

The Analysis of Abnormal Intensity in Hanyuan during Wenchuan Earthquake based on Seismic Responses Analysis

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SUMMARY:

Far away from the epicenter, Hanyuan old county suffered heavy earthquake damage during Wenchuan earthquake, which is the only abnormal intensity of VIII degree in VI degree intensity region, it is rare and typical high abnormal intensity region. In order to inquire the abnormal intensity reason, scientific investigation was carried out. And five test bores which are located in concentration of abnormal intensity region of old county were drilled and tests of soil dynamics were carried, data of soil construction and their dynamical parameters were got at first hand. With the use of 1-D equivalent linearization wave motion method that is widely used in ground response analysis in China, the old county parameters of surface ground motion were calculated. The analysis of results shown that one of main reasons of abnormal intensity maybe amplification of Hanyuan old county site is notable.

Keywords: Wenchuan earthquake Hanyuan site abnormal intensity seismic responses.

1. INTRODUCTION

May 12, 2008, 8.0 earthquake occurred in Sichuan province, strong earthquake caused enormous economic losses and casualties, and destroyed a lot of foundation and public facilities .From seismic intensity distribution (figure.1) (Yuan,2008) ,it shown that the intensity of the earthquake epicenter is up to XI degree and attenuation is like oval. Far from epicenter, southwest of nearly 200 km Hanyuan county intensity is VIII degree, which is in the area of intensity VI degree. It is typical high-intensity in low-intensity areas during Wenchuan earthquake, and it is very rare that cross twice the intensity, the research significance is remarkable. Some scholars analyzed the reason through scientific investigation and obtained certain results (Gao *et al.*, 2008; Bo *et al.*, 2009; Qi *et al.*, 2009), but the results are based on the Wenchuan earthquake scientific investigation, most of the results are qualitative and poor in calculations data.On this basis, this paper is based on a fine site investigation and drilling data, and proceed site seismic analysis from the soil structure, expect to find answers of Hanyuan abnormal intensity from Hanyuan site soil construction.

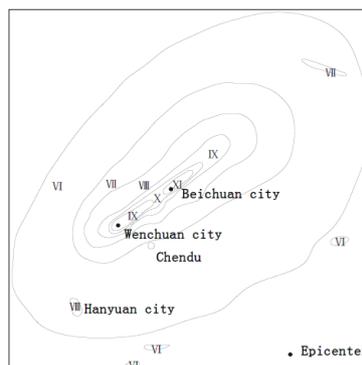


Figure 1. Map of seismic intensity distribution during Wenchuan earthquake

2. SEISMIC INTENSITY INVESTIGATION

Hanyuan is a mountain county in the south of city of Yaan, adjacent to Dadu and Liusha river. The county is divided into the old county and new county. The old county is located in Fulin town, the new county is located on the Luobo mountain heights where it is between the Dadu river and Liu Shahe river, and is also resettlement project of the Pubugou water power engineering. There are total 40 towns, 256 villages, 0.32 million people in Hanyuan county. According to statistics of Hanyuan government, earthquake damage involved in 251 villages and 0.22 million people, with 23 dead, 22 wounded seriously, 0.137 million collapsed building and 1.542 million unsafe house. According to results of the national scene earthquake disaster assessment group of Wenchuan earthquake and Hanyuan abnormal intensity scientific investigation, old-fashioned wooden construction, brick-concrete structure and frame construction houses are main structure of building in Hanyuan. Seismic damage index of the brick-concrete and frame building is 0.66, while the old huts housing is 0.75, as shown in figure 2 and figure 3. According to national standards of the People's Republic of China "China Earthquake Intensity (GB/T17742-1999)" "the Hanyuan old county intensity is up to IX degree. Hanyuan new county destruction is slight (figure 4), and intensity was evaluated VII degree. From the entire Hanyuan county, the basic intensity is VIII degree.



Figure 2. Hanyuan old county collapse brick-concrete structure houses



Figure 3. Hanyuan old county collapse timberwork houses



Figure 4. Hanyuan new county slightly damaged houses

3. SITE CONDITION

3.1 Site Reconnaissance

Five test bores which are located in concentration of abnormal intensity region of old county were drilled, the sketch map of distribution of drilling is shown as figure 5. The drilling Zk1 located within collapsed house which is adobe construction; Drilling Zk2 was arranged in the Hanyuan Fulun town primary school, the school building has been severely damaged during Wenchuan earthquake, damaged school buildings have all been removed when borehole was drilled; The drilling Zk3 is in family building of Hanyuan Industrial Company, the building is six-story brick structure, infrastructure of water and electricity has all been removed ; The drilling Zk4 is near the house owed by a citizen at courtyard of Hanyuan bus station , the drilling is the closest to Beihoushan landslide among five 4 and three layers , the drilling is near Liusha river. The drilling and samples, standard penetration test, petrographic description of all the drillings were completed according to Chinese code for investigation of geotechnical engineering. A total of 27 representative soil samples were taken, soil density and dynamic shear modulus ratio and damping ratio with shear strain variation were got by in situ tests, laboratory soil routine tests and resonant column tests. They were provided for the basic data and calculation parameters of analysis and calculations.

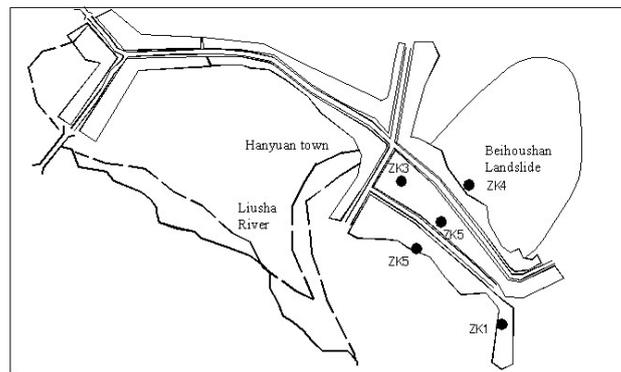


Figure 5. The sketch map of distribution of drilling

3.2 Site Soil Construction

The Hanyuan old county is situated in the convergence zone of two- three terraces and proluvial fan of Liusha riverside, underground soil is relatively loose, distribution of Quaternary sediments is uneven, layer is not stable and thickness is not the same. The layers of miscellaneous fill, silty clay, silt, medium sand, fine sand, gravel were obtained from the drilling investigation. The layers of site are more complicated, thickness of cover are greater, the thickness is more than 50m. Combined with test results of the shear wave velocity, in accordance with code (Ministry of construction of the people's republic of China. 2010) the types of site were classified. From table 2.1, it can be shown that the classification of the Hanyuan old county site is class III, it is soft site.

The characteristics of bedrock ground motion can be changed by site soil construction. The site soil construction is one of the reasons that cause severely damage in Hanyuan old county. Scholars have done a lot of research on the effect of soil construction and the layer cover thickness (Bo *et al.*, 2003; Bo *et al.*, 2004; Bo *et al.*, 2003;Olsen, 2000), and usually use the soil seismic response analysis method to study the impact of site soil(Liao *et al.*, 1989). Site soil acts as how much to impact damage of Hanyuan during this earthquake, it was revealed by the earthquake response analysis method.

Table 2.1. The Hanyuan site types

Drilling Numbers	ZK1	ZK2	ZK3	ZK4	ZK5
Equivalent shear wave velocity (m/s)	171.1	160.4	156.2	157.7	163.9
Cover thickness(m)	50.7	>50	>50	>50	>50
Site types	III	III	III	III	III

4. EARTHQUAKE RESPONSE ANALYSIS

4.1 Calculation Parameters

The data of the five site drillings in the old county was got, and drilling columns was taken as the calculation profiles. From the columns, the soil is composed of miscellaneous fill, silty clay, medium sand, fine sand, gravel, Xigeda strata. The shear wave velocities were used is field test data. The relationships between dynamic shear modulus ratio, damping ratio and the shear strain were got by soil test. With mathematical statistics and least squares method, regression analysis silty clay (soft plastic, plastic, hard plastic), middle sand, fine sand, silt, three types of soils in the eight shear strain shear modulus ratio and damping, as were shown as figure 6. Miscellaneous fill, gravel and bedrock parameters were given refer to the empirical value. Jiuxiang strong motion records were taken as the input ground motion, which is nearest to Hanyuan county, time history curses of strong motion were shown as figure 7. Strong motion records is a total of 63459 points, and time step is 0.005s , the peak acceleration from east to west (EW) is 72.7cm/s² , and from south to north (SN) is 80.35cm/s² , half of the peak acceleration were taken as input ground motion.

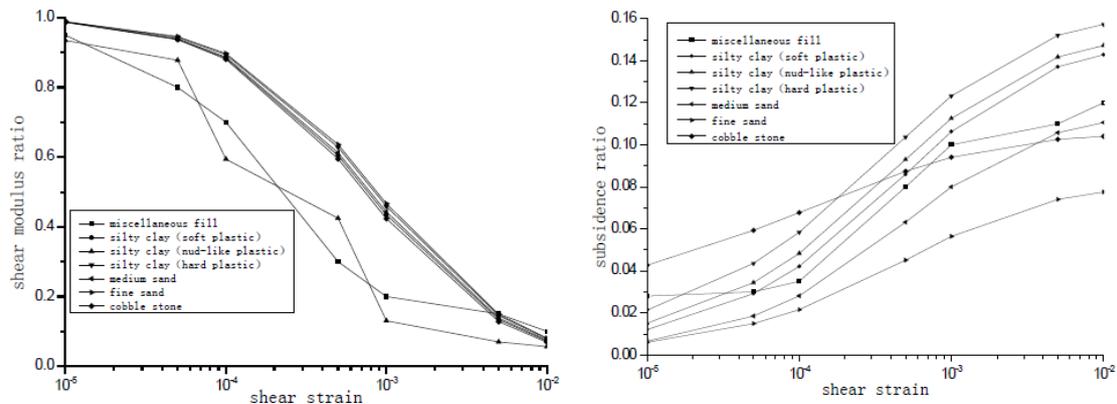


Figure 6. Soil dynamic shear modulus ratio and damping ratio

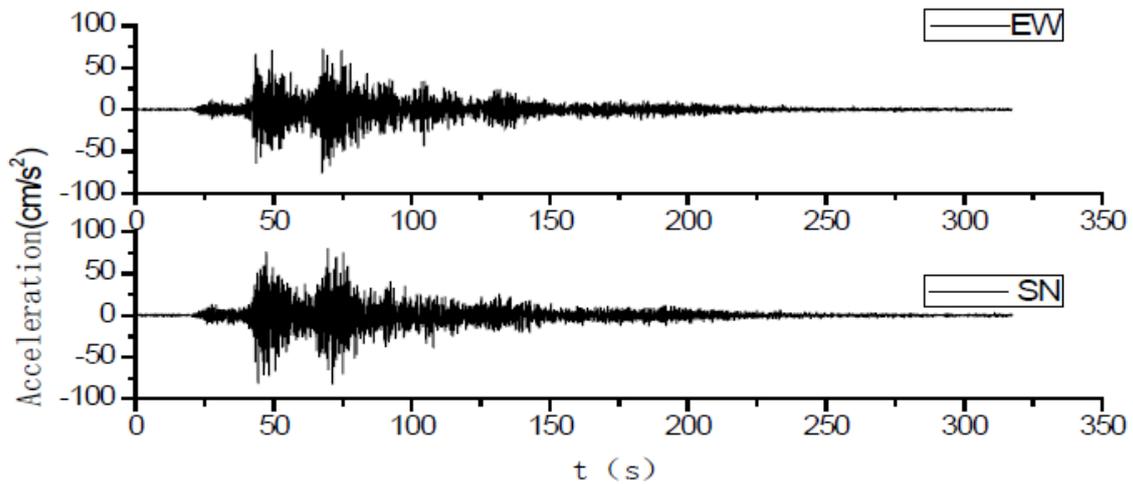


Figure 7. Time history curses of strong motion record of Jiuxiang

4.2 Calculation Result

With the use of 1-D equivalent linearization wave motion method, each soil profile has been calculated, the Hanyuan old county peak ground acceleration and the magnification factor M (M is defined as the peak ground acceleration divided by input peak ground motion) were got, the calculation results is shown in table 3.1 . From the calculation results, it can be shown that all drillings magnification of peak ground acceleration is greater than 2, the effect of amplification is significant. According to the National Standards of the People's Republic of China" China Earthquake Intensity (GB/T17742-2008) ", the Hanyuan old county peak ground acceleration values is 0.15g , the calculation value are higher than this value. So abnormal ground motion cause Hanyuan abnormal damage during earthquake. In order to compare difference of ground motion of the abnormal area and intensity VI zone, five strong-motion 10 acceleration records were selected in intensity VI zone. In order to eliminate influence of the fault distance, the fault the upper and lower plates and the rupture direction, the location of stations that were selected were at same fault plate and fault distance are nearly equal, they were shown in table 3.2. Compared to the two tables, it shown that values of Hanyuan old county surface ground motion are greater than the peak of the strong-motion earthquake record. It indicates that ground motion amplification of the Hanyuan old county soil construction results in abnormal surface ground motion, according to national standards of the People's Republic of China seismic Design of Buildings " Hanyuan earthquake intensity VII is 0.15g, abnormal seismic is beyond the actual capacity of the ground housing earthquake-resistance, resulted in the destruction of a large number of buildings, lead to abnormal earthquake damage. The special site soil construction of Hanyuan old county is one of the main reasons of Hanyuan high abnormal intensity.

Table 3.1. The comparison of peak acceleration and their amplification factor among soli profiles' ground response

Borehole No.	ZK1		ZK2		ZK3		ZK4		ZK5	
	EW	SN	EW	SN	EW	SN	EW	SN	EW	SN
Input ground motion	174.8	199	2058.1	181.8	205.2	187.7	200.2	188.5	199.2	177.7
PGA (cm/s²)	174.8	199	2058.1	181.8	205.2	187.7	200.2	188.5	199.2	177.7
Magnification Times (M)	2.40	2.48	2.82	2.26	2.82	2.34	2.75	2.35	2.74	2.21

Table 3.2. The comparison of peak acceleration among ground response and strong motion record

The name of the strong motion station	Distance from the fault	EW-PGA (cm/s ²)	SN-PGA (cm/s ²)
Kangding	153.4	21.69	34.18
Yidong Hanyuan	156.75	82.73	80.78
Jiuxiang Hanyuan	163.05	74.91	83.04
Wuzi river Hanyuan	177.91	63.21	49.01
Wajiao Shimian	188.65	75.61	93.89

5. CONCLUSION

High abnormal intensity is a common phenomenon of earthquake damage. The reason is a lot , but it is often is closely associated with site conditions .This paper analyzed earthquake damage anomaly only from the site, and got reason of the Hanyuan abnormal seismic intensity is the site belongs to the weak and deep site, and ground motion is amplified by special soil construction, the action is very significant. The reason of seismic abnormal intensity may be not more than one, and need to do more investigations and studies deeply, collect data of geological and construction widely, research the effect of terrain and landslides , multiple factors should be considered. The answer for the question can be got scientifically and rationally.

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