Microzonation of Ground Motion Parameters in Shangluo City

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Abstract. This paper studied the regional seismic tectonic characteristics, regional seismic activity characteristics, the near-field seismic tectonic characteristics, near-field earthquake activity characteristics about the site of Seismic Microzonation in Shangluo City, seismic belts and potential seismic source zone were divided, calculating the seismic risk analysis of the bedrock of the site, surveying engineering geological conditions in the site, carrying out the seismic response analysis of the site, and zoning the ground motion parameters of the site. The above results provide a basis for the seismic fortification of the proposed general engineering in the site.

1. Introduction

Compared with national seismic zonation [1], seismic microzonation has the following characteristics: seismic microzonation pays more attention to the influence of local site conditions, considering the role of local site conditions in more detail, distinguishing different earthquake damage effects, and considering the surrounding seismic and geological environment detailed; and the mapping scale is much larger than the national seismic zonation map.

Seismic microzonation has something in common with the national seismic zonation map, both of which provide seismic fortification requirements for general construction projects. However, seismic microzonation is a more detailed and meticulous work aimed at specific sites, which is more targeted, takes more factors into consideration, and requires higher precision. However, the national seismic zonation map is more macro. To provide the maximum earthquake that an area may experience under a given transcendence probability under general site conditions, the two complement each other, and neither is indispensable.

2. Seismological and geological characteristics in site of seismic microzonation

The regional scope involves three first-order neotectonic zones and several second-order neotectonic units. The neotectonic movement of the North China platform is weak. The Qinling-Baba fold belt, which is connected with the Yangtze platform in the southern margin of Ordos block, is still active strongly and is the frequent area of strong earthquakes. The fault activities in the region are mainly concentrated in the central Qinling-Daba Mountain uplift area, and most of them are active faults before the late Pleistocene. The Holocene active faults are mainly concentrated in the northern part of the region, and the boundary faults of Weihe Basin in the northern part of the region are mostly developed since the late Pleistocene. The active faults are not developed in the Ordos block. There are 28 active faults in the region, of which 18 occurred moderate and strong earthquakes in the history of Late Pleistocene or Holocene active faults (Figure 1). According to historical records and modern instrument records, 52 earthquakes of magnitude 4½ or above have occurred in the region since 2300
BC, including 30 earthquakes of magnitude 5.0 to 5.9, 6 earthquakes of magnitude 6.0 to 6.9, 1 earthquake of magnitude 7.0 to 7.9, and 1 earthquake of magnitude 8.0 to 8.9. The largest earthquake was the 8½ earthquake in Huaxian County, Shaanxi Province on February 2, 1556.

3. Seismic risk analysis
The moderate-strong seismicity in this region is mainly distributed in the Fen-Wei seismic statistical area and the seismic statistical area of middle reaches of the Yangtze River. The North China Plain and Ordos have little influence on regional seismicity. In Fen-Wei earthquake statistics area, the earthquake activity in one hundred will be the average or slightly higher than the average; in the earthquake statistics in the middle reach of Yangtze river area and the north China plain seismic statistical area, the future seismic activity in one hundred will be in average; in ordos earthquake statistics area, the activity is very weak, and the future seismic activity in one hundred may still maintain the weak active state. Based on the results of the classification of tectonic potential source in the latest zonation map, combined with the study of seismic activity and seismic geological characteristics in this region, the boundary of the potential source area involved in the near field area was determined, and 25 potential source areas were identified within the regional scope (Figure 2). The II type attenuation relation in southern Shaanxi is selected to determine the ground motion parameters of bedrock in different transcendence probability levels within the scope of the project site through seismic risk probability analysis, which provides basic data for seismic response analysis of soil layer and ground motion parameters determination of the site.

Figure 1 Regional seismotectonics
CPSHA method was adopted for probability analysis of seismic risk in this site [2]. According to the seismicity parameters and attenuation relationship of each potential seismic source area, the seismic risk analysis and calculation of 86 boreholes in the small area were carried out by using the program of ESE recommended by the China Earthquake Administration. In Figure 3, there are the peak accelerations of bedrock at each calculation point with a 50-year overtaking probability of 63%, 10% and 2%. According to the calculation results, the peak accelerations of 63%, 10% and 2% of exceedance probability in 50 years show a decreasing trend from north to south, which is related to the distribution characteristics of potential seismic sources with high magnitude. We divide the peak acceleration of bedrock into two different areas (I and II). The positions of drilling ZK20 and ZK41 were selected as the bedrock input control points in Area I and Area II.
4. Survey of conditions of the site

Evaluation of Seismic Safety of Engineering Site (GB17741-2005) [3], the drilling project was carried out on the microzonation site. Drilling holes were laid out in a 1km×1km grid distribution in the site. The actual drilling number is 63, and the total footage is 1297m. Among them, there are 59 control holes with an footage of 1,291m, and 4 identification holes with an footage of 96m for determining the boundary of engineering geological units. In addition, there are 23 collection boreholes. If there are collected boreholes on or near a grid point, the boreholes on that grid point may not be constructed. The shear wave velocity test and dynamic triaxial test of typical soil were carried out for each borehole. The results of subdivision of engineering geological units of small zoning sites are shown in Figure 4.

Figure 4 Engineering geological unit zoning map of seismic microzonation in Shangluo City

5. Seismic response of soil layer

Taking Area I as an example, we describe the results of seismic response analysis of soil layers in sites through the situation that the probability exceeds 10% in 50 years. The following figure is the curve of horizontal ground motion acceleration response spectrum at the bedrock input control point with the probability of exceeding 63%, 10% and 2% in 50 years in Area I.

Figure 5 Horizontal bedrock acceleration response spectrum (5% damping ratio) with 10% of exceedance probability of control points in Area I in 50 years

Firstly, taking the acceleration and response spectrum of bedrock at the control point in Area I as the target, the ground motion time history (Figure 6) was synthesized by numerical simulation, which was used as the ground motion input value for the seismic response analysis of the soil layer in the site to conduct the ground motion response analysis. Using ESE software recommended by China Seismological Administration, the time histories of bedrock ground motions with different exceedance probability levels at each calculation control point are synthesized respectively. In order to consider the effect of randomness of phase, three samples with different random phases were synthesized for each transcendence probability level. The time periods of the synthesis were all 0.02 seconds apart,
and the number of discrete values ranged from 4096 to 8192.66 control points of target response spectrum were selected within 0.04 ~ 6.0s to ensure the accuracy of target response spectrum fitting during synthetic ground motion. In the process of synthesis, the time history of the synthesized acceleration accurately meets the peak acceleration of the target and approximates the response spectrum of the target acceleration by approximating the target spectrum step by step. The fitting relative error is less than 5% when the target acceleration response spectrum is fitted in this area (Figure 7).

![Figure 6](image1.png)

**Figure 6** Time history of bedrock corresponding to 50-year exceedance probability of 10%

![Figure 7](image2.png)

**Figure 7** Fitting curve of target spectrum of bedrock corresponding to 10% probability of exceedence in 50 years

### 6. Determination of site ground motion

Based on the analysis of the overall characteristics of the ground motion peak acceleration of each effective response calculation point, the ground motion peak acceleration is classified according to the requirements of the code, which is generally in the first gear and spatially concentrated into a partition. Subdivision boundary is one of the important contents of seismic microzonation. Here, on the basis of the distribution division of calculated values, the comprehensive determination is made by referring to the characteristics of each engineering geological unit, site wave velocity, special soil properties, administrative boundaries, streets and other factors. For example, the boundary position of the adjacent engineering geological units and the road direction in the site are fully considered when determining the zoning boundary. It is also an important content to determine the representative value of the division. The representative value of the peak acceleration of ground motion in different zones should be comprehensively determined based on safety and convenience of use. According to the calculation results, the zoned peak ground motion acceleration and seismic response spectrum at the level of 50 years exceedance probability of 63%, 10% and 2% were zoned, and only Area A was separated (Figure 8 and Table 1). According to the national standard of the People's Republic of China Code for Seismic Design of Buildings (GB50011-2010)[4] and Seismic Safety Evaluation of Engineering Sites (GB 17741-2005)[5], and the parameter values in Table 1, the general buildings in the small area site can be fortified against earthquakes.
Figure 8  Ground motion acceleration response spectrum and site ground motion response spectrum of Area I in horizontal direction (exceeding probability of 63%, 10% and 2% in 50 years)

Figure 9  Division of ground motion parameters of the site

Table 1  ground surface horizontal design ground motion peak acceleration and response spectrum (5% damping ratio) parameter values of the project site

| Partition | probability of Exceedance | $T_1$ (s) | $T_g$ (s) | $\beta_m$ | $\gamma$ | $A_{max}$ (gal) | $\alpha_{max}$ (g) |
|-----------|---------------------------|-----------|-----------|-----------|-----------|----------------|-------------------|
| Area A    | 50 years 63%              | 0.10      | 0.35      | 2.5       | 0.9       | 45             | 0.113             |
|           | 50 years 10%              | 0.10      | 0.40      | 2.5       | 0.9       | 135            | 0.338             |
|           | 50 years 2%               | 0.10      | 0.50      | 2.5       | 0.9       | 255            | 0.638             |

7. Conclusion

Compared with national seismic zonation, seismic microzonation has the following characteristics: seismic microzonation pays more attention to the influence of local site conditions, considering the role of local site conditions in more detail, distinguishing different earthquake damage effects, and considering the surrounding seismic and geological environment detailedly; and the mapping scale is much larger than the national seismic zonation map. With the deepening of research of seismotectonics, the accumulation of seismic data and the continuous expansion of urban scale, it is suggested that the area should begin new microzonation of ground motion parameters in the future to meet the needs of new economic development.

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