

A Chinese Earthquake Database for Casualty Modelling

Yuanyuan Li

Institute of Public Safety Research,
Tsinghua University, Beijing, China
l-yy09@mails.tsinghua.edu.cn

Wenguo Weng

Institute of Public Safety Research,
Tsinghua University, Beijing, China
wgweng@tsinghua.edu.cn

Tao Chen

Institute of Public Safety Research,
Tsinghua University, Beijing, China
chentao.b@tsinghua.edu.cn

Hongyong Yuan

Institute of Public Safety Research,
Tsinghua University, Beijing, China
hy-yuan@mail.tsinghua.edu.cn

ABSTRACT

In order to conduct empirical casualty modelling in China, Chinese historical earthquake events is the essential basis. However, commonly used casualty databases that focus on Chinese earthquakes and provide comprehensive information rarely exist. Regarding this situation, we derived an earthquake casualty database of Mainland China from authorized Chinese published data sources. The casualty database records 520 earthquake events with magnitude 5.0 and greater where at least one casualty is recorded in the time span from 186 BC through December 2011. Each earthquake case contains information on seismic parameters, deaths tolls, number of heavy injuries and light injuries, as well as areas and population of affected regions from intensity VI to intensity IV. Compared with PAGER-CAT, this casualty database provides 146 unique earthquake events and provides more detailed information on heavy injuries and light injures, as well as areas and exposure population of affected regions. This casualty database is an essential supplement for global casualty databases and provides a basis for earthquake casualty modelling on post-earthquake risk estimation in China.

Keywords

Earthquake, casualty, database, China, modeling.

INTRODUCTION

Earthquake is a frequent disaster in China, due to shallow source and high population density, an earthquake often leads to huge economic losses and casualties. A rapid assessment of casualties based on seismic parameters and condition in affected areas after the event is essential for emergency rescue. In this sense, empirical casualty models based on historical earthquakes plays an important role in post-earthquake rapid risk estimation. At present, empirical modeling is obtained by regressing the relationship between historical casualty data and seismic parameters, in which magnitude, intensity and population density are commonly used. Samardjieva proposed a model that consists of a correlation between the number of casualties and magnitude as a function of population density. The USGS PAGER system's empirical model obtains preliminary loss estimation by reconstructing earthquake scenarios and optimization method. Most of China-specific empirical models focus on one earthquake case and develop scenario-based fatality rate. However, empirical models on large-scale and derived from sole earthquake are not suitable for other regions. In general, empirical modelling has regional difference and is limited to available loss data in hand, especially for China, who has such a large geographical areas and earthquake fault zones. Therefore, in order to obtain China-specific empirical casualty model, the first step is to compile a comprehensive Chinese earthquake casualty database.

There are some global earthquake casualty databases, such as USGS Preliminary Determination of Epicenters (PDE; Sipkin et al. 2000), the UTSU catalog of deadly earthquakes (Utsu 2002) and EM-DAT (Hoyois et al. 2007). In particular, USGS compiled eight catalogs including the above three and built a worldwide catalog

called PAGER-CAT (Allen et al. 2009). However, this globe earthquake database is not aimed at China, when we checked Chinese earthquakes contained in PAGER-CAT, it is found that many disastrous earthquakes have no records of numerical value of fatalities and injuries.

In terms of local earthquake database, China Earthquake Data Center provides an online earthquake database (<http://www.china-disaster.cn/>), sharing information on dates, magnitudes, casualties and economic losses of earthquakes events, but this database is not scientifically organized and lack of necessary explanation, e.g. the source of each earthquake event is not stated, which makes it difficult to ensure its reliability. In addition, a considerable number of earthquakes are not included in this catalog. Chinese researcher Chen-Qifu attached an earthquake casualty catalog between 1980 and 2003 in his literature (Chen et al. 2005), which listed earthquake source parameters and casualties, however, more detailed data, such as overall affected areas and population are not provided. Overall, commonly used casualty databases that focus on Chinese earthquakes and provide comprehensive information of casualties rarely exist.

In terms of this situation, we compiled five authorized earthquake catalogs and derived this Chinese earthquake casualty database. The five data sources are written in Chinese, and these are published books/online databases from China Earthquake Administration (CEA) and literatures from researchers working at CEA. The compiled database includes events in a time span from 186BC until December 2011. As for each earthquake event, not only seismic parameters are stated, information on earthquake impacts, in particular, the number of deaths and injuries (heavy and light), intensity at epicenter, the affected areas, overall affected population, and when available, affected areas and population within every macroseismic intensity is also provided.

EARTHQUAKE IMPACT DATA SOURCES

As previously mentioned, five earthquake impact data sources were used to compile the mainland China earthquake casualty database. Detailed information of the casualty databases is shown in Table 1.

No.	Database	Author	Type	Format	Content	Time coverage
1	China Network earthquake catalog	China Earthquake Network Center	Online database	table	Seismic parameters	1900-2013
2	A comprehensive compilation of historic and recent earthquakes status in china	LOU Baotang	book	table	Seismic parameters, casualties.	2221BC-1994
3	Earthquake cases in China	China Earthquake Administration (CEA)	book	text	Field survey reports	1966-1999
4	Collection of Earthquake Damage Assessment Reports in mainland China(1990-1995,1996-2000&2001-2005)	CEA	book	text	Field survey reports	1990-2005
5	China Earthquake Yearbook (A review of earthquake damage loss in Chinese mainland)	Researchers in CEA	book /literature	table	Seismic parameters, casualties.	2006-2011

Table 1. Casualty databases describe label

EVENTS SELECTION

In general, we are to collect earthquake events with magnitude ≥ 5.0 and at least one casualty in Mainland China from 2221BC until December 2011. Taking the number of citations in peer reviewed literatures as a measure of reliability, Database No.2, No.4 and No.5 has high priority and is marked as primary databases, Database No.1 and No.3 serve as supplementary database.

Figure 1 shows the procedure of selecting earthquake events in this catalog. Firstly, earthquake catalog is downloaded from China network earthquake catalog; the function of database No.1 is to provide a comprehensive earthquake catalog to avoid discarding any disastrous earthquake events. Then the detailed seismic parameters and damage data are collected from other databases.

Database No.2 is used as the primary data source in the time span from 2221 BC to 1994, and if necessary, Database No.3 and No.4 are adapted to provide complementary information in case that data is not available in Database No.2. For time span between 1995 and 1999, Database No.4 is preferred to be used. As for the remaining time coverage, Database 4 and Database 5 are selected as the unique data source.

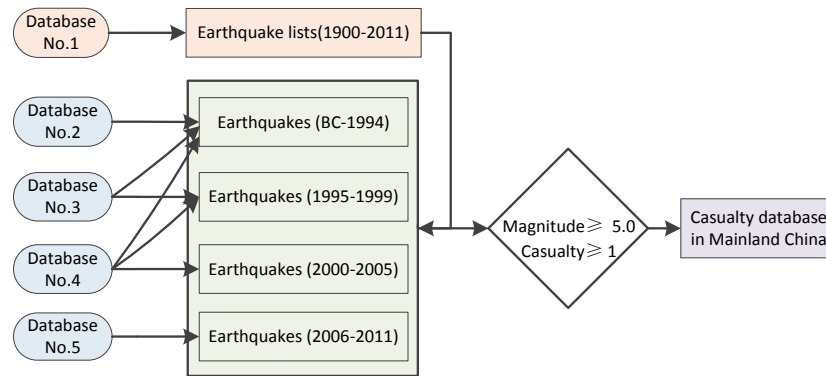


Figure 1. The procedure of selecting earthquake events

DATABASE OVERVIEW

The derived database includes 520 earthquake events with a magnitude of 5.0 and greater where at least one casualty was recorded in prior to 2011, and the earliest record traces back to 186 BC. There are 401 earthquake events that caused deaths, in which 4 earthquakes lead to more than 100000 deaths. Figure 2 is the distribution map of earthquakes in this database based on fatality. Figure 3 indicates the distribution of fatal earthquakes based on year range and fatality range.

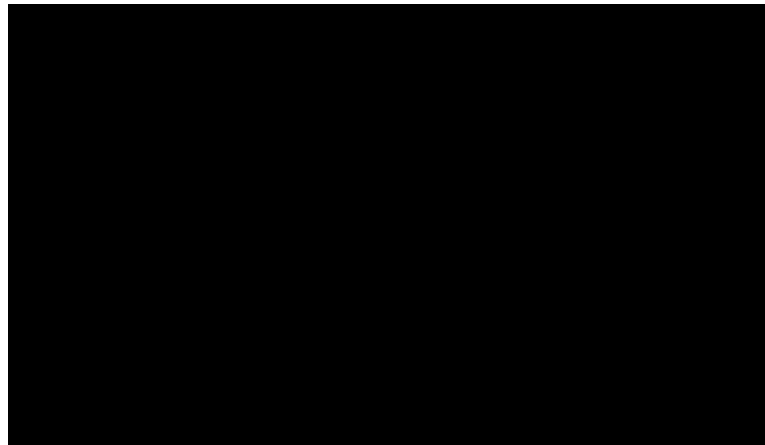


Figure 2. Distribution map of earthquake events in this database. The size of circles is related to the number of deaths. Circles in red refer to the earthquakes caused deaths more than 10000.

Pies in Figure 4 show the distribution of earthquakes and deaths based on regions. From pie (a) number distribution, we can see that Yunnan and Sichuan provinces are the most seismically vulnerable provinces in China, the number of earthquakes happened in these two provinces makes up 48 percent of the whole number. The remaining provinces expect the mainly five contributing provinces make up 33% of the total earthquakes. For the pie (b) deaths distribution, we can see that the most seismically active provinces: Yunnan, Sichuan and Gansu only account for 17% of deaths in total. The reason lies in the largest 4 earthquakes ever happened in Chinese history, which are located in Shan'xi, Shanxi, Ningxia and Hebei province, and caused 200000, 830000, 235502 and 242000 fatalities, respectively. Lastly, the remaining provinces represent 20% of the whole deaths.

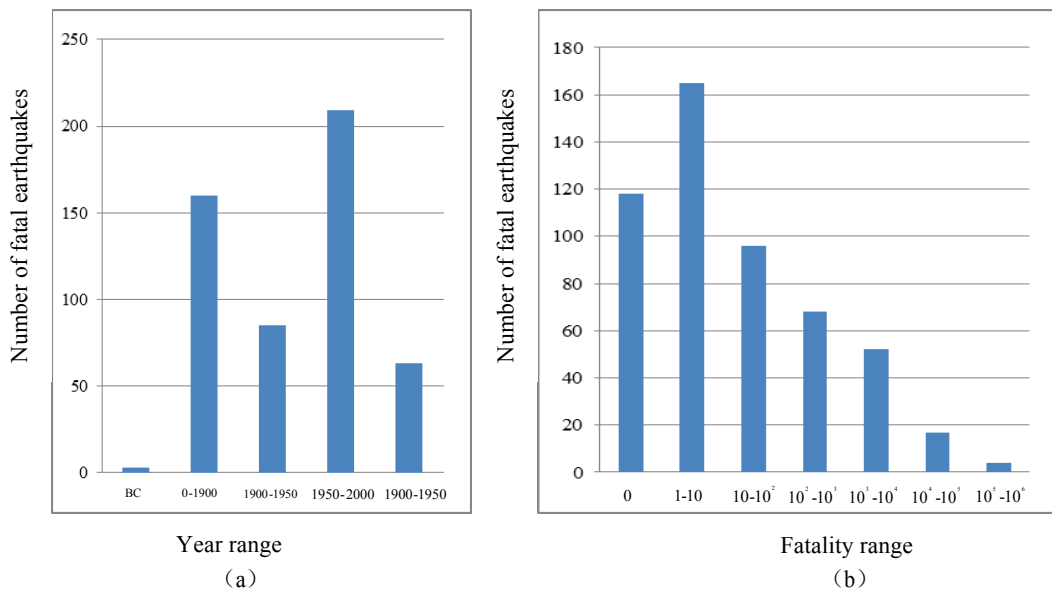


Figure 3. Number of fatal earthquakes based on year range (a) and fatality range (b) in this database.

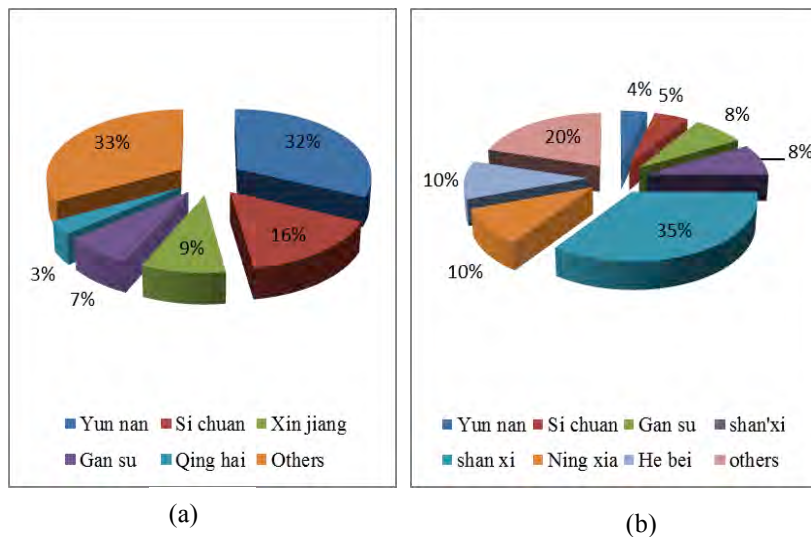


Figure 4. (a) and (b) shows the proportion of the number of earthquakes and the number of deaths, respectively, in different provinces

COMPARISON WITH PAGER-CAT

In order to verify the robustness of this casualty database, a comparison is made between this database and PAGER-CAT. It is known that PAGER-CAT is derived from eight earthquake catalogs and a PAGER-CAT preferred data is selected for deaths and injuries. The earthquake record in PAGER-CAT is dated from January 1900 and the latest version is updated to June 2008. To present a comprehensive and accurate comparison, we take data credibility in this casualty database into consideration, so the time coverage of the comparison is constrained to January 1950 through June 2008.

Table 2 shows the constraints and the result of comparison of these two databases. It indicates that there are 257 and 124 earthquake events indicating death number in the two databases. In particular, our database has 146 earthquake events which are not included in PAGER-CAT. By checking the 124 earthquakes events with casualty data in PAGER-CAT, it is found that of these 124 earthquakes, PAGER-CAT has 13 unique earthquake

Proceedings of the 11th International ISCRAM Conference – University Park, Pennsylvania, USA, May 2014
S.R. Hiltz, M.S. Pfaff, L. Plotnick, and P.C. Shih, eds.

cases, and has 111 same earthquake cases with our database. Among the 111 events, the number of fatalities and injuries on 77 earthquake events are recorded basically the same value in the two catalogs, the difference is PAGER-CAT shows the whole number of injuries, while our database gives the number in the form of heavy and light injuries. The 77 earthquakes contain three situations: 1) the same value of deaths and injuries, which has 64 events; 2) the same value of deaths, and the difference of injuries number is less than five, 9 events; 3) the same deaths value, one database provides injury number while the other one has no injury records.

Casualty database	PAGER-CAT	
Mainland China Magnitude(Ms) \geq 5.0	ISO_country: CHINA PAGER_prefMag(MW, MS, ML, Mb): \geq 5.0	Constraints
257	350	Number of earthquake events
257	124	Events indicating deaths number
77		CEA
	34	Researchers in CEA
146	13	Unique events

Table 2. Comparison with PAGER_CAT

CONCLUSION

An earthquake casualty database of Mainland China derived from original Chinese data sources is presented in this paper. Compared with PAGER-CAT, this casualty database provides 101 earthquakes in common and 146 earthquakes uniquely. Particularly, this database provides detailed information on heavy injuries and light injures, as well as areas and population of affected regions. This database is an essential supplement for the global casualty database and the basis for casualty modelling of Chinese earthquakes. However, due to our ongoing research on empirical models based on this database, the database is not open to the public at present. We will provide web-based access to the database when the paper is published.

ACKNOWLEDGMENTS

The author Yuanyuan Li gratefully acknowledges financial support from China Scholarship Council.

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