

CHARACTERISTICS AND INSPIRATIONS OF BUILDING SEISMIC DISASTER IN WENCHUAN EARTHQUAKE

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ABSTRACT:

The M8.0 Wenchuan Earthquake was one of the most catastrophic earthquakes in modern history, which happened in Wenchuan county Sichuan province at 14:28 on May 12, 2008. It caused a large number of casualties and property losses. Based on investigation of building seismic disaster, characteristics of building seismic disaster was analyzed and inspiration of Wenchuan Earthquake was summarized and corresponding suggestions for earthquake relief work in future was given in the paper.

KEYWORDS:

Wenchuan Earthquake; building seismic disaster; earthquake engineering; structural seismic; inspiration

1. INTRODUCTION

The M8.0 earthquake happened in Wenchuan county, Aba, Sichuan province at 14:28 on May 12, 2008. The earthquake epicenter was located in Wenchuan county-beichuan county area, the earthquake intensity in meizoseismal area was up to XI degree. The earthquake not only caused catastrophic damage in the epicentral area, but also caused extensive damage in Sichuan and neighbouring provinces, what's more, its impact was spread to most of the region and even outside the country. Many times of strong aftershocks had happened after main shock, among 8 times aftershocks beyond M6.0 by 12:00 on August 7, which led to cumulative damage. Unfortunately, the earthquake occurred in the mountain area, led to many geological hazards (such as landslide, barrier lake) occurred, so that the secondary disaster was serious. According to the Ministry of Civil Affairs statistics, by 12:00 on August 7, the earthquake had caused 69,222 people dead, 374,638 wounded, 18,176 missing. According to estimate, the direct economic losses caused by earthquake could be as high as 880 billion yuan in Sichuan province, which is 88 times more than Tangshan Earthquake. Both the intensity and the strength of Wenchuan Earthquake exceeded 1976 Tangshan Earthquake, its extensive influence scope and strongest destructive power made Wenchuan Earthquake become the biggest earthquake in China since 1949.

For roundly realized the things of building seismic damage, in more than two months after the earthquake, the author had led the team members to go down to disaster area five times and altogether more than 30 person-times. And the distance was more than ten thousand kilometre. Further more, the place of investigation involved almost all heavy disaster area in Sichuan Province, which there were 13 counties and cities and 14 villages and towns, including Wenchuan County, Beichuan County, Qingchuan County, Pingwu County, An County, Jiangyou City, MianZhu City, ShiFang City, DuJiangYan City, PengZhou City, MianYang City, DeYang City, ChengDu and so on and Yingxiu town, Xuankou town, Xiaoyudong town, Tongji town, Xinxing town, Hongbai town, Yinghua town, Hanwang town, Jiulong town, Wudu town, Zundao town, Nanba town, Pingtong town and so on (see figure 1.1). Nearly ten thousand photographs were taken, from among them the massive first-hand material were obtained. Many buildings involved in the material have been demolished, so the material and research work is more valuable and precious.

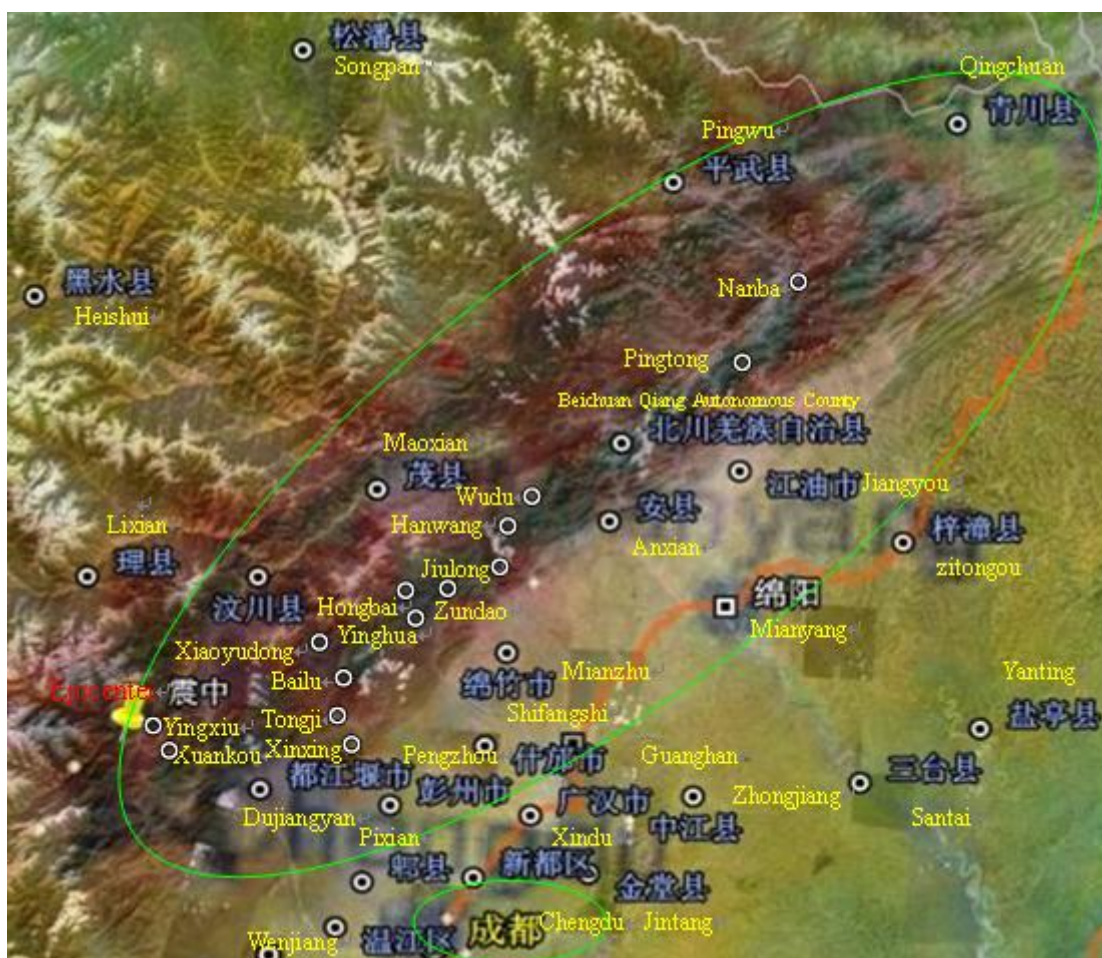


Figure 1.1 Investigation places of earthquake disaster of Wenchuan earthquake

Based on investigation of building seismic disaster, characteristics of building seismic disaster was analyzed and inspiration of Wenchuan Earthquake was summarized and corresponding suggestions for earthquake relief work in future was given in the paper.

2. CHARACTERISTICS OF BUILDING SEISMIC DISASTER IN WENCHUAN EARTHQUAKE

By its destructive power, the 5.12 Wenchuan Earthquake has made a large number of buildings destroyed,. Following to analyze and summarize the seismic damage in different structure types of buildings caused by the earthquake.

2.1Masonry structure buildings

Masonry structure buildings especially rural buildings and old buildings which lack of seismic design were damaged seriously in Wenchuan Earthquake. Firstly, in high-intensity area, more than 90 percents of masonry structure buildings collapsed or were damage seriously. Building complex and street building collapsed fleetfully. Nevertheless, the damaged buildings that did not collapse were serious quite, not to continue to use. Secondly, in medium intensity area, masonry structure buildings and bottom-frame structure buildings were damaged seriously, and some of them collapsed, and the rest were damaged seriously or destroyed intermediately. Thirdly, in lower intensity area, the number of the masonry structure buildings which were damaged seriously or destroyed intermediately were relatively less. Most of them were damaged slightly or

basically whole. And the main majority of housings were whole or only minor damaged, however, the walls of some of old brick houses were damaged, tiles of large slope roof dropped, Cubby or small chimney on the top of buildings were damaged or collapsed.



Figure.2.1 Collapse of a masonry structure building



Figure.2.2 Collapse of a masonry structure building



Figure.2.3 Collapse of bottom of a bottom-frame building



Figure.2.4 Damages of a bottom-frame building



Figure.2.5 Collapse of exterior lengthways wall of a masonry structure building



Figure.2.6 Collapse and damage of exterior lengthways wall of a masonry structure building

2.2 Multi-story reinforced concrete structure buildings

Comparatively reinforced concrete structures had better seismic performance, but in the meizoseismal area, the reinforced concrete frame structures collapsed and were damaged seriously, and, in the medium-low intensity areas, the damage was relatively minor. For multi-story reinforced concrete structures, the damage mainly occurred in the frame column and in filler walls, and the most serious damage occurred in the end of the column and in the beam-column joints, however, the secondary beam and floor were often less damaged.



Figure.2.7 Collapse of a frame structure building



Figure.2.8 Damages of the corner column



Figure.2.9 Damages of the top end of columns



Figure.2.10 Damage of the bottom end of a column

The characteristics of damage varied with the intensity of the earthquake. Firstly, in the high-intensity area, the frame structures suffered moderate to severe damage and even collapse. The major damage occurred in end column or joints, including the concrete being crushed and the reinforcement yielding seriously in end column or joints. After the joint was damaged, the horizontal cracking and dislocation occurred in end column. Serious shear cracks of filler walls made the structure damage seriously or partially collapsed. Secondly, in medium intensity area, frame structures suffered minor damage or moderate damage. Major damage that structures suffer included horizontal cracks of end column, vertical cracks and cracks of beam end, slightly crushing of the concrete at the joints, slightly curving of steel, and lots of shearing diagonal cracks in filler walls. Thirdly, in the low-intensity, the frame structures were basically well. The brick filler walls were well mostly, only a few was damaged slightly.

After the earthquake, for most of the frame structures, we found that the failure mode with the “strong column weak beam” had not been realized. The damage of end column was more serious than beam end.



Figure.2.11 Damages of the ends of a beam



Figure.2.12 Fracture of a stair slab

2.3 Industrial buildings

There are many industrial buildings damages in Wenchuan earthquake. The industrial buildings were constructed in periods of 50 's of 19 centry until now, so some building were designed without earthquake resistance protections and some were designed by code for seismic design of building but different version. Thus the anti-seismic measures adopted and provention level of industrial buildings are different. In summary, the damage of buildings with seismic designed are lighter, while, the damage of the old structure are much more serious.

Genarelly, there are severl structure types of industrial buildings such as reinforced concrete column workshop, with precast reinforced concrete roof or lightweight steel roof, and steel structure workshop. Comparatively speaking, the damage of steel structure workshop is more lightly than reinforced concrete column workshop, the damage of workshop with lightweight steel roof is more lightly than precast reinforced concrete roof. The seismic damage of the industrial buildings in high intensity region are mainly including destruction of roof and collapse of the maintenance wall. While there were few pillars collapsed, but seriously damaged at upper stair column. The seismic damage in lower intensity region are maily failure of maintenance wall or damage of skylight truss.



Figure.2.13 Collapse of precast reinforced concreter roof



Fig.2.14 Collapse of lightweight steel roof



Figure.15 Collapse of the maintenance wall



Figure.16 Damage of skylight truss

3 LESSONS AND ENLIGHTMENTS DRAWN FROM WENCHUAN EARTHQUAKE

3.1 *Understanding Wenchuan Earthquake correctly*

The seismic damage of Wenchuan earthquake is extremely serious. the main reason should be that the earthquake magnitude is so huge and the earthquake intensity exceeds the fortification intensity too much. Two intentions should be avoided, first is requesting the structure strong enough to resist any possible earthquake because of this serious seismic damage, and the second is ignoring the technology and management problem which had been exposed in the seismic damage by the excuse of large earthquake magnitude.

3.2 *System engineering of earthquake disaster prevention*

The government reacted rapidly to Wenchuan Earthquake, and the relief work were done effectively which greatly reducing the casualties and property losses. However, the earthquake disaster prevention include defending, resisting, reducing, relieving, and other technical activities, so that it is a system engineering which affecting all levels of society. It is worth to draw lessons from Wenchuan earthquake and sum up the relief experiences to China.

3.3 *Earthquake resistance protections and new problem*

From seismic damages investigating of Wenchuan Earthquake, we can know that most structures with earthquake resistance protections undergone the tests as well as many new questions and challenges are present. Firstly, the seismic damage of buildings with seismic fortifications is much lighter than those without seismic fortifications. Secondly, the seismic damage of buildings designed according to code for seismic design of buildings(GB50011-2001) is much lighter than those according to its old version GBJ11-89. At the same time, it should be noted that there also some damage, different degrees, happened in the earthquake resistant buildings thus there are also new challenges for us.

(1) Failure mode of structure

The failure mode of the frame structure did not match the expectations of current design idea. In many frame structures, the damage to columns is much more serious than beams obviously. How to implement the design idea of "strong column-weak beam" effectively is worth to be studied. There are large number of buildings

collapsed such as large-bay structure, framework, bottom-frame structure and masonry structure, so it is worth to study of the collapsing mode and mechanism to enhance the capacity of earthquake reduction and disaster prevention.

(2) Earthquake disaster prevention of rural buildings and old buildings

Most of all rural buildings were damaged seriously or even collapsed in Wenchuan Earthquake. It is necessary to strengthen the construction management of the rural buildings. Meanwhile, it is an urgent need to propose some simple, practical and cost-effective anti-seismic measures to reduce the damage of rural housings. Old building collapsed seriously too in Wenchuan Earthquake. It is necessary to carry out the seismic strengthening work to improve seismic capacity of such buildings and the strengthening methods for old buildings is necessary to study.

(3) Construction problems

There are many building damages caused by improper construction in Wenchuan Earthquake. The cases were frequent that spacing of stirrups were not even and sometimes the number of stirrups were little at frame joint. The cases were common that improper disposal of construction joint at the end of the column, beam and wall body, too. Reliable construction quality and correct construction method are the guarantee to qualified seismic performance of buildings.

(4) Earthquake Damage of stair

A large number of stairs damaged in Wenchuan Earthquake with fractured of ladder plate, torsional broken of stair girder, destruction of platform or/and column stair. The damage of stair is ignored in previous seismic design and should be pay much attention to.

(4) Other technical problems

There are also other topics worthy to study such as, seismic joint and anti-collision, the stiffness and strength control of building, evaded distance of fault, analysis model for structure design, stiffness contribution of filler wall and its linking mode to frame, etc..

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