

Quick reconnaissance report on May 12, 2008 Wenchuan Earthquake

By Yan XIAO

Professor Xiao is an expert in earthquake design and retrofit of buildings and bridges. His research collaborated with other experts have been used in retrofitting the vast numbers of bridges in California and elsewhere. He also conducted many in-situ earthquake reconnaissance investigations, including the 1994 Northridge earthquake, the 1995 Kobe earthquake and the 1999 Turkey Izmit earthquake, etc. He is a professor of the Department of Civil Engineering, University of Southern California, and also the supervisory dean of the Civil Engineering College, Hunan University, China, where he directs the Ministry of Education Key Laboratory of Building Safety and Efficiency.

He organized a team of the Ministry of Education Key Laboratory of Building Safety and Efficiency to tour parts of the affected area, immediately after arrival to China on the evening of the May 13th. He and his team members covered Beichuan, Mianyang, Dujiangyang, Deyang, Guangan, Mianzhu, etc.

The followings are some of my comments about this extreme event:

Incompatibility between the economy development and safety

It is fair to say that the economy development does not always imply the increase of the capability of a society in resisting natural and manmade disasters. The potential loss due to these disasters may even increase corresponding to the fast economy development. Developing countries should particularly pay more attentions towards the balanced development.

Open flow of information is key in emergency response:

I am quite impressed by the emergency response in the aftermath of the Beichuan earthquake. The Chinese media kept a quite open flow of the information about the disaster. This helps stabilize the society after the disaster.

Concepts of earthquake design practices

The Chinese design code adopts the widely used concept of designing structures to “allow no damage in small earthquakes; repairable damage in medium earthquakes; and no collapse in a large earthquake.” Earthquake is a powerful natural force, it is unlikely nor economical to design all structures to perform without damage in an extreme event. However, significant effort should be made to prevent the total collapse of a structure, to avoid the loss of life. Despite the fact that these well know concepts are followed in the design codes in China, unfortunately, many buildings did not perform well in this earthquake.

Low seismic design intensity

In Chinese seismic design code, the earthquake force or risk is assessed based on design intensity, ranging from 6 to 9, which roughly compared with the US seismic zones 1 to 4. There is no need for seismic design if the area or region is set as having an intensity of 5 or below. Most of the affected areas by the May 12 Wenchuan earthquake are areas having specified design intensity 6 to 7, for example, the Wenchuan country, where the epicenter was located and the most damaged town Beichuan all have a design intensity of 7.0. Buildings designed and built, even strictly according to the design codes, are pretty much difficult to survive in an earthquake which essentially generated probably much higher intensity in most of the above mentioned affected areas. Therefore, it is not surprised to see so many and so widely spread damage and failure of the buildings.

Rely on ductility

Despite the mismatch of the design intensity and the actual intensity, there is still some hope if the buildings are (were) well designed with good design details to achieve a so called ductile design, which can essentially prevent a building from total collapse, or make it to “collapse slowly” so the people inside can have some time to escape. This is called ductility. With good ductility a building can sway back and forth in a strong earthquake without collapse. To ensure the ductility one has to make sure not the longitudinal bars but also the transverse bars well designed and detailed in columns, beams and beam to column joints. The transverse reinforcement is particularly important to confine the concrete and keep the longitudinal bars in place.

From the reconnaissance of the earthquake damage, it is clear that most of the damaged concrete building columns, and beam to column joints did not have proper transverse reinforcement.

As repeatedly seen in many previous disastrous earthquakes, brick masonry buildings performed extremely poorly in this earthquake. In addition, the use of precast hollow-core slabs without securely joining them together to form an integrated slab is extremely dangerous, like time bombs.

Poor quality of construction?

Sure, a lot of evidence can be seen, for example, missing rebars, misplacement of rebars in concrete columns, etc.

School buildings

The building design in China is categorized into 4 category, 1~4, with 1 as important buildings. For the categories 1 and 2 buildings, the design intensity needs to be increase to the higher level from the one specified for the area. School buildings are essentially category 3, meaning ordinary importance. For category 3 buildings the design intensity is the same as that specified for the area. I think the importance

category of school buildings should be increase in future.

Many things can be learnt from this disaster

- 1- Geological damage in this earthquake might be the most severe one compared with recorded earthquakes.
- 2- There are many newly designed and constructed highway, railway bridges, roads, dams, tunnels and buildings affected by this disaster. Their performances during the May 12 Wenchuan earthquake are valuable information to study earthquakes and to improve future seismic design codes throughout the world.



Collapsed arch bridge



Collapsed building in Dujiangyan



Dangerous and slow process in recovering the damaged mountain highway



Mountain slope failure in Beichuan



Poor design with too many longitudinal bars but little transverse bars



Student volunteers at the Southwest University of Science and Technology in Mianyang kept spirit high despite sleeping in the poor tents (see below)



Sleeping students at the Southwest University of Science and Technology in Mianyang