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Dynamic response of a two-axle asymmetric vehicle moving over bridges and applications

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Abstract

In this article, the dynamic response of a two-axle asymmetric vehicle moving over a bridge is studied. Considering that the weight of the vehicle is very small compared with that of the bridge, a two-stage approach is adopted for solving the dynamic response of the vehicle-bridge system. First, by modeling the vehicle as moving loads over the bridge, the analytical solution for the dynamic response of the bridge is obtained in closed-form, which will then be used as the excitation to the vehicle system. Second, by representing the vehicle as a two-degree-of-freedom (TDOF) model, the analytical solution of the coupled vertical and rotational responses of the (asymmetric) vehicle subjected to the bridge vibration are obtained. From the frequency response function (FRF) of the vehicle, various phenomena can be identified and interpreted, including those of coupling, uncoupling, beat, resonance and cancellation. All the results are verified by an independent finite element analysis, which does not rely on any assumptions. The feasibility of extracting bridge frequencies from the dynamic response of the TDOF vehicle moving over a bridge is also exploited theoretically and numerically. Concluding remarks are given for potential applications of the model studied herein.

Keywords: Asymmetric vehicle; Beat; Dynamic response; Resonance; Transmission; Vehicle-bridge interaction.