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Evaluating block shape and block volume distributions of rock faces using LiDAR and 3DEC

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The use of Light Detection And Ranging (LiDAR) has expanded rapidly since 1994, when it became commercially available[1]. The equipment mobility, as well as accuracy and rate of data collection, in comparison to conventional surveying and stereophotogrammetric methods, have enabled the application of LiDAR to traditionally unrelated fields of study. For instance, LiDAR is currently employed in applications from precise volumetric analysis in open pit mines[2] to archaeology projects in ancient ruins[3]. This abstract discusses a geotechnical engineering application of LiDAR which has relevance to rock cuts along infrastructure corridors and in open pit mines. The focus of this work is to determine the distribution of block size and block shape for a given rock cut, since each of these factors has crucial implications to the potential hazard at a specific location, should a failure occur. This work will provide geological input into hazard rating for Canadian National railroad tracks.

The process of resolving block shape and block volume distributions, is a four-step procedure. The process can be applied to any rock face that is controlled by visible and distinct discontinuities.

The first step is the collection of data. LiDAR data can be collected via aerial meth-

[1] Haneberg, W.C., Creighton, A.L., Medley, E.W., and Jonas, D.A., 2005, Use of LiDAR to assess slope hazards at the Lihir gold mine, Papua New Guinea, *in* O. Hungr, R. Fell, R. Couture, and E. Eberhardt, editors, *Landslide Risk Management*: Proceedings of International Conference on Landslide Risk Management, Vancouver, Canada, 31 May - 3 June, 2005

[2] Lamb, A.D., 2000, Earth observation technology applied to mining-related environmental issues. Mining Technology: Transactions of the Institute of Mining and Metallurgy, Section A, vol. 109, no. 3, pp. 153-156(4)

[3] Addison, A.C., Gaiani, M., 2000, Virtualized architectural heritage: new tools and techniques. *Multimedia, IEEE*, vol.7, no.2, pp.26-31

ods (fixed wing aircraft and helicopters), mobile terrestrial scanners (mounted in the bed of a pickup truck), and stationary terrestrial scanners (mounted on a tripod)[4]. The scanner must be properly aligned with respect to the discontinuities in the rock face to accurately estimate their orientation and spacing. A high resolution scan from a distance of roughly 10m has an accuracy of 12-15mm and takes between 18-25 minutes and will scan $\sim$30m^2. Optimal results are achieved when the scans are taken from mutually oblique alignments to the rockface. For the purpose of the exercise reported here, an Optech ILRIS stationary terrestrial scanner was used to collect the data. The data was collected 25km north of Kingston, Ontario, Canada.

The second step is the manipulation and "cleaning" of the raw point cloud data. Redundant data points and noise are selected and filtered to increase the visibility of zones of significance. This removal of noise allows the features of importance, such as joint surfaces to be readily recognized, identified and plotted.

The third step is the delineation of discontinuities and/or joint surfaces. Split-FX (Split Engineering) is a point cloud analysis program that enables the user to define surfaces based on mathematically derived variables. Surface orientation data are output to a stereonet plot. Joints are grouped into sets and the statistical average orientation is reported for each set. Joint spacing can also be statistically estimated; however, this process requires more intense user input.

The fourth and most demanding step is the numerical simulation of the rock face. Itasca's 3DEC code is used to generate a statistical representation of the scanned rock face based on the data delineated in Split-FX. The model will assume a flat faced outcrop with fully persistent joints. As the model is run, all failed blocks are documented and characterized using block shape and volume distribution graphs based on the approach developed by Kalenchuk et al (2006)[5]. This process quantifies the geometric distribution of discrete blocks within a failed mass.

The results of this work enable a more refined rock fall hazard assessment, wherein block shape and size are independent inputs. This will allow for more effective inclusion of rock mass parameters into rock fall hazard rating system developed by BGC[6] and employed by CN[6]. This process enables advanced geotechnical structural mapping of areas that were previously inaccessible or too hazardous to approach.

[4]Terrapoint, 2006, http://www.terrapoint.com/about/technology.html

[5]Kalenchuk, K.S., Diederichs, M.S. and McKinnon, S., Characterizing Block Geometry in Jointed Rockmasses. Int. J. Rock. Mech. Min. Sci. 43 (2006): pp 1212-1225

[6]Bruce Geotechnical Consultants Inc., 1997, Canadian National Railway Rockfall Hazard and Risk Assessment System. Field Implementation Manual