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Operational Problems of Selected Elements of the Dobrzyca Barrage on the Głomia River

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1. Introduction

The construction of barrages leads to permanent environmental transformations and changes in the water flow regime in rivers (Kałuża et al. 2014). Therefore, a design process of hydro-technical objects shall consequently emphasize design calculations related to the stability and strength of such facilities as correct hydraulic dimensioning of water structures and their components (Tymiński 2010). The application phase, however, is beset by a number of problems, which may hinder or prevent their proper use. Downstream erosion and upstream bedload accumulation are the most known and recognizable related phenomena. Additionally, badeffects of river structure localization can be observed: overgrowth of river beds (Tyminski & Kałuża 2012, Walczak et al. 2018), improper operation of fish passes, and – in case of hydroelectric power plants – deposition of organic and inorganic material on bars.

In the paper by Wiatkowski (2015) there are presented selected problems of water management of Młyny reservoir located at 6+968 in the Julianpolka river, in the municipality of Rudniki, Opole Province. The dammed reservoir is faced with numerous difficulties. It does not have a fish pass, which is criticalto migration and continuity of biological life in water. There is also no continuous monitoring of the reservoir, especially during the occurrence of extreme hydrological phenomena in the catchment area. Conducting a continuous hydrological monitoring would enhance proper water management of the reservoir. Mioduszewski & Łoś (2002) and Wiatkowski & Rosik-Dulewska (2011) indicate as a significant impediment when using small retention reservoirs the fact that these facilities are often not provided with permanent maintenance by professional services that can properly handle movable discharge devices and they lack constant technical and maintenance control. Zawadzki et al. (2015) describing the Skórka barrage on the Głomia river state that one of the main operational concerns is the current of the river that is too week to attract fish to the fish pass. Głowski & Parzonka (2007) analysing the operation of the barrage in Brzeg Dolny on the Oder river claim that upstream silting and bedload deposition have an impact on limiting the capacity of three gates of the weir. Silting has also contributed to a reduction in the reservoir capacity. On the other hand local scours created in the area of damaged reinforcements in the downstream part of the weir pose a threat to the stability of the barrage. Pagliara et al. (2017) addresses the issue of creating local scours below the impoundment structure. Dysarz & Wicher-Dysarz (2013) present their studies related to the effect a two-stage retention tank has on depositing of material in the initial part. (The calculations show that the two-stage construction of the reservoir seems to perform well. Sediment particles are settled in the upper part of the reservoir as expected). Kasperek & Głowski (2016) claim that the construction of the barrage in Brzeg Dolny has caused changes in bedload transportation, and further erosion below the dam has resulted in creating shallow areas impeding navigation. Mazur et al. (2016) and Walczak et al. (2013) present another problem i.e. the transportation of plant debris in high water and the effect of vegetation in floodplains on water velocity distributions in the river. Laks et al. (2013) present issues related to modelling of flow rate distribution in the river network with hydro-technical development exemplified by Kaliski Węzeł Wodny (Kaliski Water Node).

The study of technical condition and capacity of the weir on the Uszwica river is conducted by Tarnawski & Michalec (2007). They claim that despite a good condition of the concrete weir, the technical assessment of the structure is low due to damage to the end sill and abutments. Furthermore, it lacks control and measurement equipment required by legal regulations. Additionally, the results of their study indicate that the weir is characterised by too low capacity providing for not more than approx. 52% reliable flow rate required for this type of structures.

During many years of operation of the water reservoir in Gołuchów on the Ciemna river there were conducted research on the deformation of the dam body and changes in the level of the ground water table. The analysis of readings from benchmarks found on the structure and changes in piezometric water levels conducted by Kowalski et al. (2007) demonstrates a high degree of similarity, which evidences the stiffness and improvement in water-soil relations of the dam body.

The fact that authors of the paper have undertaken this research topic finds scientific justification in operational problems related to small retention reservoirs and barrages. On the one hand there is a large number of the aforementioned objects that serve to increase overall retention (Liberacki et al. 2016), on the other hand the literature lacksa proper in-depth evaluation of their operation and problems that may arise during their use. The paper analyses a technical condition and the operation of selected elements of the Dobrzyca barrage on the Głowia river. Location of the barrage, position of its structures in mutual relation and their operation have an effect on specific problems related to its functioning.

2. Methodology

The research facility is located in the north Wielkopolska, near Piła city. The barrage consists of a weir, a fish pass and a small hydro power plant (SHPP). Due to lack of design documentation, during field research there were conducted geometry measurements of the weir and the fish pass as well as hydrometric measurements in selected cross sections of the Głomia river.

The aim of the study was to technically assess a condition of particular elements of the barrage (Fig. 1 – weir, fish pass and power plant) and to analyse its operation under specific hydrological conditions. The main element of the Dobrzyca barrage is a three-gate movable weir. Figure 1 shows a schematic diagram of the structure.

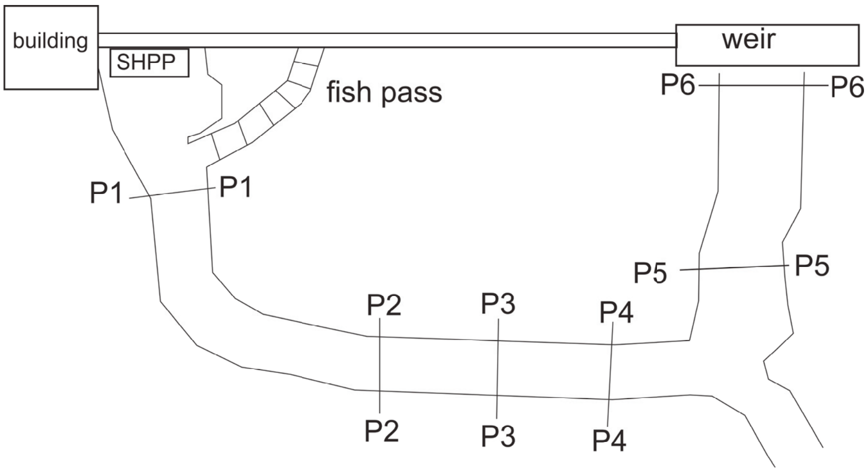

Fig. 1. Sketch of barrage elements with spacing cross section
Rys. 1. Szkic stopnia wodnego z zaznaczonym rozmieszczeniem przekrojów poprzecznych

Fig. 2. View on the weir in Dobrzyca on the Głomia river
Rys. 2. Widok jazu Dobrzyca na rzece Głomi

The weir on the Głomia river belongs to the group of movable weirs (Fig. 2 and 3). The structure has three gates of b_1 = 1.7 m, b_2 = 2.75 m, b_3 = 2.45 m respectively, and two piers of 0.57 m and 0.60 m. The weir is equipped with flat shutters – stop logs used for constant impoundment of water. There is an abutment of 0.55 m width located on the right side/bank of the weir at a distance of 0.7 m from the gate no 1. The standard impoundment level of the barrage is 64 m a.s.l.

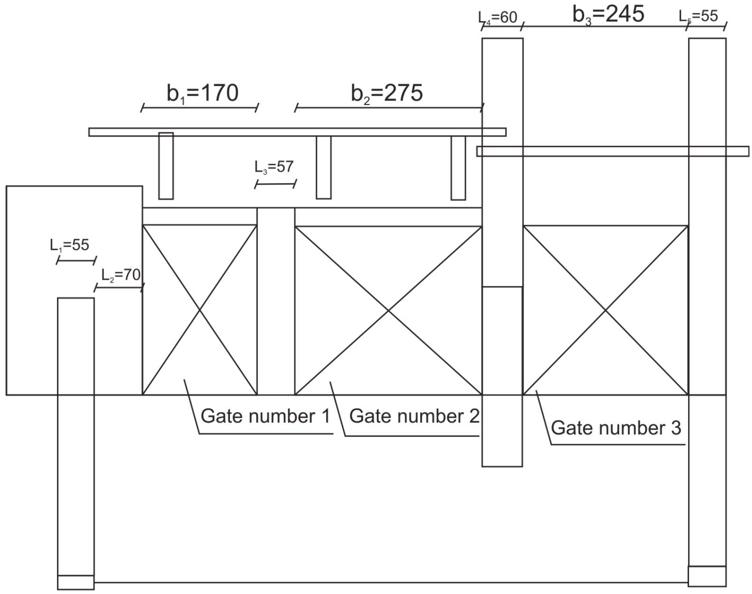

Fig 3. Weir draft, Dobrzyca barrage on the Głomia river (dimension in cm)
Rys. 3. Szkic jazu, stopnia Dobrzyca na rzece Głomi (wymiary w cm)

Small hydro power plant is equipped with two turbines: a tubular turbine and a Francis turbine, and is located in the derivational channel (Fig. 4). The advantage of this type of a channel is that it provides a greater fall than the impoundment on the weir and it shortens a natural course of the river. Comparing classic solutions, a leverage does not require maintenance services or shutters, thus it enables a significant reduction in investment outlay. Increase in the water level in the upstream part e.g. above the maximum level of impoundment causes flooding and sucking of the leverage, and consequently, water – which in the initial phase occupies only part of its cross section – fills it completely. This is the state of normal operation of the leverage.

Fig. 4. Downstream view of SHPP at the Dobrzyca barrage on the Głomia river
Rys. 4. Widok na dolną wodę MEW na stopniu Dobrzyca na rzece Głomi

An important element of the barrage is its pool fish pass, consisting of 9 pools of length from 1.2 m to 1.85 m and an average width of 1.0 m (Fig. 5). The fish pass is 0.15 m thick and its pools fish pass are approx. 0.4 m. deep. Measurements carried out during field tests have proven a poor technical condition of the fish pass and its overall malfunction.

Field research included a geodetic analysis of the studied areas.. Measurements were made using a classic geodetic survey method by means of Topcon leveller. The bottom of the river bed was subject to hydraulic measurements and geometry testing in six cross sections located on the drainage channel of hydroelectric power station and below the weir. Cross sections were made using a bottom probing technique.Measurements of velocity distributions below the weir and in the riverbed of Młynówka were conducted with the use of model 801 electromagnetic open channel flow meter manufactured by Valeport.

Fig. 5. Pool fish pass by Dobrzyca barrage on the Głomia river
Rys. 5. Przepławka komorowa stopnia Dobrzyca na rzece Głomi

The technical condition of the barrage was evaluated according to the methodology proposed by Zawadzki (2005). The choice of Zawacki's method for assessing the technical condition of hydrotechnical constructions results from the ease of the assessment, its precise weights and the clarity of the parameters. During fieldwork particular elements of the facility (fixed and movable components and control and measuring devices) were subject to technical inspection, determining their appearance and condition. Concrete elements were checked for the occurrence of cracks, defects, reinforcement exposures, infiltrations, soaks and discoloration, and fixed elements (body, abutments, reinforcement) for the appearance of lichen. The assessment of the condition of shutters and hoisting mechanisms includes the evaluation of their maintenance, the occurrence of corrosion and deformation of movable parts. According to the methodology proposed by Zawadzki (2005), the following are also to be included: equipping the facility with control and measuring devices, in particular, benchmarks, piezometers and stream gauges from the upstream and downstream side. All elements of the facility, i.e. fixed, movable components, control and measurement devices, are rated on a scale from 0 to 5, taking into account the occurrence and intensity of unfavourable or harmful processes. According to the scale: 5 means very good condition (no unfavourable processes), 4 – good condition, 3 – satisfactory condition, 2 – unsatisfactory condition, – bad condition (very bad unfavourable processes). In the absence of, for example, control equipment required for a given water facility, a rating of 0 should be adopted, indicating its unacceptable status. A final technical assessment is determined by the arithmetic mean of partial evaluations. This method was verified and applied among others by Michalec (2013), who drew attention to the subjectivity of technical condition assessment and the need to develop the competences of people performing it.

The technical assessment of the weir on the Głomia river and in Dobrzyca was carried out in two variants. Variant I (WI) involved an assessment compiled on the basis of a direct field inspection carried out by one of the "independent experts 1". Variant II (WII) provided for a technical assessment carried out by another "independent experts 2" based on detailed photographic documentation of the examined structure. Results obtained allow verifying technical assessment only on the basis of carefully taken photographic documentation.

Water distribution scenarios for particular elements of the barrage were based on the determination of the hydraulic head value, water discharge through the fish pass, weir and SHPP. Calculations of the discharge of water flowing of water from under shutters were the basis for designating water discharge for particular gates of the weir. There were assumed 6 operational variants of the weir (opening of particular shutters or simultaneous opening of two or three shutters). First three from six variants concern singly gates. Next in turn variants connected with combination of gates opening.Water distribution on SHPP was defined by the designed flow rate of particular turbines. The volume of water flowing through the fish pass was determined on the basis of measurements.

Hydraulic head curves included in scenarios show correlation between the hydraulic head value and flow rate, at the constant level of impoundment. Hydraulic head is a difference in the normal impoundment level (NI) and the downstream water level (DW). In the absence of systematic hydrometric measurements carried out in the downstream, on the basis of which the authors would be able to determine a flow rate curve, the curve has been determined based on computer simulations. The measured of the water levels were used to identify the parameters of the mathematical model of HEC-RAS. Based on the known geometry of the cross-sections, flow rate, and the water elevations the manning coefficient was specified and it was equal 0.038 $m^{-1/3}\cdot s$.

Assuming steady motion conditions, the calculations have been based on the Bernoulli equation, which describes the energy balance between two cross sections of the river bed (Brunner 2010).

3. Results

3.1. Technical condition assessment of structures of the barrage

The results of the technical condition assessment of individual elements of the barrage are presented in Table 1. The condition of the weir is unsatisfactory. There are no hoisting devices that serve to operate shutters. Footbridges are equipped only with temporary wooden railings (the structure lacks railings from the upstream side). Additionally, there is no fixed footbridge for the gate no. 3. The ordinates of piers, abutments and footbridges do not meet safety recommendations for the existing impoundment on the weir. There are observed some damaged reinforcements in the downstream. Though, riprap near the end sill is visible only at a length of approx. 1m. The structure is subject to systematic maintenance work, however, some damage to the abutment (concrete defects) are found on the right bank, as well as there are some soaks on the impoundment wall and concrete cracks in the structure near the gate no. 3. The data collected both on the basis of direct observations (WI) – 2.13 as well as an analysis based on photographic documentation (WII) – 2.25 have given an overall unsatisfactory rating.

Due to the fact that the weir in Dobrzyca on the Głomia river is not equipped with hoisting devices for wooden shutters, the author have taken a rating of 0 for calculating an average assessment value. It indicates that movable elements are in an unacceptable condition. The low technical assessment of the weir is also resulted in the condition of its concrete structure.

Table l. Assessment of the technical state of the weir, SHPP and fish pass
Tabela 1. Ocena stanu technicznego jazu, małej elektrowni wodnej oraz przepławki dla ryb

Technical state	Weir		SHPP		Fish pass	
	WI	WII	WI	WII	WI	WII
Solid elements:						
surface	2	3	3	3	3	3
cracks	2	2	4	3	4	4
decrements	2	2	4	3	4	4
uncover of reinforced rods	3	3	4	3	4	4
dripstones, lekages	2	2	4	4	4	4
tints		3	3	3	3	3
lichens	3	3	3	3	3	3
A. Movable elements:						
gate	2	2	3	3	2	2
drawing gears	0	0	3	2	2	2
deformations	1	1	2	2	2	2
corrosion	2	2	3	3		
conservation	3	3	4	4	3	3
B. Monitoring and measurement devices:						
bench-marks	2	2	2	0	2	0
piezometers	0	0	0	0	0	0
water-level Gauges	5	5	3	5	2	2
information boards	3	3	2	3	0	0
Mean	2.13	2.25	2.94	2.75	2.53	2.40

What is more, the power plant is also in an unsatisfactory technical condition. A provisional shed roofed with corrugated plate requires significant repair works. Reinforcements from the downstream side also require replenishment, especially on the right bank at the corner of the building. There is no possibility of manoeuvring with an idle discharge at the power plant – it has been permanently closed with stop logs. There is no water gauge in the downstream part. According to method WI, an average rating of 2.94 has been obtained, and according to WII – 2.75, indicating its unsatisfactory condition.

The fish pass has been rebuilt recently, however on the basis of Tymiński et al. 2017 and FAO/DVWK 2002 it was found that condition and potential for fish migration are still unsatisfactory. The entrance to the fish pass from the upstream side is very narrow. Currently, the fish pass has been remodelled as a pool fish pass (incl. chambers), except for there is no bottom opening in walls of pool fish pass overflows. Therefore, the fish pass operates as a cascade, with water flowing over upper openings (Fig. 5). In addition, the last pool fish pass is located approx. 10m from the end of the fish pass, and a difference in water levels between the last poolfish pass and the downstream is approx. 40 cm. From the downstream side the fish pass lacks several last pools fish pass (overflows). Its exit is incorrectly situated, since the last section is directed at the right angles to the outlet from the power plant. The system also does not provide reinforcements at the final section, the right bank of the fish pass. The fish pass entrance from the downstream side is very shallow approx. 20 cm. According to method WI the fish pass has been given an average rating of 2.53, whilst according to WII – 2.40, what indicates an unsatisfactory condition of the structure.

In general, the system lacks piezometers and benchmarks, as well as the basic recognition of hydraulic and hydrologic working conditions of the barrage (e.g. flow rate curves in the downstream part of the weir and SHPP). The technical condition of the Dobrzyca barrage on the Głomia river, determined on the basis of an inventory carried out as a one-step diagnostic (Zawadzki 2005), has been considered unsatisfactory. In consequence, it implies urgent and necessary repair and modernisation works. Similar values are reflected in the results of assessments obtained by methods WI and WII.

3.2. Hydraulic analysis of operation of the Dobrzyca Node

The curves for the operation of the node characterise the distribution of water into individual barrage elements. At the Dobrzyca barrage the distribution of water is divided into the fish pass, the weir and SHPP. On the basis of previously designated curves for opening of shutters, the height values of shutters' opening is taken in various combinations due to different widths of gates. Two cases are considered: the situation when SHPP does not work, and when the siphon turbine and Francis turbine included in the SHPP operate. Then, after summing up flow rates from all elements of the barrage, based on previously designated hydraulic head curves, there are taken the hydraulic head value.

In order to develop different operational concepts of the barrage there were conducted simulations taking into account the operation of the power plant (first the systematic inclusion of the siphon turbine, and after reaching a certain level of flow rate - the inclusion of the Francis turbine) and manoeuvring with shutters of the weir gates. It has been assumed that with the activated power plant, the flow rate is increased until its maximum value is reached (2,2 $m^3 \cdot s^{-1}$), which is the sum of the maximum flow rate for the siphon and Francis turbine. The downstream ordinate is read from the flow rate curve.The volume of water passed through the fish pass is constant for all analysed cases.

The distribution of water into particular elements of the Dobrzyca barrage is presented in Tables 2 and 3. Based on the compiled data, the authors have designated operational curves for the node considering opening of shutters 1, 2, 3 as well as 1+2, 2+3 and 1+2+3.

Table 2 presents the distribution of water into particular elements of the Dobrzyca barrage, on the assumption that SHPP is activated. It has been assumed that the flow rate through the fish pass is constant and equals 0.24 $m^3 \cdot s^{-1}$. At the beginning, the siphon turbine, which works until it achieves its maximum flow that is 1.00 $m^3 \cdot s^{-1}$, is activated, then additionally the Francis turbine with the maximum flow rate of 1.20 $m^3 \cdot s^{-1}$ is activated. SHPP operates until it reaches the maximum head value of 2m. The flow rate is then 7.21 $m^3 \cdot s^{-1}$. When the flow rate reaches 7.21 $m^3 \cdot s^{-1}$, SHPP is deactivated.

Figure 6 presents the operational scenario for the node assuming the operation of all openings of the weir. In the initial stage the fish pass and SHPP operate, following an increase in the flow rate all three shutters are being opened simultaneously. By opening up all gates, the impoundment structure significantly increases its capacity. Figure 7 shows how different water levels of the downstream affect the operational curve of the node for flow rates higher than 14 $m^3 \cdot s^{-1}$. Summing up the flow rate of the weir and the fish pass, the barrage can transfer 30.95 $m^3 \cdot s^{-1}$ of water. With regard to the design flow rate, that is 20 $m^3 \cdot s^{-1}$, the total capacity of the barrage is sufficient.

Table 2. Distribution water at particular elements of barrage with set working SHPP
Tabela 2. Rozdział wody na poszczególne element stopnia wodnego przy pracującej MEW

Difference of levels	Fish pass	Weir	Lift of gate						SHPP		Sum of discharge
			1	2	3	1+2	2+3	1+2+3	Syphon turbine	Francis turbine	
[m]	[$m^3 \cdot s^{-1}$]	[$m^3 \cdot s^{-1}$]	[m]	[m]	[m]	[m]	[m]	[m]	[$m^3 \cdot s^{-1}$]	[$m^3 \cdot s^{-1}$]	[$m^3 \cdot s^{-1}$]
2.89	0.24	0	0	0	0	0	0	0	0.2	0	0.44
2.83	0.24	0	0	0	0	0	0	0	0.6	0	0.84
2.76	0.24	0	0	0	0	0	0	0	1	0	1.24
2.70	0.24	0	0	0	0	0	0	0	1	0.4	1.64
2.64	0.24	0	0	0	0	0	0	0	1	0.8	2.04
2.58	0.24	0	0	0	0	0	0	0	1	1.2	2.44
2.38	0.24	0.7	0.11	0.07	0.07	0.04	0.04	0.02	1	1.2	3.14
2.34	0.24	1.20	0.18	0.11	0.12	0.07	0.06	0.04	1	1.2	3.64
2.28	0.24	1.89	0.28	0.17	0.19	0.10	0.09	0.07	1	1.2	4.33
2.22	0.24	2.49	0.38	0.22	0.25	0.14	0.12	0.09	1	1.2	4.93
2.16	0.24	3.08	0.47	0.27	0.31	0.17	0.14	0.11	1	1.2	5.52
2.13	0.24	3.65	0.57	0.33	0.37	0.20	0.17	0.13	1	1.2	6.09
2.08	0.24	4.22	0.66	0.38	0.43	0.23	0.20	0.15	1	1.2	6.66
2.04	0.24	4.77	0.76	0.43	0.48	0.26	0.22	0.17	1	1.2	7.21
2.00	0.24	5.27	0.85	0.48	0.54	0.29	0.25	0.19	1	1.2	7.71
1.98	0.24	7.71	1.31	0.71	0.81	0.43	0.36	0.27	0	0	7.95
1.95	0.24	8.21		0.76	0.87	0.46	0.39	0.29	0	0	8.45
1.87	0.24	9.21		0.87	0.99	0.52	0.44	0.33	0	0	9.45
1.795	0.24	10.21		0.97	1.11	0.58	0.49	0.37	0	0	10.45
1.73	0.24	11.21		1.08	1.23	0.64	0.54	0.40	0	0	11.45
1.66	0.24	12.21		1.19	1.36	0.70	0.59	0.44	0	0	12.45
1.59	0.24	13.21		1.30		0.76	0.64	0.48	0	0	13.45
1.57	0.24	13.71		1.36		0.80	0.67	0.50	0	0	13.95
1.54	0.24	14.21				0.83	0.69	0.54	0	0	14.45
1.48	0.24	15.21				0.89	0.75	0.61	0	0	15.45
1.42	0.24	16.21				0.96	0.80	0.68	0	0	16.45
1.36	0.24	17.21				1.02	0.85	0.75	0	0	17.45
1.31	0.24	18.21				1.09	0.91	0.81	0	0	18.45
1.26	0.24	19.21				1.16	0.96	0.87	0	0	19.45
1.21	0.24	20.21				1.23	1.02	0.92	0	0	20.45
1.17	0.24	21.21				1.30	1.08	0.98	0	0	21.45
1.13	0.24	22.21				1.37	1.13	1.03	0	0	22.45
1.10	0.24	22.71				1.40	1.16	1.05	0	0	22.95
1.09	0.24	23.21					1.19	1.07	0	0	23.45
1.05	0.24	24.21					1.25	1.12	0	0	24.45
1.01	0.24	25.21					1.31	1.16	0	0	25.45
0.98	0.24	26.21					1.37	1.21	0	0	26.45
0.97	0.24	26.71					1.40	1.23	0	0	26.95
0.95	0.24	27.21						1.25	0	0	27.45
0.92	0.24	28.21						1.29	0	0	28.45
0.90	0.24	29.21						1.33	0	0	29.45
0.87	0.24	30.21						1.36	0	0	30.45
0.86	0.24	30.71						1.38	0	0	30.95

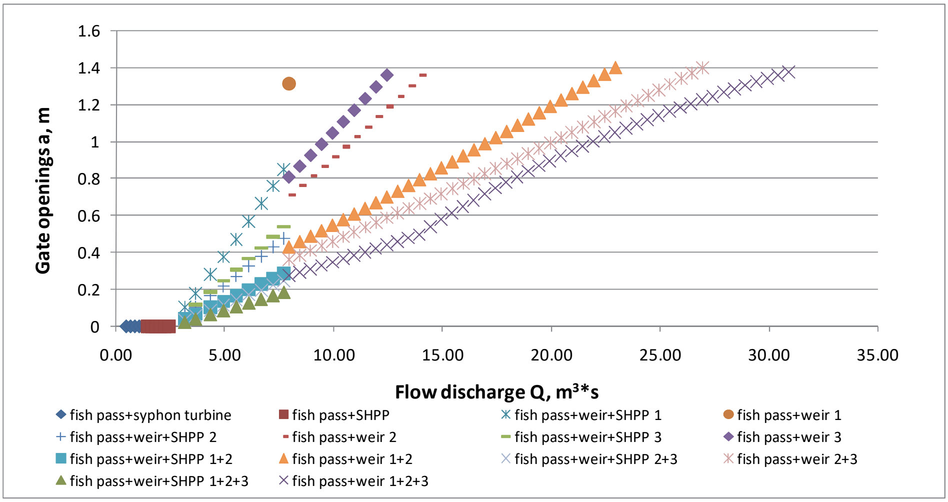

Fig. 6. Barrage operation curve with opening all gates and SHPP in Dobrzyca barrage on the Głomia river

Rys. 6. Krzywa pracy stopnia Dobrzyca na rzece Głomi dla pracujących wszystkich zamknięć i MEW

Table 3 presents the distribution of water into particular elements of the Dobrzyca barrage, on the assumption that SHPP is deactivated. It has been assumed that the flow rate through the weir depends on the hydraulic head value and the constant flow rate through the fish pass of 0.24 $m^3 \cdot s^{-1}$. The hydraulic head value is taken from previously designated hydraulic head curves.

The calculations have been made for each gate separately and for simultaneous opening of several shutters. Figure 9 presents the calculated operational curves of the node for the deactivated SHPP.

Table 3. Distribution water at particular elements of barrage with switched off SHPP
Tabela 3. Rozdział wody na poszczególne element stopnia wodnego przy wyłączonej MEW

Differ-ence of levels	Fish pass	Weir	Lift of gate						SHPP		Sum of dischar-ge
			1	2	3	1+2	2+3	1+2+3	Syphon turbine	Francis turbine	
[m]	[m^3·s^{-1}]	[m^3·s^{-1}]	[m]	[m]	[m]	[m]	[m]	[m]	[m^3·s^{-1}]	[m^3·s^{-1}]	[m^3·s^{-1}]
2.58	0.24	0.64	0.10	0.06	0.07	0.04	0.03	0.02	0	0	0.88
2.50	0.24	1.50	0.22	0.13	0.15	0.08	0.07	0.05	0	0	1.74
2.41	0.24	2.50	0.38	0.22	0.25	0.14	0.12	0.09	0	0	2.74
2.33	0.24	3.50	0.54	0.31	0.35	0.19	0.16	0.12	0	0	3.74
2.24	0.24	4.50	0.71	0.40	0.46	0.25	0.21	0.16	0	0	4.74
2.16	0.24	5.50	0.89	0.50	0.56	0.30	0.26	0.19	0	0	5.74
2.08	0.24	6.50	1.08	0.59	0.67	0.36	0.31	0.23	0	0	6.74
2.00	0.24	7.50	1.27	0.69	0.79	0.41	0.35	0.27	0	0	7.74
1.92	0.24	8.50		0.79	0.90	0.47	0.40	0.30	0	0	8.74
1.85	0.24	9.50		0.90	1.02	0.53	0.45	0.34	0	0	9.74
1.78	0.24	10.50		1.00	1.14	0.59	0.50	0.38	0	0	10.74
1.71	0.24	11.50		1.11	1.27	0.65	0.55	0.41	0	0	11.74
1.64	0.24	12.50		1.22	1.39	0.71	0.60	0.45	0	0	12.74
1.58	0.24	13.50		1.33		0.77	0.66	0.49	0	0	13.74
1.52	0.24	14.50				0.84	0.71	0.56	0	0	14.74
1.46	0.24	15.50				0.90	0.76	0.64	0	0	15.74
1.40	0.24	16.50				0.96	0.82	0.70	0	0	16.74
1.35	0.24	17.50				1.03	0.87	0.77	0	0	17.74
1.30	0.24	18.50				1.10	0.92	0.83	0	0	18.74
1.25	0.24	19.50				1.16	0.98	0.89	0	0	19.74
1.20	0.24	20.50				1.23	1.04	0.94	0	0	20.74
1.16	0.24	21.50				1.30	1.09	0.99	0	0	21.74
1.12	0.24	22.50				1.37	1.15	1.04	0	0	22.74
1.08	0.24	23.50					1.21	1.09	0	0	23.74
1.04	0.24	24.50					1.27	1.13	0	0	24.74
1.00	0.24	25.50					1.33	1.18	0	0	25.74
0.97	0.24	26.50					1.39	1.22	0	0	26.74
0.94	0.24	27.50						1.26	0	0	27.74
0.91	0.24	28.50						1.30	0	0	28.74
0.89	0.24	29.50						1.34	0	0	29.74
0.87	0.24	30.50						1.37	0	0	30.74
0.86	0.24	30.71						1.38	0	0	30.95

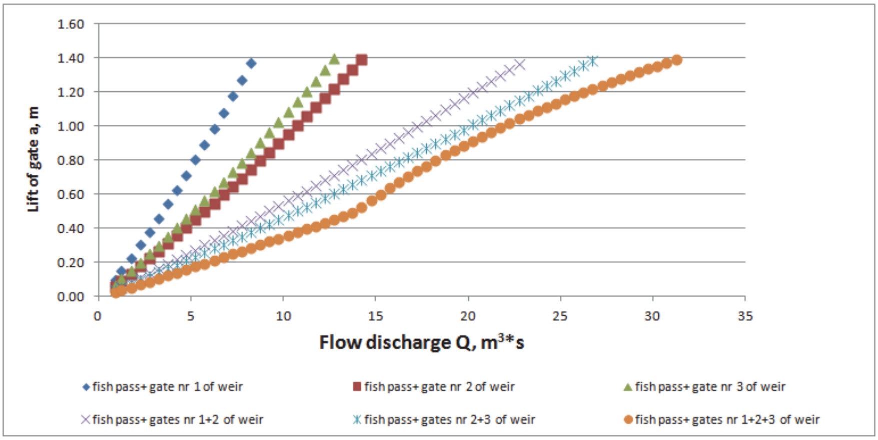

Fig. 7. Barrage operation curve at switch off SHPP
Rys. 7. Krzywa pracy stopnia wodnego przy wyłączonej MEW

Due to the high threshold of the weir, only when all shutters are simultaneously open, the downstream part of the weir is filled with water. It occurs when the opening is more than 0.5 m. By analysing Fig. 10 it can be stated that opening of the widest gate no. 2 enables the structure to transfer 13.5 $m^3 \cdot s^{-1}$, and opening of gates no. 1 and 2 increases the value to approx. 22.5 $m^3 \cdot s^{-1}$. The highest capacity is obtained when all shutters are open. The value is 30.71 $m^3 \cdot s^{-1}$.

4. Discussion

The paper analyses selected aspects of a technical condition assessment and operational issues of the Dobrzyca barrage on the Głomia river. The technical condition of the Dobrzyca weir was specified on the basis of an inventory carried out as one-step diagnostics. The unsatisfactory assessment of the structure results from i.e. condition of concrete elements of the barrage and lack of hoisting devices, both for shutters of the weir as well as the fish pass and SHPP. Furthermore, it lacks piezometers, benchmarks and a water gauge. Unfortunately, the state of this structure is not an exception. Practical experience shows many similarly neglected structures, although they do have a significant share in key and necessary development plans for small retention. Modification of Zawadzki's method (Zawadzki 2005) presented in the paper allowed for assessing the technical condition of the structure on the basis of detailed photo documentation. The assessment basically coincides with the evaluation results obtained through a direct field inventory. In extreme cases, a method based on photographic analysis can complement and validate results obtained in a classical way.

On the basis of the data included in the article by Sterpejkowicz-Wersocki & Bolt (2002) it has been stated that backwater of the Koszyce barrage on the Gwda river does not affect the estuary table level of the Głomia river. Therefore, the operation of the node depends on local hydraulic and flow distribution conditions in the downstream part of the facility.

The majority of small water structures do not have a basic recognition of their hydraulic and hydrologic operating conditions (e.g. flow rate curves in the downstream part, systematic hydrological observation). It causes a serious concern for sustainable exploitation and rational water management of the aforementioned structures.Similar problems have been studied in the Skórka barrage on the Głomia riverby Hämmerlinget al. (2017).

5. Summary and conclusions

The authors analysed the capabilities of passing water through individual elements of the barrage. By analysing operating conditions of SHPP, it is stated that there is no danger of high water in its downstream due to too high volumes of water flowing through the weir. The power plant is activated until it reaches the maximum head value that is 2m. The flow rate is then 7.21 $m^3 \cdot s^{-1}$. When the flow rate value amounts to 7.21 $m^3 \cdot s^{-1}$, the power plant is deactivated. If the power plant operates, the weir is activated at the hydraulic head value of 2.38m, however, when the power plan does not operate, the weir starts its action at the hydraulic head value of 2.58m. The capacity of all elements of the barrage allows for safe flowing of the design water. The maximum capacity when all shutters are open is 30.71 $m^3 \cdot s^{-1}$. The lack of hoisting devices may significantly impede flow rate control, particularly in periods of high water. The flow rate value through the fish pass for the existing technical condition is 0.24 $m^3 \cdot s^{-1}$. Ineffectively, due to the technical condition of the fish pass, it cannot guarantee safe fish migration.

On the basis of earlieranalysis of resultscan indicate the following conclusions:

- the Dobrzyca barrage on the Głomia river along with other impoundment structures (weirs in Krajenka and Skórka) can provide for an important element of the water management system in the catchment area of the Głomia river,
- this is crucial for both passing high waters as well as water retention during low seasons,
- the Dobrzyca barrage just like the other the majority of small water structures do not have a basic recognition of their hydraulic and hydrologic operating conditions,
- unfortunately, the current state of the facility raises legitimate concerns about the possibility of realizing its potential,
- Zawadzki's method can be successfully used to assess the technical condition of hydrotechnical constructions. This method allows even people without extensive experience to carry out research into the technical condition of the building.

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Problemy eksploatacyjne wybranych elementów stopnia wodnego Dobrzyca na rzece Głomii

Streszczenie

W skład stopnia wodnego wchodzi wiele różnych budowli, których poprawna eksploatacja umożliwia działanie całego stopnia zgodne z instrukcją gospodarowania wodą. Analizowany w pracy stopień zlokalizowany jest na rzece Głomia w km 0+640. W jego skład wchodzą: mała elektrownia wodna, jaz trzy przęsłowy oraz przepławka techniczna (komorowa). Lokalizacja stopnia, wzajemne usytuowanie obiektów i ich eksploatacja wpływają na określone problemy funkcjonowania stopnia wodnego Dobrzyca. Należą do nich, między innymi kłopoty z zamuleniem dna zbiornika, odkładaniem się na kratach rumoszu roślinnego, a także zarastaniem koryta. W pracy przedstawiono ocenę stanu technicznego budowli oraz przeanalizowano warunki przepływu wody przez stopień wodny. Wykorzystując program komputerowy HEC – RAS przebadano wpływ zmian układu zwierciadła wody w korycie rzeki na pracę elektrowni wodnej. Przeanalizowano różne możliwe warianty pracy jazu i elektrowni wodnej. Wskazano możliwe zagrożenia i niebezpieczeństwa związane z pracą stopnia wodnego.

Abstract

A barrage is a type of diversion dam consisting of numerous different structures, demanding high level of maintenance which allow for operating in accordance to water management instructions. The barrage analysed in the present paper is located at 0+640 km of the Głomia river. It includes: a small hydropower plant, a three-gate weir and a technical fish pass (pool fish pass). Location of the barrage, position of its structures in mutual relation, as well as their operation have a practical effect on its specific operational problems. These include i.e.: silting of the reservoir bottom, depositing of plant debris on the weir bars, overgrowing of the river bed. The paper presents a technical condition assessment of these structures and analyses flow rate characteristics of the barrage. With the use of HEC-RAS software the authors tested the effect the topological changes in the water table of the river on the operation of the hydroelectric power station. Besides different possible operational variants of the weir and the power station studied, potential hazards and threats associated with the operation of the barrage are indicated in the paper.

Słowa kluczowe:
stopień wodny Dobrzyca, problemy eksploatacji, budowla piętrząca, przepławka komorowa, ocena konstrukcji hydrotechnicznych

Keywords:
the Dobrzyca barrage, operational problems, impoundment structure, pool fish pass, hydrotechnical structure assessment