A Real-time Correction Method in Rapid Assessment of Seismic Intensity Distribution

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SUMMARY:
The isoseismal line is the most important guidance in the emergency assessment work of post-earthquake. In this paper, an improved ellipse intensity-attenuation model is proposed, which is completed by the establishment of semi-major axis and semi-minor axis length matrix. Based on the initial value of the length matrix got by the regression of historical data and survey data from the site, we use the LMS algorithm to revise the length matrix and then draw the isoseismal line, which is called the matrix intensity-attenuation model. In the end, the practicability of this model is verified by the case of Lijiang 7.0 earthquake.

Keywords: disaster emergency, isoseimal line, matrix model, real-time correction

1. INTRODUCTION

Every destructive earthquake causes great casualties along with lots of damage to varying degrees and even extermination of building and civil engineering structures. Emergency rescues must be launched quickly to save people's life and property by the government. The isoseismal line briefly shows the directly influence, damage, scope and distribution of the earthquake. It is also easily understood and accepted by the government and society, which is of extreme importance for the emergency relief deployment and action. The emergency assessment work of post-earthquake requires the isoseismal line which is constantly revised according to the updated information.

There are three factors to draw the isoseimal line: macro-epicentral intensity and its location, the direction of semi-major axis, the value of semi-major axis and semi-minor axis length in isoseismal line.

It is generally believed that the main shock releases most of the strain energy and the aftershocks continue to release the left strain energy. The geographical distribution range of the aftershocks can reflect the general focus region. With the stress adjustment and rupture propagation of the focus region, the aftershocks have a trend of extending outward. In general conditions, the geographical distribution range of the aftershocks within 24 hours is much bigger than the focus region. The number of the aftershocks within 2 hours is limited, but the aftershocks are all around the focus region. The geographical distribution range of the aftershocks within 4 or 8 hours can significantly reflect the focus region. So we can use the geographical distribution range of the aftershocks within 4 or 8 hours to estimate the location of macroscopic epicenter.

There are three ways to define the direction of semi-major axis: 1) We can use the tectonic map of the major active faults to define it. When there is only one active fault go through the epicenter, the probability of the direction of semi-major axis being corresponded to the direction of the fault is very high. When the epicenter locates on the confluence of several active faults, the direction of semi-major axis is not only, but the probability of the direction of it being corresponded to the direction of the most important and nearby active fault is very high. 2) Using the focal mechanism solution to define

the direction of semi-major axis is another method. 3) The geographical distribution range of the aftershocks is basically in accord with the direction of semi-major axis. So in actual work, we can consider the direction of active faults, the focal mechanism solution and the geographical distribution range of the aftershocks to define the direction of the semi-major axis.

2. THE INTENSITY ATTENUATION IN MATRIX MODEL

We always use the intensity attenuation relationship to draw the isoseismal line in the disaster emergency assessment work. But in the actual work, the assessment area is always smaller than the actual area in the high-intensity earthquake area while the assessment area is always larger than the actual area in the low-intensity earthquake area. That is because every isoseismal line is only decided by three regression coefficients in the attenuation formula, and the three regression coefficients relied on each other, which makes the high-intensity earthquake area narrowed and the low-intensity earthquake area exaggerated. So, in this paper an improved intensity-attenuation model in ellipse model is proposed, which is completed by the establishment of semi-major axis and semi-minor axis radius length matrix. Based on the initial value of the length matrix got by the regression of historical data and survey data from the site, the LMS algorithm is used to revise the length matrix and draw the intensity isoseismal line, which is called the intensity-attenuation in matrix model.

Totally 138 earthquake events above 5.0 magnitude are collected. These events have happened in Chinese mainland since 1966 and their data sources are credible and intensity isoseismals are relatively clear. Data arrangement and calibration work are also made for these events. Based on the statistical analysis, we get the relationship between the radius length and the earthquake magnitude as the initialization of semi-major axis and semi-minor axis radius length in isoseismal line (see Table 2.1 -2.3).

Table 2.1. The Initialization of Radius Length in Isoseisms（M⩾7.5）

intensity	$M\geq 7.8$		$7.5\leq M\leq 7.7$	
	semi-major axis radius length	semi-minor axis radius length	semi-major axis radius length	semi-minor axis radius length
XI	$e^{0.302M}$	$e^{2.518M-17.933}$		
X	$e^{0.367M}$	$e^{0.967M-4.833}$	$e^{2.773M-18.987}$	$e^{3.154M-22.202}$
IX	$e^{1.082M-4.777}$	$e^{0.401M-0.077}$	$e^{2.302M-14.486}$	$e^{2.452M-15.951}$
VIII	$e^{2.690M-17.011}$	$e^{2.079M-12.476}$	$e^{2.956M-18.851}$	$e^{3.106M-20.316}$
VII	$e^{1.470M-6.677}$	$e^{2.151M-12.461}$	$e^{3.361M-21.278}$	$e^{3.402M-21.902}$
VI	$e^{3.298M-20.265}$	$e^{2.077M-11.041}$	$e^{2.043M-10.478}$	$e^{2.059M-10.899}$

Table 2.2. The Initialization of Radius Length in Isoseisms（6.0⩽M⩽7.4）

intensity	$6.8\leq M\leq 7.4$		$6.0\leq M\leq 6.7$	
	semi-major axis radius length	semi-minor axis radius length	semi-major axis radius length	semi-minor axis radius length
IX	$e^{0.415M-0.342}$	$e^{1.314M-7.458}$		
VIII	$e^{1.372M-5.831}$	$e^{0.480M-0.600}$	$e^{1.220M-5.687}$	$e^{1.787M-9.981}$
VII	$e^{1.218M-4.469}$	$e^{0.495M-0.098}$	$e^{1.060M-3.885}$	$e^{1.584M-7.423}$
VI	$e^{0.518M+0.956}$	$e^{0.922M-2.374}$	$e^{0.773M-1.180}$	$e^{1.077M-3.518}$

Table 2.3. The Initialization of Radius Length in Isoseisms（5.0≤M≤5.9）

intensity	5.2≤M≤5.9		5.0≤M≤5.1	
	semi-major axis radius length	semi-minor axis radius length	semi-major axis radius length	semi-minor axis radius length
Ⅶ	$e^{1.906M-8.591}$	$e^{2.452M-12.287}$		
Ⅵ	$e^{0.852M-1.939}$	$e^{1.483M-5.879}$	$e^{2.628M-11.072}$	$e^{0.535M-1.195}$

And then based on the survey data from the site, we use the LMS algorithm to revise the length matrix. The rules are as follows:

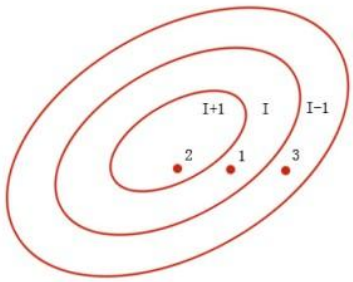


Figure 2.1. A schematic diagram of isoseisms correction

1) The solid line in figure 2.1 is the primarily determined isoseismal line. For an investigation site with the intensity I, if it is located in the point 1 position, we don't need to revise the isoseismal line, if it is located in the point 2 position, we need to revise the isoseismal line with intensity I+1, if it is located in the point 3 position, we need to revise the isoseismal line with intensity I.

2) Based on the investigation site's semi-major axial and semi-minor axial projected length, we can work out the semi-major and semi-minor axis radius length of the investigation site located ellipse.

And then, we can use the LMS algorithm to revise the length matrix. Now we take the semi-major axis radius length of isoseismal line with intensity I revising for instance.

$$R_{Ia} = R_{Ia}^{'} + \eta(R_{Ia}^{*} - R_{Ia}^{'}) \tag{2.1}$$

Where R_{Ia} is the revised semi-major axis radius of the isoseismal line with intensity I, $R_{Ia}^{'}$ is the uncorrected semi-major axis radius of the isoseismal line with intensity I, R_{Ia}^{*} is the semi-major axis radius length of the investigation site located ellipse, η is the learning speed(the value of η is 0~1).

3. NUMERICAL EXAMPLE

A case of Lijiang 7.0 earthquake is used to verify the practicability of this method. According to Yunnan seismic network, a 7.0-magnitude earthquake hit Lijiang in Feb.3th, 1996. The earthquake was at a depth of 10km. The piedmont fault in Yulong Mountain is the main causative structure of this earthquake. And the direction of semi-major axis is almost the same as the direction of the piedmont fault in Yulong Mountain. Based on the known condition, 20 investigation sites are selected at random to verify the practicability of this method (see Figure3.1).

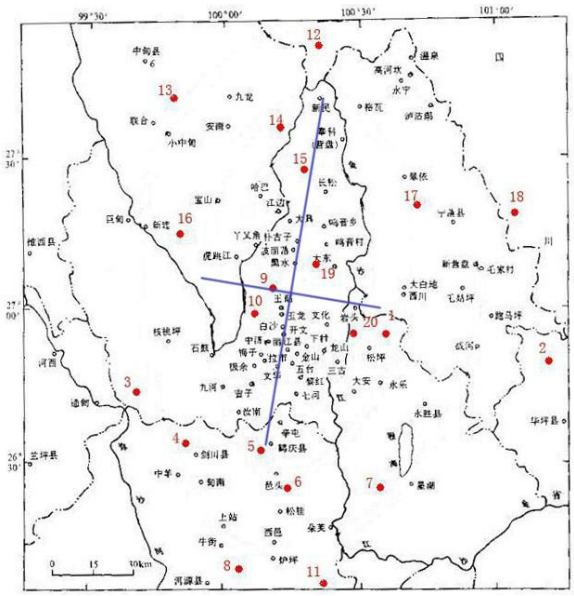


Figure 3.1. Intensity survey data distribution in Lijiang

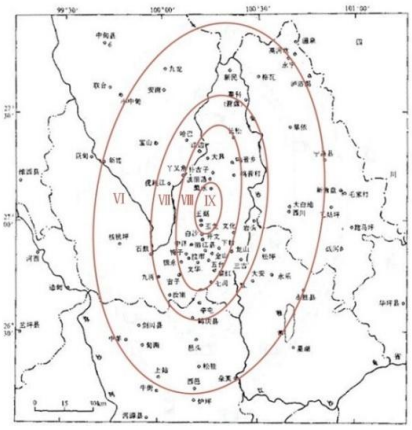
Based on the revised method presented by this paper, we can get the radius length at different numbers of intensity survey data (see Table 3.1- 3.2). According to the data, the isoseismal lines at different number of intensity survey sites are drawn (see Figure 3.2).

Table 3.1. The Semi-major Axis Radius Length at Different Numbers of Intensity Survey Data

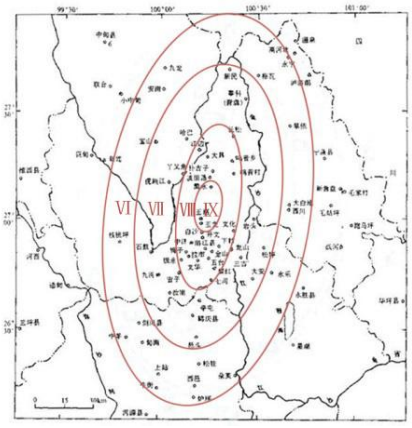
Semi-major axis radius length	Initial /km	At 5 sites /km	At 10 sites /km	At 15 sites /km	At 20 sites /km	Actual /km
Ⅸ	12.97	12.97	13.04	13.04	28.46	32.00
Ⅷ	43.51	43.51	43.51	44.65	53.48	49.75
Ⅶ	57.80	73.79	73.79	73.79	73.79	61.25
Ⅵ	97.71	97.71	105.78	105.78	105.78	98.00

Table 3.2. The Semi-minor Axis Radius Length at Different Numbers of Intensity Survey Data

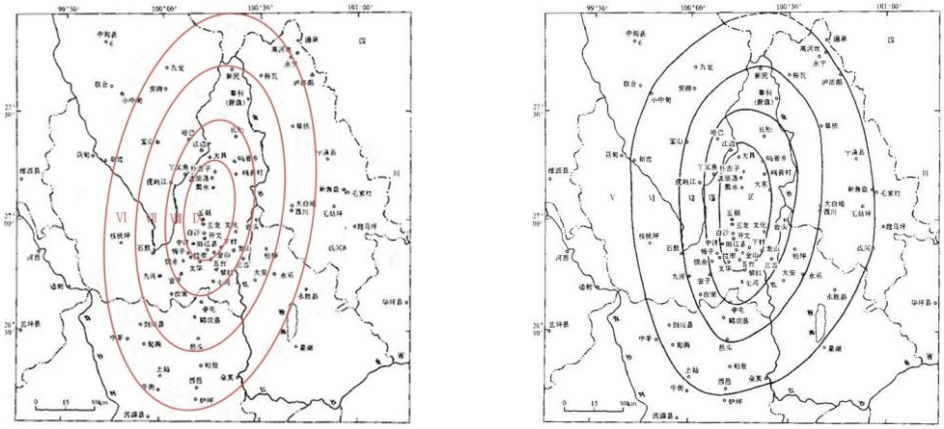
Semi-minor axis radius length	Initial /km	At 5 sites /km	At 10 sites /km	At 15 sites /km	At 20 sites /km	Actual /km
Ⅸ	5.70	5.70	6.52	6.52	14.23	13.00
Ⅷ	15.80	15.80	15.80	22.33	26.74	30.00
Ⅶ	28.99	36.89	36.89	36.89	36.89	36.25
Ⅵ	59.15	56.94	52.89	52.89	52.89	62.50



a) The initial isoseisms



b) The isoseisms at 10 data



c) The isoseisms at 20 data d) The actual isoseisms

Figure 3.2. The isoseisms at different number of intensity survey data

4. CONCLUSION

The emergency assessment work of post-earthquake requires the isoseismal line which is constantly revised according to the updated information. The result of Lijiang numerical example shows the matrix model presented by this paper is simple and practical in the emergency assessment work. The initial isoseismal line given by this model has a more closely relation with the actual isoseismal line than those given by the intensity attenuation relationships. And with the increase of the investigation sites, the isoseismal line drawn by this method becomes more and more close to reality.

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