Problems associated with the rehabilitation of the bottom outlets of the Poiana Uzului Dam in Romania

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Abstract. After some 30-40 years of uninterrupted operation, important hydraulic works are in serious need for rehab or retrofit interventions. Works of this type can be made difficult or even prevented by various unforeseen situations, unknown to the specialists because they were not previously accompanied by events that affected neither the operation of the hydraulic systems nor the safety of the constructions and installations. The paper presents the experience of a group of specialists and the way in which the aforementioned unforeseen problems were solved during the rehabilitation works of the bottom outlets of a large dam in Romania. Poiana Uzului dam is the highest buttress dam in Romania (80 m max. height, commissioned in 1972), creating a multipurpose storage reservoir of circa 88 hm³ used for water supply for population and industry, hydroelectricity and flood protection. According to the national dam safety norms, the dam is ranked into the 1st class of importance, which corresponds to a design discharge value of Q0.1% (maximum discharge value with an annual exceedance probability of 0.1%). According to the Romanian design standard STAS 4273-83, for the 1st class of importance, the dam discharge capacity has to be also verified for a much higher value, Q0.01%. The dam was provided with 3 bottom outlets, each equipped with trash racks and 2 “butterfly” valves. The advanced wear of the bottom outlets equipment determined malfunctions of the service valves, as well as deterioration of the thrash racks, metal fragments posing serious threat upon the safe operation of the valves and of the outlets. Rehabilitation of the bottom outlets equipment was not possible with the complete emptying of the reservoir since it represents the only source of water for a number of circa 150,000 inhabitants in about 7 localities in the neighbouring areas. However, the intervention was possible with partial emptying of the reservoir, using professional divers to perform repair works in very difficult conditions. The lower limit to which the reservoir was emptied was conditioned by a program of monitoring the water quality parameters, allowing the uninterrupted supply of water for population consumption.

1. Introduction
After some 30-40 years of uninterrupted operation, important hydraulic works at Poiana Uzului dam, in Romania, are in serious need for rehabilitation interventions. The above mentioned interventions were difficult due to their positioning at the bottom outlets’ level, some 50 m below the normal retention level of the reservoir.
The Poiana Uzului buttress dam, with a maximum height of 82 m and a reservoir volume of 90 hm³, was commissioned in 1972 (figure 1). Located on Uz River, upstream of Dărmănești city in Eastern Romania, the hydraulic development was created for the water supply of the downstream industrial zone both for population and industry and for hydropower purposed, via a 4.1 MW small power plant located immediately downstream of the dam [1], [2].

Figure 1. Poiana Uzului dam in Romania, downstream view and lateral upstream view

The main characteristics of the largest buttress dam in the country are presented below [2]:
- maximum height: 82 m;
- crest length: 500 m;
- crest width: 4 m;
- number of buttresses: 33;
- blocks width (buttress head): 15 m;
- buttresses current width: 5 m;
- crest elevation: 515.90 mASL;
- upstream slope: 1 : 0.50;
- downstream slope: 1 : 0.45;
- total concrete volume: 0.70 hm³;
- total reservoir volume: 90 hm³.
Figure 2 shows the main characteristics of the buttress dam [1].

![Figure 2. Poiana Uzului dam. Main characteristics (adaptation from [1]); plan view; b) typical cross section through non-overflow blocks; c) typical cross section through overflow blocks](image)

The dam and the hydraulic development are operated by the Romanian Water Authority “Apele Române”, Siret River Basin Directorate, under the coordination of the Ministry of Environment, Waters and Forests.

For flood control and regulating the reservoir retention elevation, the dam is equipped with a system of 3 bottom outlets, each provided with intake trash racks and 2 “butterfly” type valves (figure 3).

During the heavy rains period in 2016, problems in operation at the service valve of bottom outlet no. 1 determined a series of post event investigations. The investigations showed the valve body was clogged with various submerged solid materials (metal pieces, branches, logs).

The situation was analyzed by a group of dam safety specialized experts and the Safety Report was presented and approved by CONSIB – National Commission for Dams’ Safety.

The Report stated the need for an immediate refurbishment of the upstream access area of the bottom outlet no. 1 and the inspection and visualization of the other two bottom outlets, to determine their safety condition too.

In the year that followed, the dam owner and operator commissioned a top design company to conceive the remedial works and measures through the project “Restoration of the trash rack and bell cofferdam at bottom outlet no. 1 and rehabilitation of the butterfly (safety) valve at Poiana Uzului Dam” [3].
The complex works within the project could be performed only with the help of a team of professional divers, which implied lowering the water level in the reservoir to a level that ensured the safe working water pressure and conditions.

![Poiana Uzului dam. Typical cross section through an overflow block and bottom outlet](image)

**Figure 3.** Poiana Uzului dam. Typical cross section through an overflow block and bottom outlet

2. **Rehabilitation works**

   To ensure safe conditions for the underwater works, it was necessary that in a period of 2 months (March - April 2019), the reservoir elevation to be lowered to 479.00 mASL, situated with approx. 12 m above the lower elevation of the bottom outlet no. 1.

   The operation of the storage reservoir was within the limits of the "Operation Rules for the Poiana Uzului Reservoir", updated by Siret River Basin Directorate in 2017 and approved by the Romanian Water Authority in 2018.

   Compared to a maximum retention height \( H = 62.00 \) m, during the period of approx. 60 days when the underwater works had to be performed, Poiana Uzului Storage Reservoir was not completely emptied but was decreased to circa 53% of the maximum hydrostatic head, the maximum depth of the reservoir \( H_i = 33 \) m ensuring the safety of the diving teams involved in the remedial operation.

   Rehabilitation of the bottom outlets equipment was not possible with the complete emptying of the reservoir since it represents the only source of water for a number of circa 150,000 inhabitants in about 7 localities in the neighbouring areas (figure 4).

2.1. **Main operation steps**

   After lowering the reservoir level, the complex repair works were preceded by a comprehensive visual inspection of the state of the upstream face of the dam as well as of the abutments, the conclusion being all were in a good condition, with no evident traces of degradation, instabilities or other marks of incidents.
Figure 4. Poiana Uzului dam. Detail of the rehabilitation zone: (1) – Minimum operation level [maSL]; (2) – the equipment cabin; (3) – thrash rack (to be rehabilitated); (4), (5) – repair and service “butterfly” valves

The repair works were planned according to a succession of phases. Among the most important, one can mention:
1. construction of a floating platform (pontoon) to allow the deployment of underwater operations.
2. building of new trash rack and cofferdam;
3. construction of trolley and lifting equipment;
4. underwater inspection of the remedial zone;
5. desilting of the access area corresponding to bottom outlet no. 1;
6. removal of damaged parts;
7. launch and assembly of the new trash rack;
8. launch and assembly of the new cofferdam;
9. removal and repair of the damaged valve;
10. bottom outlet refurbishment works
11. launch and assembly of the refurbished valve;
12. operation testing etc.

2.2. Relevant aspects regarding the rehabilitation process
The repair works required some adaptations of the existing systems or the use of innovative systems to allow the difficult and complex intervention of the underwater working team.

2.2.1 Lowering and handling the equipment. The drive cables are wound on the double drum of a winch inside the dam and act on the cofferdam by means of equalizing rollers located in a sloping niche, parallel to the running path. The existing winch has been replaced with a new one in order to safely lower the new equipment.

The lifting system was used for lowering and launching the pontoon, as well as for all the operations related to the disassembling and replacement of the thrash rack and the launch and installation of the cofferdam (figure 5).
2.2.2 Manual desilting of the bottom outlets access area. After the underwater inspection, it was found that the bottom outlets access zone was 80% clogged. The desilting operation was particularly difficult and required the manual intervention of the diving team. The time limitations determined the desilting operation at a working rate of 7 hours a day x 15 days.

Figures 6 and 7 illustrate the sketch of the clogging degree of the access section in the bottom outlet and some aspects from the amount of debris collected during desilting operation.
2.2.3 Replacement of the damaged thrash rack. After desilting and unclogging, the existing damaged thrash rack was removed. Figure 8 shows the advanced state of corrosion and deterioration.

    The 40+ years old thrash rack was replaced with a new one, having a similar size and shape. The difficulties of the diving team were determined by fixing and sealing the new item.
2.2.4 Installation of the “bell” cofferdam. After the new thrash rack was installed, the intake section of the bottom outlet was sealed using a “bell” shaped cofferdam. Figure 9 shows aspects from the cofferdam positioning and installation.

2.2.5 Removal and refurbishing the “butterfly” valve. Before the removal of the valve, an inspection was carried out inside the bottom outlet to evaluate the efficiency of the sealing provided by the cofferdam. After removal, the valve was subject of a thorough factory refurbishment (Figure 10).

The valve was completely disassembled, and all its components were reconditioned. New sealing rings were fitted to the shutter. After tests and functioning checks, the valve was reassembled and repositioned.
3. Conclusions
Following the experience gained during the refurbishment works for bottom outlet no. 1 of Poiana Uzului dam in Romania, a series of conclusions can be drawn:

- Most of the Romanian large dams were built and commissioned during the decades 1960 – 1980. After more than 30 years of uninterrupted operation, some of these dams are in serious need for rehabilitation and/or modernisation;
- Interventions at bottom outlets may pose serious problems, especially when it is not possible to fully emptying of the reservoir;
• Various problems threatening the success of rehabilitation works may depend on the in-time operation of the storage reservoir and hydraulic development. Thus adverse effects may be due to:
  o Excessive siltation of the reservoir, affecting the normal operation of the outlets;
  o Inadvertency in handling the bottom outlets hydromechanical equipment;
  o Lack of proper maintenance of the constructions, hydraulic systems and equipment;

• The advanced wear of the bottom outlets equipment determined malfunctions of the service valves, as well as deterioration of the trash racks, metal fragments posing serious threat upon the safe operation of the valves and of the outlets. Such phenomena have not been previously foreseen during the design stage of the project.

• Rehabilitation of the bottom outlets equipment was not possible with the complete emptying of the reservoir since it represents the only source of water for a number of circa 150,000 inhabitants in about 7 localities in the neighbouring areas. A serious issue to be solved remains the identification of an alternative source of water for the population and industry in such exposed areas.

• The rehabilitation at bottom outlet no. 1 was possible with partial emptying of the reservoir, using professional divers to perform repair works in very difficult conditions.

• The lower limit to which the reservoir was emptied was conditioned by a program of monitoring the water quality parameters, allowing the uninterrupted supply of water for population consumption. It was observed that a lower reservoir elevation resulted in deterioration of the water quality and the need for a superior treatment of water.

• Most of the desiltation was done manually by the professional divers, causing delays in rehabilitation works. As a result, the company in charge of the repair works developed a system allowing a mechanised, safer, faster intervention for unclogging and desiltation in such cases. The new system is proposed for the rehabilitation of bottom outlets nos. 2 and 3 of the dam. The successful application of the system may result in an extensive use for most of the Romanian dams.

Acknowledgment
The authors wish to acknowledge the documentary materials provided by Uzinsider Company S.A., Mr. Al. Doldur, general manager that successfully performed the difficult repair works. The valuable collaboration with Mr. V. Nechifor and Mr. B. Creanga from Siret River Basin Directorate is highly appreciated by the two authors.

References
[1] T. Bugnariu, R. Sarghiuta, and A. Abdulamit, “The global elastic modulus of buttress dams”, Thirty years from the Romania Earthquake of March 4th, 1977, Bucharest, Romania, March 2007.
[2] A. Abdulamit, S. Demetriu, A. Aldea, C. Neagu, and D. Gafroi, “Ambient Vibration Tests at Some Buttress Dams in Romania”, Procedia Engineering, ISSN 1877-7058, Volume 199, pp. 2196-2201, 2017.
[3] Siret River Basin Directorate, “Restoration of the trash rack and bell cofferdam at bottom outlet no. 1 and rehabilitation of the butterfly (safety) valve at Poiana Uzului Dam”, 2017.