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Filter-pressed tailings facility design, construction, and operating guidelines

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ABSTRACT

Filter-pressed tailings facilities have been designed, constructed, and operated since the late 1980 when Greens Creek, Alaska first adopted the method. Currently more and more mining companies are considering filter-pressed tailings management as a way to reduce water consumption and possibly reduce the risk of failure of the tailings facility. This paper describes guidelines for decision making in support of the design, construction, and operation of filter-pressed tailings facilities. The guidelines are based on recent projects on which the authors have worked. The paper emphasizes the need to characterise the site, establish realistic tailings properties, take into account site-specific climate and seismicity, and the possible need to amend tailings to achieve moisture contents that facilitate compaction and strength gain of the tailings. The paper discusses alternate stack geometries that may be required to facilitate construction, achieve moisture control, manage surface water, and limit seepage and groundwater impact. Finally the paper proposes a risk assessment approach to guide selection of tolerable risks that are inevitably involved in all tailings operations—and pursue the goal of a zero-failure operation.

1 INTRODUCTION

Since the expert report on the failure of Mount Polley stated that the safest tailings facility is one with no water on or in the tailings, much attention has turned to filter press tailings facilities. This paper follows on one we wrote on a similar topic some years ago, Caldwell (2013). In this paper we write about the many observations and ideas about filter press tailings stacks that have come our way in the past two years.

What we write is based on case histories that we are involved with, our reading of what many others write about the topic, and intensive discussions and arguments with our tailings colleagues. The views are our own, and we are responsible for them. But nothing we write here should be taken as advice, for every tailings sack is different and nothing is of general applicability.

Figure 1. Placing filter pressed tailings at the Greens Creek facility. This stack has been in successful operation since the late 1980s.

2 THE FILTER PRESS SYSTEM

The filter pressed tailings stack is but part of a bigger system which may include:

- The grinding circuit
- The filter press units
- The conveyance systems
- The stacker pad
- The mine backfill system.

The grind of the tailings is determined by the need to reduce the ore to a size or gradation that yields optimum metal recovery. The best gradation for the tailings stack plays little to no part in the selection of the grind. A coarse grind that would be best for tailings placement may yield too little metal recovery. Conversely, a very fine grind may yield greater metal recovery, but cost too much to justify the energy of grinding and filter pressing.

The more expensive the filter press plant, the more water it is likely able to squeeze out. We know of plants that can get the tailings down to fourteen percent moisture content. But this cost money. And may not be optimum for the mine backfilling system.

At mines where filter pressing is done, a certain percentage of the tailings may be returned underground as backfill. This commonly involves reslurrying the tailings, adding cement, pumping underground, and placing in worked-out stopes. Too dry a filter cake from the filter press plant, and the slurry plant and cement addition units may be compromised. Some plants we know of like to receive the tailings at no less than nineteen percent moisture content. This is too wet for convenient placement at the tailings stack.

The issue arises because the demand of the underground backfilling system varies erratically. Interruption of placement may occur frequently and unscheduled. Thus the pressure is on the filter plant operators to always have a nineteen percent moisture content tailings ready to switch from delivery to the stack to delivery to the backfilling system.

Conventionally, the tailings destined for the stack is conveyed to a stacker pad by a conveyer. At the stack it is dumped into piles from which it is placed into trucks for delivery to the tailings facility. In wet climates, it may be good to have a roof over the stacker pad to avoid rain onto the tailings. Yet some believe the effect of rain onto the tailings at the stacker pad is a minor factor in tailings moisture control, and many stacker pads do not have roofs.

Figure 2. The roof over the stacker pad of the Marlin Mine, Guatemala filter press tailings facility.

If there is room, it is best to have a large stacker pad area. Thus if the tailings are delivered to the stacker pad wet, they may be spread and allowed to drain and dry before being put in trucks and taken to the tailings facility itself.

3 MOISTURE CONDITIONING

If the tailings are above optimum compaction moisture content, it may be necessary to condition them before compaction. The tailings need to be dried somehow. Options include:

- Stockpiling in a non-placement area and allowing them to drain and dry
- Repeated ploughing and disking
- Addition of lime
- Addition of cement.

Stockpiling may be suitable where there is a dry and a wet season. Tailings produced in the wet season may be stockpiled and allow to dry during the dry season. This involves double handling and the need for a large stockpile area.

At sites where rain is intermittent or even torrential, it may be possible to arrange the workday so that just before the storm, the upper surface of the tailings is compacted with a smooth-drum roller. This prevents precipitation entering the tailings, and instead induces it to runoff. The upper surface of the tailings should be inclined to expedite runoff while limiting erosion by the runoff..

Then when the storm is passed, go back and disk or plough the tailings to reduce moisture content.

Lime or cement may be added in amounts from a 0.5 to 1.5 percent. The lime or cement changes the optimum compaction moisture content, thereby facilitating compaction. In time the lime or cement may also contribute to an increase in the cured strength of the tailings.

Figure 3. Filter pressed tailings in place and being disked to reduce moisture content.

4 PORE PRESSURE MANAGEMENT

If in spite of the best efforts, the tailings are placed too wet, excess pore pressures may develop. Is it suspected this is happening, it is advisable to push a few cone penetrometer tests (CPT). This rapidly establishes the presence of excess pore pressures. If the pore pressures are too high, you may have to install wick drains to expedite pore pressure dissipation. Alternatively slow down tailings placement and allow the pressures to dissipate naturally. The old rule of a rate of rise of no more than two meters a year is a good one---albeit seldom attainable.

If development of excess pore pressures is a persistent issue, it may be advisable to place layers of waste rock every few meters rise of the tailings. The tailings are generally far less permeable than the rock. The presence of layers of permeable, unsaturated rock provides a great system to expedite natural pore pressure dissipation.

In addition, the rock may add some to the overall strength of the tailings and enable the stack to be constructed to steeper inclinations.

5 COLD WEATHER CONSTRAINTS

Greens Creek where for some thirty years there has been a successful filter pressed tailings facility is in the south panhandle of Alaska. It is not hot there, nor too cold. It is generally wet. Snow is generally not an issue.

There are many mines, however, in very cold and very wet climates. There are mines where there is a lot of snow that persists for long periods of the winter. Such sites are not good locations for filter pressed tailings facilities. You just cannot fight the snow and the rain and the wet tailings. Avoid consideration of filter pressing at such sites.

6 ACID GENERATING TAILINGS

Conventional wisdom is that acid generating tailings should be deposited underwater -- Wilson (2015). And at closure the tailings facility should be arranged to keep the tailings wet in the long term.

The fight rages whether it is practical or reasonable to close a wet tailings facility and keep a pond over the tailings in perpetuity. This is not the place to resolve the issue. There are many operating mines where acid generating tailings are being placed beneath water and are planned to stay that way past closure.

The issue we address is if a new filter press stack of acid generating tailings is feasible. In our opinion the answer is of course yes. The issues are really no different from those faced by heap leach pad operators. Place a basal liner. Construct a low infiltration cover. Compact the tailings so they are low permeability and do not pass water. Place the tailings dry so that their post-closure transient seepage is small. And at the worst, provide for perpetual capture and treatment of the seepage.

7 STACK GEOMETRY

The geometry of the filter pressed tailings stack is determined by the topography of the site. We distinguish these basic stack geometric shapes:

- Pyramid that may have a nearly square base of may have an elongated base. The ground on which the pyramid is constructed should preferably be flat or inclined at a gently slope.
- Sidehill where the stack is placed against the hillside and rises from a valley floor subtended by the hillsides.
- Valley Fill where the stack fills the valley extending from one adjacent hillside to the other.

The primary advantage of a pyramid is that it receives only directly incident precipitation. Thus it produces least contact water that may need to be treated. Sidehill stacks involve uphill diversion channels. If the overall stack is high, it may be necessary to construct a series of uphill diversion channels as the tailings elevation rises. Regardless of the number of such sidehill channels there is always some additional uphill area contributing excess water to the contact water system. And there is always the fact that the sidehill channels are sized for a limited precipitation event---when it rains more, the channel overflows and excess water comes down onto the tailings working surface.

A true valley fill has to be able to deal with the upgradient runoff. This may be diverted or may be allowed to come on down to the tailings working surface. From there the excess water may be pumped off. Depending on the water quality, the excess water may be discharged or treated.

The pyramid is disadvantaged by the limitation of lesser volume (capacity) per footprint area than the other two basic layouts. In addition, the pyramid has a larger exterior perimeter surface that ultimately has to be covered at closure. Yet at closure, there is no doubt but that the pyramid represents the most stable geomorphic form: as many old pyramids and earth mounds from Egypt, to Chaokia, to central and south America attest, earth mounds may remain stable for more than 1,000 years.

Figure 4. The Chaokia earth mound in Illinois. It has stood stable for over 1,000 years.

8 MINE WASTE ROCK

At most mines there is waste rock to be managed. The waste rock may be beneficially used in construction of the tailings stack. Specifically the waste rock may be used to construct starter perimeter berms. The more waste rock available, the larger the berm can be and hence the greater contribution it may make to overall stack stability.

As the tailings rise, perimeter berms of waste rock may be placed before placing a subsequent rise of the tailings. Use of the waste rock to construct perimeter outer slopes aids greatly in limiting erosion of the silty, sand tailings, and provide a good base for a subsequent soil cover.

Figure 5. The Escobal Tailings Stack. In the foreground is the perimeter embankment made of waste rock that is covered soon after placement with topsoil and vegetated.

Figure 6. The outer face of the Escobal Tailings Stack. Here the tailings rise above the waste rock that is partially covered with soil and to the left already supporting vegetation.

9 CASE HISTORY 1

Martin et al (2015) describe the evaluation of alternative designs for the El Toqui, Chile tailings facility. They conclude that the filter press tailings can be used to construct a twenty-five meter high embankment behind which thickened tailings may be placed. This is an innovative and cost-effective approach.

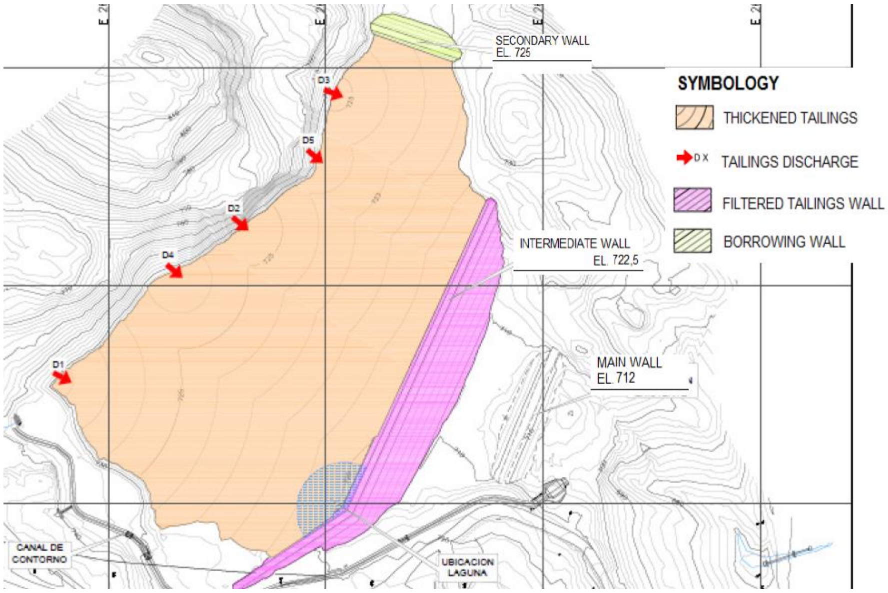

Figure 7. The layout of the propose El Toqui tailings facility.

10 CASE HISTORY 2

Although the Rosemont Copper mine proposed for Tucson, Arizona is controversial and delayed at present, they have mounted an extensive public relations campaign to promote the benefits of filter press tailings and the reduction of water use associated therewith. Their YouTube video is worth watching.

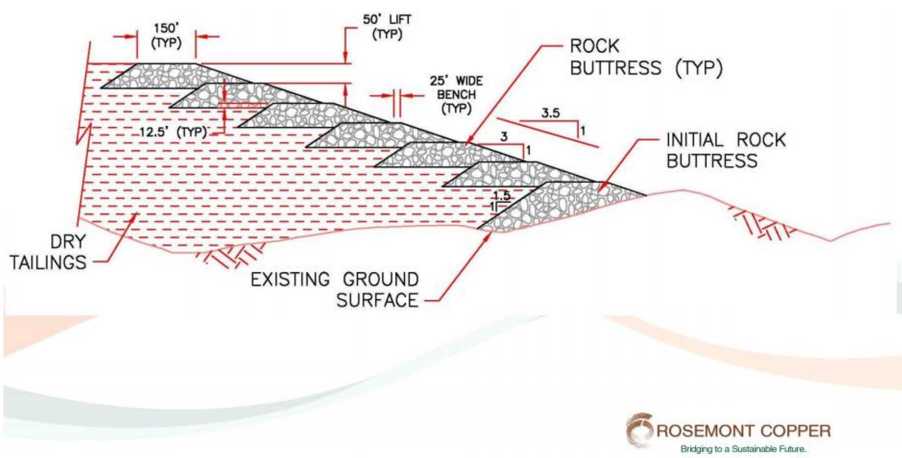

Figure 8. The Rosemont Copper filter press tailings facility would use a standard approach involving perimeter rock buttresses. See Newman 2010.

11 RISK ASSESSMENT

A standard risk assessment involves the following:

- Definition of the system.
- Identification of hazards.
- Quantification of probabilities.
- Definition of consequences.

- Quantification of risks.
- Establishment of risk tolerance.
- Ranking of risks.
- Identification of risk avoidance strategies.

Some risks to be considered in compiling a filter press tailings stack risk assessment are:

- The stability of slopes proximal to the stack and hence the issue of landslides.
- Erosion by large precipitation events.
- Flooding of the tailings placement surface by large storms.
- Failure to achieve design tailings moisture contents and the consequential development of excess pore pressures.
- Excessive seepage to groundwater.
- Earthquake and seismic stabilty.

A typical filter press risk register should include sections on: design; construction; operation; stack performance; closure; and post closure. The most significant risks associated with operation involve placement of tailings that are wetter than that required for optimum compaction. Tailings should not be placed at a moisture content where excess pore pressure could develop—and if it does, drains to relieve such pressure should be installed.

A second major issue to be managed as part of operation is control of the runoff water that if not rapidly removed could form a pool of contact water towards the backside of the upper surface of tailings being placed. The upper surface of the tailings should be placed at an inclination to grade to a central area of the surface. Precipitation runoff will flow to the low area. Such water must be immediately pumped back to the plant for treatment. In no case must a pool of water be allowed to develop or stand on the surface of the tailings placement area.

The risks associated with a pool include development of a phreatic line in the body of the tailings that could induce slope failure and the possibility of the pool overtopping the perimeter berms and hence the flow of water and tailings to the environment.

In general the risk associated with filter press tailings stacks are tolerable as part of responsible mining. In particular, we believe that of all tailings facility types, the long-term, post-closure performance of a filter press stack is vastly superior and the long-term risks small.

12 CONCLUSIONS

Filter press tailings facilities have been in successful operation for nearly thirty years. More and more mines are using or considering the approach. There are limitations include scale and climate. But the filter press manufacturers, the design engineers, and the mine operators are rising to the challenges and we can expect more advance to come.

Figure 9. The Greens Creek filter press tailings stack showing the outer slope on which vegetation has established naturally.

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