Influence of Aerodynamic Model Assumptions on the Wind-Vehicle-Bridge Interaction

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Abstract

Wind-induced vibrations are commonly the leading action in the ultimate and serviceability state of the long-span bridges. There is a multitude of aerodynamic models for simulating wind action on a bridge deck based on various theories. Within this study, the influence of the implied assumptions in the aerodynamic models is studied regarding the Wind-Vehicle-Bridge Interaction (WVBI). As a reference object, a suspension bridge under gusty wind is chosen, for which the aerodynamic models are evaluated based on accident and comfort criteria. Different aspects of the WVBI are also included such as road roughness and wind forces on the vehicle.

Keywords: Wind-Vehicle-Bridge Interaction, Long-Span Bridges, Wind-Induced Vibrations

1 Introduction

Flexible long span suspension bridges are prone to wind-induced vibrations. The light weight, low structural damping and aerodynamic shape make this type of structures a true challenge for a structural engineer to determine their response. In the ultimate limit state, high wind speeds are governing for determining section forces and displacements along with checks against instability such as flutter. For the serviceability limit state, the situation is quite different, since prescribed deformation, driving stability and comfort criteria are governing. Usually, these criteria need to be fulfilled for lower wind speeds and depend on the bridge type and its design purpose. Some typical criteria include: limiting the acceleration perceived by drivers and pedestrians, derailment of trains and accident speeds for vehicles. In this paper, the accident and comfort criteria based on acceleration in the cabin and loss of contact for road-wheel for light road trucks are studied passing a suspension bridge excited by turbulent wind. In WVBI, modeling the wind forces can be twofold, namely: the wind forces acting on the vehicle and on the bridge. The first type is commonly done by the quasi-static formulation using predefined static wind coefficients in case of WVBI, while there are many aerodynamic models for the wind forces acting on the bridge. The aerodynamic models for forces acting on the bridge deck due to its motion (self-excited) and incoming turbulence (buffeting) are developed mainly on two theories: the quasi steady and the linear unsteady theory. The first types of models typically include the nonlinear relation between the static wind coefficients and angle of attack, neglecting the rise time of the self-excited and

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