Evaluation of Alternative Approaches for Additional Damping in Dynamic Calculations of Railway Bridges under High-Speed Traffic

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Abstract : Planning engineers and researchers use various calculation models with different levels of complexity, calculation efficiency and accuracy in dynamic calculations of railway bridges under high-speed traffic. When choosing a vehicle model to depict the dynamic loading on the bridge structure caused by passing high-speed trains, different goals are pursued: On the one hand, the selected vehicle models should allow the calculation of a bridge’s vibrations as realistic as possible. On the other hand, the computational efficiency and manageability of the models should be preferably high to enable a wide range of applications. The commonly adopted and straightforward vehicle model is the moving load model (MLM), which simplifies the train to a sequence of static axle loads moving at a constant speed over the structure. However, the MLM can significantly overestimate the structure vibrations, especially when resonance events occur. More complex vehicle models, which depict the train as a system of oscillating and coupled masses, can reproduce the interaction dynamics between the vehicle and the bridge superstructure to some extent and enable the calculation of more realistic bridge accelerations. At the same time, such multi-body models require significantly greater processing capacities and precise knowledge of various vehicle properties. The European standards allow for applying the so-called additional damping method when simple load models, such as the MLM, are used in dynamic calculations. An additional damping factor depending on the bridge span, which should take into account the vibration-reducing benefits of the vehicle-bridge interaction, is assigned to the supporting structure in the calculations. However, numerous studies show that when the current standard specifications are applied, the calculation results for the bridge accelerations are in many cases still too high compared to the measured bridge accelerations, while in other cases, they are not on the safe side. A proposal to calculate the additional damping based on extensive dynamic calculations for a parametric field of simply supported bridges with a ballasted track was developed to address this issue. In this contribution, several different approaches to determine the additional damping of the supporting structure considering the vehicle-bridge interaction when using the MLM are compared with one another. Besides the standard specifications, this includes the approach mentioned above and two additional recently published alternative formulations derived from analytical approaches. For a bridge catalogue of 65 existing bridges in Austria in steel, concrete or composite construction, calculations are carried out with the MLM for two different high-speed trains and the different approaches for additional damping. The results are compared with the calculation results obtained by applying a more sophisticated multi-body model of the trains used. The evaluation and comparison of the results allow assessing the benefits of different calculation concepts for the additional damping regarding their accuracy and possible applications. The evaluation shows that by applying one of the recently published redesigned additional damping methods, the calculation results can reflect the influence of the vehicle-bridge interaction on the design-relevant structural accelerations considerably more reliable than by using normative specifications.

Keywords : Additional Damping Method, Bridge Dynamics, High-Speed Railway Traffic, Vehicle-Bridge-Interaction
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