ABSTRACT

The aim of this research is to investigate the relationship between fragmentation and brittleness of rock by taking into account the influence of the Class II characteristic behaviour of the rocks have on this relationship. Fragmentation of rock under compressive failure depends on its self-sustaining failure and the energy available in the post-failure region to shatter the rock. The fragmentation produced under this condition depends to a large extent on the energy available to cause fragmentation and on the brittleness of the rock. From review of the literature, it appears that no research has attempted to link brittleness and fragmentation. Rock failure under dynamic loading conditions, such as in blasting, rockbursts, crushing, and milling, as well as during conventional unconfined compressive strength testing of rock specimens and the subsequent fragments size distribution is a little-understood phenomenon. This relationship will be helpful in the solution to many practical mining and civil engineering problems. This includes the prediction of optimal fragmentation and the design of stable structures as a result of dynamic processes particularly associated with fragmentation.

The research carried out involved the analysis of rock parameters determined from different rock Classes (Class I and Class II) under destructive tests using a soft testing machine and a closed loop servo-controlled testing machine (stiff machine). The tests were conducted according to ISRM suggested methods at the Genmin Laboratory, Wits University while the post-failure stress-strain curves estimation were done using a closed loop servo-controlled testing machine at the Rock Engineering Department at Aalto University Finland. In addition, non-destructive tests were conducted with the output being monitored using a dual-beam cathode ray oscilloscope. From the destructive tests, the static parameters were determined while the dynamic parameters were estimated from the non-destructive tests. The fragments

from the tests using the soft testing system were collected for size characterization/distribution.

Dynamic fracturing test entailed blasting a few rock blocks with explosive. The rock types used included Class I and Class II rocks. The rocks were prepared into blocks of dimensions 150 mm length x 100 mm width x 100 mm height. Holes were drilled into the blocks with 8 mm diameter drill bits to a depth of 80 mm. The holes were spaced at 44.7 mm with a burden of 28 mm in a rectangular blasting pattern. Each of the holes was charged with a 720 mg electric detonator to ensure consistent charge per hole and per rock block and shot instantaneously inside a cylindrical blasting chamber at AEL Mining Services. After each blast, the fragments were collected for size distribution/characterization.

The comparison of static mechanical and dynamic properties with fragments size as a measure of fragmentation from compression test show that the higher the property value the more the fragmentation produced for the Class II but the same cannot be said for the Class I rocks. The relationships between different measures of fragmentation with brittleness concepts based on static mechanical properties and moduli were analysed. Further assessment of the relationships between the different measures of fragmentation with brittleness concepts estimated from normalised stress-axial strain curve, and extension strain criterion show that, fragments size at X_{50} and X_{10} is a better measure of fragmentation than the “fragments volumes”.

The brittleness concepts estimated from normalised stress-axial strain curve, designated as NSSC and the extension strain criterion (i.e. critical extension strain, e_c), show better correlation with fragmentation under compressive failure (for the segregated samples, Class II and Class I) and the blasting test for the combined sample than shown with the brittleness concepts based on static mechanical properties and moduli. The relationship show that the higher the value of the brittleness concepts (i.e. NSSC and critical extension strain, e_c), the finer the fragmentation. Under compressive failure, NSSC is a better concept for quantifying the brittleness of rock for the segregated samples (Class II and Class I). On the other hand, the critical extension strain shows stronger correlation at both X_{50b} and X_{10b} than the NSSC for the blasting test. Therefore, critical extension strain is a better index for quantifying brittleness of rock under blasting test.

A modification was applied to the Kuz-Ram model to take into account the brittleness behaviour of rocks based on critical extension strain. Thus, understanding the relationship between fragmentation and brittleness can bring about optimal prediction of fragmentation, and consequently, result in an economic gain for the excavation industry.