Pre-study for geoelectrical monitoring for detection of internal defects and anomalous seepage in the Älvkarleby test embankment dam

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Electrical resistivity tomography (ERT) can be used to monitor the interior of hydropower embankments dams, and thereby detect zones with anomalous material properties and flow induced variation in the resistivity caused by changes in total dissolved solids (TDS) and temperature. Furthermore, monitoring of embankment dams in connection with a substantial change in the reservoir water level can detect anomalous leakage paths via differential wetting of zones with different hydraulic properties. In Sweden, where the available hydropower energy capacity is utilised, installation of electrodes must be done post-construction of embankment dams, which for practical reasons generally means installed along its crest, in the top of the core, using a 2D ERT approach. This has the advantage of focusing the sensitivity to the core itself, which is the part of the dam that shall stay impervious over time. However, the orientation of the electrode layout in combination with the 2D approximation leads to severe 3D effects, which distorts the inverted model resistivities and geometry. Furthermore, the resolution decreases with depth, which is a major limitation for high dams. A way ahead would be if electrodes could be installed on deeper levels inside the dam close to the core, which might be possible using modern drilling technology. This electrode lay-out concept was investigated with numerical modelling using extended gradient, cross-line bipole-bipole and corner arrays between horizontal-horizontal, vertical-vertical and vertical-horizontal lines respectively. To interpret the data 3D inversion is required to handle the structure's geometry due to the zoned construction with materials that have large contrasts in resistivity. A test embankment dam installation was built during the autumn of 2019, with electrodes and various sensors installed inside the dam to evaluate the applicability of the suggested approach. We present results of numerical modelling simulating potential defect scenarios where several measurement sequences of close to 8,000 data points using the abovementioned arrays are inverted all at once. In order to resolve subtle variations inside the core, the finite element grid design is based on prior knowledge about the internal material distribution, with broken smoothness constrains at known material boundaries. In combination with region-based control of the resistivities of the different material zones, the inversion in combination with a time-lapse approach it shows promising results.

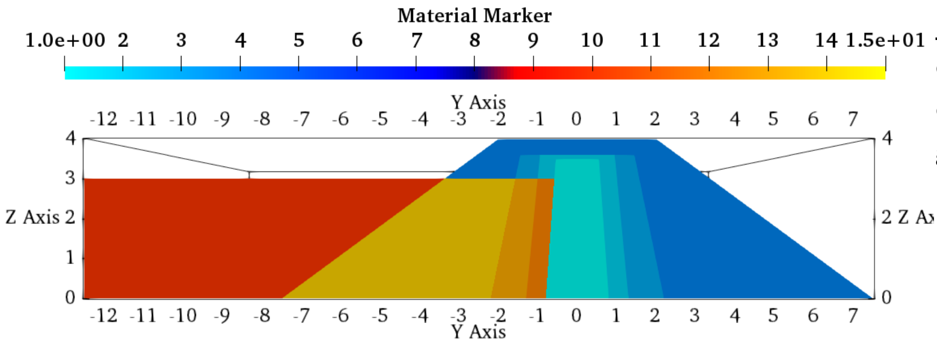

Figure caption: Side view of Älvkarleby test embankment dam model geometry. The colours indicate different material zones, and do not reflect the relation between the resistivity of