Urban Building Damages in Sichuan Earthquake and Seismic Design Countermeasures in Reconstruction

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Summary

The May 12, 2008 Wenchuan earthquake in China was a mega earthquake with a magnitude of MW 8.0. This paper firstly presents a summary of the observations of building damages in the event. The causes inducing eight types of building damages are analyzed. The main reason lies that the earthquake ground motion is extremely larger than expected and most of the collapsed building did not have minimum seismic capacity. By now, the post-quake reconstruction of the region has been performed over one year. The seismic countermeasures in the reconstruction are proposed herein and have been applied into two engineering cases. One seriously-damaged primary school in Dujiangyan City was retrofitted by applying structural control concept. The analytical results shows, it is convenient to avoid heavy strengthening work and easy to meet performance objectives of reconstruction. The sustainable material (timber) was used to build another primary school in the city, which will be put into use in the fall semester of 2009.

Keywords: Wenchuan earthquake; building damage; reconstruction; structural control; sustainable material

1. Introduction

On May 12, 2008 a magnitude of MW 8.0 earthquake hit Wenchuan in China, at 14:28 local time. The earthquake had a shallow focal depth of approximately 19 km, with the epicentre located 80km WNW of Chengdu, capital of Sichuan province. The nation was devastated by the mega earthquake.
This paper presents a summary of the observations of building damages and analyzes the causes inducing those damages. By now, the post-quake reconstruction of the earthquake-hit region has been performed over one year. The seismic countermeasures in the reconstruction are proposed in the paper and have been applied into two engineering cases.

2. Building damages analysis

The team investigated the earthquake-hit region shocked to find that, lots of buildings were severely damaged and even collapsed after the shock of Wenchuan Earthquake.
1) The main reason of building damages is that the earthquake ground motion is extremely larger than expected. Another important reason is that most of the collapsed building did not have minimum seismic capacity. 2) Those buildings, well designed, constructed and occupied according to the 2001-version of Chinese Seismic Codes have good earthquake resistant capacity and behavior. 3) Man-made misused buildings, such as infilling masonry balcony walls, destroying structural walls, changing original doors and windows, were seriously damaged. 4) Roof extruded stories seriously damaged and even collapsed in the earthquake. In Chinese code, the seismic design forces of those stories are set to

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be three times of the analytical results to consider the whiplash effect. We have to reconsider the code requirement not only about the design force, but the structural details. 5) It is verified again, the buildings with irregular plan and elevation layouts damaged more seriously than that with regular structures. 6) For masonry buildings with large space, the number of force-bearing walls is less and thus they cracked more severely than those having more walls. That is also the reason why many school buildings collapsed and students died in the Wenchuan earthquake. Another damage phenomenon needs to be noted. Walls below the windows (although they have RC beams above and below) play the role of energy dissipation. 7) We also find that the connection between different material structural members seriously damaged. 8) The concept design of strong-column-and-weak-beam was reproduced in a few cases but most of damages happened in the pattern of strong-beam-and-weak-column.

3. Seismic countermeasures for reconstruction

After the field investigation of building damages, following seismic countermeasures are proposed to the government for the post-quake reconstruction.

1) Under the condition that little progress has been made in the earthquake warning and prediction system, it is necessary to reasonably set seismic protection intensity to ensure the earthquake-resistant capability of buildings. 2) District planning should be carried out to choose favourable construction site and avoid site susceptible to the geologic disaster. 3) Engineers in rural areas should learn more knowledge of the seismic concept and structural design to ensure the structural safety in the future. 4) The government should enforce the supervision and administration of the implementation of design and construction codes to make sure of the construction quality. 5) The seismic protection, especially seismic measures, of large span/space buildings should be appropriately improved. The seismic safety grade of very important structural members should also be enhanced. 6) Advanced technologies should be used to reduce the seismic disasters of building structures, such as base-isolation, energy dissipation and active and hybrid structural control. 7) Sustainable development material, which is of good seismic resistance as well as environmental friendly, can also be put into the use of reconstruction.

4. Two cases using seismic countermeasures for reconstruction

The first case is a seriously-damaged school building retrofitted by applying structural control concept, while the second is a new-built one constructed by sustainable material. Both engineering practices confirm the importance of adopting advanced earthquake-resistant technologies for the design of structures in seismic regions.

Fig. 1 Elevation of the damaged Primary School Fig. 2 Construction of the retrofitting damper bracings

Fig. 3 Damaged building of Xiang'e Primary School Fig. 4 Construction of New Xiang'e Primary School