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DAMAST – Technologies for the safe and efficient operation of water reservoirs

Client II – International partnerships for sustainable innovations

In the course of creating a climate-friendly energy supply, new dams are being built all around the world. In many places, natural or induced earthquakes, especially in combination with other extreme events such as heavy precipitation or landslides, jeopardize the safety of these dams, thus also endangering local populations. In the "DAMAST" project, German, Georgian and Armenian partners examine the underlying processes as well as safety-relevant parameters of water reservoirs based on the example of the Enguri Dam in the Caucasus. The project will develop transferable monitoring concepts for dams in tectonically active regions.

Safe and efficient: power and water

Many dams are located in seismically active regions of the world. Even if the technical facilities are designed to handle for such events, seismic activity in the immediate vicinity, known as 'induced seismicity', can be triggered by operating activities on water reservoirs, thus endangering the population. For example, an earthquake in China, which occurred in 2008 and resulted in over 80,000 fatalities, is attributed to the filling of a large dam. The simultaneous occurrence of multiple extreme events leads to an increased risk. For example, the combination of earthquakes, landslides or heavy precipitation with the unfavourable distribution of sediments in the water reservoir can lead to the sudden mobilization and displacement of the sediments in the reservoir. This can lead to strain and possibly damage to dam walls.

The "DAMAST" project aims to help systematically reduce hazards at water reservoirs as well as to ensure their long-term and efficient operation. The objective is to develop monitoring concepts that can also be transferred to other dams in comparable locations. These goals will be achieved through the use of using innovative methods for collecting and analysing the relevant data.

In addition to reducing the risks posed by natural hazards (earthquakes, landslides, heavy precipitation) and induced seismicity, "DAMAST" is dedicated to ensuring the long-term efficiency of reservoir operation. Due to reservoir sedimentation, i. e. the filling of the reservoir with sediments, the bottom drains in the retaining walls are frequently impaired and there are significant losses of storage volume, thus leading to a reduction in plant efficiency after 40–50 years of operation. The construction of replacement storage is very expensive, while defective bottom drains also endanger the operational safety of the dam system. It is expected that sediment influx into reservoirs worldwide will increase significantly in the future as a consequence of climate change.

The 227 meters high arch dam of the Enguri Dam in Georgia.

Monitoring from land, water and space

Using the example of the Enguri Dam in the seismically active region of the North Caucasus, "DAMAST" will investigate which hazards arise through the operation of water reservoirs, such as initial filling or annual water level changes, and how these hazards can be reduced. A combination of innovative monitoring processes, the use of model scenarios for the spatial and temporal development of seismicity and consideration of the local and regional deformation of the dam and the surrounding terrain will enable suitable monitoring measures to be developed. This information will also form the basis for drawing up recommendations for dam operation and for improving risk management.

In order to obtain a better understanding of the underlying processes that lead to seismic events, in particular as a consequence of cascade effects, "DAMAST" will first

take steps to identify relevant key parameters. Different methods will be used in a modular monitoring concept in order to acquire seismological, meteorological, geodetic and geological data and to record sediments and changes to the dam structure. These methods include remote sensing techniques, well logging, modern seismic recording techniques, terrestrial radar interferometry, underwater drones, multi-beam bathymetry, multi-frequency echo sounding and sampling for sediment characterization, and novel mini-sensors. The monitoring of seismicity, deformations and pore pressure, which has a significant impact on induced seismicity, should provide valuable information about the correlations between the reservoir's water level and induced seismicity in the vicinity of the reservoir.

Compared with other dams, Enguri Lake has a very high annual water level fluctuation of around 100 meters.

From monitoring to decision-making support

The results of the project are expected to show if and how improvements can be made to risk management by creating an early warning system to support decision-making. This project sees cooperation between medium-sized companies and scientific institutions with on-site logistical support provided by dam operator Engurhesi. The recommendations developed will help Engurhesi with operational decisions and assist authorities and administrative bodies to implement suitable monitoring concepts and use early warning systems to further reduce the risk to the population. Dam facilities in comparable alpine and seismically active regions also stand to benefit from the results of this project.

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