Geophysical Research Abstracts
Vol. 20, EGU2018-18689, 2018
EGU General Assembly 2018

Back-analyses of a co-seismic landslide and a rockfall event using UAV-enabled mapping

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On November 17th 2015, a Mw 6.5 earthquake occurred in the island of Lefkada, Greece at a depth of 11 km. Coseismic landslides were mapped using satellite imagery collected shortly before and after the earthquake event. Higher-resolution landslide mapping also took place using an Unmanned Aerial Vehicle (UAV) equipped with an ultra-high definition optical camera. Using the UAV-based imagery, three dimensional models of the landslides were created.

The scope of this study was to determine the mechanical properties of the failed rock-mass by conducting a back analysis of a specific co-seismic landslide. The geometry of the ground surface before the earthquake was obtained from the Hellenic Cadastre, whereas the ground surface after the earthquake was obtained by UAV-enabled mapping in April 2016 and December 2017.

Three dimensional limit equilibrium analysis was performed using commercial software TSLOPE (Tagasoft Ltd) using ordinary method of slices and Spencer methods. For specific landslide locations, the ground surface before the earthquake and the (failed) slope surface are considered as pre-failure and post-failure surfaces respectively. A seismic load, equal to 0.5g was considered based on nearby strong motion recordings. The back-analyses resulted in a cohesion-friction angle (c-φ) envelope, which is used to characterize the strength of the failed rockmass.

Kinematic back-analysis was also performed for a rock block mobilized during the earthquake, which impacted one structure and killed a person inside the building. A detailed survey was conducted using an Unmanned Aerial Vehicle (UAV) with an ultra-high definition (UHD) camera, which produced a high-resolution orthophoto and a Digital Elevation Model (DEM) of the terrain. The sequence of impact marks from the rock trajectory on the ground surface was identified from the orthophoto and verified in the field. Using the impact points from the measured rockfall trajectory, an analytical reconstruction of the trajectory was developed.

It was concluded that it was impossible to replicate the actual trajectory of the rockfall by performing a 2-D rockfall analysis, indicating limitations in the present formulations of rockfall propagation. Using 3-D analysis software, namely Rockyfor3D (Ecorisq) and recommended input parameters, rock trajectories better approximated the actual trajectory,indicating that the 3-D analysis can be more accurate than the 2-D analysis.