A numerical approach for the assessment of crosswind effects on barrier-protected trains running on bridges

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Abstract

This paper introduces a new methodology to assess the influence of a windscreen on the crosswind performance of trains running on a bridge. Considering the difficulties encountered in both carrying out wind tunnel tests that consider the vehicle speed or complete CFD analyses, a simplified CFD approach is here discussed. Instead of simulating simultaneously the windscreen plus the moving train, the numerical problem is split into two parts: firstly, a simulation of the windshield alone is used to extract the perturbed velocity profile at the railway location; secondly, this profile used as an inlet condition for the wind velocity acting on an isolated train. The method is validated against a complete train plus windshield simulation in terms of pressure distribution and aerodynamic force coefficients on the train, and flow streamlines. This approach opens to the possibility of evaluating the aerodynamic performance of a vehicle on bridges considering bridge and vehicle as separated. Wind velocity profiles measured on the bridge during a wind tunnel campaign could be used as the initial condition for numerical simulations on vehicles.

Keywords: bridge; vehicles; train; windscreen; crosswind; CFD; wind profile.

1 Introduction

Due to the high travel speeds at which they usually proceed, high-speed trains are subject to problems generally not encountered by other vehicles, one above all, the overturning caused by crosswinds. This event must be avoided and to this, standards and test procedures have been defined [1] [2].

The standard for the study of train aerodynamics is to perform wind tunnel tests on stationary models considering the relative wind velocity with changes in the wind angle of attack obtained with models and surrounding rotations. With these configurations, errors are introduced in the analyses considering that the travelling speed of the train is neglected from the equations [1] [3].

Attempts to build an experimental setup with moving models were conducted in the 1990s [4] [5] [6], finding that this type of tests are possible but the difficulties of implementation outclass the gain obtained from the more precise data.

Other critical points are related to the difficulty of maintaining a steady-state condition for a time long enough to consider the recordings statistically valid [7] [8] [9] [10] [11] [12].

Things become way more difficult when the vehicle must run in a flow field perturbed by a bridge with all its attachments, parapets, windshields, and guardrails [13][14].

Recent studies with CFD multi-body instruments on high-speed train demonstrated how the overturning risk rises when the train enters or exits

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