（様式２）

氏　　名　：プルワント

論文題名　：DESIGN OF SUPPORT SYSTEM BY OVERHAND CUT AND FILL MINING METHOD IN UNDERGROUND GOLD MINE, INDONESIA
（上向き充填採掘法を用いたインドネシアの坑内掘り金鉱山における坑道支保システムの設計）

区　　分　：甲

論　文　内　容　の　要　旨

Although mineral resources have mainly been extracted by open pit mining method in Indonesia, the underground mining will be promoted in terms of the increasing mining depth and the environmental protection. Overhand cut and fill mining method is used in steeply dipping ore bodies in strata having a relatively weak strength and comparatively high grade ore. In cut and fill mining method, as the mined voids are backfilled with waste rock or tailings, the surface subsidence due to mining operation can be controlled and the impact on the environment is small. Generally, the declines are developed from the surface and then the cross-cut is drivaged from decline to the ore bodies to extract ore. As both of the hanging wall and the footwall are weak compared with orebodies, overhand cut and fill mining method was applied in Cibaliung underground gold mine, Indonesia. However, failures have occurred in declines, cross-cuts and stopes due to the extraction of ore in the area where the ore bodies are heavily fractured. Hence, a reassessment of the current support system and a development of more effective one have to be conducted in order to continue an effective and safe mining operation under these conditions. From these backgrounds, the effect of an induced stress due to the overhand cut and fill mining operation on the stress conditions around the roadways/openings have been evaluated in Cibaliung underground gold mine, Indonesia and then a design guideline for an appropriate support system in declines, cross-cut and stopes have been proposed in this study, consisting of seven chapters as follows:

Chapter 1 introduces the background of this research, geotechnical issues and mining technology related to this research topic and an involved outline of the dissertation.

Chapter 2 describes the current support system and its design guideline used in Cibaliung mine. Moreover, as this support system has been developed and used in another gold mine, Pongkor underground gold mine in Indonesia, the effect of this support system on the stability of roadways in Pongkor mine and it characteristics are discussed by means of numerical analysis.

Chapter 3 discusses the effect of current support system on the stability of roadways in Cibaliung mine. According to the results obtained from the numerical analysis, the current support system does not work well in this mine. This is because the geological conditions such as rock mass fracture state, mechanical properties of rock, in-situ stress conditions are different with those of Pongkor mine. Moreover, the effect of additional stress induced by mining operation on the stress and rock mass conditions around roadways are not evaluated and considered in the current support design. Hence, it can be said that a new design guideline of support system considering these factors has to be developed in this mine.

Chapter 4 describes empirical and numerical methods in order to evaluate the effect of induced stress of stope on the stability of declines in quantity. Based on these results, the prediction chart of maximum tangential stress factor is proposed. This prediction chart includes the features that the maximum principle stress works only in the tangential direction along the wall and the stress conditions around the roadway is changed into the initial stress condition with increasing the distance from stope to roadway. It can be said from this prediction chart that the failure of roadway may be occurred when the distance from roadway to stope is less than 20m and the location of the maximum principle stress factor

is changed as the distance between roadway and stope decreases. Based on these results, it is made clear that the stability of roadway cannot be maintained because enough supports are not installed in the area that the stress concentration factor is large in the current support system. Hence, the stress condition around the roadway have to be evaluated precisely and then the support system has to be designed considering the stress condition in order to maintain the stability of decline affected by mining operation in stope. The stability of the roadway can be maintained under the condition that a 15cm thick layer of shotcrete and H-beams with spacing 0.6m are installed, and the length of the rock bolt is changed from 1.8m to 2.4m and they are installed at 1.0m intervals on the sidewall roadway far from stope, and done at 0.5m intervals on the roof and the sidewall roadway near from stope.

Chapter 5 discusses the design of a support system for the cross-cut which connects the decline and orebodies/stopes and is developed in hanging wall by means of numerical analysis. It can be said from the results that the stability of cross-cut cannot be maintained by using the current support system when the distance of cross-cut and stope is less than 20m because a failure zone caused by induced stress of stope is developed in the roof. This situation could be improved by the application of a cable bolt. The stability of the roof of the cross-cut can be improved by installation of 11m cable bolt in the vertical direction. Besides, the anchor effect is also obtained by connecting the roof and sill pillar, which is left as a safety pillar in the upper part of the stope, by using cable bolt. However, the failure zone still develops at the roof under the condition that the distance between the cross-cut and stope are less than 10m. Therefore, standing support such as steel arch and cribs has to be installed in order to maintain the stability of the cross-cut.

Chapter 6 discusses an appropriate support system for the stope using numerical analysis by changing the thickness of the sill pillar and the installation pattern of rock bolts with a focus on the condition of fractures in the ore body. It can be said from the results that the stope can be maintained by using the current support system under the rock mass condition that Rock Quality Designation (RQD) value, which is index for the description of rock mass fractures state, is larger than 60. On the other hand, in case that the value of RQD is less than 60, the length and the number of installation rock bolts should be changed from 5m to 7.5m and from 3 pieces to 9 pieces, respectively. Furthermore, not only changing the thickness of the sill pillar and the pattern of the construction of the rock bolt, but also by installation of standing support such as rigid arch and cribs or increasing the strength of backfilling materials are required in order to maintain the stability of the stope when the extraction level reaches to 150m depth.

Chapter 7 concludes with the results of this study.