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Tracking the behaviour of hydraulic structures. Case study - Valea de Peşti Dam, Hunedoara County

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Abstract. Taking into consideration the strategic importance of barrages and accumulation lakes, watching the behavior of the hydrotechnical construction is an essential activity throughout its entire life. A very important component of this watching is represented by tracing the shiftings of the bench marks, set for this reason, both horizontally and vertically. As a particular case there will be presented the Valea de Pesti Barrage, which was watched from the point of view of the horizontal and vertical shiftings, since its construction until present, obtaining shifting graphics for each bench mark, graphics from which an anticipation of this hydrotechnic objective behavior can be done.

Keywords: hydraulic structures, barrages, accumulation lakes

1. GENERAL OVERVIEW REGARDING THE DISPLACEMENTS AND DEFORMATIONS HYDROTECHNICAL CONSTRUCTIONS

Hydro-technical constructions of large dimensions modify their geometrical shapes over the time, and their position in space, as a result of the various factors: changes in groundwater level, pressure of the wind, nature of the soil foundation, influence of its own weight on the foundation, micro-seismic phenomena etc.

Tracking measurements carried out over the constructions or lands on which they are located, represent an important topic of the engineering surveying and they have the purpose to determine the geometric modifications of the shape and their relative or absolute position.

Below, the **case Valea de Peşti Dam, Hunedoara County** will be presented.

During the 35 years of exploitation, the dam was exploited at normal strain level, with significant annual variations, filled every spring at NNR (826,50 mdM) and then emptied in order to compensate the deficit between the natural flow and the requirements.

From the start-up in 1973 measurements have been carried out in the situation of empty lake, having as result the initial series to benchmark the deformations of the dam, according to which the reports have been made further in time.

Interpretation of the measurements made for monitoring the dam implies knowing the elements which can determine the evolution of the traced parameters.

This category includes progress in implementation level of the lake , the temperature of the air and water, precipitations, affluent and defluent flows etc.

The evolution of these external factors can also cause changes in the monitoring program.

The progress in implementation is of great importance in determining the efforts and pore pressures (in the case of clay materials inside the foundation and the body of the dam).

The level of the lake determines efforts and pressures in the dam and foundation; variation in the level of the lake is generally much faster than the filling level variation in execution.

It is therefore necessary that monitoring the lake level should be done more often; rapid growth does not allow redistribution of the efforts and can lead to dangerous concentrations, a sudden decrease does not allow drainage of pore pressures and may cause loss of stability of the slopes or protection works (supporting alls, tiles or waterproofing protection etc.).

Highlighting the daily variations is therefore necessary to verify compliance with the exploitation instructions, for organizing visual observations and measurements in areas where sudden variations may occur.

Outside temperature variations affect concrete and metal elements.

Seasonal temperature variations influence the measured displacements registered as relative displacements, as well as absolute displacements.

In the very cold periods, when the previous levels of variations were exceeded, led to opening of joints and cracks, but also to the emerging of new cracks.

The function of the evacuators may influence the pore pressures in the area, it may also lead to material movements and erosions and hence the displacements of the construction elements.

2. STABILITY OF SLOPES

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The lake has natural slopes, well wooded. There were no reported occurrences of instability during exploitations. In the area of the dam maintenance is in process (deforestation of forest areas for good visibility of the geodesic landmarks. Dam structure is in good condition. Joint openings between two concrete elements present similar seasonal variations with variations of air temperature, having shifts more or less important.

External requests (level in the reservoir, air temperature and precipitations) for the evaluation of the dam status and its supervision are carried out with the following devices and specific measures.

Minimum water level in the lake was recorded in 1978 with a value of 792.70 mdM (other lows: March 18, 1993 with a value of 796.20 26.11.1990 with ASL and ASL 798.20 value).

The lowest average was in 1985 with a value of 813.28 mdM. The rates ranged from 827.25 mdMB (2004-November) and 792.70 mdM (1978). Annual maximum levels fall within a very small range: 826.60 and 827.25 mdMB very little over the levels NNR (826.50).

Naturally, the minimum or medium levels present larger variations.

After 1990 the average annual registered an increase due to a decrease in water requirements.

In 2003 we registered the lowest annual level variations during all exploitation period, the lake level remained virtually constant.

The air temperature does not have great importance for the safety of the dam, it is actually important for the mask aging and for increase analysis of the flows. Rainfall are also important (their nature and moments of melting for the solid precipitations).

Recorded rainfall values characterize the geographical area and the altitude where the dam is located; distribution of rainfall is uneven.

Annual precipitation ranged between 398 mm and 1224 mm, with a mean of 762 mm. Monthly highs had values between 82 mm and 328 mm (July 2005). The highest values were recorded in summer months (over 200 mm). When the flood occurred in August 1999 (referred to as the largest) daily rainfall was only 71 mm, and the month totaled 144 mm. Daily maximum value of 162 mm was recorded in July 2005.

3. ANNUAL DOCUMENTATION FOR MONITORING THE BEHAVIOUR OF VALE DE PESTI DAM

Geodetic survey started in 1973 by executing the original series, and has continued to the present, usually with one series of observations in each year except 1985-1990.

The monitoring is done by using geodetic equipment for spatial tracking as well as level tracking.

At the Valea de Pesti Dam movements and deformations are tracked using geodetic network, which comprises the following:

- 12 stable landmarks;
- 2 guidance landmarks;
- 7 level landmarks;
- 12 space study landmarks;
- 17 level study landmarks;
- 50 transport level landmarks;

Measurements were taken using the equipment supplied according to the specific deformation measurement applied to this dam. Thus, there was used:

- Total Station LEICA TCR 802 for adaptive and reflective device forced centering bolt and pilasters network.

- Level Leica DNA 10

As a result of vegetation evolution, in the area a decrease of visibility was registered, a new landmark was built in 1996 located on the portal overflow gallery. This landmark is used for guidance and level support. Also other 4 landmarks were built in the house of access valves, embedded in the shaft collar.

Azimuthal direction measurements were performed in 10 of the network pilasters: P1, P2, P10, P11, P6, P7, P8, P9, P12, P13, in 4 series of 3-15 targets with 10cc tolerance. Also the distance measurements were performed on automatic correction of the influence of temperature and air pressure of 7-8 measurements for each distance from standstill same as the measurement direction.

Level measurements were performed on the crest of a wave and on polygonal network links of support landmarks. The equipment used was previously corrected and verified before starting geodetic observations.

4. PROCESSING OF MEASUREMENTS AND PRESENTATION OF DEFORMATIONS

Processing the measurements recorded in the field was conducted under a special set of computer programs (TOPOSYS) created for planimetric networks , the results representing the horizontal deformations of the building. In order to calculate the vertical movement was used the software Leica DNA level 10.

Rigorous mass processing was performed in several steps by testing the network stability and quality of the measurements.

By analyzing the evolution of level and planimetric deformations during time, the current series show small movements of the objective, proving its good stability.

Low precision of the last series was influenced by improper materialization and signaling of landmarks, as well as the obstruction of visas between pilasters of the network. In this case the conclusions for optimization of these studies, as in the previous studies, by issuing for obstacles and marking landmarks of study and pillars. Making such deforestation is necessary to be made urgently, before the next step.

Network composition enables the development of these types of response to requests on three main directions:

- Left border-Right border (X);
- Upstream - Downstream (Y);
- Settlement (Z).

In general the measured geodetic displacements show a stabilization trend.

Regarding geodetic measurements, in order to maintain reliability of the solutions interpretation, it is required that around geodetic points (pillars, benchmarks) should not appear jointing in time due to the leakage of wastewater.

Maximum settlement level during 1973-1999 is 74.3 mm for landmark 130 on the canopy, falling generally within the normal range of this type of dam, leading to the conclusion that the fillings from rock fill were well compacted during execution.

Maximum horizontal displacement from launching, after 20 years of operation was 21.2 mm, being much less than the allowable limit, located in the section from the left bank to the canopy.

The nature of these horizontal movements is a residual plastic deformation due to the release of the dam under load, elastic deformations resulted from changes of the level are very low, close to the precision measurement survey and so, basically, hard to determine.

Reports were made to the initial series, the first 3 years were consumed approximately 50% of total settlements and in the first 10 years about 70-90%.

Maximum settlement is recorded in the canopy, but also at the 3 berms of the downstream level: 813mdM, 796 mdM, 782 mdM and their plan distribution is normal considering the asymmetry of the valley, having the steeper left bank and right bank leaner.

In the period 1973-2005, were carried out a series of 36 geodetic measurements, generally on an annual basis. Distribution along the canopy of vertical displacements of different series of measurements results lead to the conclusion that the settlement is proportional to the section height, as normally should be.

For the landmarks on the 3 berms downstream we have similar phenomena, continuous appearance of curves showing normal behavior.

Vertical displacements are maximum at the canopy - 78.9 mm in the direction of the old river bed where fillings have higher height (R130).

Displacements on the longitudinal direction of the dam have a normal antisymmetric aspect, being directed towards the valley (R050).

Horizontal movements showed a slight deformation trend downstream.

Movements of the left bank - right bank present stabilization trends.

In general most of the profiles analyzed present plan deformations of max 22.3 mm in the direction Ox, overall global and relative displacements are small and within the normal behavior of the dam.

5. CONCLUSIONS

As a final conclusion we can say that the Valea de Pesti dam is operating within normal exploitation limits so far, and it is expected that in the absence of extraordinary and repeated events the dam will behave normally. Planimetric movements as well as settlements have a decreasing trend each year due to so-called phenomenon of stabilization of dam, displacement values getting closer to 0.

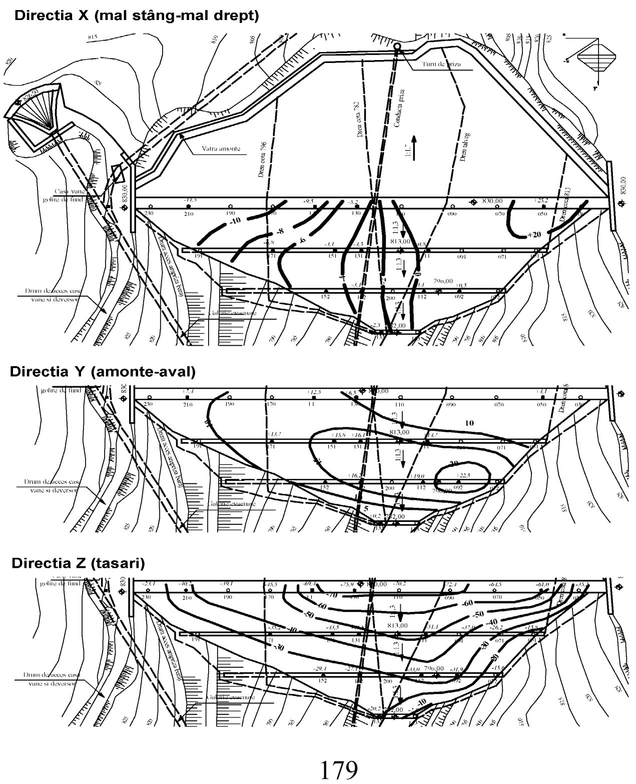

Fig. 1. Horizontal displacement graph

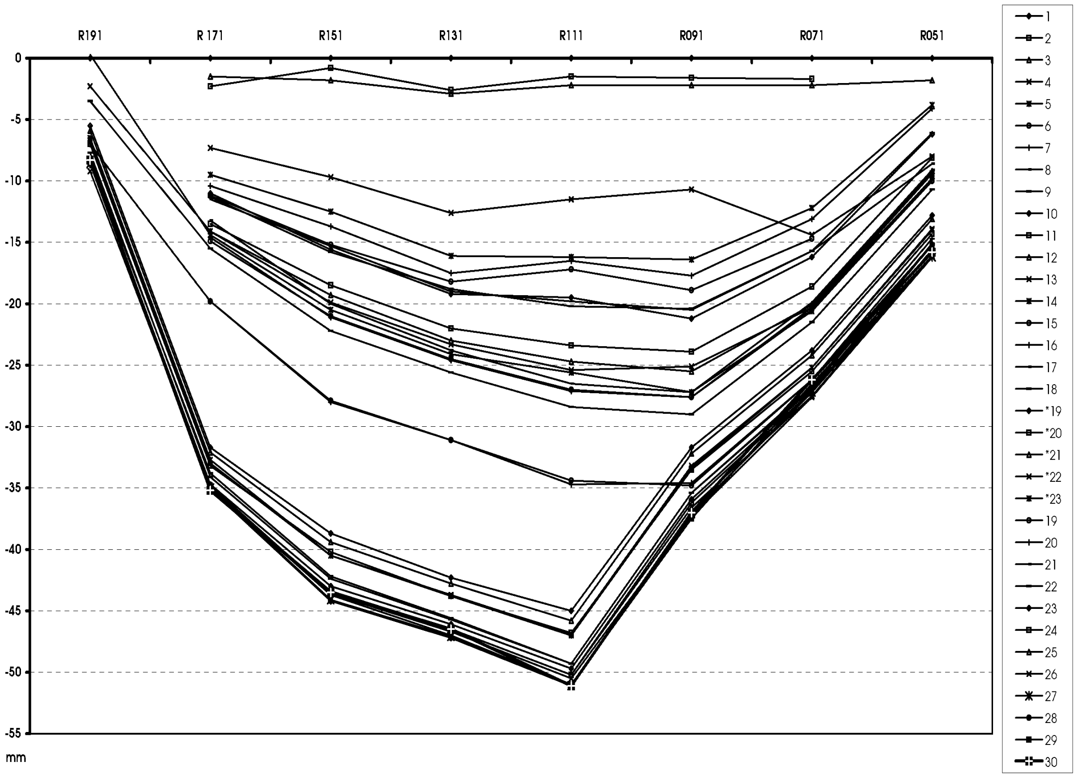

Fig. 2. Vertical displacement graph - berm

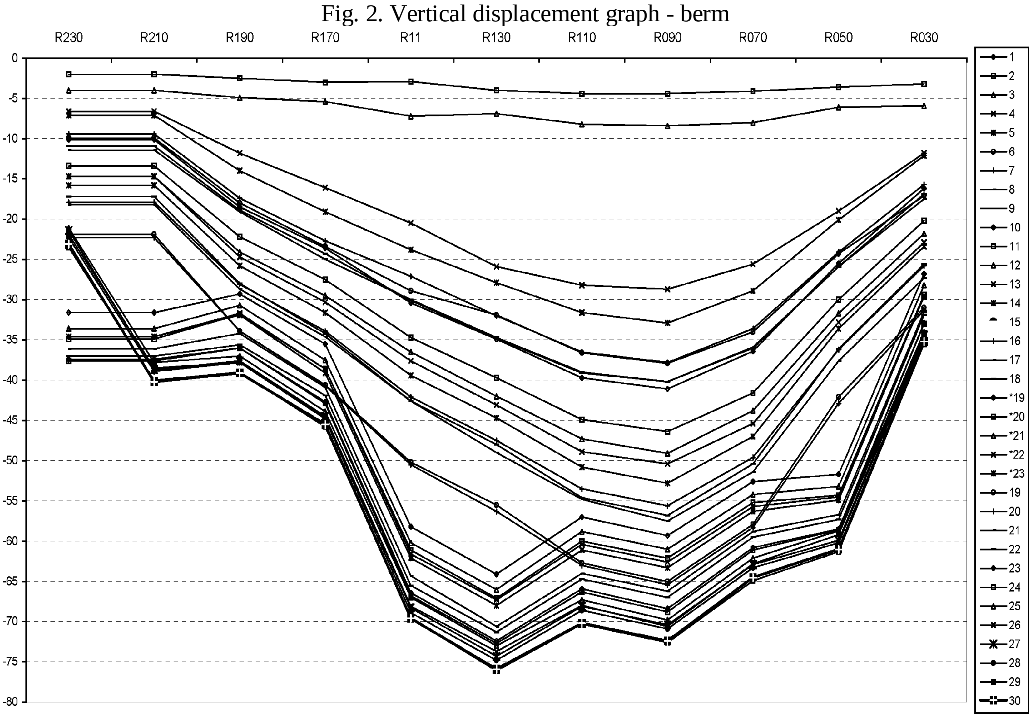

Fig. 3. Vertical displacement graph - canopy

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