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EXTENDED ABSTRACT

Endurance Time Method for Seismic Assessment of Isolated Bridges Equipped with Active and Semi Active Control Systems

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1. Introduction

The present study has been performed aiming to appraise the efficiency of endurance time method for evaluation of some vibration control methods in comparison with traditional time history dynamic analysis. Endurance Time method is a dynamic structural analysis that evaluates structural responses under different intensities. In this method structure is subjected to an intensifying predefined acceleration function and different damage indices of structure are evaluated through analysis time. The Endurance Time acceleration function have been generated for different spectra, such as ASCE07 design spectrum, in previous researches of ET group. Due to its inherent dynamic nature, there is no restriction on its application and it can be applied to any structure with any plan or height or any degree of freedoms. Furthermore, it can be used in linear or nonlinear analysis also it can significantly reduce computational demand compared to time history analysis. In this research the Endurance Time method has been applied to an isolated bridge with different control systems such as Active, Semi Active and Passive by using classical linear quadratic regulation (LQR) algorithm and Sliding Mode control (SMC). Two approaches including LQR and pole assignment method have been used for determination of sliding surface as an important parameter in SMC algorithm. The effectiveness and robustness of SMC and conventional LQR control to reduction in displacement response of the structure have been verified by different researchers. Viscous dampers with two different dissipation rate of $c_{vmin} = 1\text{MN/m}$ and $c_{vmax} = 4\text{MN/m}$ have been considered as two passive control mechanisms. When these bridges are subjected to ground motion with large intensity, the deck displacement becomes excessively large so in this study, different control strategies are used to mitigate this phenomenon. Sliding Mode control with LQR approach has provided the best efficiency in dynamic response mitigation. Herein, the column-isolator-deck system has been idealized as two-degree-of-freedom lumped mass system. To evaluate its seismic behavior, a set of seven suitable records is selected and a wavelet-based procedure has been used to match their spectra with a target spectrum. These records are used for the comparison of the results of Endurance Time analysis with nonlinear time history analysis as a verified method. Results indicate that the Endurance Time method is capable of predicting the seismic behavior of isolated bridge with different control systems within acceptable accuracy. Considerable variance in the analyses result under ground motion records necessitates to apply numerous records to get reliable results while it is possible to attain close estimates using endurance time method. Although ground motion records and endurance time method both have resulted in similar trends for structural displacement response with different control approaches, results are more dispersed for different earthquake records with standard deviation of 1.2 up to 3.36 but this parameter decreases using endurance time method to 0.35 up to 1.58 and this method provides an accurate and time saver tool to evaluate the performance of structural vibration control methods under seismic excitations.

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2. Modeling and analysis

2.1. Isolated Bridge Analysis Model

In this study a five-span continuous isolated viaduct designed based on Japan Design Specification of Highway Bridges is analyzed to investigate the effectiveness of structural control. The column-isolator deck system is idealized as two DOF lumped mass system. The column and the isolator are assumed to be perfect elastoplastic and bilinear elastoplastic, respectively. For both the column and the isolator the Bouc-Wen (Faycal and Joze 2007) hysteretic model is used to measure the stiffness restoring force. A schematic representative of the model is shown in Fig. 1.

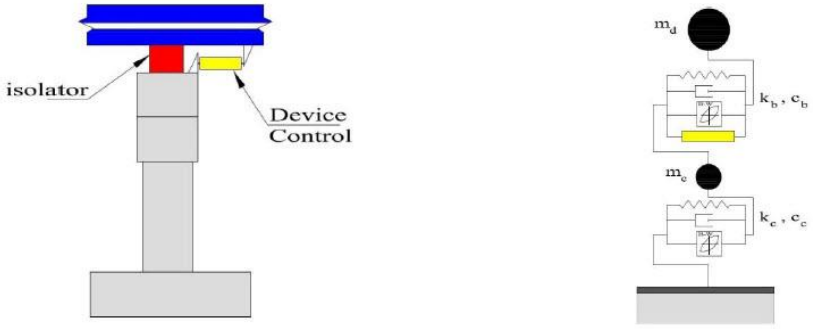

Fig. 1. Left: a schematic representative of the model right: the mathematical model of the bridge

The parameters used for Bouc-Wen model is listed in Table 1.

Table 1. Bouc-Wen model parameters used in isolated bridge (Lee and Kawashima, 2006)

`	Initial Stiffness $k_i\left(\frac{MN}{m}\right)$	Yield Dis. $D_{yi}(m)$	Bouc-Wen Model Parameters				
			α_i	A_i	β_i	γ_i	n_i
Column	112.7	0.0309	0	1	0.5	0.5	95
Isolator	47.6	0.016	0.191	1	0.5	0.5	95

2.2. Scaling of Ground Motions and ET Functions

A set of seven record is selected from FEMAp695 to investigate the capability of ET functions. These ground motions are scaled in such a way that the spectrum of each individual record matches the design spectrum at by the means of wavelet analysis in frequency-time domain. These spectrum matching is based on proposed algorithm by lilhanand and Tseng.

3. Results and discussion

The main purpose of these control systems is to reduce the structural responses. Here, the most important response parameter is deck displacement. For both GM and ET function the mean and standard deviation of the response is calculated. For the GM the average maximum results seven scaled GM is considered while in order to determine the maximum response for in ET method, maximum absolute value of the response up to the intended time is calculated. Fig. 2 shows the maximum deck displacement under different control system for both analysis methods.

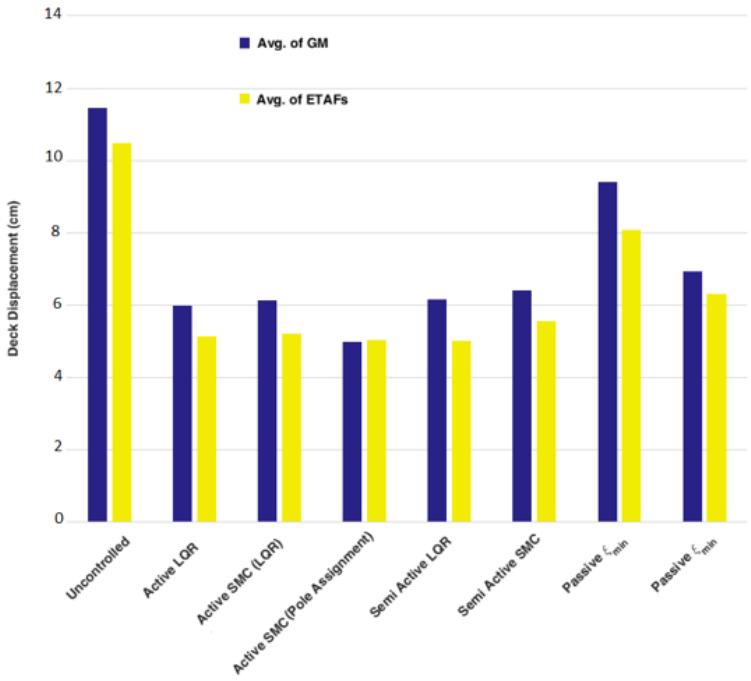

Fig. 2. Average of maximum deck displacement in time history analysis and ET method

4. Conclusions

In this paper, the effectiveness of ET method in different control systems has been studied for a nonlinear isolated bridge and the results of ET method and traditional time history were compared with each other. Simulation results indicates that ET method is capable of predicting the seismic response of isolated bridge under different control systems with acceptable accuracy. This method avoids the major pitfall in time history analysis, which requires selecting or generating of time history ground motions compatible with target response spectrum; while it has no limitation in modeling different structures with different complexity.

5. References

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