Evaluation and Improvement of Wind Environment and Vehicle Runnability on Long-span Bridge Deck under Strong Crosswind

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Abstract

Ensuring the safety of various vehicles or trains passing through the bridge deck under strong crosswind is one of the most important topics for a long-span bridge. Based on the project of Xihoumen Bridge, which will remain open to vehicle traffic until the incoming crosswind at the mid span reaches up to 36.5m/s, the wind environment near the deck surface above different traffic lanes were analyzed through numerical simulation and experiment, and the crosswind loadings were evaluated by the equivalent wind velocities for different vehicle models. As the need of adopting appropriate wind barriers to reduce crosswind speed above the deck surface was confirmed, 14 types of wind barriers were evaluated by the crosswind reduction factor, and their effects on the flutter and vortex-induced vibration (VIV) performance of the girder section were also checked. Finally, the optimum solution, an adjustable wind barrier, was proposed.

Keywords: wind environment; vehicle safety; long span bridge; strong crosswind; flutter; vortex-induced vibration; drag force; wind barrier.

1 Introduction

To meet with the need of economic and social development for an advanced transportation network, more and more long-span bridges have been planned or already built in the eastern coastal areas of China. Most of these bridges are sea-crossing passages over navigational channels and located in wind prone areas, which results in the requirements of large span, high elevation and elaborate wind-resistant design. Aerodynamic instability, beyond any doubts, is the first and foremost concern in the design of a long-span bridge in a wind prone area [1]. After the aerodynamic safety has been secured, one of the most important topics for a bridge engineer is to ensure the safety of various vehicles or trains passing through the bridge deck under crosswind, which may experience overturning, sideslip or rotation accidents.

When the incoming wind passes through a bridge girder, the wind velocities at different locations around the girder section generally will not keep the same value with the incoming flow speed. So the wind environment near the deck surface, in particular, the crosswind velocity profiles above six traffic lanes, should be determined. If the equivalent wind velocities defined based on the crosswind velocity profiles exceeds corresponding wind speed criterion of vehicle driving safety, it is appropriate to adopt wind barriers to reduce crosswind speed above the deck surface.

On the other hand, since the installation of wind barrier will change the air flow pattern around a girder section, it will certainly affect the

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