MINGECHEVIR DAM BREAK RISK MANAGEMENT SYSTEM

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Abstract

The paper deals with results of the modeling of remote control system of physical stability of hydraulic-fill dam. Case study application has been made for Mingechevir dam on Kura river. This dam is highest in Europe that was constructed through sprinkling. The offered model includes aero-geodetic benchmarks maintained in the body of dam, floating water level measure station on reservoir and water level (water discharge) recorders on rivers Kura, Iori and Alazani. The remote system supplied with solar battery, digital measurement sensors with GSM/GPS connection with Dam Management Office.

Keywords: dam stability, river, reservoir, remote control, aero-geodetic benchmarks, water level recorder

I. Introduction

Like all technical facility also dams hold a potential risk of breaking [1]. In some sense, the term “dam protection” is a misnomer. Since disasters are, from the point of view of the dam, inherently random in nature, no dam can be “protected”. On the other hand, the experience accumulated from the natural disasters and dam failures of the past few years suggest that having the right information, in the right format, at the right time in the hands of the competent people significantly reduces the consequences of disasters and accelerates the recovery process.

By the quantity of major dams (height of a dam> 60m and power of HPS > 100MW) the Kura River basin takes 14th place in the world. The first on the list is Yangtze river (China) with 26 major dams [2]. There are 8 major dams on Kura River basin. Its intended purposes are hydropower, flood control, irrigation, etc. to achieve balanced and sustainable development of the country.

The largest of them is Mingechevir hydraulic-fill dam, which was put into operation in 1953. This dam is highest in Europe that was constructed through sprinkling [3]. The height of dam is 81 meters, a crest length 1550 meters, width on the dam crest 16.7 meters and total capacity of soil 15.6 million cubic meters. Unfortunately, for the existence period the dam inspection, evaluations, modifications and upgrades of the Mingechevir dam was never spent. Therefore, it dam can be considered as an “old dam”. Practically right off after constructions of dam and fillings of reservoir of the same name (with length 70km, width from 3 to 18km, deepest point about 75 meters, total area 605 km^2, and water storage in reservoir is more than 16km^3) the safety issues became actually: collected waters can break embankment dam and catastrophic flash flood will carry by Kura river valleys, destroying all on the way. Potential flood area is 800 000 hectares with around 3.5 million of inhabitants. From the other hand, heavy flooding and/or break one of dams in neighboring Georgia (Khrami, Chitakhevi, Jinvali HPSs, and Sioni, Tbilisi, Dalimta reservoirs etc. [4]) will be enough for catastrophic "domino" destruction of all downstream dams in Azerbaijan. Sad lessons of destruction of the cascade of dams in August, 1975 in Southern China [5] can repeat in the cascade of dams on Kura river basin at any time.

To this end, there is a need for more adequate legal frameworks for dam operation and control of physical stability. The presented paper is devoted results of the first attempt in modeling of the remote control system of dam physical stability.

II. Risk factors

The large scale field works carried out by authors covers the physical, environmental, ecological and socio-economic aspects of integrated flood and dam-break risk analysis in Kura river basin [6]. This activity is arranged into several themes:

- ✓ Risk analysis - hazard sources, pathways and vulnerability of receptors.
- ✓ Preliminary efforts for risk mitigation.
- ✓ Pilot applications - for Mingechevir hydraulic-fill dam.
- ✓ Co-ordination and management.

The modeling of the remote control system is first step of pilot applications.

The physical stability of Mingechevir dam is multi-parametric issue. Some more important factors influencing dam stability may be classify as below:

- ✓ Geological structure of riverbed in dam location;
- ✓ Seismic activity of region in dam location;
- ✓ Engineering data of dam and position of the depression curve;
- ✓ Genesis of maximum runoff conditions in Kura river and water level in reservoir;
- ✓ Process of sedimentation in reservoir;
- ✓ Anthropogenic accidents in upstream;
- ✓ Dam operating conditions etc.

Wear and tear of the hydro-technical facility in Mingechevir HPS, hydraulic-fill dam and reservoir of similar name, absence of due supervision of safe exploitation make substantial the crevasse of water reservoirs and holding lagoons of runoffs that can result in catastrophic consequences.

An importance among enumerated factors there are seismic activity and water level in reservoir. According to the risk assessment carried out by authors the investigated hydraulic-fill dam are vulnerable to earthquakes.

The Caucasus is located in one of the most active Alpine-Himalayan collision belt. Over the past two thousand years, there have been many earthquakes in the Caucasus. Some have been catastrophic, resulted in thousands of deaths, infrastructure destruction and environmental degradation. Sometimes damage caused by earthquakes may be more linked to landslides generated after them than to the actual earthquake.

Since 1800, over 2,000 significant earthquakes have been recorded in the Caucasus, 1,200 in the last half of the 20th century. While they differed in intensity, their capacity was generally less than 8MSK. Compared with the most active seismic regions of the world, (Japan, California) the Caucasus seems calm. However, over the past decades several powerful earthquakes of 6-6.5M have shook the region (Spitak, 1988; Sachkhere, 1991; Barisakho 1992; Eastern Turkey 1976, 1983 and 1992; North Iran, 1990 and 1997; Baku 2000). Among these earthquakes, the most disastrous was the Spitak 9MSK earthquake. After this earthquake, some of the regions of the Caucasus, including Mingechevir dam location were declared 9MSK earthquake zones [7].

Rivers of the Kura basin has extremely irregular discharge throughout a year [8, 9]. Ration of extreme discharge to average discharge level is 1.63-6.67 which makes sometimes to overcome its negative impact. Therefore, water level in reservoir is depending on grade of intake flow from Kura, Iori and Alazani rivers. In addition to it, there is intensive sedimentation process in reservoir [10].

III. Modeling of the dam stability remote control system

As mentioned above, physical stability of dam is multi-parametric issue. Therefore, modeled remote control system includes five main parts:

- ✓ Aero-geodetic benchmarks on body of dam;
- ✓ Floating water level measure station on reservoir;
- ✓ Water level (water discharge) recorders on rivers Kura, Iori and Alazani;
- ✓ Appropriate software and algorithms;
- ✓ Dam Management Office (DMO) and Early Alert System.

The first point on list implicates establishment of aero-geodetic benchmarks in body of dam for regular observation over possible dam translocation. The 20 benchmarks with digital transformer of location with GSM/GPS communication should be installed 3÷4 meters deep in the body of dam. It will allow to distant measure total annual linear motions ≥2÷3 sm. The second point implicates establishment of the floating automatic water level measurement station with solar battery and GSM/GPS communication with DMO. According to the offered model the wireless network of water level recorders with GSM/GPS communication will be established in most important points of Kura, Iori and Alazani rivers in upstream of the Mingechevir dam.

The principle scheme of the data collection system is presented on Figure 1. The sensors maintained on benchmarks and water level recorders makes digital data logger of the results of measurements and communicates them through GSM/GPS transmission to DMO. Every sensor supplied with solar battery which is guarantee of autonomy activity of system and provides powering of GSM/GPS. During daylight running time the solar batteries simultaneously charges accumulators (Figure 2.). Simultaneously reception of signal from all of sensor locations and using appropriate software / algorithms supports to "real-time" on-line regime working of DMO. Sensor locations are presented on the Figure 3.

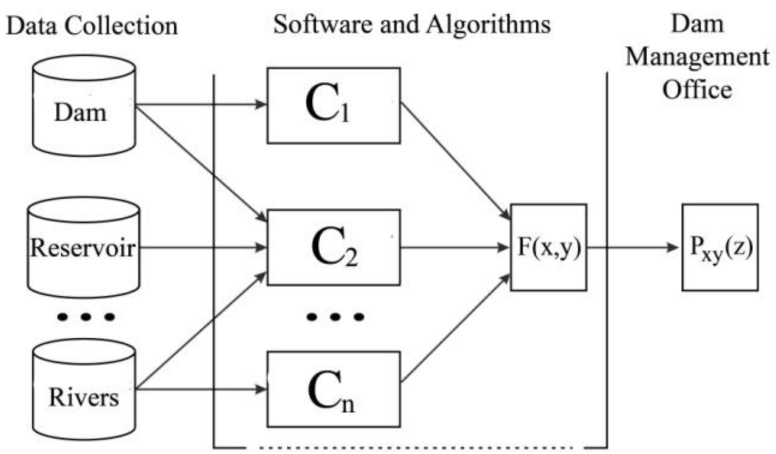

Figure 1: *Data collection system*

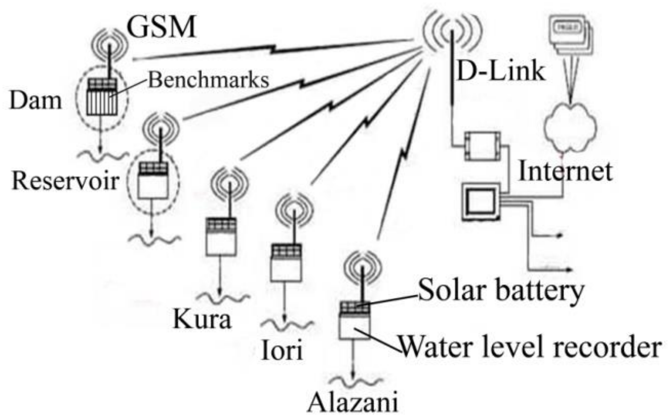

Figure 2: *Principle scheme of offered remote control system*

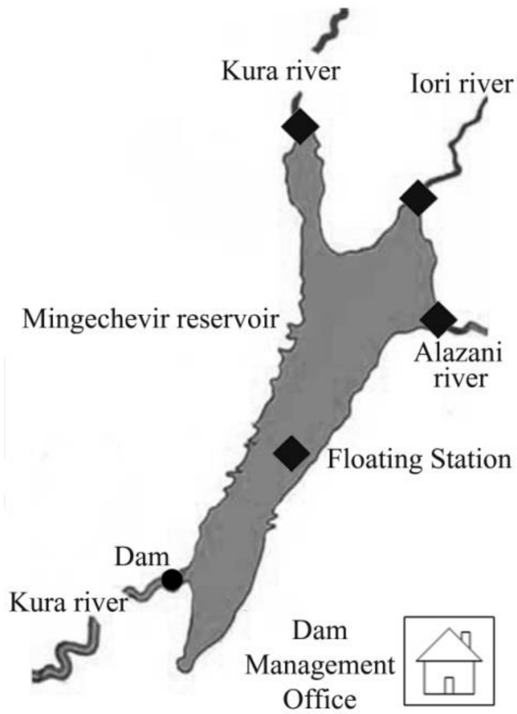

Figure 3: *Sensor locations*

Concluding remarks. The Mingechevir hydraulic-fill dam safety problem of such size and complexity requires a structured approach to the risk management and risk mitigation. The presented paper is first results in modeling of the remote control system of Mingechevir hydraulic-fill dam physical stability.

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