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KINETIC ENERGY DISSIPATION EFFECTS OF ROCK FALL ATTENUATING SYSTEMS

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INTRODUCTION ON ROCK FALL ATTENUATING SYSTEMS

Rock fall attenuator systems do not completely halt falling rocks but intercept rock fall trajectory, guiding it under a tail drape and dampening bounce heights (see Figs. 1). In this way there is the potential to dissipate large portions of the kinetic energy through barrier impacts deforming the netting and interaction with the slope during its transport to the base of slope (Badger et al., 2008). Application of rock fall attenuator systems are suited to regions of high frequency rock fall whereby cleaning and maintenance can be better managed. Or for situations where existing protection measures, such as rock galleries, do not meet the required energy level of rock fall hazard. Attenuator systems can be applied to dissipate the energy of rock fall to the design value of the existing installations or site specific design conditions.

Figs. 1 Catchment area of attenuating structure (left) and guided boulder along rock face (right)

It has become apparent that much of the energy dissipation capacity of these systems can be attributed to ground impacts, and the ability of the netting to redirect the rock boulder to ground contact. This highlights how these systems should be considered in combination with the underlying terrain as well as the expected rock fall hazard.

EVALUATION OF ATTENUATING EFFECT

In Figures 2 this redirection of the impacting rock block is demonstrated. We calculate the impact velocity from the moments before net contact indicated in red. This velocity is then used to extrapolate the theoretical trajectory of the test block if there where no netting in place. Through this we are able to perform a calculation of the kinetic energy dissipation effects of the rock fall attenuator system. Extrapolating the theoretical trajectory of the test block and applying a restitution coefficient where slope impact is made the instantaneous exit velocity of the test block without nets can be obtained. For testing to date it has been calculated that the attenuator system can dissipate 43 to 84% of the kinetic energy of the modelled trajectory without nets when measured and modelled velocities are compared. From qualitative analysis of the video data and direct trajectory plotting, it has been noticed that much

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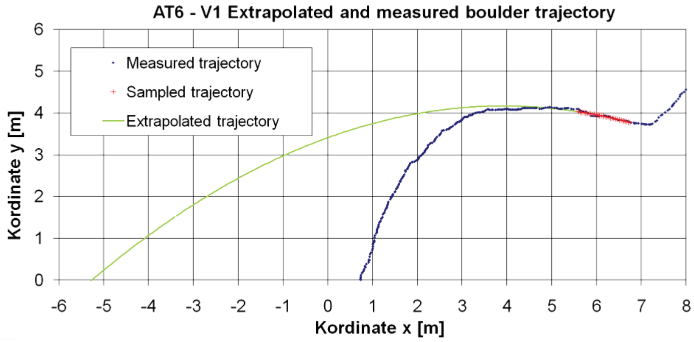
of the reason for this variation in the effectiveness of the attenuator system is due to the angle at which the test block impacts the netting in addition to the angularity of the impacting block.



Figs. 2 High speed video image of first impact into attenuator system (left); measured and extrapolated trajectory with and without attenuating system (right)

Loading features such as a first impact wave, mesh snagging and tail drape exit wrapping have been identified from video analysis. Correlating this with force peaks, captured with load cells installed in the system support ropes, the portions of the attenuator system that conduct the most work attenuating the rock boulder are also observed.

FURTHER FIELD TESTING

In an attempt to better quantify the overall amount of kinetic energy these attenuator systems can dissipate, rock rolling experiments at the same test site without the presence of the attenuator netting are planned for March of 2011. This will enable a direct measure of the rock fall velocities possible on the test slope, and will better calibrate the proposed method for assessing the attenuation effect of these systems. Moreover, the data will be used for the calibration of sophisticated 3D numerical rock fall codes (RAMMS, 2010; Rockyfor3D, 2010).

BENEFITS

An understanding of the design controls available to optimizing the dissipation effects of the netting is crucial to their application. With quantitative information of the kinetic energy dissipation effects of rock fall attenuator systems, installed attenuators can be better designed to site specific rock fall problems and design goals. Important for their design is to consider how these systems work in conjunction with the terrain in which they are installed. Choice of netting properties (weight, length and mesh size) that are tailored to terrain properties (slope angle, surface roughness, and material), and expected rock fall hazard (shape, size, and velocity), are the challenging decisions the rock fall engineer must face. With the experience from full scale testing, we are coming closer to design guides that will be able to direct such design decisions. Moreover, the planned field testing will help gain greater insights into the impact dynamics of rock to ground contacts and the ensuing rock fall trajectory. This is important both for numerical modelling goals and to help identify the nature of rock fall trajectory with respects to terrain and rock boulder shape. This will be particularly important when considering impact angles and the resultant attenuation effect of rock fall attenuator systems.

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