RESEARCH INTO THE INFLUENCE OF EARTHQUAKE INDUCED BY THREE GORGES RESERVIOR ON SEISMIC RISK ANALYSIS IN DOWNTOWN AREAS OF CHONGQING

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Abstract：

The possibility of induced reservoir earthquake would augment after Three Gorges Reservoir sluiced. Many scholars studied the effects of induced earthquake by the head of Three Gorges Reservoir and around. The problem about the influence of earthquake induced by reservoir on seismic risk analysis in Downtown Areas of Chongqing is worth to be studied.

This paper analyzes and sub-partitions latent hypocentral distributions affecting Downtown Areas of Chongqing firstly, and concludes the latent hypocenter which plays the biggest role in seismic risk analysis based on seismicity characteristics and the feature of earthquake geology in Chongqing Area, and respectively presents their relevant seismicity parameters such as M_0, M_u, b, etc. Secondly the attenuation relation of earthquake motion can be attained according to Conversion Intensity-Range accompanied by establishing attenuation relation of seismic intensity in Chongqing Area and by virtue of corresponding relations between intensity and motion parameter of Western America rich in records of earthquake motion.

Finally the estimated value of designed motion parameter of different protected levels will be obtained via adopting the software package of seismic safety evaluation criterion from China Earthquake Administration.

It's shown that the influence of earthquake induced by Three Gorges Reservoir on seismic risk analysis in Downtown Areas of Chongqing is very low, and it will be obtained the seismic intensity, the attenuation relation of earthquake motion and the estimated value of designed motion parameter of different protected levels, which is for reference to determine reasonable criterion of earthquake resistant protection and improve urban comprehensive disaster reduction capacity.

Keywords: Three-Gorge-Reservoir, Induced Earthquake, Latent Hypocenter, Downtown Areas of Chongqing, Seismic Risk Analysis

1. Intruduction:

Earthquake which causes as a result of the human activity, is the induced earthquake, because the reservoir storage causes earthquake, also calls it the reservoir induced earthquake .In addition to tectonic earthquake in Chongqing area, the risk of earthquake disasters induced by the production

activities of human have become increasingly prominent and the most notable one is the reservoir induced earthquake. The Jiangkou electric station reservoir in Wulong of Chongqing began to impound water on December 27, 2002 from 180m above sea level, and to January 26, 2003 when the water level of 244m occurred the earthquake with magnitude of 3.5. The Three Gorges Reservoir of Yangtze River since May 2003 started to impound and as the water level reached 135m in elevation, on the front line from Zigui to Badong in the area and close-by the reservoir to have taken place in more than 2,000 earthquakes, the largest earthquake of magnitude was 2.1. Along with the water level rising further, whether it will induce a greater magnitude of the earthquake , or lead to increase the seismic risk of the surrounding cities and towns along the reservoir banks, particularly in emerging municipality of downtown areas of Chongqing? How we should consider them carefully? For what are the great concerns for the engineering sector.

According to the seismic activity environment in Chongqing and characteristics of earthquake geology in near-field, we analysis the seismic risk on the main city of Chongqing by using integrated probability of seismic risk analysis methods, and compare whether or not the Three Gorges reservoir induced earthquake as a latent hypocentral zones of the impact on risk analysis in downtown area of Chongqing.

2. The characteristics of seismic activity in downtown area of Chogqing and historical earthquakes on the impact of Chongqing .

The main seismic activities in Chongqing are small-medium sized earthquakes, but with the exception of a medium strong earthquake focus of the activity from 1854 to 1856, in modern times more than five magnitude of the medium strong earthquake activity began in 1989 (Tongjing town in Yubei District took place the earthquake with magnitude of 5.2 and5.4). And then in 1997 and 1999 (magnitude of 5.2 and 5.0 in Rongchang county). It happened 4 times earthquakes with magnitude over 5 within 10 years. Since the 1989 the annual rate of magnitude of 4 has been 1.6 times. Because of the shallow epicentre and the strongly feeling of shake, it coused the serious economic losses although the intensity of the earthquake is not too high.

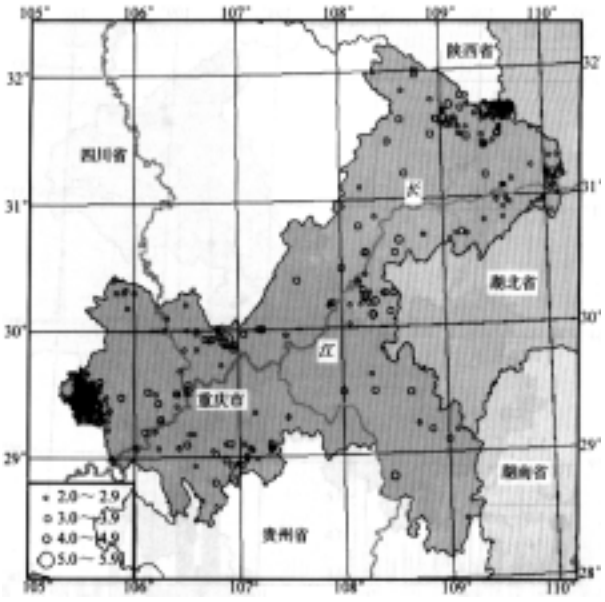


Fig. 1 Seismic Epicenter Profile（Years between 1970 and 2003，$M_L \geq 2.0$）

Figure 1 is the Seismic Epicenter Profile (ML≥2.0) in downtown area of Chongqing.It shows that stratum-room distribution is very uneven .For example ,the earthquakes is more focused on the line of Rongchang,chengkou to Wuxi, but less on the south east region of Chongqing.

Throughout the analysis of temporal and spatial distribution characteristics for

seismic activity in Chongqing region and its adjacent areas ,the evaluations for characteristics of regional seismic activity are following:

1. Seismic activity in this region belongs to the medium level, and the largest earthquake in the history is not more than the magnitude of six.

2. The downtown areas of Chongqing in the level of seismic activity is not high on the background.

3.Comprehensive probability analysis of seismic risk in downtown areas of Chongqing

In this paper, we adopt the probability of earthquake risk analysis methods (CPSHA) which consider the time and space to the heterogeneity for seismic activity. And this method is advanced in the literature[2]. This method unifies the seismic geologic condition and the seismic activity material, and uses some kind of quota probability as expression.

3.1. Compartmentalize the areas of latent hypocentral zones for Chongqing

In the method of CPSHA compartmentalized for latent hypocentral zones has the application of a strong main purpose ,which is to get the non-uniformity description of the rate of the regional earthquake. Latent hypocentral zones means areas where may occur devastating earthquake.

Principles of compartmentalizing latent hypocentral zones can be simply summed up in two: the analogy for earthquake's conformation and duplication principles of areas activities. According to the recognition ,the basic principles and the methods for latent hypocentral zones, and colligate the comprehensive research results of seismic geology, geophysical field and seismic activity in Chongqing, in addition, also consult the results of the earthquake division for countrywide. Above all,we sufficiently make use of the information that mentioned-above to divise the latent hypocentral zones for Chongqing and Sichuan Basin.

This programme plot out a total of 12 latent hypocentral zones as shown in Figure 2. Of which there's one latent hypocentral zones for maximum magnitude of 6.5, 4 zones of maximum magnitude of 6.0 and 7 zones of maximum magnitude of 5.5 .

3.2. Determine the parameters of seismic activity in down town areas of Chongqing

Determining the parameters of seismic activity is one of the basic work for seismic risk analysis of the probability , which includes the seismic activity parameters for statistical areas and latent hypocentral zones. And here we mainly express the after one.

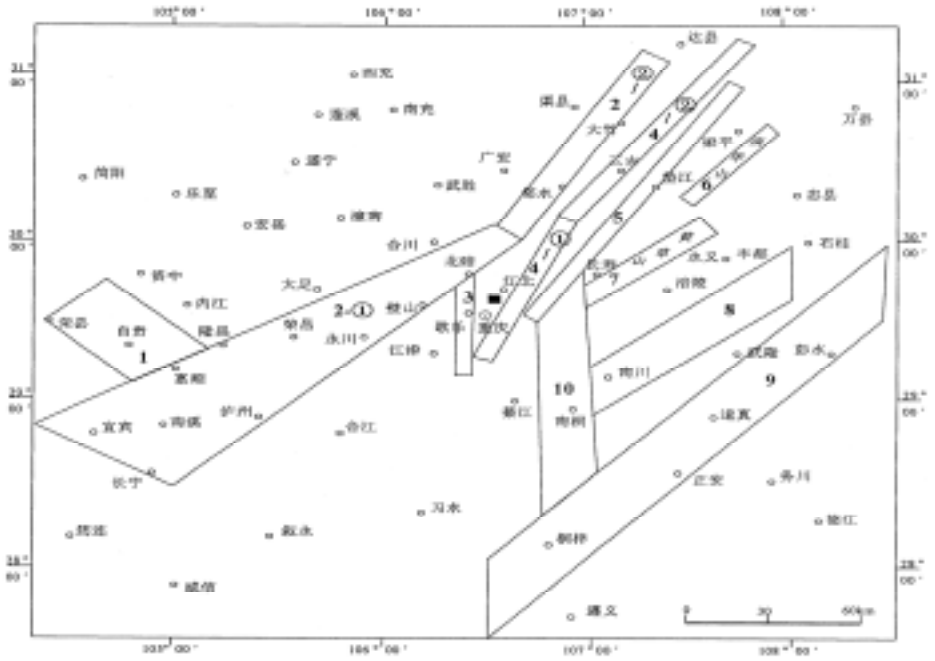


Fig. 2 Latent Hypocentral Diagrammatic Sketch

1).Spatial-distribution function f_{iMj}

The usual practice is following: First, select a number of factors that are related with the characteristics of time and space for seismic activity, then judge them by experience to quantify, and last get the result by normalization in longitudinal direction and so the sum again before the normalization of cross-cutting [4].

Spatial-distribution function of earthquake for Potential epicentre zones is a constant which is related with magnitude of earthquake and credited like this $f_{i,Mj}$. Its physical meaning is the probability of earthquake whose secondary earthquake magnitude is $M_j \pm 0.5 \times \Delta M$ occuring in the range of the first N latent hypocentral zones. In order to reflect the non-uniform of the temporal and spatial distribution of seismic activity objectively ,we usually adopt the approach of magnitude-profile to distribute the year-average-rate of earthquake in the seismic zones.

Just for the first i latent hypocentral zone within seismic zone, the magnitude -profile M_j of the annual average rate can be get form:

$$\nu_{i,M_j} = \frac{2\nu \exp[-\beta(M_j - M_0)]sh(\frac{1}{2}\beta\Delta M)}{1-\exp[-\beta(M_{uz} - M_0)]} \cdot f_{i,M_j} \qquad (1)$$

Using this method, the spatial-distribution function of latent hypocentral zones which gives the largest contribution to the regional seismic risk analysis is shown in table 1.

2) Oval's long axis orientation and its directional function

Throughout the studuy of distributional characteristics of isoseismal's long and short

axis orientation in Chongqing region, we could find that the majority of isoseismal's long axis orientation is consistent with structure of regional activities . So according to the orientation of region we can predict future earthquake-major axis direction. In the calculation of risk analysis, the isoseismal orientation is relevant with structures orientation of its corresponding latent hypocentral zones. Its directional functions can be expressed as:

$$f(\theta) = \delta(\theta) \qquad (3)$$

The letter θ in the type is the angle of structure orientation to north direction in the latent hypocentral Zones.

Table 1 Space-Distribution Function of Latent Hypocentral Zones

Nunmberof epicentre	Name	maximum	4.0－5.5	5.6－6.0	6.1－6.5
1	Zigong	6.0	0.0624	0.0785	0.0000
2-1	Yibin-Rongchang	6.5	0.0962	0.1015	0.1552
2-2	Dazhu-Linshui	5.5	0.0287	0.0000	0.0000
3	Gele	5.5	0.0121	0.0000	0.0000
4-1	Baxian-Tongjing	6.0	0.0182	0.0265	0.0000
4-2	Sangu	5.5	0.0122	0.0000	0.0000
5	Dianjiang	5.5	0.0160	0.0000	0.0000
6	Nanhuamountain	5.5	0.0115	0.00000	0.0000
7	Huangcaomountain	5.5	0.0145	0.0000	0.0000
8	Nanchuan-Shizhu	6.0	0.0366	0.0514	0.0000
9	Tongzi-Pengshui	5.5	0.0883	0.0000	0.0000
10	Changshou-Nantong	6.0	0.0388	0.0534	0.0000

3.3. The attenuation relations of seismic intensity in downtown areas of Chongqing

Seismic intensity that shocked as one of the strong or weak indicators is used abroadly by field of professional earthquake engineering. With regard to the research on attenuation relations of seismic intensity in downtown areas of Chongqing, Wang Xiaolong [5] has selected 18 times of 47 intensity isoseismal datas including historical earthquakes to do a regression analysis on the relationship of intensity attenuation in Chongqing area. Because the historical data about position of the epicenter is not so accurate and generally the earthquake magnitude can be determined by isoseismal of intensity ,which could reduce the reliability of results, so as a principle it is not suitable to ues it as the statistics information for attenuation of seismic intensity. Secondly, the survey data of actual intensity is very discrete, and so many human factors will influnce isoseismal line when outlining it. If we establish the attenuation relations on the base of scene isoseismal map may conceal some of the uncertainties or diversities. Therefor in this paper, the attenuation relations of seismic intensity is established by basing on seismic data of Chongqing and its neighbouring areas, processing the data and improving attenuational model and the statistical methods.

① Attenuation model of seismic intensity

The equation for combining model of attenuation:

$$I = B_1 + B_2 M + B_3 \ln(R_1 + R_a) + B_4 \ln(R_s + R_b) + \varepsilon \qquad (4)$$

Where, I is seismic intensity, M for the magnitude. Ra and Rb are near-field saturational factors of intensity decay for long and short axis directions. The average focal depth in Chongqing Area is 10 ~ 12 km, and in this paper near-field saturational factors are Ra = 15, Rb = 7(reference [2]). R_l and Rs are the half length of oval's long and short axises for the intensity of fist I; B1, B2, B3, B4 are the regression coefficients; ε is an uncertainty random variables for the regression analysis which usually assumed to be normal distribution, and its average value is zero, and the standard deviation is σ.

② Statistical regression results

According to the above information, we adopt a conservatism-regression method to get the attenuation relations of seismic intensity:

Long axis $$I = 1.9390 + 1.7403M - 1.7543\ln(R+15) + \varepsilon \qquad \sigma = 0.6333 \quad (5)$$

Short axis $$I = -0.1403 + 1.7403M - 1.3729\ln(R+7) + \varepsilon \qquad \sigma = 0.6333 \quad (6)$$

3.4 Comprehensive probability calculation for seismic risk

3.4.1 Analysis model of seismic risk

In order to consider the influnce of uncertainty for the seismic risk analysis, we use logic-tree method of uncertainty parameter for reference to calculate seismic risk model, and then choose the median value of the model result as seismic risk analysis results.

3.4.2 Distributing point of grid computing for seismic risk analysis

In order to get more accurate results of seismic risk analysis in downtown areas of Chongqing we need to get control calculation points of enough density and uniform distribution. Based on this, if we don't considere the influence of the gurgitation of bedrock and field condition in the researching areas ,we can distribute uniform mesh in the study areas by using 2 km × 2km grid size to receive a total of 666 grid points as the calculation points for the probability analysis of seismic risk, and to use the final calculation results of the 666 points as main basis for small divisions of downtown areas of Chongqing. Figure 3 2 km × 2 km mesh map in downtown areas of Chongqing.

3.4.3 Analysis for the results of Seismic risk probability

Calculate the probability via adopting the software package of seismic safety evaluation (ESE) and by the introduction of methods for China's probability of seismic risk analysis (CPSHA). Take risk analysis model for 666 points in downtown areas of Chongqing and for each model we all calculate the three levels of transcendental probability for 50 years of 63%, 10% and 2%, then adopt the median value of 666 points results as the results of seismic risk analysis. At last we could receive some ground motion parameters, such as the intensity , the rock acceleration response spectrum and transverse peak acceleration of bedrock ect.

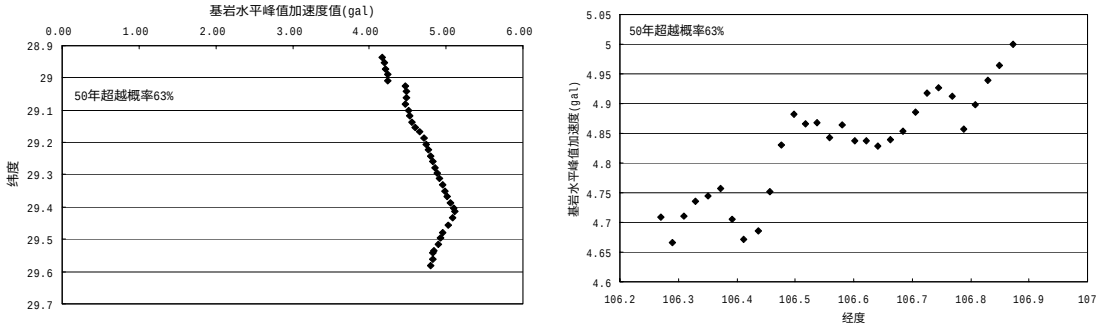
4.Conclusion

1. In downtown areas of Chongqing ,the transverse peak acceleration of bedrock whose transcendental probability for 50 yeas of 63 percent, 10% and 2% are 8,39 and 86.

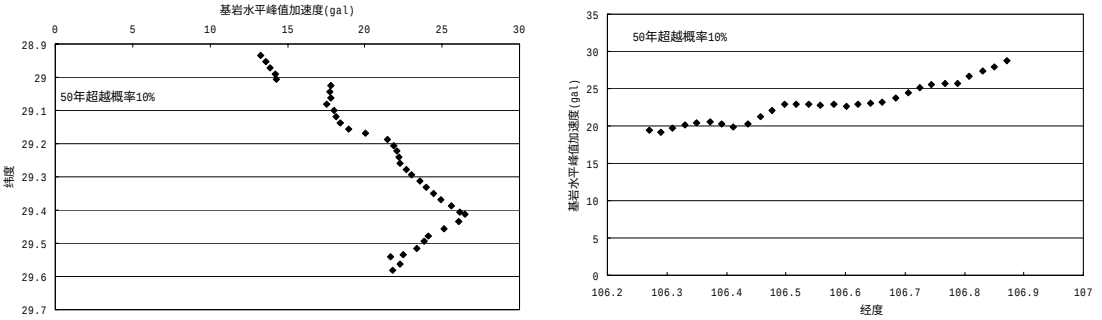
2. The acceleration response spectrum for 50 yeas of three transcendental probability of four kind of fields in downtown, which is switched from the rock acceleration response spectrum ,can be used as reference information by the region seismic distribution and construction.

3. Latent hypocentral zones of RongChang with magnitude of 6，so with JiangJin 5.5,Huaying mountain 6.0 and Chongqing 5.5 give the greatest impact on seismic risk in downtown areas of Chongqing, and the results can be used as reference for all types of Engineering feasibility study stage.

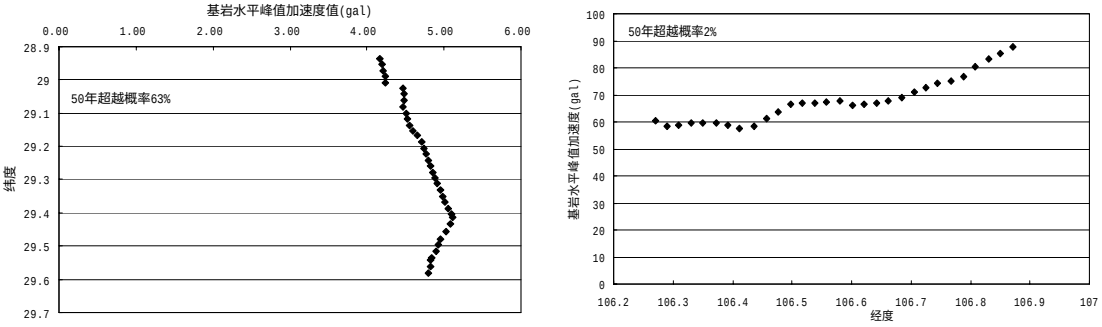
4. Induced earthquake has a relatively weak influence on the seismic risk in downtown areas of Chongqing.



（a） Sixty Three Percent Transcendental Probability per Fifty Years



（b） Ten Percent Transcendental Probability per Fifty Years



（c） Two Percent Transcendental Probability per Fifty Years

Figure3 Distribution Diagram of Peak Acceleration on Rock along Warp and Woof in Downtown Areas of Chongqing

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