ARMA Student Competition 2023

Problem

For this challenge, teams are asked to evaluate the stability of a cemented paste backfill stope exposed during vertical retreat stope mining. The adjacent stope is to be mined in a series of blasts. The analysis can be made along a two-dimensional longitudinal section through the stope center. In the event of instability, make recommendations of an alternative design solution that minimizes backfill costs. *FLAC2D* 9 software and a model template will be provided to all participating teams.

The existing cemented stope is three-dimensional, measuring 72 m in height by 27 m in length and 15 m in width. The vertical retreat stope is to be excavated in a series of 6 m high vertical cuts. Backfill strengths can be based on 28-day cure times.

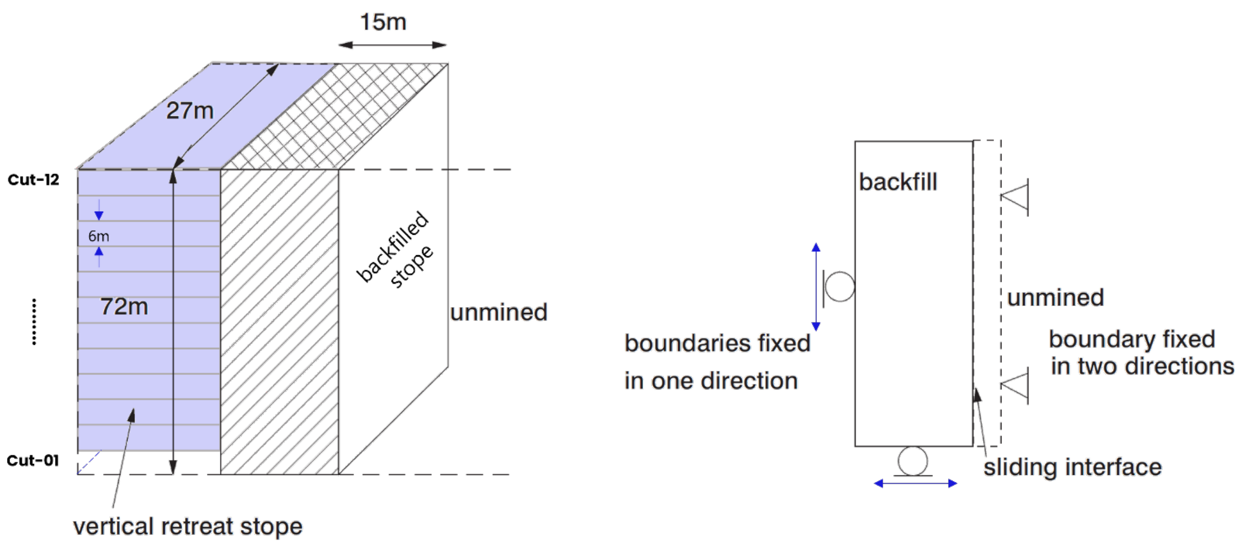

Figure 1. Schematic illustrating true three-dimensional backfill pillar geometry and two-dimensional representation.

Properties

Model the cemented paste backfill and rock as a Mohr-Coulomb material. In all cases, assume the following properties:

Table 1. Material properties.

Property	Backfill	Rock	Interface
Density (ρ, kg/m^3)	1,550	2,700	----
Young's Modulus (E, MPa)	430	70,000	----
Poison's Ratio (v, unitless)	0.39	0.27	----
Friction (φ, °)	35	47	35
Tensile Strength (t, MPa)	0.1	10	0
Cohesive Strength (c, MPa)	TBD	30	0

The uniaxial compressive strength (*UCS*) and tensile strength of the paste backfill can be estimated using the Equation 1:

$$UCS = 2c\cos\varphi\,/(1 - \sin\varphi) \qquad [1]$$

Backfill *UCS* can be estimated using lab strength test results shown in Table 2.

Table 2 Paste backfill strength, after 28 days curing, vs binder content (after Pakalnis et al., 2005).

Cement Content (%)	**2**	**4**	**6**	**8**	**10**	**12**
Paste Fill - *UCS* (MPa)	0.2	0.5	0.9	1.3	1.7	2.0

Assume that there is an interface along the backfill and the adjacent unmined rock with a friction angle of 35°, and normal- and shear-stiffness of 1 GPa; ignore the interface in any factor of safety (FS) analysis. Use a zone size of 1.0 m when modeling. Models can be run in large strain mode.

Criterion

The backfill FS must be ≥ 1.25 when fully exposed to VRM stope, while minimizing stope backfill costs. Note that FS analyses must be run in small strain mode; while displacements reported during FS analyses, may be indicatory, they are fictious due to the shear strength approach.

Report

The submitted report should address the following topics:

- Problem definition.
- Figure representing the geological/geotechnical model.
- Overall approach, including assumptions.
- Numerical modeling approach.
- Numerical modeling results, including design FS, stable cumulative maximum displacement, stable and unstable zone failure states.
- Final design recommendation.
- What are the key risks to the proposed solution?
- How could these risks be mitigated?

Ideally, the report should be less than 8 pages, but there is no formal limit.

References

R. Pakalnis, Caceres, C., Clapp, K., Mori, M., Brady, T., Williams, T., Blake, W., and MacLaughlin, M. (2005). "*Design Spans – Underhand Cut and Fill Mining,*" presented at 107th CIM-AGM Toronto, April 2005, 9 pages.

Karim, R., Simangunsong, G.M., Sulistianto, B., and Lopulalan, A. (2013). "Stability Analysis of Paste Fill as Stope Wall Using Analytical Method and Numerical Modeling in TheKencana Underground Gold Mining With Long Hole Stope Method," Procedia Earth and Planetary Science 6, 474 – 484.