

RECONNAISSANCE REPORT OF 0512 CHINA WENCHUAN EARTHQUAKE ON SCHOOLS, HOSPITALS AND RESIDENTIAL BUILDINGS

Chiun-lin Wu¹, Juin-Fu Chai², Chu-Chieh Jay Lin¹, and Fan-Ru Lin³

¹ Associate Research Fellow, Center for Research on Earthquake Engineering (NCEE), Taipei,
Chinese Taiwan

² Research Fellow, Center for Research on Earthquake Engineering (NCEE), Taipei, Chinese Taiwan

³ Assistant Research Fellow, Center for Research on Earthquake Engineering (NCEE), Taipei,
Chinese Taiwan

Email: clwu@ncee.org.tw, chai@ncee.org.tw, jaylin@ncee.org.tw, frlin@ncee.org.tw

ABSTRACT :

On May 12, 2008 at 14:28 local time, an M_s 8.0 earthquake struck the Sichuan Province, China. Millions of houses were destroyed and damaged, leaving approximately 4.5 million people homeless. The government reported around 69,200 dead (18,000 still missing) and 374,000 injured. Right after the earthquake, civil engineers and search and rescue team from Taiwan headed for the affected region to provide immediate assistance. It is sincerely hoped that the reconnaissance information shared herein could help the affected communities in making a safer society in the future.

KEYWORDS: Wenchuan earthquake, reconnaissance, building damages

1. INTRODUCTION

On May 12, 2008 at 14:28 local time, an M_s 8.0 earthquake struck the Sichuan Province, China. Millions of houses were destroyed and damaged, leaving approximately 4.5 million people homeless. The government reported around 69,200 dead (18,000 still missing) and 374,000 injured. Following the earthquake, the civil engineers of Taiwan immediately dispatched a team to the affected region on May 27th to collect information about structural and geotechnical damages as well as to provide helpful information for seismic assessment, retrofitting and rebuild planning. We may be the first reconnaissance team to reach the damaged area nearest to the epicenter to survey the schools, hospitals, residential buildings, landslides and bridges. Since then, several reconnaissance teams from Taiwan visited the area of Chengdu, Dujiangyan, Pongzhou, Xiaoyudong, Mianzhu, Zhiulong, Wudu, Hanwang, Bailu, Hsuanko, Xanzhao, Yingxiu (epicenter) and Highway 213. More than 5000 photos were taken to document the damages this catastrophic earthquake had made. This information should help us in preparation of disaster mitigation plan. This paper will focus on the failures and damages on different types of building structures. We would also like to take this opportunity to express our deepest sympathies and condolences to the people of China and to the families of the victims for the loss of life and destruction caused by the earthquake. It is sincerely hoped that the reconnaissance information shared herein could help the affected communities in making a safer society in the future.

2. FIELD OBSERVATIONS ON BUILDING DAMAGES

The observations of building damages in the affected region consist of schools, hospitals, commercial and residential buildings. There are three major structural types commonly seen in the affected area, i.e., reinforced concrete (RC), unreinforced masonry (URM) and brick (masonry) buildings. The URM buildings are a unique structural system which consists of vulnerable brick columns, reinforced concrete beams, and precast concrete hollow floor planks with wire mesh as seen from the collapse photograph (Figure 1) taken at the affected region. Most of the public buildings are constructed using

RC and URM systems, while most of the residential houses and school classrooms were made of URM with four or five stories and bricks with only one or two stories.



Figure 1 Photographical close-up view of the collapsed Employee Dormitory of the 3rd People's Hospital at Hanwang township, Mianzhu County after earthquake.

2.1. School and Commercial-Residential Buildings

A significant number of casualties and injuries in the rural areas were associated with the total collapse of the URM and masonry buildings. Figures 2-3 show the collapsed buildings of an elementary school at Dujiangyan. Photographs also show failure and damage of commercial-residential buildings at Dujiangyan (Figures 4-9), Yingxiu (Figures 10-11), and traditional houses at Mianzhu township (Figures 12-13). Since there are no ductile structural elements in the URM and masonry buildings to resist the lateral force caused by earthquakes, it seems that structural collapse and undesirable consequences of human life losses and injuries are inevitable during a severe seismic event.



Figure 2 Collapse of elementary school buildings at Dujiangyan.



Figure 3 Collapse of elementary school building at Dujiangyan.



Figure 4



Figure 5



Figure 6



Figure 7



Figure 8 Collapse of commercial-residential buildings at Dujiangyan.



Figure 9 Partial collapse of commercial-residential buildings at Dujiangyan.



Figure 10 Soft story collapse of residential buildings at Yingxiu.



Figure 11 Collapse of residential buildings at Yingxiu.



Figure 12 The black clay roof damage and wall cracking of a traditional house at Mianzhu.



Figure 13 Collapse of traditional houses at Mianzhu.

There are also engineered RC buildings that sustained severe damage or collapse, e.g., buildings of Hsuanko High School at Yingxiu Township, Wenchuan county near the earthquake epicenter as shown in Figures 14-23.



Figure 14 Total collapse of school building.



Figure 15 Severe diagonal shear cracks on the gravity wall between window openings.



Figure 16 Severe damage of school building.



Figure 17 Pancake type of failure due to weak columns.



Figure 18 Collapse of school buildings.



Figure 19 Building collapse due to joint failure.



Figure 20 Column failure due to insufficient transverse reinforcement.



Figure 21 Soft story collapse.



Figure 22 RC beam and nonstructural partition wall failure in the classroom.



Figure 23 Column failure due to insufficient transverse reinforcement.

2.2. Hospitals

Figures 24-25 show the collapsed buildings of the 3rd People's Hospital at Hanwang township, Mianzhu County. Unfortunately, these four-story URM buildings collapsed during the earthquake hit, and they were not able to operate with normal function to rescue the injured and save lives right after this natural catastrophe.



Figure 24 Collapsed Employee Dormitory of the 3rd People's Hospital at Hanwang township, Mianzhu County after major aftershocks.



Figure 25 Building collapse of the 3rd People's Hospital at Hanwang township, Mianzhu County.

2.3. Factory and Tower Structures

Figures 26-28 show the damaged factories and Figures 29-32 show the undamaged towers and chimneys in the earthquake affected region. The towers and chimneys may have a lower natural frequency than dominant frequency content of the seismic waveforms, which may have helped survive high accelerations. Figure 33 shows a clock tower, on which the time stopped at 14:28pm when the earthquake hit Hanwang township.



Figure 26



Figure 27



Figure 28



Figure 29

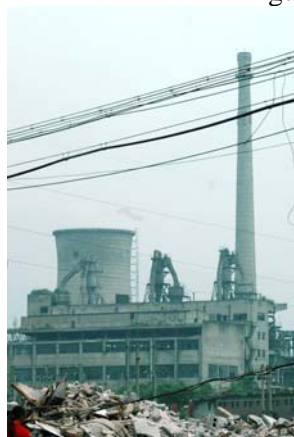


Figure 30



Figure 31



Figure 32



Figure 33

3. OBSERVATIONS ON RESPONSE AND RECOVERY

Immediately after the earthquake, more than 100,000 China Army, police, fire fighters and civilian volunteers from other provinces came to Sichuan to join the rescue forces. Three days later, international rescue teams joined the missions and saved thousands of lives together. The central Chinese government allocated billions RMB budget for immediate relief and rescue efforts. Loads of construction materials, water, foods and medical supplies were transported to quake-hit regions to help massive recovery task. The damaged roads to the mountainous regions were immediately repaired, and made accessible for emergency transportation. Figure 34 shows the people lined up waiting for reliefs, and Figure 35 shows the farmers working on the rice field in affected zone right after the earthquake. Figure 36 shows emergency tents at the refuge area.



Figure 34 People waiting in line for water and food supplies.



Figure 35 Farmers working in rice field right after the quake.



Figure 36 Emergency tents at the refuge area.

There are around 5 million people left homeless by the earthquake. Therefore, China's Ministry of Housing and Urban-Rural Development called on local authorities to build 1.5 million temporary homes (shelters) with 20m² each for 3 persons. Figure 37 shows the trucks from other provinces delivering construction materials to Sichuan to build temporary homes. Figure 38 shows the material for building temporary houses pile up next to the tents. Figure 39 shows the community of finished temporary houses at Dujiangyan and Figure 40 shows the temporary houses under construction near Pongzhou. These houses will accommodate quake refugees for 3 years during the post-quake restoration of the city.



Figure 37 Transportation of construction materials through highways to affected area.



Figure 38 Construction materials delivered to earthquake affected area.



Figure 39 Community of finished temporary houses at Dujiangyan.



Figure 40 Temporary houses under construction near Pongzhou.

4. CONCLUDING REMARKS

Earthquakes are part of human life in earthquake prone regions, and there is no way to get rid of them but we can learn how to survive earthquakes with better odds from past experience through updated science and engineering knowledge as well as state-of-the-art technologies. Here are the preliminary conclusive remarks the NCREE reconnaissance team have learned from the Wenchuan earthquake, even though the picture is by no means comprehensive:

- (1) The high seismic risk of older type or non-engineered building collapse can be considerably reduced through proper retrofitting schemes and past experience worldwide in using such schemes.
- (2) The existing requirements for seismic design forces in the code are lower than the demands observed from the Wenchuan earthquake. Through upgrading the code, new buildings will be able to perform better in severe earthquake events in the future.
- (3) The design and construction practice in the earthquake affected areas indicates a lack of seismic detail, which should be avoided in the future.
- (4) Earthquake awareness and preparedness in the general public, especially schools, should be raised to a new level after the earthquake.
- (5) Post-quake restoration is a long term multidisciplinary task, including rehabilitation and repair of a large number of existing buildings, recovery of communities that were heavily damaged or even completely demolished during the earthquake, and timely comfort of severely suffered minds as well.
- (6) The post-quake restoration requires not only a tremendous amount of monetary budget but efficient integrative administration from governmental sectors as well in order to help refugees in the affected areas back to their normal life as early as possible.

ACKNOWLEDGEMENTS

We gratefully acknowledge Sichuan Association for Science and Technology (SCAST), and Sichuan branch of the Taiwan Affairs Office of the State Council, China for their kindness and enormous help when the team conducted earthquake reconnaissance investigation.