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論文題名　：MINING SYSTEM AND DESIGN FOR DEVELOPMENT OF UNDERGROUND COAL MINE FROM OPEN-CUT HIGHWALL FOR THICK COAL SEAM
（厚層炭層を対象とした露天掘り残壁からの坑内掘り炭鉱開発における採掘システムおよびその設計に関する研究）

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論　文　内　容　の　要　旨

The surface mining method is generally considered to be more advantageous than the underground method, especially in recovery, grade control, production capacity, economics, flexibility, safety and working environments. Therefore, the surface mining method is common in major coal producing countries. Most of coal is produced from open-cut mines in Southeast Asian countries. However, the conditions of their surface mines are worsening each year: the stripping ratio is increasing, approaching economic ratio, the regulation of environmental protection, and poor infrastructure for coal from inland mining areas. To meet the demand for coal in Southeast Asian countries and the rest of the world, underground mines have to be developed in the near future. Under these circumstances, the development of new coal mines from open-cut highwalls are being planned in several mines in Southeast Asian countries including Thailand, Indonesia, etc. Moreover, some of the Southeast Asian mines have thick coal seams. However, if the conventional mining systems and designs introduced in US, Australia and European countries are applied, several geotechnical issues can be expected due to the mines' weak geological conditions. From these backgrounds, a mining system and design for development of underground coal mines from open-cut highwalls especially in thick coal seams have been proposed in this study, consisting of six 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 research site conditions of this study in Mae Moh Mine, Thailand and introduces the multi-slicing mining method with a stowing system for thick coal seams. Moreover, the concepts of punch mining system and highwall mining ones are also discussed for their applicability of transition area from open pit to underground mines in this chapter.

Chapter 3 describes the miming method and the mine design in the transition area for thick coal seams. When the underground mine is designed and developed from open-cut highwall, special attention must be paid for the effect of the mining operation on the stability of the highwall. In order to make the criteria for the applicability and the design of the single to multi-slice extraction method in the transition area from open pit to underground mines for different pit depths and thicknesses of coal seams under strong and weak geological conditions by means of FLAC 3D. Here, the application of longwall/shortwall mining method is considered the extraction method due to their safety and high productivity. The designs of the boundary pillars, inter-panel pillars and panels are investigated and discussed in this chapter. From the results of the single-slice extraction method with a 3 m mining height, it is found that the conventional longwall mining method can be applicable in the transition area from open pit to underground mine under weak geological conditions. However, the results represent that the deeper the pit depth is, the more stress concentrates around the toe of the slope. It can be said that a panel width of 300 m and a boundary pillar width of 100 m are appropriate in all the pit depths of 200 m, 300 m and 400 m in strong geological conditions. On the other hand, a boundary pillar width of 150 m is required in a 400 m deep pit, although a pillar width of 100 m is appropriate in 200 m and 300 m deep pits under weak geological conditions. For the extraction of 10 m thick coal seam by using the two-slice longwall mining method with a 3 m height for each slice and 3 m thickness of coal seam left between slices, the slope stability problem is not expected under strong geological conditions, even if the panel width of 300 m is applied. A boundary pillar width of 100 m is sufficient for all the mining depth conditions. On the other hand, the slope instability and many geotechnical

issues including slope failures, large ground subsidence and large failures around the panel and pillar are occurred under weak geological conditions when a panel width 300 m is applied. However, it is found that a panel width of 100 m is appropriate in 200 m and 300 m deep pits. The boundary pillar widths for the 200 m and 300 m deep pits are 100 m and 200 m, respectively. In the 400 m deep pit, however, with a boundary pillar width of 200 m, the panel width should be small, about 60 m, and an inter-panel pillar width of 100 m is required in order to maintain the stability around the transition area from open pit to underground mine. In order to increase the coal recovery and improvement of stability of slope, application of the longwall mining method in conjunction with stowing is proposed and discussed in this chapter. It can be found that stowing is quite effective to reduce the subsidence at the highwall as well as the failures around the panel and pillars and to maximize the coal recovery. In addition, the immediate panel-by-panel stowing is more effective in comparison to slice-by-slice stowing. No obvious operational problems due to subsidence and strata control at the underground mine are expected in all the pit depths when stowing is applied. A panel width of 100 m can be designed for all the pit depths and the boundary pillar widths for 300 m and 400 m deep pits are 100 m and 200 m, respectively.

Chapter 4 discusses applicability and a suitable design of the mining method proposed in Chapter 3 for the transition area at Mae Moh Mine which has the an ultra-thick coal seam under a weak geological condition. According to the results obtained from the numerical simulations, the overall condition of the open-cut highwall is expected to be in stable condition. However, many problems would be expected due to slope failures and subsidence during underground mining even in the single pass operation. Mining in conjunction with stowing is quite effective to control surface subsidence. However, in Mae Moh Mine, since the coal seams are too weak and the open-cut highwall are very large, the longwall mining method might not be feasible at the transition area from the open pit to the underground mine, even if the stowing is applied. Large slope failures occur even though a subsidence of about 5 cm is observed at the slope. According to the results, it is found that a short wall with the length of 30 m and immediate stowing after panel extraction is more appropriate in the transition area from the open pit to the underground mine in order to control the slope failures, as well as subsidence, in Mae Moh Mine. It was also found that a boundary pillar width of 200 m is appropriate, and the two-slice extraction can safely be applied in the transition area in conjunction with stowing method.

Chapter 5 discusses and proposes an alternative method of mining in conjunction with stowing for the weak and extra-thick coal seam at the deep site far from the open-cut highwall at Mae Moh Mine. In this chapter, application of the longwall method and the bord-and-pillar method, in conjunction with stowing, for mining the weak and extra-thick coal seam at the deep site far from the open-cut highwall is investigated and discussed. According to the results of a series of numerical analyses, it can be found that multi-slice longwall mining method with temporary supports and a stowing system, as well as bord-and-pillar mining method with an alternative method for the cutting and stowing system, can be employed for the weak and extra-thick coal seam. These are effective methods for control ground disturbance and subsidence in order to improve mine safety and to maximize coal recovery.

Chapter 6 concludes the results of this study.