The Characteristic and earthquake Damage of single-storey industry workshop of Mianzhu city in WenChuan Earthquake

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ABSTRACT :

A strong earthquake of M8.0 occurred at 14:28 on May 12, 2008(local time) in WenChuan County of Sichuan Province (north latitude 31.0°, longitude 103.4°). The intensity of epicenter reached Ⅺ degree. Six province or city including Sichuan, Gansu, Shangxi, Chongqing, YunNan and NingXia suffered vary extent damage by the earthquake. Wenchuan earthquake was the strongest in China since 1949 and the seismic disaster is particularly serious. Until at 12:00 on July 15, 2008, Wenchuan earthquake has caused 69,197 deaths and 374,176 injuries, 18,263 missing.

The characteristic and earthquake damage of single-storey industrial buildings of Mianzhu City are specially introduced in this paper. General classification of industry building in affected area includes single-storey brick column workshop, single-storey reinforced concrete column workshop and single-storey steel column workshop. And the typical earthquake damage of buildings is analyzed. The earthquake damage shows the industry buildings that well anti-earthquake designed are damaged more slightly than those without anti-earthquake designed.

KEYWORDS: earthquake damage, single-storey industry workshop, Wenchuan earthquake,

1. INTRODUCTION

A strong earthquake of M8.0 occurred at 14:28 on May 12, 2008(local time) in WenChuan County of Sichuan Province (north latitude 31.0°, longitude 103.4°). The intensity of epicenter reached Ⅺ degree. Six province or city including Sichuan, Gansu, Shangxi, Chongqing, YunNan and NingXia suffered vary extent damage by the earthquake. Wenchuan earthquake was the strongest in China since 1949 and the seismic disaster is particularly serious. Until at 12:00 on July 15, 2008, Wenchuan earthquake has caused 69,197 deaths, 374,176 injuries and 18,209 missing. Figure 1 shows the epicenter of Wenchuan earthquake.

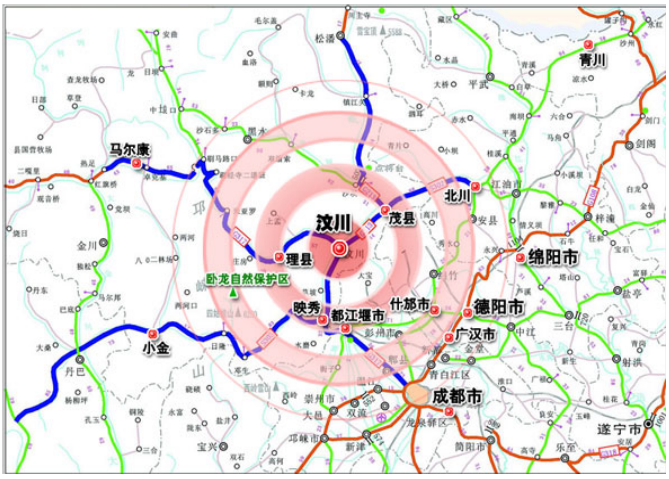

Figure 1 the epicenter of Wenchuan earthquake

Mianzhu City locates in the northwest of Sichuan Basin and locates east longitude 103°54'-104°20', north latitude 30°09'-31°42'. Its dimensionality area is 1245.3 square kilometers. Mianzhu city's precinct includes 19 towns and 2 rural towns. The total population is 520,000. The distance from Chengdu is 83 km and that from Mianyang is 74 km. This earthquake caused Mianzhu 11,117 death, 38,000 injuries and 258 missing in Mianzhu city.

The surrounding industrial buildings of Mianzhu City include single-storey brick column workshop, single-storey reinforced concrete column workshop and single-storey steel column workshop. A number of 20 workshops are investigated, which include 13 workshops of single-storey brick column, 6 workshops of single-storey reinforced concrete column and 1 workshops of single-storey steel column. Overall, the steel column plants are intact in Ⅷ intensity; the reinforced concrete workshops are medium damage in Ⅸ intensity; the single-storey brick column workshops are mostly medium damage in Ⅷ intensity. The characteristics of three categories industrial plants and earthquake damage level are introduced by following.

2. THE EARTHQUAKE DAMAGE SITUATION OF INDUSTRY WORKSHOPS

The industry buildings of Mianzhu city were investigated by sampling investigation and key investigation methods. The total area of the investigated buildings was more than 21,427.74 m^2. The surrounding industrial buildings of Mianzhu City include single-storey brick column workshop, single-storey reinforced concrete column workshop and single-storey steel column workshop. And the damage degree of each building was identified. The table 1 shows the damage situation of single-storey industry workshops in Mianzhu city. Table 2 illustrates the characteristics and earthquake damage level of industrial plants.

Table 1 the damage situation of single-storey industry workshops in Mianzhu city

intensity	Structure category	intactness	Slight damage	Medium damage	Severe damage	Collapse
Ⅷ	Brick column	3	2	5	-	-
Ⅸ	Reinforced concrete column	-	-	4	-	-
Ⅸ	Brick column	-	-	2	1	-

Table 2 the characteristics and earthquake damage level of industrial plants

Name	Structure general situation			Intensity	Damage level
	Column type	The section of column (mm)	Roof type		
Jufeng edible fungi development corporation in Mianzhu city.(No.1)	Concrete column core and brick outer column	side: 380×380 interior: 500×600	Light steel room-frame, Tile roof	Ⅷ	Medium damage
Jufeng edible fungi development corporation in Mianzhu city. (No.2)	Concrete column core and brick outer column	650×500	Light steel room-frame, Asbestic tile roof	Ⅷ	Medium damage
Jufeng edible fungi development corporation in Mianzhu city. (No.3)	Brick column	500×370	Light steel room-frame	Ⅷ	Medium damage
Jufeng edible fungi development corporation in Mianzhu city. (No.4)	Brick column	370×370	Wooden roof truss	Ⅷ	Slight damage

Jufeng edible fungi development corporation in Mianzhu city. (No.5)	Brick column	500×500	Wooden roof truss	Ⅷ	Slight damage
Jufeng edible fungi development corporation in Mianzhu city. (No.6)	Brick column	500×370	Light steel room-frame	Ⅷ	Medium damage
Yuan sheng porcelain industry	Brick column	740×600	Wooden roof truss	Ⅸ	Medium damage
Mianzhu marble factory (No.1)	Brick column	500×500	Wooden roof truss, Tile roof	Ⅸ	Severe damage
Mianzhu marble factory (No.2)	Brick column	490×490	Wooden roof truss	Ⅸ	Medium damage
Mianzhu City Xiting Packing Co., Ltd. (No.1 and 4)	Reinforced concrete column	700×500	Precast reinforced concrete roof truss	Ⅸ	Medium damage
Mianzhu City Xiting Packing Co., Ltd. (No.2)	Reinforced concrete column	700×500	Precast reinforced concrete roof truss	Ⅸ	Medium damage
Mianzhu City Xiting Packing Co., Ltd. (No.3)	Reinforced concrete column	700×500	Precast reinforced concrete roof truss	Ⅸ	Medium damage
Hung-sen Glass Co., Ltd. in Mianzhu City (No.1 and 2)	Side :brick column middle :steel column	530×530	Light steel room-frame	Ⅷ	intactness
Hung-sen Glass Co., Ltd. in Mianzhu City (No.3)	Brick column	500×500	Light steel room-frame, Asbestic tile roof	Ⅷ	intactness
Hung-sen Glass Co., Ltd. in Mianzhu City (No.4)	Brick column	500×500	Light steel room-frame	Ⅷ	Medium damage
Hung-sen Glass Co., Ltd. in Mianzhu City (No.5 and 6)	Side : Reinforced concrete column middle :steel column	500×500	Light steel room-frame	Ⅷ	intactness
Hung-sen Glass Co., Ltd. in Mianzhu City (No.7)	Steel column (I-section)	900×450	Light steel room-frame	Ⅷ	intactness

3. THE ANALYSIS OF TYPICAL EARTHQUAKE DAMAGE

3.1 The number 1 Workshop of Jufeng Edible Fungi Development Corporation in Mianzhu City.

It is three-span industry workshop. The column core is concrete and outer column is brick. The section of side

column is 380 mm × 380mm and the section of interior column is 500mm × 600mm; the span is 4m, the heights of columns are 4m and 6m respectively. With 14 frames, the distance of column is 4m. So the length of this workshop is 56m. The enclosure wall is brick wall. This workshop's roof is Light steel room-frame with tile roof and there is the diagonal brace between roof-frame. After the earthquake, the horizontal circular cracks occurred in the bottom of interior brick columns.

The cause of damage: 1) Since the column is reinforced concrete interior and brick outer, outsourcing bricks are easily broken and scattered, then the slenderness ratio of member is increased and the bending capacity of column will be decreased. 2) The bending strength of brick column is weak and the deformation capacity is low, so the horizontal cracks occurred in the brick column likely when the building is subjected to a higher seismic intensity.

Figure 2 the whole building of Jufeng Edible Fungi workshop

Figure 3 he local earthquake damage

3.2 Yuan sheng porcelain industry

Yuan sheng porcelain industry is single-span brick column workshop with the section of740 mm ×600mm. The span is 15m and the height of column is 4.4m. With 5 frames, the distance of column is 6m, so the whole length is 30m. The enclosure wall is brick wall. This workshop's roof is wooden roof truss and there is diagonal brace between roof-frame. The purlin is on gable wall and there are ring beam and wind resistant pillars. After earthquake, the top of goalpost destroyed and individual roof slab fell. And the diagonal cracks appeared in the joint between purlin and gable wall.

Figure 4 the whole building of Yuan sheng porcelain industry

Figure 5 he local earthquake damage

3.3 The number 1 workshop of Mianzhu marble factory

This building is single span brick column workshop with the section of 500mm × 500mm. The span is 14.8m and the height of column is 4.5m; With 8 frames, the distance of column is 3.7m, so the whole length is 29.6m.

The enclosure wall is brick wall. This workshop's roof is wooden frame with tile roof and there is diagonal brace between roof-frame. The purlin is on gable wall and there are no ring beam but with wind resistant pillar. After earthquake, the gable wall is out plane damage. And the top of side column destroyed and there is transparent vertical crack. The middle of column at the gate broke. The intercross crack appeared in the front longitudinal wall. Most of column broke at the height of window table-board and inclined inside.

The cause of damage: 1) Purlin is simply shelved in the gable wall, and there is lack of effective connection measures between the roof and the top of gable wall. The gable wall is the backward and forward swing like the cantilever beam when the building is subjected to earthquake, and then the damage outer plane occurred. 2) The thick of the surface mortar and cement of the column below the window is about 1 cm. Thus it leads to abrupt change in stiffness and uneven stiffness between the upper and the lower.

Figure 6 the whole building of Mianzhu marble factory

Figure 7 the local earthquake damage

3.4 The number 3 workshop of Mianzhu City Xiting Packing Co., Ltd.

This building is single span reinforced concrete column workshop with the section of 700mm × 500mm. The span is 23m and the height of column is 7.5m; With 17 frames, the distance of column is 5.5m, so the whole length is 93.5m. The enclosure wall is brick wall. The building's roof is precast reinforced concrete roof frame with colored steel sheet roof. There are ring beam and wind resistant pillar. There is column bracings and braces between roof frames. After earthquake, local roof trusses fell. Most of the top of longitudinal walls fell outside. And the rain platform broke and fell. The space of expansion joint changed large.

The cause of damage: 1) there are weak connection between the reinforced concrete column and roof frame, the longitudinal wall and roof frame. 2) The precast reinforced concrete roof frame is heavy, so the earthquake force to which the building is subjected is large.

Figure 8 the whole building of Xiting Packing Co.

Figure 9 the local earthquake damage

3.5 The number 7 workshop of Hung-sen Glass Co., Ltd. in Mianzhu City

This building is two-storey steel workshop. The seismic design intensity is 7 degree. The column is I-section steel column and the cross-section is 900mm × 450mm. The span is 27.2m; the height of the first floor is 4.9m and that of the second floor is 12.5m. With 7 frames and the distance of the column is 6.3m, so the whole length is 44.1m for two-storey section. However, with 8 frames the whole length is 50.4m for one-storey section. This workshop's roof is Light steel room-frame and there is the diagonal brace between roof-frame. After the earthquake, the building is intactness.

Figure 10 the whole building of Hung-sen Glass Co.

Figure 11 the local earthquake damage

4 CONCLUSION

In this paper, the Characteristic and earthquake Damage of single-storey industry workshop of Mianzhu city are introduced in WenChuan Earthquake. The following summary contains the characteristics of building damage:

(1) The buildings well anti-earthquake designed are damaged more slightly than those without anti-earthquake designed;

(2) The seismic performance of the steel column is more superior to that of the brick column.

(3) The earthquake damage of brick column building was mainly in the bottom of middle column and the gable wall.

(4) The earthquake damage degree is closely related to many factors such as roof type, strength grade of masonry, the quality of construction, the situation of using and maintenance, etc.

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