Application of the VIKOR and FAHP multi-criteria optimisation methods for choosing the optimal groundwater control system: case of pumping station “Bezdan 1” (Serbia)

Прилагане на мултикритерийни оптимизационни методи VIKOR и FAHP за избор на оптимална система за контрол на подземни води: пример с помпена станция „Бездан 1“ (Сърбия)

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Keywords: groundwater management, hydrodynamic model, optimization model, fuzzy logic, decision-making process, expert judgment.

Optimisation models are of assistance in the process of decision-making, enabling an expert to connect all the necessary data and relations in a given situation and, as a result, enabling them to choose the optimal alternative, overcoming all of the task’s complexities. By applying optimisation methods, an expert receives information which indicates the future consequences and impacts of a certain decision.

Based on previous hydrodynamic calculations, this paper illustrates an example of determining an optimal groundwater control system by using “classic” and fuzzy methods of multi-criteria decision analysis. The applied methods mentioned herein are: VIKOR – Višekriterijumsko kompromisno rangiranje (in Serbian); Multi-criteria Compromise Ranking (in English) (Opricović, 1998) and FAHP – Fuzzy Analytic Hierarchy Process (Chang, 1996). The applied algorithm “Fuzzy optimisation in the hydrodynamic analysis for the purposes of groundwater control system design” may also be found in Bajić (2016) and Bajić et al. (2017a), with the calculations having been performed in a dedicated application (Bajić et al., 2017b).

Using an earlier hydrodynamic analysis made for the purpose of lowering groundwater levels (Fig. 1), three alternate solutions for the system of groundwa-

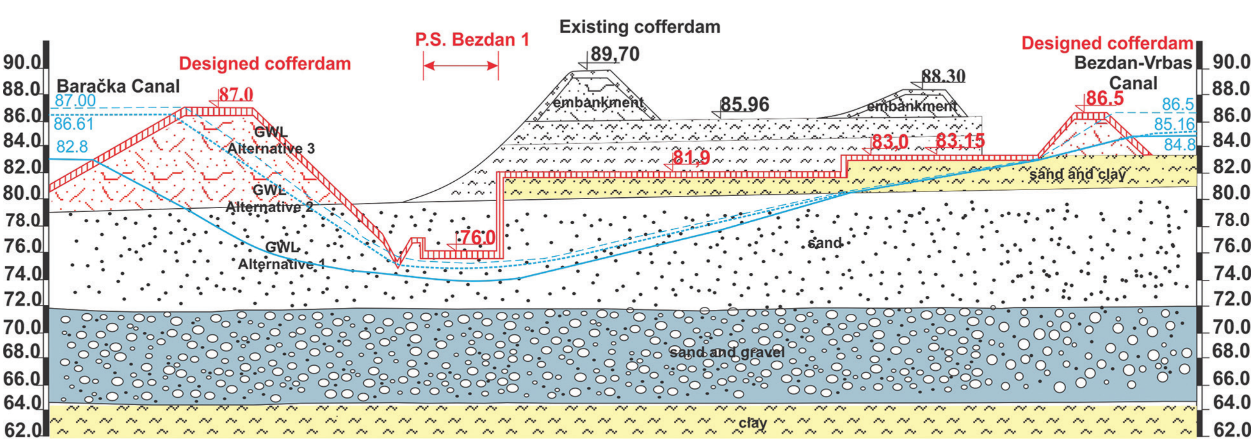

Fig. 1. Lowering of the water table as a result of groundwater control system operation according to the alternative solutions (A_1, A_2, A_3)

Table 1. Alternative ranking

VIKOR method		FAHP method	
Combination	compromise solution	alternative	rank
1	A_2, A_1, A_3	A_1	3
2	A_1, A_2, A_3		
3	A_1, A_2, A_3	A_2	1
4	A_2, A_1, A_3	A_3	2
5	A_2, A_1, A_3		

ter control have been defined (A_1, A_2, A_3) that protect the area of pumping station Bezdan 1 so that it can be constructed (Polomčić, Bajić, 2014). By utilising the FAHP and VIKOR methods and analysing different factors such as: time (K_1), groundwater control system properties (K_2) and safety factor (K_3), different evaluations are given which affect the optimal alternative. The FAHP method calculations may be found in Bajić and Polomčić (2014). Alongside the VIKOR method calculations, a sensitivity analysis for the results was conducted by varying weight coefficients of criteria functions for 5 combinations (Table 1). In the first combination, none of the criteria functions were given priority. In the second, third and fourth combinations, special priority was given to the following criteria: time, groundwater control system properties and the safety factor respectively. In the fifth combination, the calculated weight coefficients of the criteria functions were assigned by using the AHP (Analytic Heiracrhy Process) method for each criteria function.

After the weighted coefficients were calculated in dedicated applications, the alternatives for both methods are ranked and shown in Table 1. According to the results of the FAHP method, each alternative is given weight and the optimal alternative proved to be A_2. In the first combination of the VIKOR method calculation, where none of the criteria functions were given priority, Alternative 2 stands out as a compromise solution. In the second combination, where the criteria function of time was given priority, Alternative 1 is a compromise solution. In addition, Alternative 1 is also a compromise solution for Combination 3. For Combinations 4 and 5, Alternative 2 represents a compromise solution. The final decision, according to the VIKOR method, is to adopt Alternative A_2 in accordance with the solution from Combination 1, where no subjective influences were present nor was priority given to any of the criteria functions.

Finally, it may be concluded that, in this case, the results gained by utilising "classic" methods of multicriteria optimisation and the results gained by utilising the fuzzy approach also correspond, with the final decision being to adopt Alternative 2 as the optimal solution.

Acknowledgment: Our gratitude goes to the Ministry of Education, science and technological development of the Republic of Serbia for financing projects "OI176022", "TR33039" and "III43004".

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