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Monitoring the Văliug dam behaviour during exploitation by using topographical observations

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Abstract: The main objective of construction behaviour surveillance activity is an accurate evaluation of the technical status of the construction along its entire lifetime. Dam owners are required to follow over time the behaviour of these constructions based on specialized projects. Projects of dam behaviour surveillance must comply with general regulations in the field, provided by law and the norms of specific technical and design elements set out through periodic assessments of the safety status. River engineering in general and dams for water reservoirs in particular, are constructions with a very long lifetime, and therefore their achievement involves financial efforts particularly important. Surveillance their behaviour during construction, at the beginning of exploitation and also during all the exploitation period means the guarantee of their safety and also the possibility to prevent accidents that could turn to catastrophes.

Keywords: surveillance, construction behavior, dam, total station, water reservoir, water management

1. INTRODUCTION

River engineering in general and dams for water reservoirs in particular, are constructions with a very long lifetime, and therefore their achievement involves financial efforts particularly important. Dams require defensive engineering to ensure their continuing security.

Surveillance their behaviour during construction, at the beginning of exploitation and also during all the exploitation period, means the guarantee of their safety and also the possibility to prevent accidents that could turn to catastrophes.

The number, but also heights and lengths of the dams achieved until now, have grown constantly together with the technical problems.

Hydrotechnical constructions behaviour surveillance is the systematic activity of collecting, recording and recovering data and specific information, resulted from the observations and measurements of parameters that define the status and evolution of constructions state safety in relation with all actions to which they are exposed.

One of the fundamental requirements for socio-economic development throughout the world is the availability of adequate quantities of water with the appropriate quality and an adequate supply of energy. Hydropower is a renewable source of energy and supplies about 20% of the world's needs. Properly planned, designed and constructed and maintained dams contribute significantly toward fulfilling our water supply and energy requirements. To accommodate the variations in the hydrologic cycle, dams and reservoirs are needed to store water and then provide a consistent discharge to maintain the required daily flow in our rivers throughout the year.

According to P130-1999 Normative regarding the behavior in time of buildings indicative, Current surveillance of constructions must be apply to all buildings of any category or class of importance and ownership form on Romanian territory, except for residential buildings with ground floor and ground floor plus first floor household annexes located in rural areas and in villages belonging to cities, as well as temporary constructions, and has a permanent character, its validity length coincides with the physical length of existence of these constructions.

Dams play an important role in meeting people's needs. A dam is an engineering structure constructed across a valley or natural depression to create a water storage reservoir. Such reservoirs are required for three main purposes:

- provision of a dependable water supply for domestic and/or irrigation use;
- flood mitigation;
- generation of electric power.

In providing water supply, the reservoir storage is filled during the periods of above average stream-flow. For flood mitigation, the storage reservoir must be kept nearly empty during drought and periods of low rainfall, so that when rainstorms occur, the storage volume available in the reservoir provides a serious buffer against severe flooding events. For the power generation, the storage reservoir provides a head of water upstream of the dam and the potential energy of this water is converted first to kinetic and then to electrical energy.

On a worldwide scale, it is clear that the objective of constructing safe and stable dams is not always achieved. During the 1900–1970 period, for example, about 1% of the 9000 large dams in service throughout the whole world have failed, and another 2% have suffered serious accidents (Table 1).

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Table 1. Dams failure during 1900 - 1970

Dam name	Country	Year of fail	Dam height [m]	Number of casualties
Austin	U.S.A.	1911	15.0	100
Gleno	Italy	1923	52.0	600
Saint Francis	U.S.A.	1928	63.4	400
Mohne	Germany	1943	40.3	1200
Quebrada la Chapa	Columbia	1953	47.8	250
Malpasset	France	1959	66.5	421
Vega de Terra	Spain	1959	34.0	144
Oros	Brasil	1960	54.0	50
Babii Iar	U.S.S.R.	1961	44.5	145
Hioriki	South Korea	1961	50.6	250
Vajont	Italy	1963	265.5	1994
Breadfield	England	1964	30.0	238
Sempor	Indonesia	1967	53.6	200

However, life casualties, according to data from Table 1, are lower compared to that resulting from other disasters on the inhabitants; psychological impact and psychical trauma on people is at very high level because of these kinds of events.

2. THE FEATURES OF VĂLIUG DAM

A large dam has two essential requirements. First, it must be reasonably watertight. Second, the dam must be stable. Movements and deformations of the dam and its foundations cannot be eliminated, but they must be predicted and allowed for in the design.

Because of these requirements, the location and design of dams are undoubtedly influenced to some extent by structural and/or geological features. It therefore follows that geological factors and the proximity of construction materials are elements of overriding importance in determining the type of dam constructed at a given site. Once a site has been selected for a dam, consideration has to be given to deciding which type of dam is most suited to the site.

Hydrotechnical construction works whose design must take into consideration the concept of safety and low budget dualism. Thus, If is an attempt to increasing the investment budget, accepting a risk of dam failure, then the safety of construction decreases, and vice versa. Raising the level of safety construction, with intent to reduce operational risk, can generate oversize of the building, an increase the volume of material and labour consumption, with effect increase investment budget [2].

Văliug water accumulation is situated in Semenic massif, along the water course Barzava, Barzava hydrographical basin, downstream of Văliug Locality and upstream of Reşiţa, Caraş-Severin County. Bârzava Superioară river basin is situated in the west side of Romania, neighboring in its south side with with Caraş and Moraviţa basins, at south-east with Nera river basin and at north-east and east with Timiş river basin. In its dam section, Bârzava river have affluents from the Hydropower plant Crăinicel. The accumulation is part of the hydroenergetical arrangement of the upper course of Bârzava river. The intake basin that create the reservoir has a surface of 79 km. The acces on the dam that creates the accumulation is made from the County Road Reşiţa-Văliug on a distance along 3 km. along a communal road[1].

- the hydrographic code is: V-2-38;
- cadastral landmark : does not exist;
- dam construction period: 1907-1909,
- the commissioning year of the dam: 1909;

The water arrangement, along with Gozna, Secu, Timiş-Trei Ape accumulations ensure the necessary water supply for Reşiţa and achieve as basic function electrical energy and is adding its contribution to flood mitigation in a less manner.

The importance class of the construction is IV, RB=0.231, the importance category is C, according to “dam of regular importance”[3].

The front dam is built of rough stone masonry, cement and lime mortar, with construction features:

- length front sealing, 90.45 m;
- crest width 3 m;
- constructive height 27 m;

The bank slopes are as follows:

- upstream 20:1, downstream 3:1.85;
- the minimum height for foundation 478.50 mdM;
- the crest height 505.50 mdM;
- the maximum height 27.00 m;
- the dam base with 18.00 m.

In the upper zone of the upstream face of the dam there is a vertical pipes network with 60 mm diameter that is draining the water from infiltrations. Further the water, is evacuated downstream of the dam by horizontal collector drains with 120 mm diameter. At the base of downstream face of the dam there is a collector channel on each versant.

The completion dam is built of rough stone masonry, cement and lime mortar having the following construction features:

- length front sealing, 110.12 m;
- crest width 1.5 m;
- constructive height 12 m;

The bank slopes are as follows:

- upstream 20:1, downstream from the crest to to height of 501.5 mdM 4:1 and further to the base 3:1.837;

- the minimum height for foundation 492.66 mdM;

- the crest height 505.50 mdM;

- the maximum height 12.00 m;

- the dam base with 8.00 m.

The surface spillway (Figure 1) is made in free overflow manner with practical profile having a length of 37.0m, built on the left bank of the dam, the water being collected by a collector channel fitted with a rapid channel and steps falls.

The crest height of the spillway is 504.50 mdM.

The collector (Figure 1) channel has a funnel shape in horizontal plane, with the width decreasing untill 4 m. and the longitudinal slopes varying between 2.5 and 9 %. The section height at the enterance of the collector channel is 503.10 mdM.

Figure 1. The left bank of Văliug Dam with the spillway, view from the left crest of the dam

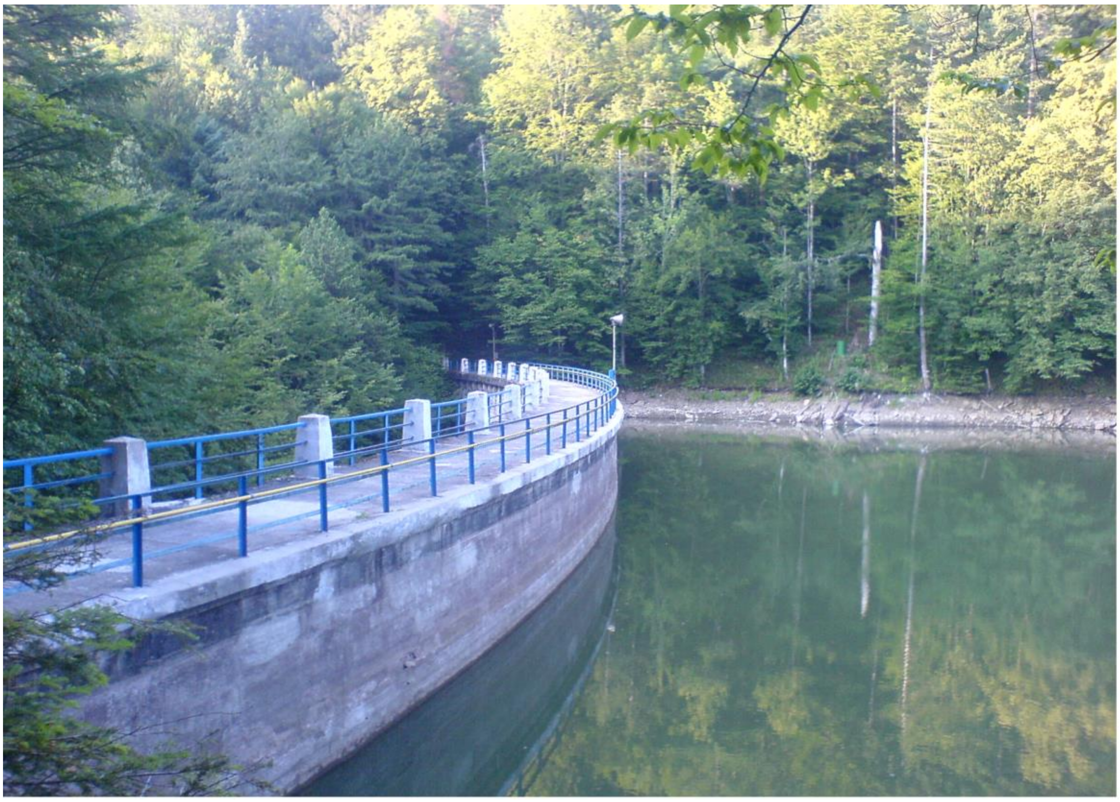

Figure 2. The right bank of Văliug Dam, view from the right crest of the dam

The rapid channel has the following futures:

- Length 52 m;
- Width 4.0 m;
- Height 1.5 m;
- Bank slopes 5:1;
- Longitudinal slope of the channel 3.5%;
- Height on the terminal section 500.32mdM;

The spillway channel opens to several dissipation steps of made by concrete basins founded on the bed rock:

- Discharging channel height:500.32 mdM;
- Bârzava thalweg height: 480.00 mdM;

The construction has been made as mentioned before 100 years ago, the project has been unknown. The capable discharge for a spillway blade of 1.00 m is 79 m^3/s.

3. THE TOPOGRAPHICAL NETWORK

The Văliug Dam in its 100 years of exploitation had a normal behaviour. The current measurements made along the dam exploitation referred mainly to the air temperature, rainfalls, the water level in the accumulation basin, the discharged flows of the spillway or evacuated by the bottom drain. In 2007 the topographical network for observation and topographical measurements was made by fixing topographical landmarks dispose on the dam crest on both banks of the dam.

The network consists of four fixed landmarks and 19 mobile landmarks situated along the dam crest (#1 to #11 on the left bank crest of the dam and #12 to #19 on the right bank of the dam) [4].

At present, the topographical network does not presuppose a topographical landmarks used for planimetrical observations, such as displacements and deformations.

Table 2. Subsidance of Valiug dam

SUBSIDENCE CHART
FOR THE OBJECTIVE: VĂLIUG DAM Level type: **LEICA DNA 03+invar stuff**
SITE NAME: Văliug Dam, jud Caraş-Severin Operator name: Gabriel Eleş
Measuring date: 02.09.2015/Stage # 4
Water level in the dam reservoir: 498.35 mdM

Landmarks	Height (mm) [absolute values]			Cumulative subsidence	Days from the first stage	Subsidence from the previous stage	Days from the previous stage
	Initial	Previuos	Actual	[mm]		[mm]	
RFN I	506767.6	506767.6	506767.6	0.0	2978	0.0	333
RMN 1	505489.1	505488.4	505488.5	0.6		+0.1	
RMN 2	505493.6	505492.1	505492.1	1.5		0.0	
RMN 3	505479.7	505478.4	505478.2	1.5		-0.2	
RMN 4	505472.4	505471.0	505470.8	1.6		-0.3	
RMN 5	505469.7	505468.9	505468.6	1.0		-0.3	
RMN 6	505476.0	505475.9	505475.2	0.8		-0.7	
RMN 7	505473.6	505473.7	505473.5	0.1		-0.2	
RMN 8	505473.3	505473.7	505472.8	0.5		-0.9	
RMN 9	505483.0	505483.4	505482.3	0.7		-1.1	
RMN 10	505479.9	505480.0	505480.0	0.0		-0.1	
RMN 11	505486.2	505485.6	505485.6	0.6		0.0	
RFN II	505893.8	505893.8	505893.8	0.0		0.0	
RFN III	507030.8	507030.8	507030.8	0.0		0.0	
RMN 12	505476.9	505475.8	505475.4	1.6		-0.4	
RMN 13	505473.9	505473.7	505473.5	0.4		-0.3	
RMN 14	505456.5	505456.8	505456.1	0.4		-0.7	
RMN 15	505455.9	505454.7	505454.9	1.0		+0.2	
RMN 16	505457.5	505457.2	505456.4	1.1		-0.9	
RMN 17	505462.8	505462.3	505461.6	1.2		-0.7	
RMN 18	505462.7	505462.3	505461.8	0.9		-0.5	
RMN 19	505460.8	505461.3	505460.5	0.3		-0.8	
RFN IV	309402.7	309402.7	309402.7	0.0		0.0	

The topographical measurements were made by using electronic equipment LEICA DNA 03 and the invar staff. The results are presented in Table 2.

As is already know Leica digital levels measure and save the height and the distance to the stuff at a press of a button, and calculate the height of the point. Yhe standard deviation per 1 km of double run (ISO 17123-2) is 0.3 mm when using invar staff.

For better surveillance on construction behaviour the topographical measurements and observations must be correlated with other observations such as water level in the basin (Figure 3), air and water temperature (Figure 4),

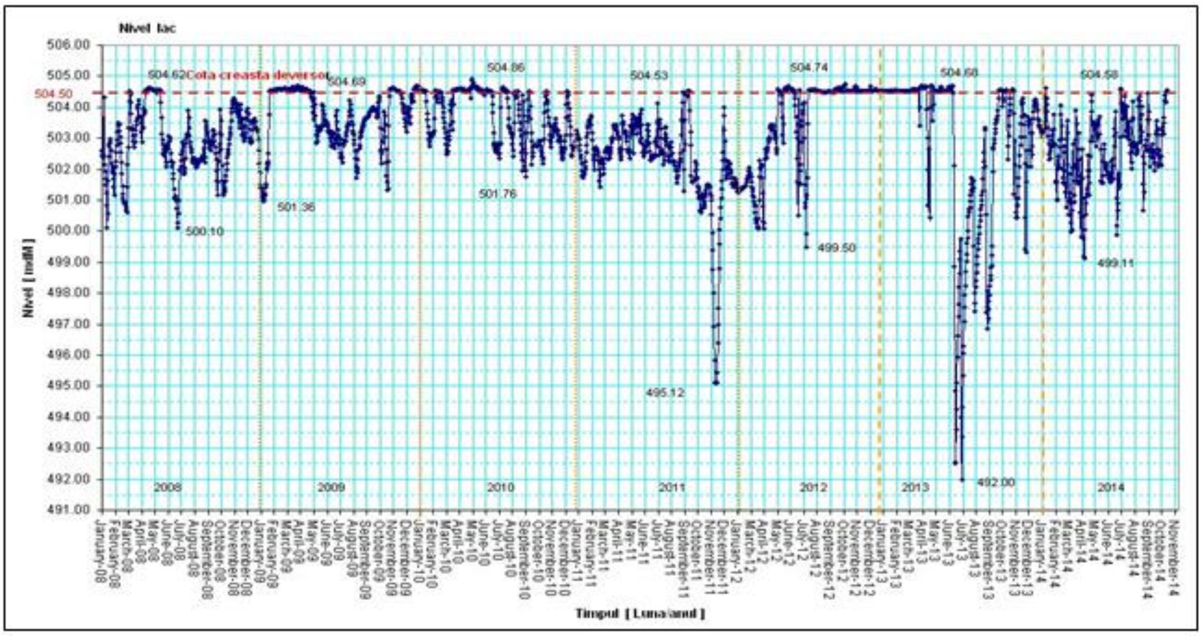

Figure 3.The daily variation of temperature from 01 January 2008 to 01 November 2014

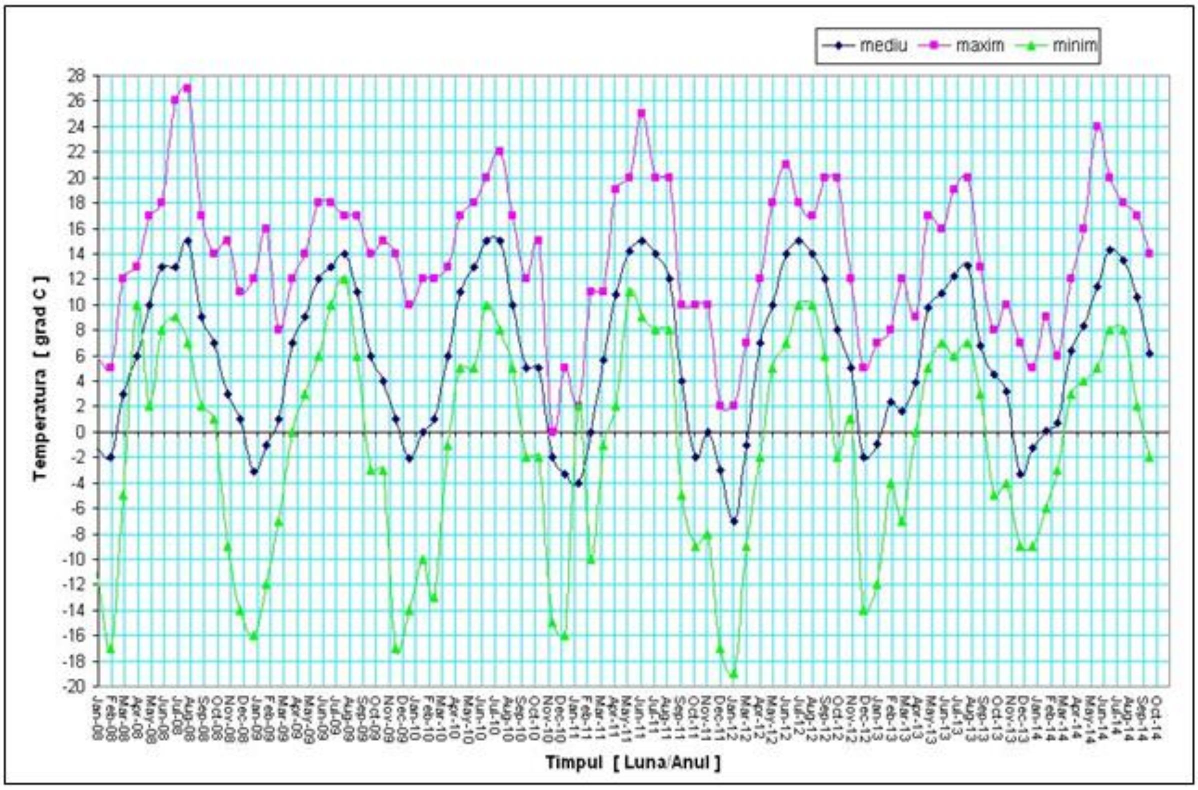

Figure 4.The air temperature variation. Average monthly values, maximal and minimal

4. CONCLUSIONS

Finally, maintenance plays a crucial factor in dam survival. Dams appear monolithic, but require ongoing maintenance. Concrete cracks and must be grouted with fresh concrete, earthen slopes naturally erode and must be maintained, spillways must be kept clear and functioning, and so forth. Many modern dams have the potential to last indefinitely if well maintained, but all dams are vulnerable to inadequate maintenance. Although the world's largest embankment and concrete dams would likely outlast all other human constructions if we vanished tomorrow, they will not do so in good working order.

The ability and willingness of dam operators to maintain the dam is therefore an important consideration in dam safety. Societies and dam owners are strongly motivated to maintain most water dams, which provide ongoing values like electricity generation, flood control, water supply and irrigation water. Many of these dams also exist in areas where a failure could cause large-scale loss of life and property downstream.

Tailings dams, in contrast, are built to contain wastes, and are cost-prevention devices and unwanted burdens, rather than being value-generating assets. This creates a risk dynamic which ICOLD specifically highlights as problematic in a study of tailings dam risks. Tailings dams must often be maintained long after the related profit-producing mines and plants close, and after the responsible companies move on or dissolve – meaning that dam maintenance becomes a totally unwanted cost. As a result, economic and psychological forces can conspire against proper long-term maintenance for tailings dams.

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