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Influence of windbreak walls on trains against crosswinds

Challenge

High-speed trains are associated with a number of challenges where large steady and unsteady aerodynamic loads can compromise the safety and integrity of the train body. Under strong crosswinds, external aerodynamic pressure changes and forces can cause turbulence and possibly derailment. This causes additional challenges in implementing safety features and measures need to be taken to improve the safety, stability, performance and efficiency of high-speed trains.

Background

Windbreak walls are usually built along railway tracks and are able to reduce the area of the train surface exposed to the oncoming crosswind. This in turn reduces the magnitude of the aerodynamic coefficients acting on the train. In reality, it is not possible to develop an entirely uniform windbreak structure due to possible complexities in the surrounding terrain such as cuttings, which cannot be avoided and this raises massive challenges. Such discontinuities can possibly result in a negative effect along with a loss in ride quality.

Methodology

The purpose of this study is to explore both experimentally and numerically the performance of a passenger train under crosswinds with different types of windbreak walls in order to provide an understanding of the aerodynamic flow. The experimental campaign in this study was carried out in the University of Birmingham's wind tunnel facility while the numerical tests were performed using the various Computational Fluid Dynamics (CFD) simulation software available on the BlueBEAR High Performance Computing (HPC) service.

Results and Conclusions

The stationary experimental data was compared to existing data to determine validity and further verified by comparing the numerical results and experimental results. The numerical simulations were then expanded to test a moving train model in order to assess the relative movement of the train with different windbreak walls along with providing further details of the flow around transition regions in windbreak walls. Overall, the windbreak walls used in this study have proved to be capable in reducing the loads on a train surface significantly even with varying angles of transition regions.

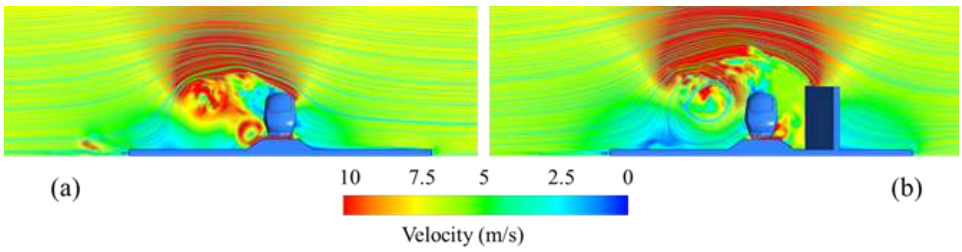

Figure 1: Velocity contours and streamlines for case (a) without the windbreak wall and (b) with windbreak wall at a yaw angle of 90°.

Case study

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Product Used
OpenFOAM
ANSYS CFX and Fluent
ANSYS ICEM CFD
HEXPRESS/HYBRID
EnSight
MATLAB

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University of Birmingham

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