8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

DAMAGE DETECTION IN CONTINUES BRIDGE DECK AND ASCE BENCHMARK VIA INSTANTANEOUS ENERGY METHOD

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Keywords: Damage detection, Structural health monitoring, Instantaneous responses, Energy index, ASCE benchmark

One of the main concerns for structures and infrastructures is their inspection via the Structural Health Monitoring (SHM) approaches to ensure their functionality and/or performance. Structures are exposed to natural hazards and manmade accidents in their lifetime, which may cause serious damages. In order to detect theses defects SHM is an efficient tool to ensure structural safety and protection (Pierdicca, 2016). One of the major challenges of current engineering knowledge is to obtain low-cost SHM especially after the occurrence of an accident (Xu & Xia, 2011). SHM aims to detect real characteristics of a system and detecting its possible damage. This may be due to changes in geometric characteristics, material modifications, or reductions in cross-sections and so on. Among various SHM approaches, health monitoring of infrastructures (ISHM), especially bridges has been presented more challenges for engineers. In modern societies, ISHM as an efficient tool can play a significant role in the maintenance and safety of bridges. Its main purpose is to be a part of the structural maintenance schedule to evaluate their real performance against unexpected environmental disasters (Wong, 2004; Abe & Fujino, 2009).

This paper attempts to propose a new damage detection procedure for continuous deck bridges and also the three-dimensional framework of the ASCE benchmark structure. First, by utilizing HHT, the instantaneous amplitude and frequencies of the measured acceleration responses are extracted for both healthy and damaged cases. Then, by introducing the instantaneous amplitude energy damage index (EDA) and the instantaneous frequency energy (EDI), the location of damages are detected. To assess the feasibility and reliability of the proposed methods, several analytical models of concrete bridges of one and two-spans, and the ASCE benchmark problem have been used. To consider the robustness of the proposed method, contamination of signals during the data acquisition process is investigated. The results in the analytical and experimental models showed that the proposed methods can determine the damage locations with appropriate accuracy for different damage scenarios and it may provide reasonable results for rapid estimation.

DAMAGE DETECTION METHOD

According to the change in the instantaneous frequency signal energy and amplitude, EDI index is defined as follows:

$$EDI_i = \frac{(Ef_h)_i - (Ef_d)_i}{(Ef_h)_i} \qquad i = 1,2,\ldots,\mathrm{m} \tag{1}$$

where Ef_h and Ef_d are the instantaneous frequency signal energy for healthy and damaged cases, respectively. m is the number of sensors. The higher the EDI index locates the situation of that sensor close to damages. The EDA index uses the instantaneous amplitude instead of the instantaneous frequency in Equation 3.

ANALYTICAL MODELING AND DISCUSSION

The phase I of the ASCE benchmark study is modeled using a finite element model involves different damage levels. To use acceleration and displacement responses, the ASCE Benchmark model was simulated by using SAP2000 and a random noise was applied for the excitation load. Besides, the two continues Deck Bridges was also modeled for the second analytical modeling.

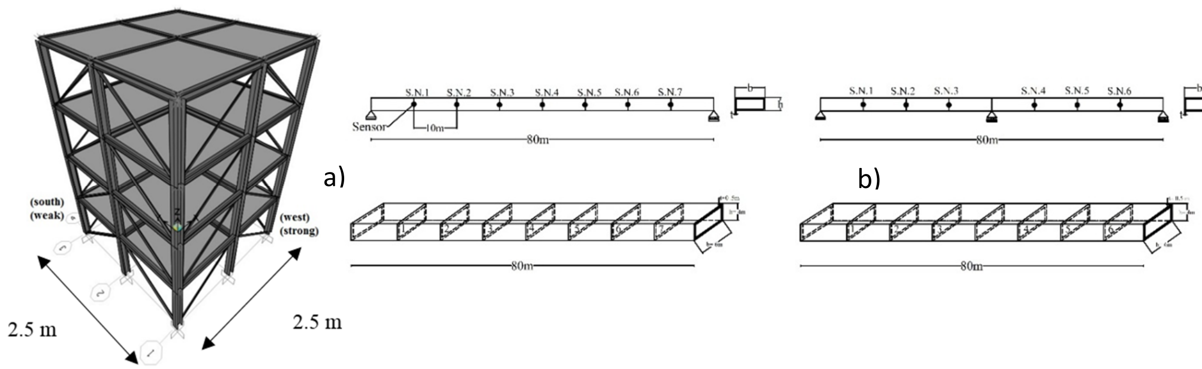

Figure 1. a) Analytical model of the ASCE benchmark and; b) Three-dimensional and front view of single-span, and two-span bridges.

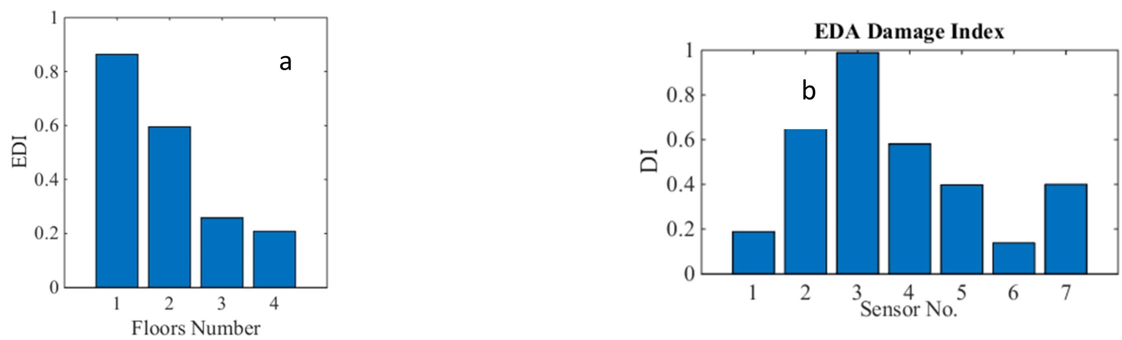

Figure 2. a) EDI damage index for damage case (a), and b) EDA damage index for damage scenario 1 of single-span bridge.

In Figure 1-a, the EDI damage index is evaluated when all the first floor braces in the ASCE structure are broken. Due to the loss of the first-floor braces and the difference between responses, the amount of instantaneous frequency energy is increased and the EDI index shows an increase in the energy level of the damage location in the first floor. In Figure 1-b, the EDA damage index for a single-span bridge is calculated with a 40% damage rate between points two and three. Due to the reduction of stiffness which caused by damage at points two and three, the difference in responses is shown in the form of an increase in the instantaneous amplitude energy in sensors numbers two and three. Consequently, the damage location is shown correctly. Based on the results, it was found that the damage indices have more reliability, proper accuracy for damage detection in analytical and experimental models.

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