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# The design of the technical flood protection measures on Svitava River, Czech Republic

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**Abstract.** The paper present the design of the technical flood protection measures on Svitava River in Březová above Svitava town. The current state of the study area was evaluated and determined based on related documents available for public as well as on the personal survey of the landscape. Technical solution as proposal of adjustment of the Svitava River (by composite trapezoid), extracting sediments and designing, stabilization of the bank and construction of the protective floodwall is shown in the paper. The riverbed slopes were fortified with a stone riprap with a sieve of grass mixture.

## 1. Introduction

Natural floods are caused by natural phenomena, where the water from the riverbed occurs outside the channel. These natural phenomena might be [1]:

- reaching the water level or maximum discharge of the stream,
- intensive and long-term rainfall,
- snow melting
- ice barriers on the flow and ice passage, etc.

However, other factors also contribute to the origin of the flood, for example [1]: size, shape and morphological characteristics of the river basin; shape of the channel; type of surface; density and ordering of the river network; geological, hydrogeological and pedological conditions; occurrence of objects and reservoirs on the stream [2,3].

The pre-flood environment, such as soil saturation, vegetation cover or retention capacity of the river network, etc. [1,4], also affects flood threats.

In order for flood protection measures to work well, their interdependence is important. It is a combination of [4,5]:

- flood prevention (e.g. adaptation of buildings to floods risk, appropriate land use, etc.),
- protection (e.g. technical and non-technical/natural flood control measures flows to reduce the probability and impact of floods),
- preparedness (e.g. informing the population about the situation and how to behave when flood situation occur, in case of emergency),
- rescue system (e.g. rescue plans).

By non-technical measures are meant delimitation of flood zones, forecasting and warning systems and education of the public how to behave in case of emergency before the flood occurred and during the flood. In flood zones the restrictions where construction, permitting or construction works is not permitted is applied. The exception is water structures, which have a positive effect on flood protection. [1,4-6]

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Technical measures on watercourses are mainly riverbed adjustment in order to ensure sufficient capacity and stability of the bottom and banks for design flow [7]. These include the establishment of the retention areas in the reservoirs and dry polders, the construction of the weirs, temporary dams, dams, protective walls, natural mounds, embankments, increasing of the capacity of the riverbed and its maintenance, sediment extraction from the river, controlled flooding, bypass of the streams, reduction of depth and side erosion, and more [1,5,8].

In the paper is presented the flood protection on the Svitava River by adjusting the shape of the riverbed, extracting sediments and designing a protective floodwall. Controlled flooding is considered in places where it is not necessary to protect private property. Outside the area of interest, a theoretical flood control measure is proposed, which present how is necessary to limit the large flood into the urban area of the city. It was considered to use a protective wall, a natural embankment and a mobile barrier.

## 2. Material and Methods

### *2.1. Study area*

The Svitava River belongs to the sub-basin of the Dyje, which is part of the International Danube River Basin District. The sub-basin of the Dyje River is the second largest basin in the Czech Republic, which is adjacent to the sub-basin of the Morava, to the tributaries of the Váh, Upper and Middle Labe, Lower Vltava and Upper Vltava. The area is located in the south-eastern part of the Czech Republic. It is managed by Povodí Moravy enterprise. The water from the basin of Svitava River flows into the Black Sea.

Svitava is 98.39 km long and its catchment area is 1,149.4 km$^2$. The river springs on northwest of Svitavy town near the Javorník village at an altitude of 471 m above sea level. Along its entire length, the river is densely populated. It flows southwards through the towns Březová above Svitava, Letovice, Rájec-Jestřabí, Blansko and Adamov, where it has a predominantly natural and meandering shape flowing in a deep valley (nearby Svitavy town, figure 1). The industrial zones began to be formed around the stream and its meanders were regulated in late 19$^{th}$ century in the southern part of Brno (at an altitude 191 m above sea level). The river was straightened gradually in Brno [5,8,9].


**Figure 1.** Sub-basin of Dyje River with the study area of Svitavy River.

The study of area of Svitavy River is located in the urban area of the town of Březová above Svitavou, which lies on the Moravian-Czech border in the Pardubice Region. Nowadays, around 1690 inhabitants live in the town. The built-up area is mostly located in close proximity to the flow. There is a railway

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line and road running along the whole section, which creates a barrier to possible flooding into the floodplain. The site is known for its important resources of groundwater, which are pumped and used for the treatment and distribution of drinking water, especially in Brno and its surroundings [9].

The original riverbed in the study area was non-capacity in some places even for flows smaller than $Q_1$ = 5.9 m$^3$/s. On the basis of the calculations of the course of water levels using program HEC-RAS, a flood control measure was proposed for the design flow rate $Q_{20}$ = 24 m$^3$/s. The proposed adjustment was to extend the channel in five sections and a design of the protective wall on four sections of the stream. The design consists of adjusting the shape of the riverbed to a 2-stage trapezoid with a deepen bottom. The flow will develop and change freely within the designated range at normal flow rates. The example of this riverbed is depicted in figure 2. The proposal took into account the ownership of the land, so there was an effort to minimize land acquisition.

**Figure 2.** The example of composite trapezoid channel with the movable bottom with the protective wall.

The adjustment does not change the original riverbed in any way. The shape of the riverbed is adapted from a simple trapezoid to a composite trapezoid. Ordinary daily flow rates are concentrated into a smaller part of trapezoid of wide 2m flow in the bottom. The shape of this part is unfortified and therefore it can evolve spontaneously in the defined area. The bottom part is excavated approximately 0.5 m below the original flow bottom. Its capacity is about $Q_{30d}$ = 1.35 m$^3$/s with the slopes of 1: 1.5. The shape of the designed channel is shown in the figure 3.

The width of the channel varies according to the possibility of utilize the space along the banks. The shape of a composite trapezoid with a slope of 1: 2 is designed almost along the entire length of the study area in the river km 74.479 to 76.744. In the last part of the section, the protective walls on both banks are designed. The shape of the channel is in the last section is rectangle with a movable bottom in r km from 76.744 to 76.924. The height of the banks is almost the same as that of the original channel what helps with a smooth connection to the original terrain along the banks.

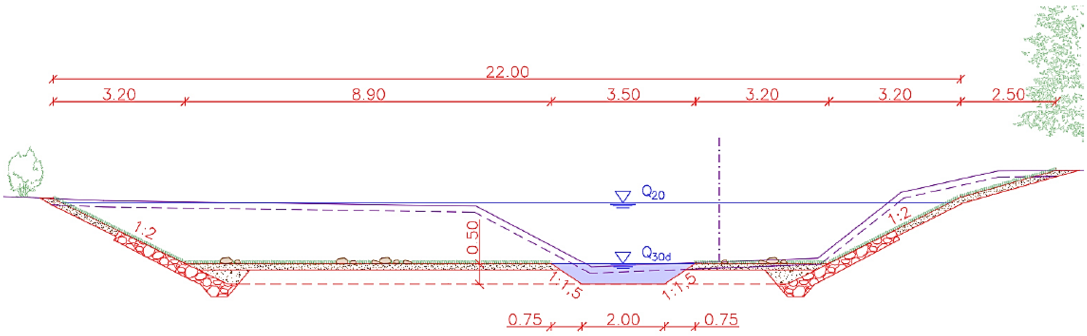


**Figure 3.** The composite trapezoid channel with the movable bottom.

From the geological data of the Svitava River in the sections of interest, it was clear that the riverbed was massively clogged. Therefore, the excavation of the bottom that leads to removing of these deposits and bottom levelling was designed.

## 3. Results and Discussion

The removal of the bed sill of the former sluice gate will be removed and the channel will be smoothly connecting the original bottom to the adjusted one in r km 76.479. The removal of this bed sill should not in any way impair the hydrological regime of the flow.

There is also a bed sill, which will be removed in r km 76.403. It is located in in a part of the channel that will be extended, and therefore its construction would be an obstruction in the adjustment. A given section of the flow is completely fortified with a concrete, which will also be removed. It can therefore be assumed that after removal of the concrete fortification the step would have to be repaired or possibly extended. Both constructions have a height of approx. 0.5 m. These bed sills present a migration barrier; therefore, their removal will improve the conditions for the animal migration.

By adjusting the bottom with sediment, deposits and bed sills removing, the average longitudinal slope changes to 3.8‰.

In four parts of the flow section, a protective wall is designed as a technical flood control measure due to insufficient channel capacity for the design flow (figure 4). The wall is designed in places where the wall was already in the original channel or where there was no space to channel expanding or implementation of the natural water protection measures.

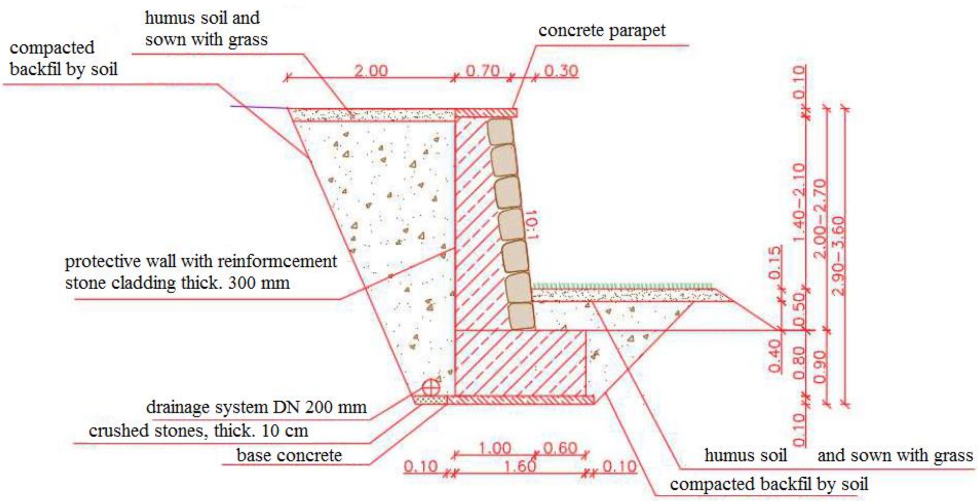


**Figure 4.** Protective wall.

Based on geological survey it was found out that in some parts of the river there is subsoil with low-bearing capacity. Respecting this, the walls are designed to be founded at least 1.5 m below the ground level. The walls are made of reinforced concrete with stone cladding on the inside. The wall is 2.0 - 2.7 m above the level of the excavated bottom and 0.9 m below it. During the construction, a line drainage system will be installed along the wall, which serves to drain the water and so protect the substructure. A more detailed description with dimensions is shown in the figure 4.

Due to the absence of the granularity curve, the roughness of the channel and the effective grain were estimated based on a personal inspection and from the tables as $d_{ef}$ = 40 mm. The design of the new slopes´ fortification was based on the previous fortification of the original bank, what was evident from the personal inspection. It is necessary to stabilize the slopes in the riverbed up to the theoretical bottom level so that the spontaneous changes in the excavated bottom do not cause the banks erosion and leads to the collapse of the fortification.

The fortification is made of stone riprap up to a height of 0.8 m from a quarry stone sown with the grass mixture in a thickness of 250 mm with a gradual extension up to 300 mm. The aggregate weighs

80 – 200 kg. The slope fortification is designed along the entire length of the channel of the interest, with the exception of banks with protective walls. A more detailed description is shown in the figure 5.

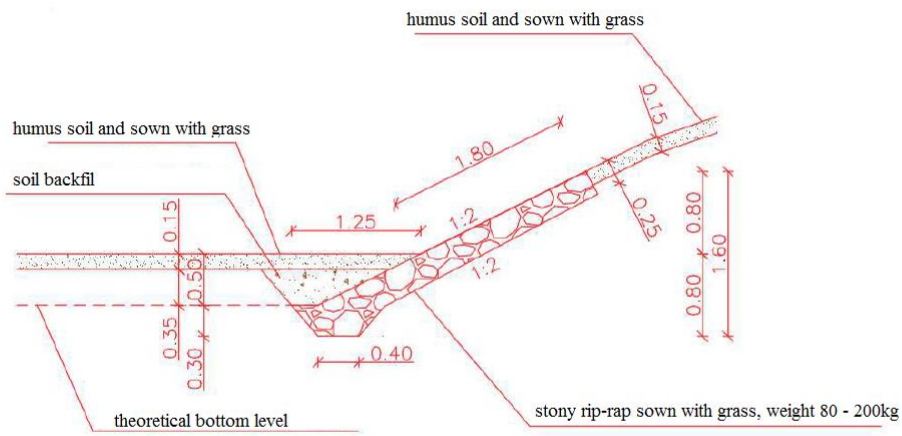


**Figure 5.** The stabilization of the bank.

## 4. Conclusion

Flood protection along the Svitava River was designed with respect to ownership. The proposal consists of the stream adjustment of into the shape of a composite trapezoid with a migratory ridge. The stream can spontaneously meander in the defined space. The riverbed slopes were fortified with a stone riprap with a sieve of grass mixture. Original trees are designed along the river as accompanying green respecting the system of its planting described in [10]. Protective floodwalls were designed in the least-capacity sections of the stream. Increasing of the high of the bridge structures so that they were capacity for the design flow was design.

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