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Large Eddy Simulations of the Flow Around High-Speed Trains Cruising Inside Tunnels

Stability and ride comfort of high-speed rolling stock are, for reasons of external aerodynamics, dependent on the external design in conjunction with properties of the vehicle dynamics and the design of the infrastructure, herein referring to the confining tunnel walls. It is a fact that some Japanese high-speed trains are quite prone to tail vehicle vibrations only inside tunnels, while (to the authors? knowledge) other nation?s comparable train systems are not. In this context the current work describes our results of external aerodynamics, calculated with large eddy simulations, about two simplified train models inside two double track tunnels with comparable blockage ratio. These models are based on the German Inter-City Express 2 and the Japanese Series 300 Shinkansen trains. The focal points of this study are the origin of unsteady aerodynamic tail forces, their spectral characteristics and the impact of spontaneously emerging coherent flow structures adjacent to the train?s surfaces. Full scale tests of the above trains have shown that only the Shinkansen train is subjected to a reduced ride comfort inside tunnels, with a quite obvious lateral vibration at about 2 Hz at top speed (300 km/h). Our unsteady flow calculations have successfully predicted the more detrimental lateral aerodynamic forces. In addition, a spectral analysis of the unsteady side force resulted in a quite prominent frequency at the Strouhal number of 0.09 (based on the speed and height of the train), which correlates well with the Japanese full scale tests.

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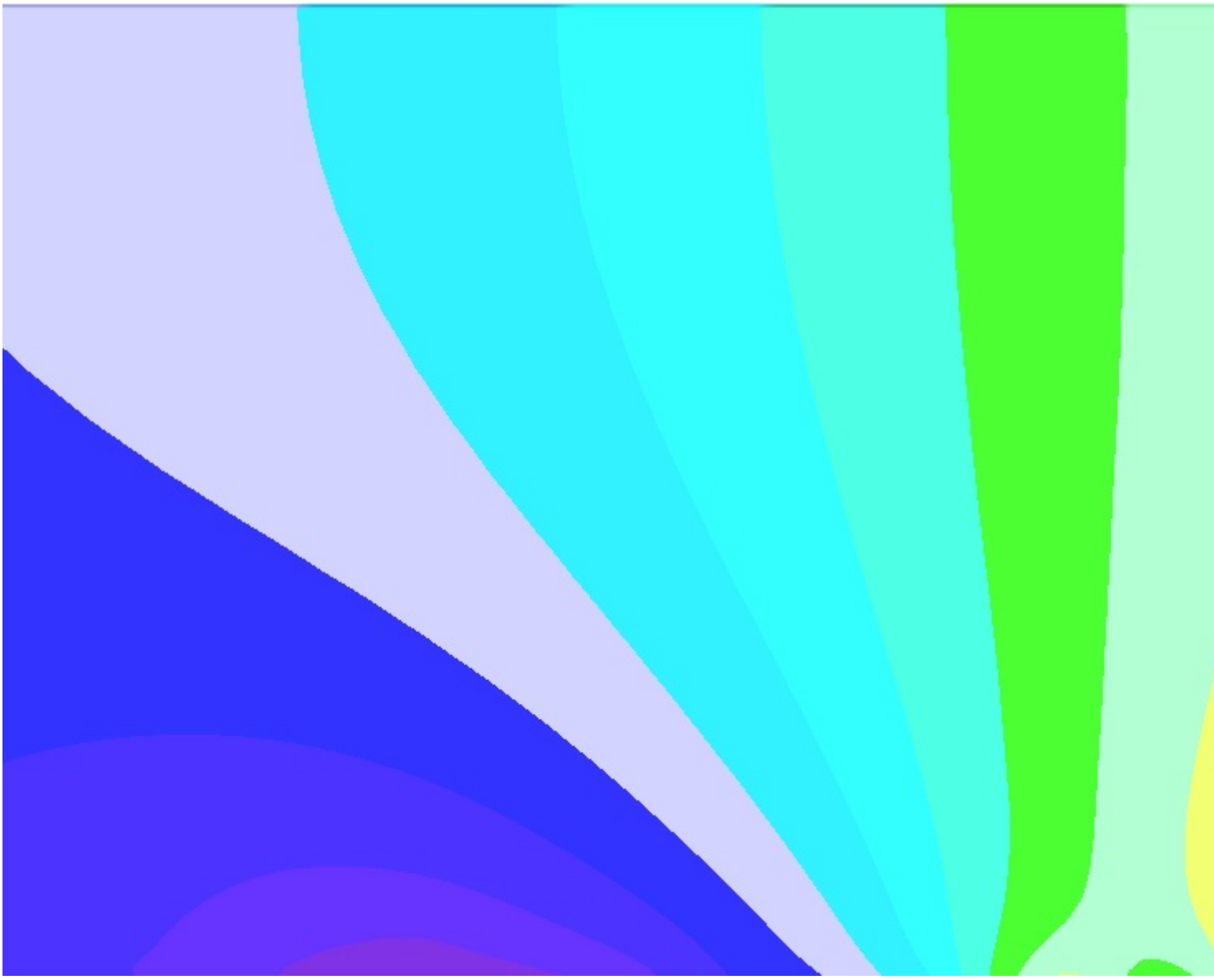
Conference Location:
Jyväskylä
Conference Proceeding PDF:
ECCOMAS04-BombardierTrains.PDF[1]
Conference Date:
Saturday, July 24, 2004
Publisher:
P. Neittaanmäki, T. Rossi, S. Korotov, E. Oñate, J. Périaux, and D. Knörzer (eds.)
Conference Name:
European Congress on Computational Methods in Applied Sciences and Engineering
Image:



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