Rock Mechanics Study on the Recovery of Residual Pillars in Pinglidian Gold Mine, China

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Keywords: Residual Pillars Recovery, Roof Loosening Layer Detection, Numerical Modeling, Stress Monitoring in Field, Backfill Materials Test.

Abstract. The Pinglidian gold mine locates at the Laizhou city, Shandong province, China. Up to 2013, the orebodies had been mined out, however, there is leaving mined voids of about 120,000 m^2 and also leaving a large number of ore pillars. The residual pillars have to be recovered. In order to safely recover those residual pillars in the mine, some rock mechanics study work, including the detection of roof loosening layer depth of mined voids, the 3-d numerical modeling and the field monitoring of the stresses changing of pillars adjacent to recovering operation, has been done, and for recovery operation of backfill method with hydraulic prop supporting, the required mechanical properties of cemented tailings fill materials have been tested. Finally, a trial recovering stope has been successfully and safely mined.

Introduction

The Pinglidian gold mine locates at the Laizhou city, Shandong province, China, and just near the Bohai Bay beach. No.1 orebody is the main deposit of the mine, buried about 200 m beneath the surface, and burying conditions are strike direction of NE15° , dipping angle of 5~25°, thickness of 0.15~0.78 m, length of 550 m, and the average gold grade of 5.41 g/t[1].

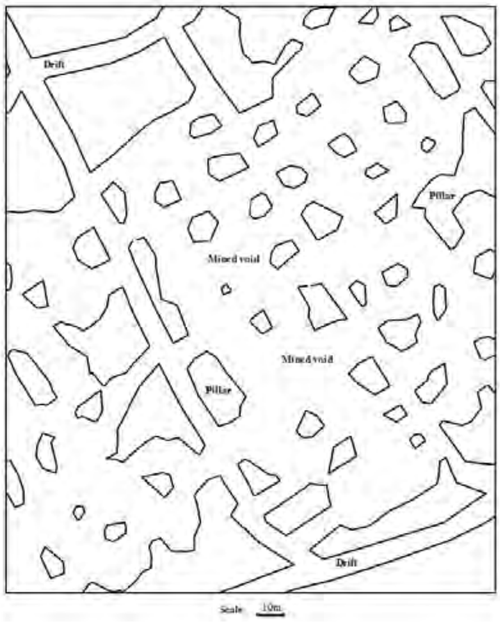

Fig. 1 Plan View of a Part of Mined Voids and Residual Pillars at -100m Level

As the surface subsidence is forbidden, hence, a room-and-pillar stoping method had been designed and the mining production started in 1996. Up to 2013, the orebodies had been mined out, however, there is leaving mined voids of about 120,000 m^2 and also leaving a large number of ore pillars at 5 levels, i.e., -70 m, -85 m, -100 m, -115 m and -130 m level respectively (Fig.1). By field investigation, total ore quantity of residual pillars of the mine is about 53,000 t. From today's point of view, the original designed room-and-pillar mining method may not be proper, as the residual pillars have to be recovered.

To recover the residual pillars of the Pinglidian gold mine, a research program has been set up, including the rock mechanics study work for safety assurance and the mining method design. In this paper, some results of the research work are presented.

Detection of Roof Loosening Layer Depth of Mined Voids

For the research program, a trial stope named 1058# at -100m level was selected, which was serviced for both purposes of the rock mechanics study and the recovery operation.

In order to judge roof stability of mined voids, a sonic device was used to detect depth of roof loosening layer, which was caused by induced stresses and displacements of mining[2], as shown in Fig.2. The detected sonic velocity of the trial stope was seen in Fig.3, and from which the roof loosening layer depth of mined voids was deduced at a range of 1.12 m to 2.30 m[3].

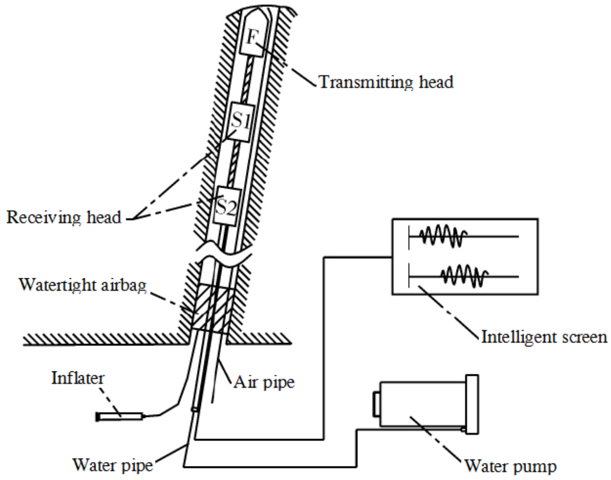

Fig. 2 Sonic Device Used in Detecting Roof Loosening Layer Depth of Mined Voids

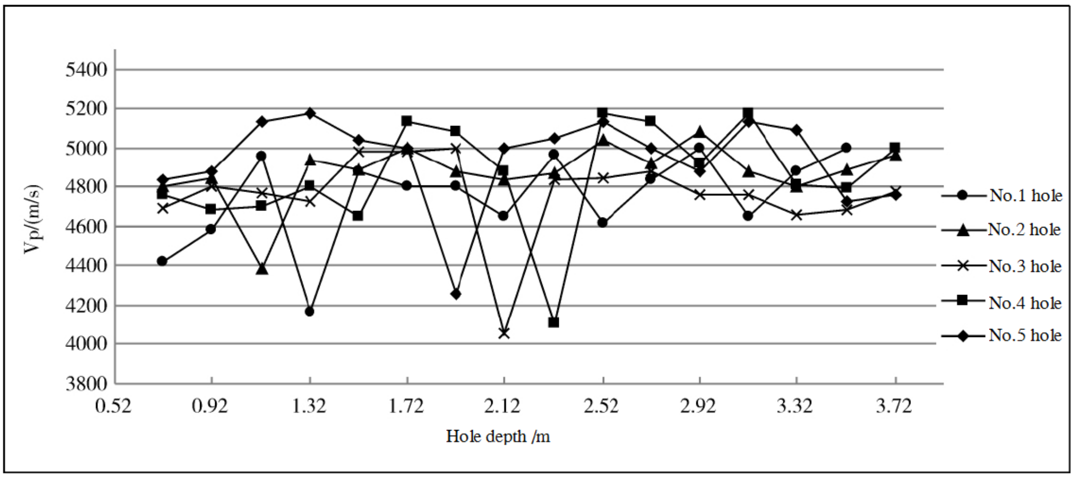

Fig. 3 Detected Sonic Velocity of No.1058# Stope at -100m Level

Numerical Modeling

To analyze the distributions of stresses and displacements of country rock masses and pillars before and after pillar recovered, FLAC3d numerical modeling method was used[4], the 3-d model is shown in Fig.4, and the parameters inputted in modeling are listed in Table 1.

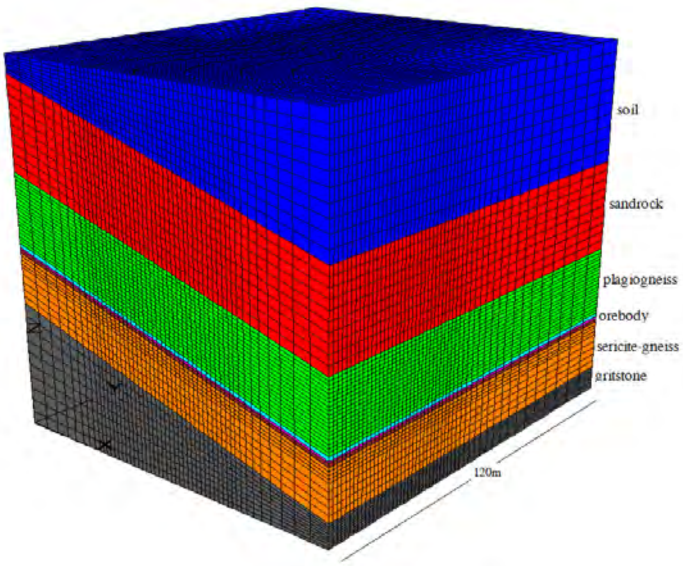

Fig. 4 Model Used in FLAC3d Numerical Modeling

Tab. 1 Parameters of Rock Masses Used in Numerical Modeling

Rock type	Unit weight [kg•m-3]	Modulus [MPa]	Poisson's ratio	Cohesion [MPa]	Friction angle [°]	Tensile strength [MPa]
Surface soil	1,800	4,250	0.280	1.80	27.0	0.80
Sandrock	2,450	10,750	0.250	2.40	33.0	1.20
Plagiogneiss	2,659	15,410	0.279	2.32	40.0	1.20
Orebody (Quartz sandrock)	3,386	20,833	0.125	4.48	48.7	0.96
Sericite-gneiss	2,717	7,473	0.170	3.36	32.6	1.25
Gritstone	2,600	16,000	0.160	3.50	31.0	1.20

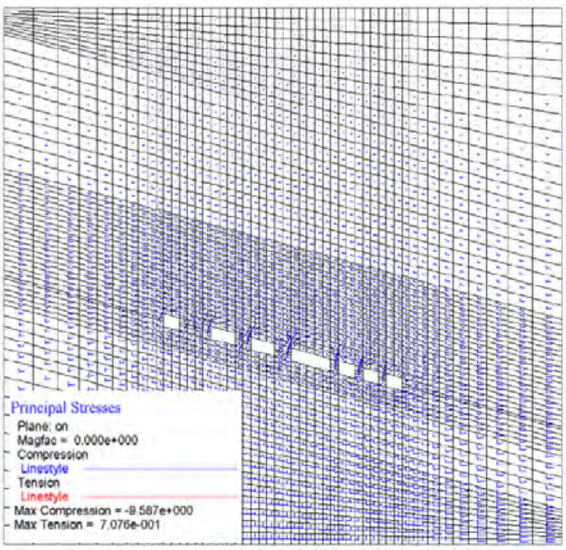

Fig. 5 Distribution of Principal Stresses around Residual Pillars at -100m Level

Fig.5 shows the distribution of principal stresses in pillars before pillars recovered, where it could be found that there are high stress concentration zones both inside pillars and in the roof of mined voids, and especially, it could be seen that there is a stress concentration zone at both upper corners of residual pillars.

From above study and analysis, it would be proved that the residual pillars of the mine are in unstable conditions, hence, for safely recovery of those residual pillars, a carefully designed backfill mining method should be used.

Field Monitoring the Stresses Changing of Pillars

During recovery of residual pillars, in order to monitor the stresses changing of pillars adjacent to recovering operation, 17 bore-hole stress meters were set up in the trial stope[5] (Fig.6), and a multi-points stress monitoring system was used (Fig.7), which could continuously record the stress changing automatically (Fig.8).

Fig. 6 Bore-Hole Stress Meter

Fig. 7 Multi-Points Stress Monitoring System Used in Field

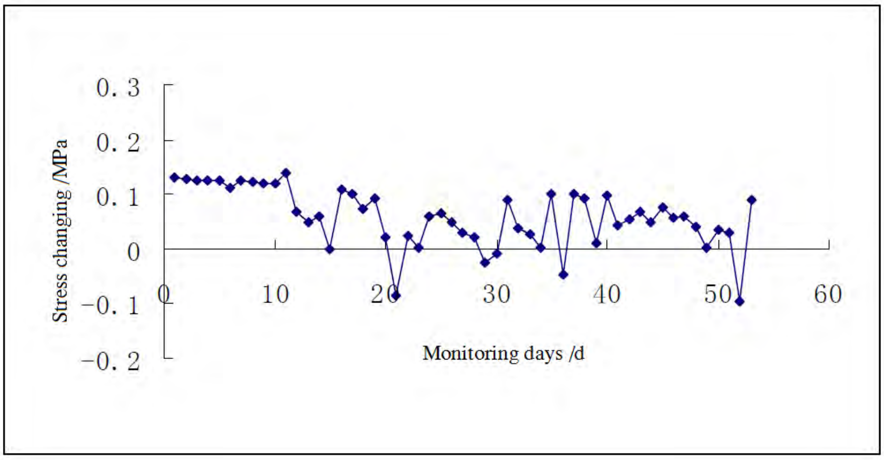

Fig. 8 Recorded Stress Changing of Bore-hole Zk6# in 1058# Stope at -100m Level

Tests of Strength Properties of Backfill Materials

Several recovery mining methods were designed, and one of them is called backfill method with hydraulic prop supporting, and by the trial recovery operation, finally that recovering method was selected[6].

To design suitable cemented fill materials, a number of laboratory tests were carried out, and some results are shown in Figs 9, 10 and 11. Hence, the designed cemented fill materials were that the required cemented fill strength was 0.8MPa at curing time of 28d.

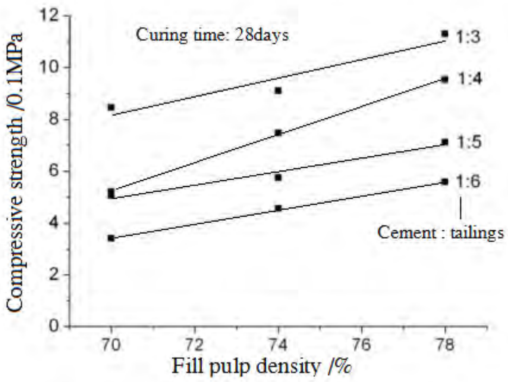

Fig. 9 Tested Relationship of Cemented Fill Strength to Pulp Density

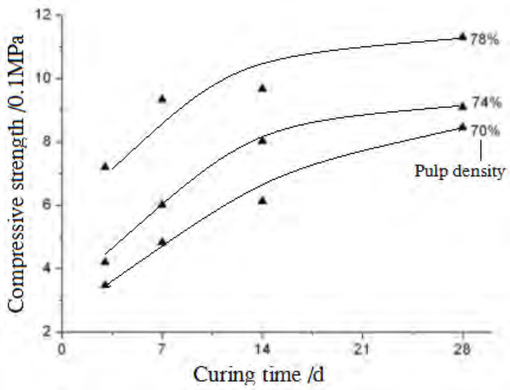

Fig. 10 Tested Relationship of Cemented Fill Strength to Curing Time

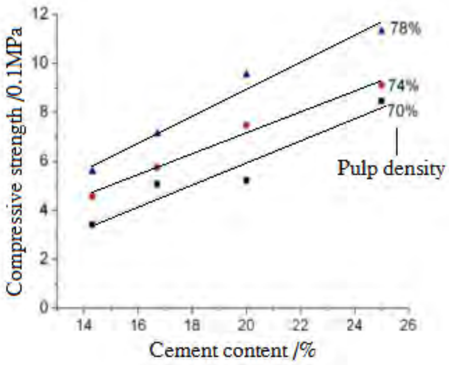

Fig. 11 Tested Relationship of Cemented Fill Strength to Cement Content

Summary

The recovering operation of residual pillars of the trial stope in the Pinglidian gold mine has been successfully implemented, and resulted in mining safety and economic benefit, which has proved that the rock mechanics study work and the tests of strength properties of cemented fill materials are adaptive and helpful.

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