Rock slope stability monitoring systems — effects upon mine safety

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Abstract

The largest waste stream from most underground stoping operations is mill tailings. Due to developments in mill processing, over the past 100 years tailings have tended to become progressively finer to increase metallurgical recoveries and hence to allow processing of previously uneconomic ore. However, the finer nature of tailings results in either low recoveries of hydraulic fill from tailings or unacceptable fill drainage properties.

1 Introduction

The largest waste stream from most underground stoping operations is mill tailings. Due to developments in mill processing, over the past 100 years tailings have tended to become progressively finer to increase metallurgical recoveries and hence to allow processing of previously uneconomic ore. However, the finer nature of tailings results in either low recoveries of hydraulic fill from tailings or unacceptable fill drainage properties (Parida and Kumar, 2004).

2 Principles of rock slope stability

Paste can be considered a non-segregating slurry, which means that it has negligible excess water when stationary and remains essentially as a homogeneous single phase product. The density of paste fills from underground hard rock mines is typically between $75\%_{Cw}$ and $85\%_{Cw}$ (solids by weight), depending on particle size distribution and solids specific gravity.

Table 1 Paste fill for mining operations

Material	Yield Stress (Pa)
Cream	45
Yoghurt	80
Toothpaste	110
Paste backfill	2,000 – 70,000
Peanut butter	20,000

The longer the paste is left idle, the greater becomes the yield stress to reinitiate flow, as shown in Figure 1. If this yield stress is high, and there is insufficient energy available to remobilise the paste, the line will become plugged.

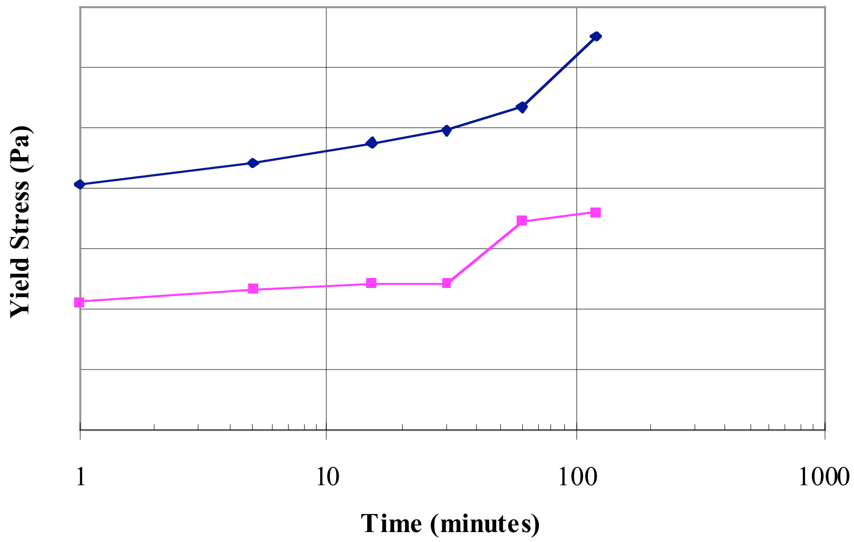

Figure 1 Variation of MDI concentration with distance from spray site, MDI concentration with distance from spray site

The non-segregating behaviour of paste materials offers a number of operational and management advantages as an underground fill material. The absence of a requirement for critical velocity allows slow pipeline velocities to be used, resulting in reduced pipe wear (Tyler and Werner, 2004). The ability to stop and start the flow allows work to be done on the fill distribution system or fill plant without necessarily having to flush the distribution system.

The full stream of tailings is often used in the preparation of paste but very rarely can the complete stream be used because of volume increases resulting from crushing/grinding of ore. Previously, fine tailings streams could not be used as fill, mainly because of a lack of preparation technology and no real need to do so. The advantages of using the full stream of tailings include:

(Please use bullet points judiciously)

- The tailings are deposited at a greater density. This is not only in fill underground but also for tailings deposited on surface, reducing storage volume.
- A unique aspect of paste technology is the type of flow. The so called plug flow of paste fill has the following advantages:
  - Pipe velocities are often low, resulting in generally low wear of pipes and boreholes.

2.1 Paste fill performance

The two key performance requirements for a paste fill are, firstly, flow properties to transport the paste to the stope and, secondly, for the paste to meet the required demands on the fill stability. Vietti and Coghill (2006) have stated that the mining method will have a major impact on the selection of a filling method and filling should be considered an integral component of the mining process, rather than as a post mining activity.

2.2 Rate of filling

The demands on a fill mass are often closely related to the time between completion of ore extraction in the stope to be filled, and commencement of adjacent stoping.

2.2.1 Placement rate areas

The maximum placement rate is often determined by the supply of tailings from the mill. Although the total mill tailings product is commonly used in the paste fill, it is unlikely that all of the mill tailings generated can be placed underground. This is because the density of the paste fill is significantly less than that of the ore extracted to create the void to be filled. This supply—demand imbalance occurs even where a substantial quantity of ore concentrate is removed during mineral processing.

> *"The maximum placement rate is often determined by the supply of tailings from the mill. Although the total mill tailings product is commonly used in the paste fill, it is unlikely that all of the mill."*

2.2.1.1 Paste fill areas

Minerals Council of Australia (2007) states that the maximum placement rate is often determined by the supply of tailings from the mill. It is unlikely that all of the mill tailings generated can be placed underground. The interphase flux of liquid water and water vapour is coupled with heat transfer (Pashias et al., 1996) as follows:

$$C_h \frac{\partial T}{\partial y} = \frac{\partial}{\partial y}\left(\lambda \frac{\partial T}{\partial y}\right) - L_v \left(\frac{P + P_v}{P}\right) \frac{\partial}{\partial y}\left(D_v \frac{\partial P_v}{\partial y}\right) \tag{1}$$

Where:

C_h = volumetric specific heat (J/m^3-°C).

T = temperature (°C).

λ = thermal conductivity (W/m-°C).

L_v = latent heat of vapourisation (J/kg).

Acknowledgements

In situ density testing is an important method for determining the true density of a fill, both in terms of the absolute value and variability within the fill volume. In some cases, laboratory density tests can be inaccurate, particularly if the fill contains a wide size distribution and in situ flow mechanisms produce packing densities which vary from those produced in the laboratory. A common form of in situ density test is the sand replacement method.

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