Innovations in Tailings Management – Hydraulic “Dry” Stacking

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ABSTRACT: Tailings dewatering and water recovery have been a desirable objective of tailings deposition for many years and numerous attempts to achieve cost effective methods have been tried and tested over time. The size of the prize is significant and is growing as water scarcity increases. The solution for low-cost, high-water recovery, tailings storage arises from a systems approach and cannot be done in isolation from the complete flowsheet design.

Hydraulic dry stacking (HDS) is an innovative concept for tailings management developed after the successful implementation of coarse particle recovery (CPR) technology in base metal sulphide operations.

CPR generates a well graded fine to coarse sand reject waste stream removed from the process circuit prior to final flotation. HDS repurposes this waste stream and considers it a valuable product to be utilised in the management of tailings, with significant benefits particularly in the areas of sustainability, safety and public accountability.

The paper aims to present a summary of the proof of concept analyses conducted to date, including large scale laboratory trials, field scale trials and simulations, to support the efficacy of the technology by meeting key performance indicators including:

- Significant improvements in water recovery from tailings entrainment.
- Reduced carbon footprint over other trending technologies such as filtered tailings stacking.
- Reduced cost of disposal over other trending technologies such as filtered tailings stacking.
- Increased resistance to liquefaction over traditional hydraulically placed and managed tailings.
- Ability to visualise the state of the tailings, with safety status and public disclosure.

1 TAILINGS DISPOSAL

1.1 *Tailings Safety*

The safe storage and management of tailings is essential if mining is to maintain its social license to operate. Catastrophic failures in recent years have put mining into the spotlight for all the wrong reasons and the significant positive contribution that the industry is making to the energy transition is overshadowed by such tragedies.

In August 2020, The Global Industry Standard on Tailings Management was published and among other things, they focus on the tailings liquefaction risk and the areas downstream under threat from deadly mud-flows, releasing material with high potential energy. Halabi et al (2022) provides an excellent overview of tailings dam failures with reference to failures associated with liquefaction.

Unsaturated tailings are far less likely to undergo liquefaction (Yoshimi, 1989) and hence a tailings storage approach that removes the water will deliver enhanced safety performance; this is often the primary reason cited for moving to energy-intensive tailings disposal methods such as filtered tailings stacks.

HDS is a simple approach that utilizes the free draining reject sands from CPR to deliver effective dewatering channels throughout the tailings mass, accelerating consolidation and driving saturation levels towards (and below) 90% - mitigating much of the liquefaction risk. The technology exploits hydraulic delivery systems and although operating costs will rise the approach will deliver comparable safety, water, closure performance while still being significantly less expensive than filtered tailings. Increased costs related to monitoring and measurement can be expected, but these higher costs are necessary regardless of the technology chosen.

The future of tailings disposal involves tighter monitoring, management and control of a facility; knowing the saturation levels, consolidation rates and real-time water balance will become the norm, not the exception. Tailings facilities should be considered water sources and construction sites that are delivering valuable land for post-closure use.

1.2 *Water Recovery*

Water removal delivers a safer facility but with 70% of Anglo Americans operations in water scarce areas, the conservation of water delivers tremendous value through the reduction, or even elimination of freshwater abstraction. Tailings storage is almost always the biggest water sink within a mining operation.

Each tailings facility is different but in studies across the company’s sites, we are targeting a 30% reduction in water loss per tonne of tailings placed. Once water removal is facilitated through the stack design, we need to keep it out. Separate water return dams that are fully lined (or even covered) can offer additional water conservation by reducing the large shallow lakes or wet beaches often associated with large tailings facilities.

1.3 *Closure*

The mantra of zero waste is often discussed in the context of mining operations but the scale of the issue is often overlooked with lower grade deposits exploited driving a disproportionate quantity of uneconomic material requiring disposal / storage. Through the utilization of HDS, the tailings storage area can be designed from the start to offer valuable footprint for economic activities such as agri-voltaics or other value-accretive purposes to leave a mining site more economically productive than before the mining operation began. Rapid consolidation of the tailings, coupled with creative long term regional development thinking can change the conversation about tailings – from one of risk mitigation to opportunity creation.

2 INTRODUCTION OF HDS

2.1 *Enabling Technology*

Coarse Particle Recovery (CPR) has been used industrially for the last twenty years. The Eriez HydroFloat is effective for floating coarse particles, compared with conventional flotation because it uses a counter-current aerated fluidized bed and zero-order froth (Mankosa et al, 2016).

The company has been active in applying the technology in base metal sulphides, and the early application in sulphides flotation was in tail scavenging. The three main advantages of tail scavenging of coarse particles are improved global recovery, typically 3-6%, the potential to increase the grind size of the mill circuit, and the de-coupled nature of the CPR plant with respect to the main concentrator.

While these benefits alone can provide justification, an added benefit of generating a coarse waste stream (which reduces the volume of material going through the ball mill) makes the economics more attractive. This coarse waste, characterized by a very low fines content (<5% <100um), delivered a free draining sand – raising water recovery opportunities.

2.2 *Developing the HDS concept*

The potential water benefits of employing COP was first noted through the adoption of a separate sand stack (Filmer, 2018) or blended stack (Filmer, 2020) but then realized the potential of co-disposal of the discrete tailings streams into an engineered stack that encourages air entry, facilitating rapid consolidation and dewatering (Filmer, 2020). The HDS concept was developed with WSP Golder in 2019, with an initial design for a large-scale demonstration facility first presented in early 2020.

The expected benefits were driven by water recovery and included several drainage channels across the facility, connected with contiguous planar drains delivering a tailings sandwich which, it was hypothesized, would deliver very rapid dewatering.

The reject sands, termed “CPR sands” all had one thing in common – hardly any material less than 100 microns; and hence were free draining under gravity. Given the CPR sands were derived from the total tailings themselves; as a drainage medium they were highly compatible and testing (described in detail below) demonstrated excellent dewatering capacity.

As the technology has been developed, new variations have been developed and patented – the construction of large, thin, planar drainage layers across large multi-km^2 tailings facilities was operationally difficult and although feasible at a demonstration scale of ~100tph, the application for a large copper operation at thousands of tonnes per hour was going to be capital intensive.

Recent designs have focused on rapidly placing drainage channels and exploiting the anisotropy between horizontal and vertical permeability. As described below, the testing and design journey undertaken has delivered a robust design concept that has the potential to fundamentally change the way tailings are viewed.

3 PROOF OF CONCEPT LARGE SCALE LABORATORY TEST WORK

3.1 *Material Characterisation Test Work*

To assess the efficacy of the concept of interbedded tailings and CPR sands a series of laboratory tests were conducted by Golder Associates to assess the material characteristics of both tailings and CPR sands. Mogalakwena platinum mine provided representative samples of tailings and CPR sands; extensive testing has now been completed across a number of sites.

The following testing was conducted to characterise the materials geotechnical properties for the purpose of assessing the efficacy of the HDS concept:

- Classifications including particle distributions and plasticity;
- Column settlement tests;
- Slurry Consolidometers;
- Soil water characteristic curves, and
- Triaxial permeabilities.

3.1.1 *Classification*

The basic classification results are presented in Table 1, with the particle size distributions in Figure 1.

Table 1. Summary of geotechnical classifications.

Parameter	Tailings	CPR Sands
Specific gravity	3.03 t/m^3	2.94 t/m^3
Plasticity Index	NP	NP
Cu	16.85	2.18
D_{80}	110 µm	380 µm
Fines Content	63%	0%
Clay Content	8%	0%

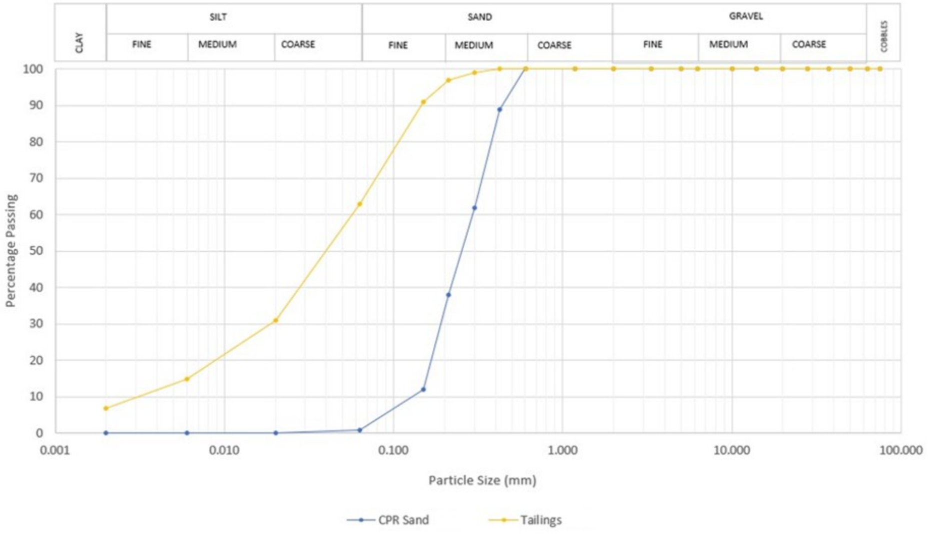


Figure 1. Particle size distributions.

Undrained column settlement test were conducted in order to establish an estimate of the initial voids ratio of samples reconstituted in the large scale laboratory test apparatus. In addition to this, a falling head permeability test was conducted on the CPR sands upon completion of a drained column settlement test. The characteristics values are summarised in Table 2.

Table 2. Summary of column settlement test results.

Parameter	Tailings	CPR Sands
Initial % solids	47%	50%
Settled dry density (γ_d)	1.06 t/m^3	1.35 t/m^3
Voids ratio (e_o)	1.96	1.11
% solids at e_o	61%	72%
Moisture content at e_o	65%	38%
Vertical permeability at e_o		2.01 E-04 m/s

Large strain consolidometer tests were performed using a slurry consolidometer. Samples were prepared at the initial voids ratio (e_o) obtained from the column settlement tests. The characteristics values are summarised in Table 3 at an applied pressure of 50 kPa.

Table 3. Summary of consolidometer test results at 50 kPa applied pressure.

Parameter	Tailings	CPR Sands
m_v	1.1 m^2/MN	0.11 m^2/MN
C_v	240 m^2/yr	72,235 m^2/yr
C_c	0.14	0.05
e	0.9	0.88
γ_d	1.54 t/m^3	1.54 t/m^3
k_v	7.2 E-08 m/s	2.0 E-04 m/s

Soil water characteristic curves (SWCC) were assessed initially using the particle distributions (Chin 2010) and subsequently assessed by laboratory test work. The drying curves are presented in Figure 2.

The test results show that the tailings material is a well graded silt to fine sand with a low non plastic clay fines content, corroborated by scanning electron microscope results indicating clays predominated by iron sulfide or sulfates. The materials consolidate quickly and have an air entry value indicating that they are likely to be conducive to gravitational dewatering at low suction pressures. The CPR sands are a well graded fine to medium sand with no fines (i.e. particles passing 63 um sieve). The materials are effectively considered to be free draining sands.

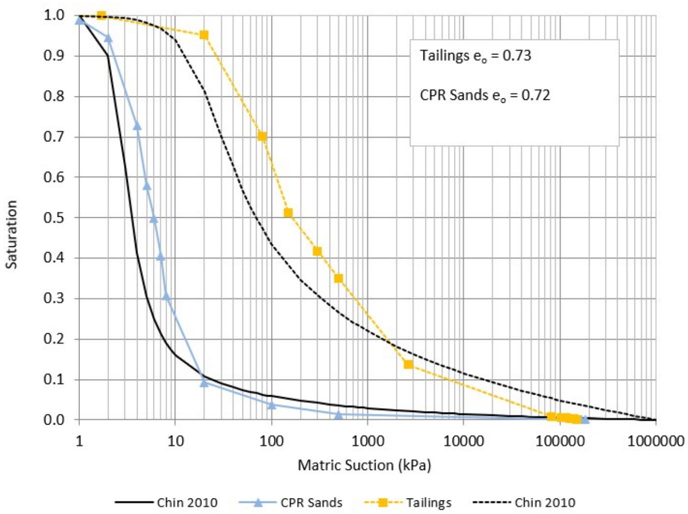


Figure 2. Soil water characteristic curves for tailings an CPR sands.

3.2 *Large Scale Test Rig*

In order to ascertain how well the interbedded tailings and sand lenses may drain in a field scale operation beyond reliance on standard laboratory test results and computer modelling, a large laboratory test was devised.

The test was undertaken on samples of CPR sands and tailings obtained from Mogalakwena platinum mine. Preliminary assumptions on layer thicknesses were used to infer the size of the test apparatus. An approximate 1/10th vertical scale was selected with interbedded layers of CPR sands 150 mm thick and layers of tailings 350 mm thick. Three 500 mm layers were to be formed with drainage valves provided at the base of each sand layer.

A large Perspex box with internal dimensions 1 m x 1 m square, was constructed out of 3 equally sized 500 mm deep sections bolted together, supported on a structural steel frame. The modular approach was selected for ease of transportation, filling, post-trial sub sampling and decommissioning.

The apparatus was fitted with a large array of instruments focused dewatering of the tailings and CPR sands. Instruments included:

- Eight LS-10 vibrating wire piezometers;
- Eight Teros32 tensiometers;
- Five MPS-6 ceramic plate soil water potential sensors;
- Nine Teros12 volumetric water content probes, and
- Two TPC-4000 total pressure cells (1 horizontal, 1 vertical).

The instruments were mounted on a central frame at various depths of each layer, as can be seen in Figure 3. In addition to the instruments mounted in the apparatus a series of raspberry pi cameras were set up outside the box to enable some visual assessment of the layer consolidation during set up for initial conditions.

3.2.1 *Test Procedure and Initial Conditions*

The intention of the procedure was to establish three fully saturated interbedded layers of CPR sands and tailings such that they were as close to the estimated initial voids ratios predicted from column settlement test prior to observing the desaturation phase.

Other than the very first layer of CPR sands (layer 1), the CPR sands and tailings were manually mixed into slurries at 50% solids and poured into the box in their respective layers using a header tank and dropper pipe arrangement. The first layer of CPR sand was placed moist tamped and wetting using a very slow misting technique. This technique was abandoned for subsequent layers in favour of the slurry deposition method due to the time for placement and the difficulty of placing moist tamped CPR sands on top of very soft fully saturated tailings.

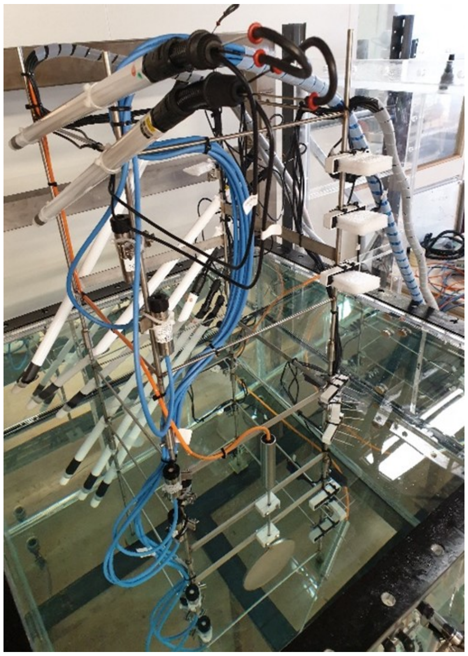


Figure 3. Instrumentation on internal mounting frame.

The apparatus was filled over the course of approximately 50 days with each tailings layer allowed to consolidate under self-weight prior to placement of the subsequent layers in order to minimise the amount of consolidation that would occur during the desaturation stage. Consolidation of placed layers was assessed by visual observation using the raspberry pi cameras. Each layer placement was carried out in several stages to allow for the decanting of excess supernatant water.

The volume of solids used in each layer of CPR sand and tailings was recorded during preparation of samples. The layer thickness was measured as accurately as possible and the initial conditions established, as summarised in Table 4.

Table 4. Initial conditions for each layer

Layer ID	Initial voids ratio (e_o)
Tailings Layer 3	1.35
CPR Sand Layer 3	0.52
Tailings Layer 2	1.46
CPR Sand Layer 2	0.51
Tailings Layer 1	1.12
CPR Sand Layer 1	0.87

The difference in the voids ratio of CPR sand layer 1 compared to layers 2 and 3 is a function of the method of placement. The placement using the slurry method rendered much lower voids ratios than obtained in column settlement tests, which is likely to be attributable to the larger area of deposition enabling greater supernatant release.

3.3 *Simulation*

A simplified 2 dimensional transient seepage model of the laboratory test was developed in SEEP/W to assess the likely behaviour of the test in advance of the starting the desaturation stage. The model was not coupled to a consolidation analyses, and as such relatively conservative values of permeability were modelled.

Suction developed in the box after 15 days is presented on Figure 4 and includes the position of Teros32 suction transducers (tensiometers A to I) and MPS-6 soil water potential instruments (W1 to W5). The estimate degree of saturation from was also assessed.

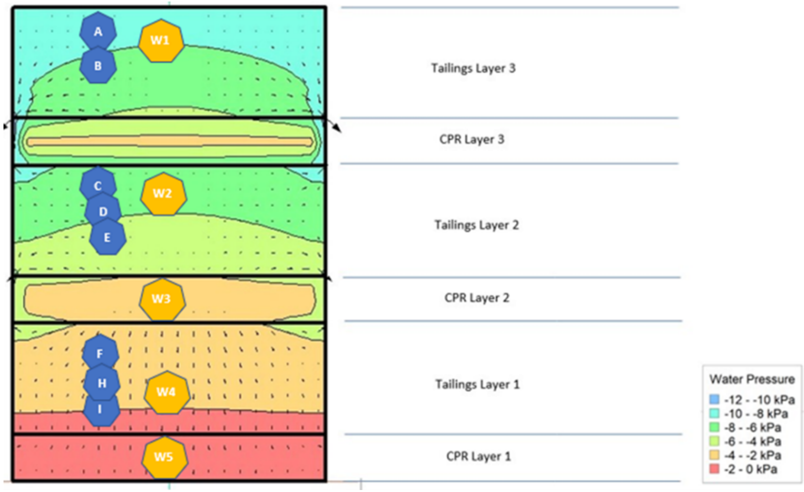


Figure 4. Simulated suction pressures in apparatus.

3.4 *Test Results*

The desaturation stage of the test commenced on 25th February 2020. The drainage valves, located on each face of the apparatus at the base of each CPR sand layer, were opened and the apparatus allowed to drain. The valves were closed off at the end of that day to ensure that the instruments were all functioning correctly and re-opened the morning of 26th February 2020 and allowed to drain continuously until the morning of 9th March 2020, when they were closed off again. Instrumentation was observed throughout the period of drainage and for 8 days following the final closing of the valves. The piezometer instruments were allowed to stabilise in order to observe the effective phreatic surface without influence from suction pressures until 24th March 2020. Measurements were halted at this stage. The valves were opened again on 3rd of April 2020 to enable further observation of the desaturation of the layers until the rate of flow from the apparatus reached approximately 2 litres per day, at which point the test was halted.

The majority of water was released from the bottom layer of CPR sands with only a small amount being evacuated from CPR sand layers 2 and 3. Vertical flow through the tank appears to have been predominant with suction forces drawing the water into lower layers. A simple water balance assessment indicated that 26% of the water in the sample was evacuated during the test. Only 4% of the total flow came from valves in CPR sand layer 3, 10% from CPR sand layer 2 and 86% from sand layer 1.

The soil water potential instruments indicated significant movement of water in the upper two layers of tailings (tailings layers 2 and 3) observed by the sudden drop in water potential in W1 and W2 suggestive that air entry has occurred within those layers, while no air entry seems to have occurred in the tailings layer 1 or CPR sand layers 1. Some nominal air entry seems to be observed in CPR sand layer 2 (W3) and 2. No capillary break appears to have formed. C The tensiometers measured suction pressures very close to those developed in the simulation. The suction pressure observed in tailings layer 2 was measured with tensiometers C, D and E as indicated on Figure 4. The suction pressures are presented on Figure 5.

Suction pressures in tailings layer 1 reached -3 kPa, in tailings layer 2 they reached -6 kPa and in tailings layer 3 they reached -9 kPa. When compared to the soil water characteristic curve for the tailings the result would indicate a reduction of the degree of saturation in a given layer not less than 95%. This is a function of the scale of the experiment and needs to be assessed at a larger field scale trial. The suction pressures generated in the CPR sand layers result the degree of saturation dropping to a range of approximately 20 to 40%.

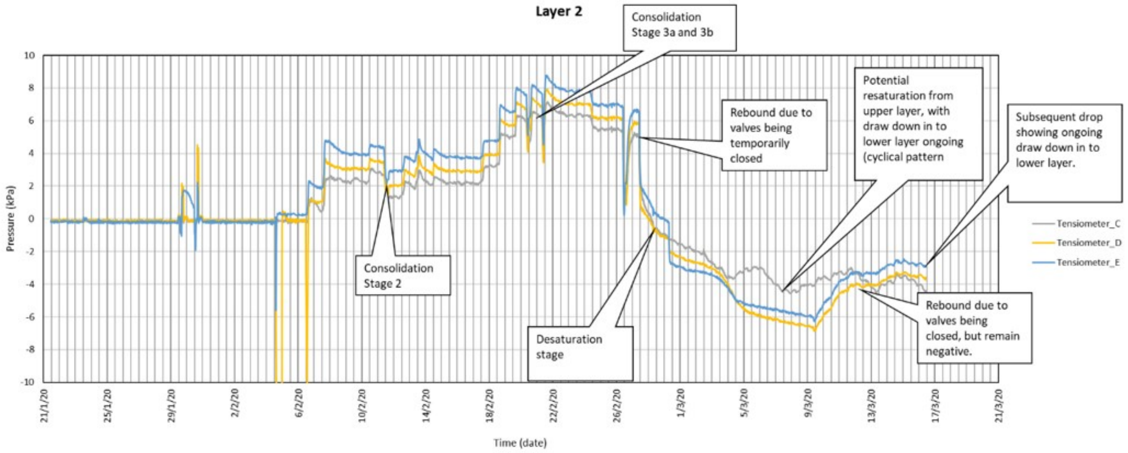


Figure 5. Suction pressures developed in tailings layer 2.

The phreatic surface was drawn down to the bottom 2 layers of the tank and when the drainage valves were closed off the true phreatic surface was observable in the vibrating wire piezometers. Instruments X1, X2 and X3 all being installed within tailings layer 1 showing the final head of water in the tank just below the top of CPR sand layer 1.

The degree of saturation was assessed in each layer using moisture content probes. It is important to note that the data is based on correlations from volumetric water content probes to degree of saturation. However, the degree of saturation is a function of gravitational water content, so there is no direct correlation since the conversion is also a function of the density and voids ratio. The upper bound curve appeared to fit well with the results from the extraction of undisturbed sub-samples of tailings. The moisture content probe results are presented in Table 5.

Table 5. Final degree of saturation from upper bound fit (Figure 12).

Layer ID	Degree of Saturation (%)
Tailings Layer 3 Top	73.9
Tailings Layer 3 Middle	97.0
Tailings Layer 3 Bottom	94.5
Tailings Layer 2 Top	91.7
Tailings Layer 2 Middle	97.3
Tailings Layer 2 Bottom	98.7
Tailings Layer 1 Top	100
Tailings Layer 1 Middle	100
Tailings Layer 1 Bottom	100

The degree of saturation results from sub-sampling are presented in Table 6. The results are close to the expected degree of saturation based on the development of suction pressures and the soil water characteristic curves. The difference observed in the moisture content probe data appears to be a function of air drying and desiccation in the top layer.

Table 6. Final degree of saturation.

Layer ID	Degree of Saturation (%)
Tailings Layer 3	95.1
CPR Sand Layer 3	24.9
Tailings Layer 2	95.1
CPR Sand Layer 2	47.1
Tailings Layer 1	99.6
CPR Sand Layer 1	99.6

3.5 *Repeat Test*

The large-scale test rig was decommissioned and shipped to University de Santa Maria in Valparaiso, Chile and a repeat of the test was carried out on copper tailings and CPR sands supplied by the El Soldado copper mine. The test was modified to better represent the real-world scenario with drainage allowed from the outset of the trial with all CPR sands and tailings placed as a slurry. The rate of rise was scaled to represent a field rate of rise of approximately 2 m per year.

The development of suction pressures increased slightly up to a maximum of -15 kPa, and the ultimate phreatic surface was lower down in the bottom tailings layer 1. The resultant degree of saturation in the tailings and CPR sand layers were also significantly lower yet the soil water characteristic curves indicates a much higher air entry value of 100 kPa for the copper tailings compared to 20 kPa for the platinum tailings. The water volumes flowing out of the tank were significantly higher than observed in the previous test indicating that the results were not a function of increased air-drying and desiccation but rather an improvement in gravitational dewatering observed during each stage of placement and consolidation with a lot more water evacuating from the CPR sand layer rather than re-saturating the tailings layer below. The final resultant degree of saturation record from sub-sampling from each layer are summarised in Table 7.

Table 7. Final degree of saturation from repeat test with modified method.

Layer ID	Degree of Saturation (%)	
	Range	Average
Tailings Layer 3	50-89	76
CPR Sand Layer 3	18	
Tailings Layer 2	54-99	69
CPR Sand Layer 2	13-16	15
Tailings Layer 1	33-100	79
CPR Sand Layer 1	50-78	64

3.6 *Conclusions*

The findings show that gravitational dewatering is improved by the interbedded placement of tailings with CPR sand layers. Even if tailings do not dewater significantly below a degree of saturation of 95%, the water recovery from CPR sand layers, enabled by splitting the tailings and CPR sands and maintaining them as discrete zones within a co-disposed facility is of significance regarding water stewardship goals, particularly in areas of water scarcity.

If however, in practice, tailings do indeed reduce to degrees of saturation of less than 80% significant improvement in the resistance to cyclic liquefaction may be observed (Yoshimi et al. 1989), and even greater water recovery will be attainable.

The rate of consolidation of tailings will also be improved by shortening the drainage pathway of tailings thus accelerating closure and reducing the cost associated with managing long term consolidation when land-forming and repurposing tailings dams.

The results from the initial laboratory trials have paved the way to the development of a large scale field trial at the El Soldado copper mine.

Note: a second technical paper detailing the specifics of the repeat testing completed at USM is under preparation and will be seeking publication in early 2023.

4 DEMONSTRATION FACILITY

4.1 *Conceptual design*

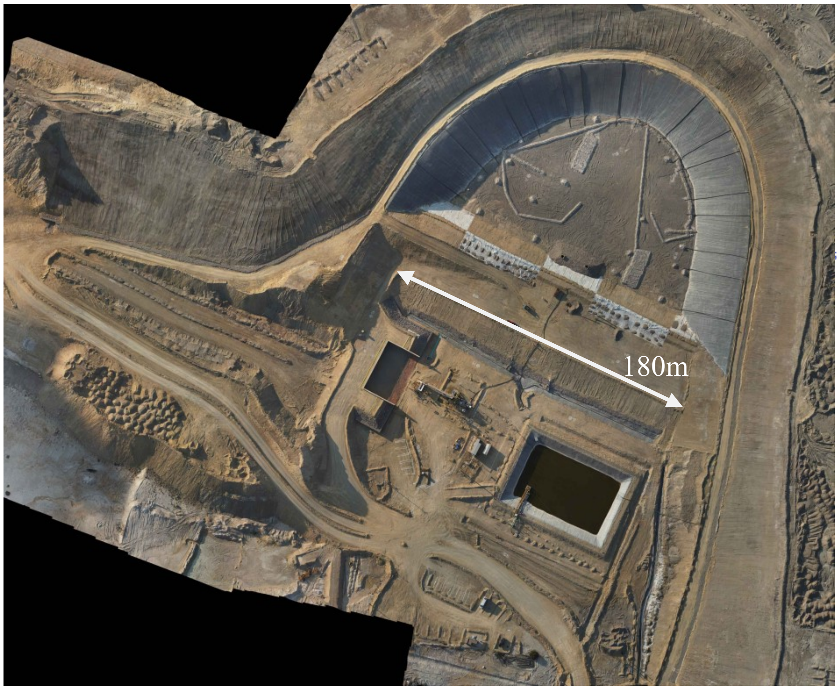
The HDS concept that requires demonstration is the use of the CPR Sand as a link between layers of conventional tailings deposition, allowing a targeted increase in water recovery of around 30%. Increased water removal, taking the tailings below saturation levels, delivers significant stability and resistance to liquefaction benefits. Operational safety remains a concern and a greater human / machine / facility interaction will need management and will incur additional costs. The benefits of the proposed approach remain significant: Safety, Water, Legacy.

All the information needed to demonstrate the benefits must be recorded correctly. The trial will be a unique learning opportunity on the behaviour of CPR sands when discretely co-disposed with tailings. Instrumentation, and the creation of a robust and representative database, has been a priority from the start – delivering the evidence the regulatory authorities will need to support the technology. Section 4.3 below provides an overview of the data collection effort.

Delivering a 'real' trial is important – hence the construction of a 250,000 m3 capacity state-of-the-art tailings facility in the heart of the El Soldado industrial complex. Construction of the facility took a year and with commissioning completed in July 2022, the facility will operate through all seasons, followed by closure trials starting in Q2 2023.

Located in an operating mine, the facility contributes to the existing tailings storage capacity and there is a real opportunity to apply some of the placement techniques to the existing active facility at the mine.

Figure 6 shows the layout of the facility immediately prior to commissioning, the first layer of instrumentation is visible in the basin, together with the water return pond and sand stockpile and fluidiser for sand placement.



the technology is rolled out and developed

Figure 6. Digital composite of HDS demonstration prior to commissioning

4.2 *Instrumentation and Monitoring*

A combination of common and advanced instrumentation technology has been installed to provide confidence in the efficacy of the solution. The instrumentation system is set up as a LoraWAN edge-based solution. The sensors are connected into nodes (loggers/transmitters) that use low energy long range radio waves to deliver the readings to a central gateway. The gateway then conveys the readings from all sensors to a central data repository.

The instrumentation has been combined with a digital data acquisition system (DAS) which allows all stakeholders to observe the operation of the facility in real time. The users can access the data through an online dashboard from anywhere around the world. The instrumentation was divided into two groups, safety and validation.

4.2.1 *Safety*

The safety instrumentation is installed to monitor the safe operation of the facility, this includes, in-place-inclinometers (IPI's) to assess slope movement as well as total pressure cells (TPC's) and vibrating wire piezometers (VWP's) to assess development of excess pore pressures in the foundation.

4.2.2 *Validation*

To determine the effectiveness of the HDS deposition approach an array of instrumentation will be installed throughout the stack. The main aim of the instrumentation is to confirm the dewatering of the tailings and to assess water balance. The following instrumentation has been selected: vibrating wire piezometers, suction transducers, moisture content probes, self-heating fibre-optics, and flow gauges on water collection channels. Automatic Lidar surveying systems will also be used to monitor rates of rise and consolidation stages (layout presented in Figure 7).

The vibrating wires and suction transducers are installed throughout each tailings layer and will be used to gauge the water levels through the HDS and to assess continuity of the suction within the stack driving gravitational dewatering.

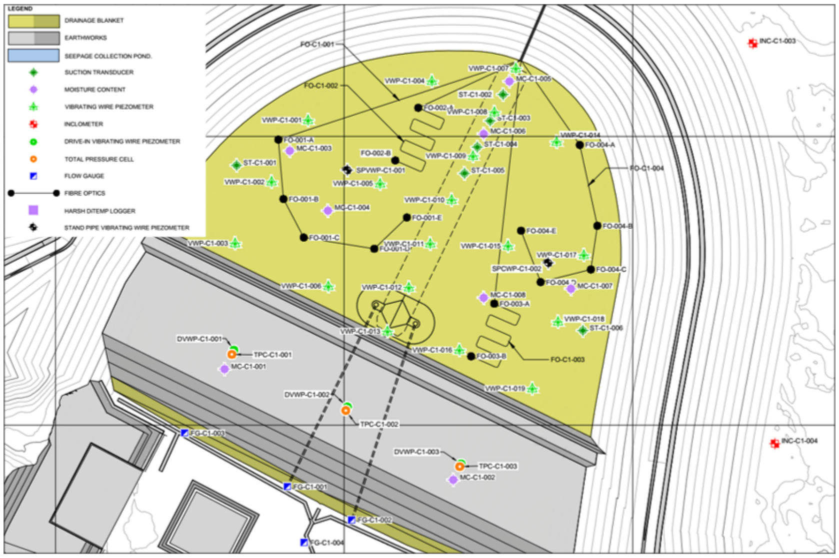


Figure 7. Instrumentation layout for first tailings cells layer

The degree of saturation will be assessed in real time in each layer using self heating fibre optics and moisture content probes all of which have been calibrated for the specific materials that they will be installed within. The real time monitoring will enable the observation of any wetting fronts passing from the tailings layers placed in to the layers below.

The moisture content probes record an apparent dielectric permittivity, which have a range of 1 (air) to 80 (water). Laboratory testing on tailings samples at known moisture contents was completed to determine a correlation between the permittivity and the actual moisture content, this relationship has been applied to the data acquisition system to report moisture content.

The self-heating fibre optic cabling system is capable of heating and recording the rate at which the surrounding soil temperature changes. Calibration was completed by the equipment provider (Smartec) in their laboratory. Various moisture contents were tested, and a calibration relationship determined for use on the results of the trial. Due to the influence of density on the moisture content, data from moisture content probes and fibre-optics will be assessed for trends rather than actual moisture content, which will be assessed by taking undisturbed samples upon completion of the trial.

The results for each tailings layer will be observed and plotted spatially so that the rate of moisture change can be observed across each of the cells.

Flow gauges will be installed at four locations around the facility. The flow gauges will accurately record the water volumes leaving the HDS trial. The gauges utilise a laser level combined with geometric inputs to determine the flow rates. These values will be used to accurately validate the water balance for the HDS.

The tailings cells will be monitored using Lidar equipment, surveyors will create daily point clouds of each of the cells so that the development can be tracked over the facility's life. Each cell is divided into 100 points, the elevation of each point will be monitored, this will be used to track the rate of rise during deposition and the consolidation of the cells between deposition stages.

4.2.3 *Validation*

The data will all be stored within a server based data acquisition system, with copies retained on the mine site's central data lake. The data will be stored both in its raw and interpreted form in case there is a need to utilise the raw data at a later date.

4.2.4 *Future Work – Machine Learning*

One of the aims of the project use machine learning on trends from the data to assess if a simplified instrumentation array can be implemented at full scale while still providing the required evidence on the state of the stored tailings and CPR sands.

5 CONCLUSIONS

Hydraulic Dry Stacking (HDS) is a patented, innovative, engineered tailings placement method that leverages the free-draining sands from the adoption of Coarse Particle Recovery (CPR) within the flotation process flowsheet.

The new system approach delivers a new type of tailings facility that will benefit from rapid dewatering and consolidation, leading to rapid closure and re-purposing of land that, under traditional tailings disposal, would remain sterile for many years.

A series of geotechnical tests have been developed that can provide the design criteria needed to design HDS for both greenfield and brownfield applications.

The unique demonstration project at El Soldado will continue until mid-2023 and is expected to demonstrate significant advantages over traditional tailings storage and more technical papers that share the learning will follow in due course. A second demonstration trial is starting in Q3 2022 at our Mogalakwena mine in South Africa and this will involve the development of HDS in a portion of an existing, operating tailings facility.

More technical papers will follow describing the results from both trials, as well as additional geotechnical papers as we improve the large scale testing and investigate further improvements to the technology.

There is significant potential for the mining industry here – can HDS allow a mines' tailings production to be seen as a safe, water generating asset that, on completion, can deliver value accretive land to the benefit of our communities.

The authors would like to thank Anglo American for their financial support in the development of this new approach to tailings management. WSP Golder have been instrumental in the geotechnical design.

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