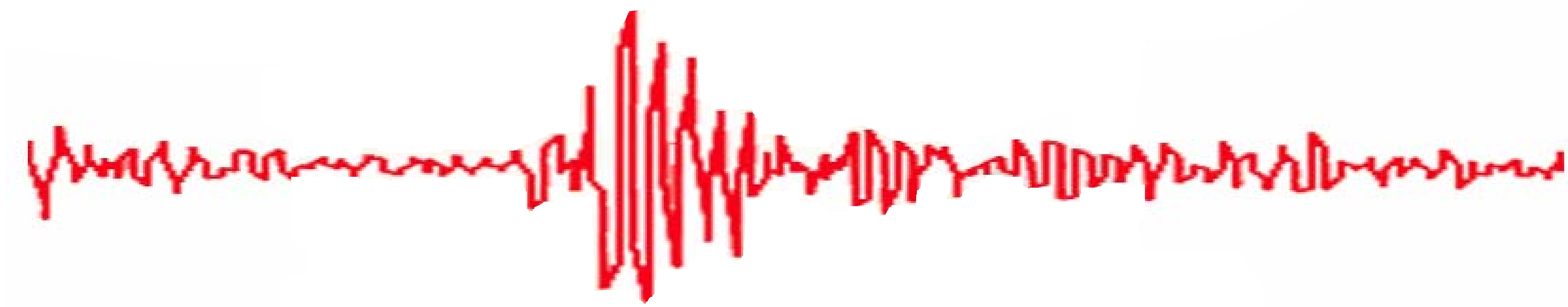
National Information Center on Earthquake Engineering

2015 GORKHA (NEPAL) EARTHQUAKE

Effects on Built Environment & A Perspective on Growing Seismic Risk in Bihar-Nepal Region



Team members:

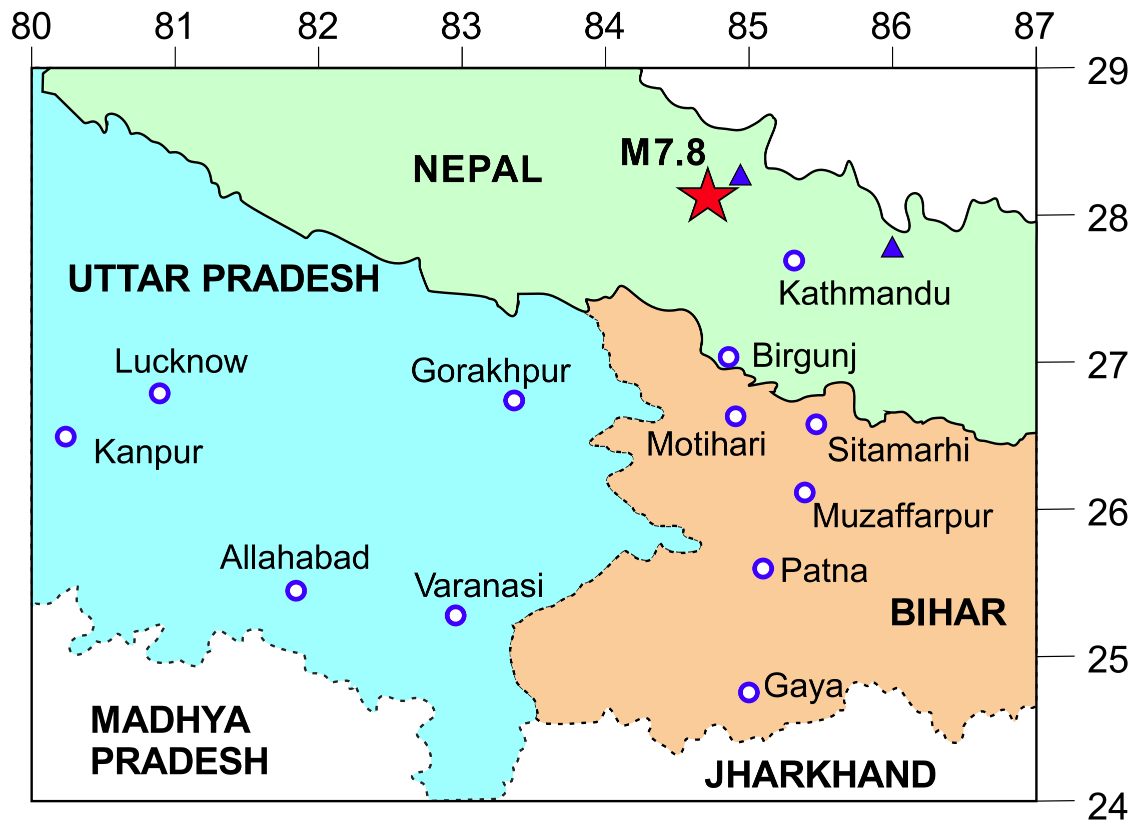
Durgesh C. Rai, Vaibhav Singhal,
S Lalit Sagar, Bhushan Raj S

Department of Civil Engineering, Indian Institute of Technology Kanpur

2015 Gorkha (Nepal) Earthquake

The M7.8 earthquake struck Nepal on 25th April 2015 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.

Two major aftershocks of M6.6 and M6.7 were also felt within the next two days of the earthquake.

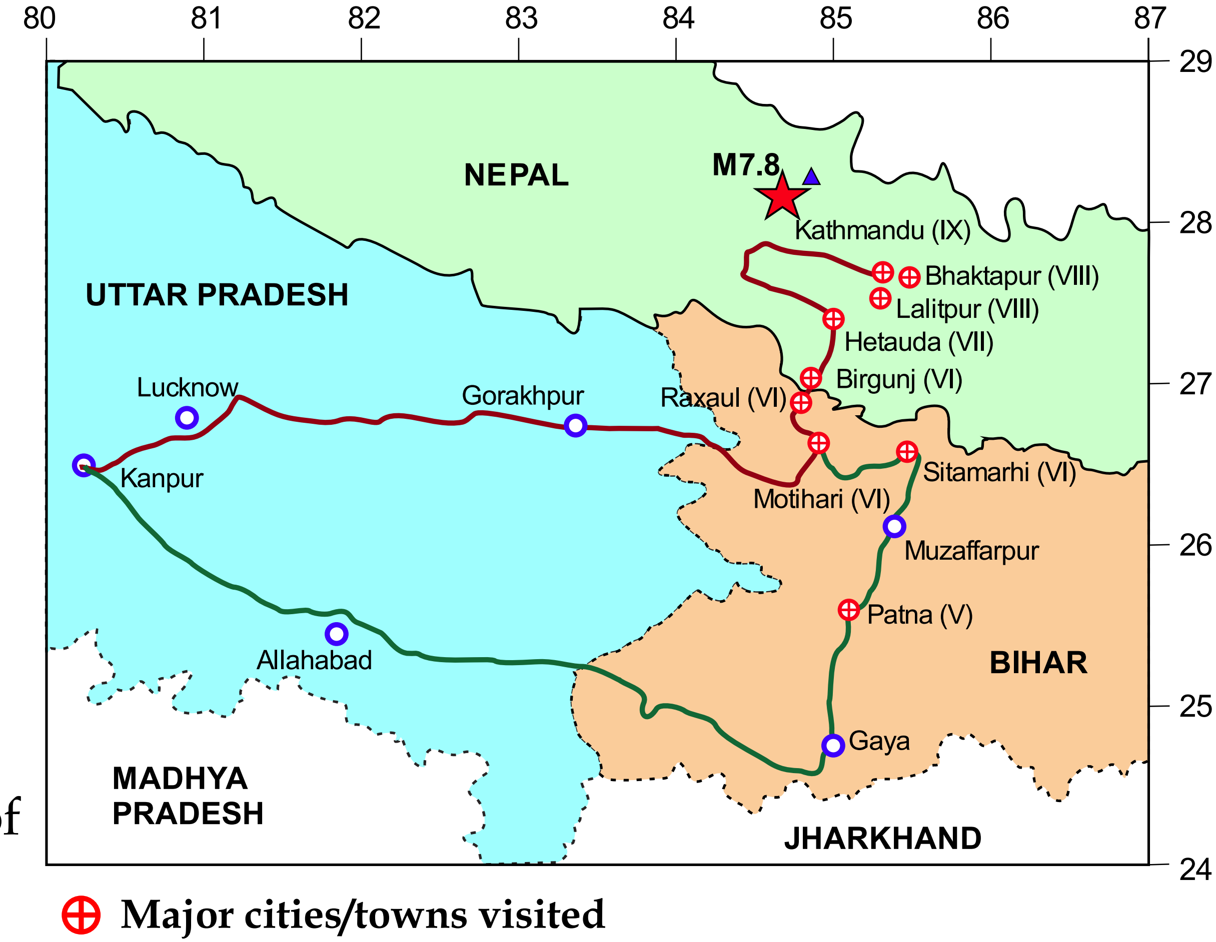


2015 Gorkha (Nepal) Earthquake…

The team visited several affected cities and towns of Central Nepal and North Bihar such as Kathmandu, Bhaktapur, Lalitpur, Motihari and Sitamarhi.

The maximum observed shaking intensity during this earthquake was IX in MSK scale.

About 8020 deaths were reported of which 7913 were from Nepal, 78 from India, 25 in China and 4 from Bangladesh. Also, about 18950 people were reported to be injured.



Geological Hazards

Landslide on road to Kathmandu, Nepal

Vertical movement of ground which resulted in severe damages to roads

Performance of Unreinforced Masonry (URM) Buildings

Complete collapse of 50~60 year old URM buildings in Nikoshera (Bhaktapur, Nepal)

Old unreinforced masonry buildings suffered maximum damage during the earthquake due to their deteriorated strength over the years and the absence of concrete members aggravated the level of damage. However, the adjacent RC buildings suffered only minor damage.

Performance of Unreinforced Masonry (URM) Buildings…

Out-of-plane failure of the wall and step-type diagonal cracks

Severe damage to the walls due to the absence of lintel band around openings

The old masonry buildings suffered partial to complete collapse due to the inadequate lateral strength of the masonry walls and the poor connection between the wall and diaphragm.

Performance of Unreinforced Masonry (URM) Buildings…

Cracks were formed at the corners of the masonry wall making it vulnerable to collapse under out-of-plane shaking

In most of the URM buildings, the structure lost integrity after formation of cracks at the corners of the wall making it highly vulnerable to out-of-plane collapse

Performance of Unreinforced Masonry Buildings in India

School building in Motihari, Bihar
(Photo: PTI)

Masonry house in Madhubani, Bihar
(Photo: PTI)

Some areas of North Bihar experienced a shaking intensity of VI and below. 3 poorly built *kaccha* houses were completely collapsed and 142 buildings were partially damaged.

Performance of Reinforced Concrete (RC) Buildings

Pancake collapse of four storey building in Kathmandu, Nepal

Collapse of buildings highlighted the structural deficiencies in the RC buildings of the affected region. This includes poor reinforcement detailing, faulty construction practices, poor quality of construction materials and so on.

Performance of Reinforced Concrete (RC) Buildings…

Open ground storey failure of 5 storey building in Kathmandu, Nepal

Some RC buildings the ground storey is left open without infill walls for utility purposes such as parking. This practice makes the ground storey weak with respect to the upper storeys leading to a mechanism known as the weak storey collapse.

Collapse of intermediate weak storey in buildings of Kathmandu, Nepal

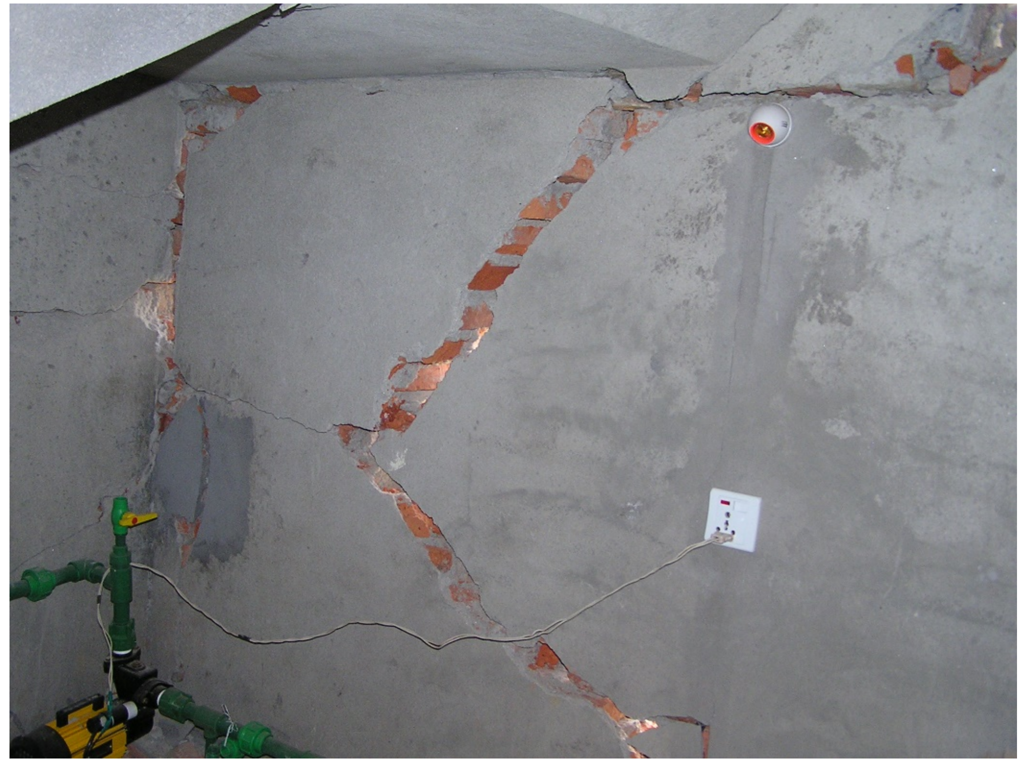
A number of buildings collapsed during the earthquake due to faulty construction practices such as absence of adequate walls led to formation of weak storey mechanism.

Performance of Reinforced Concrete (RC) Buildings…

Collapsed buildings having poor geometric configuration (Too long in one direction)

Performance of Reinforced Concrete (RC) Buildings…

Diagonal cracks in the wall due to lack of confining RC band around openings



Half-brick thick infill walls severely damaged in a building in Kathmandu

The RC buildings that were partially destructed had inadequate reinforcement and masonry walls were projecting beyond the columns.

Performance of Reinforced Concrete (RC) Buildings…

No RC band around opening

No columns at the corners of building plan

Performance of Tall RC Buildings

16 storey apartment building in Patan

Diagonal cracks in the infill walls of high-rise buildings

Combined in-plane and out-of-plane failure of infill wall

Infill walls were severely damaged in tall RC buildings

Poor construction practices in RC Buildings

Poor geometric configuration (Too long in one direction)

Poor construction practices in RC Buildings…

Due to the extension of masonry wall beyond column line, the columns supporting the projection will be overstressed and the outer wall will also susceptible to damage due to lesser stiffness.

Box type construction: Extension of wall beyond column line

Free Standing Structures

Damage to most of the freestanding structures in and around Kathmandu and some parts of North Bihar was observed

Heritage Structures

Most of the temples were built in pagoda style, having timber frames and brick masonry walls. The walls were of random rubble masonry core and dressed with brick masonry.

The roofs were supported by timber struts and the connection between the wall and the frame was made using timber hooks.

Performance of Heritage Structures

Image: *Corbis Ian Trower*

Dharahara Tower

Performance of Heritage Structures…

Durbar Square in Sundhara

Image: Andrej Pauš

Performance of Heritage Structures…

Temples in Bhaktapur Durbar Square

Performance of Heritage Structures…

Sway of timber frame and masonry collapse of Temple in Lalitpur

Performance of Heritage Structures…

Failure of Pagoda Structures

Summary of Earthquake Effects

- The M7.8 event lead to a widespread devastation with significant number of fatalities and huge loss to property.
- Significant damage was observed in the 50~60 year old unreinforced masonry buildings because of inadequate lateral strength.
- Well constructed reinforced concrete (RC) buildings performed in a relatively better way with minor damages. However, dramatic collapse of some RC structures can be attributed to open ground storey, poor geometric configuration of buildings, poor reinforcement detailing in structural members, etc.
- The damage to the RC buildings was aggravated due to the construction of buildings on filled-up lands, use of half-brick thick infill walls and extension of walls beyond column line.
- The cultural heritage structures, being old and weak were unable to resist the seismic forces and were damaged seriously.
- Landslides were observed, and vertical movement of soil lead to damage of roads and pedestrian bridges at some places.

Closing Remarks

- The damage to built environment, economic loss and human casualties caused by Himalayan earthquakes are increasing rather proportionally with the growth of settlement and population.
- Despite the available knowledge base, the communities in high seismic regions such as Nepal and neighbouring Indian states are not adequately prepared due to lack of implementation of earthquake-resistant building technology. However, with adherence to seismic codes and recommended construction practices, it is possible to mitigate such large-scale disasters.
- NICEE @ IITK has several resources available at its website *www.nicee.org* for seismic risk mitigation of built-environment.

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