The Role of Stress for Safe Water Reservoir Operation

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Abstract:

The Enguri-high-dam was chosen for the study of water level induced seismicity due to its height of 271 m and extraordinary water level variations. On site-research allows to quantify underlying processes and mechanisms of dam-environment interactions – to reduce risks for public and the environmental impact. The interdisciplinary collaborative effort www.DAMAST-caucasus.de initiated a transfer to enhance the lifetime of Enguri-High-Dam supplying 40% of Georgian electricity demand.

THE CHALLENGE(S): Earthquakes are triggered by stress modifications in the underground. Hence the question arises, how is induced seismicity connected to water level changes? What are potential risks of water dams for environment and population? The answers require an improved understanding of processes in the underground. What is the share of sedimentation into a reservoir and pore-pressure stress coupling through water level variations on induced seismicity?

METHODOLOGIES: In the DAMAST projects research on methods for a comprehensive deformation monitoring system around, at and within the Enguri Arch Dam, has been ongoing since 2019. To study the seismicity a dedicated seismological network was established at the dam which is able to detect even micro-seismic events. Historical and operational data as well as the results of the new observations serve as basis for the analysis. This allows to identify correlations between different processes and mechanisms as well as to derive recommendations for a safer operation of the facility.

RESULTS In addition to established methods, new concepts such as the successful testing of GB-SAR for dam deformation monitoring have been implemented and Artificial Intelligence (AI) methods were used. Numerous, up to 300 m deep drill holes had been drilled in the vicinity of the dam and have been monitored with modern borehole logging tools as well as with hydraulic fracturing to deduce the state of stress, which turned out to be manly influenced by local topography. The influence of periodic water level fluctuations on the regional deformation as well as the structural deformation of the dam could be shown using PSInSAR, 3D terrain and dam models and GB-SAR measurements. Increasing water levels lead to subsidence and sideway displacement of the lake shores and deformation of the dam itself.

Large-scale numerical models provide information on the deformation behavior of the dam embankment and enable to calculate the distribution of shear and Coulomb Failure stresses based on the compiled stress data. Modelling results have been compared with the time series and location of the micro-seismicity. Model data, geometries and measurement data are then used to train a Convolutional Neural Network (CNN).

The projects focus on the SDGs of clean energy, environment and climate protection which are linked to SDGs of innovation and infrastructure, good jobs, economic growth and poverty reduction. Inherent are contributions to the quality of education. he trained young researchers have the potential to play a decisive role within future authorities, e.g. for project approval and control. This is extremely relevant to achieve the SDGs and for the direct users such as owners of hydropower and irrigation reservoirs.