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New Technologies in transforming natural hazards to hydro-technical object

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Abstract The biggest and one of the most interesting landslide in the basin of the river Visočica caused arising of natural accumulation of the water Zavojško lake. To avoid the risks of uncontrolled waters, Zavojško lake has been drained. In the second stage, during overhaul of landslide, the hydro-technical measures have been taken at the dam, which was made stronger, strengthened and exceeded. It provided accumulation of Zavojško lake with the water. Then, 520 hectare of the land have been flooded. Today, priority of the Zavojško lake is in the water supply of the Pirot and Nis and hydroenergetic supply of the of the Water Power Plant in Pirot with the power of 80 MW which has been used from 1990. In this paper we describe how can new technologies be used in creating useful hydro-technical objects

Keywords: Natural hazard, hydro-technical system, informational technology,

1. Introduction

Serbia is well-known as a place with numerous landslides. High potential for forming landslides is present in more than 65% territory. High hazard of

landslides is the consequence of a single and cumulative influences of the different geo-space factors of the area; 80% unconnected sediments, 68,2%-the slopes more than 5 degree, 62,9%-territory upper than 200 m above sea level and the

area that was not afforested enough-27,8%etc. One of the most important landslide is situated in the East part of Serbia in the basin of the river Visočica, the left mouth of Temstica, which is the right tributary of Nišava. This landslide, in spite of the attention of publicity, caused at once numerous socio-economic consequences and a completely changed landscape in the lower flow of the river Visočica. In order to overhaul the risks and consequences of the landslide, hydrotechnic and land-reclamation measures were taken. It was done to overhaul this big natural accident and its affects valorized financially. In that way the accumulation of the Zavojsko lake was formed. [1] The coordinates of the outstanding slopes of the accumulation, with the medium level of the water, according to ellipsoid is between 43 degree 6'24.61" and 43 degree 12'17.35" North latitude and 22 degree 44'35.92" East longitude.

2. Visočica valley

Visočica has trans-border flow the river ($L=71$ km; $F=596$ km²) whose basin includes a part of the area of Southeast Serbia and West Bulgaria. In the territory of Serbia, it is 54 km long and the surface of the river basin is 491 km². It is formed at the East and Southeast slopes of Old Mountain and represents the central source of the water and drainage system of that part of Serbia. The left side of the valley has no significant tributary, it is very steep, narrow and limestoneed. The right side of the valley has mild forms of relief and extended net of continuous and temporary flows. Dominations of the water proof racks and outstanding mountain characteristics of the area in the basin of the river Visočica, the vertical dissection of the relief, significant quantity of rainfalls and relatively small evaporation influence very positively to the quality and quantity of the water resources. Annual sum of waterfalls is 700 mm in the area of the accumulation till 1157 mm what is the quantity of the highest parts of the river basin. In the summer part of the year, from April to October, 57% is extracted and only during May and June 23.3% of total annual sum of the waterfalls. [4]

In the basin of the river Visočica and next to it, Toplodolska river, several hydrotechnic works have been done for inter-basin directing of the rivers and

creating artificial piracy. From 1953, in the territory of Bulgaria, the part of the water (0.58 m³/s)

Visočica is directed to the basin of the river Brzije (from Ogošte to the Dunabe). From 1990, water from accumulation Zavoj has been directed by the tunnel which is 9 km long through the valley of the river Nišava, 15 km upstream to its natural mouth. The plans of inter-basin transfer of the water has also been realizing from the Toplodolska river to Zavojsko lake by the tunnel 16 km long and then using the existing system to Pirot. It is predicted to build new accumulation to the Dojkinačka river, tributary of Visočica. [6]

3. Forming the Zavojsko lake

The Zavojsko lake is the natural-technic accumulation which is arisen behind the dam and made by earth and concrete, in downstream of river Visočica, 17 km North from Pirot. The dam was formed under the natural circumstances far from the previous planned location. The lake was named after the flooded mountainous village Zavoj. Before flooding, the settlement had 1335 inhabitants. Accumulation was arisen by the septum. The septum is formed by existing landslide and using the new one, rather bigger at the right side of the valley of the river Visočica, combining exogenous-geomorphological predisposition. The dam started to be formed by earth and rock. This mass was falling down along the steep slope. Then, over the base which was slightly connected and saturated by the water this natural accident had happened in 1963. Then rocky and earthen material was moved and it was falling down with average speed from 7 m/h. The following day, in the riverbed canyon, at the 540 m above sea level, the natural dam has been formed and in the area of upstream, accumulation of water has been started. At first the slide included area named Izvor and Southeast slope of the steep valley of the Izvorski Dol, in the height range of 790-960 above sea level. Length of the slide was 1.3 km, the average width was 160-220 m and maximum depth was 30 m. From the top of the landslide to the bottom of the river Visočica, there

was 420 m and horizontal distance was 1555 m (Stanković S. 1993, Zeremski M. 1964). [5] From 1.950.000 m³ materials accumulated in the shape of flooded remains. The dam has been formed and its height is 40 m, width of the base is 530 and in the crown 120-140 m. Behind this natural obstacle, the lake has been formed at the elevation 569 m with maximum depth 30 m. Length of the lake is 7.2 km, length of the coast is about 20 km and volume of the water is 11 million m³. Maximum level of the water in the lake was in the period from 14 to 22 March. Accumulation had long shape with average 200 m and maximum 500 m. The surface of the water mirror was 2.8-3.1 km². After the Palić lake, accumulation Zavoj is the biggest natural lake in Serbia. [2]

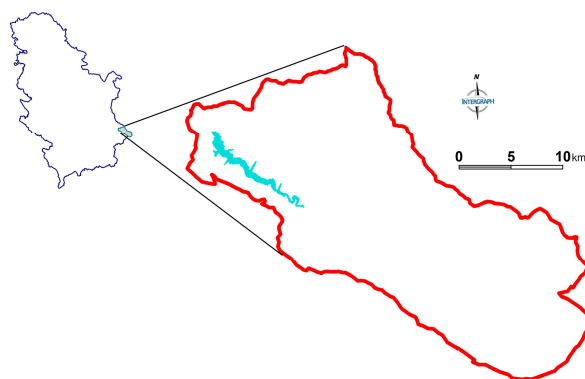


Figure 1 Position of accumulation in Serbia map

4. Enclosure the map of the lake

Occurrence of the Zavoj lake had two stages. Because of the uncontrolled growth of the level of the water in the lake, there was a real danger for the settlements, population and infrastructure downstream in the valleys of Temštica and Nisava. Because of that, in the first stage, they started to discharge water in a controlled way. At first, using the reverse canal in loose material and, then, using the laterally dug canal in the parent base long 604 m. By that tunnel, in December 1964, accumulated water was discharged and the natural lake has been drained. In the second stage, they started with hydro-technical works at the dam, which was strengthened, extended 450 m and made to be higher. It made conditions for creating bigger and more

secure poly-functional accumulation, whose height was 86 m. So, the lake was formed, long 16.35 km with elevation of slowing down at the surface 5.53 km³. Maximum depth of the lake was 70 m and the length of jagged coast 40 km.



Figure 2 Zavoj lake

The works on filling accumulation again lasted 15 years. In the basin anti-erosion measures had been made in order to reduce pouring of accumulation. It contributed to keep economic and ecological stability and quality of the cumulative basin. Analyses showed that total production of silt in the basin of Visočica, upstream from accumulation Zavoj ($F = 451.4 \text{ km}^2$) has been reduced in the period from 1970 to 2003 for 34% (Mustafić S. et al. 2008). By building bifunctional accumulation Zavoj ($F = 584 \text{ km}^2$, $V = 170 \times 10^3 \text{ m}^3$) in 1989. All the conditions for functional activating of the surface springs were realised, the first level Temštica (755 km^2). From accumulation, only 12 km^2 was excluded or 2% of total territory of the basin Visočica. From 22 accumulations, which have been formed, in the water supplying of Serbia, according to the basin and volume, cumulative waters Zavoj are at fifth place (Milincić M, 2009) 520 hectares of the land have been flooded by accumulation. From that number 12% unfertile land (20.8 km of the roads) and 80% agricultural and forest land. For the need of the Water Power Plant, the tunnel was dug (9.093 m, diameter 4.5 m) for reverse of the water at the two turbines of the Water Power Plant Visočica with the power of 80 MW, which is in function from 1990. Because of this fact, that the basin Visočica has high amplitude of the water

level, so accumulation also has changeable water level. The accident, which has influenced to location of the lake and adverse morphometry were limiting factors in functional valorization of the accumulation. Mountainous space of the basin of accumulation Zavoj and limiting of the international border, Serbia and Bulgaria, influenced on the process of the settling, population and economic stagnation and disintegration of the that area (Milinčić M, 2009). [1]

5. Conclusion

Forming of the every accumulation directly or indirectly, continuous or temporary causes the changes in the area which are partly positive and partly negative. The strongest pressure at socio-economic and physical-geographic system of the space is shown in the zones of forming accumulation and threatening large infrastructure. These projects, sometimes, has for the consequence geographic transforming of wider regional parts. Although, the questions of the positive and negative effects are different and they have opposite perception. Cumulative basins were always the most reliable way to regulate and make balance of flow and to supply needed quantity of the water for all kinds of consumers.

In Serbia, all the surface springs and accumulations are in the function of water supply and they have been continually used over 8 decades. During the 70s of the last century, they were promoted as the most secure and required model for growing needs for water. Then, surface springs are protected in the area of 10.249 km² in total Serbian territory. Key objects for realizing the aims of rational and functional exploitation of the surface springs, represent the connection between the system of surface springs and system of water supply. At the same time, every location of water accumulation shows requirements and delicacy to the components related to physical-geographic and socio-geographic of that area. Because of that, analyzed springs Temstica and, at the same time, accumulation Zavoj is denoted as very potential in the frame of South Morava regional system of water supply.

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