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Hazard assessment for rock slopes utilizing integrated remote sensing, failure mode assessment and event simulation

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Remote sensing techniques for mapping and characterising rock slope structure and stability have been evolving rapidly over the past decade. In this submission, we will describe the integrated work being conducted by the Geomechanics Research Group at Queen's University, which includes 6 years of data collection on active rock slopes in western Canada which are located adjacent to the main cross Canada railway corridor. This research is conducted as part of the Canadian Railway Ground Hazard Research Program.

A number of different remote sensing techniques have been employed, both to take advantage of new technologies and processing techniques, and to gain information from different data collection techniques and various vantage points, whether terrestrial or aerial. We have shown that data sets collected with different data density and accuracy can be combined to provide a more complete representation of the rock slope conditions, identification of potential hazardous slopes can be done from combined analysis of photographic images and aerial LiDAR data (Carter et al, 2018, this conference) and change detection between sequential data sets can be used to understand the temporal, seasonal and weather related rock slope deformation and failure. Similar work is being done to understand the behaviour, conditioning and triggering mechanisms for debris channels that transmit the failed rock to track level (Bonneau et al, 2018, this conference).

Utilizing data collected during more than 5 years of field work at these sites, we have been able to relate the geological conditions including lithology, structural configuration, slope geometry and aspect to the frequency and magnitude of the detected events (van Veen et al, 2017), which range in volume from 0.01 m^3 to the largest single event we have recorded of 3400 m^3. In many cases, slope movements have been detected months to years in advance of the ultimate failure (Kromer et al, 2017), and ongoing work is being done to forecast these events, including the detection of the failure mode as controlled by the bounding structures, and the expected mode of deformation and therefore limits of deformation before failure occurs by rotation and/or translation (Rowe et al, 2017). The current research work is focused on assessing the geometry and configuration of representative roughness surfaces for the various structures mapped from the remotely sensed data, in order to refine the analysis of rate and magnitude of deformation to improve forecasting and warning (Graham, 2018, this conference).

In some circumstances, the frequency of data collection is sufficiently high to permit identification of the location of rock detachment from the source zone, the impact points of the fragmenting rock block as it travels down the slope, and the location and distribution of the rock fragments collected at the slope base. Utilizing the Unity game engine, Zac Sala et al (2018, this conference), have been able to validate rockfall process simulations, and assess risk and mitigation strategies.