Alternative approach for additional damping in dynamic calculations of railway bridges under high-speed traffic

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Abstract

The consideration of vehicle-bridge-interaction effects can be crucial in the computational determination of realistic dynamic bridge vibrations during high-speed train crossings. In order to implement these effects in calculations with the simplified moving load model, the concept of additional damping of the bridge structure was developed. Besides normative specifications, further numerically and analytically derived approaches are now available for determining the additional damping value. In this numerical study, four different approaches for determining the additional damping are applied to the dynamic calculations of 65 railway bridges. The calculation results are compared with those obtained by applying a more sophisticated multi-body model of the train. The results indicate that applying one of the recently developed approaches can reflect the influence of vehicle-bridge-interaction significantly better than the currently normatively prescribed approach.

Keywords: bridge dynamics; high-speed railway traffic; vehicle-bridge-interaction; additional damping

1 Introduction

The expansion of railway traffic as a highly efficient, economical, and environmentally friendly means of transport plays a central role in achieving the overarching goal of climate neutrality. In this context, the expansion of the existing high-speed rail network led to several challenges for engineers and researchers; One of them is the reliable computational prediction of structural vibrations of railway bridges during high-speed traffic.

There are various calculation models applicable with different levels of complexity, calculation efficiency, and accuracy. The definition of the mechanical model representing the dynamic excitation exerted by crossing high-speed trains proved to be an essential influencing factor on the quality of calculation results of dynamic bridge vibrations. When choosing a vehicle model, different goals are pursued: On the one hand, the selected vehicle model should allow for calculating bridge vibrations as realistic as possible. On the other hand, the computational efficiency and manageability of the model should be preferably high to enable a wide range of applications.

A commonly adopted and straightforward vehicle model is the moving load model (MLM), which simplifies the train to a sequence of axle loads moving over the structure with constant velocity. However, the MLM cannot capture effects due to the dynamic interaction of vehicle and bridge vibrations and can therefore significantly overestimate the structural vibrations, particularly when resonance occurs (among others, described in [1–5]). More sophisticated mechanical models depicting the vehicles as multi-body systems, such as the so-called detailed interaction model (DIM),