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Effect of time on the tensile strength of several Bushveld Complex rock types

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2013-07-15
http://hdl.handle.net/10539/12834

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Abstract

Despite observations of spalling and damage of Bushveld Complex (BC) mine excavation wall rock over the passage of time, there have been very few time-dependent or creep tests carried out in South Africa on rock, particularly on BC rock types. The research detailed in this dissertation deals with the investigation of stress and strain conditions influencing spalling of wall rock in BC mine excavations, and the influence of time on the tensile strength of several BC rock types. The research includes a review of the BC mining environment; a review of literature relevant to time-dependent behaviour of rock; laboratory testing of BC rocks in uniaxial compression and in indirect tension; time-dependent laboratory testing in indirect tension; and elastic numerical modelling of typical BC mine excavations. The results show that the magnitude of the tensile strength of BC rock types is approximately 5% of their uniaxial compressive strength magnitudes. The long term uniaxial compressive strength of the BC rocks, interpreted from the axial stress-volumetric strain graphs in the UCS test is on average 78MPa, which is 56% of the UCS value. The tensile strength of the BC rock types was found to be time-dependent. However, ultimate minimum long term tensile strength values could not be determined in this research owing to limited testing machine availability. Although the individual test specimen failure times showed large variations, logarithmic time-to-failure trends of the nine test categories in the research showed a general time-dependent behaviour. The long term tensile strength is shown to be less than 70% of the normal tensile strength. Extension strains at tensile strength failure ranged between 1.6×10^{-4} and 2.1×10^{-4}. Values corresponding with the long term tensile strength are less than 70% of this range, namely, less than 1.1×10^{-4} to 1.5×10^{-4}. The time-dependent data presented in the dissertation represent new knowledge, since such rock testing and analysis does not appear to have been carried out before on BC rock types.

The compressive stresses determined in the numerical models were found to be an order of magnitude lower than the compressive strength of the rock. Tensile stresses in the models were of comparable magnitude to the tensile strength of the BC rock types investigated in this research. The numerical models showed that large zones of extension strain can occur around BC excavations, and that the magnitudes of the

extension strain can substantially exceed the critical values determined from the laboratory testing. There is no conclusive prerequisite for tensile conditions to exist, to induce critical extension strain. The implication of this is that there are substantial zones surrounding BC mine excavations that will be prone to spalling conditions and perhaps more significant failure.