Signal stationarization technique in output-only damping identification

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Abstract

The aim of this study is to propose the enhanced damping estimation process with output-only system identification technique by signal stationarization algorithm using amplitude-modulating (AM) function. First, a series of field measured data was analysed to demonstrate the effect of nonstationarity in operational monitoring data from cable-supported bridge. Next, in order to eliminate an effect of nonstationarity due to a traffic loading, AM function was calculated by the temporal root-mean-square function of measured responses. The approximated stationary process was extracted by dividing the sample record by envelop AM function. For the verification of the proposed techniques, a signal stationarization algorithm was applied to the measured acceleration response from cable-stayed bridge. After then, a damping ratio of cable-stayed bridges was estimated by applying Natural Excitation Technique combined with Eigensystem Realization Algorithm (NExT-ERA) to the stationarized signal obtained from 3-day ambient vibration data. To show the enhanced performance of the proposed procedure for damping estimation, the mean and coefficient of variance (COV) of estimated damping ratio were compared with/without signal stationarization process. The amplitude-dependency of estimated damping ratios was also analysed according to applying a signal stationarization.

Keywords: damping estimation; operational modal analysis; nonstationary; signal stationarization; cable-supported bridge

1 Introduction

The modal damping ratio is most important parameters in serviceability assessment of flexible bridges (Seo et al., 2013; Park et al., 2016), which can only be estimated after a bridge construction is being completed. Although a forced vibration test is the most confidence method to estimate damping ratio, it is not feasible during bridges in service due to high costs. Accordingly, operational modal analysis (OMA) is widely used to estimate modal properties. In contrast to natural frequency or mode shape, damping estimation is still challenging with large error bounds due to several issues (Rainieri and Fabbrocino, 2014;).

One of the reasons for large error bound is nonstationary in loading. OMA, which is performed without loading information, generally assumes that input loading is stationary Gaussian white noise. In reality, however, the main loading sources for civil structures are nonstationary loadings such as earthquake, extreme wind or traffic loading, causing nonstationary responses (Feng et al, 2006; Guo et al, 2012; Lin et al, 2013).

This research focused on the nonstationarity due to the traffic loading which is the main loading source of cable-supported bridges (Kim et al., 2005, Kim and Kawatani 2008). At first, the effect of traffic loading was examined using the operational monitoring data of the suspension bridge shown in

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