Geophysical Research Abstracts
Vol. 16, EGU2014-8536, 2014
EGU General Assembly 2014

Dynamic behaviour of quartzo-feldspathic loess slopes in the Canterbury Port Hills, Christchurch, New Zealand

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Evidence from New Zealand and elsewhere indicates that thick loess materials are highly susceptible to failure in earthquakes. After the 2010-11 Canterbury Earthquake sequence, 36 large landslides were mapped of which the majority were in fine grained loess deposits in the Canterbury Port Hills. Similar thick loess soil covers 10% of the land surface of the South Island of New Zealand and is also present within the southern part of the North Island. The wind-blown depositional characteristics result in sediments that can mantle steep rock slopes, and can stand in vertical faces.

Understanding the mechanisms and triggering conditions under which the loess failures develop, and the relative susceptibility of different loessial soils to failure, is essential in assessing future earthquake-induced landslide risk. In general, investigation of the susceptibility of fine-grained soils to failure in earthquakes has hitherto concentrated on modelling approaches. In most cases, failure potential is determined as a critical ground acceleration threshold above which movement occurs through sliding of a soil block on the slope. Whilst such approaches are widely used, limited empirical data sets are available to assess their suitability.

This study provides one of the first empirical datasets on the behaviour of loess soils during seismic events through a series of specialist dynamic back pressured shear-box tests on intact field samples collected from marginally-stable loess slopes in the Canterbury Port Hills. The tests were designed to replicate field conditions under different horizontal shaking characteristics. During each test, the strength reduction and excess pore pressures generated were measured as the sample underwent failure. The dynamic test results were analysed in relation to field mapping and site-monitoring data collected during the latter parts of the earthquake sequence.

The study provides new knowledge regarding the mechanisms of shear-surface development in fine grained soils and improves our understanding of these mechanisms using high-quality data obtained from the non-carbonate, quartzo-feldspthic loess in Canterbury. The study considers the suitability of existing modelling approaches and provides improved dynamic shear strength data to better inform future seismic hazard assessments.