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Dynamic Analysis of Earth Dams under De-Noised Earthquake Records

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ABSTRACT: In this study, the dynamic behavior of earth dams with clay core was analyzed using the finite element method. The seismic responses of earth dams under main and wavelet-based decomposed earthquake records were investigated. Earthquake records were decomposed up to five stages by using the wavelet de-noising method. The ratio of acceleration response spectrum to maximum acceleration, ratio of velocity response spectrum to maximum velocity, ratio of displacement response spectrum to maximum displacement, Fourier amplitude spectrum and time history of Arias intensity of earth dam crest under main and wavelet-based decomposed earthquake records were analyzed. The results demonstrated that the acceleration response spectrum ratio of dam crest under de-noised records up to 3rd level and the velocity and displacement spectrum ratios of dam crest up to 4th level has an acceptable accuracy in comparison to the responses under main earthquake records. Results of the dynamic analysis indicated that Fourier amplitude spectra and Arias intensity of earth dam crest under de-noising based records up to 4th level are compatible with main earthquake records. The results also showed that the wavelet-based decomposed earthquake records can be a reliable alternative for main earthquake records in the dynamic analysis of earth dams.

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1. INTRODUCTION

Evaluating the dynamic behavior of earth dams under earthquake loading has great importance. Some researchers have argued that there are various methods for the dynamic analysis of earth dams [1-3]. The effects of dam reservoir interactions and valley geometry on the seismic response of the La Villita embankment dam were investigated by Pelecanos *et al.* [4]. Some experiments, such as shaking Tables [5] and centrifuge [6] were used to examine the seismic behavior of earth dams. The results of the study on the dynamic behavior of concrete faced rockfill dam (CFRD) that provided by Xu *et al.* [7], revealed that acceleration response and seismic-induced deformations are influenced by rockfill characteristics. Seismic deformations and settlements of embankment dams have been extensively studied by some researchers [8-11]. Wavelet transform (WT) is one of the powerful methods for the analysis of signals. In this study, the seismic response analysis of the earth dam under two types of earthquake loading was investigated. The earthquake loading includes main and decomposed records. The decomposed records were obtained from the de-noising method based on the wavelet theory. The ratio of acceleration response spectrum to maximum acceleration, the ratio of velocity response spectrum to maximum velocity, the ratio of displacement response spectrum to maximum displacement, Fourier amplitude spectrum, and time history of Arias intensity of earth dam crest were explored.

2. METHODOLOGY

One of the powerful mathematical tools used in signal processing is wavelet transform (WT). Wavelet theory has been widely used in civil engineering such as the process of earthquake records [12]. There are two types of wavelet transform such as discrete wavelet transform (DWT) and continuous wavelet transform (CWT). In the de-noising method (DNM), the main earthquake is divided into low and high frequencies without downsampling.

The seismic response analysis of the earth dam under the main and decomposed earthquake records was performed using the Plaxis program. For this purpose, the acceleration time history of 8 earthquake records with different magnitudes was selected as the main records. It is shown in Table 1.

To decomposition, first, the earthquake records were decomposed up to 5 stages by utilizing the de-noising method (DNM) based on the wavelet. Two types mentioned records (main and decomposed records) were applied as input ground motions to the earth dam model. In the numerical modeling, the elastoplastic constitutive Mohr-Coulomb was utilized for describing the soil behavior of core and shell and the linear elastic model was used for dam foundation.

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Table 1. Earthquakes used in dynamic analysis

Number	Earthquake	Year	M_w
1	Abhar	2002	6.4
2	Imperial Valley	1979	6.5
3	Rudsar	2004	6.4
4	San Fernando	1971	6.6
5	Kobe	1995	6.9
6	Kocaeli	1999	7.6
7	Loma Prieta	1989	6.9
8	Hollister	1961	5.5

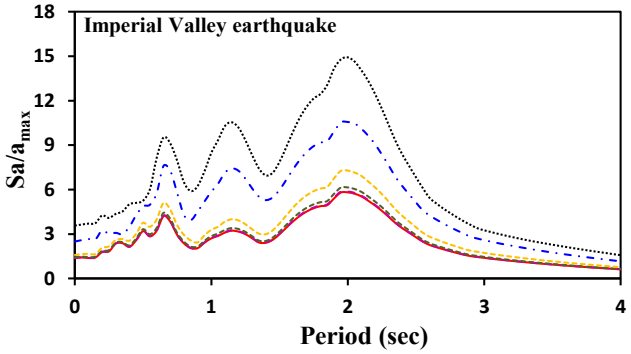

Fig. 1. The ratio of acceleration response spectrum

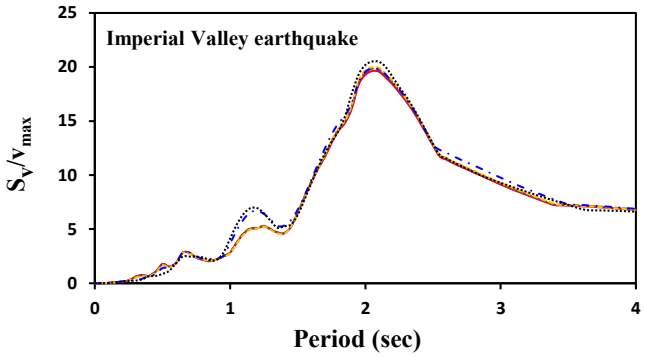

Fig. 2. The ratio of velocity response spectrum

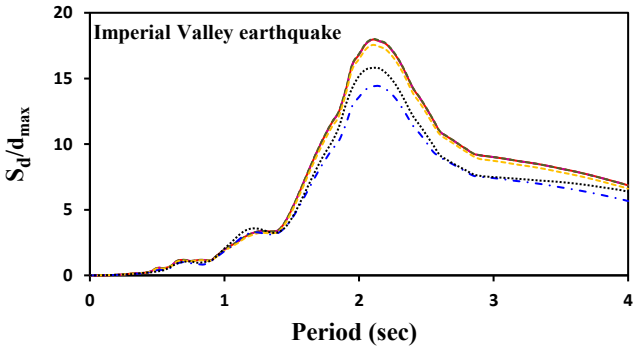

Fig. 3. The ratio of displacement response spectrum

3. RESULTS AND DISCUSSION

The ratio of acceleration response spectrum to maximum acceleration (S_a/a_{max}) is presented in Fig. 1. As seen in this Figure, the S_a/a_{max} based on the de-noising method up to the 3rd level is greatly compatible with the S_a/a_{max} under the main earthquake record.

Figs. 2 and 3 respectively show that the ratio of velocity response spectrum to maximum velocity (S_v/v_{max}) and the ratio of displacement response spectrum to maximum displacement (S_d/d_{max}) have an acceptable accuracy up to the 4th level decomposition.

4. CONCLUSION

In this paper, the earth dam with the height of 50 m under the main and denoising-based records was analyzed seismically. The ratio of acceleration response spectrum to maximum acceleration (S_a/a_{max}), the ratio of velocity response spectrum to maximum velocity (S_v/v_{max}), the ratio of displacement response spectrum to maximum displacement (S_d/d_{max}), Fourier amplitude spectrum, and time history of Arias intensity of earth dam crest was calculated. Comparisons indicated that the ratio of acceleration response spectrum to maximum acceleration (S_a/a_{max}) up to the 3rd levels of decomposed records is consistent with the results of the main records. Comparing the S_v/v_{max}, S_d/d_{max}, and time history of Arias intensity obtained from dynamic analysis under de-noising decomposed earthquake records had an acceptable accuracy in comparison with those of the dam crest under the main earthquake records up to levels 4. Therefore, it can be concluded that the records based on the de-noising method can play the role of main earthquake records.

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