Converting slurry tailings facilities to filtered dry stacks – a case history

John Lupo – Newmont Mining Corporation
Marcelo Mussé - Consultant
Objectives

General discussion on the geotechnical issues.
Case history on a successful conversion.
Lessons learned.
Recommendations.
Purpose

Water management

• Critical issue
• Consumption (mining industry)
• Efficient use
• Greater interest in using filtered dry stack tailings.
Filtered Dry Stack Tailings

Lowest amount of water consumption.

Generally easier to handle and often can be stacked, thereby reducing storage space requirements, construction costs and, often, permitting costs.

Often can support concurrent reclamation.

Can have high up-front capital cost and operating costs. These costs need to be offset by the value of water in a cost-benefit analysis.
Existing Slurry Impoundments

Existing slurry tailings impoundments often targeted for filtered tailings storage:

• May reduce overall capital cost (no or limited construction required for storage)
• Impoundment area already permitted
• Real-estate for construction of a new facility often not available

However slurry impoundments are designed with a different intent that can complicate conversion.
Conversion Considerations

Slurry impoundments generally designed for no or limited access into the impoundment.

Access and tracking with heavy equipment a requirement for placement and stacking of filtered tails.

The ability to access and track over the slurried tailings surface is a function of the tailings mechanical and hydraulic properties, drainage conditions within the impoundment, depositional history/management and time.
Impoundment Characterisation

Prior to considering conversion, some level of characterisation (geotechnical, hydrogeologic, and geochemical) must be done. The level of characterisation is dependent on the site conditions, tailings properties, impoundment design basis and uncertainty. Characterisation could range from very extensive to minor.
Conversion from slurry to filtered dry stack changes the geotechnical, hydraulic and geochemical environment within the impoundment. For example:

• Air flow will now occur within the tailings mass...
• Stacking tailings introduces new failure mechanisms not considered in original design or risk assessment...
• While filtered tailings are generally unsaturated, local zones of saturation will develop ..... 

Are these changes and risk well understood and are they acceptable for the short and long-term performance of the facility?
Case Study
3 ktonne/ day operation in Mexico, in operation for several years.

Existing slurry tailings impoundment, fully lined (HDPE) to minimize seepage and water loss. Robust main containment embankment constructed of engineer fill.

Deposition by spigotting with some cycloning.

Tailings facility nearing maximum capacity.
Background 2 of 2

Limited real-estate near the operation for expanding the existing tailings impoundment.

Alternative sites not viable (both from cost and permit time schedule basis).

Dwindling water supply.
View of slurried tailings impoundment, looking upstream toward main containment embankment

Slurried tailings deposition by spigotting and cycloning

Old tailings storage cell

Reclaim pool
Characterisation Work

Geochemical characterisation completed by others. No geochemical issues identified.

Geotechnical:
• Borings and test pits (limited due to soft beach and availability of equipment).
• Laboratory: particle size distribution, moisture-density, and shear strength.

Process:
• Bench scale vacuum and mechanical filtration tests.
Tailings Grain Size

PSD shows 65 to 70 percent passing 0.075 mm
A Few Points on Shear Strength....

Shear strength testing is not a “one program fits all”. The program should be tailored toward the anticipated loading of each distinct project.

In addition, shear strength is just one component of the design approach. What is as important as shear strength is the stress path and volume behavior of the material (e.g. dilatant versus contractive behavior).
For this project ....

The main containment embankment is a very robust design and stability under the worst loading conditions was not an issue. No additional shear testing (beyond the original work) was conducted on these materials.

In-place tailings in variable states of density, so individual tests may have little meaning. Another approach would be needed.
Filtered Tailings

Filtered tailings would be produced at a more uniform density and moisture content.

Consolidated drained tests conducted at the maximum dry density and optimum moisture content.

These tests showed a positive volume change with shear, indicating dilatant behavior (phi = 33 degrees and zero cohesion).
Drained vs Undrained

Why test the filtered tailings under drained conditions and not undrained?

- Observations from site suggest that the tailings are well draining, even with 65-70% fines.
- Given the low processing rate and desire to maintain a low stacking height, development of saturation and excess pore pressures in stack unlikely.
- Out-of-spec tailings (e.g. wet or near saturated tailings) from filter plant would not be placed in stack, per the design.
## Filtration Tests

<table>
<thead>
<tr>
<th>Description</th>
<th>Cake dry density (kg/m(^3))</th>
<th>Cake moisture content (% by weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical press</td>
<td>1,715</td>
<td>14 to 16%</td>
</tr>
<tr>
<td>Vacuum belt</td>
<td>1,498</td>
<td>21 to 25%</td>
</tr>
</tbody>
</table>

Note: Moisture-Density tests indicate the filtered tailings have maximum dry density of 1,756 kg/m\(^3\) and an optimum moisture content of 12% by weight.
Filtered Tailings

Exit filter presses at or near the maximum dry density (Standard Proctor).

Moisture content a few points above optimum.

Filtration produces a material that is “preconsolidated”, dense state.

Reflected in shear as dilatant behavior. Important for liquefaction and seismic stability evaluations.
Design Concept
Schematic of Facility Prior to Conversion

- HDPE Liner
- 3H:1V Slope
- 8 m crest
- 3H:1V Slope
- Reclaim Pool
- Slime Tailings
- Sandy Tailings
- Main Containment Embankment
Schematic of Converted Facility

Design dry stack with maximum 2m lifts to minimise loading and potential for bearing failure. Filtered tailings compacted to maximum dry density and at optimum moisture content. Rock drainage layer placed to assist in drainage and stability.

Construct a 3 m thick platform providing a 10 m setback to stabilise toe of dry stack to provide stability and confinement.

Place out-of-spec tailings basin formed by filtered tailings and natural ground.

Placement of filtered tailings over soft slimes could result in local bearing failure. Adopt an “observational” approach to material placement.
Filtered Tailings Lift Concept

Extraction wells provided to help reduce phreatic surface within impoundment.
Concept

The design concept relies on the ability to stack filtered tailings over the existing slurried tailings surface.

As part of the conversion, the area nearest the main embankment needs to be drained and dried to the extent possible. On site experience indicated that the dried beach nearest the embankment could be trafficked by 40t trucks.
Test Fill

Although observations suggested that the dried surface could be trafficked, there was uncertainty on the bearing capacity under a fill.

Test fill was used to test the concept that the variable tailings could support a modest load from fill.

Test fill: 30 m x 50 m by 5 m thick fill placed and compacted.

Test fill showed some local signs of displacement (mud wave), but overall was stable.
View of Platform Construction
View of Filtered Dry Stack Tailings 4 Years Later

Inactive tailings impoundment now covered by filtered tailings

Old slimes and out-of-spec material area

Location of old reclaim pool

Compacted filtered tailings

Main embankment

Uncompacted filtered tailings
Conclusions

The filtered dry stack concept presented has worked well for over 4 years.

Facility was converted to dry stacking without an interruption of the operation.

The facility is being constructed following the original design concept with some minor changes (lesson learned).

Water levels within the impoundment have dropped consistently and no longer causing issues with material placement.
Lessons Learned 1 of 2

Safety is the number one issue. A safety plan with daily safety briefings were used to maintain a high level of diligence within the work force.

Not everything goes to plan, a key issue was getting as much water off the surface as soon as possible to allow some surface drying to occur. In a few areas, this was not achieved. As a result, some local bearing failures did develop. The remediation for these areas included placing a thicker rock drainage layer over the surface to help support the placement of tailings.
Lessons Learned 2 of 2

The success of this conversion is due primarily to having a high level of construction quality assurance on-site, full time. This level of observation help minimise issues that may have compromised the performance of the facility as well as increase the safety of the workers on the facility.
THANKS