



A 3D Analysis of Rock Block Deformation and Failure Mechanics Using Terrestrial Laser Scanning

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Many natural geological hazards are present along the Thompson River corridor in British Columbia, Canada, including one particularly hazardous rocky slope known as the White Canyon. Railway tracks used by Canadian National (CN) and Canadian Pacific (CP) Railway companies pass through this area at the base of the Canyon slope. The geologically complex and weathered rock face exposed at White Canyon is prone to rockfalls. With a limited ditch capacity, these falling rocks have the potential to land on the tracks and therefore increase the risk of train derailment. Since 2012, terrestrial laser scanning (TLS) data has been collected at this site on a regular basis to enable researchers at Queen's University to study these rockfalls in greater detail. In this paper, the authors present a summary of an analysis of these TLS datasets including an examination of the pre-failure deformation patterns exhibited by failed rock blocks as well as an investigation into the influence of structural constraints on the pre-failure behavior of these blocks. Aligning rockfall source zones in an early point cloud dataset to a later dataset generates a transformation matrix describing the movement of the block from one scan to the next. This process was repeated such that the motion of the block over the entire TLS data coverage period was measured. A 3D roto-translation algorithm was then used to resolve the motion into translation and rotation components (Oppikofer et al. 2009; Kromer et al. 2015). Structural information was plotted on a stereonet for further analysis. A total of 111 rockfall events exceeding a volume of 1 m^3 were analyzed using this approach. The study reveals that although some rockfall source blocks do not exhibit detectable levels of deformation prior to failure, others do experience cm-level translation and rotation on the order of 1 to 6 degrees before detaching from the slope. Moreover, these movements may, in some cases, be related to the discontinuity planes on the slope that were confining the block. It is concluded that rock blocks in White Canyon may be classified as one of five main failure mechanisms based on their pre-failure deformation and structure: planar slide, topple, rotation, wedge, and overhang, with overhang failures representing a large portion of rockfalls in this area. Overhang rockfalls in the White Canyon are characterized by blocks that (a) are not supported by an underlying discontinuity plane, and (b) generally do not exhibit pre-failure deformation. Though overhanging rock blocks are a structural subset of toppling failure, their behavior suggests a different mechanism of detachment. Future work will further populate the present database of rockfalls in White Canyon and will expand the study to include other sites along this corridor. The ultimate goal of this research is to establish warning thresholds based on deformation magnitudes for rockfalls in White Canyon to assist Canadian railways in better understanding and managing these slopes.