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High resolution measurement of earthquake impacts on rock slope stability and damage using pre- and post-earthquake terrestrial laser scans

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Understanding the behaviour of rock slopes in response to earthquake shaking is instrumental in response and relief efforts following large earthquakes as well as to ongoing risk management in earthquake affected areas. Assessment of the effects of seismic shaking on rock slope kinematics requires detailed surveys of the pre- and post-earthquake condition of the slope; however, at present, there is a lack of high resolution monitoring data from pre- and post-earthquake to facilitate characterization of seismically induced slope damage and validate models used to back-analyze rock slope behaviour during and following earthquake shaking. Therefore, there is a need for additional research where pre- and post- earthquake monitoring data is available.

This paper presents the results of a direct comparison between terrestrial laser scans (TLS) collected in 2014, the year prior to the 2015 earthquake sequence, with that collected 18 months after the earthquakes and two monsoon cycles. The two datasets were collected using Riegl VZ-1000 and VZ-4000 full waveform laser scanners with high resolution (c. 0.1 m point spacing as a minimum). The scans cover the full landslide affected slope from the toe to the crest.

The slope is located in Sindhupalchok District, Central Nepal which experienced some of the highest co-seismic and post-seismic landslide intensities across Nepal due to the proximity to the epicenters (<20 km) of both of the main aftershocks on April 26, 2015 (M 6.7) and May 12, 2015 (M7.3). During the 2015 earthquakes and subsequent 2015 and 2016 monsoons, the slope experienced rockfall and debris flows which are evident in satellite imagery and field photographs. Fracturing of the rock mass associated with the seismic shaking is also evident at scales not accessible through satellite and field observations.

The results of change detection between the TLS datasets with an emphasis on quantification of seismically-induced slope damage is presented. Patterns in the distribution and expression of rock mass damage are also explored. The findings presented herein provide insight into the response of rock slopes to seismic shaking and highlight the application of remote sensing to understand slope behaviour.