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Spectral analysis of structures using wavelet theory and concept of time of strong ground motion

Noorollah Majidi[1,*] , Ali Heidari[2]

[1] Student of Master of Civil Engineering, Shahrekord University
[2] Associate Professor of Civil Engineering, Shahrekord University

ABSTRACT: In this paper, for the first time, the simultaneous analysis of wavelet transformation and the concept of the time of strong ground motion in spectral analysis of structures has been used. The purpose of this research is to optimize the calculations related to the main earthquake spectrum. Accordingly, the earthquake is filtered up to 5 steps. At each stage, the filter provides two waves of approximations and details. Because the wave of approximations is closer to the original earthquake, this wave is used for calculations. For this reason, at each stage of the filter, the number of earthquake records is half past. Subsequently, based on the concept of the time of strong ground motion in the wave of the main earthquake and the wave obtained from the wavelet filter, part of the earthquake that has a strong movement is separated. So at this stage, there was a reduction in earthquake records. After that, the spectrum of each of the waveforms is plotted. At the end, a two-dimensional 10-story structure and a three-dimensional five-story structure with each spectrum obtained from two discrete wavelet concepts and the duration of a strong ground motion are analyzed. The results show that by reducing the computation of the spectrum by more than 93%, the structure can be analyzed with an error less than 4%. It can be said that the proposed technique is one of the best techniques presented in the optimization of calculations related to spectral analysis of structures.

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1. INTRODUCTION

Given that the volume of computations is high in the method of time history analyzing history, spectral analysis is used instead [1-3]. Although wavelet transformation is 23 years old [4], but its history in the dynamic analysis of structures dates back to about 16 years ago [5-6]. The best way to analyze earthquake wave is wavelet transform. The wavelet transform is divided into two groups: continuous and discrete. Given the nature of the acceleration of the earthquake mapping, the wavelet discrete transformation is more appropriate [6]. In this paper, for the first time in order to obtain the acceleration spectrum, the combination of two concepts of the duration of a strong ground motion and a discrete wavelet transform is used. In this regard, at first, the acceleration of the earthquake mapping is filtered up to 5 steps. At each stage of the wavelet filter, an approximate wave and a wave of details are obtained. Then, the duration of the strong ground motion is obtained in different ways. In the next stage, a part of the approximate wave that is related to the time of the strong ground motion is separated. In the next step, the acceleration spectrum is plotted based on the duration of the strong movement. At the end, the structure is also analyzed using the spectrum. In the next step, the acceleration spectrum is plotted based on the duration of the strong movement. At the end, the structure is also analyzed using the spectrum.

*Corresponding author's email: noorollahmajidi1373@gmail.com

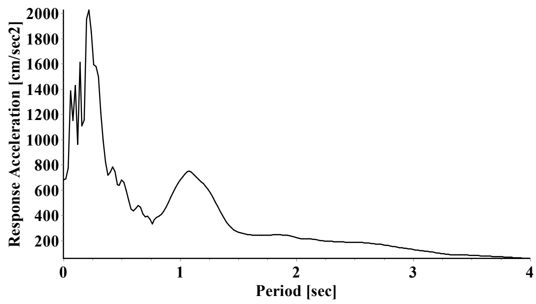

Fig. 1. Major earthquake spectrum

2. MAJOR EARTHQUAKE SPECTRUM

The response spectrum is the maximum graph of a selective response (such as displacement, velocity, or acceleration) versus the natural vibration time of the system (or related quantities, such as periodic frequency) [7]. In Fig. 2 the main earthquake spectrum is shown.

3. DURATION OF STRONG GROUND MOTION

The time of a strong ground motion is a parameter that at that time, there is dominant earthquake energy to vibrate a structure. This parameter is also important in nonlinear analyzes. The first definition for this parameter is called the bracketed time period, which is the time between the first and

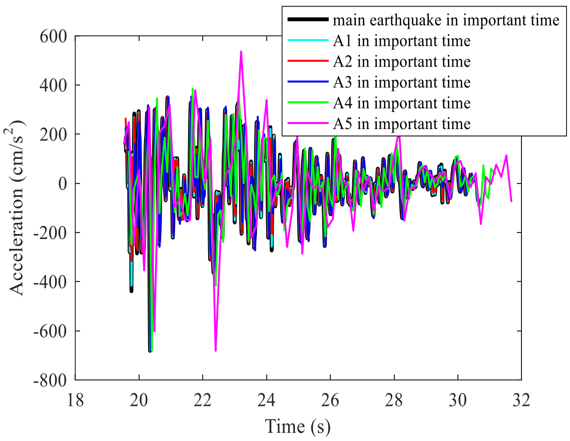

Fig. 2-1. Comparison of the acceleration of the main earthquake and waves A1 to A5 in important time

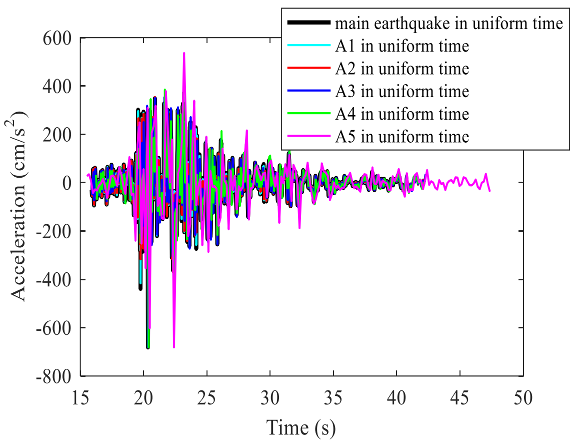

Fig. 2-3. Comparison of the acceleration of the main earthquake and waves A1 to A5 in uniform time

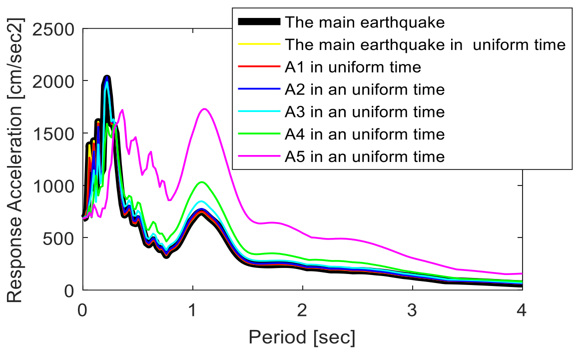

Fig. 2-3. Comparison of the response spectrum of the main earthquake and waves A1 to A5 in uniform time

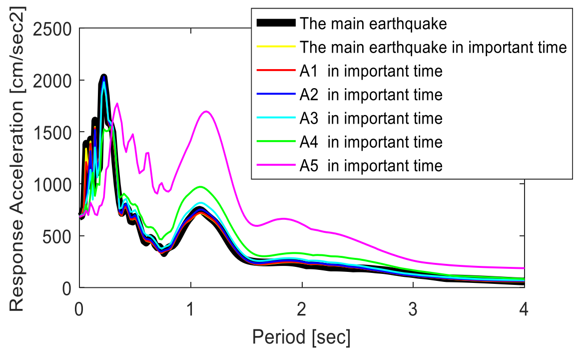

Fig. 3-1. Comparison of the response spectrum of the main earthquake and waves A1 to A5 in important time

last time the acceleration of the earth is greater than 0.05g [8-9]. The mapping acceleration curve derived from the two concepts of wavelet transformation and the duration of strong ground motion is shown in Fig. 2.

The response spectrum curve derived from the two concepts of wavelet transformation and the duration of strong ground motion is shown in Fig. 3.

In the remainder of this research, the response of several different structures to the main spectrum of the earthquake and the spectrum of wavelet filters is investigated. The results of the surveys show that the proposed method reduces the calculation of dynamics analysis by more than 90 percent.

4. CONCLUSIONS

From this research, it is concluded that the proposed technique is an applied technique for analyzing structures in order to optimize computations in finding the desired seismic response spectrum. In brief, the following results can be obtained from this paper:

1- The waves of the wavelet filters express the start time of the strong ground motion in all states with an error of around 0.5%.

2- The waves of the wavelet filters express the end time of the strong ground motion in all states with an error of around 4%.

3- Considering the analysis of two-dimensional structures, it can be seen that the A2 wave spectrum in an important and uniform time interval with an error of less than 4.5 percent, while in both cases reduces the number of earthquake records by more than 93 percent, The best is the wave.

4- According to the 3D-structure analysis, one can find that the A2 wave spectrum is the best in a uniform period with an error of less than 3.5% while reducing the number of earthquake records by more than 93%.

5. REFERENCES

[1] A.K. Gupta, Response spectrum method in seismic analysis and design of structures, Routledge, 2017.

[2] F. Yu, F. Zhou, L. Ye, Dynamic performance analysis of a seismically isolated bridge under braking force, Earthquake Engineering and Engineering Vibration, 11(1) (2012) 35-42.

[3] M. Krawczuk, M. Palacz, W. Ostachowicz, The dynamic analysis of a cracked Timoshenko beam by the spectral element method, Journal of Sound and Vibration, 264(5) (2003) 1139-1153.

[4] J. Morlet, Sampling theory and wave propagation: 51st Ann, Internat. Mtg, Soc. of Expl. Geophys., Session S, 15 (1981).

[5] E. Salajegheh, A. Heidari, Dynamic analysis of structures against earthquake by combined wavelet transform and fast Fourier transform, AJCE, 3(4)(2002) 75-87.
[6] E. Salajegheh, A. Heidari, Time history dynamic analysis of structures using filter banks and wavelet transforms, Computers & structures, 83(1) (2005) 53-68.
[7] R. Varghese, A. Boominathan, S. Banerjee, Numerical Analysis of Seismic Response of a Piled Raft Foundation System, in: Soil Dynamics and Earthquake Geotechnical Engineering, Springer, 2019, pp. 227-235.
[8] J.J. Bommer, A. Martinez-Pereira, The effective duration of earthquake strong motion, Journal of earthquake engineering, 3(02) (1999) 127-172
[9] S.L. Kramer, Geotechnical earthquake engineering. In prentice–Hall international series in civil engineering and engineering mechanics, Prentice-Hall, New Jersey, (1996).

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