Vehicle-bridge interaction: Influence of the train type on the dynamic response of bridges due to a train crossing

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Abstract

This paper investigates the differences between the maximum vertical bridge acceleration during a train crossing when calculated with moving loads and with vehicle-bridge interaction considering a 2D multi-body model. This influence of the interaction is currently defined for the bridge design by an additional damping value, included in Eurocode 1. For investigating the additional damping, multi-body model parameters of 14 real high-speed passenger trains were collected and evaluated statistically as presented in boxplots. This collection builds the basis for the presented results as well as a planned parameter study. The interaction effect is visualized by exemplary resonance plots, showing the overestimation of the additional damping in the current approach for some trains and even a negative additional damping value in case of the ICE 4. Also, it was discovered that there is no correlation of the dynamic bridge response to whether it is a conventional or articulated train.

Keywords: bridge dynamics, railway bridges, train crossing, vehicle-bridge interaction, moving loads, multi-body models, additional damping value

1 Introduction

In general, dynamic bridge design is based on a moving load model of the trains, since this is much less time demanding than calculating the bridge crossing under consideration of the vehicle-bridge interaction. Still, the interaction effect is of importance for dynamic calculations, since it is proved that it contributes to the energy dissipation and generally has a positive effect on the structural responses, especially in case of resonance excitation [1], [2].

Eurocode 1 [3] specifies the additional damping, which can be applied in a simplified moving load simulation in order to include the vehicle-bridge interaction effects for a dynamic analysis of railway bridges, but still allows a time efficient calculation. The additional damping was determined in 1999 by the European Rail Research Institute (ERRI) based on only two vehicles (ICE 2 and Eurostar). The interaction effects were evaluated under consideration of a simplified interaction model, whereas the additional damping is expressed as a function of the span length [4].

As shown in previous research (see Arvidsson et al. [5]), this approach seems to be non-conservative in certain cases. Several calculations with detailed interaction models and different vehicle-bridge