A study on fast assessment of medium and small earthquake

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Abstract

The key to rapid assessment of earthquake losses is to identify the seismic intensify area. The information about the scale of earthquake may help the government and the relative department to make countermeasures, dispose disaster rescue action and strive for foreign aid. In this paper, the data of history earthquakes of Zhejiang Province and its surrounding areas, after being processed by GIS system, are used to access the length of the earthquake axis parameters. Then the data are compared with the tectonic structure of the area to determine the classification. After that, the rapid assessment of earthquake model is applying to the axis parameters of earthquakes, which have impact in Zhejiang Province. The model can provide references of earthquake rapid assessment.

Keywords: Fast Earthquake Loss Assessment, GIS, Earthquake disaster emergency

1 Introduction

After the destructive earthquake, using the existing technical conditions may quickly draw the longitude, the latitude and the magnitude of earthquake. However, the rapid assessment requires more detailed information, for example, the Intensity distribution. Based on the intensity distribution and the emergency database, the loss of earthquake, which contains the casualties and the property loss, may be estimated. This evaluation mode is more meaningful to the government.

In order to get the Earthquake Intensity Attenuation Model of Zhejiang province and the surrounding area, we collect great references of historical earthquake intensity material. After analysing these data statistically, we get the Earthquake Intensity Attenuation Model of Zhejiang province and the surrounding areas. Firstly, we adopt the Earthquake Isoseismal Line Drawing Diagram Evaluation Model to get the Long and Short Axis Polynomial Relation Model under different intensity influence field. Secondly, we statistically analysed the example of earthquake in Zhejiang province and the surrounding areas, and get the Seismic Influence Field Model. Through the use of mode for rapid earthquake assessment, may calculation future earthquake damage prediction [1].

2 The design of Fast Evaluation Mode

After the earthquake, making the Snap judgments needs to identify the scope the range of earthquake. introduced the Isoseismal Line Model . We will use this model in our research. After earthquake, the earthquake quick determine system can be used to measure the epicentre, the seismic intensity ring or isoseismal line. Actually, the situation of the seismic intensity ring is very complex. In most cases, it is irregular oval shape. In order to build this model, we assume that all the isoseismal lines are regular ellipse. The VII degree circle isoseismal line will appear multiple times. It means there will be many epicentres in this earthquake. We assume that there are only one intensity ring, which is in the same level, to simplify the process. If there are several different heart intensity rings, we will select the largest as the modelling data sources. Based on the above hypothesis, according to the structure fracture and tectonic division condition of local area, we may measure the direction of the minor axis of ellipse. According to the minor axis, major axis of an ellipse to measure the magnitude of earthquake may get the parameter of the minor axis and major axis. It may quickly get the intensity ring and provide reference for the earthquake evaluation [2].

2.1 DATA REDUCTION

Zhejiang province is an Eldorado, the records of local area is widespread. Although earthquakes are not common in this part of the world, but the record of the few earthquakes is very detailed. This research is concerned to the destructive earthquake. In fact, the records about the destructive earthquake is very detailed. The 43 isoseismal maps of this research comes from the record of earthquake of magnitude 4 or over, which happened in Zhejiang province. Firstly, we use the ArcGIS to calibrate the isoseismal maps into the Xian 1980 coordinate system. Then vectorise the epicentre and the isoseismal line of different intensities. Secondly, we mark the name and earthquake magnitude of the epicentre, and the name and the intensity of isoseismal line. Thirdly, after vectorising the isoseismal line and the epicentre, we

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combine the epicentres into one map. Superposing this map with the boundary and earthquake structure-zoning map of Zhejiang province. Then look the tendency of aggregations of earthquake in three blocks: 1) the north of Zhejiang province and the south of Jiangsu province; 2) the south of the Yellow Sea, the north of Jiangsu province; 3) the Yangtze estuary. In other blocks, the number of earthquake is too little to build the model. Actually, the earthquakes, which happened in Zhejiang province lack the record of isoseismal line. We mark these points to explain the limiting factor of modelling. The application of historical earthquake records have two limiting factors in modelling. Firstly, due to the lack of earthquake records in Zhejiang province, Jiangsu province, and Shanghai where earthquake are infrequent, the research result becomes uncertainty; Secondly, the magnitudes of earthquakes in Zhejiang province are below the standard of example which can be choose in research (magnitude lower than 6). The magnitude of earthquakes are often concentrated in 4 to 6.

After determining the research object, we add up the major and axis of isoseismal line in three blocks. In most cases, the isoseismal line is closer to elliptical. With the help of ranging function of ArcGIS, we may read the major and axis of isoseismal line. Following is the outcome.

2.2 THE MODEL AND RESULTS

The index model is suitable for the earthquake statistics. We adopt the classic index model.

$$y = ae^{bx} . \tag{1}$$

It uses CurveExpert 1.38 as processing program, which match automatically by default. Although the earthquake magnitudes are distribute in the narrow region, the result is desirable [3, 4]. It is worthwhile to note that there is unusual data; these data should be deleted, for the cause of earthquakes, which happened in these areas are different from the other earthquakes. For example, in the V degree zone of the adjustable shaft model of northern Zhejiang and southern Jiangsu, we can a point, which is isolated from the other points. In addition, it is not because the large gap which between the lateral axis and earthquake magnitude. The result of curve fitting is y1=52.999exp(0.293x). After deleting the data of this point, the result of curve fitting is y2=26.786exp(0.432x). The shape of the curve is improved obviously. If the prediction of the magnitude of the earthquake is 6.1, then y1=316.57 km, y2=373.56km, the difference obviously. The results is selected according to the above case. Following is the result of curve fitting (Fig. 1, Fig. 2, Fig. 3, Fig. 4).

TABLE 1 The Earthquake Cases Statistics

IV degree area statistics					
magnitude	*Statistical number*	*magnitude*	*Statistical number*	*magnitude*	*Statistical number*
the north of Zhejiang province and the south of Jiangsu province		the south of the Huanghai Sea, the north of Jiangsu province		Yangtze estuary area	
4¾	1	4.8	1	5.0	3
4.9	1	6.2	1	5½	1
5¼	1	6½	2	6.1	1
5½	2	6¾	1		
5.8	1	7.0	1		
6.0	1				
V degree area statistics					
magnitude	*Statistical number*	*magnitude*	*Statistical number*	*magnitude*	*Statistical number*
the north of Zhejiang province and the south of Jiangsu province		the south of the yellow sea, the north of Jiangsu province		Yangtze estuary area	
4¼	2	4.8	1		
4½	2	5½	1		
4¾	4	6.0	2		
4.9	1	6.2	1		
5.0	2	6½	3		
5¼	1	6¾	2		
5½	2	7.0	1		
5.8	1				
6.0	1				

TABLE 2 The Fitting results Model of the Seismic Intensity Attenuation

the area	**Long axis**	**Short axis**
the north of Zhejiang province and the south of Jiangsu province V degree	y=26.786exp(0.432x)	y=12.806exp(0.458x)
the north of Zhejiang province and the south of Jiangsu province IV degree	y=1.720exp(0.968x)	y=0.357exp(1.187x)
the south of the Yellow Sea, the north of Jiangsu province V degree	y=17.225exp(0.536x)	y=1.497exp(0.856x)
the south of the Yellow Sea, the north of Jiangsu province IV degree	y=4.809exp(0.808x)	y=6.753exp(0.724x)
Yangtze estuary IV degree	y=38.004exp(0.459x)	y=59.933exp(0.298x)

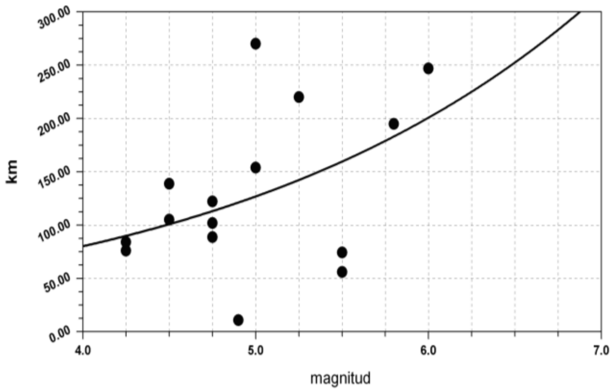

FIGURE 1 The Fitting results Model of the area of the Southern Zhejiang and the south of Jiangsu province V degree short axis

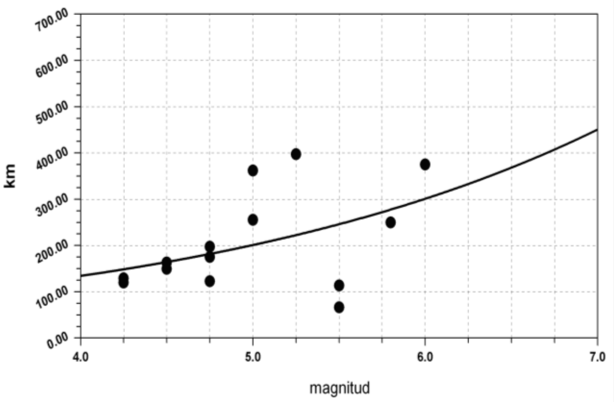

FIGURE 2 The Fitting results Model of the Southern Zhejiang and the south of Jiangsu province V degree Long axis

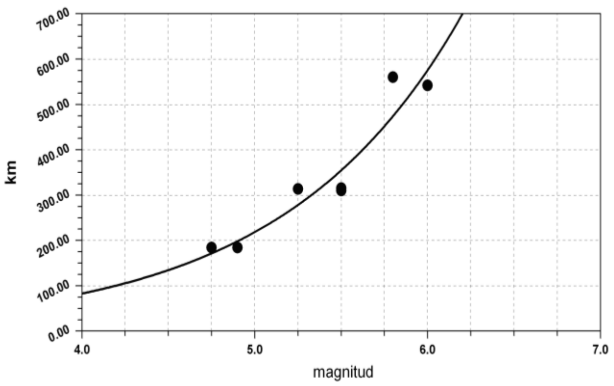

FIGURE 3 The Fitting results Model of the area of the Southern Zhejiang and the south of Jiangsu province IV degree short axis

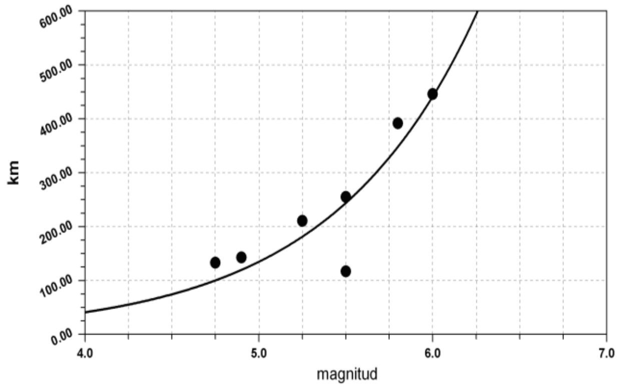

FIGURE 4 The Fitting results Model of the area of the Southern Zhejiang and the south of Jiangsu province IV degree Long axis

3 The model of seismic hazard evaluation

We can use the data and the divinable model of earthquake to make the rapid evaluation of seismic hazard. In the calculation, we use GIS to read the acreage of residential building in different villages and the proportion of residential building in each village. Then we use the Earthquake Intensity Attenuation Model of Zhejiang province and the surrounding area to calculate the infection of earthquake, and judge the distribution of population and the Gross Indices of Macroeconomic Operations, which may belong to corresponding area of seismic intensity [5, 6].

3.1 THE CALCULATION OF ECONOMIC LOSSES

We think that the economic loss caused by damage mainly because building direct economic losses, with the following formula said

$$L(I) = \sum_{s=1}\sum_{j=1} b_s(j)\beta_s(j) + \sum_{s=1}\sum_{j=1} Q_s(j)W_s \,. \qquad (2)$$

In this formula, "*j*" represents the earthquake damage level. It consisted of 5 levels (sound, mild, moderate, severe and destroy); "*S*" represents the type of building. It consisted of 3 levels (steel, multi-layer, single); $b_s(j)$ represents the loss ratio of "*s*" class building in the "*j*" kind of damage (intensity 5, 6, 7, 8, 9, 10), it is the value ratio of the cost of rebuilding and the total value of building; $Q_s(j)$ represents the total value of the "*s*" class building in the "*j*" kind of damage; $Q_s(j)$ represents the loss ratio of the "*s*" kind of building damage in the "*j*" kind of damage. It is the value ratio of the loss of interior assets and the total value of indoor assets; $Q_s(j)$ represents the value of indoor assets in "*s*" kind of building.

The Fast Earthquake Loss Assessment. Actually, the distribution of building is not average. That using 1:50000 construction layer to correct. The database, which is used for the rapid evaluation of seismic hazard, is based on the GDP and the vital statistics of villages and towns. In order to use the vital statistic data adequately, we depend on the residential distribution chart and allot the information of census and the GDP data according to the proportion of the occupied acreage of residential buildings. At last, we can use the data and the divinable model of earthquake to make the rapid evaluation of seismic hazard [7, 8].

3.2 THE CASUALTIES CALCULATION FORMULA

Casualties prediction include: calculate number of the casualties and number of the injured in the affected areas in a given earthquake condition.

$$M_d(I) = c\eta(A_1 r_{d1} + A_2 r_{d2} + A_3 r_{d3})\,, \qquad (3)$$

$$M_h(I) = c\eta(A_1 r_{h1} + A_2 r_{h2} + A_3 r_{h3})\,. \qquad (4)$$

In the formulas (3) is number of the casualties and (4) is number of the injured, C is for the personnel percentage indoors in the earthquake, A_1 is for the destroyed houses' area, A_2 is for severely damaged houses' area, A_3 is for medium damaged houses' area, η is for personnel density indoors. Units: people/m2; r_{d1}, r_{h1} are respectively the mortality rate and the seriously injured rate in the destroyed house; r_{d2}, r_{h2} are the mortality rate and seriously injured rate in the severely damaged house; r_{d3}, r_{h3} are respectively the mortality rate and seriously injured rate in medium damaged houses. In the forecast, time can be divided into the day and the night, now suppose during the day in the earthquake indoors personnel percentage is for 40%, and during the night in the earthquake indoors personnel percentage is for 100%. The daytime is from 8:00 to 18:00, and the night time from 18:00 to 8:00 [9].

In Blind estimate system casualties calculating is similar to property losses calculating, using space superposition analysis method to calculate the casualties. First, the overlying town's clustered houses' area and separate house's area can be obtained by the space superposition method, then put the result into the casualties calculation formula to get the number of the dead, and the injured and the homeless.

4 Conclusion

The rapid evaluation of earthquake loss uses experiential models to evaluate the loss of earthquake in a short time. The information about the scale of earthquake may help the government and the relative department to make countermeasures, dispose disaster rescue action and strive for foreign aid. If we can estimate the distribution and degree of the earthquake in a short time, the government may make a scientific decision to rescue disasters, then more people who lived in the earthquake area may rescued, the loss of economy may reduced. In the future, more researches can be made on the new methods of seismic hazard evaluation [10].

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