Chapter 16

Structural Health Monitoring: Vibration-Based Damage Detection and Condition Assessment of Bridges

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ABSTRACT

Structural health is a vital aspect of infrastructure sustainability. As a part of a vital infrastructure and transportation network, bridge structures must function safely at all times. However, due to heavier and faster moving vehicular loads and function adjustment, such as Busway accommodation, many bridges are now operating at an overload beyond their design capacity. Additionally, the huge renovation and replacement costs are a difficult burden for infrastructure owners. The structural health monitoring (SHM) systems proposed recently are incorporated with vibration-based damage detection techniques, statistical methods and signal processing techniques and have been regarded as efficient and economical ways to assess bridge condition and foresee probable costly failures. In this chapter, the recent developments in damage detection and condition assessment techniques based on vibration-based damage detection and statistical methods are reviewed. The vibration-based damage detection methods based on changes in natural frequencies, curvature or strain modes, modal strain energy, dynamic flexibility, artificial neural networks, before and after damage, and other signal processing methods such as Wavelet techniques, empirical mode decomposition and Hilbert spectrum methods are discussed in this chapter.

DOI: 10.4018/978-1-61692-022-7.ch016
INTRODUCTION

Bridge structures are regarded as very important components of transportation networks. Any damage or even collapse of bridges resulting from their poor performance disrupts transportation systems and directly results in the tragedy of life and property loss (Rantucci & Seismology, 1994; Sohn, 2003).

Many bridges in Australia built several decades ago, are suffering deterioration with age, and now subjected to heavier and faster moving loads than those under which they were designed. Some bridges which are being refunctioned for changed transportation conditions could undergo load pattern changes, too. For example, the Victoria Bridge in Brisbane (Queensland, Australia) has been reconfigured to accommodate bus lanes on one side (Figure 1) (Todd & Rodney, 2005), and this accommodation leads to asymmetrical load to the bridge structure. Such factors can result in localised distress and, if not monitored, bridge failure with tragic adverse consequences could cause disruption to normal life and costly renovation.

The retrofit and reconstruction of bridges are always costly for infrastructure owners. On the other hand, every civil structure, no matter what materials have been used, has a limited life. This life cannot be accurately determined, given the uncertain variation in environmental conditions and changing bridge functions. Structural health monitoring (SHM) is a considerably cost-efficient way to maintain the infrastructures and diagnose damage at an early stage. It is imperative to guarantee the safety and efficiency of bridge structures throughout their life spans or beyond by monitoring their health condition and, accordingly, undertaking appropriate maintenance. Normally, SHM assumes that the structural health of a bridge can be evaluated through observing the changes in its vibration properties. This is the most cost effective means of preventing bridge failure and ensuring their safe and efficient performance.

TRADITIONAL DAMAGE DETECTION

The traditional damage detection strategies consist of visual inspection and localised non-destructive

Figure 1. Asymmetrical vehicle loads on Victoria Bridge–Busway accommodation
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