Flutter Fragility Analysis of Long-Span Bridges Based on 3D Typhoon Model Using Geographically Weighted Regression

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Abstract

The long-span bridges in coastal region of China exposed to the challenge of typhoon-induced flutter instability with the continuous increase the span length and flexibility of bridges. A Monte-Carlo-technique-based framework to analyse the flutter fragility long-span bridges subjected to typhoon winds is developed. A 3D typhoon boundary layer wind field model and a geographically-weighted-regression (GWR) -based stochastic track model are proposed to generate a large quantity of synthetic tracks around the bridge site before achieving the typhoon wind hazard curves at the height of the bridge deck. The flutter critical wind speed of the bridge is derived accounting for the structural modal and damping randomness as well as experiment-induced errors of aeroelastic flutter derivatives. The typhoon-induced flutter failure probabilities of the bridge are then predicted and compared with code-suggested target reliability indices.

Keywords: typhoon; long-span bridge; flutter; fragility; geographically weighted regression; uncertainty; extreme wind speed; probability of failure; reliability index.

1 Introduction

The aerodynamic flutter instability issue of long-span bridges has received intensive attention since the collapse of the 853.4 m-main-span Old Tacoma suspension bridge in 1940. As a divergent motion that would lead to catastrophic failure of the bridge, flutter is the top priority issue during the wind-resistant design process. Recently, the advanced high-strength materials, progressive technologies of construction and continuous improvements of design theory have allowed the main spans of bridges to be longer than 2 km or even reach 5 km to cross wide canyons, rivers and straits [1-2]. The risks of wind-induced aeroelastic instability for such extremely slender and flexible structures should be carefully evaluated,

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