NICEE@IIT KANPUR RECONNAISSANCE SURVEY OF THE 2016 IMPHAL EARTHQUAKE OF JANUARY 04, 2016

National Information Center of Earthquake Engineering
Indian Institute of Technology Kanpur, India

Prof. Durgesh C Rai (IIT Kanpur), *Dr. Hemant B Kaushik (IIT Guwahati)* and *Dr. Vaibhav Singhal (IIT Patna)* undertook a reconnaissance survey of the earthquake affected regions during January 14 to January 17, 2016 and visited Imphal and adjoining areas.

EARTHQUAKE AND ITS SEISMOLOGICAL SETTING

The M6.7 earthquake of January 4, 2016 struck at 04:35 am IST with its epicenter located in the Tamenglong district (24.83°N 93.66°E) of Manipur about 30 km west of the state capital Imphal. The earthquake was strongly felt in all northeastern states of India, Bangladesh and Myanmar. The worst affected regions are Imphal, Tamenglong, Noney and Thoubal. A few aftershocks of magnitude less than 4.0 were also felt within a day of the main shock. A part of the north-east India, especially Assam, Nagaland and Mizoram also experienced intense shaking during this earthquake. Eight people have been reported to die in India and five in Bangladesh, and nearly 200 people were injured.

The earthquake occurred as a result of strike-slip faulting in the plate boundary region between the Indian and the Eurasian plate. This boundary region has a history of experiencing large and great earthquakes: 19 earthquakes of magnitude larger than 6 have occurred within 250 km of this earthquake over the past century. The largest event was M8.0 in 1946 on the Sagaing fault about 220 km to the southeast of the 2016 earthquake. Another event of M7.5 in January 1869, (Cachar earthquake) caused widespread damage in Imphal City. Other nearby damaging events include a M7.3 earthquake 150 km to the east of the 2016 event in the Indo-Burma region in August 1988, and a M6.0 earthquake 90 km to the southwest in December 1984 causing several fatalities and injuries (Source: USGS).

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 VI at Imphal and Tamenglong in Manipur on MSK scale. However, unexpected severe damage at an intensity of VI in Imphal was observed in buildings, such as, residential apartments of central agriculture university at Lamphelpat, a 3-storey building in Keishampat (Fig. 1), New Market and Laxmi Market in Imphal (Fig. 2), and a 4-storey building in Dewlahland.

PERFORMANCE OF STRUCTURES

Even though, the Indian standard code for seismic design, IS 1893:2002, has identified the northeastern part of India, including Imphal City, as the zone of most severe seismic hazard (i.e., zone V), 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. Several RC buildings in Imphal suffered varying degree of damage, from minor to complete collapse, during this earthquake. In such earthquake prone areas, the built structures should comply with the code of practice, however, lack of enforcement of existing regulations and negligence during construction explain such damage in the region. In contrast to the poor performance of RC buildings, the traditional constructions made using bamboo/wood and *Assam*-type performed satisfactorily during this earthquake.

It was surprising to observe that publicly funded buildings, which are supposedly designed and constructed properly under strict technical supervision, also performed poorly. For example, damage to two new buildings, New Market and Laxmi Market, in women's Ima Keithel Market Complex left large number of vendors without facilities to conduct their business (Fig. 2). Inter State Bus Terminal (ISBT), government polytechnic building (Fig. 3), and staff quarters in the complex of Sport Authority of India (Fig. 4) and Central Agriculture University are some of the government construction that were expected to perform satisfactorily during the earthquake but experienced moderate to severe damages, in some cases even before occupation.

Inherent poor construction features significantly added to the seismic vulnerability of structures. These features include weak and 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. 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 M6.7 event, except a few dramatic building failures/collapses due to faulty design and construction practices lacking earthquake resistant features. Traditional construction like *Assam* type houses performed well as expected and needs to be reinstated. 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 a 3-storey building in Keishampat, Imphal

Fig. 2. Damage to RC columns in Laxmi Market, Imphal

Fig. 3. Collapse of clock tower in Government Polytechnic building in Takheypat ,Imphal

Fig. 4. Damaged staff quarter in the complex of Sport Authority of India (SAI), Imphal

For favour of inclusion in your esteemed publication.

Prof. Durgesh C Rai
Co-ordinator
National Information Center of Earthquake Engineering
Indian Institute of Technology Kanpur
Phone: 0512 2597717, Fax: 0512 2597794, Email: nicee@iitk.ac.in