A Study on the Influencing Factors on Ground Motion in a Valley Site

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A trapezoid valley site is chosen as a research site, and according to numerical models based on orthogonal design, the factors influencing ground motion in the valley site are studied with two-dimensional finite difference method. The influencing factors are ranked, and then the calculation results are verified by ground motion analysis. The conclusions are as follows: there are four factors that have important effects on ground motion of trapezoid valley sites, but the effects are different as the location of sites changes, the influencing factors rank differently with different site locations; The ranking of the influencing factors is the same for all the sites located within a distance of 40m from the valley’s side, among them, the most effective one is the valley slope angle ranks, followed by depth-to-width ratio, overburden thickness, at last the input ground motion intensity. The impact of the factors on surface ground motion is roughly the same in the valley sites within a certain distance to the valley side, and the geometric parameters of the valley terrain play a greater part in influencing ground motion. With the increase of distance away from the valley’s side, the ranking of the influencing factors also changes, the rating of slope angle moves backward, the ranking of the input ground motion and overburden thickness move ahead. The effect of valley geometric parameters on ground motions is gradually weakened, but the effect of other two influence factors are gradually increased, similar to cases of a horizontal layered site. Strong motion records in Anning River valley site were analyzed, and the results show that the valley topography has a significant amplification effect on ground motion, and that the numerical results of this paper are credible.

Key words: Valley site; Ground motion; Finite difference; Influencing factors

INTRODUCTION

The existing research results and the investigation results of earthquake damage have proved

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that the valley site has a significant effect on ground motion. The abnormal ground motion occurred in the valley sites during the Haiyuan M8.5 earthquake in Ningxia Hui Autonomous Region, the M7.7 earthquake between Tonghai and Eshan in Yunnan Province, and the Haicheng earthquake in Liaoning Province, which resulted in serious earthquake damage (Xiao Wenhai, 2009). In 2005, the M7.8 earthquake in the Pakistan-controlled Kashmir region caused heavy casualties and serious damage to the buildings and infrastructure of the town of Barakot along the Kaghan River (Qu Guosheng et al., 2008). There was a high intensity anomaly in Hanyuan County during the Wenchuan Earthquake in 2008. The study showed that the valley topography had a significant effect on the Hanyuan earthquake damage (Li Ping, 2013). In addition, there were different levels of earthquake damage in different locations in the valley sites, such as the Anyi River in Anchang Town, Shiting River in Shifang City, Baishuihe River in Gansu Province, Fujiang in Pingwu County, Dabashan River in Qinghuan County, Dongyang River in Qinghuan County, and the Jianjiang River, which proved again that the valley site has a notable impact on earthquake damage (Wang Wei, 2011).

Domestic and foreign scholars have conducted a series of studies on the effects of the valley site on ground motion using the methods of strong motion records analysis, analytical method and numerical simulation. The strong motion records analysis using the traditional spectrum ratio method and the generalized strong motion records analysis method study the amplification effect of the valley site (Wang Haiyun, 2011; Ren Yefei et al., 2013). The premise of the method is to obtain a large number of effective strong motion records, therefore the application of this research is limited. Using analytical methods, researchers simplify the valley topography into semicircular or semieliptical depressions and solve them by mathematical and mechanical methods. The results show that the incidence angle, waveform and the shape of the valley have significant influence on the characteristics of ground motion (Wong H.L. et al., 1975; Jin Feng et al., 1993; Lee W.H. et al., 1994; Liang Jianwen et al., 2000, 2001a, 2001b, 2002, 2003; Liu Tianyun et al., 2000; Cui Jiangyu et al., 2001; Dong Jun et al., 2005). The analytical method has higher requirements than mathematical and physical calculation methods. Because of limitations in the mathematical method, it can only simplify the valley model when analyzing problems, and cannot fully consider the influence of valley shape, size, mechanical characteristics of the soil layer and other factors. Moreover, it can only be used to study a special simplified problem, which is quite different from actual situations. The numerical simulation method overcomes the disadvantages of the analytical method. With the rapid development of computers, this method is more and more popular in the response analysis of strong ground motion in valley sites. Finite element, boundary element, infinite boundary element and spectral element methods have been widely used by domestic and foreign scholars to study the valley site effects on ground motion widely, and significant results have been achieved (Bordini P. et al., 2014; Frischknecht C. et al., 2004; Che Wei et al., 2008; Tsaur P.H. et al., 2008; Sohrabi-Bidar A. et al., 2010; Zhang Xiaobo et al., 2010; Liu Bideng et al., 2011; Gao Y.F. et al., 2012; Zhang N. et al., 2012; Zhang Jianyi et al., 2012; Chen Qingjun et al., 2013; Song Zhenxia et al., 2013; Chen Yunque et al., 2013; Jin Dandan et al., 2014). It is generally agreed that the slope angle, depth-to-width ratio and incident angle of the input ground motion have significant effects on the ground motion of the valley site, therefore the effects of the valley site cannot be ignored. However, most research results are based on deep V and U-shaped valleys, there are few studies on trapezoidal valleys which are suitable for human habitation and development. In addition, the research models rarely considered the influence of soil layers. Most of the research calculation models chose simple or specific valley sites, so the results are not universal.

The trapezoid-shaped valley was taken as a research site in this paper. According to numerical models based on orthogonal design, the factors that influence ground motion in valley
sites were analyzed by the two-dimensional finite difference method and transmission artificial boundary theory. Factors were ranked based on their effects, then the research results were verified by ground motion analysis. The results obtained laid the foundation for modeling for the later systematic analysis of valley site effects on ground motion.

1 CALCULATION MODEL AND CALCULATION PARAMETERS

In order to comprehensively study the influencing factors of ground motion on the valley site with the least amount of calculations, the orthogonal calculation method is undoubtedly the best choice. The calculation model design adopts the orthogonal experimental design method. The orthogonal experimental design method can not only reflect the influence of many factors, but also reduce the workload of calculations. It is widely used in geotechnical tests and multi-factor analysis. The orthogonal experimental design method is based on the selection of the main influencing factors and the different states of these factors. Using the orthogonal table as a tool, the experimental scheme is arranged to make them a reasonable research method. Modeling was done based on the above idea, and the $L_{27}(3^4)$ orthogonal table was introduced in this study, the number 9 indicates the number of calculations, likewise the number 4 indicates the factor, and the number 3 indicates the factor level (Xie Dingyi et al., 2011). According to the above research results, the dip angle of the valley slope, depth to width ratio, thickness of the cover layer and intensity of input ground motion are selected as four influencing factors in this study, as shown in Table 1 and Table 2.

**Table 1** Settings of factors and calculation degree

<table>
<thead>
<tr>
<th>Calculation degree</th>
<th>Dip angle $A/\degree$</th>
<th>Depth to width ratio $B$</th>
<th>Thickness of cover layer $C/\text{m}$</th>
<th>Input ground motion $D/\text{gal}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>0.5</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>1</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>2</td>
<td>40</td>
<td>200</td>
</tr>
</tbody>
</table>

A trapezoidal valley model, which simplifies the geometry and is symmetric, is used as a computational model, as shown in Fig.1. The dip angle $\alpha$ is $30^\degree$, $45^\degree$ and $60^\degree$, and the thickness of the cover soil is $20\text{m}$, $30\text{m}$ and $40\text{m}$, respectively. The underlying soil is the bedrock. The depth $h$ of the valley is $40\text{m}$. The width of the valley bottom was calculated by the fixed ratio of depth to width. The ratio of depth to width is 0.5, 1 and 2, respectively. The calculation monitor point starts at A in Fig.1, selecting 17 points with an interval of $20\text{m}$, denoted as $J_1$-$J_{17}$. In the numerical simulation of wave motion, the size of the calculation unit has a great influence on the effective frequency band of the ground motion result. In order to ensure the wave with a frequency of $10\text{Hz}$ has 10 units in one wavelength when the shear wave velocity of the soil layer is $200\text{m/s}$, while satisfying the stability conditions, the side length of the calculation model is determined as $2\text{m}$, and the units are quadrilateral and an isosceles triangle (Fig.1). In the calculation, the width and the time step of the input pulse function is taken as $0.1\text{s}$ and $0.0001\text{s}$, respectively, so that the frequency band of the input wave can be expanded to about $20\text{Hz}$. This paper focuses on the influence factors of valley topography, so the valley covers are simplified. The binary stratum soil layer and bedrock are used, and the empirical values are taken as the calculation parameters of model soil, as shown in Table 3.
Table 2  Calculation plan and program

<table>
<thead>
<tr>
<th>Calculation number</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Calculation plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>A_1B_1C_1D_1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>A_1B_2C_2D_2</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>A_1B_3C_3D_3</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>A_1B_2C_3D_3</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>A_1B_2C_3D_1</td>
</tr>
<tr>
<td>6</td>
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<td>2</td>
<td>A_1B_3C_2D_1</td>
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<tr>
<td>7</td>
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<td>3</td>
<td>2</td>
<td>A_1B_3C_2D_1</td>
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<tr>
<td>8</td>
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<td>2</td>
<td>1</td>
<td>3</td>
<td>A_1B_2C_1D_1</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>A_1B_3C_2D_1</td>
</tr>
</tbody>
</table>

Note: Calculation number 1 represents one calculation. The selected calculation plan A_1B_1C_1D_1 is; dip angle 30°, depth to width ratio 0.5, thickness of cover layer 20m, input ground motion 50 gal, and so on.

![Fig.1 Sketch map of the computation model](image)

Table 3  The physical and mechanical parameters of the soil of model

<table>
<thead>
<tr>
<th>Soil types</th>
<th>Soil layer</th>
<th>Bedrock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density /kg·m⁻³</td>
<td>1850</td>
<td>2200</td>
</tr>
<tr>
<td>Shear wave velocity /m·s⁻¹</td>
<td>200</td>
<td>800</td>
</tr>
<tr>
<td>Poisson ratio/μ</td>
<td>0.3</td>
<td>0.2</td>
</tr>
</tbody>
</table>

2  CALCULATION RESULTS

The two-dimensional finite difference and multiple transmission artificial boundary theory were used as the calculation method. The specific method can be found in the references (Liao Zhenpeng et al., 1984, 1986; Liao Zhenpeng, 2002). The pulse function was input when calculating and analyzing, and the results of the pulse seismic reaction were captured. Because of the limited space, the result of calculation number 3 was given, as shown in Fig.1. The seismic phase can be traced from the pulse seismic response. The results show that instability did not occur in the calculation process, so the calculation results are credible. In this paper, the acceleration magnification \( M \) is selected as the analysis data, defined as the ratio of the surface peak acceleration of each observation point to its corresponding input peak acceleration. The peaks of ground motion of the valley site were obtained by the following methods: The typical EI central wave was selected for input ground motion, and the peak value was adjusted according to the designed calculation plan. The Fourier spectrum of input ground motion was multiplied by the transfer function of each site point, and the Fourier spectrum of the ground surface response of each point was obtained. The corresponding Fourier spectrum inversion calculations were carried out, thus the peak acceleration of each observation point was obtained by the time history of ground motion and then the magnification \( M \) of acceleration was obtained. The relevant calculation
Fig.2 Seismic response of all observation points of input pulse of calculation No.3

Table 4 The amplification of ground motion (M) at each calculation points

<table>
<thead>
<tr>
<th>Position</th>
<th>Calculation number</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1</td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>J2</td>
<td>2.88 2.97 2.39 3.30 4.90 3.09 8.80 12.29 5.32</td>
</tr>
<tr>
<td>J3</td>
<td>2.73 2.57 2.64 2.77 4.22 3.22 2.96 7.29 3.93</td>
</tr>
<tr>
<td>J4</td>
<td>3.40 2.82 2.58 2.73 3.85 3.29 3.33 11.59 3.86</td>
</tr>
<tr>
<td>J5</td>
<td>3.46 3.18 2.73 2.96 3.12 3.26 4.27 2.69 3.21</td>
</tr>
<tr>
<td>J6</td>
<td>4.63 2.88 3.15 3.16 3.04 3.92 4.40 2.96 3.03</td>
</tr>
<tr>
<td>J7</td>
<td>2.77 2.86 3.01 2.56 3.07 4.29 6.50 2.70 3.02</td>
</tr>
<tr>
<td>J8</td>
<td>2.63 3.46 2.98 2.80 5.13 8.04 5.12 2.65 2.73</td>
</tr>
<tr>
<td>J9</td>
<td>4.04 3.14 2.61 2.98 2.82 7.98 3.46 2.68 3.21</td>
</tr>
<tr>
<td>J10</td>
<td>2.05 2.69 2.77 2.72 2.84 3.47 2.53 2.60 2.94</td>
</tr>
<tr>
<td>J11</td>
<td>3.36 3.17 2.89 3.09 2.85 2.95 2.53 2.56 2.59</td>
</tr>
<tr>
<td>J12</td>
<td>3.23 2.61 2.67 2.44 2.84 2.52 3.05 2.97 3.07</td>
</tr>
<tr>
<td>J13</td>
<td>3.51 3.36 2.85 2.59 2.93 2.23 3.05 3.15 2.97</td>
</tr>
<tr>
<td>J14</td>
<td>1.00 2.96 2.55 2.80 3.17 2.31 2.31 2.46 2.67</td>
</tr>
<tr>
<td>J15</td>
<td>2.57 2.91 3.26 2.45 3.54 2.28 2.80 2.48 3.11</td>
</tr>
<tr>
<td>J16</td>
<td>2.88 2.51 2.41 3.06 2.98 2.62 2.62 2.94 2.91</td>
</tr>
<tr>
<td>J17</td>
<td>2.73 2.44 2.42 2.45 3.55 2.24 3.01 2.37 2.48</td>
</tr>
</tbody>
</table>

Recently, the analysis of the influence degree of influencing factors in orthogonal experiments mainly uses the range and variance analysis method. In this paper, the range analysis method is used. The analysis results obtained by using the calculation results at J3 are given in Table 5. In the table, Ki represents the sum of the calculation results corresponding to any one of the factors and the horizontal number i (the sum of the ground motion magnifications). For example, the sum of the level 1 ground motion magnifications for column A is 8.80. S represents the number of occurrences of each level on a column, and the corresponding average value of each level is $k_i =$
$K/S$. For level 1 of column A, $K_1$ is 8. 80, which occurs three times, so $k_1$ is $8.80/3 = 2.93$. The $R$ in the table is the difference between the maximum and minimum of the average value corresponding to each level, which is 3.34 for the column A. For different calculation conditions, the range is an index reflecting the influence of the calculation conditions on ground motion. The greater the range is, the greater the impact on the calculation of indicators will be, when this factor level is changed. According to the size of the range, the influencing factors are ranked, and the final results are shown in Table 6.

**Table 5  Range analysis of orthogonal calculations for point $J_3$**

<table>
<thead>
<tr>
<th>Test number</th>
<th>Column number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>$K_1$</td>
<td>8.80</td>
</tr>
<tr>
<td>$K_2$</td>
<td>8.74</td>
</tr>
<tr>
<td>$K_3$</td>
<td>18.77</td>
</tr>
<tr>
<td>$k_1$</td>
<td>2.93</td>
</tr>
<tr>
<td>$k_2$</td>
<td>2.91</td>
</tr>
<tr>
<td>$k_3$</td>
<td>6.26</td>
</tr>
<tr>
<td>Range $R$</td>
<td>3.34</td>
</tr>
<tr>
<td>Influence ranking</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 6  The ranking of influence factors and different calculation positions**

<table>
<thead>
<tr>
<th>Position /m</th>
<th>Dip angle $A/{^\circ}$</th>
<th>Depth to width ratio B/m</th>
<th>Thickness of cover layer C/m</th>
<th>Input ground motion D/gal</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>40</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>60</td>
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<td>3</td>
<td>4</td>
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<td>80</td>
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<td>4</td>
<td>1</td>
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<td>3</td>
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<td>120</td>
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<td>1</td>
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<td>140</td>
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<td>180</td>
<td>2</td>
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<td>4</td>
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<td>200</td>
<td>4</td>
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<td>3</td>
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<td>220</td>
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<td>240</td>
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<td>4</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

The calculation results show that the above four factors have an important impact on the
surface ground motion of trapezoidal valley sites, but the degree of influence varies with the location. The influence factors of different locations of the trapezoidal valley site are different. The sites J1-J3 have the same rank of each influence factor on the surface ground motion. The biggest influence factor is the valley slope angle, successively the next one is the ratio of depth to width and the thickness of the cover layer, and the last one is the input ground motion intensity. It indicates that the influence of various factors on the surface ground motion is basically the same when the valley site is closer to the valley slope. The slope angle and the depth-to-width ratio of the river valley are the geometric parameters of the valley, therefore, it can be seen that the geometric parameters of the site terrain has a greater effect on ground motion. As the site is farther away from the valley slope, the ranking of influencing factors also changes. Generally, the slope angle shifts backward, the input ground motion and the thickness of the cover layer move forward. This indicates that the main influencing factors of the site have also changed. The influence of the valley geometric parameters on ground motion gradually weakens, and the influence of the latter two factors gradually increases. The impact of this site effect is similar to that of the horizontal layered site.

3 DISCUSSION

3.1 Analysis Based on Strong Motion Records

The most effective research method for ground motion site effect is strong motion records analysis. The Anning River valley was selected as the site to verify the calculation results in this paper. The author has carried out the work of the Xichang Earthquake Prevention and Disaster Reduction Plan and Mianning County Earthquake Prevention Plan, so a great deal of data on geophysical exploration, drilling, engineering geology and seismo-geology about the Anning River valley site was collected. In addition, strong motion stations in the valley of the Anning River were set up by the digital strong motion network of China, and high-quality acceleration records of the main shock were obtained during the Wenchuan earthquake.

In this paper, the strong motion records of 3 stations in the Anning River valley are taken as the analysis data. Among them, the Xiaomiao station is the bedrock station, the Mianning and the Lizhou station are the soil-site stations, and the distance between them is close. The main earthquake acceleration time history curves were obtained by the three stations, as shown in Fig.3. The minimum value of the acceleration peak is 4.1cm/s² and the maximum value is 22.1cm/s², as shown in Table 7. The acceleration response spectrum curves of the three stations are shown in Fig.4, and there is a large difference in the shape of the response spectrum. The response spectrum curves of the Xiaomiao station show a single peak, which is narrower than that of the other two stations. The other two stations show multiple peaks and a slightly wider shape. The traditional spectral ratio method which is widely used at present was used to analyze the different reasons, and the Xiaomiao station was selected as the reference station. In the traditional spectral ratio method calculation, the Parzen window smoothing was taken, whose bandwidth is 0.4Hz. The calculation results are shown in Fig.4. The results show that the ground motion amplification of the two soil-site stations is significantly different, except for the frequency range of 0Hz–3Hz in EW, 0Hz–2Hz in NS and 0Hz–1Hz in UD component. The amplification of Mianning station is greater than that of Lizhou station, which is approximately seven times higher, locally.
Table 7  The parameters of stations in the Anning River area which recorded the mainshock acceleration time-histories during the Wenchuan earthquake

<table>
<thead>
<tr>
<th>Station</th>
<th>Site type</th>
<th>EW</th>
<th>NS</th>
<th>UD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xiaomi</td>
<td>Bedrock</td>
<td>5.8</td>
<td>4.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Lizhou</td>
<td>Soil layer</td>
<td>15.9</td>
<td>22.1</td>
<td>11.5</td>
</tr>
<tr>
<td>Mianing</td>
<td>Soil layer</td>
<td>14.5</td>
<td>17.7</td>
<td>10.7</td>
</tr>
</tbody>
</table>

**Fig.3**  Acceleration time histories from different stations

**Fig.4**  The response spectra from different stations (damping: 5%)  

**Fig.5**  The amplification of soil site on ground motion in the Anning River and the Qionghai area during the Wenchuan earthquake

The strong motion records obtained from the two soil-site stations are from the main shock of the Wenchuan earthquake, and the input ground motion intensity and spectral characteristics are the same. Therefore, the site condition of the stations is the main reason for the different effect on the ground motion amplification. At first, we analyzed the effect from thickness of the cover layer of the station site. According to the construction data of the station and the engineering geological data, the two stations are located at the valley sites of the Anning River, the sites are open and
flat and the strata are mostly of a binary structure with a surface of about 1m–2m of silty soil and fine sand. Their bottom is a sandy gravel layer which consists of granite, volcanic rock, quartzite, basite and so on. The thickness of the cover layer is more than 100m, which is a deep overburden site, so the influence of the thickness of the cover layer is similar. Therefore, the thickness of the cover layer does not have a significant effect. Then, we analyzed the effect of the location of the terrain. Although the two soil stations are located in the plain of the Anning River valley, there are differences in location. According to the coordinates of the two stations, it can be seen from the topographic map that the Mianning station is about 1.3km away from the center of the Anning River, but the Lizhou station is about 1.6m away from the center of the Anning River. Although there is a lack of the Anning River valley profile of the sites where the two stations are located, the terrain of the river valley where the two stations are located is not the same from the geophysical exploration and drilling data of the Xichang Earthquake Prevention and Disaster Reduction Plan and the Mianning County Earthquake Prevention Plan. Therefore, the amplification effects on ground motion are different because of the different influences of river valley topography. Because of the insufficient concentration of strong motion networks in China, there is no strong motion station at the river valley site, which makes it impossible to obtain more information for research. Although the above analysis results are relatively superficial, it has shown the amplification effect of river valley topography on the ground motion, and it also verified that the numerical simulation results are credible. On this basis, more precise numerical simulation calculations can be carried out to obtain the influencing parameters on ground motion effects by more specific valley sites.

3.2 Design Ground Motion Parameters of Site

At present, in seismic design, the empirical method of approximate estimation is mainly used to consider the site influence on the design ground motion parameters. The method firstly determines the category of the engineering site according to certain site classification principles and methods, and then the ground motion parameters of the engineering site based on the relationship between the site type and the ground motion parameters or the standard regulation are given. In the Chinese Seismic Design Code, two indicators, namely shear wave velocity and cover thickness, are generally used to classify the site. This method is widely used in Code for Seismic Design of Special Structures, Code for Seismic Design of Buildings, Specification of Earthquake Resistant Design for Highway Engineering, Code for Seismic Design of Hydraulic Structures of Hydropower Project and Code for Seismic Design of Railway Engineering. The classification method is simple and easy to operate, and to be grasped by engineering technicians. However, the influence of the topographic effect is not considered by this classification method, and the influence of the topography is not necessarily considered when determining the seismic parameters. Therefore, it may sometimes underestimate the amplification effect of ground motion, which brings potential danger to engineering construction. In the Code for Seismic Design of Buildings (GB50011-2010), there is no corresponding adjustment coefficient for valley sites when determining the seismic influence coefficient. The determination method for valley sites is the same as that of other horizontally layered sites, and the influence of valley topography is inevitably not taken into account when determining seismic design ground motion parameters. However, as a complex site type, the valley site can be seen from the above analysis that the geometric parameters of valleys site have an important impact on ground motion, even the different valleys of the same site type are obviously different, and moreover the magnification of ground motion may differ greatly. Underestimated ground motion parameters may be selected in engineering seismic design, which will bring potential hazards to buildings.
4 CONCLUSION

Due to the phenomenon of refraction and reflection caused by the propagation of seismic waves in river valleys, the effect on ground motion is more complex. In this paper, the two-dimensional finite difference method combined with transmission boundary theory is used to analyze the influencing factors on ground motion in valley sites, and the following conclusions are obtained:

(1) The impact of the valley site on ground motion varies with the location of the site, and the impact of each influencing factor is different.

(2) For the valley site, the factors affecting the surface ground motion are the same within a certain distance to the valley slope. The greatest factor is the valley slope angle, followed successively by the depth-to-width ratio, the thickness of the cover layer, and the last, the input ground motion intensity. In this site, the geometric parameters of the valley topography have a greater effect on ground motion, and it is also verified by strong earthquake records analysis that the terrain of the valley site has an important influence on the ground motion parameters.

(3) As the distance from the valley slope increases, the ranking of the influencing factors also changes. In general, the major influencing factors on the ground motion change when the distance of the site to the valley slope is larger than 40m. The ranking of slope angle shifts backward, the input ground motion and the thickness of the cover layer move forward. The influence of geometric parameters of the valley on the ground motion gradually weakens, and the influence of the latter two factors gradually increases. The impact of the site on ground motion is similar to that of a horizontal layered site.

(4) Data from the Anning River valley site and strong motion records are selected for comparative analysis. The results show that the amplification effect of ground motion on the river valley site has a close relationship with the location of the site, which also indirectly proves the reliability of numerical analysis.

In conclusion, the effect of valley sites on ground motion is a complex process. So it is necessary to conduct more precise calculations and analysis using reasonable two-dimensional or three-dimensional seismic response analysis methods, combining the geometric parameters of the valley site with the site conditions to calculate the influences of the geometric parameters of the valley site and the site conditions on the ground motion parameters. In this way, the design ground motion parameters of the river valley site can be scientifically and reasonably obtained to mitigate or avoid earthquake disasters.

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