

INFRASTRUCTURE BEHAVIOR OF EXISTING STEEL BRIDGES IN OPERATION

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Abstract: *Estimating the carrying capacity of old steel bridges in mining, you need to take in consideration two things: the infrastructure and the superstructure. On the superstructure you can make some investigations, but the problem becomes more difficult when inspecting the infrastructure. This paper presents some typical solutions for the infrastructure of old metal bridges in operation*

Keywords: *bridges, infrastructure, old bridges in operation;*

1. Introduction

Estimating the carrying capacity of the existing metal structures is an important problem for the idea of the construction's sustainability.

Rehabilitation of existing steel structures is a way of sustainable development and also an act of culture. Generally we can say that the main aspects are:

- Positive socio-economic impact for the region which would be able to obtain the maximum benefit from the rehabilitation of the structures

- The rehabilitation program will be conceived to achieve safety at all construction stages and to allow no compromises during the different construction stages.

- Exemplary work sites from an environmental perspective have to be conceived.

- The current problem is the safety of the construction. It needs to be safe for further

exploitation. We need to keep in mind that the traffic and the loads on axles have increased and also the material fatigues.

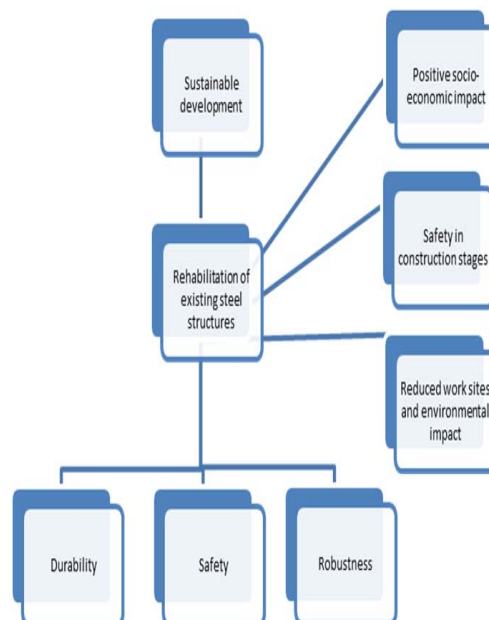


Fig. 1. *Correlation schema for rehabilitation of existing structures*

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The determination of the carrying capacity of the structure is performed usually after specific regulations. [2], [3], [4]. European standards – EUROCODES – do not relate to existing constructions, but to new ones.

A separate chapter is assessing the technical condition and carrying capacity of the infrastructure.

These were made with the specific technology existing at the end of the nineteenth century and early twentieth century.

In this paper we present several typical solutions for the foundations of railway bridges and existing old road in operation.

Currently in Europe, it is used to extend the life span of old structures in order to maintain the historical value.

In that period, the bridges were calculated using much easier loads. Therefore each element of the structure must be reinforced with ingenious solutions in order to meet the current traffic conditions.

The rehabilitation is a difficult and complex process.

2. Typical infrastructure solutions for existing steel bridges.

In general, you cannot find a lot of information regarding to the infrastructure of bridges built between XIX and XX centuries.

A list of instructions could be obtained from the railway administration. Also an on-site inspection of the infrastructure is rather difficult and it's based on good knowledge of the expert, as well as observations on the behavior of the construction in time.

A first solution is the direct foundation.

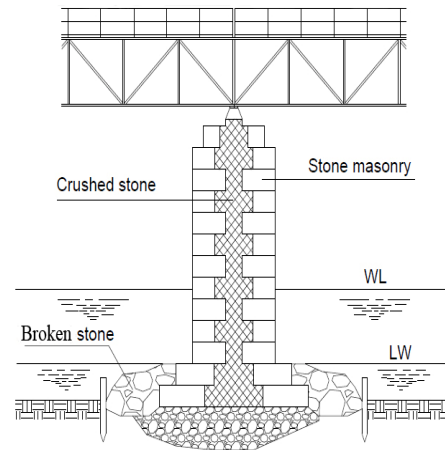


Fig.2 Direct Foundation - pier

Direct foundations were built on good soil for foundations, at reduced water levels or where there was the possibility of deviating the river course in order to realize it onshore. This solution was used for building light bridges with light loads (highway bridges). In general the bridge's piles were covered with stone masonry and inside they were filled with crushed stone or "ciclopian" concrete.

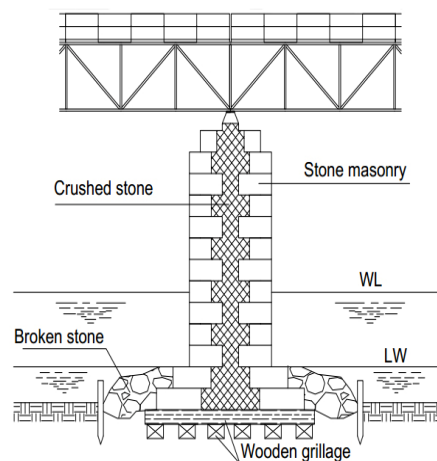


Fig.3 Wooden grillage

The same solution could also have a wooden beading material (grillage) in order to have a better repartition of the foundation ground.

With increasing loads from year to year and where to soil was not good for direct foundation, the solution with timber piles was adopted.

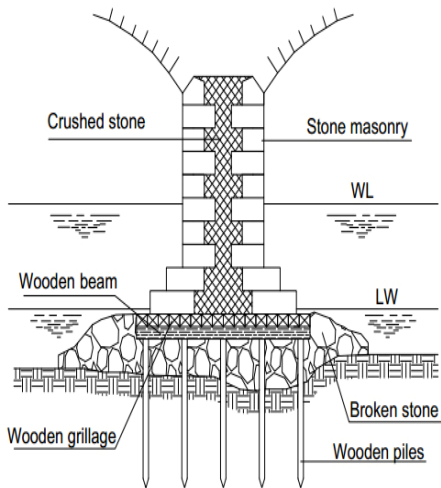


Fig.4 *Wooden piles*

The wooden piles were fitted in the ground at the right level with pile drivers. The top of the piles were covered with stones. Over the wooden piles, the structure was fitted with a surface made out of timber beams on which they continued building the stone masonry.

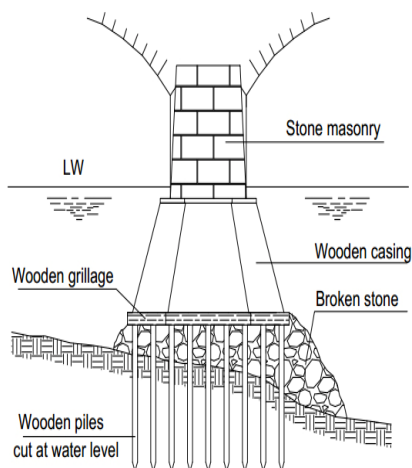


Fig. 5 *Sunken wooden piles*

A step forward was the solution with built-up wooden caissons, that was fitted

on top of the wooden beading material. The casing was set in the right position and then it was sunk. Afterwards, inside the caisson, the pile was built. After the work, the caisson was removed and used to build the next pile.

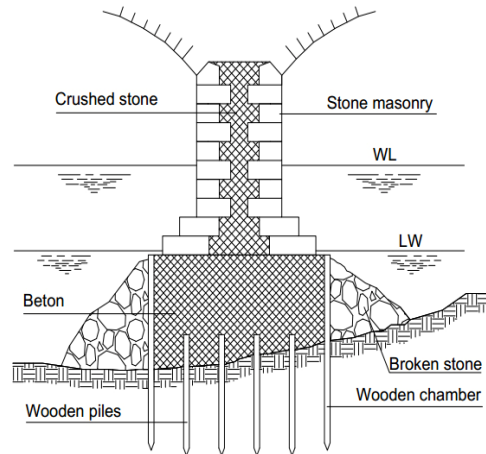


Fig.6 *Wooden caisson*

A step forward was to provide a double wooden sheet pile wall, in order to protect the pier.

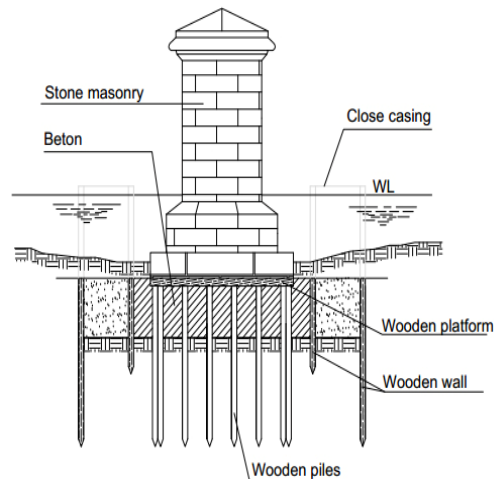


Fig.7 *Double wooden sheet pile wall*

Between timber walls, clay was put up in order to protect the pier. With the help of steam machineries, they dried the work-space in order to work on dry land.

Another way of building piles was with a

compressed air caisson. With this solution, the bridge “Regel Carol” over the Danube was built in Cernavoda .

3. In time behaviour of existing bridges infrastructure

Generally maintenance of these structures is poor. In time producing a series of degradation. Below we describe some typical defects:

Settlements and inclined piers An important aspect concerns to scoring of foundations. By placing the infrastructure in the river bed, increases the water flow rate. On reaching a critical speed, it can produce scoring. The following considerations will describe some possible situations of scoring. Wear (Stone masonry). Water has the effect of abrasion on natural stone. Wear may be more pronounced at the stone’s masonry soft rock (sandstone).

Displacements. Their occurrence indicates subsidence structure, which can lead to destruction of infrastructure.

Discovered joints. Absence of stone masonry. Absence of mortar and lack of stone masonry indicates subsidence structure, which can lead to destruction of infrastructure.

Defects of stone masonry. This defect may occur by crafting the infrastructure with floats and boats.

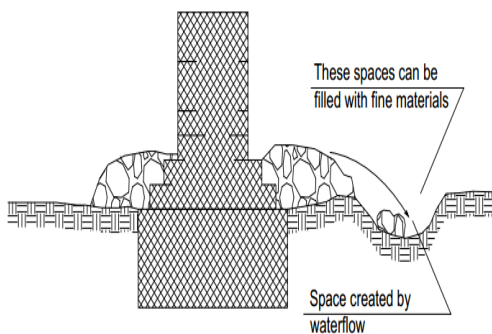


Fig.8 Scoring next to a pile

In the figure is presented the consequences of scoring next to a pile that is protected with embankment.(scoring next to a pile)

Another situation can occur to pile founded directly where scoring reduce the carrying surface of the foundation on the Foundation soil; in consequence cracks and settling may occur.

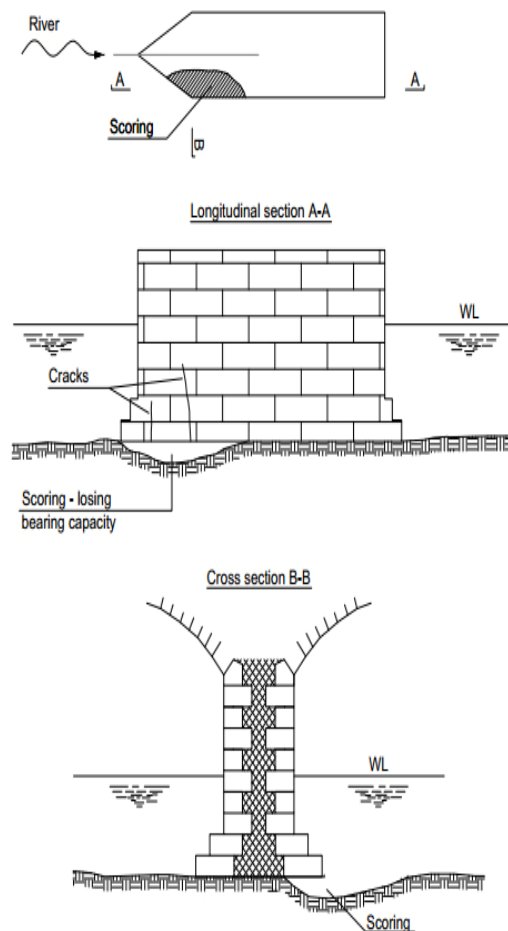


Fig.9 Scoring under the foundation

At foundations on piles scoring can lead to reducing their carrying capacity by reducing friction on the mantle, danger of buckling and pilots destroyed by the rot.

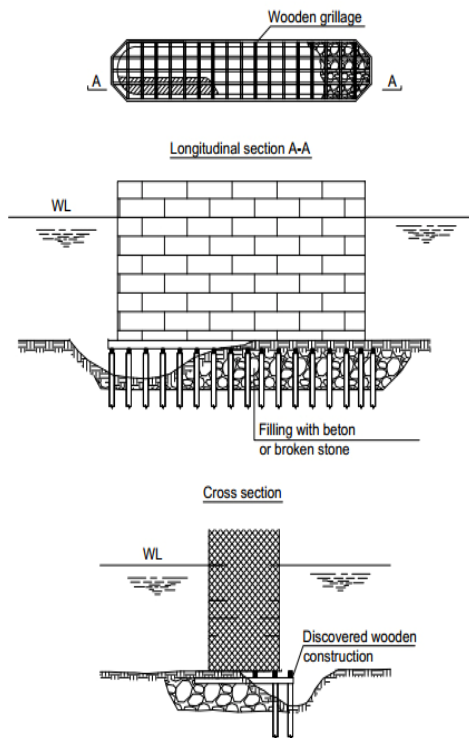


Fig.10 Sections

It emphasizes that on-site inspection of these structures is complicated and can be done by: execution of an enclosure of piling and removal of water. This method is expensive and difficult.

Another method consists in verifying the structure under water by a diver. It must be specially trained.

Today there are modern methods using underwater cameras.

4. Case Study: Bridge from Săvârșin.

The general disposition and description of bridge

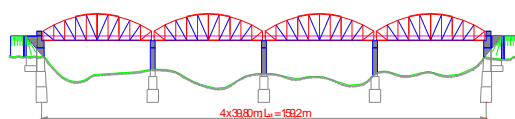


Fig. 11 Savarsin Bridge elevation

The bridge was rehabilitated in 2008. To

the infrastructure were found a number of defects and was prepared a consolidation project.

Bridge over the river Mures at Săvârșin is situated on the county road DJ 707 A (km 1 + 271 m) and is a remarkable structure with four spans $L = 4 \times 39.80 \text{ m} = 159.20$, built in 1897.

The bridge has a classical form for the period when it was built: the main truss girders with parabolic shape, with descending diagonal (tensioned) and verticals (compressed).

At the top, on four central panels wind braces are disposed. Resistance structure of the path is formed by a network of beams disposed orthogonally – stringers and cross girders who supported the Zores profiles.

Over the profiles Zores was placed a layer of ballast non-aggregated, approx. 20 cm thick and a layer of asphaltic concrete with a thickness of approx. 5 cm.

With a ratio $L / H = 39.6 / 6.22 = 1 / 6.4$, the main beams have an elegant look, bridge fits perfectly into the surrounding landscape.

Pointed out that the bridge is located near the summer residence of King Michael I of Romania.

The maintenance of the bridge was neglected; the technical condition of the bridge was bad.

The rehabilitation of the structure was realized with adequate solution without changing the general appearance of the structure. This project received the first European ECCS prize in 2010 [R.Băncilă, E.Petzek, D. Bolduș "New life for an old historical steel bridge over the Mureș river" European Convention for Constructional Steelwork AWARD - First European prize, 2010 Sept.

[www.steelconstruct.com].

A special problem was the rehabilitation of the infrastructure. Taking into account the general behavior of the structure, and carefully in situ observations (no

settlements or inclination were observed), only minor works to the abutments and piers were provided.

With the help of an old expertise the pressure on the soil was calculated; the result is lower than the allowable ground pressure. Nevertheless the structure (superstructure and infrastructure) is under surveillance. In present the traffic is normal on the bridge.

There was made an approximate calculation of the effective pressure on the sole of foundation using a geotechnical study IPTANA - 1998 In this regard were considered all of its own weight loads plus

convoy A30 loads on two adjacent openings. Resulted a pressure less than the the admissible pressure. This corroborated with the good behavior of the foundation over time leads to the conclusion of good behavior of the foundation by strengthening the superstructure.

Conclusion:

The appreciation of carrying capacity of the existing bridges infrastructure is generally difficult. It can be based on a good knowledge of foundation solutions.



Fig.12 Savarsin Bridge after rehabilitation

References

1. *** *German Norms*
2. *** *Swiss Norms*
3. *** *Austrain Norms*
4. SBB “*Empfehlung fur die Uberwachung und Hinweise fur den Neubau*” 1998 [4]
5. G. Mehlhorn – “*Der Ingenieurbau*”, Ernst&Sohn, 1995