Geophysical Research Abstracts
Vol. 18, EGU2016-5, 2016
EGU General Assembly 2016


# Quantifying rockfall risk on roads in the Port Hills, Christchurch, New Zealand

Stefan Unterrader and Sven Fuchs

University of Natural Resources and Life Sciences, Institute of Mountain Risk Engineering, Peter Jordan Str. 82, 1190 Vienna, Austria (sven.fuchs@boku.ac.at)

The Canterbury earthquake sequence starting on 22 September 2010 triggered widespread mass movements in the Port Hills area of Christchurch, the largest agglomeration of New Zealand's South Island. The MW 6.2 Christchurch earthquake of 22 February 2011 in particular generated the largest ground motions ever recorded in New Zealand and as a result initiated several thousands of rockfalls. Over 6,000 boulders were released and mapped shortly after the event. The risk from rockfall to residents in the Port Hills was quantitatively assessed by the regulatory authorities in order to develop an adjusted land zoning policy. Apart from damaging residential buildings many of these boulders also hit several road sections across the Port Hills. Due to the inherent differences between identifying hazard and risk to people in static structures and in moving objects, a recently carried out risk assessment of rockfall was limited to exposed properties. However, given the importance of local road infrastructure for commuter traffic, local risk management strategies would clearly benefit from quantifying the threat of boulders endangering traffic lines.

For this study, existing datasets describing the hazard including recently estimated frequency-magnitude bands for earthquakes and non-seismic triggering events, boulder production rates, boulder size distribution and associated run-out distances, were used. These data were provided by the Christchurch City Council's (CCC) GIS web service. A digital layer of the local road network as well as a detailed dataset of traffic counts was used for GIS analysis, and the probability of individuals being hit by boulders was calculated for each road segment that intersects one or more rockfall hazard zones. Finally, risk was computed.

The method applied follows a state-of-the-art approach in risk assessment which is generally based on the risk equation defining risk as the probability of occurrence of an event times the expected loss. More specifically, both the annual collective risk and individual risk of being hit by rockfalls on the Port Hills traffic lines were calculated. Both risk terms were assessed by drawing on a well-established method originally developed for evaluating snow avalanche risk on high-alpine pass roads. In order to reflect the discontinuous distribution of rockfall across the hazard zone (i.e. boulders will only hit certain points or follow one specific run-out path compared to the typical snow avalanche run-out behaviour) the original risk equation was adjusted. Hence, (1) the annual collective risk as well as the individual risk of being hit by rockfalls when travelling on the local road network was quantified, (2) the temporal dynamics of most susceptible elements at risk (i.e. commuter traffic) were identified and related dynamics in risk were assessed, and (3) the specific case of waiting traffic and the associated increase in fatality risk compared to moving traffic was computed.

The results of this study provide first insights in both the collective and individual rockfall fatality risk on important traffic lines across the Port Hills. Road sections that are most prone to rockfall hazard were clearly identified in high spatial resolution. Sensitivity analysis of main parameters showed that the decrease in seismic hazard expected over the next decades resulted in decreasing rockfall hazard and therefore decreasing fatality risk even if currently increasing traffic volumes will further rise. Furthermore, a closer look on the individual risk of commuters was addressing some of the challenges within the inherent static approach of the risk concept, namely the temporal dynamics in traffic flow. It was further shown that the main traffic line, Tunnel Road, is characterized by a strongly diurnal variability including two traffic peaks between 7 and 9 a.m. and around 5 to 6 p.m. Additionally, the influence of road blockage by boulders falling onto endangered road sections was also responsible for an increasing annual fatality risk of road users on most of the studied road sections. Several conceptual shortcomings in previous studies were addressing this issue, particularly with respect to simplifying assumptions repeatedly made during the risk computation. The results of this study highlight some of the most important aspects in this regard. Finally, the risk of being hit by rockfalls while travelling on the roads of the study area were compared to other risks faced (and tolerated) by the New Zealand citizens.

The spatio-temporal dynamics in rockfall risk across the Port Hills road network clearly had shown the inherent limitations of any static risk assessment. Fatality numbers in the Port Hills were low during the 22 February 2011

event because the earthquake hit around noon and it is shown that similar ground shaking intensities occurring during rush hour are likely to cause several fatalities on the main transportation lines. These risks are further increased as traffic jams are very likely to form after extensive road blockage. In addition, rockfall hitting critical infrastructure not only pose fatality risk to people travelling along these lines but also affect the ability of emergency response teams to safely assess parts of the area which otherwise would be cut off. This temporal aspect has yet to be incorporated into local risk management strategies. The clear identification of the road segments most prone to boulder hits can serve the authorities as decision support for any future mitigation works.