Review on the development of earthquake insurance in China

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Abstract. China is one of the countries that suffer the severest earthquake in the world. Since Wenchuan earthquake in 2008, earthquake insurance has become a hotspot in China, both in the earthquake engineering field and security management field. Considering the importance of residential safety and national economy, earthquake insurance is of prior necessity. The development of earthquake insurance during the past five decades in China and other countries is summarized. Several issues related to earthquake insurance in China are discussed. The paper provides a short but comprehensive review of the earthquake risk model and denotes the crucial issues and the problems that engineer could confront, and proposed potential solutions to difficulties in the development of earthquake insurance in mainland China.

1. Introduction

China is located along the southeastern edge of the Euro-Asian Plate, which is subject to continuous pressures from both the Pacific Ocean Plate and the Indian Ocean Plate. In the past hundred years, several disastrous earthquakes occurred in China, which brought tremendous loss to both the country and individuals. Figure 1 [1] shows epicenter distribution from 1911-2007 in China. Nowadays, earthquake has become a hotspot in China since 2008 Wenchuan earthquake not only in earthquake engineering field but also in security management field. However, in China commercial insurance only occupied around 2%, while in some developed countries, insurance industry can compensate around 60-70% loss when catastrophe occurs [2]. Nowadays, Chinese government recognized the importance of establishing earthquake insurance system. Especially considering the importance for residential safety and national economy, earthquake insurance has been given priority to the development in recent years.

This paper aims to provide a review of earthquake insurance development in China, mainly focuses on loss estimation method used in earthquake engineering. In addition, international experiences of earthquake insurance are introduced. In sum, the paper gives an overview of current situation of China’s earthquake insurance industry.
2. Earthquake risk model

Earthquake risk in insurance industry is often referred to its monetary impact, which earthquake insurance company concerns. In order to manage the earthquake risk, the first step is to quantify risk. Earthquake risk model is an essential part of earthquake risk analysis, insurance pricing, loss estimate, derivative pricing, etc., which contains three parts [3-5]: earthquake hazard analysis, exposure vulnerability analysis and loss estimate, as shown in Figure 2. Thus, one region’s earthquake risk is the probability of an earthquake occurs and the loss brought the earthquake to this region.

![Earthquake risk model diagram](image)

**Figure 2.** Earthquake risk model.

2.1 Earthquake hazard

Earthquake hazard analysis concerns the recurrence interval and the intensity of earthquakes [6], which refers to the frequency and the severity of earthquakes. At the beginning of earthquake hazard analysis, the research focused on deterministic method, for example, making earthquake resistant design based on a certain ground acceleration value. With the development of earthquake engineering, the research began to change to probabilistic method. The curve of exceeding probability is used to illustrate earthquake hazard in the probabilistic method. Earthquake hazard has sufficient research foundation in China. Numerous scholars has issued related articles and standards [7-9], for instance, the zonation map of mainland China, which provide basis for aseismic design, land use and economic development.
Earthquake insurance loss estimate is aggregation of single deterministic events, thus earthquake hazard analysis module for earthquake insurance is building a possible event set, and aggregating the results of each event. The main problem of hazard analysis module is the prediction of frequency and severity of earthquake has large uncertainty.

2.2 Exposure vulnerability
Exposure vulnerability analysis is to analyze how the exposure is affected by the event. The exposure includes general buildings, economic level of one region, population density, etc. Sun [10] made a comprehensive research on the exposure distribution across mainland China, including population density, level of administrative division, economy and land use. Structure vulnerability of general buildings is the main concern of damage estimate and is influenced by buildings’ structure type, built year, height and construction materials etc. [11-13]. Additionally, the social function is a component that determines the financial loss of a structure. Structure vulnerability curve shown in Figure 3 is used to describe the damage possibility in structure vulnerability analysis. However, lack of detailed inventory information of exposure in China is the main problem that earthquake insurance is facing with. Information of the interrupt of commercial industry caused by earthquake, secondary disaster impact, and indoor property data is the rough part of insurance company to collect.

2.3 Loss estimate
Loss estimate method could be used to predict the risks from earthquakes and is an essential part in ratemaking by insurance company as well. Loss of disaster includes the direct loss and the indirect loss. Government officials use results of loss estimate to prepare for emergency response and recovery. Federal Emergency Management Agency and Applied Technology Council (ATC) published a report called ATC-13 Earthquake Damage Evaluation Data for California [3] to estimate the economic impact of earthquake occurred in California. In 1995, China Earthquake Administration embarked earthquake loss estimation project leaded by Yin. Then the common method in earthquake engineering to estimate single building direct loss is to calculate the damages of different types of structures under different seismic intensity as followed [4]:

$$E_k(R_z) = \sum_{i=0}^{9} \sum_{k=1}^{5} P_r(I) * P_s(J | I) * \lambda_j$$

(1)

where $I$ represents the seismic intensity, $J$ represents the damage level, $P_r(I)$ represents the occurrence probability of seismic intensity $I$ at a site $s$. and $P_s(J | I)$ is the possibility of which a structure type $K$ suffers damage level $J$ under seismic intensity $I$.

Equation 1 shows that both structure vulnerability and loss estimate concerns the classification of structure. Several kinds of building classification are used in different earthquake insurance system.

Disaster prediction concerns more about structure damages for the building classification based on structure types. However, insurance industry focuses on financial loss, both the direct and indirect loss. Earthquake often occurs in one certain region, this characteristic brings loss concentration [14]. Considering loss concentration, social function of structures should be taken into account. The social function of structures influences not only the direct loss, but also indirect loss brought by shutdown of factory and infrastructure damage etc. Chain reactions largely affect earthquake loss and then compensation from insurance industry. Thus, both structure type and social function should be considered when make building classification in earthquake insurance system. ATC-13 not only classifies construction based on their structure types, but also their social function, which provide more information for insurance companies.

Due to the “low frequency, severe consequence” characteristics of earthquake, historical record is insufficient. However, extreme events significantly influence the mean damage, which cause underestimate of loss. For instance, the Northridge earthquake in 1994 was one of the most costly disasters in United States history with estimates of the economic losses ranging from $20 billion to more than $40 billion [15]. In addition, data quality determines the accuracy of loss estimate and then
rate making [16]. Hence, an earthquake database including damage ratio based on classification of both building type and social function in China is a substantial part in building earthquake insurance system.

3. Earthquake insurance

3.1 International experience
Earthquake insurance in many countries has gained high level of penetration, especially in the countries where the fire insurance penetration is high, such as New Zealand, USA, Japan and Australia. This is because that earthquake insurance is often inclusion in fire insurance policy. California set up earthquake insurance in 1916 and established California Earthquake Administration in 1996. Japan undertook earthquake insurance research in 1868 and issued earthquake insurance law in 1966 after Niigata Earthquake. 1995 Osaka Kobe earthquake provided important experience and a great development opportunity for earthquake insurance. After the earthquake, the Japanese earthquake insurance system developed fast. According to statistics, in 2011, compensation for Tohoku earthquake from insurance in Japan was almost near 60%, which was the largest part of payment amount. New Zealand set up “earthquake and war loss fund” in 1941, issued “earthquake and war loss regulations” in 1944, and added earthquake as addition risk in fire insurance. This fund name was changed to “natural disaster fund”. After 1999 Chi-chi earthquake, Taiwan founded Taiwan Residential Earthquake Insurance Pool. This is an insurance taken by insurance company, earthquake fund, reinsurance company and the government.

![Figure 3. Vulnerability curve.](image)

In most earthquake insurance scheme, insurance loss is shared by insured, primary insurance company and reinsurance company. The government is the assurance of the whole system. Loss Diagram is shown in Figure 4. Wang [17] highlighted some initial issues for current China situation such as the coverage of earthquake insurance, the premium source, and the insurance mode and pointed out that the more government is involved in insurance schemes, the more different they are from one another, because catastrophe insurance is primarily concerned with meeting a community need, as opposed to an individual need. Local economic, social and political factors play a major role in developing an earthquake insurance system.

3.2 Current situation in mainland China
Compared with Japan, USA, New Zealand, the development of earthquake insurance in China first started in the year of 1950s and suffered some barriers. At that time, earthquake damage was compulsory inclusion in property insurance. The People’s Bank of China made earthquake insurance an exception of property insurance since 1986. Urban and rural residential earthquake catastrophe
insurance system was officially issued in 2016. Moreover, the China Reinsurance Company has launched the first Chinese catastrophe model with independent intellectual property rights in 2018. These developments mean that earthquake insurance in China goes into a new era.

China has a large insurance market. Considering China’s special geological environment, earthquake insurance can be first applied in Sichuan and Yunnan province. The first policy earthquake insurance experimental unit was launched in Chuxiong, Yunnan Province. Dali government with six insurance and reinsurance companies signed the cooperation agreement. Till 2016 Yunlong earthquake, compensation by earthquake insurance industry was 35 million yuan. Leshan, Sichuan Province also started residential earthquake insurance in November 23, 2015. Sichuan provincial finance paid 20 million yuan for earthquake insurance reserve fund.

4. Conclusion and recommendation
China has made some progress in establishing its own earthquake insurance scheme. However, due to the low penetration of insurance, earthquake insurance system in China should be government-based compulsory insurance. Considering the achievement in Yunnan and Sichuan province experiment units, the central government, provincial government need to cooperate with primary insurance companies and reinsurance companies, and build an hierarchical mechanism to share the loss. At the beginning of the earthquake insurance establishment, government share high percentage. As the earthquake insurance system develops, government can decrease its degree of participation while primary insurance companies and reinsurance companies can increase their participation. Furthermore, function of capital market can also be intensified.

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