HISTORICAL STEEL HIGHWAY BRIDGES IN THE WESTERN PART OF ROMANIA

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Summary: *In the western part of Romania, a large number of steel highway bridges were built at the end of the 19th century and the beginning of the 20th. Many of these bridges are still in operation; the technical condition of these structures is not satisfactory due to poor maintenance. The paper presents some of the most important structures in this part of the country and proposals of assessments and rehabilitation.*
The same situation is also in the neighbor countries which belonged to the former Austrian Empire.

Key words: *highway bridge, steel, maintenance*

1. INTRODUCTION

Romania has a highway network of approximately 153 057 km on which there are over 3192 bridges. Only 83 (3%) of the total number of bridges are steel bridges. The small number of steel structures is due to the fact that short and medium span bridges were dominated in the past by the reinforced concrete and for the construction of large spans, pre-stressed concrete was used. The absence of motorways is another reason that could be mentioned. There are a reduced number of steel bridges that have in general a long period of exploitation. Many of these are situated in the western part of the country, which are nowadays real historical monuments. Most of these constructions are still in use, even if their technical condition is rather unsatisfactory [1]. Following aspects could be highlighted:

- The maintenance of the bridges was not a continuous process as the local administrations have changed in time; the result is the lack of any documentation;
- insufficient gauge (B = 5-6 m); consequently elements of the main truss girder are hit and bent;
- the structures are heavily corroded;
- all structures are riveted;
- overall tendency of administration to replace these structures.

Compared to railway bridges, the situation is different, as steel bridges prevail. Their maintenance is better, technical documentation is generally available. Therefore, the rehabilitation of existing steel construction is one of the most important present problems. Some recommendations resulted from the experience in the rehabilitation of old existing structures are presented below. It must be pointed out, that all these structures also have an historical and artistic value, some of them being technical monuments. Currently the tendency at international level consists in maintaining in exploitation, within safety conditions, the existing structures.
The funds must be as rational as possible invested, as a consequence of the lowered administrational budgets.

n regard to this matter more information is required about the safety of the structures, their sustainability and the needed costs for rational maintenance.

2. STRUCTURES PRESENTATION

Bridges have in general a classic construction, the bridge deck being composed of a girder network: longitudinal stringers and cross girders, and the main truss girders are parabolically shaped. When the bridges are located in the urban area they have an emblematic character for a certain location (Arad, Lugoj, Lipova). The appearance of these structures is specific and they integrate harmoniously into the landscape. The beginning of the construction of bridges in Banat's history is related to the name of Karoly Maderspach [2]. He designed a large number of cast iron bridges, as arches with ties. Due to brittle fracture and inhomogeneity, cast iron proved to be a less suitable material for bridge constructions. Cast iron was replaced with wrought iron and then, with mild steel respectively. In 1895 under the leadership of Romanian engineer Anghel Saligny was put into operation the Danube bridges complex Fetesti – Cernavoda. Saligny started using mild steel and after 1900 all the bridges were made of mild steel with similar properties to current steel.
The majority of the bridges in the Western part of the country, were made in Reşiţa by St.E.G company (Kaiserliche und Königliche Privilegierte Österreichische Staatseisenbahn-Gesellschaft).
The following features are representative for that period:

- The structures are generally statically determined (simple supported beams or beams with cantilevers and Gerber hinges);
- The main truss girders with a parabolic form that is adapted to the variation of the bending moment; all the diagonals are descending elements (tensioned elements);
- For the usual spans the chords of the truss girder are single plane cross sections;
- All joints are riveted;
- Foundations are executed directly;
- The width of the bridges is within 5 - 6,5 m, consequently the elements of the main girder are damaged by the large vehicles;
- Total lack of any documentation;

- Fatigue does not generally play an important role; the statement "structure has a long age and is fatigued" does not correspond to reality;
- The maintenance of these structures was totally neglected, some of the elements being heavily corroded;
- Wind bracings are disposed when possible;
- When the bridges are located in the urban area they have an emblematic character for a certain location (Arad, Lugoj, Lipova);

Span L [m]	Year of construction	Location	Type
35.84	1895	Mihăileni	
2x33.68 m	1905	Lugoj	
3x~50 m	Sf. Sec XIX	Lipova	
2x40.8 m	~1920	Câmpeni	

3. VERIFICATION METHOD OF OLD STEEL BRIDGES IN OPERATION

The rehabilitation of bridges represents a complex matter. The Romanian High-way Administration adopted a qualitative verification methodology based on the appreciation by the expert of the technical condition of the structures (AND 522-2002). Following the examination of the existing documentation a simple analysis of the structure is recommended. This can lead to some immediate restrictions in circulation. In situ tests are possible and not as expensive as railway bridges tests. The results can be used for the calibration of the structure. Material tests from elements are useful.
The analysis of technical condition of these bridges can also contain non-destructive tests. They are possible only after the removing of the deck and cleaning of the structure. In this phase a detailed and carefully inspection of the structure by the expert is compulsory.
Taking into account the year of construction, the following assumptions can be made:
- around 1900-1920, mild steel with a low carbon content;
- after 1920 mild steel with the qualities of St37.

Still existing wrought iron bridges were generally replaced immediately after the Second World War.

Charpy tests made with samples from existing bridges are relevant; due to the large dispersions of values; for useful conclusions a large number of Charpy tests are necessary. Generally, steel fabricated in this time (providing from the same steel plants, like Resita or Gyor) has the same qualities as the steel used in railway bridges.

a) %C is situated in the range 0.09…0.16%;
b) The yielding stress is 320 N/mm^2
c) The 27J transitions temperature is around 0…+5 degrees C on Charpy V Notch tests.

A more difficult problem is the fatigue assessment of the structure. Even if the usual standard is for highway bridges this verification is not foreseen, the damage accumulation methodology applied for railway bridges can be adopted. In this direction, for the Wöhler curve the assumptions made by the Swiss Railways for existing bridges can be adopted.

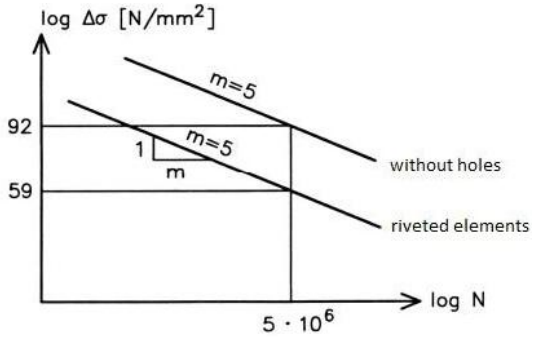

Fig.1 Wöhler Curve

Difficult is the evaluation of the stress history; also the assumption of the same spectrum for bridge life (or for certain periods) must be made. The applied stress range, the geometry of the detail and the number of stress cycles has a decisive effect on the remaining fatigue life of the structure. Information's about the circulation in the different periods are necessary. With the stress history and the appropriate Wohler curve, the accumulated damage can be evaluated using the Miner relation:

$$\mathbf{D} = \sum_i \frac{n_i}{N_i} \leq \mathbf{1}.$$

For bridges with usual spans situated on the National Highway Network, taking into account the circulation in the past, fatigue problems were not decisive. It is worth to mention that the Swiss standard SIA 161 offers a very informative diagram in this sense.

4. CONCLUSIONS

This paper is a pleading for the maintenance of old steel highway bridges from the western part of romania as technical monuments

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ČELIČNI DRUMSKI MOSTOVI U ZAPADNOJ RUMUNIJI

Rezime**:** *U zapadnom delu Rumunije izgrađen je velik broj čeličnih drumskih mostova krajem 19. i početkom 20. veka. Mnogi od ovih mostova su još uvek u upotrebi; no usled lošeg održavanja tehničko stanje ovih mostova je nezadovoljavajuće. Rad predstavlja neke od najvažnijih konstrukcija u ovom delu zemlje i predlaže njihovu dijagnostiku stanja i sanaciju.*
Ista situacija takođe se zapaža i u susednim državama, koje su pripadale nekadašnjem Austrijskom carstvu.

Ključne reči: *drumski most, čelik, održavanje*