Design of dry detention basin in the municipality of Hradec nad Svitavou

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Abstract. This article deals with the flood situation in the municipality of Hradec nad Svitavou and describes the possibility of increasing the flooding protection by means of a dry detention basin, whose task is to transform the flood wave thus reducing the damage caused by the wave. This measure will increase the time required to carry out the necessary flood preparations. Dry detention basin is based on hydraulic calculations and drawings described in more details in this article.

1. Introduction

Nowadays, the main topic of concern is droughts, but besides the issue of droughts, we are also dealing with very intensive rainfall. Because of intensive precipitation, the municipalities are facing a problem in the form of flash floods or soil silting, since this rainfall usually carries away soil from the surrounding fields. Of course, it is not possible to prevent floods completely because it is often economically unrealistic for a given municipality to build more dams in several locations or one large dam, due to the frequency of repeated floods. That is why smaller dams are being built with the aim of reducing the flood wave magnitude and shifting its peak flow so that the responsible authorities can prepare measures and further reduce the damage caused by the floods. A similar concept of flood protection has been discussed, for example, in the cadastral area of Kobeřice. [1] Ecological materials, such as alternatively treated sludge from treatment plants, can be used in the foundations of the dam slopes reinforcement as suggested by research [2]. At the same time, new cement materials based on industrial waste products can be applied in the construction of dry detention basin technical equipment [3, 4, 5]. The discharge device leads to a shaft, which is connected to the sewer system, which is why it is also necessary to deal with the situations described in the research projects [6, 7].

2. Description of current situation

The municipality of Hradec nad Svitavou is situated in a valley along the river Svitava. The Svitava River brings water to the municipality, but also serves as a recipient that drains the area in question. The first risk of flooding is associated with this river. In front of the town of Svitavy, there are two ponds (Rosička and Svitavy Pond) situated on this river, which can reduce the flood wave. This, however, is not their primary task and it is not possible to rely on their significant impact in case of a flood. There is no other flood protection on the section below these ponds and the municipality of Hradec nad Svitavou, because it is densely built-up area. During intensive rainfall, the municipality is also endangered by the runoff from the surrounding cultivated slopes as a result the valley morphology of the terrain. In the south-north part of the municipality, is located terrain deprivation leading to residential buildings and road no. 3665.see Figure.1 Due to the high gradient of the slopes (26% and 21%), we can assume a concentration of surface runoff from surrounding fields here, as well as the risk of flooding or...
silting of both the buildings and the road. There is a public transport line on this road. The valley has the shape of the letter L and its drainage area is approximately 60000 m².

2.1. Design of flood protection
Based on the morphological conditions and due to the agricultural use of part of the valley, a dry detention basin was designed as the most suitable flood protection. This will allow the cultivation of the valley under normal circumstances, and it will provide the necessary protection in the event of flash rainfall. A homogeneous, frontal dam with a height of 9.23 m and a width of 51.75 m, designed for $Q_{50}$ flow rate, was chosen with respect to the purpose and the shape of the valley, see Figure 2. The dam crest reaches the altitude of 430.00 m. Based on an engineering and geological survey, the soil used for the dam construction will be of clay-sand type, because it is found in the flooding zone. An unpaved 3 m wide road allowing crossing of agricultural and maintenance machinery will be located at the dam crest. The total width of the dam crest is 4 m, which meets the requirement of minimum width of 3 m according to ČSN 75 2410 [8] necessary for the stabilization of the dam. Arable soil will be removed to a depth of 0.8 m prior to the construction work. Basic technical data of the dam are presenting in Table 1.

| Dam parameters           | Description / Value                      |
|--------------------------|-----------------------------------------|
| Dam type                 | Homogenous earth, frontal, flow through |
| Dam crest length         | 51.75 m                                 |
| Dam height               | 9.23 m                                  |
| Dam crest width          | 4 m                                     |
| Service road width       | 3 m                                     |
| Crest elevation          | 430.00 m above sea level                |
| Dam bottom elevation     | 420.77 m above sea level                |

Due to the densely build-up area below the dam body, it was not possible to use side safety spillway here, despite the fact that the shape of the valley would be very suitable for such a solution. Based on this fact, the discharge object itself was designed as a safety spillway. The excess water will flow over stop logs and will be drained through a double drain pipe of DN 800 size into the Svitava watercourse. This method of water drainage ensures the safety of the dam against flood wave of up to $Q_{50}$. 

Figure 1. Overview of the valley.
The characteristic data on the basin, such as water level, flooding area and basin volume are expressed by the so-called Batigraphic curves. The curves show the dependence of the volume of water retained in the basin on the surface of the basin flooding. Both of these curves are shown in Figure 3.

2.2. Discharge device
A gullet is used as a discharge device of this detention basin. It is slightly embedded in the body of the dam. The distance from the dam axis is 24.6 m and the object is embedded 1.4 m below the bottom of the basin to provide better drainage. This difference is created by means of a reinforced slope with the inclination of 1:2 and the length of 4.4 m from each side. At the point of contact of the depression with the dam body, there is a retaining wall used to secure the waterward slope of the dam. An open reinforced concrete gullet with one stop log wall is chosen as the discharge device. Access to the discharge object is provided by a 27 m long service steel footbridge. The discharge object is connected to two drainage pipes with a size of DN 800 and a slope of 4%. Each pipeline will have a section of the profile covered from the top side to ensure free flow. This pipeline made of prefabricated concrete will pass under the dam body into an access chamber and will lead to the recipient. It will be connected to it at an angle of 45°. The connection point will be consolidated both upstream and downstream.
2.3. Transformation of flood wave
The knowledge of the volume course over time is necessary for the correct design of the flood wave transformation. This process is illustrated in the so-called hydrograph (see Figure 4).

![Figure 4. Flood wave transformation.](image)

This graph shows the difference between the amount of inflowing water and the amount of water that flows out of the basin after regulation. This reduction helps to delay the flood water and, in ideal case, also provides enough time to prepare for the flood and to eliminate the damage the water can cause. In the first place, however, it must be ensured that the detention basin is able to retain the given volume of water or, in case of larger volume, to safely carry it through the water works. The same applies to the area below the basin, which should be affected as little as possible by the water flowing out of the basin. In the case of this basin, the discharge device together with the capacity of the basin is able to transform the flood wave of $Q_{50}$ value (flow rate values are presented in Table 2) to less than $Q_{20}$. The flow rate of the discharge pipeline is up to 4.8 m³/s and the remaining capacity of 0.6 m³/s is reserved for the safety spillway.

| Flow parameters | Value   |
|-----------------|---------|
| $Q_{50}$        | 9.2 m³/s|
| $Q_{20}$        | 4.9 m³/s|
| Maximum flow    | 4.8 m³/s|
| Suggested flow  | 4.2 m³/s|
| Reserve         | 0.6 m³/s|

3. Conclusion
This detention basin was designed to protect part of the municipality of Hradec nad Svitavou from the effects of storm rainfall, including the flooding of houses, infrastructure of the municipality and the siltation of the municipality with soil from the surrounding land. The dam crest was designed to the ground elevation of 430 m above sea level with the top height of 9.23 m. The dam capacity is 27800 m³ of water with the surface area of 8402 m². The dam is designed as an earth dam built from local materials with two DN 800 outlets capable of transforming 50-year water into less than 20-year water. Because it is a dry basin, the flood area can be cultivated.

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