Numerical Study on Crown Pillar Stability in Transition from Open Pit to Underground – A Case Study of Golden Eagle Gold Mine, Botswana

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Introduction

Golden Eagle Gold mine began open pit mining in 2016 – 2021. During the open pit mining period, it had mined up to a maximum pit depth of 40 m with gold average grade average of 2 g/t and cut-off grade of 0.98 g/t **(Figure 1)**. Open pit mining became increasingly expensive to continue due to gradually high stripping ratios as current pit shell was designed in 2008 assuming a gold price of $1200/oz. It is for this reason that the current pit limit terminated at 40 m before it progressed to final pit limit design. In 2021, the mine undertook an optimization study that informed a decision to transition from open pit mining to underground mining operation. Therefore, the motivation of this research is to establish the adequacy and minimum thickness of the crown pillar required to be left between the base of the open pit and the roof of the stope for a safe transition from OP-UG.

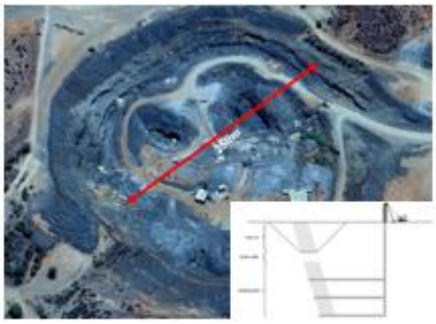

Figure 1: Google earth plan view of open pit and schematic model of crown pillar in OP-UG transition.

Methodology

Empirical Scaled Span Method

To achieve the objectives of this research thesis in determining the adequate crown pillar thickness and accessing its stability in OP-UG transition, a combined use of empirical methods particularly Scaled Span Method (**eq. 1**) and a two-dimensional (**Figure 2**) finite element model of the mine site was developed using application of Rocscience (RS2) code. The stability of crown pillar was assessed by changing thickness from 5 m, 10 m, 15 m, 20 m & 25 m with respect to variation of parameters mentioned.

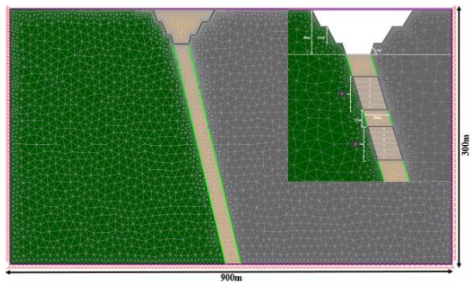

Figure 2: Numerical model.

$$T_{min} = \frac{\gamma s^2}{C_s^{\,2}\,(1 + S_R)(1 - 0.4\cos\theta)} \qquad \textbf{(eq. 1)}$$

C_s is the scaled span (m), S is the stope span (m), γ is the specific gravity, T is the crown pillar thickness (m)

S_R is the span ratio (stope span/stope length) , θ is the orebody dip angle

Results and Discussions

Empirical method calculated the required minimum crown pillar thickness to be 17 m with a factor of safety value of 1.5. Strength factor (equivalent to safety factor) and yeilded elements were the parameters used to access the crown pillar stability by contouring them in RS2 (**Figure 3**). It is observed that yielding and is intense when the crown pillar thickness decreases. Additionally, crown pillar thickness of 5 m, 10 m and 15 m have strength factor of less than 1.5 which according to scaled span method is less than required value therefore their stability is not realised. Results indicated that using the actual rock mass parameters of the mine site – GSI, orebody width of 20 m, optimum crown pillar thickness was determined to be a minimum of 20 m in a crown pillar span of 20 m, **Figure 4**.

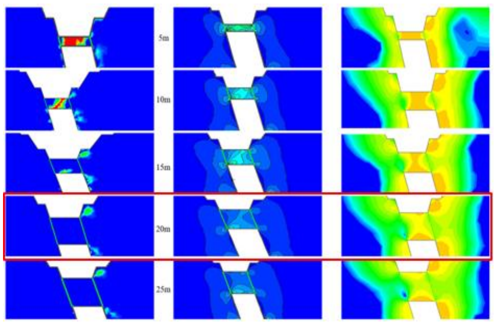

Figure 3: Effect of crown pillar thickness on crown pillar stability.

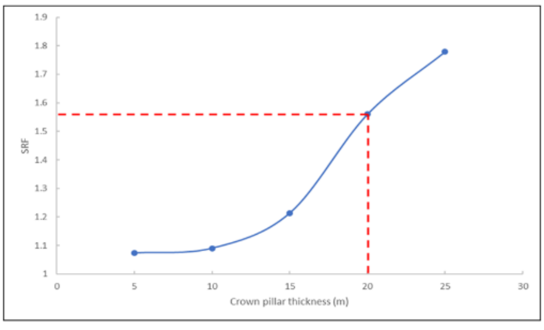

Figure 4: Strength factor in different crown pillar thickness.