Adoption of the response spectra method to calculate the dynamic response of railway-bridges

Tobias MÄHR
DI Dr. techn.
Civil Engineer
Waagner-Biro Stahlbau AG
Vienna, Austria
tobias.maehr@waagner-biro.at

Tobias Mähr, born in 1979, received his civil engineering degree from Vienna Univ. of Technology in 2004. He worked as university assistant and finished his doctoral thesis on bridge dynamics in 2009. Since then, he is structural engineer at Waagner-Biro AG, Austria.

Josef FINK
Univ.-Prof. DI Dr. techn.
Professor
Vienna University of Technology, Austria
josef.fink@tuwien.ac.at

Josef Fink, born 1961, received his civil engineering degree from Vienna Univ. of Technology. 2002-2003 Professor at Univ. Innsbruck.
2004-2008 Visiting Professor at Univ. Innsbruck, Austria. Since 2004 Professor in Vienna for Structural Steel.

Summary

In this paper, a simplified method to calculate the dynamic response of railway bridges under train service is introduced. Response spectrum analysis, which has proved itself in structural dynamics, is adopted for the given problem. If essential parameters like the natural frequency, the mass, the span width and the damping of a bridge are known, the maximum response quantities can be looked up in a diagram. The preparation of the response spectra diagrams is computationally intensive but they provide an easy and quick way to get accurate results. This method is exemplified for single span bridges and the load models defined in Eurocode. However, it is possible to expand the theory on more complex bridge systems and other load models without difficulty. With the aid of this method, the maximum dynamic response of a bridge under moving loads can be calculated in an efficient and convenient way without lacking the accuracy required by the current design-codes.

Keywords: dynamics of railway-bridges, vehicle-bridge interaction dynamics, high-speed railways, simplified methods of calculation, Rayleigh-Ritz analysis, response spectra, modal analysis.

1. Introduction

The calculation of the dynamic response of bridges under moving loads is a computationally intensive and complicated task if it is carried out in time-domain. Although much research has been done into detailed calculation methods and some excellent computer software is available, there is still a need for easy to use tools in everyday practice. For many praxis-related problems, only the maximum or minimum values of displacement, acceleration etc. are required, which allows to analyse the dynamic response in frequency domain. This leads to response spectrum analysis, which is, for example, well known in earthquake engineering [1]. *Savin* [2] uses response spectrum analysis to calculate the response of beams under moving loads on the basis of a single-degree of freedom system (SDOF). Values from a response spectrum are combined with dynamic amplification factors to achieve results in midspan. *Hauser/Adam* [3] introduce biaxial diagrams to calculate the maximum acceleration of beam bridges under moving forces. The acceleration depends on the ratio of the span width L of the beam and the constant distance D between forces. Higher modes of vibration can be taken into account. In the present paper, triaxial diagrams are developed and are referred to as response spectra diagrams. In such a diagram, a specified maximum response value is given for an arbitrary number of load models which may consist of various spaced forces. In section 2, the theoretical background of this method is explained. The procedure how to create a response spectra diagram is shown in section 3 and in section 4 an example is given to demonstrate the advantages compared to previously published methods.

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