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The Current Status of Hydraulic Backfill Techniques in South Africa

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The gold mining operation in South Africa produces a mixture of gold-bearing ore and broken waste rock which, after a primary separation of the barren waste is hauled to the surface. The end products of the mining operation are gold and two types of waste material, a broken rock and a silt sized rock flour. Up to the present a small proportion of the waste rock has been disposed of by hand packing into the stopes. The remaining waste rock is normally disposed of by mechanical tipping, while the slimes are pumped to form hydraulic fill slimes dams.

As the mining progresses in the direction of the reef, the deep (1,500—3,500 m) stope excavations close or converge under the tremendous rock overburden pressures of up to 100 MPa at a depth of 3,500 m. Conventionally the closure movement has been controlled by means of timber-concrete grillage supports on mat packs which are progressively compressed as the stope closes. The use of timber has several disadvantages:

I. The handling of the timber is labour intensive and occupies valuable shaft time.
II. The timber constitutes a fire hazard and ventilation is difficult to control because of the large open spaces between the packs.

As an alternative the hydraulic filling of stopes in deep mines with pumped tailings is an attractive proposition as a means of controlling the convergence of the stopes, absorbing energy released from the surrounding rock and increasing the percentage extraction of gold from wide reefs.

Although hydraulic stope filling has been practised in other parts of the world, it has not been used to a large extent in South Africa. The reasons for this include the following;

I. Because of the fine particle size of the slimes it was considered that a pumped slimes fill would not gain sufficient strength to provide useful support, but would simply be squeezed like toothpaste into the permanent travelways.
II. There has been a fear of "mudrushes" should a pumped fill break away while still liquid or if re-liquified by shock from blasting or rock movement.
III. To date to achieve pumpability a slimes slurry requires a water content varying from 45 % to 60 % depending on grinding. This excess water has to be removed once the fill has been placed.
IV. As a result of the fluid-like nature of the fill, retaining walls have to be used.

Over the past decade a considerable amount of work has been carried out in South Africa to overcome these difficulties.

Initially in 1977 an investigation was carried out on the strength and deformation properties of pumpable tailings slurries with water contents of up to 55 %. These slurries were established with the equivalent of 10 % of cement which resulted in a material that, initially is a pumpable slurry but which solidifies to a low strength solid soon after placing. If the solidified material is compressed at a rate slow enough to allow for consolidation, useful strengths are developed, the compressed material behaving as if purely frictional.

To prove the possibility of using a pumped cemented slurry as underground fill, a prototype experimental fill was pumped into place in a stope at a depth of 1,900 m below surface. A photograph of the retained fill taken after 3 months at a convergence of 33 % shows the retaining mesh intact even though the edges of the fill have developed a considerable bulge.

Although the results of the above tests proved encouraging the excess water and retaining wall problem had still not been overcome.

Research to date at the University of the Witwatersrand, Materials Handling Research Group, has indicated that much drier slurries pastes can be hydraulically pumped. Tests have shown that a water content of only 22—25 % is necessary for some slurries (Fig. 1) while this can be reduced to 12—15 % with the inclusion of waste rock.

These low water content slurries, however, result in high pressure gradients which necessitate the use of high pressure reciprocating pumps.

Recent tests on waste rock/slimes mixtures has made inroads into reducing the pressure gradient and could have important repercussions for existing and planned paste backfilling operations.

A series of tests was concluded with varying ratios of waste rock to slimes. The ratios varied from 20:80 (slimes: waste rock) to 60:40. The results indicated that a substantial decrease in pressure gradient could be achieved by adding the

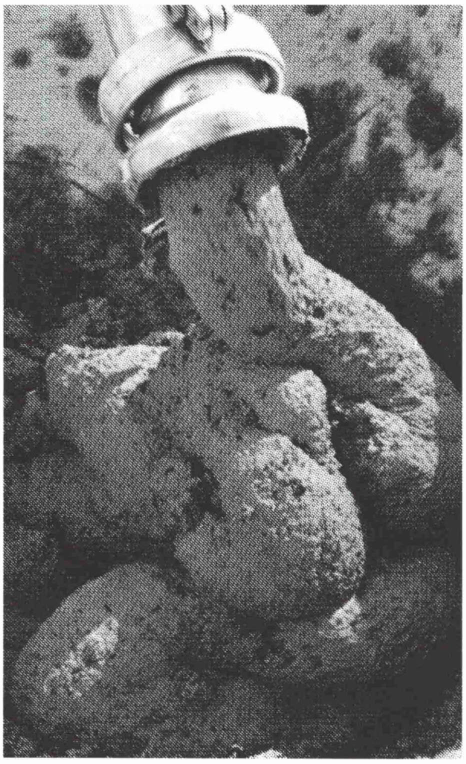

Fig. 1: High concentration slimes backfill

waste rock to the slimes. The best reduction appeared to be at a mixture ratio of 50:50.

This reduction in pressure gradient and hence power could result in an extension of the pumping distance, which in many applications is a critical factor.

It has further been established that the inclusion of the waste rock has an additional benefit in inhibiting the formation of scale on the pipe walls.

However, to obtain good pumpability, the mix for pumping must contain about 400 kg/m³ of fine material with a particle size less than 0.25 mm in size in the aggregates graded according to curve B according to DIN (German Industrial Standard) 1045 (Fig. 2).

A larger share of sand fines ensures less risk in case of fluctuations in the mix especially with crushed coarse aggregates.

The top size of the material pumped depends to a large extent on the pipe diameter; although a 1:10 ratio of particle diameter to pipe diameter is desirable, it is possible to pump without blockage problems at a 2:9 ratio.

The results obtained in the above studies has led to several South African mining houses setting up prototype backfill plants for the introduction of both a slimes only and a slimes/waste rock mixture in to the mines as a backfill.

The final formulation of the fill depends upon the availability of the constituents, the strength and energy absorption characteristics and the cost effectiveness of the backfill operation.

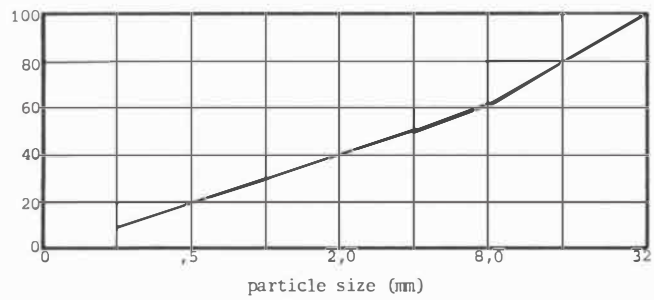

Fig. 2: Concrete grading curve for material up to 37.5 mm

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