ABSTRACT

It is common knowledge that mining activities bring about instabilities in the rock mass. These ground instabilities are excessive when the mining operations involve interacting underground and surface mining excavations. This can be attributed to strata relaxation which induces tensile stresses around excavations. This research focused on predicting the behaviour of the rock mass upon which the underground excavations were interacting with a mined out open pit. The research was based on a case study mining operation situated along the Great Dyke of Zimbabwe.

Rock mass characterisation using the Q-system was used to show the quality of the rock mass intermediate the underground and pit excavations. Finite Element Analysis (FEA) was used to model the excavations both in 2D and 3D with the purpose of predicting the stress distributions and deformations around the mining excavations. Three-dimensional modelling was done to give an insight on how the stresses were distributed in the third dimension. Thus, 3D modelling allowed for effective determination of the average pillar stress on the in-panel pillars. The 2D model was also used in the stability analysis of the intermediate pillar created between the underground and pit excavations.

The rock mass characterisation showed that the rock mass was fairly intact basing on the considerably high RQD values. However, the resultant Q-values were considerably low due to the low J_w values assigned to the rock mass. The low J_w values corroborated well with what was observed in the field survey whereby water could be seen dripping from the support boreholes. The 2D maximum principal stress analysis, showed that the zone of very low compressive stresses and tensile stresses was larger in the hanging wall of the panel in the close proximity to the intermediate pillar. The total displacements predicted by the 2D model were very small (≤4mm) thereby implying some linear elastic behaviour in the rock mass. The 3D model predicted an average pillar stress of 20MPa, whereas the 2D model predicted an average pillar stress of 6MPa. This showed that the 2D model underestimated the pillar stresses. This is attributed to the fact that 3D analysis effectively considers the tributary load imposed on the in-panel pillars which is not the case with 2D analysis.

From the stability analysis of the intermediate pillar, it was observed that the strength factor of the rock mass decreases with a decrease in the pillar width. Zones of low strength factor (SF ≤1) in the rock mass surrounding the pit highwall side were common especially on the model with an intermediate pillar width of 6m. Analysis of the minor principal stresses in the hanging

walls of the underground panels showed that the rock mass was subjected to tensile stresses with the tensile zone enlarged on the panel in the close proximity to the intermediate pillar. Usually, plastic deformation happens due to these tensile stresses. Thus, it can be concluded that in shallow excavations, the size of the plastic zone around underground panels is not only dependent on the mechanical properties of the rock but also on the position of the panels relative to other nearby excavations.

It is recommended that if underground excavations are interacting with a mined-out pit, it is prudent to backfill the pit in order to increase the rock mass confinement. However, there is potential of accumulation of water in the backfill which can adversely affect the rock mass stability. Therefore, a dewatering system must be put in place to control the water accumulations on the pit. This will reduce the risk of water inrushes into the underground workings. With the likely emergency of more such mining operations along the Great Dyke of Zimbabwe, this research equips the rock engineers and planning engineers to come up with designs of mining excavations which are economically viable and guaranteed of stability.