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# BEHAVIOR MONITORING OF DAMS DURING TIME STUDY CASE: POIANA RUSCĂ

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**Abstract: The paper describes the hydrotechnical constructions behavior in time. A classification of tracking types is shown including Poiana Rusca dam case study. The Complex arrangements is presented along woth the modern measuring methods and their need for implementation.**
**Keywords: behavior monitoring, measurements, optic fiber, finite element.**

## INTRODUCTION

Behavior monitoring is, in other words, an early notification of any dangerous phenomena for the hydrotechnical construction safety. Hence the importance of processing and interpretation of monitoring collected data [1,2]. There are two situations when operating dams in operation:

- Normal situation
- Exceptional situation.

*Normal situation* is defined by the proper functioning of the elements of the arrangement and through a proper response to demands of the projected building.
Failing the above conditions leads to the framing above situation in exceptional circumstances.
Depending on the severity of deviation from normal parameters, in the exceptional situation we distinguish several levels of risk:

- *State of attention* represents the deviation from normal operating parameters in the absence of a safety hazard Advantageous;
- *Alertness* represents distinguishing phenomena whose evolution could become a potential danger to the downstream accumulation;
- *Alarm condition* implies the need to evacuate flows causing downstream flooding areas or danger of damage or dam failure.

Follow-up hydrotechnical constructions activity is a very complex process [2]. It represents the operations of gathering, processing, storage and interpretation of information regarding the reaction. There are two levels of monitoring the hydrotechnical constructions behavior in time:

- Current-monitoring;
- Special-monitoring.

Current monitoring is observing and recording phenomena and parameters that can announce changes regarding the building capacity to meet requirements of strength, stability and durability established by design. Is made based on current monitoring instructions [3]. Special monitoring represents following the activity of construction which consists in measuring, recording, processing and systematic interpretation of parameters values defining the construction measures to maintain the strength, stability and durability established by the project. Special monitoring includes current monitoring [2]. Special monitoring is done based on a special monitoring project.
There are three levels of activity while monitoring the behavior of hydrotehnic construction [4]:
Level 1 includes:

- Visual inspection;
- Measurements with measuring devices;
- Primary interpretation of measurements made by the operational staff;
- Completion report and visual observations records of any atypical situations observed;
- Communicating the atypical situations, to decision makers in accordance with the work related information;

Level 2 includes:

- Synthesis of data from periodic visual inspections and results;
- Measurements from measurement apparatus;
- Updating, improving warning criteria;
- Proposals for updating, as appropriate, a special project monitoring;
- Interpretation of the monitoring behavior in terms of dam safety works;
- Recommendations on improving the monitoring system performance and construction repair works.

Level 3 includes:

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- Analysis and approval of annual summary reports, made by a commission monitoring the behavior of dam;
- Approval of project monitoring updates or special upgrades;
- Approving proposals for operating mode of construction to ensure safety conditions;
- Proposals on structural measures.

## MATERIALS AND METHODS

APPLICATION AT RUSCA DAM. DESCRIPTION OF THE COMPLEX HYDRO-TEHNICAL DEVELOPMENT

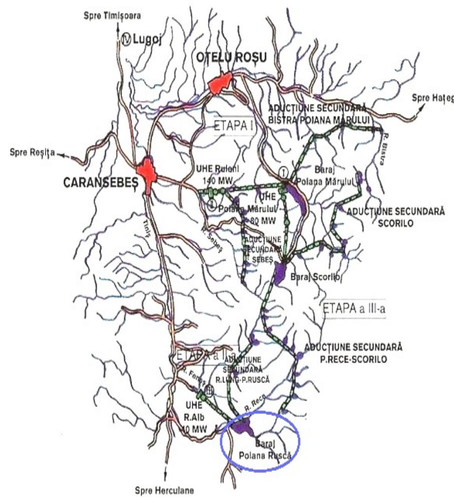


***Fig.1. Rusca Dam Hydrotechnical Arrangement [5]***

Hydrotehnical arrangement Bistra-Poiana Mărului - Ruieni fall -Poiana Rusca is located in the upper basin of the Timiş River on the Territory of Caras Severin County. (Fig.1.)

The main purpose of the investment is harnessing the hydroenergetical power potential of rivers in the area. Watersheds of the arrangement are located between the river basins: Râul Mare to the east, south Cerna, Timis west, north Bistra Ardealului. The arrangements inlcudes three stages

- The first stage includes Poiana Mărului rock-fill dam construction with a height of 125m and Underground Central Ruieni. This stage includes two inlet systems to plant Ruieni Sebes derivation. Ruieni plant inlet includes 14 km of galleries and Bistra derivation to the Poiana Mărului barrier- containing 16,3 kilometers of galleries.
- The second stage consists in constructing the Poiana Rusca dam and power plant Râul Alb.
- The third stage involves the construction of Scorilo dam 125 m height and Poiana Mărului plant and also two derivations Bistra-Scorilo and Pârâul Rece-Scorilo. This third stage uses the waters of Scorilo Lake in the Poiana Mărului power plant and through the spillway tunnel it supplements the water for Ruieni power plant.

The relief of Ţarcu Mountains is disposed in steps looking like an amphitheater. The lower level, well evidenced on the west side, to Caransebeului Hollow with altitudes of 500-800m has width 2-3km, the middle step with heights around 1100 to 1400 is more extensive and growing on the west side (to Timiş) and North (Bistra) of the mountains. The two steps are highly fragmented.

The highest level is situated at 1600-2200m altitude and comprises the highest peaks of the massif Tarcu and (Tarcu Peak - 2190m, Muntele Mic Peak - 1802m), where traces of glacial lakes are found, lakes surrounded of debris. Within the Tarcu mountains are identified several small depressions, in places where water crosses Mesozoic sedimentary rocks. These appear as enlarged portions of valleys with gentle slopes and deforested, known as "meadow". The most famous in the arrangement area is Poiana Marului, which is actually a widening of the valley Bistra Mărului at the confluence with the river Sucu. The landscape presents distinctive variations from one area to another, with strong fragmentized shapes in the dam site, but especially in the capture inlet side and on the route. The relief is grafted on crystalline formations, the torrential valleys that cross the mountain massifs and total forestation make the area a wild appearance.

GEOLOGIY AND HYDROLOGY [6]

At the base of this region is the oldest crystalline formation, metamorphosed, massive granite pierced. During the Tectonic movements in the Cretaceous (last period of Mesozoic era, characterized by massive deposits of limestone), this rigid base, forming "Danubian area" was rode by a "cover band" composed of highly metamorphosed crystalline schists in depth, known as the "Getic Canvas". Erosion has largely removed and fragmented most of the geological formations of the "Getic Canvas ", revealing the field formations under Danube and even leaving obvious traces in relief appearance. From "Getic Canvas" small patches have remained as in the northwestern Tarcu mountains and the Tarcu peak.

Post tectonic cover consists of Quaternary and neogen sedimentary deposits. In the arrangement there are met three major geological units:

- Getic crystalline formations (the Turnu-Ruieni area and is the plant rock foundation and Ruieni pressure node, spillway gallery, main and access gallery Slatina).
- Crystalline formations of autochthonous (the foundation of the dam Poiana Marului, access gallery to the main inlet and Bratonia capture, Marga capture, secondary inlet Bistra-Poiana Marului); around the accumulation Poiana Mărului crystalline schist and Maru granite are met. The main adduction crosses granite and Maru amphibolites.
- Post-tectonic cover spillway tunnel gallery of Ruieni - the polder area (Dutch name given to the lower portion of the sea or a lake pulled away from sea by damming and drainage) Zervesti. The seismic area were the arrangement is located is State 6.

POIANA MĂRULUI DAM [6]

Poiana Mărului Dam is a dam made of rock fill with the central core of clay and ballast sorting filters, with a maximum height of 125,50 meters constructive The dam is part of the first class of importance. Elevation at the crest is 625,00 mdMN, it has a width of 10,00 m and a length of 407,00 m The upstream slope is 1:1,85 and the downstream slope is 1:1,60.

The total amount of fillers in the dam body is 5 150 000m ³. The bottom discharge- is an underground gallery located at the right side, with a capacity capable flow of approx. 160m³/s; the gate house is equipped with two flat valves in the housing, arranged in tandem (crosspieces valve and valve service) with the free section of 4,08 squared meters, valves that can operate at partial openings, also in the gate house is found the bypass for the flow of service. High-water spillway is located on the right side and is composed of the following main assemblies: free spillway, funnel tower of discharger, escape gallery, high performance channel, the discharger has maximum capacity of 686 m³/s.

MAIN INLET RUIENI [6]

Ruieni main inlet consists of the following: water intake, the wet pit and adduction gallery.

The inlet gallery is an underground gallery, with a total length of 9 870 m and an inner diameter of 4,90 m and a flow of 55,4 installed m³/s. The main inlet captures the flows from Bratonea catchment.

RUIENI PRESSURE NODE [6]

Ruieni pressure node consists of the following:

Tower comprises: circular castle shaft (H = 107,60 m, D = 7,40), the upper chamber of circular (H = 17,00m, D = 19,00m), the lower house of circular shape (L = 80,00 m, D = 6,00m)

Butterfly valve house located between the main inlet and forced gallery, butterfly valve type VF 360-140 allows the isolation of two galleries;

Gallery is a gallery forced-fully armored, with a length of 497,00m and a diameter of 3,60.

RUIENI UNDERGROUND POWER PLANT [6]

Hydroelectrical power Ruieni is a underground plant located in the left side of Turnu river (1,5 km north of town Ruieni and 15 km east of Caransebeş) who enroll in grade II importance class.

The installed capacity is 140 MW plant (78-326 FVM two Francis turbines, each with an installed capacity of 70 MW). Installed flow of 55,4 $m^3$/s. Average electricity production is 264 GWh/year

The gallery is a gallery run-level pool with a length of 2666,00 m and a downward slope of 1.4 ‰.

Zervesti polder flee gallery is run through a channel of trapezoidal section, a length of 702,00 m

Both cars cavern and galleries have been excavated in weak rock. The 2,7 km of flight gallery were made with explosive. The 9.8 km of adduction with 4,90 m diameter were made by similar methods because of poor conditions in the rock cavern project's original engine room walls have been considered possible curve still later vertical granted tensioned were used in the cavern walls.

ADDUCTION AND SIDE CAPTURE [6]

The catchement are "Tyrolean plug" composed of the following:

- capture threshold is meant to achieve capture elevation with the parts field overflow, dry sewer;
- Desnisipator-is to retain and dispose solid flow transported
- Secondary pipe with secondary adduction;

SECONDARY INLET BISTRA-POIANA MĂRULUI [6]

Secondary inlet Bistra - Poiana Mărului has the role to capture the over flow of some tributaries affluent of Bistra River and transport them to Poiana Mărului lake.

Inlet has a length of 15,9 km, with slopes ranging between 1,91 ‰ -2,34 ‰. Sampling flows is accomplished through a number of five catchments Bistra Bucovei, Vallea Lupului, Bucova, Marga and Niermeş. The average flow captured is 1,665 ms / s

SECONDARY INLET SEBES [6]

Sebes secondary inlet is designed to carry the main inlet Ruieni, captured flow of some tributaries of the river Sebes. The inlet has a length of 11,7 km with slopes ranging between 2,00 ‰ - 3,12 ‰.

Sampling flows is accomplished through a number of new intakes: Cuntu, Raul Small rocky Pietrosita Sebesel II, Borlova, Borlova, Slatina. The average captured flow is 1,600 cm/s

The secondary inlet flow rate is turbined in a small hydroelectric power plant.

ZERVESTI ARRANGEMENT [6]

Zervesti arrangement, located near the river Sebes aims to allow the capture and daily-hourly regulate both the flow turbine and the HPP Ruieni difference captured on the river basin Sebes.

Also in the polder is Sebes capture, diversion channel and energy sinks.

Polder located immediately downstream channel flee Ruieni HPP, was executed.

RÂUL ALB POWER PLANT [6]

It is built in a well near the Râul Alb. The water flows from Poiana Rusca lake by the 4 274 m long headrace gallery and out into a long gallery running of 940 m in a small reservoir on the Râul Alb, from where they go in the river. The pit is 40 m deep and 20 m diameter. The pit was executed with explosive and the base of the plant is concrete.

POIANA RUSCA DAM (CASE STUDY) [6]

Poiana Rusca dam is a concrete arch dam, part of the complex hydrotechnical arrangement Bistra-Poiana Marului- Ruieni fall. Poiana Rusca is located in the upper basin of the river Timis Caras-Severin territory.

## DISCUSSIONS

MONITORING METHODS

The main purpose of the investment is harnessing hydropower potential of rivers in the area. Watersheds of the arrangement are between the river basins: Râul Mare to the east, Cerna south, Timis west, north Bistra Ardealului. In this particular case study is seeking implementation of modern methods of monitoring and measurement that will be presented in the following.

Modern measurements [7], Fiber Optic Sensors

Fiber optic sensors presents optical properties of light data crossing fiber, which can be changed by some action such as effort, pressure, or temperature acting on the fiber [9]. They are classified as:

- Singular sensors – measurement is performed in space in a single point;
- Integration sensor – they measured average value of a well established parameter followed and provides a single value;

Multiplexed sensors – measurements are performed in a fixed number of discrete points along a fiber optic cable;

Distributed sensors – parameter follow certain spatial resolution is measured at any point along a fiber optic cable.

Fiber optic sensors are completely passive, can measure a wide range of physical and chemical parameters, show potential for measurements with very good features, complete electrical isolation against electrical discharges and can be operated at very large distances of the order of kilometers.

A good example is the Fabry-Perot sensor using light reflected from two surfaces semi-mirrors. The reflective surfaces can be incorporated into an optical fiber or may be located at its end. Based on this principle we can achieve different pressure transducers, work and travel, telemeters, inclinometer or accelerometer. The most efficient way to read this type of sensor is the white light using a Fizeau interferometer.

## RESULTS

The principle of the finite element method [8].

In the finite element method to build the entire structure, equations describing the behavior of individual elements are connected in a very large set of equations describing the behavior of the structure. Problem solving using finite element method can be achieved by following several steps:

Defining the problem; Allocation of tasks, constraints and solving; Viewing the results.

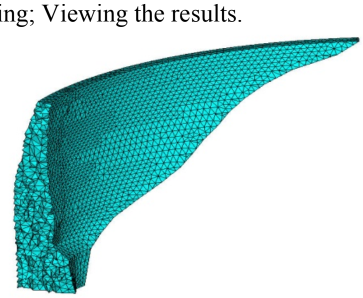

***Fig*.2. The finite element method calculus [10]**

## CONCLUSIONS

Fast and reliable analysis of a dam is made by comparing the measured values for relevant parameters, the calculated values for these parameters, the values depending on external factors (demand, precipitation, time, etc.) at the time of measurement. These methods have shown potential in establishing criteria for attention. By taking into account several assumptions depending on the level of lake water and air temperature will be dependent curves drawn between trips and lake level in the most adverse conditions. Following research will establish criteria for normal behavior of the dam Rusca.

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