Probability-based Vulnerability Assessment of Cable-stayed Bridges

Dong YAN
Civil Engineer
Beijing, CHINA
d.yan@rioh.cn

Yan Dong, born 1979, received her PhD degree in civil engineering from the Hong Kong University of Science & Technology, Hong Kong. She worked for the RIOH transport Consultants Ltd., Research Institute of Highway Ministry of Transport. Her main area of research is related to bridge risk assessment.

Summary

Vulnerability of a structure under terrorist attack can be regarded as the study of its behavior against blast-induced loads. In this study, a vulnerability assessment framework is proposed for cable-stayed bridges in the probabilistic domain. The framework consists of two stages: determining the probability of direct damage due to blast loads and assessing the subsequent probability of collapse due to component damage. In the first stage assessment, damage of the bridge component is defined as the exceedance of a predefined limit state such as displacement or yielding. The second stage assessment further calculates the probability of collapse due to direct damage of some component via an event tree approach. It is seen that the proposed methods provide a quantitative tool for analyzing the vulnerability performance of cable-stayed bridges under terrorist attack.

Keywords: Blast loads; Bridges, cable-stayed; Damage; Collapse; Probability

1. Introduction

Since the terrorist attack on the World Trade Center in 2001, the world has been facing a growing number and intensity of such catastrophic events. Recently, increased attention has been given to bridges, which are crucial to our nation's transportation infrastructure. A strategically placed truck bomb on a critical bridge could result in significant loss of life and significant structural damage. Therefore, bridge engineers now face new and urgent challenges to improve the design of structures to withstand the extreme loading condition.

The vulnerability of the critical bridges represents the system sensitivity to the unforeseen terrorist attacks. And a structure is described as vulnerable if a relatively small damage leads to a disproportionately large consequence (Agarwal et al. 2003). In real world engineering applications, the uncertainties of the structural parameters are inherent and the scatter from their nominal ideal values is in most cases unavoidable. The uncertainties play a dominant role in structural performance, thus the deterministic approach may have the possibility of leading to unreasonable and unrealistic results. The way to assess this influence is to perform probability-based structural vulnerability assessment to complement the shortcomings of the deterministic approach and get more reasonable and realistic bridge evaluation. The concept of vulnerability or fragility in a probability-based manner is derived from the seismic performance-based design (PBD) approach proposed by the Pacific Earthquake Engineering Research center (2004). Vulnerability here is defined as the probability of having specific level of damage given a specific level of hazard (Chen and Lui 2005). Elnashai et al. (2004) used deformation-based functions to assess the vulnerability of transportation structures under seismic effects. The vulnerability functions for reinforced concrete bridges were derived analytically using earthquake records and inelastic dynamic analysis techniques. Lee and Rosowsky (2006) have taken the snow load effect into account in a seismic

https://doi.org/10.2749/222137810796012180
Distributed by structurae