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Experiences in the Use of Geofabrics in Underdrainage of Residue Deposits

Experimentation dans l'usage de géotextiles pour le drainage sous les residus

Underdrainage of a residue deposit helps the stability of the perimeter slopes by drawing down the seepage surface, preventing its emergence and reducing pore water pressures. Filter layers separate the deposited material and the underlying soil from the drainage medium while passing the seepage water. In South Africa, geofabrics have been used in filter drains under the walls of several gold slimes dams. At the ERGO dam, constructed by hydrocyclone separation, details of the filter drains have been improved with experience of their performance. Conditions where the filters can become clogged by iron precipitates should be avoided. At Crown Mines, new deposits are placed by the paddock method on top of existing slimes dams with inadequate underdrainage. New toe drains, incorporating geotextiles and open plastic mesh as separator-filters and to discharge seepage water, have been detailed with a view to fast, safe, easy installation. The use of geofabrics in residue underdrainage applications must still be proved by satisfactory long term performance.

Le drainage des résidus stabilise les pentes périmétriques en abaissant la surface d'infiltration, en empêchant son émergence et en réduisant la pression interstitielle de l'eau. Des couches filtrantes séparent le matériau des drains des résidus et du sol. En Afrique du Sud, des géotextiles ont été utilisés dans des drains-filtres sous les murs de plusieurs barrages pour les boues des mines d'or. Au barrage d'ERGO - système cyclone -, des details des drains-filtres ont été améliorés en fonction de l'expérience acquise. Il convient d'éviter le blocage des filtres par des précipités ferrugineux. Aux Crown Mines, des dépots sont ajoutés à des barrages anciens dont le drainage est insuffisant. Des drains nouveaux aux pieds des pentes comprennent des géotextiles et des treillis en plastique comme filtres-séparateurs et l'écoulement d'infiltration. Leur conception permet une installation rapide, simple et sûre. La performance à long terme des géotextiles dans ces applications reste cependant à confirmer.

INTRODUCTION

Considerable quantities of waste residues are produced when valuable constituents are extracted from mineral ores. The waste products, often in slurry form, are commonly deposited in tailings or slimes dams.

The fine wet residue deposits are retained behind confining walls which are often constructed from the waste material itself. It is obviously essential to maintain the stability of the whole perimeter of each dam.

A major contribution to the slope stability can be obtained by drawing down the seepage surface by the provision of underdrainage. In this way the pore water pressures in the deposit are reduced and the material strength correspondingly increased. In addition seepage is prevented from emerging on the slopes.

It is important to ensure that the drainage system will always operate efficiently, both during construction of the residue deposit over a period of ten years or more and subsequent to its completion. For this reason, filter layers are provided to separate the deposited material and the underlying soil from the drainage medium while at the same time permitting the seepage water to pass through.

In South Africa, geofabrics have been used in the construction of filter drains under the walls of a number of slimes dams. Experiences with these applications at several gold slimes dams on the Witwatersrand are described below.

ERGO TAILINGS DAM

Project Description

The East Rand Gold & Uranium (ERGO) project has been established to recover mineral-rich material from a number of old residue deposits slimes dams in the Springs area and to extract gold, uranium and sulphuric acid. The resultant residues are disposed of in a new slimes dam sited across a shallow valley some 10 km away from the process plant.

The walls of the dam are constructed of cycloned coarse slimes within earthfill toe walls. The cyclone underflow produces a free-draining, free-standing, high strength outer wall within which the fine overflow material is deposited. The dam will eventually reach a maximum height of 64 m above the valley floor.

The dam, one of the largest in the southern hemisphere, covers an area of 790 ha and, within its perimeter of 11 700 m, 360 million tonnes of slimes will be deposited at the rate of 1,5 million tonnes per month.

Filter drains

To ensure that the outer impounding walls are properly drained, filter drains have been installed prior to the start of deposition. Longitudinal drains are provided under the centre of the coarse slimes wall and close to the toe wall and, in the valley sections where the wall will be high and wide, intermediate between the two. Lateral outlet drains are provided at intervals from 30 to 200 m depending on the expected flow volume.

The drains have been laid in stages as the wall extends further up the valley flanks. As indicated in Fig. 1, the construction details of the original installation in 1977 have been modified for the 1979 extensions as a result of observations of the drain performance. For example, it has been found beneficial to use 19 mm rather than 13 mm filter stone and to introduce a 150 mm diameter perforated pipe into the centre of the drains.

The provision of more than two layers of natural filter aggregates would have been unduly laborious and, furthermore, natural gravels for intermediate filters were not readily obtainable. Hence, geofabrics were used to wrap around the coarse filter stone and separate it from the surrounding natural ground or filter sand. This system provied to be effective and simple to lay.

On the South African Highveld 1 600 m above sea level, the sunlight is strong and it is essential to use ultra-violet resistant materials. Otherwise the geofabric is likely to become brittle and disintegrate before it is buried under the tailings cover.

Problems

Several years after the drains had been laid, it was noticed that at certain places the drains were not flowing satisfactorily.

In one area where coarse slimes deposition had started only recently, the drain became exposed by flowing stormwater (Photos 1 and 2). In places, the fabric was torn by sharp aggregate particles carried by the water, but otherwise it was not damaged physically at this stage. However, where it had been exposed to air for any length of time, as illustrated in the lower part of Photo 2, it was discoloured and impermeable to water. Freshly exposed sections, such as in the upper part of Photo 2; were still permeable. Examination of the fabric showed that it was clogged with fine slimes particles held in place by an iron oxide precipitate.

As the deterioration of the geofabric was restricted to areas where it had been exposed to the atmosphere, it was concluded that as long as the drains remained covered there was no cause for concern. An attempt was made to reproduce the phenomenon in the laboratory using the same materials (slimes, geofabric, water collected from the filter drain) as on site and exposed to air and sunlight. The test arrangement is shown in Photo 3. However, the clogging observed in the field could not be reproduced in the laboratory in five months of experiment.

A few months after the first clogging observations, it was noticed that certain of the lateral filter drains in areas close to fairly high sections of the coarse wall appeared to have insufficient drainage capacity. When one of these drains was opened up for inspection, there was little apparent clogging due to slimes. However, a noticeable ochre-brown deposit was observed on the geofabric and on the enclosed stone aggregate.

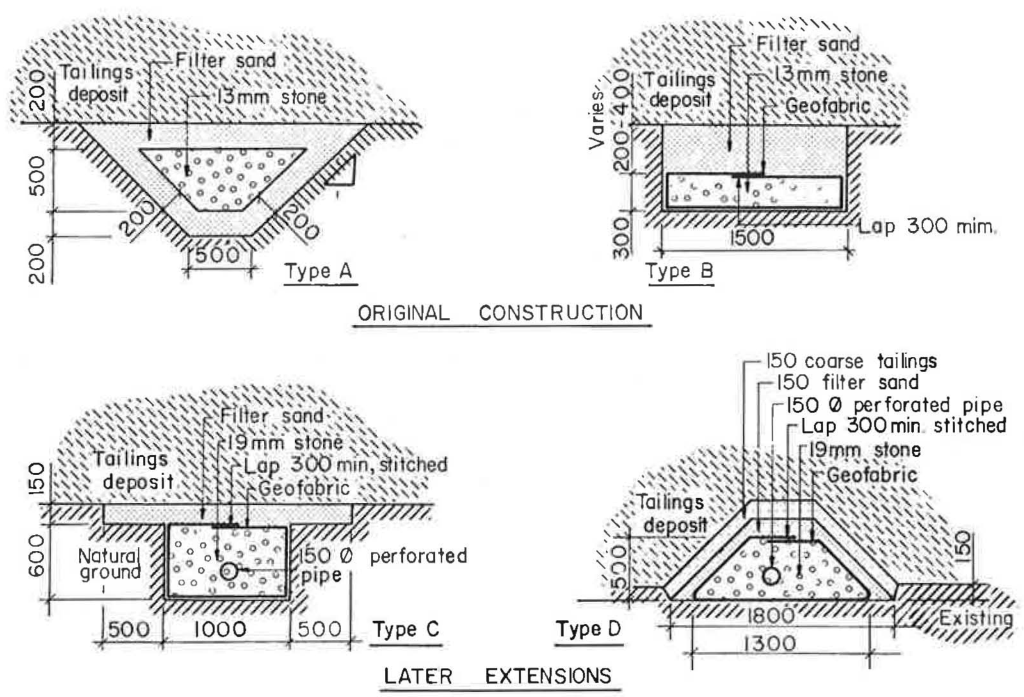

Fig. 1 : ERGO Tailings dam - Typical filter drain details

Photo 1 : ERGO Tailings dam - Exposed filter drain, no physical damage to fabric.

Photo 2 : Close-up of photo 1 - Top recently exposed and still pervious, bottom discoloured and impervious.

The observed clogging of the geofabric and the filter material has been explained as due to the precipitation of ferric hydroxides, such as goethite, on oxidation of ferrous compounds in solution at pH less than about 5. Usually the pH of the water reaching the slimes dam is above 6 and any insoluble iron compounds have been precipitated out at a much earlier stage in the process. However, when certain items of the plant are out of commission and the pH is not properly controlled, it is noticeable how quickly the ferric precipitate can build up in the filter drains at locations where oxidation can take place. This is a situation to beware of.

CROWN SANDS SLIMES DISPOSAL

Project Description

Old gold-containing sand dumps and slimes dams in the Crown Mines area of Johannesburg are being retreated in a recently completed plant. As there are no areas available in the vicinity of the city for the establishment of new residue deposits, the wastes produced by the new plant are to be placed on top of existing slimes dams which have been dormant for some years.

The new deposits will eventually add a maximum of 33 m height to the dams which are already up to 31 m above original ground level. The material is being placed by the paddock method traditional to the gold mines in South Africa.

In this method the slimes dam wall is built up in stages in paddocks 20 to 30 m wide and up to 200 or 300 m long, as follows:

1) A layer of slurry is deposited in the paddock.
2) This deposit is allowed to dry out for a few days while the slurry is directed to other paddocks.
3) As soon as the material has developed some strength, ridges 10 to 15 cm high and 30 to 50 cm wide are packed up by hand along the edges of the paddock.
4) Another layer of slurry is directed into the paddock.

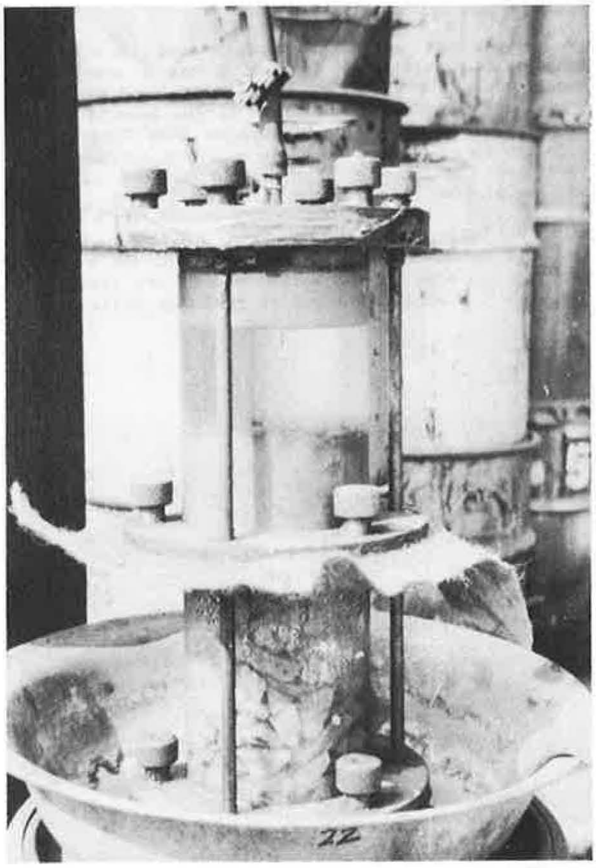

Photo 3 : Laboratory simulation of filter drain performance.

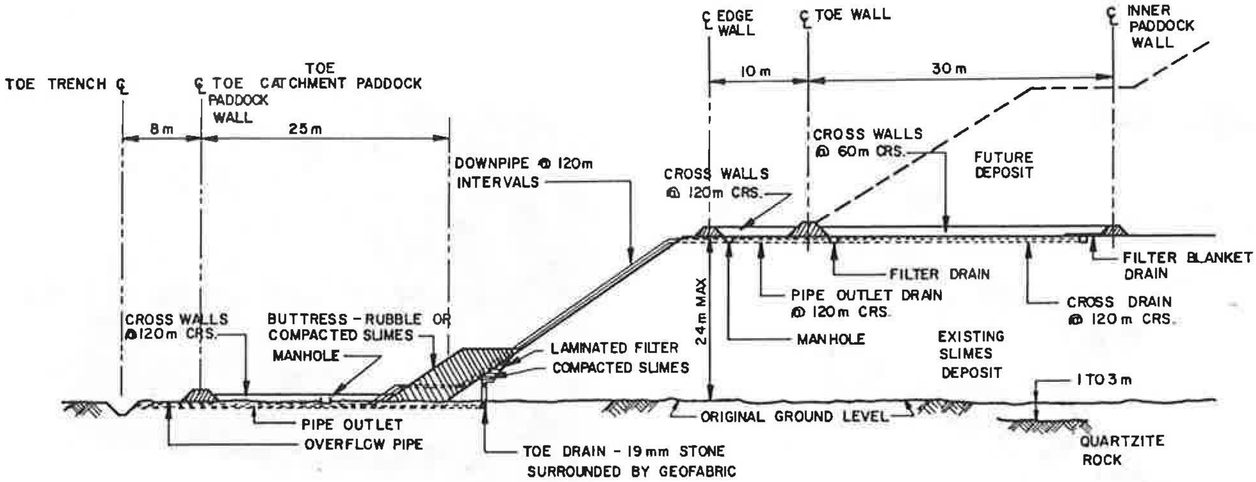

Fig. 2 : Crown Sand Slimes Disposal - Typical section on existing dam

A total of about 75 million tonnes of gold slimes will be placed at the rate of 370 000 tonnes per month on top of two existing deposits covering approximately 285 ha with a total perimeter of 7 800 m.

Drainage Provisions

By present day standards, and bearing in mind the considerable height of deposition to be added, the underdrainage of the existing dams is considered inadequate. Computer simulations of the seepage regime have shown that two sets of drains (see Fig. 2) are required to ensure that seepage will not emerge at the face and that a high piezometric surface will not adversely affect the slope stability.

Firstly, filter drains have been provided below the new wall paddocks around the perimeter of the existing dam top surfaces. These filter drains are similar to the Type C drains installed at the ERGO Tailings dam and illustrated in Fig. 1. A typical installation is shown in Photo 4.

Secondly, new interceptor drains have been installed at the toes of the existing slopes. As shown in the typical detail in Fig. 3, geotextiles have been used both as separator-filters and, in conjunction with an open plastic mesh, to intercept and discharge seepage water in the plane of the fabric. The existing slimes have a grading (100% finer than 425 um, 30 to 95% finer than 75 um and 9 to 18% finer than 2 um) typical of silt or silty fine sand.

Photo 4 : Crown Sand Slimes Disposal - Filter drain under construction with fabric turned back to expose the stone.

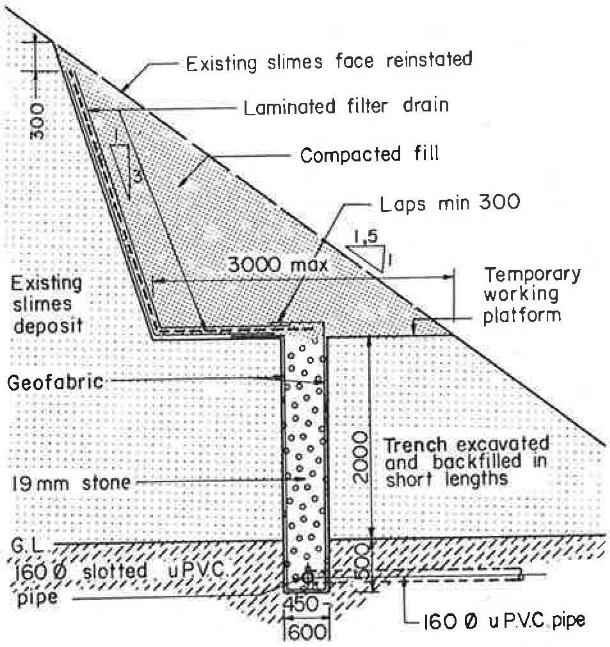

Fig. 3 : Crown Sand Slimes Disposal - Toe drain detail

Photo 5 : Toe drain under construction - Fabric laid in excavated trench, slotted pipe inserted and stone filling started.

Photo 6 : Toe drain under construction - Trench backfilled with filter stone.

The toe drain consists of a 3 m high laminated filter drain leading into a 2 m deep, stone-filled trench which is drained by uPVC outlet pipes. The geofabric prevents the fines from entering the drain while the plastic mesh provides a discharge path for the seepage water to reach the trench and outlet pipes. The laminated filter drain is actually a sandwich of a heavy grade open plastic mesh sandwiched between two layers of geofabric.

The drain was constructed by digging the trench from a working platform excavated into the face above the toe. A sheet of geofabric was inserted, the slotted pipe dropped in (Photo 5) and the trench filled with stone (Photo 6). Before the cut was backfilled with compacted slimes, the laminated filter drain was installed by simply pinning sheets of the material to the near vertical cut face (Photo 7).

Photo 7 : Placing of laminated filter drain.

Photo 8 : Crown Sand Slimes Disposal - Filter drain under healing wall.

Because of the ease and speed of installation the method eliminated construction problems which would otherwise have been experienced with conventional sand filter drains. For safety reasons, most of the working operations were carried out from the platforms and, as far as possible, personnel were kept out of the trench. The trench was opened up in short lengths which could be refilled the same day. In certain areas where the material was soft and wet, the trench had to be refilled immediately after excavation before the sides caved in.

In addition to the drains already described, filter drains were also installed to collect and remove seepage water from a particularly wet area on the side of one of the existing dams. In this area washaways had occurred in the past and a "healing wall" was now built to complete the perimeter for renewed deposition. The construction of this drain is illustrated in Photo 8.

At the time of writing, operation of the scheme is about to begin, so the efficiency of the drainage measures has not yet been observed.

CONCLUSIONS

Two examples of the use of geofabrics in the underdrainage of gold slimes residue deposits have been described. Geofabrics have also been installed in filter drains in other situations, including gypsum and diamond slimes dams.

The earliest applications have been operating for 5 years, while others have been installed only recently. Problems have been encountered at the ERGO Tailings dam with the precipitation of ferric compounds on the geofabric, but possibly similar clogging could have occurred also in graded sand drains without the geofabric. Elsewhere, in the author's experience, the geofabric drains have functioned satisfactorily.

Nevertheless, before the use of geofabrics in residue underdrainage applications can be generally accepted, the most effective installation details must still be confirmed and their satisfactory long term performance proved in practice.