Development of a New Method for Rockfall Analysis using Schmidt Hammer

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Schmidt hammer was invented by Schmidt (1951) for the purpose of examing the strength of concrete non-destructively, and it is now applied to the fields of rock engineering, rock mechanics, and geomorphology. Many studies using Schmidt hammers in the field of geomorphology have been carried out measuring the strength (or hardness) of rocks that characterize the terrain, especially for areas where it is difficult to collect rock samples for strength measurement in the laboratory. The Schimdt hammer method records large differences in the rebound values obtained by the Repeated Hit Method (RHM) and the Single Hit Method (SHM). The SHM measurement is preferable to construct an index of weathering degree of the surface layer (Matsukura et al. 2004) as repeated hits corrupt the original surface. As per present, most of the studies in geomorphology have been performed to understand the formation of landforms, such as moraines using the variability in rebounds values to infer differential weathering (for example, Winkler, 2016), but there to the authors knowledge, no work has been done to characterize rockfall triggering conditions and movement process yet.

For the survey of rockfall, geological features such as cracks, rock joins, the slope in the triggering area, the weathering patterns and level, and various other data need to be set, but many are based on qualitative criteria, which makes comparisons between sites difficult. A few quantitative methods exist however, such as the stability assessment of rock mass using hammering sound measurement (Kanbara et al. 2013) and vibration measurement with U-Doppler (Uehan et al. 2012). Nevertheless those studies remain very marginal and it is still necessary to develop further low-cost methods to evaluate the stability of rock masses on slopes and terrains difficult to access. Therefore, in this study, we attempted to evaluate the factors, estimated occurrence time, place of occurrence, and geomorphological environment of rockfall using Schmidt Hammer, UAV, and laser data, which are easy to carry because they are compact and lightweight and because they offer data from a comfortable remote position.

The survey was conducted at Gunbarrel-tributary in the Fox Glacier Valley, located on the west coast of New Zealand, using a single hit method for a giant bolder of 5 to 6 m. The data collected show differences in the Schmidt Hammer rebound values, which we could relate to the difference in the degree of weathering. On the newly broken side of the rock, the rebound value tended to be slightly higher than on the sides that were exposed to erosion for a longer period. Additionally, examining the pattern of weathering based on the Schmidt Hammer data, we can also infer that the rock was partly connected to a non-weathered bedrocks while half of it had been subjected to various weathering processes. This finding also allows us to discard a glacial origin. Indeed as half of the block did not show any weathering, we can infer that the rockfall comes from a late detachment from the bedrock. It was not deposited first by the glacier as an erratic block. Further refinement of the method is certainly needed, but the present results are encouraging.

Keywords: rockfall, Schmidt hammer, SfM, UAV