Probabilistic Assessment of Vehicle Driving Safety under Strong Winds – Cause Investigations on Two Sea-Crossing Bridges

Ho-Kyung Kim, Hyeong-Yun Cheon

Seoul National University, Seoul, Korea Rep.

Sejin Kim

FAMU-FSU College of Engineering, Tallahassee, USA

Contact: hokyungk@snu.ac.kr

Abstract

The strong side winds threaten the stability of running vehicles over the sea-crossing bridges due to the high altitude of the deck and free exposure to the upcoming winds. Therefore, bridge operators control the speed limit or close the bridges when the wind speed reaches predetermined criteria. Since the sea-crossing bridges play an essential role in transportation networks, the traffic control strategy, including complete closure, requires a careful assessment of the critical wind speed at which vehicle instability can occur. As the aerodynamic forces on vehicles depend on several influence factors, including the geometrical shape of the superstructure, the critical wind speeds variate bridge by bridge. This study demonstrates a framework to determine the critical wind speed. This study reports two overturning accidents experienced in a double-deck suspension bridge and a cable-stayed bridge. By applying the proposed framework to the cases, the authors successfully explained the cause of accidents. For this investigation, the authors used a wind tunnel measurement of aerodynamic loads on vehicles and the vehicle dynamics to determine critical wind speed curves. The authors also extended the procedure to the probabilistic risk assessment by adding the long-term wind data analysis of the bridge site. In this way, this study provides a guideline for bridge operators on balancing the driving safety and the continuous mobility of the sea-crossing bridges under hazardous high wind conditions.

Keywords: driving safety; traffic control; strong wind; probabilistic assessment; sea-crossing bridge; short-term wind prediction.

1 Introduction

The Korean peninsula is on the typhoon path, and the sea-crossing bridges are often subject to strong side winds. The total number of cable-supported bridges has increased to reach more than 90. Generally, those bridges are closed at a wind speed of more than 25 m/s on a 10-minute average. However, several bridges also have speed control protocols based on experiences or other benchmarks.

Even though there is a speed control protocol for each bridge, the bridge operators have difficulties taking timely actions for several reasons. The bridge closure requires pre-discussion with the police department in advance and preparation time on site. Also, the wind speed fluctuates all

https://doi.org/10.2749/nanjing.2022.0028
Distributed by structurae