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Data Updating and Earthquake Loss Estimation Method Based on Open Information

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Abstract

Accurate basic data is the basis of earthquake loss estimation. Due to the long construction period and the difficulty of sharing & updating of data base, the work of earthquake loss estimation will be affected seriously. To address this problem, in this paper, the open Information which can be used for earthquake loss estimation has been investigated, the influence of data change trend has been analyzed with examples, in the end, and the updating method of basic data based on public information has been given. Finally, examples of data updating and earthquake loss estimation method based on open information are given separately, and further work idea has been discussed for application of the earthquake loss estimation method based on data updating. The study will be benefit to the prediction of earthquake damage in future and the estimation of economic loss after earthquake.

Keywords: open information, earthquake loss estimation, basic data, data updating

1. Introduction

Due to the high earthquake risk, in recent years, destructive earthquakes in China have caused a large number of casualties and economic losses. In order to reduce the earthquake loss, loss prediction to evaluate the earthquake risk accurately before the earthquake and the loss preliminary estimate for carrying out effective emergency measures after the earthquake are the basis works. Therefore, the accuracy and details of the basic data are directly related to the credibility of the results.

From the late 80s last century in China the regional seismic database construction work had been carried out [1, 2], by the end of 2007, the main construction task had been completed. The data includes basic seismic emergency data information of earthquake relief headquarters at all levels [3,4,5], such as basic geographic information, social-economic statistics, basic seismic data, engineering seismic data, disaster relief forces, earthquake emergency plans and regulations, etc. Since then, further related works had been carried out [6].

However, there are still many deficiencies in the existing basic data, such as data completeness, timely update and maintenance, sharing, etc., which reduce its reasonable and efficient. The long construction period of the database and the difficulty in sharing and updating will affect the earthquake loss assessment directly. In view of this problem, authors try to explore the public data that can be used for earthquake damage assessment, analyzes the trend of data change, and gives the update method of basic data based on public information, so as to make up for the shortcomings of existing data [7,8].

2. Open data

The basis for the selection of open data is mainly to consider the parameters used in the methods for earthquake loss assessment, and these open data can be directly used or converted to obtain the required basic data.

At present, the methods of earthquake loss estimation are mainly divided into two categories: whether to consider structural vulnerability or not. If the vulnerability of the structure is taken into account, the parameters will be used, such as the level of structural damage, casualty ratio, loss ratio, etc. Regardless of structural vulnerability, most of methods are given by statistical analysis of historical earthquakes, based on population, GDP, earthquake intensity and other parameters.

Here, some types and sources of the open data are given, considering the requirements of earthquake loss estimation, and the convenience to obtain or convert.

2.1 Yearbook data

Data such as population, population density, GDP and per capita GDP can be extracted to be used as basic data for earthquake loss assessment. However, the data of the higher level is only subdivided into the lower level. So the number of yearbooks in prefectures and cities is large, or there are missing years, it is difficult to collect.

As shown in Fig.1, the yearbook data published on the website of Sichuan provincial bureau of statistics are relatively complete in terms of years, and the data format is standardized. Which are given in the form of web page retrieval to facilitate data extraction. However, the data of earlier years are given generally in the form of pictures, so the extraction efficiency is low.

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Fig. 1 – The yearbook catalog on the website

2.2 Other data

The yearbook data is relatively complete and can basically meet the parameter requirements of the earthquake loss assessment method, but it is difficult to provide more professional geographic information layer data or high-precision distribution data.

In addition to the data extracted from the above yearbook, there are elevation data, soil data,, satellite remote sensing image data, topographic and geomorphic data, road data and so on. By analyzing the correlation of these data, some professional geographic information layer data or high-precision distribution data can be obtained or converted. The spatial distribution data of land use is shown in Fig.2. (from the website of resources and environment science data center, Chinese academy of sciences)

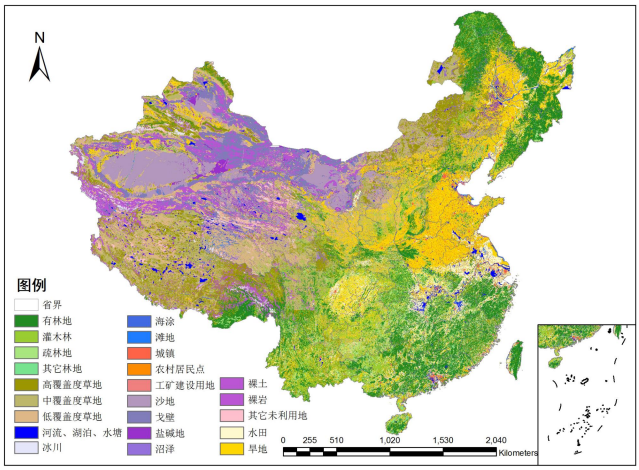

Fig.2 – The spatial distribution data of land use in China

3. Data update method

The existing basic data, due to the early database construction time, lack of necessary data maintenance and update, cannot reflect the current situation of data. And Earthquake damage prediction is to prepare for current or future earthquakes, the annual trends of the data have to be taken into account and update the existing data.

Among the above open data, the annual data of the yearbook is relatively complete. Here, as an example, the annual changing trend of population is analyzed, the data of missing years or future years are estimated, and the method of data updating is given.

3.1 Annual trends in data

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The population data of each administrative region in the yearbook will be used to update the existing data, and the data can also be distributed by kilometer grid. When the data in some year is missing, it can be given based on the data fitting analysis of other years. The population data of Sichuan province and Chengdu city are used below to illustrate annual trend changes and data processing methods.

In order to make a comparative analysis, the registered population data of Sichuan province and Chengdu city from 2005 to 2015 and the resident population data of Sichuan province and Chengdu city from 2006 to 2015 (data missing in 2005) were selected from the yearbook, as shown in Table 1 and Table 2.

Table 1 – The registered population data of Sichuan province and Chengdu city from 2005 to 2015

Year	**Sichuan province (Unit: 10,000)**	**Chengdu city (Unit: 10,000)**
2015	9102.0	1228.1
2014	9159.1	1210.7
2013	9132.6	1188.0
2012	9097.4	1173.4
2011	9058.4	1163.3
2010	9001.3	1149.1
2009	8984.7	1139.6
2008	8907.8	1125.0
2007	8815.2	1112.3
2006	8722.5	1103.4
2005	8642.1	1082.0

Table 2 – The resident population data of Sichuan province and Chengdu city from 2005 to 2015

Year	**Sichuan province (Unit: 10,000)**	**Chengdu city (Unit: 10,000)**
2015	8204.0	1465.8
2014	8140.2	1442.8
2013	8107.0	1429.8
2012	8076.2	1417.8
2011	8050.0	1407.1
2010	8041.8	1404.8
2009	8185.0	1286.6
2008	8138.0	1270.6
2007	8128.6	1218.4
2006	8167.4	1209.2

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According to the data in above tables, the scatter diagrams can be shown in Fig. 3 to Fig. 6 with the annual trend lines. Through the fitting analysis of the existing data, Eq. (1) to Eq. (4) have been given for calculating the required year data.

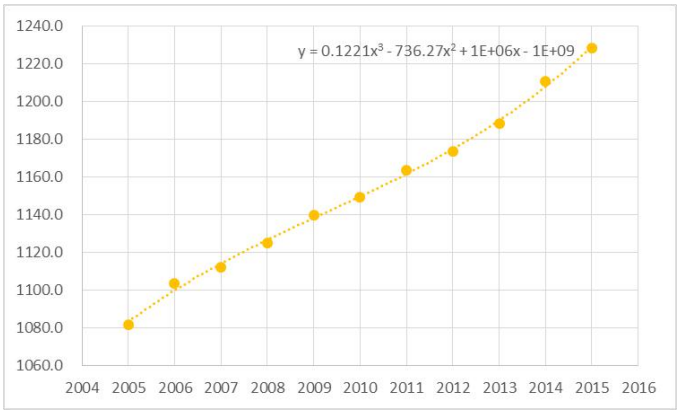

Fig.3 – The scatter diagram of registered population in Chengdu from 2005 to 2015

The trend line equation of registered population in Chengdu from 2005 to 2015 was obtained by polynomial fitting.

$$y = 0.1221x^3 - 736.27x^2 + 10^6 x - 10^9 \tag{1}$$

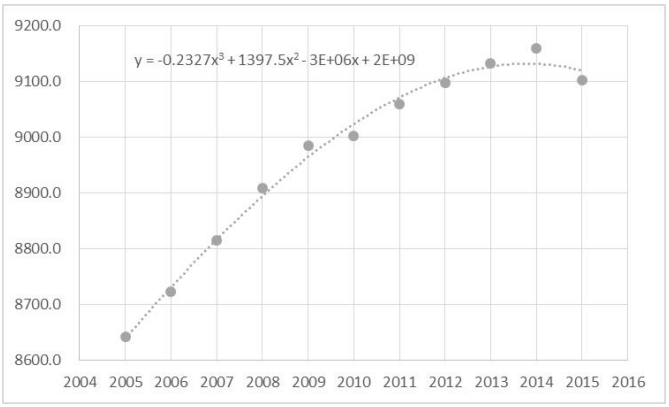

Fig.4 – The scatter diagram of registered population in Sichuan province from 2005 to 2015

The trend line equation of registered population in Sichuan province from 2005 to 2015 was obtained by polynomial fitting.

$$y = -0.2327x^3 + 1397.5x^2 - 3\times10^6 x + 2\times10^9 \tag{2}$$

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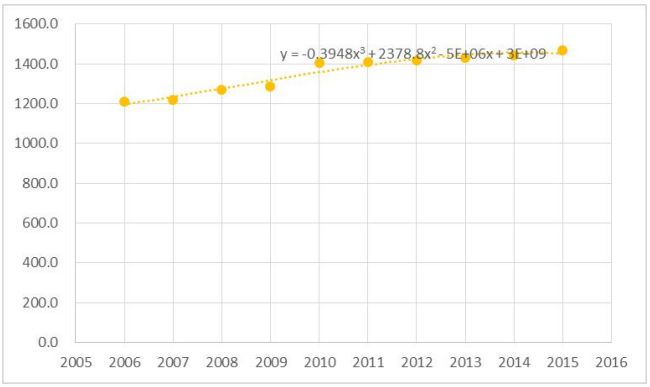

Fig.5 –The scatter diagram of resident population in Chengdu from 2006 to 2015

The trend line equation of resident population in Chengdu from 2006 to 2015 was obtained by polynomial fitting.

$$y = -0.3948x^3 + 2378.8x^2 - 5\times10^6 x + 3\times10^9 \tag{3}$$

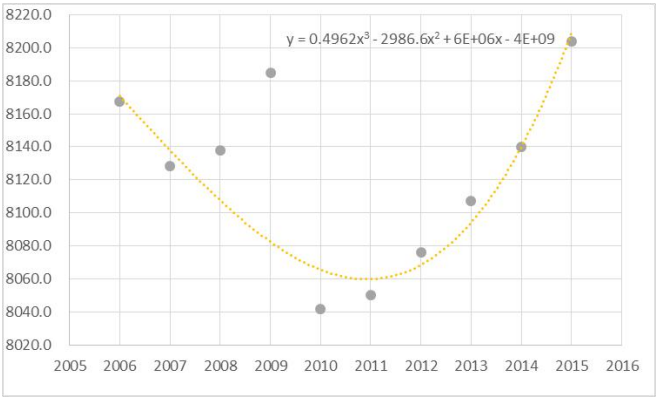

Fig.6 –The scatter diagram of resident population in Sichuan province from 2006 to 2015

The trend line equation of resident population in Sichuan province from 2006 to 2015 was obtained by polynomial fitting.

$$y = 0.4962x^3 - 2986.6x^2 + 6\times10^6 x - 4\times10^9 \tag{4}$$

It can be seen from the changes of registered population and resident population in Sichuan province and Chengdu city.

1) With the development of the Chengdu city, the registered population and resident population are increasing year by year.

2) The resident population of Sichuan province changed abnormally around 2008. But the resident population has not changed much.

3) However, the change of non-registered population in Sichuan led to a sudden increase in the number of resident population in late 2008 and 2009, followed by a sudden decrease and a gradual recovery after 2010.

It can be seen from the trend of data changes that the 2008 Wenchuan earthquake had an impact on population data changes.

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1) The earthquake affected a large area and affected most of Sichuan province. Although a large number of casualties, but accounted for a small proportion of the province's registered population, hardly see the data change.

2) However, after the earthquake, a large number of construction workers moved in Sichuan province and the non-registered population left. After completing the task, the construction workers all evacuated. The resulting surge in the resident population, followed by a sudden drop in the number of changes, is consistent with the actual situation.

3) In Chengdu city, both registered population and resident population change is relatively gentle, which is related to the fact that Chengdu city is far away from the epicenter and has little impact from the earthquake. There has been little impact on the occupancy and evacuation of construction workers.

Therefore, by fitting the data of the existing data, the trend line is given and the data of the required year is obtained with some credibility.

3.2 Data update method

Through fitting formula for the annual change trend of the basic data, the data of the required year can be calculated.

There are three main forms of data: basic data based on administrative division unit, basic data refined to kilometer grid unit, and single building data.

The data based on administrative division unit can be updated directly by the fitting data. For the basic data refined to the kilometer grid cell, update the data proportionally according to Eq. (5).

$$p_{ij} = p_i \frac{p_{ij0}}{\sum_{j=1}^{n} p_{ij0}} \tag{5}$$

As examples, the existing population data of Sichuan province based on administrative division unit and kilometer grid unit were updated by the population data of 2013 according to the above methods, as shown in Fig. 7 and Fig. 8.

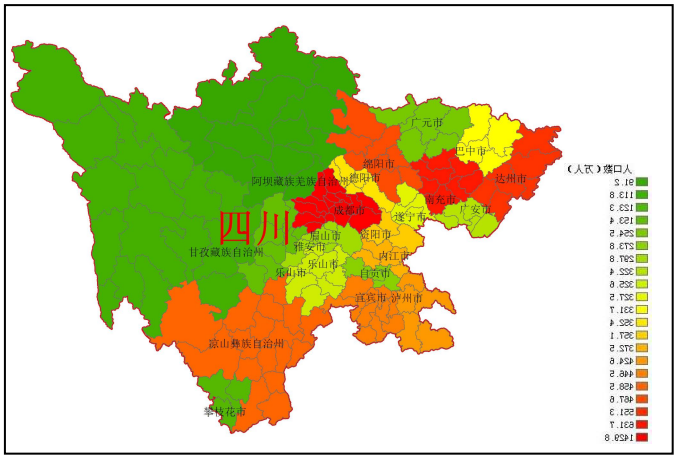

Fig.7 –Population distribution map of Sichuan province based on administrative division

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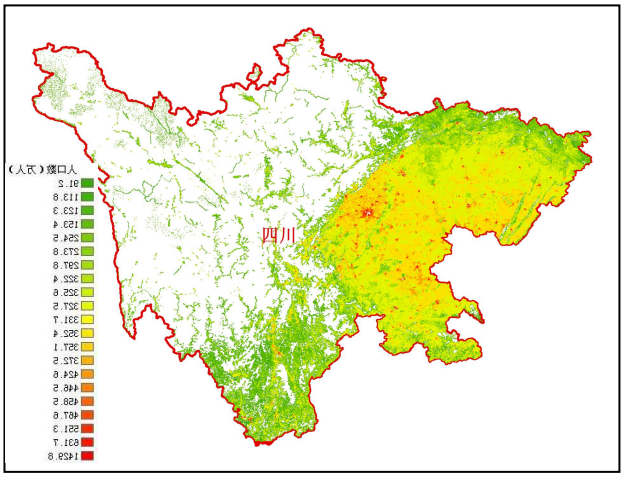

Fig.8 –Population distribution map of Sichuan province based on kilometer grid

3.3 Update of distributed data

For the basic data refined to the kilometer grid , the changes of regional development should also be considered. The data in this respect can be converted and analyzed according to the spatial distribution data of land use and spatial distribution data of night light, etc., and then the annual fitting data can be updated under the kilometer grid[9, 10]. Due to the limited space, which will not be repeated it here.

4. Conclusions

Due to the long construction period of the database and the difficulty in sharing and updating, the use efficiency of the basic data for earthquake damage assessment has been restricted. And the poor accuracy of the data directly affects the credibility of the assessment results. This paper analyses the open data and gives the update method. The main conclusions have been drawn as follows:

1）Open data can be used to update existing data. There are also many available data that can be used directly or indirectly for professional data conversion.

2）Due to the large changes of annual data, the basic data with Lack of maintenance and update will affect the accuracy of the assessment results.

3）When predicting the loss and risk of future earthquakes, it is also necessary to take into account the annual trend of the basic data and make adjustments and updates.

4）From the aspects of data type, immediacy and access channels, open data has a good development prospect. It is beneficial to update the existing data, and can even be directly utilized or converted into other professional basic data.

5）In order to make the update of basic data more convenient, it is necessary to carry out some preparatory work.

5. Acknowledgements

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6. References

[1] LI Yirui, MU Qiduo (1993): Overview of the establishment of earthquake data bases in China and their application. *Recent developments in world seismology*, **22**(3), 8-12.

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[2] XIU Jigang, YANG Maoyuan (1987): An overview of progress in the establishment of seismic data bases in China. *Recent developments in world seismology*, **16**(12), 3-17.

[3] LIANG Fang (2013): Development and construction of fundamental database for earthquake emergency response. *City and disaster reduction*, **25**(4), 28-30.

[4] NIE Gaozhong, CHEN Jianying (2002): The construction of basic database for earthquake emergency response. *Earthquake*, **22**(3), 105-112.

[5] SHUAI Xianghua, JIANG Lixin (2009): Study of national earthquake emergency command software system. *Journal of natural disasters*, **18**(3), 99-103.

[6] CHEN Hongfu, SUN Baitao (2004): GIS-Based Earthquake Database Information Management System. *Journal of seismological research*, **37**(4), 648-653.

[7] YU Shizhou (2013): Study on the buried personnel status and rescue needs after earthquake. *The research report of Institute of Engineering Mechanics*, *CEA*, 5-6.

[8] YU Shizhou (2018): Preliminary study on information acquisition technology in earthquake emergency period. *The research report of Institute of Engineering Mechanics*, *CEA*, 24-25.

[9] YU Shizhou (2017): Study on assessment method of loss and distribution in the initial stage of earthquake. *The research report of Institute of Engineering Mechanics*, *CEA*, 21-27.

[10] LIU Rushan, YU Shizhou (2014): Refined method for rapid assessment of seismic damage and economic loss. *Journal of Basic Science and Engineering*, **22**(5), 916-927.

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