REPAIRING VON BACH DAM WALL

Currently at its lowest water level in 20 years, a rare window of opportunity presented itself to repair the Von Bach Dam wall before the first inflow of the 2016/17 rainy season is expected.

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New infrastructure, no matter how well designed and constructed, of course becomes old infrastructure with the passage of time, and preparation for rehabilitation or decommissioning eventually becomes a priority planning issue that must be incorporated into the lifespan of any material structure.

This is especially pertinent in the case of large-scale public works such as dams, where there are significant risks attached to letting the ages take their toll without regular assessment and implementation of remedial actions.

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Design of the Von Bach asphalt-faced rockfill dam

The Von Bach Dam, situated outside Okahandja in Otjozondjupa Region, was built in 1970. Unlike Avis Dam in Windhoek, which is a concrete-faced rockfill dam (CFRD), the dam at Okahandja is an asphalt-faced rockfill dam (AFRD), a design that provides a more flexible sealing membrane. Other AFRDs are the Hardap Dam in Namibia and five similar dams found elsewhere in Africa.

Over the past 10 years, three large CFRD dams have failed — one in Lesotho and two in Brazil — due to compressive forces in the rigid concrete membrane; an AFRD construction would likely have been able to absorb these forces without failing.

As the CFRD construction technique is still widely used in South Africa, it has recently been adjusted to accommodate the type of movements that had caused these failures. AFRD structures are more readily found in Europe and North America, not only as dams but also as landfill sites, where leachate is not permitted to filter into the groundwater. Ultimately, the choice between CFRD and AFRD dam types depends on the availability of suitable local building materials.

The Von Bach Dam is an embankment dam, formed of locally sourced river rubble that is compacted in layers, providing side slopes with a suitable factor of safety against slope failure. The downstream face is comprised of graded rubble and filter layers to prevent erosion, and rockfill on the upstream side is graded and prepared with a porous bituminous trimming layer, approximately 150 mm thick.

At the Von Bach Dam, the trimming layer is covered with a 50 mm-thick asphalt drainage layer and two dense asphalt concrete (DAC) layers, each 50 mm thick. The DAC layers provide a watertight barrier for the dam.

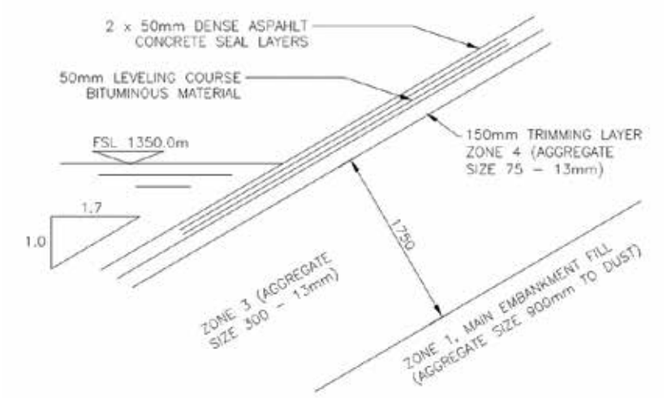
A 4 to 5 mm thick, sacrificial bitumen/mastic layer was spread on top of the DAC layers to protect them against UV radiation. UV radiation reduces flexibility in the DAC, thus making it harder and more prone to cracking. Frequent maintenance of the mastic layer increases the lifespan of the DAC and also reduces the need for maintenance on the DAC.

(Above) Example of placing and compacting a new dense asphalt concrete, done on a dam similar to the Von Bach Dam.

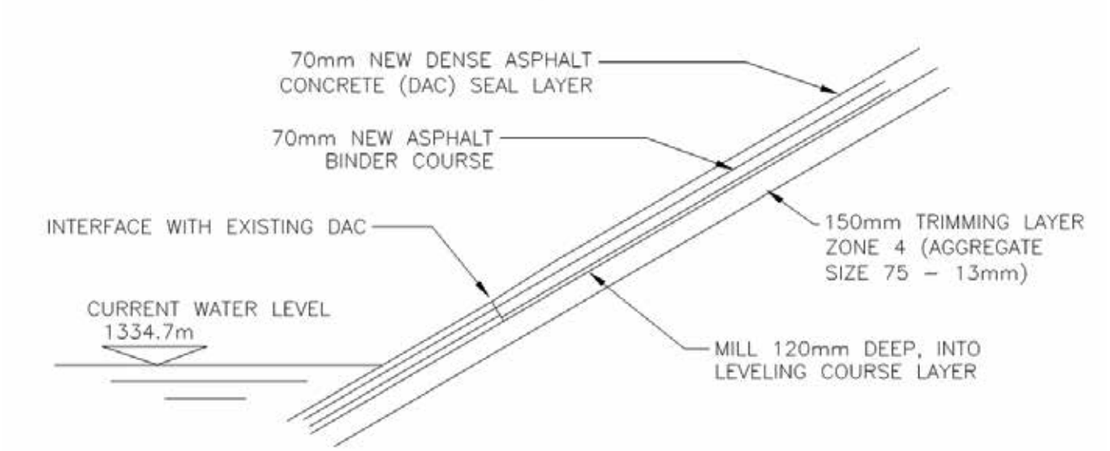
At the Von Bach Dam, an uncontrolled flow of the mastic layer over the years has exposed parts of the DAC layer to the elements and UV radiation. Degradation of the exposed asphalt followed and cracking occurred mostly along the upper slope area. Core drill tests found that the DAC along the lower part of the embankment, which is mostly covered by water, was in a better condition and suitable for several more decades of operation.

Planning for rehabilitation of the upstream AFRD face at Von Bach Dam

It is standard procedure to replace the mastic layer of an AFRD every 10 to 20 years, depending on the condition of the dam. The dense asphalt seal can last for 40 years or longer, depending on its protection against the elements. There is usually no need to replace the entire asphalt layer; in fact, often only the upper regions of the asphalt



(Above) The Von Bach Dam: cross section of the 1970 as-built asphalt seal



(Above) The Von Bach Dam: cross section of the rehabilitated asphalt seal

seal, which are frequently exposed to UV radiation and wave action, will require attention. (Inherently, asphalt that remains protected from the elements can last for hundreds of years.)

Certainly the Von Bach Dam, after 45 years of operation, was ready for an evaluation to ascertain if this remedial activity was necessary and pressing, since the exposed asphalt was showing signs of deterioration and cracking. In 2016, the dam reached low water levels not seen since 1996. There was clearly an argument for making an appraisal of the need for resealing measures since a significant portion of the upstream asphalt seal was no longer covered with water, making such an evaluation and subsequent necessary remedial actions that much simpler to carry out.

Knight Piésold Consulting (Pty) Ltd tendered with NamWater to do an evaluation of the asphalt seal of the upstream dam wall in January 2016. WALO International AG — a Swiss company established more than 90 years ago and with unparalleled experience and expertise in this area — was sub-contracted to carry out the drilling of cores into the asphalt layer.

WALO International's assessment of the asphalt layer and constituent parts revealed that there was no time to be lost with regard to resealing the exposed areas of the dam wall.

Three cores had been drilled in a vertical line on the left-hand side (looking downstream) of the main embankment, with the lowest one 300 mm above the current water level.

A fourth core was drilled at the centre-top on the same side of the wall. This latter core revealed that a crack had penetrated 140 mm into the asphalt layer.

(Above) A typical completed asphalt seal on an emabankment dam.

While all the potential ramifications of this breach of the asphalt seal can only be guessed at, certainly an uncontrolled loss of water once the dam filled again could be anticipated, with possible structural failure following.

Evaluation of historic trends of inflows into the dam based on NamWater data indicated that resealing work should be implemented immediately, since the risk of the dam filling up tends to become greater towards the end of December 2016.

These calculations made allowances for the fact that central Namibia normally receives some rainfall between September and November, but that inflows into the dam would be comparatively small over that period.

Nevertheless, looking at the historic maximum inflows led to the decision to allow for a 2 m 'freeboard' above the present water level, which would not be subject to resealing. This allowance will reduce the risk of submergence of the works should greater-than-average inflows occur during the rehabilitation period. (It should also be noted that the water volumes at Von Bach Dam are routinely augmented by water from the Omatako and Swakoppoort dams, but since these inflows can be controlled and stopped, they were factored out of the calculations used to reach the required construction freeboard.)

The wall of the Von Bach Dam is 200 m long; the upstream side falls away in a 1 in 1.7 m gradient to a thickness at the dam base of 108 m. The asphalt area estimated for rehabilitation is approximately 7,000 m^2, in the form of a horizontal band about 30 m in depth, measured from the top edge of the embankment.

Knight Piésold Consulting submitted its report, including the asphalt specialist's findings, to NamWater in July 2016. This report outlined the concerns associated with the condition of the existing asphalt seal. Subsequently, the timeframe for carrying out the necessary actions was drawn up as a matter of urgency.

Asphalt seal rehabilitation at Von Bach Dam

After a call for quotations, WALO International was appointed by NamWater as the contractor to rehabilitate the upstream dam surface.

At the end of October 2016, WALO International's specialised machinery for dam seal construction arrived by specially-chartered ship at Walvis Bay and then proceeded by road to the site. (The idea of using an Antonov large-body aircraft to fly in the equipment was considered, but then rejected by WALO International as being too pricey.)

NamWater provided valuable assistance in facilitating the swift delivery of plant and personnel at the site by

The Avis Dam is certainly a candidate for the resealing process used at Von Bach Dam if the right preparatory work is carried out initially.

(Left) Horisontal milling along the top edge of and asphalt seal embankment. The milling machine on the right is supported by a hydraulic winch.

dealing with necessary work permit applications and the other paperwork required to expedite the work as a project of great importance to national development.

Milling equipment was lowered down the surface of the upstream dam wall by hydraulic winch cables so that the old and deteriorating surface material can be milled off. The machinery was drawn vertically up the face of the dam, while the milling operation used a high-speed rotating drum with staggered tungsten bits to grind away at the existing asphalt.

The milled material was then carted off the site. Once milling was completed across the whole 30-m deep horizontal band, the area was prepared for resealing by levelling off irregularities on the embankment surface and applying a tack coat. This whole process took approximately two weeks.

Next, a larger tracked winch truck of approximately 50 tonnes was secured and manoeuvred the machinery that applied an asphalt binder layer (ABL) as the first drainage layer and then the DAC from a hopper onto the milled surface.

As per standard procedure, asphalt application was done in vertical strips from the bottom of the milled-off surface to the top (as opposed to being applied

in a horizontal band). The asphalt temperature was kept between 160 and 180°C during placement and hardened as it cooled.

A day after, the final mastic layer was applied (i.e., the asphalt layer did not require an extended curing period). This entire process took approximately three weeks and generally, the asphalt would be able to take the hydrostatic load of a full dam within 24 hours after placing.

Future applications

The asphalt seal of the Hardap Dam was replaced twice in the 1990s. An inexperienced company did work in 1995, 34 years after the dam was constructed in 1961, and was subsequently redone in 1996. The technology is, therefore, not new to Namibia.

Although the Avis Dam in Windhoek, constructed in 1930, is a CFRD, there is potential for the same sealing process to be applied at this site — either now, while it is empty due to drought, or at a suitable time in the future. At present, 'bandages' are applied over the joints in the Avis Dam concrete as a stopgap measure to prevent leakages through the joints.

Recently, WALO International sealed a 11 km-long large concrete channel in Switzerland which was built in the 1930s in a similar way to the Avis Dam, with jointed concrete panels. So Avis Dam is certainly a candidate for the process used at Von Bach Dam if the right preparatory work is carried out initially.