Excavation design in stratified rock

8.1 Design factors

Tabular orebodies hosted by stratified rock masses are quite common in mining practice. An orebody in a sedimentary setting is typically conformable with the surrounding rock in which the stratification is associated with bedding planes, foliation or related depositional features. The main geometric characteristics of these features are their planar geometry and their persistence. They can be assumed to be continuous over plan areas greater than that of any excavation created during mining. There are two principal engineering properties of bedding planes which are significant in an underground mining context. The first is the low or zero tensile strength in the direction perpendicular to the bedding plane. The second is the relatively low shear strength of the surfaces, compared with that of the intact rock. Both these properties introduce specific modes of rock mass response to mining, which must be considered in the excavation design procedure. An associated issue is that, for flat-lying stratiform orebodies, the typical mining method involves entry of personnel into the mined void. The performance of the bed of rock spanning the excavation, i.e. the immediate roof, then assumes particular importance in maintaining geomechanically sound and operationally safe mine workplaces.

Excavations in a stratified rock mass are usually mined to a cross-sectional geometry in which the immediate roof and floor of the excavation coincide with bedding planes, as illustrated in Figure 8.1. Factors to be considered in the design of such an excavation include:

(a) the state of stress at the excavation boundary and in the interior of the rock medium, compared with the strength of the anisotropic rock mass;
(b) the stability of the immediate roof;
(c) floor heave in the excavation.

Figure 8.1 An excavation in a stratified rock mass, with geometry conforming with dominant rock structure.
ROCK MASS RESPONSE TO MINING

In addressing these three different design factors, it is necessary to consider different deformation modes of the excavation near-field rock. For example, the first factor reflects concern with surface spalling and internal fracture in the rock medium, in the post-excitation stress field. The second factor involves the problem of detachment of the immediate roof from the host medium, and its loading and deflection into the mined void under gravity loading. The third problem, floor heave, is an issue where the floor rocks are relatively weak and the material yields under the stresses operating beneath the excavation side walls. It is a problem more frequently encountered in a room-and-pillar mining layout, rather than in designing a single excavation.

Since an excavation design must satisfy different rock mass performance criteria for the various modes of rock response, it is clear that a number of different analytical methods are to be employed in the design process. It also implies that it may be necessary to iterate in the design process, to satisfy the various performance requirements simultaneously.

8.2 Rock mass response to mining

Adverse performance of the rock mass in the post-excitation stress field may be caused by either failure of the anisotropic medium or slip on the pervasive weakness planes. The initial phase of the design process involves determining the elastic stress distribution in the medium around the selected excavation configuration. Following the procedure proposed for an excavation in massive elastic rock, one can then define any zones of tensile stress, or compressive stress exceeding the strength of the rock mass. The excavation shape may be modified to eliminate or restrict these zones, or alternatively, the extent of domains requiring support and reinforcement may be defined. Concurrently, it is necessary to determine the extent of the zone around the excavation in which slip can occur on bedding planes.

The criterion for slip on bedding planes is obtained from the shear strength of the surfaces. For the reference axes illustrated in Figure 8.2, interbed slip is possible if

$$|\sigma_{z} \leq \sigma_{z} \tan \phi + c$$  \hspace{1cm} (8.1)

Hence, evaluation of the extent of slip requires that the stress components $\sigma_{z}$ and $\sigma_{x}$ be determined, from the results of the elastic stress analysis, at points coinciding with

![Figure 8.2 Slip-prone zones around an excavation in stratified rock.](image-url)