Damage from the april-may 2015 gorkha earthquake sequence in the Solukhumbu district (Everest region), Nepal

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ABSTRACT: Nepal assessments of landslides (including other mass movements of rock, snow and ice) as well as human impacts were conducted by many organizations immediately following the 25 April 2015 M7.8 Gorkha earthquake and its aftershock sequence. In particular, a NASA-led satellite mapping campaign identified over 4,300 coseismic and post-seismic landslides throughout Nepal, largely concentrated in the “steep-dropped northern tectonic block” well north of Kathmandu in the Greater Himalaya (Kargel et al., 2016). The Solukhumbu District lies at the eastern margin of this zone, near the epicenter of the 12 May 2015 M7.3 aftershock. Given the enormous cultural and economic value of the Khumbu region to Nepal, we conducted two post-monsoon ground assessments of geomorphic and structural damage in the fall of 2015, and a third ground assessment of rebuilding efforts in May, 2016. While landslides and other mass movements were not as extensive as those to the west, numerous landslides and slumps were identified, mostly on steep, convex-up, east-facing slopes where the dip of metamorphic foliation (Namche orthogneiss and related rock) is towards the Dudh Kosi River channel. Also, building damage was more extensive where villages were located on terraces of unconsolidated sand and gravel perched above the Dudh Kosi River (Nakchun Village). The area upstream from Phakding experienced several co-seismic mass movements on steep slopes that had clearly failed before (previously tremors?), as evidenced by old vegetated slump blocks and steep, unstable hummocky terrain. Particularly hard-hit was the Sherpa village of Thame northwest of Namche Bazaar, constructed on unconsolidated, water-saturated glacial outwash between two lateral moraines at the mouth of the Thame Khola Valley. Aside from Thame, one is struck by the randomness of structural damage in many Sherpa villages, reflecting micro-ground conditions beneath buildings and the style and/or age of construction (dry-stacked fieldstone versus the use of mud or cement mortar, the presence of wire mesh or galion bands/spacers within stone walls, etc.). Fresh valley-flank slumps and landslides were markedly less obvious further north (towards Everest) where wide glacial valleys exist, although evidence of large rock falls and other mass movements in the past is clearly present.

Valley profile convexity:

Earthquake-triggered mass movements (past & recent):

Traditional and new construction methods:

Spectrum of structural damage:

Rebuilding the Khumbu: