Hydraulic calculation of fish ladders, Sebesel River, Romania

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Abstract. Sebesel 1 hydropower development is located on the Sebesel River, in the outskirts of Borlova, Caraș-Severin County. The realization of the fish ladder will not influence the flow regime of the surface or groundwater in the neighboring area. The fish ladder is dimensioned so as to allow the migration of the ichthyofauna upstream during the spawning period and the partial transit of the alluviums as well as the downstream provision of a servitude flow \( Q = 0.059 \text{ mc} / \text{s} \). The Sebeșel 1 hydroelectric power plant is a hydropower arrangement by shunt without accumulation lake. The plant has two power groups equipped with Pelton turbines. The power delivered by MHC Sebesel 1 is 876.03 kW. The installed flow rate is 0.90 m³ / s; gross fall: 131 m; capture rate 814 mdMN. The fish ladders are of the technical ladder type with pools. The objectives of the studies were: to describe the qualitative and quantitative structure of benthic invertebrate and fish macro communities; assessment of the ecological status of the rivers in the areas of hydropower development; highlighting the presence of fish species of conservative interest and assessing the status of their populations. The methodology was carried out in accordance with the provisions of the Water Framework Directive, Annex V used took into account the following: Assessment of the status of aquatic communities; description of the structure of fish communities; assessment of the ecological status of the river sectors. The study led to obtaining some essential information for the exploitation and maintenance of the micro-hydroelectric plant as well as the fish ladder.

1. Introduction
Sebesel 1 hydropower development is located on the Sebesel River, in the outskirts of Borlova, Caraș-Severin County. Access to the hydropower objective is made from the county road DJ608 A. MHC Sebesel 1 is located in the Sebes river basin, on the Sebesel watercourse, right tributary of the Sebes river, between the quotas 814.00 mdMN - 681 mdMN, on the administrative domain of Turnu Ruieni commune, place. Borlova extravilan, Jud. Caras – Severin [1].

The Sebesel 1 hydroelectric power plant is a hydropower plant bypass without a storage tank. The plant has 2 (two) power groups equipped with Pelton turbines. The power delivered by MHC Sebesel 1 is 876.03 kW. The installed flow rate is 0.90 m³ / s; gross fall: 131 m; capture rate 814 mdMN.

Capture Sebesel 1
- it is located on the Sebesel watercourse (cadastral code V - 2.18.1), in the extra-urban area of Borlova, Carasa-Severin county, at 814.00 mdMN.
- the catch is provided with the water outlet is the Tyrolean outlet type equipped with a rare grill, having an up-down slope of about 3°. It is located between the fish ladder (right side) and the descaler (left side).

- the fish ladder located between the water outlet and the closing wing on the right side and is of the type of stairs with pools.

- ecological flow rate imposed: 0.059 m³/s.

The adduction pipe is made of PAFSIN pipes having the diameter DN 800 mm and is located underground on the left bank of the Sebesel watercourse and has a length of 1440.00 m. The maximum working pressure is 16 bar.

The Sebesel 1 building is located on the left bank of the Sebesel River, at approx. 400 m upstream of the capture belonging to SC Hidroelectrica SA. It is made of reinforced concrete walls. The MHC is equipped with 2 Pelton turbines.

Turbine water is evacuated downstream of the plant, in the Sebesel stream by means of a drainage channel of reinforced concrete having the dimensions: length L = 20.00 m, width l = 1.80 m, height h = 2.00 m. The maximum flow of the discharge is 0.70 m³/s (Figure 1).

**Figure 1.** Area layout plan
2. Proposed works

The objectives of the studies were:
- description of the qualitative and quantitative structure of the communities of benthic macrononevertebrates and fish;
- assessment of the ecological status of the rivers in the areas of hydropower development;
- highlighting the presence of fish species of conservative interest (if present) and assessing the status of their populations

The methodology used took into account the following (extracts from studies) [2]:
- The assessment of the status of the aquatic communities was performed according to the provisions of the environmental authorization for the target, during the study period.
- For the description of the structure of the fish communities and the communities of benthic macrononevertebrates, quantitative samples were taken, in the same areas, in the months of study in the river sectors located upstream and downstream of the water catchments related to the micro-hydroelectric plants.
- Quantitative samples of benthos were taken with Surber type bentometer with a usable area of 887 cm² and with a mesh of 250 m. The collection of the ichthyofauna was done by means of the Aquarech machine with electronarcois, in the unit of time and effort, on a length of the river of 100 m for each analyzed area; this method of collection allows the release in the habitat of the fish after identification and counting.
- The assessment of the ecological status of the analyzed river sectors was carried out in accordance with the provisions of the Water Framework Directive, Annex V, based on the analysis of the composition and density of benthic invertebrates in correlation with the biotope conditions: hydrogeomorphology, hydrological characteristics, minor riverbed width, depth, depth of the riverbed substrate, riparian vegetation.

The proposed situation is (Figure 2 and 3) [3, 4]:
- The healthy (ecological) flow required to be ensured downstream is 0.059 m³ / s.
- Slit width (hole) of access: 27 cm;
- Height of access slot (orifice): 23 cm;
- Lower quota (hole) for fish ladder access: 813.20 mDN;
- Upper slit (hole) for fish ladder access: 813.43 mDN;
- Width of fanta overflow upper step: 20cm
- Height of the upper overflow step: 20 cm
- Width of submersible orifice steps: 20 cm
- Hole height submers steps: 20 cm
- The flow assured by the fish scale is 0.061 m³ / s.
- Hydraulic basin length: 1.00 m;
- Hydraulic basin width: 0.80 m;
- Fish ladder length: 28.70 m;
- Hydraulic width of fish scale hydraulics: 80 cm.
- Constructive width of fish scale: 95-110 cm;
- Number of pools: 26
3. Results and discussions
In the process of optimizing fish scales, the following principles were considered [4, 5]:

- Fish ladders are of the type of technical stairs with basins.
- The maximum speed allowed to ensure the migration of the ichthyofauna is $V_{\text{max}} = 2 \text{ m/s}$.  
- It is important for the elimination of any doubts regarding the assurance of the servitude flow so that it can be done through a small number of control sections.
  - The fish ladder must be functional during the period of the small waters (drought), which means that the speed at the slots of the fish stairs is greater than 0.6-1.0 m/s because the Ichthiofauna does not migrate at low speeds;
  - The fish ladder must be functional during the middle water period, which means that the speed at the slots of the fish ladders should be less than 1.8-2 m/s because the Ichthiofauna does not migrate at higher speeds;
  - The difference in level between the basins is recommended to be less than or equal to 20 cm;

Taking into account the principles mentioned above, hydraulic calculations have been performed to optimize fish stairs and access slots, respectively slots to ensure the required ecological flow and longitudinal connectivity of the watercourse. The limnimetric keys for all sections were verified following a campaign of measurements with hydraulic hose [3].

4. Conclusions
For better integration of fish ladders in the natural environment, it is recommended to place them with river stone.
The bottom of the fish ladder basins will be provided with the local natural stone to imitate the natural flow as well as the natural flow conditions. Placing will be done asymmetrically and randomly, keeping the general lines indicated in the drawings annexed to the memory.

The upstream part of the proposed fish ladders can be extended according to the indications received from ABA Banat (with a baffle / steering pile), to facilitate the upstream fish migration and steering them away from the grill area. The dimensions of the baffle are identical for all 5 fish ladders, namely: length 1.5m; height: 0.8m; thickness 15cm; material: reinforced concrete.

The sanitary flow / easements, related to MHC Sebesel 1 on the Sebesel river according to the INHGA study, is 0.059 m³/s [1]. The access slot of the orifice has been modified so that its dimensions are b = 27 cm and h = 23 cm which leads to a flow of 0.061 m³/s. In the situation where the access slot has dimensions smaller than 27 x 23 cm, for example 26 x 23 cm, then the servitude flow is smaller than 0.059 m³/s. The execution of the works can be done with an accuracy of 1 cm, but not less. Therefore, the size proposed in this study is recommended.

References
[1] National Administration “Romanian Waters”, Banat Branch, Data from various documents and studies, Timisoara, Romania, 1987-2015.
[2] I. Vlad, R. Beilicci, E. Beilicci and M. Visescu, “Approach channel modelling with advanced hydroinformatic tool. Study case: Small hydro power plant Huta Certeze, Romania”, The World Multidisciplinary Civil Engineering – Architecture – Urban Planning Symposium - WMCAUS 2016, Praga, Czech Republic, vol. 161, pp. 898–903, 2016.
[3] R. Beilicci, “Preparation of technical documentation for obtaining the Water Management Notice for the investment works of fish stairs at CHEMP Cuntu, CHEMP Sebeșel 2, CHEMP Craiu, CHEMP Craiu 2, CHEMP Sebeșel 1, CHEMP Cornereva”, project BC22/13.03.2017, Politehnica University Timisoara, 2017.
[4] Center for energy research and environmental protection, U.P. Bucuresti, project 14/15.03.2016.
[5] E. Gabor, E. Beilicci and R. Beilicci “Advanced Hydroinformatic Tools for Modelling of Reservoirs Operation”, The World Multidisciplinary Civil Engineering – Architecture – Urban Planning Symposium - WMCAUS 2018, Praga, Czech Republic, vol. 471, 2018.