



Analysis of seismic damage characteristics of Shuanghe Town in the meizoseismal area of Changning M6.0 Earthquake, Sichuan Province.

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Abstract

At 22:55 on June 17, 2019, Changning County, Yibin City, Sichuan Province (28.34°N, 104.90°E), a magnitude 6.0 earthquake occurred with a focal depth of 16 kilometers. The maximum intensity caused by the earthquake reached VIII degrees, and Shuanghe Town of Changning County was mainly located in the VIII-degree area. In this paper, Shuanghe Town, a representative area of seismic damage, was selected to be the study area. The unmanned aerial vehicle (UAV) was used to carry out orthophoto photography in this area, and the aerial data processing produced DSM and DOM. Meanwhile, the tilting photography was carried out on some typical area of Shuanghe Town, and the aerial data processing produced a 3D model. Based on DSM, DOM and the inclined 3D images, combined with the field investigation information, the seismic damage characteristics in the study area were analyzed in detail, and the characteristics of house damage and seismic geological hazards in the study area were also obtained. Finally, combined with the located site conditions, the structural features and the topography of the terrain to analyze the causes of the damage.

Keywords: *Sichuan Changning M6.0 Earthquake; orthophoto images; tilt images; seismic damage characteristics; damage causes;*



1. Introduction

According to the determination of China Earthquake Networks Center, at 22:55 on June 17, 2019, a 6.0-magnitude earthquake occurred in Changning County, Yibin City, Sichuan Province (28.34°N, 104.90°E), with a focal depth of 16 km. The focal mechanism solution results showed that the earthquake was strike slip type. This earthquake sequence was relatively active. As of 8:30 on June 18, 17 aftershocks of more than 3.0-magnitude were recorded, including 12 earthquakes of Magnitude 3.0-3.9, 3 earthquakes of Magnitude 4.0-4.9, and 2 earthquakes of Magnitude 5.0-5.9, which were magnitude 5.1 at 23:36 on June 17 and magnitude 5.3 at 7:34 on June 18.

The earthquake disaster affected a very large area, the population distribution of the disaster area is relatively dense, causing great casualties. As of 16:00 on June 19, 2019, 243880 people were affected by the 6.0 magnitude earthquake in Changning, Sichuan Province, with 13 dead and 220 injured, including 153 hospitalized. The study area of this paper is Shuanghe Town, the epicenter area of this earthquake. After the earthquake, the author came to Shuanghe town for field investigation and found that the characteristics of local earthquake disasters were very typical. Therefore, the characteristics of building earthquake damage, the characteristics and distribution of seismic geological disasters, the characteristics and damage mechanism of different types of building disasters in Shuanghe town were analyzed and discussed, and the disaster characteristics caused by this earthquake in the epicenter area was also summarized. The characteristics and influence of the earthquake disaster in Shuanghe town can be helped as the experience and enlightenment of the earthquake prevention and mitigation work in the future.

2. Earthquake intensity distribution and basic situation of Shuanghe town

The highest intensity of the earthquake was VIII. Total area of VI-degrees area and above is 3058 square kilometers. The long axis of isoseismal line was northwest trending, with 72 kilometers of long axis and 54 kilometers of short axis. It mainly involved six counties and districts in Changning County, Gaoxian County, Gongxian County, Xingwen County, Jiang'an county and Cuiping District of Yibin city. The VIII-degrees area covered an area of 84 square kilometers, mainly involving Shuanghe Town, Fuxing Township and Zhoujia town of Xingwen County. The VII-degrees area covered an area of 436 square kilometers, mainly including Shuanghe Town, Meidong Town, Dongdi Town, Huatan Town, Zhuhai town, Longtou Town, Tongluo Township, Jingjiang Town, Fuxing Township, Xunchang Town, Gongquan Town, Didong Town, Zhoujia town of Xingwen County, Hongqiao Town of Jiang'an County, 14 towns in total. And the VI-degrees area district covered an area of 2538 square kilometers, mainly involving 58 towns in Gaoxian County, Xingwen County, Gongxian County, Changning County, Jiang'an county and Cuiping District (Fig. 1-Fig.2).[1]



Fig. 1 – M6.0 seismic intensity map of Changning, Sichuan (according to China Earthquake Administration)

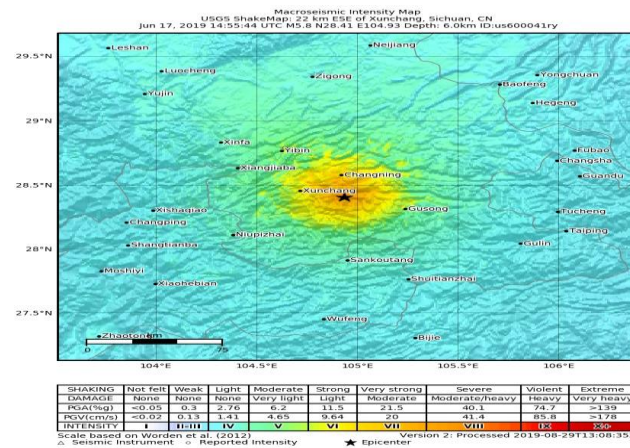


Fig. 2 – M6.0 seismic intensity map of Changning, Sichuan (according to USGS)

In this paper, the study area-Shuanghe town was the epicenter of the earthquake, mainly located in the area of VIII-degrees area. Shuanghe town is located in the south of Changning County. It is adjacent to Fuxing Township in the southeast, Gongxian County in the west, Zhoujia town in Xingwen County in the South and Longtou town in the north. Shuanghe town covers an area of 89 square kilometers, governs 12 villages and 1 community, 98 agricultural cooperatives, with a total population of more than 35000.

3. Seismic damage characteristics of buildings in Shuanghe Town

3.1 Classification of buildings in disaster area

According to the structural types, the houses in the disaster area can be divided into three types: simple houses, brick concrete structures and frame structures. [2]

(1) simple houses: in the field investigation, the houses with civil structure, brick wood structure and stone concrete structure are classified as simple houses (national standard of the people's Republic of China, 2011).

Civil structure: local main traditional houses, rammed earth wall bearing, mostly two-story, wall carrying wooden beam, herringbone tile roof or concrete cast-in-place floor, flat roof, compared with other areas in Sichuan Province, the seismic performance of traditional through bucket wooden structure houses is very poor.

Brick and wood structure: brick wall bearing, mostly two-story, wall lifting wooden beam, herringbone tile roof or concrete cast-in-place floor, flat roof. Some walls are built with hollow cement bricks and stones, without seismic measures, and most of them have been built for a long time. This kind of building has poor seismic performance.

Stone concrete structure: made of stone masonry, poor viscosity, no structural column, no ring beam, concrete roof, 1-2 floors.

(2) Brick concrete structure: brick wall bearing, reinforced concrete ring beam, structural column and cast-in-place building (roof) cover hybrid structure, good seismic performance.

(3) Frame structure: it is mainly a frame system composed of reinforced concrete beams and columns that has been formally designed to bear load and cast-in-place floor (roof) cover. The seismic performance is the best.

The frame structure and brick concrete structure are divided into five failure levels.

(1) Basically intact (including intact): the non load bearing components of brick concrete and frame structure buildings are slightly cracked and can be used without repair.



(2) Slight damage: slight cracks on individual load-bearing components of brick concrete and frame structure buildings, obvious cracks on non load-bearing components; it can be used without repair or slight repair.

(3) Medium damage: the bearing members of brick concrete and frame structure buildings are slightly damaged, with obvious cracks in some parts, and some non bearing members are seriously damaged; they can only be used after general repair.

(4) Serious damage: most of the load-bearing components of brick concrete and frame structure buildings are seriously damaged and difficult to repair.

(5) Destruction: most of the load-bearing components of brick concrete and frame structure buildings are broken, and the structure is close to collapse or has been collapsed and cannot be repaired (national standard of the people's Republic of China, 2011).

For simple houses, it is divided into three damage levels: the destruction and serious damage shall be combined into destruction; the medium damage and slight damage shall be combined into damage; the houses shall be basically intact.

(1) Basically intact (including intact): individual tile falling or wall crack of civil structure and stone concrete structure buildings; slight crack of non bearing components of brick and wood structure buildings.

(2) Damage: the non load-bearing components of civil structure and brick wood structure buildings, such as obvious cracks or serious cracks in the enclosure wall, or even partial collapse, common shuttle tiles or obvious falling tiles. It can be used after repair.

(3) Destruction: the two walls of civil structure and brick wood structure buildings collapse, the roof truss obviously inclines or collapses, and the roof collapses or completely collapses; most of the load-bearing members are seriously broken or damaged, and the structure is close to collapse. It is difficult or impossible to repair, (national standard of the people's Republic of China, 2011).

After the earthquake, the author conducted a field investigation in Shuanghe Town, and took aerial photos of Shuanghe town by UAV, and generated digital orthophoto model (DOM), digital surface model (DSM) and 3-D model. Through the on-the-spot sampling survey of Shuanghe town and the comprehensive analysis of DOM, DSM and 3-D model, it is found that about 90% of the buildings in Shuanghe town are brick concrete structures. The others are simple houses or frame structures.



Fig. 3a – The DOM of Shuanghe town

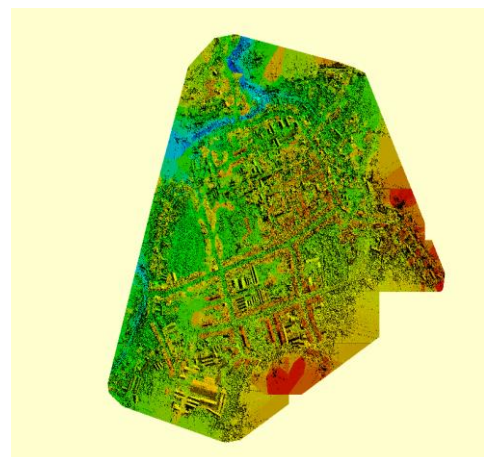


Fig. 3b– The DSM of Shuanghe town



Fig. 4 – The 3D model picture of Shuanghe town

3.2 Analysis of building damage in Shuanghe town

(1) Simple houses

Simple houses include civil structure building, brick and wood structure building and stone concrete structure building. The simple houses in Shuanghe town are mainly of brick and wood structure. Brick and wood structure buildings are mainly self-built houses of local residents. These houses are load-bearing with brick walls and wooden roof. There is no connection between the vertical and horizontal walls of the brick and wood structure buildings in the disaster area, and the masonry quality is poor. (Fig. 5-Fig.7).



Fig. 5 – Collapse of brick wall and roof of brick wood structure buildings in disaster area



Fig. 6 – The brick and wood buildings with obvious cracks in the wall



Fig. 7 – Destruction of brick and wood structure buildings in disaster area

(2) Brick concrete structure buildings

In this paper, about 90% of the buildings in the study area are brick concrete structures. Compared with simple buildings, brick concrete structures have certain seismic performance. However, because Shuanghe town is located in the epicenter of the earthquake, it is the most affected by the earthquake, so the brick concrete structures in the study area have suffered a certain damage, and the damage situation also has a great correlation with the building age. The newly built buildings' performance in this earthquake the house were better, through analysis, it is found that the brick and concrete structure buildings built in recent years show a trend of "half frame type", that is, the non-standard frame structure with brick wall and column beam bearing together. In this earthquake, the damage characteristics of brick concrete structure buildings are as follows: individual collapse, incline or partial collapse of brick concrete structure buildings, horizontal or "X" shaped cracks on a few bearing walls, dislocation of a few walls, obvious cracks on the walls between most doors, windows or window corners, wide cracks on the walls of some houses and completely through the walls (Fig. 8 – Fig.10).



Fig. 8 – "X" cracks of brick concrete structure building in disaster area

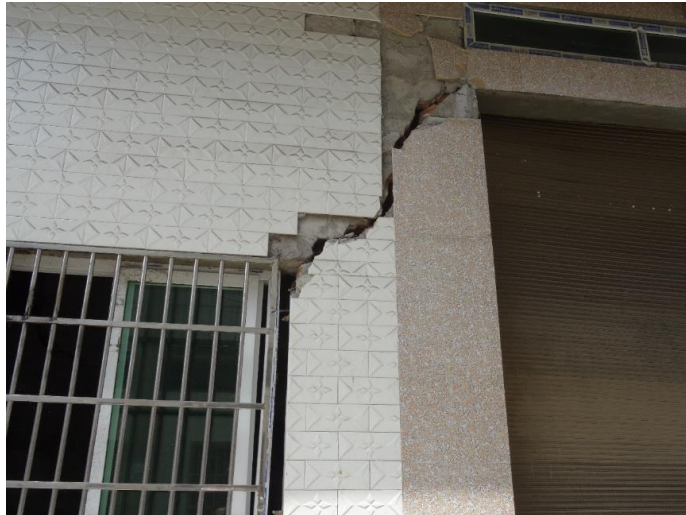


Fig. 9 –Cracks in the corners of brick concrete buildings in the disaster area



Fig. 10 –Displacement of brick concrete structure building wall in disaster area



(3) Frame structure buildings

Reinforced concrete frame structure buildings in Shuanghe town were mainly public buildings such as township government office buildings, hospitals and schools, and a few were self-built house by local residents. In this earthquake, the seismic performance of the frame structure was good, and there was basically no obvious damage. The damage phenomenon was that the wall skin of the non-bearing wall felt off. (Fig.11-Fig.12).



Fig. 11 –No damage in the earthquake of self-built frame structure buildings



Fig. 12 –The frame structure school buildings without obvious damage during earthquake

3.3 Analysis on the causes of earthquake damage to buildings

(1) Simple houses: This type of building is limited by the material characteristics that the strength of the wall is low and the rigidity is large, it is very easy to damage under the earthquake action. [3]

(2) Brick concrete structure buildings: This is the main type of local buildings. This type of buildings are easy to crack and fall off under the action of earthquake, it's mainly because the building material of brick concrete structure is brittle and its overall performance is poor, and its longitudinal wall bearing capacity is insufficient.

(3) Frame structure buildings: The frame structure buildings went by reasonable design have good aseismic performance and no obvious damage in this earthquake.



4. Earthquake geological disaster in Shuanghe town

The M6.0 earthquake of Changning City in Sichuan Province was large and the disaster area was also wide, however the earthquake didn't cause large-scale surface deformation or rupture. The main geological disasters in the study area were collapses, and landslides caused by heavy rainfall after the earthquake etc. (Fig.13-Fig.14).



Fig. 13 –Landslide caused by earthquake in disaster area



Fig. 14 –Collapses caused by earthquake in disaster area

5. Conclusion

Changning 6.0 earthquake in Sichuan Province is the largest earthquake with magnitude within 50km from the epicentre since 1900. The maximum intensity of this earthquake has reached VIII degrees. After the earthquake, heavy rainfall occurred at the epicentre area, resulting in secondary disasters such as landslides. After the earthquake, the author went to Shuanghe Town, the epicentre area, and made a field investigation, found that the local buildings damage caused by the earthquake was very typical. So the author analysed the housing construction disaster and the earthquake geological disaster through various technical methods and combined with the local geographical conditions, hoping to provide experience for the earthquake emergency work in the future.



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7. References

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