Analysis of Seismic Wave Selection in Time History Analysis

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Abstract: By introducing a series of problems in time history analysis, such as the selection principle of input seismic wave, the amplitude and frequency characteristics of ground motion, beginners can have a preliminary understanding of the selection of input seismic wave and lay a foundation for further research.

1. Introduction
With the continuous development of society, economy, science and technology and the rapid expansion of population, the number of high-rise, super-high-rise and complex-shaped buildings will grow rapidly. The Seismic Design Code stipulates that for such important, complex buildings which exceed the specified height, the calculation of seismic action in seismic design should be supplemented and verified by time history analysis method. In the calculation process of time history analysis method, the selection of seismic wave is the most important factor affecting the calculation results of seismic action. Therefore, this paper will analyze the selection of seismic wave from the selection principle of seismic wave, earthquake amplitude, spectrum characteristics, duration, number of seismic wave, rotational component of seismic wave and so on.

2. Selection Principles of Seismic Waves
How to select seismic waves in time history analysis is always a difficult problem in time history analysis. In selecting seismic wave input, two requirements should be met:

1) Firstly, some parameters of the input seismic wave should be selected in accordance with the conditions of the building location. The parameters include soil type, seismic intensity, seismic intensity parameters, predominant period and response spectrum.

2) Next, we should meet the requirements of the three elements of seismic activity. That is, spectrum characteristics, duration and amplitude of seismic acceleration time history curve, and the three selected seismic waves should meet the relevant provisions. Relevant regulations require that digital seismic wave should be selected according to the type of building site and design seismic grouping, and not less than two groups of actual strong earthquake records and a group of artificial acceleration time history curves should be selected. The average seismic influence coefficient curve should be in accordance with the seismic influence coefficient curve adopted by the mode decomposition response spectrum analysis method in the statistical sense. In statistical sense, the coincidence means that the average seismic influence curve is not more than 20% different from the seismic influence coefficient curve used by the mode decomposition response spectrum method at each period point. In elastic time-history analysis, the bottom shear force calculated by each time-history curve should not be less than 65% of that calculated by matrix decomposition response.
spectrum method. The average value of bottom shear force calculated by multiple time history curves should not be less than 80% of that calculated by mode decomposition response spectrum.

3. Earthquake Amplitude
Earthquake amplitude has two meanings, that is, the maximum value of any kind of seismic acceleration, displacement and velocity, and the equivalent value in a certain sense. To some extent, the peak value of seismic wave can reflect and represent the intensity of seismic wave.

Therefore, the maximum value of frequent earthquakes or rare earthquakes required by the fortification intensity of the building location should be equal to the maximum value of the main mode of input seismic wave; otherwise the maximum value of seismic wave should be adjusted according to the following formula.

Among them, the statistic ground motion values under the corresponding intensity are used to represent the adjusted seismic wave time history curves.

In order to select the maximum peak value of seismic record and the selected seismic wave time history curve [2].

4. Spectrum characteristics
The definition of spectrum is the frequency component of ground motion and the influence degree of each frequency. The property of the land where the building is located, the transmission area of the earthquake, the transmission distance of the earthquake and the transmission medium of the earthquake have great influence on the spectrum characteristics of the seismic wave. Many real earthquake records show that when an earthquake occurs in a certain area, different buildings in the same seismic area will have different seismic damage manifestations. This shows that different frequency spectrum components of ground motions, under different conditions, will produce different degrees of damage to structures with different natural vibration periods.

The methods of seismic wave selection satisfying the spectrum requirements are as follows: 1) Make the characteristic period of the proposed site consistent with the predominant period of the input seismic wave as far as possible. 2) Make the epicenter distance of the proposed site consistent with that of the selected input seismic wave as far as possible [2].

5. Duration
Seismic properties which have a great influence on the response of structures include the time of earthquake ground motion, especially the time of elastic-plastic response (i.e. non-linear response) in the process of earthquake. When the structure enters the stage of elastic-plastic reaction, micro-cracks will occur locally, resulting in stress concentration, and then the cracks will continue to increase under the condition of constant stress, which will further change the structure system. In addition, the local collision makes the structure move, dislocate and even collapse. From micro-rupture to collapse of structures is a cumulative process, so from the cumulative effect, the duration of earthquake ground motion has a great impact on the seismic response of structures.

The method of determining the effective duration of seismic wave in time history analysis is as follows:

1) The selected duration should include the strongest part of the seismic record.
2) Generally, the duration of ground motion is 5 to 10 times of the basic period of the structure.
3) When only the elastic time history analysis of the structure is carried out, the duration may be shorter; when the elastic-plastic time history analysis or the energy dissipation process analysis of the structure is carried out, the duration may be longer [3, the rotational component of seismic wave

**Conclusion:** The selection of seismic wave has a decisive influence on the calculation results of time history analysis method. Therefore, in the selection process of seismic wave, the above mentioned aspects should be paid close attention to in order to ensure the accuracy of the calculation results. It is believed that in the near future, great breakthroughs will be made in the selection of seismic waves. The accuracy and reliability of time-history analysis method will be able to reach a
higher level.

**Example:** MIDAS/GEN provides 32 seismic acceleration records, which are original seismic wave data.

If manual processing is needed, either the amplification factor or the maximum input acceleration can be input.

When choosing seismic wave, we need to get the maximum acceleration time history curve corresponding to seismic fortification intensity cable according to the code, and then select seismic wave according to this value.

In MIDAS program, two sets of actual strong motion records can be selected to generate two SGS files (after adjusting Sa), and then a set of artificial acceleration time history curves are saved as SGS files. The values of three SGS files are averaged and compared with the seismic influence coefficient curves adopted by the mode decomposition response spectrum method to see whether they meet the requirement of "statistical consistency", thus the selection can be judged. Whether the seismic wave is suitable.

In addition, in elastic time-history analysis, the bottom shear force calculated by each time-history curve should not be less than 65% of that calculated by modal decomposition response spectrum method, and the average value of bottom shear force calculated by multiple time-history curves should not be less than 80% of that calculated by modal decomposition response spectrum method.

When you analyze and calculate different fortification intensity or medium or large earthquakes, it is necessary to adjust the peak value of the original seismic wave to suit the analysis you need.

For example, 7-degree fortification and 8-degree fortification, when time history analysis is used, the peak value of seismic wave used is certainly different, so you need to adjust at this time.

The function of converting seismic wave into absolute acceleration response spectrum and quasi-velocity response spectrum is provided in MIDAS program.

Wave data generator is saved as SGS file after generation. Users can use the saved SGS file (text format file) to calculate Sv, Sa and Tg according to the method mentioned above. The Tg value can be used to determine whether the seismic wave is suitable for grouping the site and seismic design. Then the EPA value in Table 5.1.2-2 of the seismic code is compared with Sa to get the adjustment coefficient, which is substituted into the seismic wave adjustment coefficient. When converting seismic wave into absolute acceleration response spectrum and quasi-velocity response spectrum, the attention period should be up to 6 seconds (stipulated in building seismic code).

Article 5.1.2 of the Code for Seismic Design of Buildings stipulates that when time-history analysis method is used, seismic design shall be grouped according to site type and design earthquake.

The average seismic influence coefficient curve of not less than two groups of actual strong earthquake records and a group of artificial simulated acceleration time history curves should be in accordance with the seismic influence coefficient curve adopted by the mode decomposition response spectrum method in the statistical sense. The so-called "statistical coincidence" means that the average influence coefficient curve is not more than 20% different from the seismic influence coefficient curve used in the mode decomposition response spectrum method at each period point.

In MIDAS program, two groups of actual strong earthquake records can be selected to generate two SGS files (after adjusting Sa), and then a group of people can be selected.

The simulated acceleration time history curve is also saved as SGS file. The values of the three SGS files are averaged and compared with the seismic influence coefficient curve adopted by the mode decomposition response spectrum method to see whether it is satisfied "in the statistical sense", so that the appropriate seismic wave can be judged.

In addition, in elastic time history analysis, the bottom shear force calculated by each time history curve should not be less than the mode decomposition response.

The average value of bottom shear force calculated by multi-time-history curve should not be less than 80% of that calculated by modal decomposition response spectrum method.
Reference:
[1] GB50011-2010, Code for Seismic Design of Buildings [S].
[2] Yang Chuanding. Brief analysis of seismic wave selection in dynamic time history analysis [J]. Sichuan Building Materials, 2012, 38 (3): 52-52. [3] Hu Wenyuan, Zou Jinhua. Several issues concerning seismic wave selection in time history analysis [J]. Journal of Jiangxi University of Technology, 2003, 24 (4): 25-28. Author's brief introduction:
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