Seismic Damage Assessment of Everest and Annapurna Regions

Executive summary (Preliminary)

The main trekking routes of the Everest and Annapurna regions were assessed for seismic damage that occurred as a result of the April and May 2015 earthquakes. Two assessment teams were dispatched from June 25 to July 2 2015 to these regions. The teams were comprised of expert structural engineers, geotechnical engineers, mountain guides and trekking operators. Rapid visual damage assessment per ATC20 and Department of Urban Development and Building Construction (DUDBC) guideline were conducted. Overall current structural and geotechnical earthquake-related damage and trekking safety was assessed. Recommendations on repairs, risk mitigation and commercial readiness strategies were developed.

The Everest region

Buildings and bridges along the main trekking route between Lukla and Gorka Shep were assessed for earthquake damage. A total of 15 villages with a total of approximately 710 buildings including accommodation and residential buildings were assessed in the region.

Typical accommodation construction types included uncut stone with mortar, cut rectangular block stone with or without cement mortar. Older construction typically used mud as mortar and it was found that newer construction used cement.

Out of approximately 710 buildings, structurally concerning earthquake damage was observed in 120 buildings (17 percent). 83 percent of buildings can be given a green-tag per ATC-20/DUDBC guidelines. It was found that most of the buildings that were damaged can be repaired feasibly. Building owners have started reconstructing damaged buildings.

The nine major bridges that were assessed had no structural earthquake damage.

New geological/geotechnical damages as a result of the earthquake was not apparent in most villages. Significant rockfall occurred in Bengkar. New rockfall and debris flow features that affect the trekking route were observed between:

- Tok Tok and Bengkar
- Namche and Khumjung
- Chhuthawa and Phakding

More landslides and rockfalls are anticipated in the monsoon season as already weakened ground becomes saturated and fails. This may also be exacerbated by aftershocks. Outside these areas, the trail and villages are subject to existing geotechnical hazards. These hazards do not appear to have been significantly altered by the April and May 2015 earthquakes.

The Annapurna region

The Annapurna region building and bridge damage assessment included the Annapurna Circuit Trek area from Bhulbhele to Birethanti and the Annapurna Sanctuary Trek area from Pothana to Annapurna Base Camp. A total of 30 villages with a total of approximately 250 accommodation buildings were assessed in the Annapurna region.

Typical accommodation construction types included uncut stone with mortar, cut rectangular block stone with or without cement mortar, wood stick frame and concrete beam/column frame construction with stone infill walls. Mud was used as mortar in older construction types and largely only newer construction used cement.

Out of approximately 250 buildings assessed, structurally concerning earthquake damage was noticed at six hotels (2 percent). 98 percent of buildings can be given a green-tag per ATC-20/DUDBC guidelines. Overall there is very little structural damage in the Annapurna region. Buildings damaged can be repaired relatively easily.

Bridges assessed had no structural earthquake damage. One bridge located approximately one half of a mile north of Chame had existing soil erosion concern where edge of river bank is approaching the bridge abutment.

New geological/geotechnical damage from the earthquakes was not apparent in most villages visited. Some increase of rockfall hazard may exist above Tatopani, Bamboo and Deurali to Annpurna Base Camp, Debris slide above the Birethanti area, and potential failure to dam rivers around Dharepani. For Kimrung to Taglung, there is ongoing rockfall from high wall, track within 2 meters at the top.

Isolated rockfall and landslide features that affect the trails and villages appear to have been triggered by the earthquakes, and are typically reactivation of, or ongoing movement of existing features. Further landsliding and rockfall could reasonably be expected during the monsoon is typical for the area.

Outside these areas, the trail and villages are subject to existing geotechnical hazards. These hazards do not appear to have been significantly altered by the April and May 2015 earthquakes.

Conclusions and Recommendations

Majority of accommodations and trails are undamaged. Many of damaged accommodation structures are being repaired. Three major soil and rock hazard areas were identified along the Everest region's main trail and one high hazard area in Annapurna was observed. Diverted trails need to be defined for these four locations.

The Everest Region

- The owners are repairing and reconstructing accommodation buildings. They act as a general contractors. Owners and construction workers require engineering support and training for the latest building technique to build back better.
- Owners are also facing severe shortage in cement, rebar and labor. Supply chain needs to be facilitated.
- Three trail locations need to be diverted to avoid rock fall hazards. There are existing old trails in these areas to facilitate this.

- Signage for potential hazard areas is critical to make trekkers aware of risks.
- Post monsoon technical assessment is required.

The Annapurna Region

- Standard post-monsoon maintenance assessment for pre-exist geo hazard should be conducted
- Potential slope hazard for some villages should be assessed.
- One trail location needs to be diverted to avoid erosion.
- Signage for potential hazard areas is critical to make trekkers aware of risks.