject 11 “pre- dam intake tower”
The freely weathered concrete surfaces were strengthened with shotcrete because they had only a thin concrete overcovering.

Subproject 12 “measuring and checking devices“
The surveillance inspection system was partly supplemented by piezometer (dam and foundation water level measurement) using electric water pressure transducers with an automatic measure value survey.

The tightness of the horizontal course of the asphalt concrete sealing is monitored by inserted glass fibre cable using a procedure for leak finding with fibre optical measurements.

5. Specialities at the installation of the new asphalt concrete sealing

The main task was the renewal of approx. 37.000 m² asphalt concrete sealing on a dam lengths of about 2 km. Therefore a construction period of 7 month only, from April to October 2000, was arranged.

5.1 Existing constructions

There are two dams with gravel-sand filling (Fig. 3), which have asphalt concrete sealing. They are separated by a natural hill, which is called the Gottlobsberg.

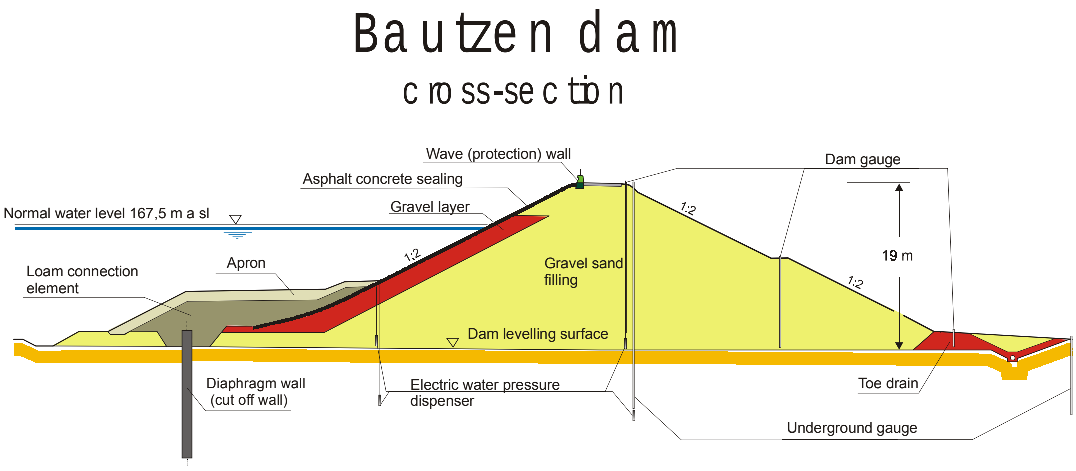

Figure 3: Bautzen dam cross-section

The underground foundation is about the same: under thin topsoil layer is a bonding cohesive of about 1.50 m, which consists of loess loam and sandy silt. Below them are sediments of pleistocenian. These layers are approximately 20 m thick and of stone and gravel.

The following tight transition layer consists of kaolinisated rock. In both embankments is the ground water level 1 m below the foundation.
The asphalt concrete sealing (entire seal surface 49.000 m²) is connected on the toe of the dam in the valley bottom areas of the embankments I and III to a small cut off sheed and in the slope areas to a cut off wall without inspection gallery. The joint between cut off wall and asphalt concrete sealing is secured with a copper sheet for balancing of the settlements. On the dam crest is the sealing on the Wave wall made of concrete connected.

The permeable underground in the area of the dams is sealed with an underground sealing (diaphragm wall of clay, cement concrete). The integration of approx. 2 m into the tight layer of the underground results in a seal surface of approx. 30.000 m² with a slot depth of 30 m on embankment I and 25 m on embankment III.

For the compensation of different settlements of the slot wall and the asphalt concrete sealing a connection element structure was installed.

The preliminary examination shows that the loess loam covered parts of the asphalt concrete sealing, the loam connection element and the slot wall are in a satisfying condition and do not have to be reorganised.

A constructive speciality is the connection element. It does not permit a direct control about the asphalt concrete sealing and does not corresponded to the rules of the modern technique. The suitability of this construction was, however, during the 25 years of operation also proved by measurement equipment.

During the new erection of dams a possibility for control of ACS is a direct seepage collecting from the drainage layer. In this case it would have meant a complete new construction, probably with an inspection gallery of 2 km length.

5.2 Planning of repair work

The repair works of the asphalt concrete sealing has been on the part above the loam connection element bounded. There has the new asphalt concrete sealing the following requirements to fulfil:

- Optimum of gripping with the old bearing layer,
- careful connection to the old asphalt concrete sealing in the part of the connection element,
- single layer binder and sealing structure with high homogenous quality,
- round shaped transition of the sealing on the crest,
- proofed contact joints to the wave walls,
- controllable sheet seams with leak finding.

The tendered works are:

- milling the double layer and the bearing layer,
- installing asphalt binder with a thickness of 8 cm including balancing little roughness,
- draw up the sealing until the crest way (with roundings),
- use of polymer modified bitumen,
- sealing with bituminous mastic coating,
- installing fibre optic cables in the area of the sheet joints into the binder layer.

5.3 Installation of the new asphalt concrete sealing

A horizontal working bridge paver was used, with which the number and length of the joints (sheets) were lowered to a minimum. This was done by driving the upper chain drive on the crest way and the lower chain drive on the slope. From the geometry of the dams resulted after the milling the following procedure for the installation:

1. upper part of the dam embankment I with a track width of 18,5 m as asphalt binder layer

2. upper part of the dam embankment I with a track width of 18,0 m as asphalt concrete layer

The dam embankment III was fabricated alike (Fig. 4). For transferring the bridge paver from embankment 1 to embankment 3 the old construction road was renovated. Thus the bridge paver could be transferred around the Gottlobsberg automatically, with which time in comparison to a disassembly and following remounting, could be saved.

All links were finally manufactured with conventional vertical construction technique or by hand.

Figure 4: Embankment III with bridge paver

5.4 Leak finding of the horizontal sheet seams with fibre-optic measurements

The temperature diversion along a glass fibre cable can be found out with optical measurement procedures. Glass fibres in the cable are used as sensors. The optical qualities of the glass fibre depend among other thing on the local environmental temperature. This technique is used to detect and locate leakages in sealing elements and to locate water seepage paths in the underground.

Gradient-method
If there is enough difference between the soil temperature in the environment of the glass fibre cable and the temperature of the waters seepages on a falling temperature- gradient can be recognised and measured. This procedure is called gradient-method. There has to be enough space between the glass fibre cable and the waters in a reservoir (Fig. 5).

Warming up method
The warming up method is used if there is not enough space between the cable and the waters and so also not enough temperature difference. For this are the hybrid-glass-fibre cables necessary. These cables contain besides glass fibres also electrical cables. These cables get a voltage as for a short circuit stream flows. The because of this raising temperature in the cable is measured by the glass fibres. Additional to the (conductive) heat conduction of the material which is around the cable appears if around the cable water flows a heat transmission (advective). That leads to a clearly smaller warming up of the cable (Fig. 5).

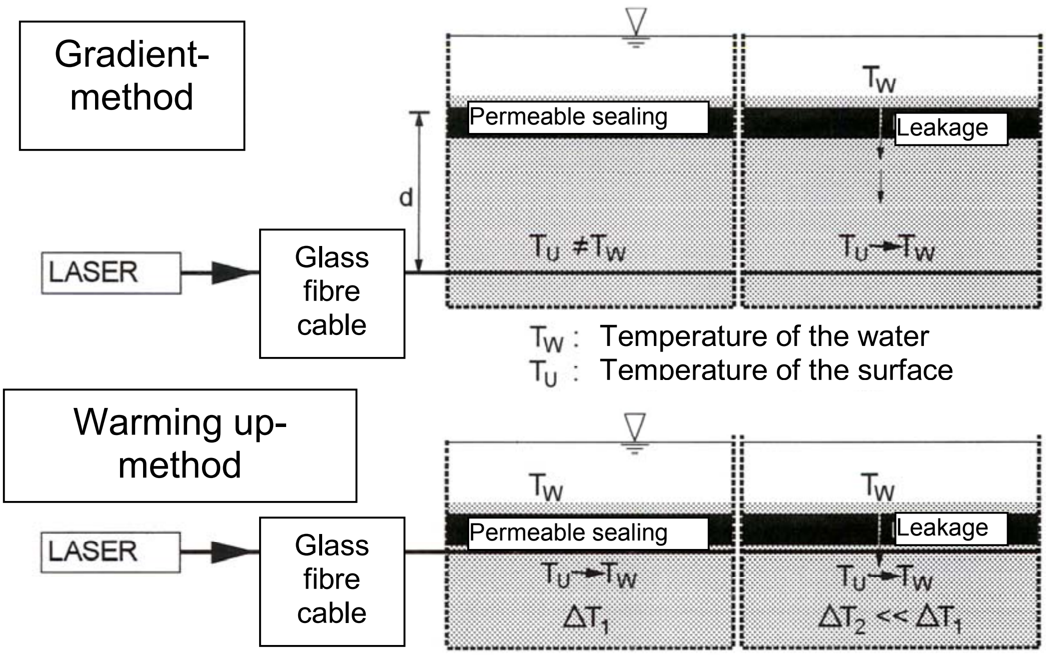

Figure 5: Leak finding methods

The installation of fibre optic cables with electrical cables into the asphalt concrete sealing is shown in figure 6.

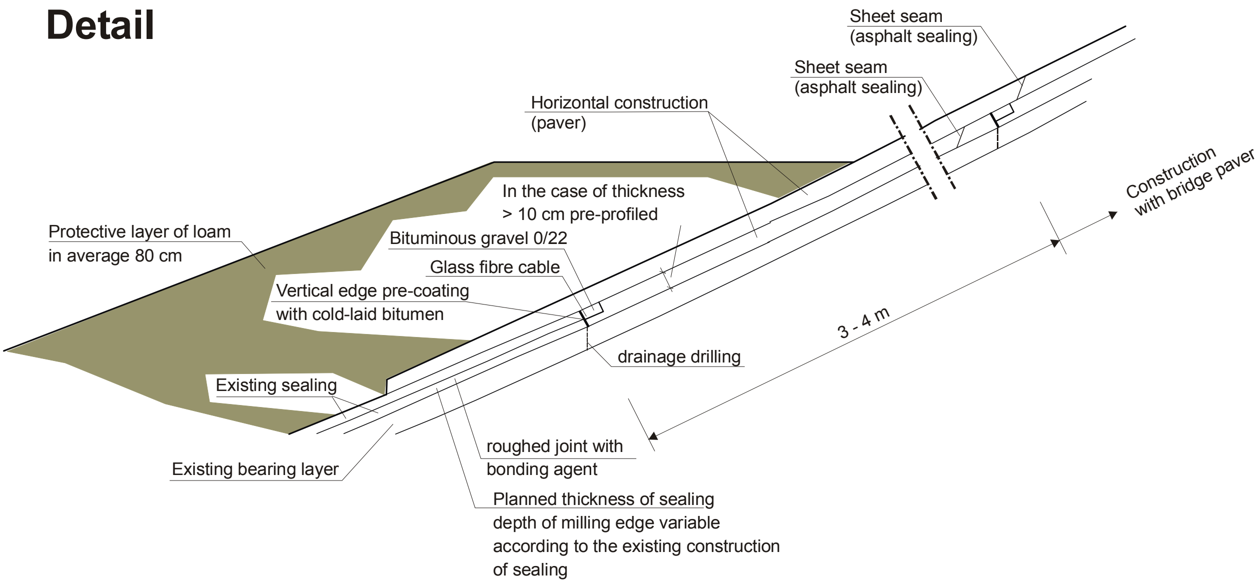

Figure 6: Detail of cross section (figure 3)

As a result of measurements with the warming up method the curves shown in figure 7 resulted. The upper diagram shows results of measurement with water level underneath the cable. The diagram at the bottom represents the measurement with a water level about 3 m above the cable. This indicates low local water seepage at embankment III near Gottlobsberg (discontinuously part of the curve). At the time of printing (July 2001) the reasons were analysed. We are confident to present the reasons at the ICOLD Annual Meeting in September 2001 in Dresden.

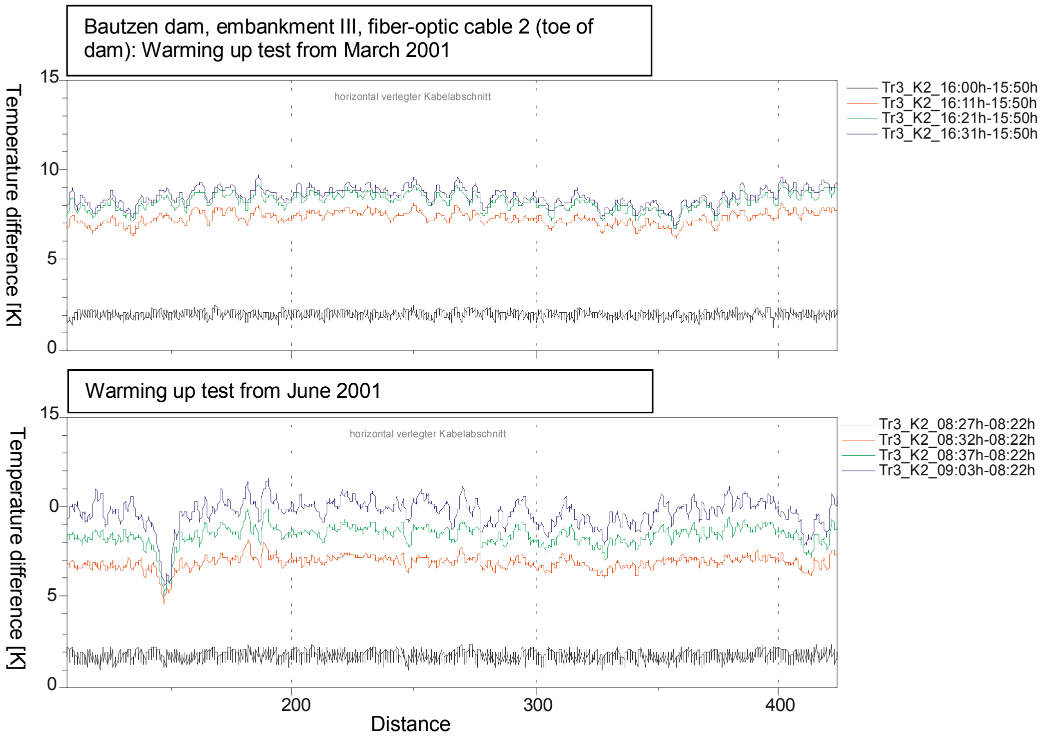

Figure 7: Curves from warming up tests

6. Summary

The Bautzen dam was extensively rehabilitated between 1999 and 2001. Two dams with a length of 1600 m and 300 m dam up the river Spree since 1973 to a reservoir with a surface of approximately 5.6 km² and with a reservoir of approximately 48 x 10^6 m³. The asphalt concrete sealing of the dams and the intake tower as well as the stilling basin from reinforced concrete are renewed in the context of the renovation. The renewal of the asphalt concrete sealing took place with a bridge paver via horizontal installation of a binder and a sealing layer. The bridge paver could at both dams assigned, and which are optimised construction period thereby. As a check of the tightness fiber-optic cables for fiber-optic temperature measurements were built into the asphalt concrete sealing. In March 2001 the sample dam up began. The results of measurement of this zero-measurement acknowledge the usability of this measuring method for the proof of permeablenesses of an asphalt concrete sealing.

7. Keywords

Asphalt concrete sealing
Bridge paver
Bautzen dam
Fiber-optic cables
Leak detection
Seepage detection

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