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Determination of temporary support for squeezing zone underground mine PT. Cibaliung Sumberdaya

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Abstract. Underground Mining activity will always face deformation and instability of the rock mass around the underground openings. A large deformation was reported to occur on decline tunnel of PT. Cibaliung Sumberdaya (PT. CSD). Prior to this event, the same tunnel, which the tunnel wall had been refurbished into the proposed original shape. This implies that the squeezing zone had developed around the tunnel and the same support system couldn't resist the increasing load. Therefore, an analysis of squeezing zone around the excavation should be carried out. Conducted analysis started by the modelling the excavation should be carried out. Conducted analysis started by modelling the excavation the tunnel to get causing the cross cut failure. Then, back analysis was carried out to estimate the decreasing strength of the rock mass inside the squeezing. After that, squeezing zone can be determine the support systems to prevent the failure of rocks. The strain from back analysis results showing that similarity compared to the monitoring result when the modulus deformation E and the strength parameter mb and s of Hoek-Brown Failure criteria of the materials in the squeezing zone is 40 % peak strength. Analysis for temporary support shows that need 250 mm thick shotcrete, 1 m of spacing rock bolting, and 0.5 spacing reinforcement beam. Although, the floor of tunnel should be given extra consideration because could given high load, so must be installing rock bolt to helping stabilization.

1. Introduction

PT. Cibaliung Sumberdaya (PT CSD) is an underground gold mining company. Access to mining in Cikoneng vein area is through decline. Ore mining is done by overhand method through crosscut and after stope mining filled with filling material from tailing and waste rock. Inter-level mining using sill pillar from reinforced concrete. Crack encountered on the left wall (west side) fan acces trending: N 225 E / 80, N 225 E / 50, N 350 E / 32 and Bending at CKN Acc 1129. In connection with the movement, PT. CSD views the need for external opinion to evaluate tunnel stability.



2. Method

2.1 Study Area

PT. Cibaliung Sumberdaya is an underground gold mining company and is a subsidiary of PT. Aneka Tambang. Tbk. The gold mine ore deposit is an epithermal low-sulphidation of vein extending from north to south, or from Cikoneng to Cibitung (Figure 1)

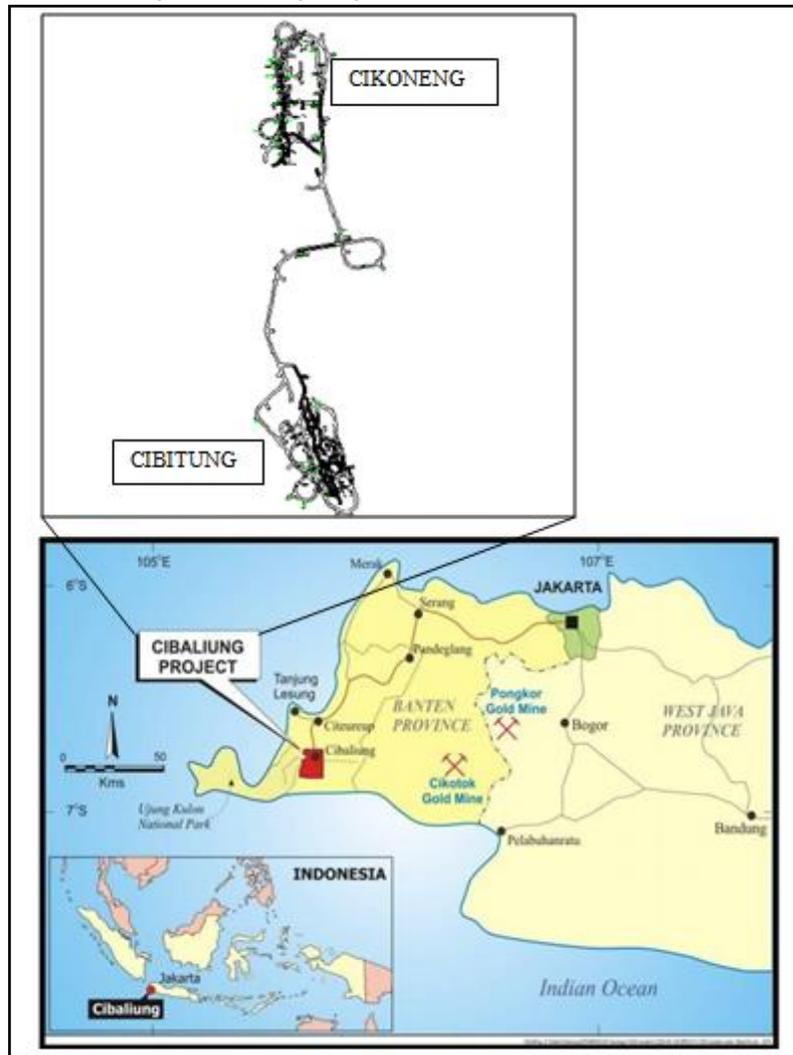


Figure 1 Map of Regional Landscape PT. Cibaliung Resources (Geotechnical Work Unit of Mining Department of PT CSD)

PT. Cibaliung Sumberdaya is located at the southwestern tip of Java Island, east of Ujung Kulon National Park which is administratively located in Mangku Alam Village - Padasuka District Cimanggu Pandeglang Regency, Banten Province and geographically located at coordinate position 105038'05,5 "E and 6045'04,8 "S, bordering on:

- North : Area of Tanjung Lesung and Citeureup.
- East : District Cibaliung and Cimanggu.
- South : Cikaung District.
- West : National Park Ujung Kulon.

2.2 Analysis Tool

Geoteknik studies

• Basic Criteria

In the analysis for the stability of openings several parameters used are:

a. Safety Factor

The safety factor is the comparison between rock strength and the voltage acting on the rock. In this study, the safety factor value of $FK > 1.30$ serves as a basis for stating that the openings are in safe condition. The safety factor can be calculated based on the Mohr Coulomb criterion with the following formula.

$$FK = \frac{\frac{\alpha_1 + \alpha_3}{2} \sin \phi + C \cdot \cos \phi}{\frac{\alpha_1 - \alpha_3}{2}} \quad (1)$$

b. Great displacement

Rock conditions experience instability when observed displacement is greater than the expected displacement of elastic theory. Based on observations in 13 large underground aperture openings, Cording (1974) suggests that displacements and loosening along weak spheres begin to occur when the observed displacement is three times greater than the elastic displacement. If the displacement exceeds the calculation of elastic displacement by five to ten times, then the excavation and buffer procedure should be modified to avoid greater movement.

• Elastic Displacement

a. Rock Mass Properties

In performing analysis for geotechnical rock properties are required. For rocks in Cibaliung, generally the intact rock properties obtained from Cibaliung can be seen in Table 1

Table 1 Rock Properties

Material	g	sc	E	V	GSI	mi	D
	(MN/m ³)	(MPa)	(MPa)				
Vein (ore)	0.0231	61.32	10703	0.06	50	20	0.8
Andesitic Breccia (FW)	0.027	75	1100	0.25	40	25	0.8
Polymictic Breccia (HW)	0.0271	51.07	985.6	0.14	40	19	0.8
Filling	0.026	0.6	400	0.25	9	25	0.8

The above properties are still in intact rock, therefore it must be converted first into rock mass (rock mass) using roclab software with the following results.

Table 2 Rock Mass Properties

scm	Em	c	F
(MPa)	(MPa)	(MPa)	(°)
8.106	5126	0.33	51.97
7.955	1302.9	0.304	49.3
4.711	2104.5	0.246	44.11
0.014	5.27	0.012	6.61

b. Calculation Method

Calculation of elastic displacement using properties vein as in Table 2 above. For calculations determining the magnitude of displacements in elastic theory. the stress in the rock mass representing the vertical direction (σ_v) is obtained from σ_{cm} .

The first step is to determine the vertical strain. By knowing the value of modulus deformation mass of rock (E_m) hence can be calculated strain happened by stress with equation:

$$\epsilon_v = \sigma_v / E_m \tag{2}$$

As a result of the vertical stress (σ_v) the strain obtained from equation (2) is a strain in the vertical direction. While for horizontal strain done with vertical strain approach multiplied by Poisson's ratio.

$$\epsilon_h = \epsilon_v \times \nu \tag{3}$$

Assuming the initial distance is the width of the span on the roof or wall of the opening opening. it can be calculated the elastic displacement (δ) which occurs as a result of stress based on elastic theory as follows.

$$\delta = \epsilon \times \text{span wide} \tag{4}$$

Another assumption of rock mass conditions other than elastic is homogeneous and isotropic. The complete elastic displacement calculation results can be seen in Table 3.

Table 3 Elastic Transfer Calculation (δ) CKN 1129 ACC Aramco

Parameter	ϵ_v	ϵ_h	δ_v (mm)	δ_h (mm)	δ_v max(m m)	δ_h max (mm)
Material = Vein	0.0044	0.000975	8.87	1.95	44.34	9.75
$\sigma_{cm} = 8.1$ MPa						
$E_m = 5.12$ GPa						
$\nu = 0.22$						
Span = 3 m						

$\delta_{max} = 5 \times \delta$ (criteria of displacement by Cording 1974)

3. Results

The result of the empirical and numerical modelling determination temporary support for CKN_DeclineCikoneng with Rock Mass Rating (RMR). Rock mass deformation at CKN_Decline which is the primary access point for transporting the ore from the stop area to the rom pad is known from observations in the first and second supervision. Early indications are known through the narrowing of the left and right walls of the tunnel. as well as the occurrence of shotcrete cracks due to the development of rock mass. Therefore it is necessary to monitor with convergence meter to know the speed of deformation. check condition of rock samples in core box to know alteration and geological strength index change (GSI). do sampling for laboratory test about physical and mechanical properties of rocks and soil around observation area. and numerical modeling with finite element method from Rockscience (*Phase*²). All of the above steps aim to know the behavior of convergence caused due to rock mass characteristics or due to the redistribution of stress.

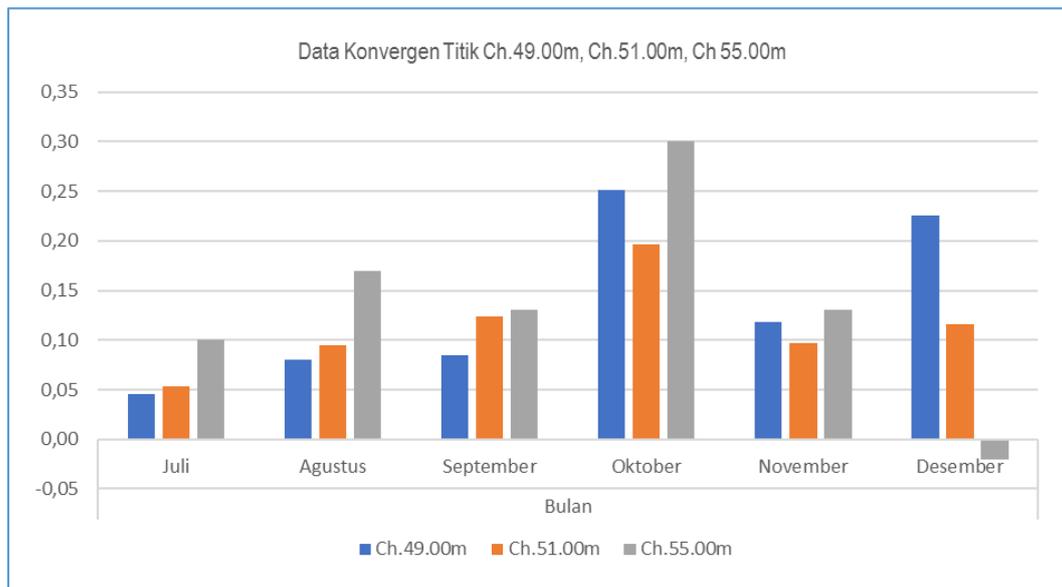


Figure 2. Graphic of convergence in the Decline Cikoneng

According to the displacement value chart it can be seen that the displacement value from July to December 2017. The trend occurred in October 2017 was the maximum displacement at Ch.49.00m of 0.25mm, Ch.50.00m of 0.20mm and Ch.55.00m of 0.3mm. The value is between 0.2 - 3 which means relatively stable, but found the bending, crack and failure in the fan accaft 1129 Cikoneng access.

Existing conditions on the opening hole Acc Fan Shaft 1129 Cikoneng Block is a bending hole on the right roof and found crack on the left wall and failure on the right wall. Geotechnical modeling is done numerically using Phase2 v 8.0 software. Properties used in the model refer to the rock and buffer properties of PT Cibaliung Sumberdaya.

4. Discussion

The analysis was carried out in three phases. In the first phase, the field stresses were applied to the rock mass. Boundary conditions were used to restrain the wall soft he model and external field stresses were used to simulate the far field stresses. In the second phase, the advance of the face was simulated using the core replacement technique to determine the tunnel response during construction (short term). The third phase examines the long term degradation of the rock mass. This is accomplished by decreasing the GSI in the short term plastic zone by a factor RMR, thus decreasing the rock mass strength and stiffness.

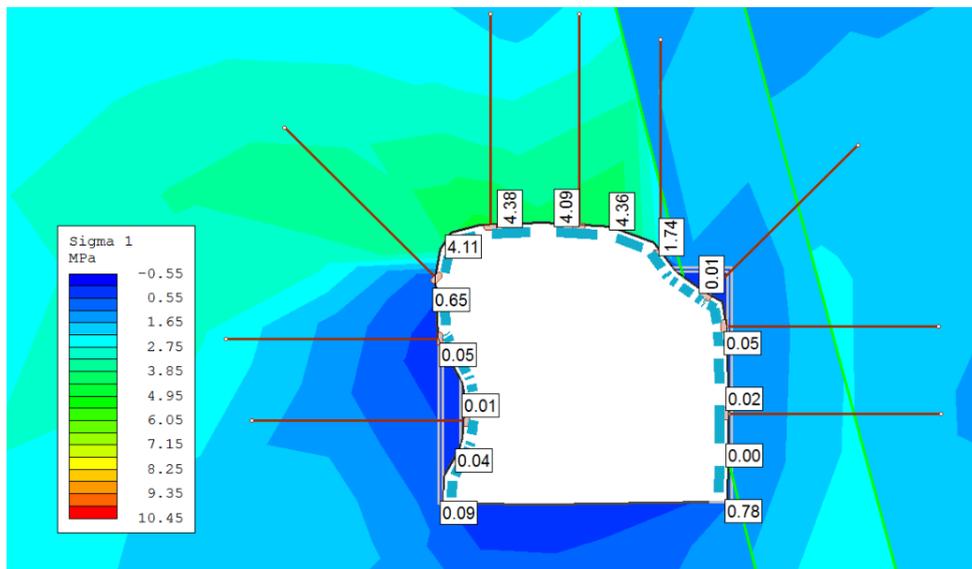


Figure 3. Actual Sigma 1

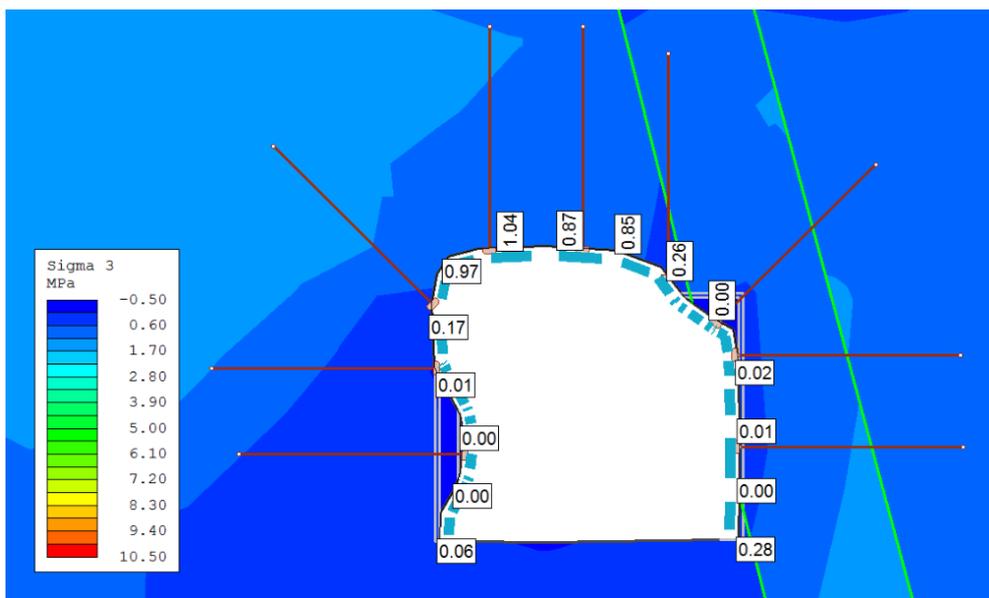


Figure 4. Actual Sigma 3

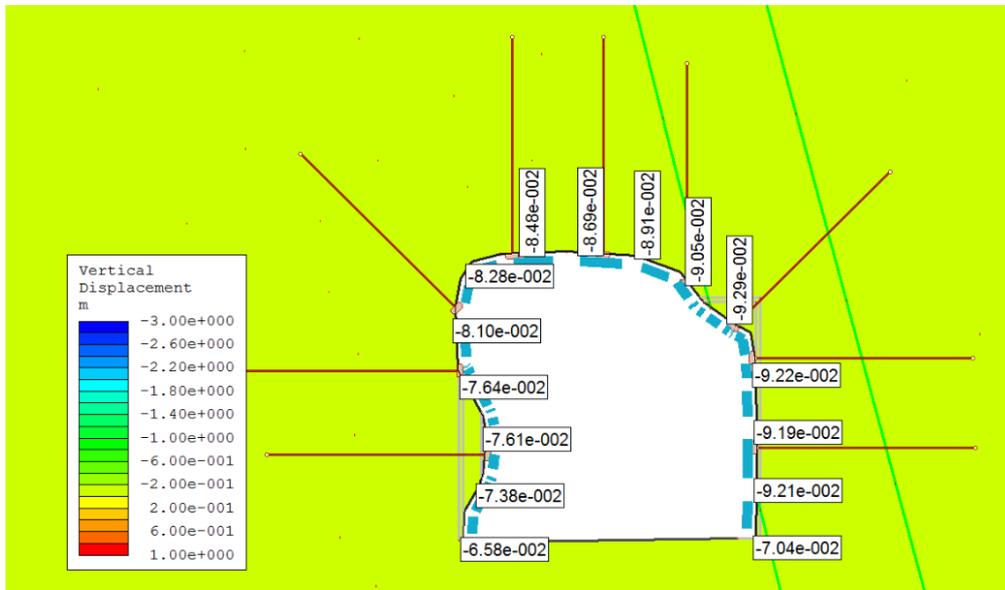


Figure 5. Actual Vertical Displacement

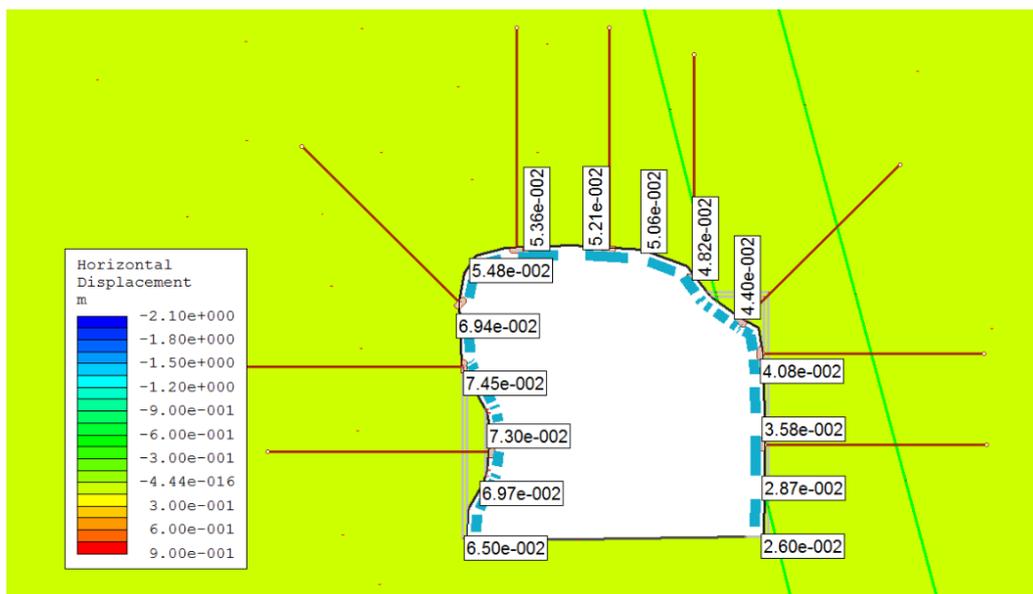


Figure 6. Actual Horizontal Displacement

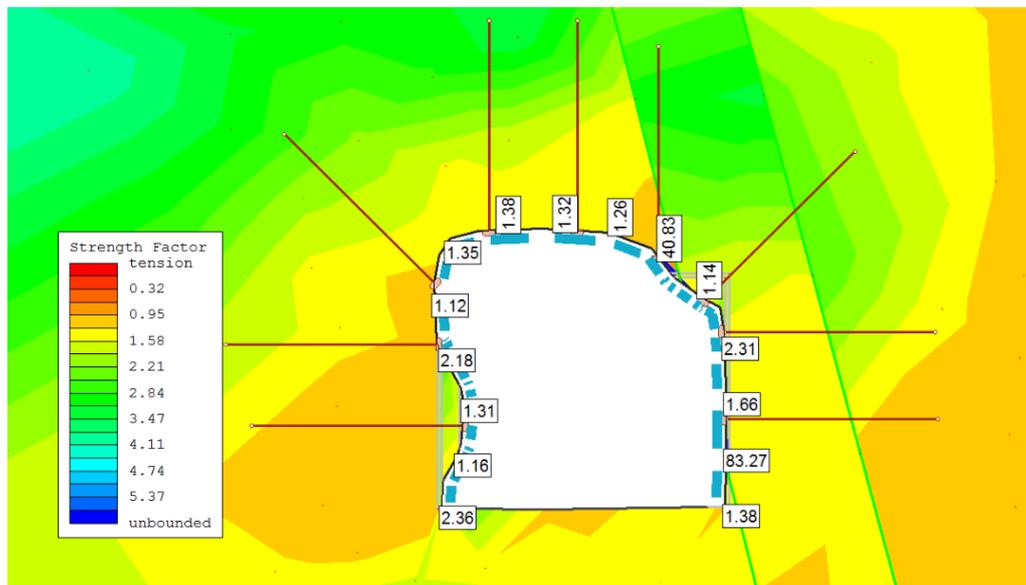


Figure 7. Actual Strength Factor

5. Conclusion

Conclusions from field visits and convergence data show that based on maximum displacement speed:

1. The convergence measurement data on the Cikoneng decline from July to December along the observation path (Ch.49.00m. Ch.51.00m. Ch.55.00m) shows the greatest deformation in October: Maximum deformation at Ch.49.00m of 0 . 25 mm. Ch.51.00m of 0.20 mm and Ch.55.00 of 0.30 mm
2. Analysis for temporary support shows that need 250 mm thick shotcrete. 1 m of spacing rockbolting, and 0.5 spacing reinforcement beam. Although, the floor of tunnel should be given extra consideration because could given high load, so must be installing rockbolt to helping stabilization.
3. The existence of Bending on the roof and failure may be caused by a block of rock that has been separated from the parent rock due to the solid structure that separates the rock into blocks. The indicator can be seen in the form of water seepage on the roof.

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