

Hydrogeological risk factors of dam and reservoir construction - a case example “Bogovina”

PETAR DOKMANOVIC, IGOR JEMCOV, SASA MILANOVIC, BOJAN HAJDIN

Faculty of Mining and Geology-Department of Hydrogeology, Djusina 7 str.
Belgrade, Serbia and Montenegro

Abstract: The dam and reservoir “Bogovina” was designed to build in the karst area of Crni Timok valley (Eastern Serbia). Reservoir level was designed without respect of risk factors and some negative hydrogeological indications. Complex, but unfortunately late, hydrogeological investigations, that define the mechanisms of significant water losses from the reservoir area, make questionable construction of dam and reservoir “Bogovina”.

Key words: karst, dam, risk factors, hydrogeological investigations, water losses.

INTRODUCTION

The particular attention, in respect of risk factors of dam and reservoir construction in karst, has to be paid to reservoir watertightness. An appropriate project concept, prior to exploration conduction, can significantly reduce the risk factors, (to the acceptable levels) while the reductions of exploration work enhance them. Up to day practice has shown that projected initial exploration “savings” often later recompense itself many times over. “Bogovina” reservoir, with maximum reservoir level of 275 m a.s.l., is typical example of risk factor negligence during the primary stages of research. Despite preliminary hydrogeological investigations, which had questionable results, detailed risk factor investigation was not analyzed until the first stage of the project execution.

CHARACTERISTICS OF RESEARCHED AREA

The investigated area belongs to the Karpat-balkanoid’s arc of the Eastern Serbia, which is characterized by significant presence of Mesozoic limestone-karst, with complex relations with non-carbonate rocks (Figure 1).

The limestone rock massif is characterized by well developed morphological karstic forms. The largest one is Bogovina Cave (Figure 1), in the contact zone between limestone (karst aquifer) and orbitoline sandstone (b1) and Oligocene sediments of Bogovina basin (b2), as the hydrogeological barriers. Barrier role of Oligocene sediments was deteriorated artificially by coal mining, which causes induced subsidence and fractures. A major part of karst ground water discharge through the Mrljis spring and, during high water periods, through the temporary springs: Bogovina cave and Fundonj cave (Fig. 1).



Figure 1. Simplified hydrogeological map

IMPORTANT RESULTS OF INVESTIGATIONS

Hydrogeological investigations include: analysis and interpretation of available geological and hydrogeological data; detail geological mapping; hydrometry; tracing tests; geophysical investigations; piezometric boreholes and wells drilling and pumping tests.

During geological mapping, many important karstic zones have been identified with a particular emphasis on the left bank of the future reservoir area, as a potential infiltration zone of stored waters (Figure 1). Particular elevation points were determined as follows: Bogovina caves (266 m a.s.l.) and Fundonj cave (263 m a.s.l.).

Hydrometry along the characteristic part (zone of the Mrljis spring) of Crni Timok River shows significant infiltration into the karst aquifer.

Large cavernous systems were identified, by drilling, up to depth of 90 m.

Dye tests carried out during the medium water level periods, has shown direct hydraulic connection between ponors in Bogovina cave with: 1) Mrljis spring, and 2) Abandoned mine galleries.

Tracing test, provided during high level water periods, has shown the direct hydraulic connection between ponors in the Bogovina cave with Fundonj spring. These tests indicate considerable and complex development of karstic channel systems in wider area of Bogovina cave.

The connection between different underground water levels in the Bogovina cave and Bigar spring zone (Figure 1) was confirmed during the pumping tests. These tests were done at several wells, located around the Mrljis spring area.

Exploration drilling and WPT results in sandstone, in dam site area (Figure 1), confirmed their hydrogeological role of partially permeable barrier. Previously tracer tests indicated this phenomenon. Highly developed karstic channel system, various hypsometric positions and azimuths of channels were determined during speleological explorations.

POSSIBILITIES FOR WATER LOSSES

The presented research results point out possibility that during maximum water level of 275 m a.s.l., the reservoir would suffer because of significant water losses:

- During high hydrostatic pressures (ca. 4 Bars) the water infiltration will be intensified through the reservoir bottom, particularly in spring Mrljis area.

Treatment of karst features of primary rock mass, which are covered and masked (by alluvial or other secondary deposits), is expensive. Unconsolidated deposits will be eroded and carried away from karstic channels and caverns. As consequence, origin of collapse and reactivation of karstic fossilized conduits are expected. After reservoir impounding up to the elevation of ca. 266 m a.s.l., infiltrated waters will form underground flows towards the Bogovina cave, and further into three directions:

- 1) Underground flow toward Fundonj spring
- 2) Underground flow toward abandoned mine and
- 3) Surface drainage (by discharging from Bogovina cave) towards the riverbed of Bogovina River. In all three cases the drainage occur downstream (outside the river catchment) of foreseen reservoir area. (Figure 1)

- Also, the water infiltration throughout the left reservoir bank, with the losses outside of catchment are characterized with some hydraulic mechanism.
- The assumption that the water losses will occur throughout the right side of the reservoir is possible too. Due to hypsometric relations karst-nonkarst in a valley of Arnauta river, as well as assumed character of sandstone barrier in this zone (b3), there is real possibility that infiltrated waters will flow out towards the direction of Arnauta River, and further down (outside the river basin) from reservoir.

CONCLUSIONS

Hydrogeological investigations did not take place in early stage of design. Instead, explorations started during the relatively late phase of preparation of “Bogovina” dam and reservoir design.

- On the base of newly collected results the water losses are possible in the case of designed reservoir water level.
- Possibility for sufficient watertightness geotechnical treatment is questionable. To confirm this idea additional investigations are necessary.
- Correction of reservoir level is other possibility.

The real evaluation of risk factor has to be the key parameter for decision of the project's future.

REFERENCES

- DOKMANOVIC, P., JEMCOV, I., HAJDIN, B., MILANOVIC, S. (2002): *Hydrogeological references for the reservoir “Bogovina”*, Faculty of Mining and Geology, Belgrade.
- MILANOVIC, P. (2000): *Geological Engineering in Karst* - Monography, “Zebra Publishing Ltd.”, Belgrade.