



## **EARTHQUAKE DISASTER EVALUATION IN CHINA**

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### **SUMMARY**

The concept, contents and brief history of Earthquake Disaster Evaluation in China are given in this paper. Several methods used in Earthquake Disaster Evaluation and their usages are discussed in detail. The features and procedure of Earthquake Disaster Evaluation in China are given, and the future research trend on Earthquake Disaster Evaluation is discussed.

### **INTRODUCTION**

Earthquake Disaster Evaluation is to evaluate future earthquake risk and social influence by the estimation of the type, degree, spatial distribution, casualty and economic losses of an or several future earthquake potential in the large or medium cities, area, factories, mines other enterprise with seismic background, based on the Seismic Intensity Zonation Map of China, seismic risk analysis and seismic micro-zonation.

Earthquake Disaster Evaluation is one of the important measures to mitigate seismic economic losses and casualty, and is the main work of seismic prevention and hazard reduction in China. The results of Earthquake Disaster Evaluation shows the future earthquake damage such as the economic losses and casualty induced, which is the scientific basis to the earthquake emergency response countermeasure, and seismic precaution plan. It is also make much more contribution to the urban development plan, plan of retrofit of existing engineering structures, earthquake insurance and the rebuilding post-earthquake.

Generally, Earthquake Disaster Evaluation include following aspects:

- a) Seismic risk analysis and seismic micro-zonation.
- b) Earthquake Disaster Evaluation of site soil including liquefaction of soil, potential earth slide, et al.
- c) Earthquake Disaster Evaluation of kinds of buildings including multi-story brick building, single-story brick building, old single-story building, single-story industry factory building, steel enforcement concrete building, et al.
- d) Earthquake Disaster Evaluation of lifeline system engineering including system of electricity, water supply system, gas supply system, transportation system and communication system.
- e) Earthquake Disaster Evaluation of special engineering including chimney, water tower, dam, nuclear power station, et al.

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- f) Estimation of secondary disaster including fire, explosion, flood, and leakage of poisonous gas induced by earthquake.
- g) Estimation of casualty including death, wounded and homeless people.
- h) Estimation of economic losses including direct loss and indirect loss.

## **BRIEF HISTORY OF EARTHQUAKE DISASTER EVALUATION IN CHINA**

In China, researching work on Earthquake Disaster Evaluation commenced after the shock of the Tangshan earthquake. Before the Tangshan earthquake, China Seismological Bureau (CSB), when is called State Seismological Bureau (SSB), and the Ministry of Construction conducted a project to do the aseismic appraisal of Tangshan City. But this project had not started Tangshan earthquake came; the damage was serious and was a great shock to the world. After the earthquake, the earthquake engineering researchers of China study the necessity of this project which was not started, they get the conclusion that to do the aseismic appraisal of buildings only to the basic intensity can not explain the risk and influence of strong earthquake, and have no effect in the post-earthquake emergency response and salvation action. So during the work of seismic prevention and hazard reduction of Anyang City in Henan province, the concept of Earthquake Disaster Evaluation was advanced by professor Yang Yucheng of institute of engineering mechanics (IEM) in 1980. In the same time, Earthquake Disaster Evaluation was also included in seismic prevention and hazard reduction of Yantai City and Xuzhou City. After that, Earthquake Disaster Evaluation was approved by most of earthquake engineering experts.

In 1982, State Seismological Bureau promulgate a regulation on Earthquake Disaster Evaluation, aimed at effectively mitigating earthquake damage by preventive measures on the basis of seismic zonation and microzonation. Then Earthquake Disaster Evaluation was taken as one of the bases for seismic prevention and hazard reduction. And Earthquake Disaster Evaluation were conducted in many cities including Xiamen City, Zhanjiang City, Sanmenxia City, Taiyuan City, Datong City, Linfen City, Benxi City, Haikou City, Tianjin Harbor, Daqing Oilfield, Kelamayi Oilfield, and Shandong Petrochemical Works from the midst of 1980's to early in the 1990's.

In this early developing period of Earthquake Disaster Evaluation, occurred many methods of different kinds of engineering. But there still existed in some problem in Earthquake Disaster Evaluation. On the methods are not enough to do all the Earthquake Disaster Evaluation in all the cities, sometime a method must advanced for special building in a certain city, because China is a large country with various kinds of building. On the other hand, Earthquake Disaster Evaluation must get to a high level with the development of technology and society, especially the development of computer. So in the "Eighth Five Year Plan", the National Science Foundation sponsored a weighty project "basic research on disaster mitigation of city and engineering", in which, Earthquake Disaster Evaluation was one of the research objectives. In the project, study on the methods of Earthquake Disaster Evaluation were conducted and geography information system (GIS) was first used to build the information database and computer aid earthquake emergency response system in the Earthquake Disaster Evaluation of Anshan City, Anshan City and Zhenjiang City.

In the "Ninth Five Year Plan", China seismological Bureau conducted a project on Earthquake Disaster Evaluation to make further study on the methods on nearly all the aspects

of Earthquake Disaster Evaluation, and developing expert system and geography information system in Wulumuqi City, Hefei City, Zigong City, Binhai District in Tianjing City and Minnan Area (includes Zhangzhou City, Quanzhou City, Nanan City).

### METHODS IN EARTHQUAKE DISASTER EVALUATION

We can view the result of Earthquake Disaster Evaluation from two different ways. Directly, the result of Earthquake Disaster Evaluation shows the damage of buildings and systems due to earthquake, such as function loss of system, economic loss and casualty. The result of Earthquake Disaster Evaluation should give the hazard distribution, comparison between different systems, comparison between kinds of building. Indirectly, Earthquake Disaster Evaluation is estimation the ability of kinds of building and systems using methods not same as the aseismic appraisal, that is why the result of Earthquake Disaster Evaluation can be used in the retrofit of engineering and in the urban development plan and so on.

The Earthquake Disaster Evaluation can be made to a single structure, or to a group of structures. Also it can be made to a city, an area or a community under probable earthquake, based on the usage of Earthquake Disaster Evaluation, sees Table 1.

Table 1 Earthquake Disaster Evaluation usage to objective

Usage	Objective
Urban development and remake	Block (group)
System precaution	System (group), Key structures (single)
Aseismic strengthening	single
Emergency plan	Single, group
Key building and structures	Single
Scale of damage (loss and casualty)	Community (Group)
Serious hazard area	Group

The several methods used in Earthquake Disaster Evaluation include structural seismic response analysis methods, aseismic check computation method, simplified assessment method and statistical method.

Structural seismic response analysis method is normally used in the damage assessment of structures with little or no historical earthquake damage experience such as high concrete buildings, based on the structural response theory and experiment study results.

Aseismic check computation method is used in the damage assessment of complicate structures with little or no historical earthquake damage experience and difficult to conduct structural response analysis, based on design code.

Simplified assessment method is used in the damage assessment of structure witch number is great and has plentiful of historical earthquake damage experience, such as multi-story brick

building, single-story concrete column industry factory. This method is the simplification of structural response theory based on the earthquake damage experience.

Statistical method is used in the damage assessment of simple structures with number is great and has plentiful of historical earthquake damage experience, such as single-story brick column industry factory, old single-story building.

Now in China, simplified assessment method and statistical method are used widely because that Haicheng earthquake and Tangshan earthquake provided much more damage experience for most kinds of building and lifeline system. See table 2 and table 3 for the methods used in Earthquake Disaster Evaluation of buildings and lifeline system engineering respectively.

The methods used in the assessment of casualty and economic losses are only statistical methods. There are several methods to assess indirect economic loss, but no one is so good to give a reasonable result.

Table 2 methods used in Earthquake Disaster Evaluation of buildings

Kinds of building	Structural seismic response analysis method	Aseismic check computation method	Simplified assessment method	Statistical method
Multi-story brick buildings		•	•	
Single-story brick building			•	•
Old single-story building			•	•
Multi-story concrete building	•	•		
Steel structure	•	•		
Single-story factory			•	•

Table 3 methods used in Earthquake Disaster Evaluation of lifeline system engineering

Kinds of building	Structural seismic response analysis method	Aseismic check computation method	Simplified assessment method	Statistical method
High voltage instrument	•	•		
Bridges	•	•	•	•
Communication instrument		•		
Underground pipeline	•	•		
Oil and gas tank	•	•		
Harbor			•	•

## **PROCEDURE AND FEATURES OF EARTHQUAKE DISASTER EVALUATION**

As in the description above, the Earthquake Disaster Evaluation in China has many features including:

- a) Most methods used in Earthquake Disaster Evaluation are based on the theory of structural analysis and historical earthquake damage experience. So the results of Earthquake Disaster Evaluation is much more reasonable.
- b) The Earthquake Disaster Evaluation can be carried out in different objective based on the usage. This make Earthquake Disaster Evaluation can be used in various ways and to get what concern with.
- c) Every part of Earthquake Disaster Evaluation are interrelated such as the assessment of buildings and lifeline systems is based on the results of seismic risk analysis and seismic microzonation, the assessment of economic losses and casualty is based on the assessment of buildings and lifeline systems.
- d) All of assessment are not in the same scientific level, because of different methods are used.
- e) Until now, all of the Earthquake Disaster Evaluation can not be verified during a real earthquake.

In general, the procedure of Earthquake Disaster Evaluation is as following:

- a) To choose the working area and divide to calculation unit.
- b) To determine the working content and methods to use.
- c) To collect material on site needed in Earthquake Disaster Evaluation
- d) To check, analyze and sort out the material collected and to get data needed.
- e) To conduct seismic risk analysis and seismic microzonation.
- f) To conduct the damage assessment of site soil.
- g) To conduct the damage assessment of kinds of building and lifeline systems
- h) To assess the casualty.
- i) To assess the economic losses.
- j) To write the report of Earthquake Disaster Evaluation.

## **CONCLUSION**

China is an earthquake country, and great economic loss and lot of people died or wounded in the past earthquake. Chinese government pays much attention to earthquake prevention and hazard reduction. In May 2000, First National earthquake prevention and hazard reduction meeting was held in Tangshan City. More than half of local government held their provincial earthquake prevention and hazard reduction meeting. This will promote work of earthquake prevention and hazard reduction in China. As the main aspect of earthquake prevention and hazard reduction, Earthquake Disaster Evaluation research tendency would be several aspects including:

- a) Study on basic theory of Earthquake Disaster Evaluation, such as study on methods of new type of building, complex structures with large span and extra-height.
- b) Modification of existing methods for use in different area with special features.
- c) Study on new technology, such as GIS, et al.

Enact national lows on Earthquake Disaster Evaluation, and make Earthquake Disaster Evaluation standard.

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