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FLOOD PROTECTION PARTIAL ANALYSIS OF THE OLT BRIDGE IN SÂNTIMBRU

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Abstract

In many places in Transylvania, we can observe the ruins and remains of buildings, from which many interesting conclusions can be drawn. As part of a more comprehensive research, in which the flood protection safety of old Transylvanian bridges is examined, in this case the rebuilt road bridge in Santimbru was investigated. Modelling and hydraulic calculations performed on the basis of in situ measurements can reveal the old hydraulic construction requirements used in the design of the bridge, and then the data were also considered in the light of today's standards.

Keywords: *technical history, bridge design, flood .*

1. Introduction

The examined bridge over the Olt River in Sântimbru (Csíkszentimre in Hungarian) is located on the county road number 133 in Harghita County, Romania, and probably adds to the list of bridges that were blown up in September 1916 by the retreating Austro-Hungarian army. The original design plans of the bridge are not known, but the structure is not unique on the Olt River, similar bridges were built in Sâncrăieni (Csíkszentkirály), Sfântu Gheorghe (Sepsiszentgyörgy) and other places. A postcard illustrating the original state of the bridge is shown in **Figure 1**. **Figure 2** proves that the railing at the bridgehead, which is completely different from the current railings on the bridge's superstructure, corresponds to the one shown on the old postcard.

According to the Hungarian text carved on a plaque on the bridgehead (**Figure 3**): „The renewal of the Olt bridge was carried out in 2016 by the town hall of the settlement, with the financial support of the Harghita county council,

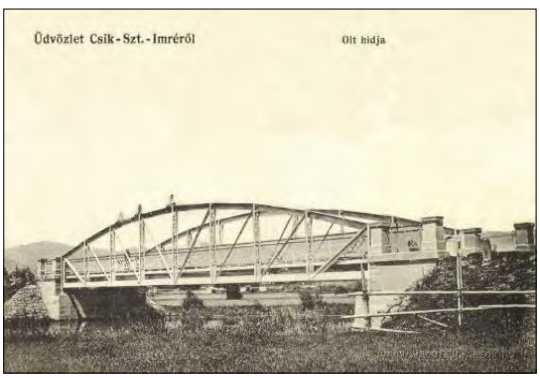

Fig. 1. *The image of the old Olt bridge in Santimbru on a postcard from 1912.* **[1]**

Fig. 2. *The current state of the old bridgehead.*

Fig. 3. *The plaque on the bridgehead.*

Fig. 4. *The road bridge built over the widened riverbed on the site of the old arched bridge.*

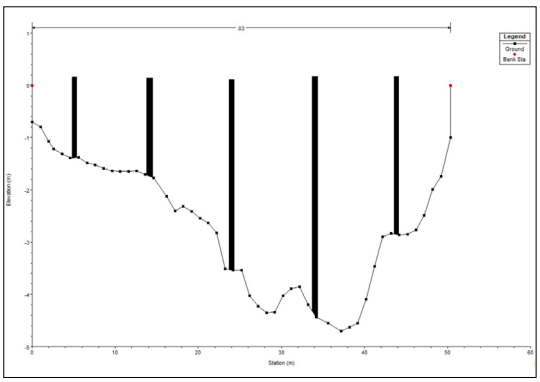

Fig. 5. *The current cross-section of the Olt River at the current bridge.*

the Santimbru commoners, the Santimbru local council" (translation by the authors). Additional information is engraved in the bridgehead: "Built in 1980". According to local residents, however, it was only renovated in 1980, the bridgehead was present much earlier. The original bridge (without piers) had a single span of approximately 25 meters.

The current bridge is 52 meters long and has 5 piers, being adjusted to the embankment built on this section of the Olt River after the widening of the riverbed (**Figure 4**).

2. Preliminary calculations

The subject of this investigation is the point in the Santimbru section of the Olt River where the bridge illustrated in **Figure 1** was located and where the current road bridge shown in **Figure 4** is located. The characteristics of this section of the river are shown in **Table 1** and **2**.

At a distance of approximately 4.2 km above the former bridge there is a hydrometric station, the known data of which greatly helped the accuracy of the calculations.

Using the above data, the values shown in **Table 3** resulted from the preliminary hydrological calculations, considering the maximum water flow of the 1% and 5% probability floods.

The current cross-section of the riverbed under the new bridge built after the riverbed widening works was modelled based on field measurements, as shown in **Figure 5.**

Table 1. *Long-term average flow.* **[2]**

River name	Cadastral number	Average flow
Olt	VIII.1	5.74 m^3/s

Table 2. *The parameters of the Olt River in the analysed cross-section* **[3]**

Parameter	Value
Length	62 km
Average slope	1.2 %
Sinuosity	1.27
Retention area	956 km^2
Average altitude above sea level	642 m

Table 3. *Ahe maximum flood flows of the Olt River in the cross-section below the bridge.*

Probability	Q_{max} p%
1 %	430 m^3/s
5 %	232 m^3/s

Under and around the current bridge, a large amount of sediment has been deposited in the riverbed. Based on the geometry of the undamaged bridge abutments and the bed level, the late cross-section assumed to be taken into account in the design of the bridge was modelled by ignoring the subsequent widening of the bed, as shown in **Figure 6.**

3. Design specifications

Based on the Romanian regulations, the selection of the flood yield used in the design of bridges is made according to the 4068/2 standard **[4]** depending on the importance classification of the construction. According to standard 4273 **[5]**, the bridge in Santimbru belongs to importance class 4, so the water flow value for design is the flood water yield with a 5% probability.

A 2010 government decision **[6]** stipulates that the target set on the basis of the national strategy for the future is that for rural settlements, the 1% probability flood water yield should be the design flow value, for increased safety.

During hydraulic design, when determining the water flow through the section of bridges, a certain free height must also be taken into account, which in our case means a height of 1.5 meters according to the Romanian PD-95 standard. **[7]**

4. Hydraulic calculations

Hydraulic modelling was carried out using the HEC-Ras program of the US Army Corps Engineers. The mentioned program uses Chézy-Manning hydraulic model.

With the help of a first model, it was examined to what extent the assumed cross-section in the case of the old bridge corresponds to the Romanian standards before 2010 and to the current standards.

Based on the results (**Figure 7**) we can state that the old bridge meets the requirements of Romanian design standards before 2010, since the model of the assumed original cross-section results in a 1.85-meter clear height at the maximum flow of a 5% probability flood. On the other hand, in the case of the maximum flow of a 1% probability flood, the free height is only 0.96 meters, so it does not meet the currently formulated national flood protection strategy requirement.

With the help of a second model, we examined the current cross-section of the riverbed in the case of the already mentioned maximum flood flows, under the existing road bridge.

As can be observed in **Figure 8** the current cross-section results in a free height of 11 cm in the case of a 1% probability maximum flow, and 90 cm in the case of a 5% probability maximum flow, so it does not provide the minimum 1.5-meter free height required by the PD-95 standard for flood discharges in case of the pre-2010 or post-2010 Romanian flood protection design standards.

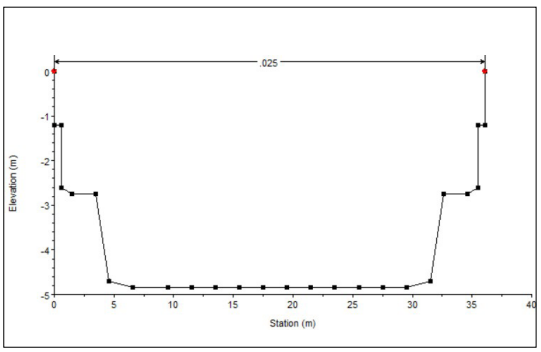

Fig. 6. *The supposed old cross-section of the riverbed under the bridge.*

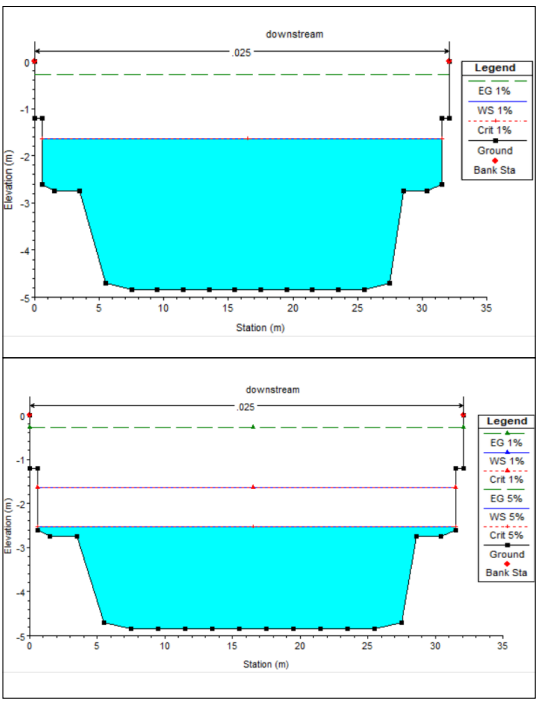

Fig. 7. *The assumed old cross-section of the riverbed with a 1% and 5% probability flood flow, under the old bridge.*

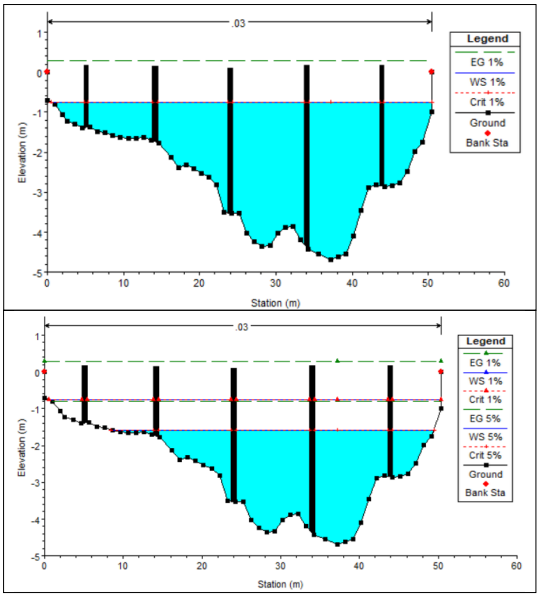

Fig. 8. *The current cross-section of the riverbed with a 1% and 5% probability flood flow, under the current road bridge,*

5. Conclusions and further plans

The hydraulic calculations carried out on the basis of measurements at the bridge in Santimbru indicate that the standards used in the design of the old bridge may have been stricter than the Romanian regulations valid until 2010, because the assumed cross-section of the riverbed at that time ensures the prescribed free flow height in case of the 5% probability flood water flow. This probability can be unequivocally substantiated only after studying the design regulations of the time, since the assumed cross-section was taken into account as an idealized model without alluvium and deposits.

Our second conclusion is that the current cross-section does not ensure the free height required by the standards, so it would be necessary to remove the deposited bed sediment (**Figure 9**) and stabilize the riverbed.

Further plans include the search and examination of the remains of Transylvanian bridges similar to the bridges in Sancraieni **[8]** and Santimbru in order to determine the original design requirements.

Fig. 9. *Deposited riverbed sediment.*

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