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HIGH HEAD HYDROPOWER STATION TECHNICAL REHABILITATION AND REFURBISHMENT

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Abstract. The specific subject of the presented paper is to describe the technical and constructive rehabilitation and refurbishment of the Grebla HydroPower Station (HPS) and its annex elements. The Grebla HPS operates the discharge captured from Văliug Dam reservoir, as employed in the complex scheme of Upper Bârzava River Hydropower Arrangement, upstream of Reșița Town, south-west of Romania. The headrace gallery is loaded mainly by a bottom catchment at the base of the Gozna Dam, but also by adding the already turbinated discharge from Breazova HPS tailrace. The main headrace canal has a length of 14.2 km, accomplished mostly by excavation and lined by stone masonry with mortar. Still, about one third of the headrace length is represented by tunnels dug into the rock, some being concreted, others built in brick, and others being in natural state. In addition to these, there are also eight masonry aqueducts, with a total length of 65 m. The main canal ends at the Ranchina surging tank from where the three rivet metal penstock pipes (of 900mm in diameter) are loaded.

Keywords: hydropower station, refurbishment, rehabilitation.

1. INTRODUCTION

The technological rehabilitation of the Grebla HPS and its annex elements was imperative in order to achieve a complete optimized running of the hydropower system of which they are part [5].

The proposed works do not increase the capacities of water catchment and transport in the complex scheme. The works were proposed as a necessity to replace the existing equipment, which are worn out both physically and morally.

Basically, by making the investment, it is aimed to ensure a proper efficiency on the use of the captured discharges in the existing water supply system at the hydropower plant, along with a better running of the installed equipment for the electricity production process.

The presumed investment falls within the context of the correct and rational use of available resources and territory conservation, as addressing topics relating to the growth and development of the production of energy from renewable sources and the rational use of energy potential. It also comes in the framework of the increasing energy market liberalization and of the significant weight of problems relating to environmental protection, of the sustained development and of the Kyoto Protocol themes [1,3].

The Grebla Hydropower Station is part of the Upper Bârzava River Hydropower Arrangement (Figure 1) [2]. The water arrangement of the upper Bârzava River, upstream of Reșița Town, was carried out in several stages, starting as early as the XVIIIth century with riverbed regularization works for log rafting development, and continuing with works depending on the growth of the metallurgical and steel industry and of the town of Reșița.

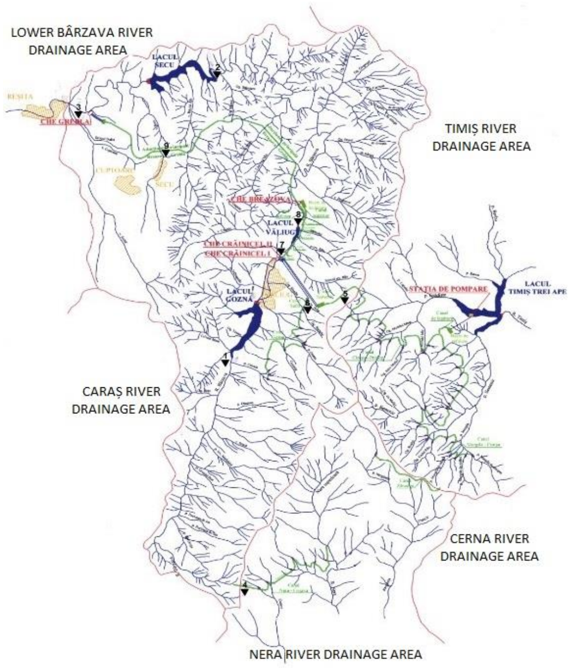

Figure 1. Upper Bârzava River Hydropower Arrangement

The river drainage area is located in the Semenic Mountains region, on the western foot of Semenic Massif, at an altitude between 460.00 and 250mSL.

The Grebla HPS (Figure 2) was commissioned in 1905. Three Pelton turbines were initially installed in the power station, with two more Pelton turbines for the facility internal services and lighting. It is currently equipped with two Francis turbines of an installed discharge of 3m^3/s, which are to be replaced with two new Francis turbines with installed discharges of 1.5 and 3m^3/s respectively.

The Grebla HPS employs mainly the discharge captured from the water storage at Gozna Dam. The connection with the power station is made through a

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hydraulic scheme accomplished from a headrace canal, a surge tank and penstocks pipes. The main water supply canal is charged by the mean of a bottom catchment located at the base of the Gozna Dam, as well as by taking over the turbinated discharge from Breazova HPS tailrace. The headrace main canal has a length of 13.40 km, mostly accomplished as a ground excavated trench with stone and mortar masonry lining. In the same time, about one third of the headrace is represented by tunnels dug into the rock, some being concrete lined and others of masonry, while others are in a rock natural state. There are also eight masonry aqueducts, with a total length of 65 m. The earth-fillings and the canal sections accomplished on embankments have a total length of 1.1 km. The headrace canal ends at the Ranchina surging tank from where the three metal penstock pipes are charged. The pipes are made of riveted metal and have a diameter of 900mm.

Figure 2**.** Grebla HPS main building, prior the rehabilitation

2. EXISTING SITUATION. SOLUTIONS AND WORKS PROPOSED FOR REHABILITATION

The height regime of the building is of ground floor, the power station structure being provided with a technical basement. The maximum height of the building is +10.05 m from the level of the natural terrain. The building is characterized by a relatively simple volume, being designed as of one homogeneous structure.

The actual foundations of the construction are accomplished as concrete continuous foundations under the structural supporting walls, foundations arranged parallel to the canal. The hydro-power equipment room is endowed with a general concrete mat, which discharges directly onto the supporting ground rock and which does not show settlements or cracks. This general foundation mat sustains the equipment's foundations – turbines and generators.

According to the on-site performed non-destructive testing [6], the concrete existing in the foundations of the equipment shows the C16/20 class.

The building supporting structure is made of stone masonry walls, the contour ones being of 65cm thickness.

The floor arranged over the technical basement is made of reinforced concrete arches that supported on metal beams, while the gaps of doors and windows are provided with reinforced concrete lintels.

The existing roof is made in metallic structure solution, with steel trusses over which is arranged a covering made of corrugated galvanized sheet.

The exterior walls finishing is accomplished on natural stone.

According to the technical expertise report [7], the general condition of the construction is good. There are no degradations of materials as due to the ascent of capillary water or due to the rainwater collecting. The effects of the frost cleftness cycles are not visible and there are no cracks in the structural load-bearing walls.

Both the infrastructure and the superstructure of the building are not affected by uneven settlements or sliding of the foundation supporting ground.

The floors arranged over the basement are on proper working condition and do not show degradations. The roof supporting structure does not show any damage due to the rainwater infiltration.

The whole structural ensemble of the building does not show degradations generated by previous seismic phenomena.

As about the proposed works, the main ones are:

- the partial demolition of the foundations from the existing equipment (turbines, generators) in the machine room (floors and concrete massifs) and their reconstruction according to the requirements for the placement of new equipment;
- demolition of the cable channel foundation and increase of the related functional space;
- demolition and geometry restoration of the access space corresponding to the vacuum tube;
- demolition and restoration of the wall in the access area of the new forced pipeline with DN 900.

These substantial interventions within the power station are shown by the following figures 3 and 4.

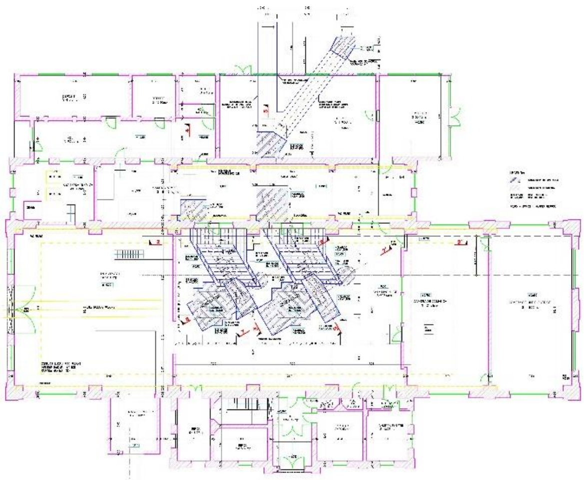

Figure 3. Plan of interventions at Grebla HPS building

The restoration of the structural resistance elements, necessary to support the new equipment, is made with reinforced concrete of C30/37 class [4] and corresponding to the exposure class XC1+XA1+XM1. At the same time, the restoration of the access gap corresponding to the vacuum tube will be done also with C30/37 reinforced concrete, corresponding to the exposure class XC2+ XA1+XM1.

As about the concrete floors and beams supporting the equipment, they are to be reinforced with double nets (made up of straight bars) and with resistance bars, made of concrete steel PC52, respectively with OB37 the distribution bars (the steel bars coating with concrete is to be of at least 25 mm).

The cooperation of the new structural elements with the existing structures is achieved by anchoring the new reinforcement rods in the existing supporting material on a depth of at least 40 diameters, respectively by fixing it with injection mortar.

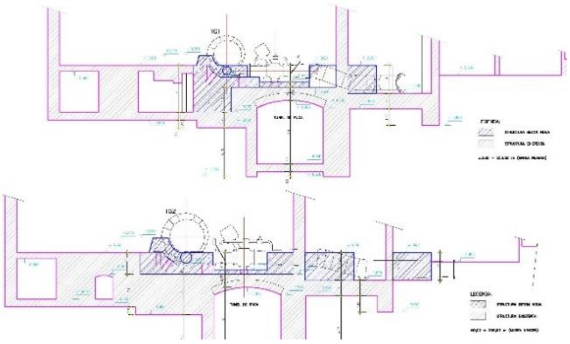

Figure 4. Cross-view by Grebla HPS pointing out some of the intervention structural works

For sure the most important aspect of the power station rehabilitation is the replacement of the old turbines with new, more efficient ones. They are located in the machinery room, as shown in Figure 5.

Figure 5. Machinery room at Grebla HPS, previously the rehabilitation process

The performances of the turbines installed in the power plant in the initial and proposed situation are presented in Table 1 [5].

Along with the hydropower machines replacement, it is also foreseen the replacement or modernization of all hydraulic, electrical, operating and automation equipment related to the power station.

The turbine water intake valves as well as the downstream coffer-gates on the turbinated water runway will be refurbished or replaced.

As about the very important elements on the hydraulic scheme which are the Ranchina surging tank (basin) and the water intake in the penstock pipes, they are located at the downstream end of the main canal at a distance of about 670 m upstream of the power station (Figure 6).

Table 1. The basic parameters of the Grebla HPS

Grebla HPS	**u.m.**	**existent**			**proposed**		
turbines number	pcs	2			2		
turbines type	-	Francis			Francis		
water source	-	headrace main canal			headrace main canal		
water head	m	211	211	**total**	211	211	**total**
installed discharge	mc/s	3,0	3,0	**6,00**	1,5	3,0	**4,50**
turbines power	kW	5500	5500	11000	2900	5500	8400
generated power	kVA	6800	6800	13600	3350	6750	10100

Figure 6. View of the Ranchina surge tank

This Ranchina loading tank functions also as a sedimentation basin, which from the three penstock ND900 metal pipes that supply the power station turbines start. The three forced pipes are connected with a collector from which the water is distributed to the two turbines installed in the power station.

The vacuum tubes from the two turbines evacuate the turbinated water discharge into the tailrace canal. Currently, in the power plant are mounted three valves in front of the collector in the power plant and one spherical valve in front of each turbine. Currently, in the power station there are three valves employed in front of the collector and also one spherical valve in front of each turbine. In the power plant are mounted two Francis turbines of horizontal shaft, the corresponding generators and their auxiliary equipment.

As about the proposed intervention at Ranchina intake (figure 7), there can be mentioned:
- the washing gate is going to be replaced with a new (galvanized) one;
- two new automatic cleaning machines, equipped with hydraulically operated arms, for cleaning the grate will be installed for the grate on the access to the penstock pipes (the cleaning machine will be automatically operated from the power station control room);
- the installing area will be adapted to the needs of fitting new grates, also tailored to the requirements of the automatic cleaning machine;
- two new machines for cleaning the grate will be installed, as equipped with hydraulically operated arms.

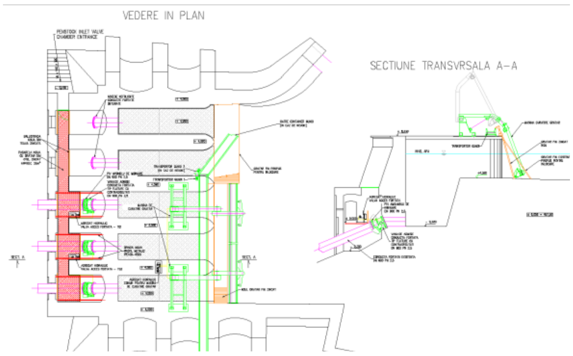

Figure 7. Interventions plan at Ranchina surge tank

The access valves to the penstock pipes (3pcs) will be replaced by new hydraulically operated butterfly valves of the same size. They are to be mounted with new mounting compensators and are going to be operated remotely from the power station control room. For the three valves operation control, two maneuvering groups will be installed (the valve for the pipe leading to TG1 turbine will be operated by the first group, and the two other valves will be operated by the second hydraulic drive group).

Each forced pipe will be equipped with overpressure sensors behind each butterfly valve that will signal the alarm situation in the control room.

All three forced ducts will be endowed with vent valves and ventilation ducts.

All the metal elements will be protected against corrosion.

In the existing situation, from the surge tank common outlet start three penstock metal pipes ND 900 that lead the water to the power station (figure 8), where the three pipes are connected to a collector from which the water is distributed to the two turbines. Each forced pipe has one valve before the collector and each turbine has a spherical valve in front of it.

Figure 8. The three penstock metal pipes

So, the present shared outlet will be completely disassembled and the connection of the forced pipes to the turbines will be modified. The TG1 small turbine will be supplied directly from a ND900 forced pipe, the two other penstock pipes will be connected with a “Y” collector and will feed the large TG2 turbine.

3. CONCLUSIONS

The structure houses equipment and installations necessary for the production of electricity using water as raw material, respectively its potential energy.

The considered investment falls within the context of the proper and rational use of available resources and the conservation of the territory. It addresses to specific themes related to the growth and development of renewable energy production and the rational use of energy potential, as well as to the increasing liberalization of the concerning market and the share of environmental protection issues, to a sustained development and to the Kyoto Protocol themes respectively.

There can be considered that the investment implementation will not have a negative impact on the environment, but relatively by the contrary.

As speaking about the local community, one can admit that the investment has major benefits due to a more efficient electricity supply over its entire operation and will also contribute to ensuring the general electricity needs.

Basically, by making the investment, there is ensured a higher efficiency of the use of the tributary flows in the existing water supply system at the hydropower station and for sure a better operation of the equipment installed for the power production process.

We have to emphasize that the hydropower potential employment is going to be made under the same conditions of the site hydrological and hydropower characteristics, as of the existing arrangement, but with higher benefits.

The works are done only as a necessity to replace the currently existing equipment, meaning machines that are worn out both physically and morally.

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