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The design of flood protection in Kobeřice municipality

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Abstract. This paper describes the current situation of flood protection of the municipality of Kobeřice and the method to be used to increase it, which is the construction of a flood pool – detention basin intended for the reduction of the negative impact of flash floods within the territory of the municipality. The actual design of the detention basin is based on hydraulic calculations and the prepared drawing documentation.

1. Introduction

Water is one of the main prerequisites for life on the Earth and it forms an important part of the environment as a renewable natural resource of significant importance. At present, the obvious rise of climate changes in connection with the global warming of the Earth's surface also help to understand the importance of water for the life and development of the society. It is evident that there will be more inconsistence in annual precipitation in very near future. This will result in frequent and large floods, or a period of low precipitation volume and low humidity, which will have adverse affects on agriculture and water supply.

Flood protection means measures that prevent and minimize the damage of floods with respect to the lives and property of citizens, companies, and the environment. The purpose of flood protection is the highest possible reduction of damage due to the flooding, especially of urbanized areas. It is a fact that absolute flood protection is impossible to achieve. We can partially limit and influence the peak flood flow rates or transform the flood wave, thus affecting the time course of the floods. This allows us to take more effective measures to save lives and property.

2. Description of the current situation

The municipality of Kobeřice is situated in an area where it is not endangered by any larger watercourse (figure 1). The Oldřišovský Stream runs through the centre of the municipality and it mostly passes through a built up area. In municipality of Kobeřice are 3 301 permanent residents (as of January 1, 2016). At present, Kobeřice does not have any flood protection measures. The so-called storm rainfalls that can cause flash floods are the biggest threat to the municipality. The location of the municipality from the point of view of the geomorphology of the terrain makes it even worse. The last flood in the municipality was recorded in June 2010. The Oldřišovský Stream drainage basin is mainly formed by cultivated agricultural land, the slopes located in this area are not provided with any landscaping elements (e.g. alleys, balks, etc.) and there are no anti-erosion measures either. As a result, the retention capacity of the landscape is very limited, the rate of rainwater drainage from the landscape is high, and there is also land erosion. This causes a direct threat to the lands, residential buildings and the inhabitants of the municipality in the form of storm rainfalls.

The territory of Kobeřice municipality is drained by watercourses of the second and third order. The largest watercourse in the area under consideration is the Oldřišovský Stream, which runs to the territory of the Republic of Poland as the Bílá Voda watercourse, where it subsequently flows into the Odra River. The average specific outflow in the area is 3 l/s^1km^2. There are small water reservoirs located on the Oldřišovský Stream, which do not serve as the flood protection of the municipality [1,2].

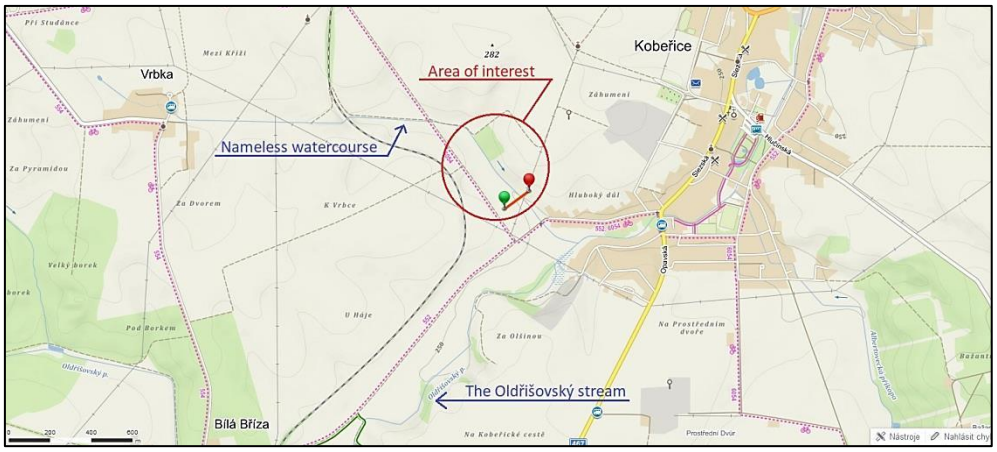

Figure 1. Location of the area of interest in Kobeřice municipality [3].

3. Design of flood protection

With respect to the local, morphological and agricultural conditions, the concept of a small water reservoir with a retention function is proposed as the most suitable flood protection of the municipality of Kobeřice. There is a nameless watercourse running through the site of the designed flood pool which is a left-side tributary of the Oldřišovský Stream (figure 1). The total length of this stream is 2.64 km and its hydrological characteristics are shown in table 1.

Table 1. Hydrological data of the left-side tributary of the Oldřišovský Stream.

Watercourse	Left-side tributary of the Oldřišovský Stream (HOZ - IDVT 10217069)
Hydrological order number	2-04-01-0070
Profile	r. km app. 0.370 – Tributary from Vrbka village
Long - term average annual precipitation level in the basin of P_a	628 mm
Long-term average flow rate	9.1 l/s

A similar concept of flood protection was dealt with in the cadastre of Bolatice municipality, which is referred to in the article called The Design of Flood Protection in the Cadastre of Bolatice Municipality [5].

3.1. Construction of flood-protection dam

The design of the flood pool includes a homogeneous earth dam and the type of soil to be used for the construction of this dam is selected on the basis of engineering-geological survey recommendations. The most widespread types of suitable soils found in the area in question are brown and luvic soils [6,7].

The dam is designed with the height of 4 m and the length of the dam crest is 141.50 m. The width of the dam crest is 4 m and it will be at an altitude of 253.26 m above sea level. The bottom of the flood pool is located at an altitude of 249.26 m above sea level, while topsoil removal reaching the depth of 0.6 m will be made at the site of the future dam. The removed topsoil will be used for the

final fertilization of the windward and waterward slopes. The dam crest is designed as horizontal and movable. There is a 3 m wide service paved road. Quarry rubble with the fraction of 8/16 mm in the thickness of 100 mm and with the fraction of 63/125 mm in the thickness of 300 mm is to be used for the road reinforcement. The road design is carried out in compliance with ČSN 75 2410 [8]. A sample cross section of the dam body is shown in the figure (figure 2). The following table presents the basic dam technical data.

Table 2. Technical parameters of the dam.

Dam parameters	Description / Value
Dam type	Homogenous earth, frontal, flow through
Dam crest length	141.5 m
Dam height	4 m
Dam crest width	4 m
Service road width	3 m
Crest elevation	253.26 m above sea level
Dam bottom elevation	249.26 m above sea level

A safety crest spillway with a capacity of Q_{100} is designed as part of the dam profile to transfer high water. The safety spillway is connected to a drainage channel with a depth of 0.8 m, a bottom width of 4 m and a gradient of slopes of 1: 1. The drainage channel will be led and discharged into the left-side tributary of the Oldřišovský Stream at an angle of 45 °. A 3 m wide cutoff is designed according to ČSN 75 2410 [8] in order to stabilize the dam. The depth of the cutoff is designed to 0.8 m. The designed waterward slope gradient is 1: 3 and quarry stone along the entire length of the slope is designed as the toe of dam at its end. The windward slope is designed with a gradient of 1: 2.5. The reinforcement of the windward and waterward slope is designed using humus with sowing in the min. thickness of 100 mm across the whole range. A toe drain at the windward toe of the dam is designed to drain away the water leaking through the dam body and its subsoil.

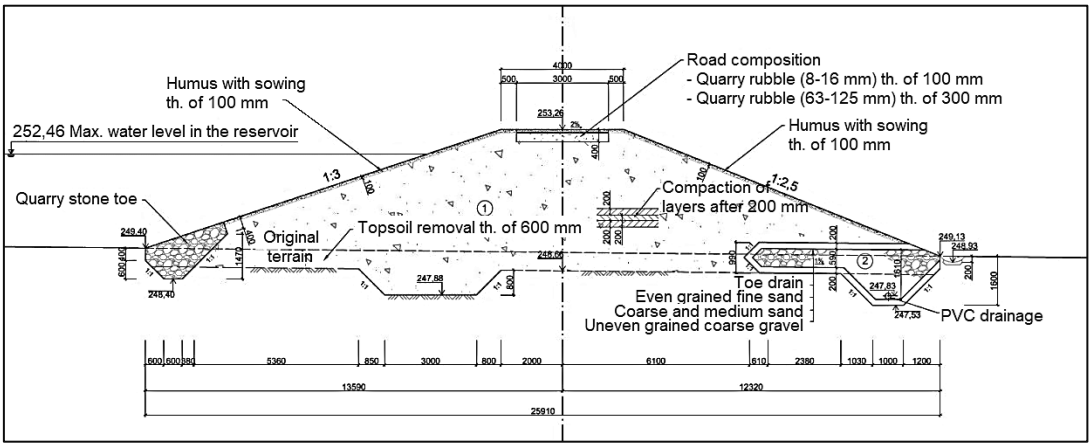

Figure 2. Sample cross section of the dam body.

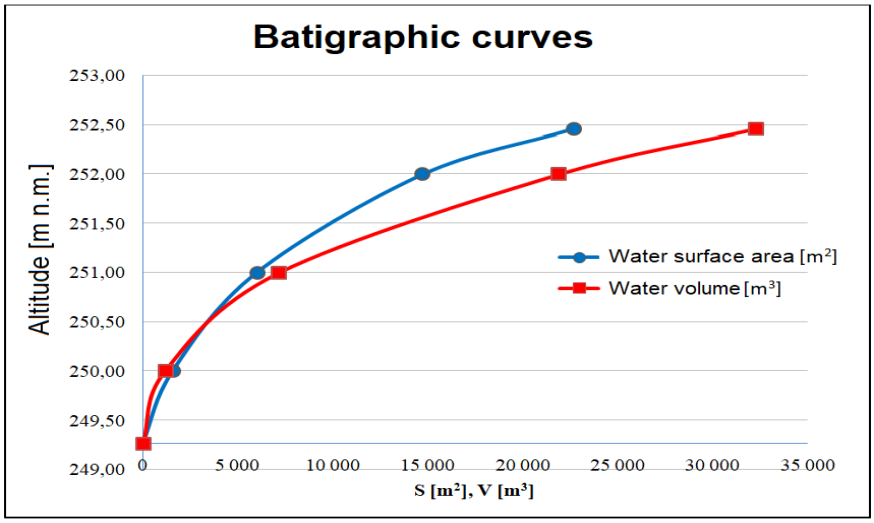

Figure 3. Batigraphic curves.

The characteristic data of the reservoir (water level, flood area and reservoir volume) are expressed by the so-called batigraphic curves. They represent the dependence of the volume of accumulated water in the reservoir and the flood area on the water level in the reservoir. Fig. 3 shows the batigraphic curves of the reservoir.

3.2. Flood pool outflow regulation

Gullet type of draining device has been chosen to regulate the drainage of accumulated water from the flood pool. The location of the gullet is designed in the waterward slope at a distance of 8.5 m from the pool axis and 5.1 m from the toe of the slope. The water inlet to the gullet will be provided by a reinforced channel to the toe of the waterward slope. In addition, a concrete trough at a slope of 10 ‰ with concrete wings and a total length of 4.6 m is designed through the dam body. The normal flow rate in the stream-bed of the left-side tributary of the Oldřišovský Stream will be taken away by a circular culvert DN 350 located at the bottom part of the gullet. A coarse screen is designed in front of the circular culvert. At peak flow and full flood pool filling, the water will drain through the gullet stop log wall. A reinforced concrete pipeline DN 600 running through the dam body is designed to drain the water from the gullet.

In order to ensure the safety of the dam, a safety spillway is designed to transfer the peak flow rate of Q_{100}, whose value is 5.54 m^3/s. It is possible to take part of the flow rate away by means of the gullet, thus reducing the designed flow rate of the safety spillway. Due to the safety of the dam (e.g. sewer pipe blockage, etc.), the Q_{100} flow rate has been chosen as the designed one. The spillway edge of the safety spillway is designed for the length of b = 7.0 m, the overflowing jet height was designed at h = 0.4 m and the slopes of the safety spillway are designed at a gradient of 1: 5. The safety spillway will be reinforced by means of quarry stone pavement in the concrete bed with a thickness of 0.40 m.

3.3. Flood wave transformation

In order to capture and transform the flood volume through the retention area of the flood pool, it is necessary to know the volumetric flow of the flood over time, the so-called flood hydrograph. This graph (see figure 4) represents the course and transformation of the flood wave, which shows the relation between the inflow and outflow of water from the flood pool per unit of time. From the point of view of the protection against the adverse effects of flood, it is especially important to reduce the peak flow rate and shift the critical flood flow time. The main issue is to ensure the safety of the waterwork itself and the safety of the area below the flood pool. The drainage of the water from the designed flood pool is simulated during a calculation of the flood wave transformation to the capacity flow rate of the drainage pipe DN 600 Q_{kap} = 0.816 m^3/s. The controlled drainage of the water from the

flood pool is made by means of a circular culvert DN 350 controlled by a slide-valve and by a spillway through the gullet stop log wall. In case of Kobeřice flood pool, the flood wave simulations and transformation of their peak flow rates are performed for the flow rates of Q_2, Q_{20} a Q_{100}.

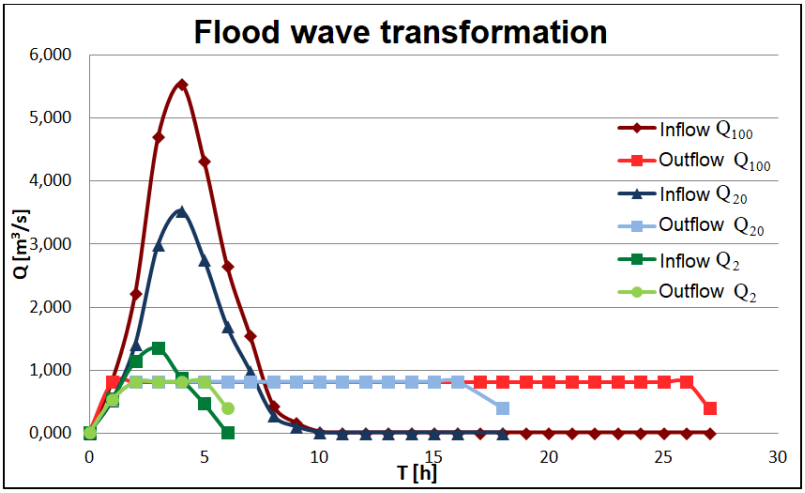

Figure 4. Flood wave transformation.

4. Conclusion

A small water reservoir with a retention function has been designed in order to protect the municipality of Kobeřice, whose task is the retention of a flood flow and its controlled drainage. The water reservoir has a designed earth-fill homogeneous dam with the height of 4 meters and the length of 141.5 m. This dam determines the controllable area of the reservoir with the volume of V_{max} = 32 258 m^3 and a flood area of S_{max} = 22 651 m^2. The safety of the dam is ensured by a safety spillway designed to transfer the peak flow rate of Q_{100}. A gullet outlet, with a lower circular culvert DN 350 equipped with a reinforced concrete waste pipe DN 600, is used to drain the accumulated water from the reservoir.

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