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DESIGN GROUND MOTION PARAMETERS FOR IMPORTANT ENGINEERING STRUCTURES

Zhang Xue-Liang

Institute of Earthquake Engineering,
Seismological Bureau of Jiangsu Prevince, Nanjing, China

SUMMARY

In this paper, based on a seismic hazard analysis and a nonstationary random process model for generating the artifical ground motion, a method has been proposed for determining design ground motion parameters of important engineering structures, in which incorporating information about the seismology, geological tectonics and distribution of historical earthquakes in the regional site are used to identify potential seismic sources and taking into consideration the character of the site, whether the major potential seismic sources were nearby or distant, and the maximum magnitude and distance from the site.

INTRODUCTION

A recent tendency in the aseismic design for important engineering structures, the choice of design ground motion parameters has become more detailed than in the past to consider various factors influencing the design loads on structures such as seismology, seismicity parameters of potential seismic sources, the propagation path, local site condition and epicentral distance etc. (Ref.1,2). It is very important projects for determining design ground motion for important engineering structures with reasonableness and reliability which is a significant basis for operation of earthquake safety and economy aseismic design (Ref.3). The design ground motion parameters chosen based on seismic hazard analysis are more reasonable than those obtained by selecting ground motion records obtained elsewhere under similar site condition or from the code (Ref.1,3,4). In this paper, a method is proposed in which the determining design ground motion parameters comprises a series of steps. First, the data of geological tectonics, historical earthquake and seismicity within a radius of 320kms from the site are used to identify possible potential seismic sources which are likely to affect the site. Attenuation laws have been developed from the data of ground motion with similar maximum magnitude of major potential seismic sources, hypocentral distance from the major source to the site, seismological and geological conditions within the regional site. The probability method was used in seismic hazard analysis to determine the design peak acceleration of ground motion for a certain annual probability of exceedance which was chosen as the criterion for safe earthquake of important engineering structures. Then site spectra and acceleration time history envolopes were then chosen for each of major potential seismic sources, taking into consideration the character of the site, whether the sources were nearby or distant and the maximum magnitude and distance from the site. Finally, a nonstationary random process model is used to generate a set of artificial time-histories of ground motion, either for both near and far sources or just one of these, are generated based on the site spectra and shape function of ground motion derived from the seismological and geological tectonics features of the site of interest. These artificial ground motion records were the design ground motion parameters for important engineering structures.

POTENTIAL SEISMIC SOURCES

Considering a region with a radius of 320kms around centre of the site of important engineering structures, active fault, large deep rupture, seismicity given by the distribution of historical earthquake and correlation between active fault and destructure earthquake as well as the character of seismicity at fault basins were developed to identify the potential seismic sources in region which are likely to affect the site. It is usually that the identification of potential seismic sources in region given by specialist studied and judged with various viewpoint from these data, are unusually agreement. It may be to get several set of potential seismic sources with various contour and number from the same region. It is not to be wondered that induced different results is due to judge difference by specialists from the given data. Hence when the probability method is used in seismic hazard analysis, it is not emphasized to choose the unique set of potential seismic sources from several set in the range of region. We may keep to the all of set and given the various weighted coefficient value for each set in seismic hazard analysis, the weighted coefficient value is determined based on the reliability of each set. Adopted this method will been increased the reliability of assessment seismic hazard of regional area by uncertain correction for identified potential seismic sources in seismic hazard analysis.

SEISMICITY PARAMETERS

Seismicity parameters of potential seismic sources are key factors such as the parameter reflects the ratio of large and small earthquakes in seismic source region, annual occurrence rate and maximum magnitude to affect the seismic hazard evaluation of regional area. It is usually to assume in spatial uniform and stationarity of time in the regional site using the probability method in seismic hazard analysis. Some regions lack the necessary length of data on earthquakes, in which case we may choose the seismic zone as statistical unit to get the seismicity parameters (Ref.1,2,5). In fact, the seismicity may be divied to the quiet and active periods, the recurrent period of earthquake will be changed long with raising magnitude from the analysis results of historical earthquake records. The occurred positions of earthquake on various magnitude is nonuniform in spatial distribution. The seismicity parameters in spatial nonuniform and time nonstationarity is important factors to affect the evaluation of seismic hazard in regional area. It may be used the weight function to be considered for correction of nonuniform and nonstationarity in the seismic hazard analysis. The position of occurring large earthquake may be restricted as small range of distribution as possible in the region of potential seismic sources, based on the incorporating information about the seismology, geology and seismicity in the region (Ref.6).

ATTENUATION RELATION

The attenuation relationship is one key factor in seismic hazard analysis which lead to large variation in seismic hazard estimation for the site of important engineering structures and also affect to the correction value of design ground motion parameters of engineering for aseismic design. Selection of realistic attenuation relation is one of the very important project in seismic hazard analysis. It is usually used several method for selection attenuation relation in seismic hazard analysis as following:

Equal Magnitude Method or Equal Distance Method (Method 1) It is one of these which is used to be derived the ground motion attenuation relation from the know intensity in the regional area with a radius of 320kms around centre of the site of important engineering structures, where there is poor ground motion data (Ref. 7,8).

Seismic Intensity or Ground Motion Data (Method 2) Either the distribution of seismic intensity observations from historical earthquake felt in the vicinity of the regional area may be used where there is poor ground motion data to obtain an attenuation formula for seismic intensity or the ground motion records is chosen to be considered in the regional area with similar seismological and geological conditions to obtain a ground motion relation (Ref.2).

Based on the Seismic Hazard Analysis (Method 3) The attenuation relation is obtained to comprise two steps (Ref.9). First, a preliminary choice is made of the attenuation formula for ground motion or seismic intensity, based on the parameters given for various regions of potential seismic sources considering the seismological and geological conditions. The major regions of potential seismic sources is identified by comparing the annual probability of exceedance for each of the contribution sources in seismic hazard analysis using a fault-rupture model (Ref.10). According to the maximum magnitude of earthquake and distance from the major regions of potential seismic sources in regional area, the attenuation formulae of ground motion are statistically obtained by selecting ground motion data with similar magnitude, hypocentral distance and seismological conditions, and also taking into account the following feature of attenuation formulae have been noticed.

1. If the maximum magnitude in the major region of potential seismic sources is moderate, but the attenuation formulae was derived from ground motion data including a lot of small earthquake, then the earthquake hazard for site of important engineering structure in regional area would be underestimated.

2. If the maximum magnitude in the major region of potential seismic sources is large, then because the ground motion data is very rarely obtained for large earthquake, the attenuation relation in analysis must be carried out carefully by comparison with other large earthquake. It is found that the attenuation formulae give the acceleration increasing steadily with magnitude, but in fact the increase in acceleration for large magnitude is only gradual.

Finally, the distribution of seismic intensity observations from historical earthquake felt in the vicinity of the site may be used where there is poor ground motion data to obtain an attenuation formula for seismic intensity. Then the attenuation formulae of peak ground motion and seismic intensity in regional site of engineering structures may be applied to compare peak accelerations with conversion peak accelerations from the seismic intensity by seismic hazard analysis for assessment of reliability of the predicted peak accelerations from selection attenuation relation of ground motion (Ref.9).

On method 1, a lot of ground motion records in western North America may be used to the region in which is poor ground motion data, but the local seismological and geological conditions are to affect the amplitude of ground motion, which are difficult to be considered in this method.

On method 2, its advantage is that the long historical earthquake records may be used to the area where there is poor ground motion data, and the local seismological and geological condition are also considered. But in fact, the local conditions of area are not taken into account when the value are converted from intensity to peak accelerations used the general formula which is obtained from statistical ground motion records in any where. Selection ground motion is at random, it is difficult to reflect the character of local conditions and also difficult to judge the reliability.

On method 3, based on the seismic hazard analysis, the attenuation relation of ground motion is chosen. Its advantage is that the maximum magnitude of major region of potential seismic sources, hypocentral distance, the distribution of seismic intensity of historical earthquake felt in the vicinity of regional area, and seismological and geological conditions in the regional area can be considered in detail as incorporating informations in which these important factors affect to the attenuation character. It could be increased the reliability for estimating seismic hazard for the site of important engineering structure. But acquired the ground motion data in the world can not be better utilized wide in seismic hazard analysis.

As stated above, the proposed method is that method 1 and method 3 are combined to take into account to be used in seismic hazard analysis. It will overcome the weakness in method 1 and method 3. It is more reliable for correctly estimating the design ground motion parameters in choice attenuation relation of ground motion.

SEISMIC HAZARD ANALYSIS

It is usually to consider to take a fault-rupture model (Ref.10) when the probability method is used in seismic hazard analysis to determine the peak ground acceleration. But it will be overestimated the seismic hazard of site for important engineering structure due to the attenuation model given the equal intensity contour of long axis is not in agreement with the distribution of seismic intensity observations from historical earthquake felt in the regional area. For overcome the weakness, it is fine to adopt an equivalent fault-rupture length that is the difference of equal intensity contour between long axis and short axis (Ref.11).

Based on the seismic hazard analysis, according the risk level of important engineering structure as criterion for the assessment of seismic risk that is for a certain annual probability of exceedance, the design peak acceleration of ground motion can be obtained in the seismic hazard analysis for important engineering structures.

SITE SPECTRA AND SHAPE FUNCTION

Based on the investigations of character of site response spectra for important engineering structure, it is indicated that the spectral shape various with epicentral distance and the spectral peak migrates towards longer periods as the magnitude or epicentral distance increases. A proposed method for determination of design response spectra for important engineering structures is best based on seismic hazard analysis, incorporating information about the seismology, geology and the distribution of historical earthquakes in the regional site, the potential seismic sources significant effect on the site are identified. According to the major seismic sources with maximum magnitude and distance from the site, then the site spectra are constructed to choose the data of ground motion with similar maximum magnitude of major potential seismic sources, hypocentral distance from the major sources to the site and seismological and geological conditions, taking into consideration whether the sources is in the Near-or far-feild for major potential seismic sources (Ref.1,4).

The shape function of the ground motion time history is usually given by statistical analysis from ground motion data for major regions of potential seismic sources using values appropriate for the maximum magnitude and the distance from the site (Ref.2).

ARTIFICIAL GROUND MOTION

Artificial accelerograms on rock are generated to match the target near-source and far-source spectra and corresponding shape functions of the acceleration histories, thus achieving the required amplitudes, frequencies and duration. The technique is to use a nonstationary random process medel (Ref.1,2,4).

It is clearly revealed that dynamic responses of soil layers are very complex during earthquake excitation. It was, therefore, proposed that the artificial time-history of ground motion on soil layer in regions with deep alluvim and especially for deep alluvial layer were better achieved using the wave motion analysis method to obtain the seismic response at the surface of the soil layers (Ref.12).

CONCLUSIONS

The proposed method was applied to choose the design ground motion parameters for important engineering structures, Its advantage is that it can be used the data included seismological and geological information, ground motion records and seismic intensity observations from historical earthquakes in the regional site for systematically considering these factors such as seismicity parameters of potential seismic sources, the propogation path, local site conditions and epicentral distance etc., Which are to affect the design ground motion parameters. Although increasing the amount work, it enhance the reliability for correcly estimating the design ground motion parameters of important engineering structures in aseismic design. It well be saved the investment for important engineering structures in construction.

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