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Analysis of existing steel railway bridges

Josef Vičan,[a]* Jozef Gocál[a], Jaroslav Odrobiňák[a], Peter Koteš[a]

[a]*Department of Structures and Bridges, Faculty of Civil Engineering, University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovakia*

Abstract

Railway bridges represent the significant parts of the railways due to their key and strategy position in transportation infrastructure. During the years of exploitation, many degradation processes and external influences attack the bridge structures. Due to those effects their durability and reliability is decreasing depending on time. On the other hand, the traffic load remains almost the same or even higher than in the past. But, bridges should not to become the limiting component of communication capacity and traffic reliability passage. In the period of 2013-14 the collective of the Department of structures and bridges has worked up the Guideline “Determination of load-carrying capacities of railway bridges” [1]. The Guideline was prepared for Slovak Railways and it was also published in the Czech Republic as the methodology instruction [2]. Therefore, the paper describes general concept and basic assumptions for evaluations of existing railway bridges and determining their load-carrying capacities based on the principles of Eurocodes.

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Keywords: Evaluation, existing railway bridge, bridge load-carrying capacity, passage of service load, partial safety factors for loads and resistances

1. Introduction

Since 1960s, a great attention was paid to initiate standardized bridge inspection, evaluation procedures and maintenance strategy to ensure sustainability of railway bridges as the important transportation infrastructure elements. Data collected through these inspection activities formed the basis for computer-based Bridge Management Systems (BMS) [3, 4, 5].

* Corresponding author. Tel.: +421 41 513 5501; fax: +421 41 513 5660.
E-mail address: vican@fstav.uniza.sk

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Evaluation of existing bridges represents the substantial process and source of information relevant from the viewpoint of decision-making processes related to the strategy of bridge maintenance, repair or reconstruction [5]. To be objective, the bridge evaluation should be based on the reliability concept respecting the load-carrying capacity as the basic parameter of the existing bridge reliability. Therefore, evaluation of existing bridge should incorporate not only periodic inspection and subjective assessment of actual bridge condition but also verifying the bridge reliability affected by the actual bridge condition.

From this viewpoint, the bridge evaluation should be considered when significant deviations from the project descriptions are found, when some relevant damage is observed, or when the bridge exceeds its planned service life. Concurrently, the bridge load-carrying capacity is the decision parameter for determining the passage of corresponding railway service load over the bridge.

2. Generally

The below described concept of the determination of load-carrying capacities of existing bridges is fully compatible with the principles of Eurocodes. The Guideline follows the Service handle SR5 [6], valid till publishing the new ones. The structure of the Guideline is consistent with European standards. Firstly, the general parts valid for all types of bridges are introduced. Then, the four Annexes (from A to D) specify the rules for determination of load-carrying capacities of individual bridges according to the materials, of which they are manufactured, i.e. steel bridges, composite steel and concrete bridges, concrete bridges, and masonry bridges, respectively. The Annex E introduces a pattern for the table of summarized load-carrying capacities of bridge members and parts. In the Annex F, the approaches to more precise calculations of the partial safety factors for load effects and cross-sectional and structural member resistances are given.

Two types of the bridge load-carrying capacities are introduced in the Guideline. Normal load-carrying capacity (further load-carrying capacity only) is defined as a dimensionless quantity expressing the ration of the limit effects of variable vertical rail traffic load from the viewpoint of satisfying relevant ultimate or serviceability limit states, to the effects produced by the Load Model 71 (LM71) according to standard [7]. From this definition it is clear, that the load-carrying capacity should be expressed in the form of Rating factor (RF_{LM71}) of variable traffic load represented by the LM71. The newly introduced exceptional load-carrying capacity should be determined by means of analysis of the existing bridge according to approaches and principles presented in the Guideline respecting additional alleviations compared to normal load-carrying capacity.

Relevant bridge administrator or competent authority of Slovak Railways specifies the required category of the bridge load-carrying capacity. According to the precision of methodology used for the load-carrying capacity determination, four categories designated as A, B, C and D are defined in the Guideline. The great attention is paid to the determination of load-carrying capacities of category C and D, which are defined as follows:

- Category C: the load-carrying capacity determined by means of analysis of existing bridge based on its verified actual condition or in the case of a new bridge based on the results of its design analysis
- Category D: the same procedure as for category C has to be done and completed by the experimental analysis of the bridge behavior verifying the correctness and availability of the bridge computational model

The evaluation of the passage of the appropriate service load defined in accordance with the standard [8] represents the relevant result of the determination of the bridge load-carrying capacity. The service load is the general term for line and locomotive categories of railway traffic load with associated speeds and also for special railway track vehicles.

The general part of the Guideline specifies background and relevant principles and rules valid for all types of railway bridges to determine their load-carrying capacities based on the fulfilment of the appropriate criteria of the relevant ultimate and serviceability limit states. It means specification for bridge actions, dynamic effects of the variable traffic loads, partial safety factors for actions, material properties and procedures of determining its design values, methods of the bridge global analyses and procedures for determination of bridge load-carrying capacity depending on its category mentioned above (A, B, C, and D). The procedure how to evaluate the passage of the service load over the assessed bridge based on the comparison of the determined load-carrying capacity to the