Recording and Surveillance of Ageing asphaltic concrete linings by metric 3D Imaging

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ABSTRACT:

Kärntner Elektrizitäts AG (Kelag) owns several hydro power developments in high mountain regions including embankment dams ranging from small structures, such as closing compensation basins up to one 110 m high rock fill dam all tightened with an upstream asphaltic concrete lining.

One of those is Haselstein reservoir which was constructed in 1967 and 1968. For safety assessment KELAG started a documentation campaign of the whole asphaltic lining of the Haselstein compensation reservoir using a special high resolution 3D imaging system allowing a detailed visual inspection of the surface as well as metric measurements and the area-based observation of movements..

Haselstein reservoir is a component of KELAG's Fragant Group of hydropower facilities. Haselstein serves as an intermediate elevation daily storage pumping reservoir with a maximum depth and operating capacity of about 18 m and 40,000 m^3, respectively. It is situated at an elevation of about 1470 m and was constructed by grading cut-and-fill embankments on a moderately steep hillside within a deep-seated landslide deposit.

The deep-seated landslide underlying Haselstein Reservoir and extending upslope to an elevation of about 2100 m has an estimated maximum thickness and volume of about 150 m and on the order of 7.5 x 10^7 m^3, respectively. The amount of displacement within the sliding mass is estimated to be approximately 350 to 450 m. This deep-seated failure is interpreted to have initiated thousands of years ago in the post-peak and waning stages of the last glaciation, resulting from some unknown combination of very pertinent conditions that represent a sequence of unloading from an initially overstressed regime.

Subsequent to observations of deformations in the asphaltic concrete lining in 1979, the asphalt lining was repaired, and in 1983 survey monuments were placed along the observed zone of lining deformation, along the rim (crown) of the reservoir and along the hillslope above the central area of the reservoir.

Survey measurements along the observed zone of reservoir lining deformation taken from 1983 through 2004 indicate a range of about 20 to 35 cm of displacement in the downslope direction, corresponding to displacement rates of about 1 to 1.8 cm/yr. The location of maximum recorded displacement for these survey points is close to the center of the reservoir.

Because of the high rate of deformation, documentation of the surface conditions of the asphaltic concrete lining at regular intervals is essential for a safe operation of the reservoir.

In order to record the actual conditions of the lining a high resolution 3D imaging system based on panoramic images was used as this approach bears considerable advantages.

The used imaging system consists of a panoramic line scanner capable to acquire very large digital images (100 Megapixel and even beyond) having a wide operational area ranging from distances of one metre up to more than 1.000 metres. The large images ensure that also fine details are captured. The arrangement at Haselstein allows to resolve failures or joints in the lining in the range of 3 mm over the whole lining surface.

The measuring principle is photogrammetry thus at least two images of the desired surface area have to be acquired from two different angles. By means of special software one high resolution stereoscopic image pair is composed to a metric 3D image which means an image with depth information.

Once a 3D image is ready, a special 3D software component allows to assess the results and get geometric measurements just by clicking on the 3D images. Possible measurements are positions in x,y,z co-ordinates (identify points of equal height), lengths (distances) in metres, areas in square-metres, or spatial orientations by two angles (dip and dip direction). Sections through the surface at arbitrary locations deliver the according profiles.

All measurements are in a given reference co-ordinate system, which is achieved by tying the 3D image to the reference by means of control points with known positions from regular surveying.

Using a 3D imaging approach a permanent record of the actual surface conditions of the asphaltic concrete lining is resulting. Any assessments can be cross-referenced to nature easily as all measurements happen on image data and the high resolution allows even to identify small degradation signs. The contact-free measuring principle eases assessments and repair measures can be optimised based on the analysed 3D images of the surface which reduces maintenance and refurbishment costs.

Repeated use of 3D imaging allows to compare any movements not on a point-base only but rather over the whole area of the lining.