NICEE - IIT KANPUR RECONNAISSANCE SURVEY OF THE 2015 GORKHA (NEPAL) EARTHQUAKE OF APRIL 25, 2015

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Civil Engineering faculty and students of IIT Kanpur, *Durgesh C Rai*, *Vaibhav Singhal*, *Bhushan Raj S* and *S Lalit Sagar* undertook a reconnaissance survey of the earthquake affected regions during May 3 to May 8, 2015 and visited major towns in Bihar (India) and Nepal.

EARTHQUAKE AND ITS SEISMOLOGICAL SETTING

The M7.8 earthquake of April 25, 2015 struck at 11:41 am IST with its epicenter located in Gorkha district (28.15°N 84.7°E) in the central Nepal, about 80 km NW of the capital Kathmandu. It was a shallow focus event (depth 15 km), which was felt in India, Nepal, Bhutan, Bangladesh and China. In Nepal, this earthquake caused unprecedented loss of life and devastation. The worst effected regions are Kathmandu, Bhaktapur, Nuwakot, Sindhupalchok, Dhading and Gorkha. Strong aftershocks of magnitude 6.6 and 6.7 were also felt within a day of the main shock. A large part of the northern India, especially eastern UP, Bihar and north Bengal, also experienced intense shaking during this earthquake. Total deaths were reported as 7,913 in Nepal, 80 in India, 25 in China and 4 in Bangladesh.

The April 25, 2015 earthquake occurred as the result of thrust faulting on or near the main thrust interface between the Indian plate and the Eurasian plate. This boundary region has a history of large and great earthquakes. Four events of larger than M6 have occurred within 250 km of this earthquake over the past century. The largest, M8.0 event known as the 1934 Nepal-Bihar earthquake caused widespread damage in Kathmandu and Bihar, and caused around 10,000 fatalities. During this 1934 event intensity X (Mercalli scale) shaking from Motihari through Sitamarhi to Madhubani in Bihar caused extensive liquefaction in 128 km long and 30 km wide area (slump belt) which left most of the buildings totally collapsed in these regions.

GENERAL OBSERVATIONS AND SHAKING INTENSITIES

General damage to buildings and other structures agreed well with the intensity of ground shaking observed at various places, with the maximum of IX at Kathmandu, Nepal; VIII at Bhaktapur and Lalitpur, Nepal; and VI in and around Sitamarhi, Bihar on MSK scale. Relief efforts in the affected areas have been seriously hampered by the difficult terrain. The immediate requirement was to provide temporary shelter along with medicine, food, blankets, etc. for survivors, before these areas become further inaccessible due to approaching rainy season.

PERFORMANCE OF STRUCTURES

It was rather perplexing to discover that a great majority of buildings seriously lacked earthquake-resistant features which are so essential for a satisfactory seismic performance in the design level shaking. Most of the RC buildings in Kathmandu suffered varying degree of damage, from moderate to complete collapse during this earthquake. Many unique and inherently poor construction features significantly added to the seismic vulnerability of structures. These features include weak and very slender partition walls in brick masonry, extended floor plans in upper stories supported on cantilevered beams and slabs, open ground storey, poor beam-column connection details, large vertical and horizontal plan irregularity, etc. Fig. 1 shows typical example of collapsed multi-story buildings in Kathmandu. In older town of Bhaktapur, several old unreinforced masonry buildings which were still used as residential structures suffered maximum damage due to their deteriorated strength over the years (Fig. 2).

The poor earthquake performance of cultural heritage such as temples and palaces is a source of concern as almost all historic structures suffered varying degree of damages in this earthquake. The exterior walls of these temples are constructed of clay brick or stone masonry while the interior building frame and floor diaphragm is constructed of timber. Heavy damages have been observed to several temples and monuments at Kathmandu and Bhaktapur (Fig. 3).

In India, since the intensity of shaking was small (less than VI) even poorly built structures did escape serious damage during this event, however, damages were reported in *kaccha* houses in Sitamarhi district in north Bihar, about 3 such houses were completely collapsed and 142 were partially collapsed. Damage and partial collapse of free standing masonry walls have been reported in Bihar and UP. Most of the RC-frame buildings in affected regions in Bihar are not constructed as per the Indian code of practice and have many deficiencies as observed in buildings at Kathmandu. Thus the building stock in Bihar is highly vulnerable under expected shaking intensity of IX for a design level earthquake of Indian seismic zone V. This region had already witnessed a Mercalli shaking intensity of X during 1934 Nepal-Bihar earthquake which caused widespread damage in north Bihar districts. Civic authorities in these areas in spite of being aware of the presence of unacceptable level of seismic risk appear to have no risk mitigation strategies.

CLOSURE

The damage to built environment, economic loss and human casualties caused by Himalayan earthquakes are increasing rather proportionally with the growth of settlements and population. The general pattern of damage to structures, landslides, etc. is consistent with the shaking associated with the M7.8 event. Cultural heritage structures being old and weak were deficient in strength and thus suffered maximum damage. The temples and heritage structures which survived this event needs to be safeguarded against future tremors. Despite the available knowledge base, it is unfortunate that society is not adequately prepared due to lack of implementation and, therefore, the seismic risk in the region capable of large earthquakes has risen to unacceptable levels which may lead to a large-scale disaster, if not mitigated.

Fig. 1. Collapse of multi-storey buildings in Kathmandu

Fig. 2. Collapsed unreinforced masonry buildings atBhaktapur

Fig. 3. Severe damages to temples and palaces in Durbar square at Kathmandu

For favour of inclusion in your esteemed publication.

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