Study on Assessment Method of Buried People after Destructive Earthquake

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SUMMARY:
After the destructive earthquake, people pay more attention to the casualty and its distribution. And the search and rescue is the primary task in the early stage of earthquake emergency. According to limited disaster information and the vital character changing of buried people in this stage, how to estimate the number and distribution of buried people is directly related to the efficiency of rescue and emergency. In response to above conditions，related studies are carried out. In this paper, the existing casualty assessment methods are analyzed comparatively. And considering general information gained in the early stage of earthquake emergency, the assessment model is built tentatively based on the data of population distribution in kilometre grid.

Keywords: assessment method, buried people, destructive earthquake

1. GENERAL INSTRUCTIONS

After the destructive earthquake, the emergency works main focus on the search and rescue. Relative to the serious disaster and vast disaster area，the rescue force is so limited. In same time, the vital character of buried people is constantly changing. So to estimate the casualties and its distribution based on the limited information and carry out the effective measures quickly, is crucial to reduce the casualties.

The related research works in China are most about the estimating method of seismic casualties. XU jiandong (2008) gave an initially assessment method on seismic casualties and buried people，based on the prediction method of building seismic damage. And MA Yuhong (2000) analyzed the influence factors of seismic casualties after comparative study of existing assessment methods. Due to the vital character of buried people is changing with time, ZHAO Zhendong (1998) and ZHOU Suqing (2004) established a dynamic assessment method of seismic casualties. In these methods mentioned above, authors didn't consider the distribution of casualties and the possibility of parameters attained in the early stage of earthquake emergency. However, those are crucial to earthquake emergency and rescue.

In this paper, considering the distribution assessment of casualties and the possibility of parameters attained in the early stage of earthquake emergency, the influence factors are analyzed. Final, the assessment model is built tentatively. It contributes to the rescue in the early stage of earthquake emergency.

2. ASSESSMENT REQUIREMENTS

2.1. Service Time

In the early stage of earthquake emergency, the assessment method is used to estimate number of buried people and its distribution. In this term, only some simple data can be attained, such as the

magnitude, occurrence time, and location of epicentre. In addition to above data, the public statistic information of the administrative divisions involved in this earthquake can be used in the assessment. Include the seismic fortification intensity, administrative level, population distribution based on Km grid, and the data from yearbook, etc.

2.2. Task

The causes of casualties main include building collapse, secondary disasters, such as fire, tsunami, landslide, etc. Among them, casualties caused by building collapse occupy about 75%, and FU Zhengxiang (1993) provided the related data showed in Tab. 2.1. For different causes, the influencing factors of assessment and the measures adopt in rescue are different. In this paper, only the casualties caused by building collapse are considered.

Table 2.1. Causes of casualties

Causes of casualties	1900-1949	1950-1989
Others	7.50%	12.78%
Landslide	2.78%	8.06%
Fire	15.28%	2.78%
RC building collapse	2.08%	11.11%
Wooden building collapse	6.25%	5.56%
Masonry building collapse	66.11%	59.72%

According to the limited information in this stage, the parameters used in assessment of buried people must be attained easily. As the results of the assessment method, the number of buried people and its distribution are important to emergency decision. In the same time, the vital character changing constantly of buried people is considered.

3. RELATED FACTORS

3.1 Population and Influence Intensity

In the existing assessment methods of casualties, main include the method based on the prediction of buildings damaged and the statistical method with parameters population and influence intensity. In the former method, the building data are necessary, but for most regions, the basic information of buildings are lack and difficult to obtain timely in the initial emergency. The latter method is mainly based on the population and influence intensity of the regions. The population data are from the public statistic data, such as data from the Yearbook, and the influence intensity can be calculated by the intensity attenuation formula. In contrast to the former, it is more suitable for assessment of buried people in this stage. As an example, the following formula Eqn. 3.1 is used. YIN Zhiqian (1996).

$$\ln R_I = -44.466 + 14.331 \ln I + 0.960 \ln \rho_I \tag{3.1}$$

Where, I is the influence intensity, R_I is the death rate in the region with influence intensity I, ρ_I is the d he population density in the region with influence intensity I.

3.2 Occurrence Time

The occurrence time is directly related to the rate of person in room, and then influences the final results. In the statistical study based on the historical earthquake data, values of casualty are very different with occurrence time changing. In Tab. 3.1, the ratios of the result in night to the result in day are shown. In second column, the ratios are calculated by statistical method, and the others are

calculated by prediction method.

Table 3.1 Ratio of the Result in Night to the Value in Day

Intensity	statistical method LIU B.C.	prediction of Zhongshan city	prediction of Dongwan city	prediction of Yanliang city
Ⅵ	-	-	4.25	-
Ⅶ	7.3	-	3.95	-
Ⅷ	3.8	1.91	2	1.34
Ⅸ	2.2	1.91	1.35	1.3
Ⅹ	1.3	1.82	-	1.35
Ⅺ	-	-	-	-
Ⅻ	-	-	-	-

3.3 Regional Level

In addition, compared with the intensity calculated by attenuation relationship, the type of structure, construction quality and resistant measures are also important in intensity assessment, especially in analysis of the regional difference. For simplifying the method, an adjustment coefficient of region level is given. There are three region levels: city, town, and village. As the adjustment, the Eqn. 3.2 is given.

$$\ln R_{IJ} = -44.466 + 14.331 \ln \lambda_{J1}(I_J + \lambda_{J2}) + 0.960 \ln \rho_{IJ} \tag{3.2}$$

Where, I_J is the influence intensity of region with level J, R_{IJ} is the death rate in the region with level J and influence intensity I, ρ_{IJ} is the population density in the region with level J and influence intensity I, λ_{J1} and λ_{J2} are two adjustment coefficients of the region with level J.

3.4 Rescue Efficiency

In addition to death toll, in the early stage of earthquake emergency, the number of buried people includes persons rescued successfully. In 2008 Wenchuan M8.0 earthquake, the total number of death and missing was about 87000. The persons rescued successfully were about 6450. More than 100000 persons involved in the rescue. Here, as an example, assumes that the number of persons rescued successfully will increase with the increasing of rescue teams in linear function, which is shown in Eqn. 3.3.

$$N_{sr} = \lambda_r \times N_r, \quad \lambda_r = N_{sr0} / N_{r0} \tag{3.3}$$

Where, N_{sr} is the number of persons rescued successfully, λ_r is a constant, N_r is the number of persons in rescue teams, N_{r0} and N_{sr0} are the number of persons in rescue teams and the total number of death and missing in 2008 Wenchuan M8.0 earthquake.

3.5 Earthquake Fortification Intensity

Earthquake fortification intensity is an important influence factor, especially in distribution assessment. In 2008 Wenchuan M8.0 earthquake, the Mao County with earthquake fortification intensity Ⅶ, many houses were built with earthquake protective measures, although the building were also damaged seriously, the collapsed building were seldom. In Dujiangyan city, most persons were killed due to some collapse buildings without engineering design.

4. ASSESSMENT METHOD

4.1 Number of Buried People

Considering these factors mentioned above, the Eqn. 4.1 is built initially for assessment of buried people.

$$N_b = 0.75(\sum_{I=6}^{I=12}\sum_{J=1}^{J=3}\lambda_{It}\lambda_{If}A_{IJ}\rho_{IJ}R_{IJ} + N_{sr}) \tag{4.1}$$

Where, N_b is the total number of buried people, λ_{It} is an adjustment coefficient related to the occurrence time of earthquake in the region with influence intensity I, λ_{If} is an adjustment coefficient related to earthquake fortification intensity in the region with influence intensity I, A_{IJ} is the area of the region with level J and influence intensity I.

4.2 Dynamic Assessment

4.2.1 Dynamic assessment of rescue

In fact, the number of buried people is changing with rescue measure carried out. According to the data in historic earthquake rescue, the change rate is approximate to the positive exponent trend as Eqn.4.2, and about 90% persons are successfully rescued in 24 hours, then the variation coefficient a can be calculated and the curve is drawn, see Fig. 4.1.

$$f(t) = 1 - e^{-at} \tag{4.2}$$

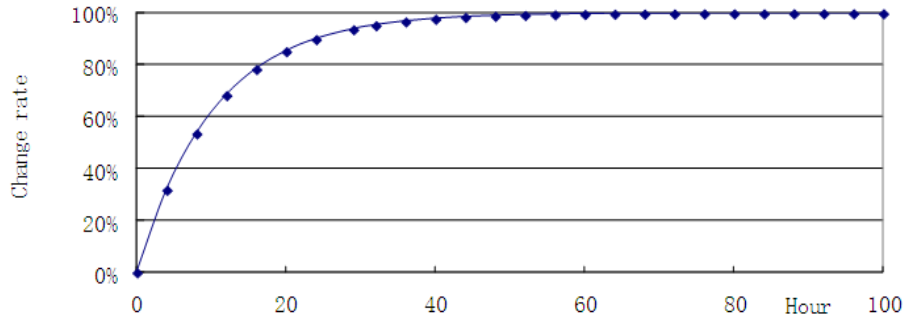

Figure 4.1. Change rate of person rescued successfully

4.2.2 Dynamic assessment of casualty's state

According to the vital character of buried people is changing constantly, ZHAO Zhendong (1998) defined conception such as index of casualties and state-function of casualties, and established a dynamic assessment method of seismic casualties. The method is directed to a single buried people. In this paper, the method in Eqn. 4.3 is used for assessment of casualty's state in whole region.

$$C(t) = \left(C_0^{1/n} + S_0 t\right)^n \tag{4.3}$$

Where, t is buried time, $C(t)$ is the death rate in time t, C_0 is the initial death rate, S_0 is the average trap environment of casualties, and n is the average physical quality index of casualties.

For these factors, experience values were set simplify based on the region level determined above. As

an example, the curve of death rate changing with time t is shown in Fig.4.2, with n=2, C_0=0.4 and S_0=0.005.

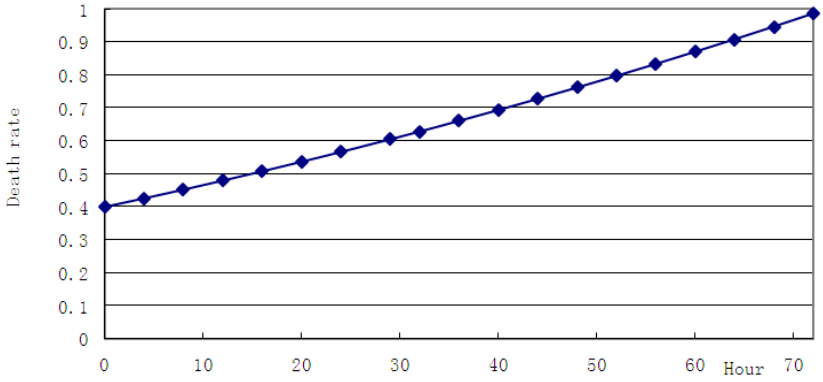

Figure 4.2 Curve of death rate changing with time

Above all, the number of buried people alive can be calculated by Eqn.4.4.

$$N_{blt} = [1 - C(t)] \times [N_b - N_{sr}(1 - e^{at})] \tag{4.4}$$

Where, N_{blt} is the number of buried people alive.

4.3 Distribution of Buried People

4.3.1Data based on Km grid

As preparation, national population data based on Km grid are collected before earthquake, and using space analysis of GIS, other related information can be load to the attribution table of cells in Km grid, such as the region level, earthquake fortification intensity and so on. Based on method and data above, it is possible to estimate the distribution of buried people, then to determine the serious area.

4.3.2 Cell index based on Km grid

For a single cell, cell index is determined as a ratio of the value in cell to total number of buried people. Then the number of buried people for a single cell can be calculated by Eqn. 4.5.

$$N_{blti} = C_i N_{blt} \tag{4.5}$$

Where, N_{blti} is the number of buried people for a single cell, C_i is the cell index of i cell in Km grid and calculated by Eqn. 4.6.

$$C_i = \frac{\lambda_{ti}\lambda_{fi}\rho_i R_i}{\sum_{i=1}^{n} \lambda_{ti}\lambda_{fi}\rho_i R_i} \tag{4.6}$$

Where, λ_{ti} is an adjustment coefficient of i cell related to the occurrence time of earthquake with influence intensity I, λ_{fi} is an adjustment coefficient of i cell related to earthquake fortification intensity with influence intensity I, ρ_i is the population density of i cell and R_i is the death rate in i cell which can be calculated by Eqn. 3.2.

5. CONCLUSIONS

Based on the information just after earthquake, the influence factors of buried people are analyzed, and then assessment method is built initially. The results include number of buried people, their distribution and survival state.

According to the lack of related data, in the further study, it is difficult to quantize the parameters of the method. And comparing with the actual earthquake damage, statistical analysis and empirical estimate will be carried out to correct method further.

Due to the uncertainty of influence factors, it isn't significance to emphasize the accuracy of the results. But as the overall grasp, the results of distribution assessment are used for difference contrast of the cells in km grid, and to determine the serious area. It contributes to the rescue in the early stage of earthquake emergency.

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