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# The geomechanics of thickened and paste tailings

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## Abstract

*The overall objective of thickened and paste tailings disposal has been stated many times: it is to thicken a tailings slurry to the point where it is non-segregating, and will beach to form a sloping, sub-aerial deposit.*

*The advantages of this type of scheme have been stated to include higher density, higher strength (including avoidance of a slimes pond), improved seismic resistance, and better closure and rehabilitation prospects (including lower compressibility). The aim of this paper is to show how these outcomes are a product of the interaction of fundamental tailings properties, site management practices, and climatic conditions of the site. A typical set of test results is presented and discussed in the context of unsaturated soil mechanics.*

*The absence of segregation in thickened and paste tailings is an important factor, but it is often overlooked.*

*The paper addresses the influence of evaporative drying on the sub-aerial beach. The induced suction stresses, combined with compressibility (consolidation) largely influence the rate and extent of density and strength gain that is attributable to the thickened discharge method.*

*Finally, the influence of overall site management practices (e.g. filling rate), together with climatic conditions, are discussed to illustrate how these may act as constraints on the potential to achieve optimum results.*

**Keywords:** *thickened tailings, soil suction, density, compressibility, strength*

## 1 Introduction

Many papers and texts have been published which make generalised assertions regarding the benefits of thickened tailings. These benefits are typically stated to include better water recovery, higher in situ density, and higher strength (e.g. Robinsky 1999). There is a theoretical and factual basis for these claims, but other than a general reference to the beneficial effects of evaporative drying, the details are often not explored.

The in situ parameters of a thickened tailings deposit are the result of an interaction between (a) the fundamental geotechnical and rheological parameters of the tailings, (b) the climatic conditions of the disposal site (primarily rainfall and evaporation), and (c) the details of the deposition methodology adopted for the site (including rate of rise and possible rotation of discharge locations).

The overall aim of this paper is to provide some context for the observed effects in the light of soil mechanics theory including aspects of unsaturated behaviour. The paper relates to thickened and paste tailings facilities, in which the tailings have been thickened to be non-segregating. The outcomes cannot be generalised to other methods of disposal.

For the purposes of illustration, selected results from tests on one particular ore type are included in this paper. The material is a copper tailings derived from a deep open pit porphyry orebody. The particle size distribution is on the coarse side of what might be considered to be ‘typical’ tailings, but the results have been used because there is a reasonably complete set of tests available.

Finally, it should be noted that for the sake of brevity, where the term ‘thickened tailings’ is used in this paper, it should be taken to infer ‘thickened and paste tailings’.

It is also noted that the issue of geochemistry (AMD) is not discussed in this paper.

# 2 Preliminaries

## 2.1 Thickening

It should go without saying that thickened discharge schemes start with a thickener (with the exception of a very few special cases which involve re-pulping of filter cake).

A detailed discussion of thickening is beyond the scope of this paper, but it is worth noting a few points:

1. The solids concentration of thickener underflow has a major influence on the site water balance.
2. Taking the tailings type as a given, the solids concentration of thickener underflow is almost the sole determinant of the slurry rheology, which in turn influences the resulting beach profile.
3. It is important that thickening should be targeted to achieve a concentration higher than the segregation threshold of the tailings slurry. This is particularly relevant for coarser grained tailings (high content of sand sized particles) and/or tailings with a high particle density (SG). If this is not achieved, the tailings will segregate on deposition and many of the advantages of thickened discharge will not be realised.

It is also worth noting that too much can be attributed to the degree of thickening that is achieved. This is due to a perception that a higher underflow solids concentration will result in a better end product in terms of strength and density. This is not necessarily correct. Whilst there is no question that slurry concentration has an influence on beach slope, its direct effect on strength and density in many cases is not supported by the test results (refer Section 3.4.3). It is noted that other studies (e.g. Reid & Fourie 2015) present contradictory results whereby some of the samples tested give consolidation curves that appear to be dependent on initial solids concentration, and others do not. It remains the contention of this paper that provided the tailings slurry is non-segregating, and the deposited tailings beaches at a finite angle that ensures that any bleed water runs off (i.e. does not pond and reduce evaporation), variations in the degree of thickening are likely have little or no influence on the post-deposition properties of the tailings. However, for design purposes, it is recommended that testing should be undertaken using a slurry concentration close to the expected thickener underflow density.

## 2.2 Rheology, segregation and beach slope

The issues of rheology and the resulting tailings beach profile have been extensively covered elsewhere. From the viewpoint of a geotechnical analysis of the deposited tailings, it is sufficient to note that the principal requirements for beach development for a thickened tailings scheme are (a) non-segregation (i.e. the slurry density should be above the segregation threshold), and (b) a beach angle that will support fast removal of bleed and rainfall off the tailings to enable the maximum influence of evaporation effects.

Pirouz et al. (2008) discuss empirical tests to assess both sheared and unsheared segregation of tailings slurries.

# 3 Geotechnical characterisation

## 3.1 Introduction

This section provides an overview of the geotechnical parameters which are intrinsic to the behaviour of thickened tailings. The effects of climate and site-specific practice are discussed in Section 4.

## 3.2 Index properties

The basic index properties of a tailings include particle size distribution, plasticity (usually as measured by the Atterberg limits test), and soil particle density (SG).

The combination of particle size distribution and plasticity (Atterberg limits) is generally a reasonable guide as to the overall behaviour of a tailings material. A new International Commission on Large Dams guideline (ICOLD 2019) includes a broad classification of expected tailings properties based on these parameters.

It is good practice to undertake these tests, as a matter of routine, on all samples that are to be subjected to more detailed testing and evaluation. It is also good practice to repeat these tests on any further samples that are obtained from the same source for subsequent testing, even if these are ostensibly the same material.

For the example tailings, the soil particle density (SG) is 2.64, and the Atterberg limits are liquid limit (LL) = 21, and plasticity index (PI) = 6. In terms of the Unified Soil Classification system (ASTM 2011) the material classifies as 'silty clayey SAND' (SC – SM).

## 3.3 Particle size distribution

The particle size distribution curve for the example tailings is shown in Figure 1, indicating a relatively coarse tailings, with just over 50% retained on the 75 µm sieve.

Seddon (2018) noted that the particle size distribution that results from typical milling of hard rock tailings tends to result in a grading close to that required for maximum packing density. For comparison, the theoretical maximum packing density for a -300 µm material is also shown on Figure 1, with close agreement evident.

The fact that thickened tailings are (by definition) non-segregating means that this grading is maintained throughout the deposit, and is one reason why relatively high in situ densities are obtained in thickened tailings deposits.

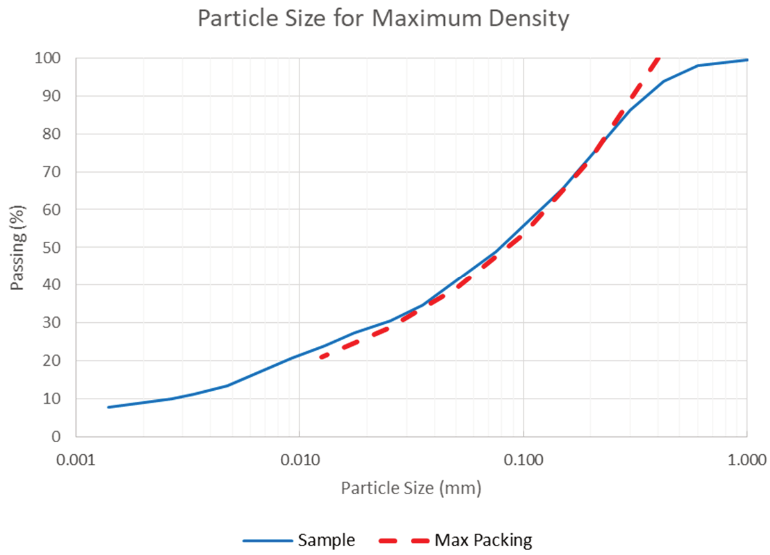


**Figure 1 Particle size distribution and maximum packing curve**

## 3.4 Settled density

### *3.4.1 Initial conditions*

Settled density tests are carried out to investigate the condition (density and moisture content) of tailings immediately after the slurry has ceased to flow and the solids have settled out on the beach. This is the 'start point' for subsequent consolidation and desiccation processes. The retained moisture at the initial settled density also enables calculation of the volume of bleed/decant water, if any.

The sedimentation (and subsequent self-weight consolidation) of soil particles falling through water has been investigated by Been & Sills (1981). Their work was based on slurries of very low initial solids concentration.

For these slurries, they identified two phases of settling: (a) effectively unhindered settling above (b) a bed of higher concentration transitioning into a soft soil where hindered settling (consolidation) occurs.

In the context of thickened tailings, it is important to realise that all of the unhindered settling phase takes place in the thickener. The thickener underflow is already at the hindered settling phase. For this reason, settling tests on thickened tailings are essentially consolidation tests.

### *3.4.2 Testing*

Tests for settled density may be drained or undrained. Drained tests result in higher effective pressure on the sample, and therefore give higher densities. Because the actual drainage conditions on a beach (at relatively short time frames in the order of hours to one or two days) are difficult to determine, it is most common to use the results of undrained tests.

To minimise the influence of sidewall friction, it is good practice to carry out settled density tests in containers having a relatively high width/depth ratio. Testing of thin depositional layers also aligns with observed behaviour of tailings on a self-managed beach, where typically only thin layers accumulate before deposition shifts to another area. In some cases where site deposition is more controlled, testing of thicker layers may be more appropriate.

### *3.4.3 Results*

It is a common misconception that a higher density slurry (i.e. as measured at the point of thickener underflow) will result in a higher deposition density. This probably comes about from test programs where samples at different solids concentration are tested, with all tests commencing from a constant volume of sample. This results in different mass of solids being tested, and hence different final thicknesses and stress levels, without any recognition of the influence of final effective stress on the result.

In general, for thickened tailings, testing should be undertaken using sample sizes that will result in a layer thickness that reflects site practice (a range of 30 to 60 mm would be typical). Similarly, the initial slurry density should reflect the expected solids concentration of the thickener underflow.

For the example tailings, settlement tests were undertaken at solids concentrations of 57, 65 and 68.9%, and initial thicknesses which gave final thicknesses ranging between 40 and 175 mm. The segregation threshold for this material was 47% solids, hence all these tests are comfortably in the non-segregating range.

Because the sample is near surface and normally consolidated, the vertical effective stress varies significantly with depth, in a non-linear manner. However, for the purposes of comparison, an approximation of the vertical effective stress throughout the sample can be made by converting the overall dry density to buoyant unit weight, and using a depth equal to half the final sample thickness. The results are shown on an e versus log p plot on Figure 2. This overestimates the stress at this point, but is considered to be sufficient for purposes of illustration. It will be seen that the nominal effective vertical pressures range between about 0.2–1 kPa depending on the layer thickness.

The results of a Rowe cell consolidation test on the material are included for comparison. It is apparent that the results align well with the Rowe cell compression curve, as would be expected. The major influence on the results is the thickness of the test sample (vertical pressure). By comparison, differences due to initial solids concentration are smaller, and possibly influenced by test accuracy.

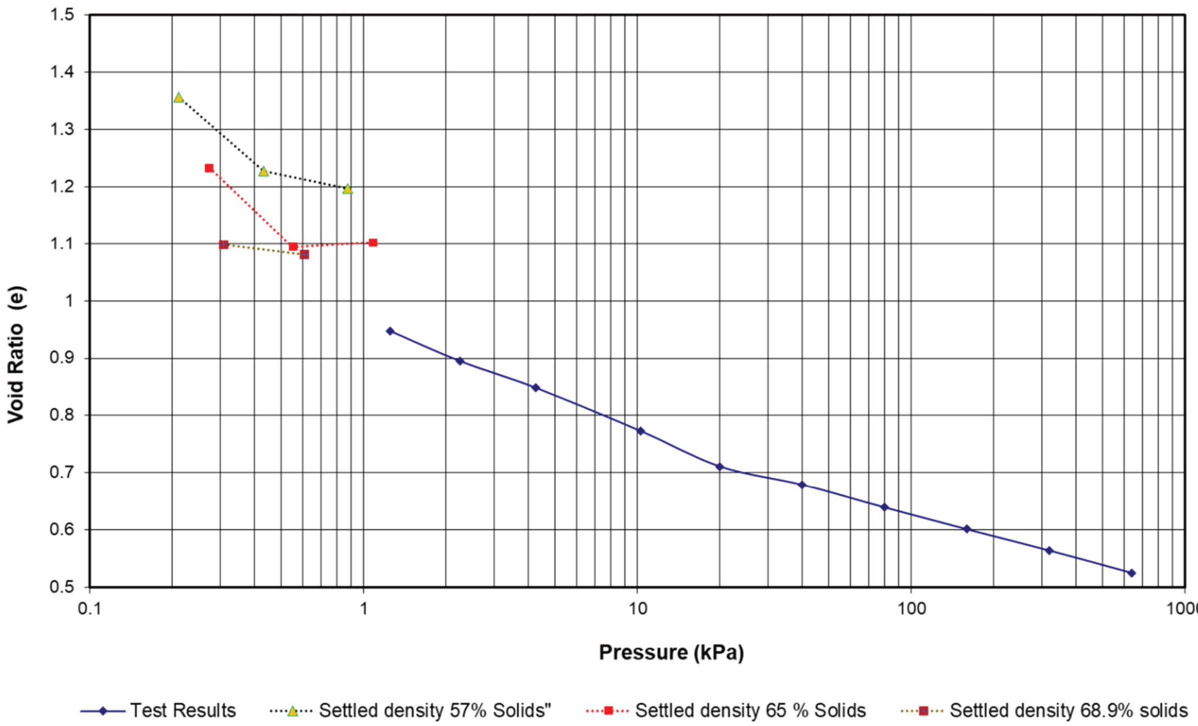


**Figure 2 Settled density and consolidation test results**

## 3.5 Shrinkage limit

The shrinkage limit test is carried out as a measure of the maximum density that can be achieved by drying of the sample.

The test is usually carried out in a relatively wide container to speed up the test time and minimise side friction effects.

The test results for the example tailings are shown in Figure 3 (in terms of dry density versus moisture content). This indicates a maximum value (the shrinkage limit density) of close to 1.60 t/m$^3$. Also shown in Figure 3 is the theoretical saturation line (for a material with G = 2.64). It is apparent that as the sample is dried, the associated volume change results in it remaining saturated from the placement moisture content (in this case 66%) to a moisture content lower than 30%.

The influence of volume change on a tailings material undergoing evaporative drying is discussed by Mbonimpa et al. (2006). They propose use of an alternative plot of void ratio versus moisture content, which is presented in Figure 4.

The results indicate that the sample reaches the air entry value and begins to de-saturate at a void ratio of 0.75 (dry density 1.50 t/m$^3$). The void ratio at the shrinkage limit is 0.65 (dry density 1.60 t/m$^3$).

Reference to Figure 2 shows that the air entry value (AEV) is reached at a consolidation density equal to a vertical stress of around 15 kPa. The final shrinkage limit density is equivalent to a pressure of around 60 to 70 kPa.

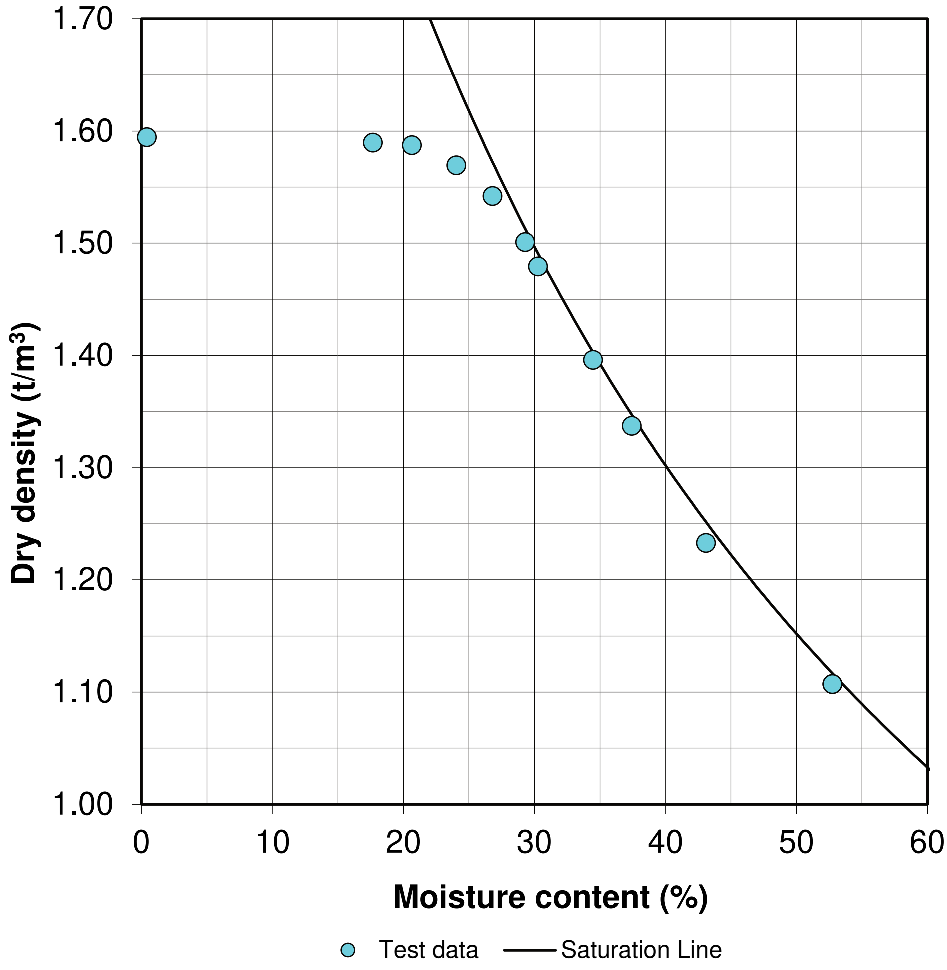


**Figure 3 Shrinkage limit density test results**

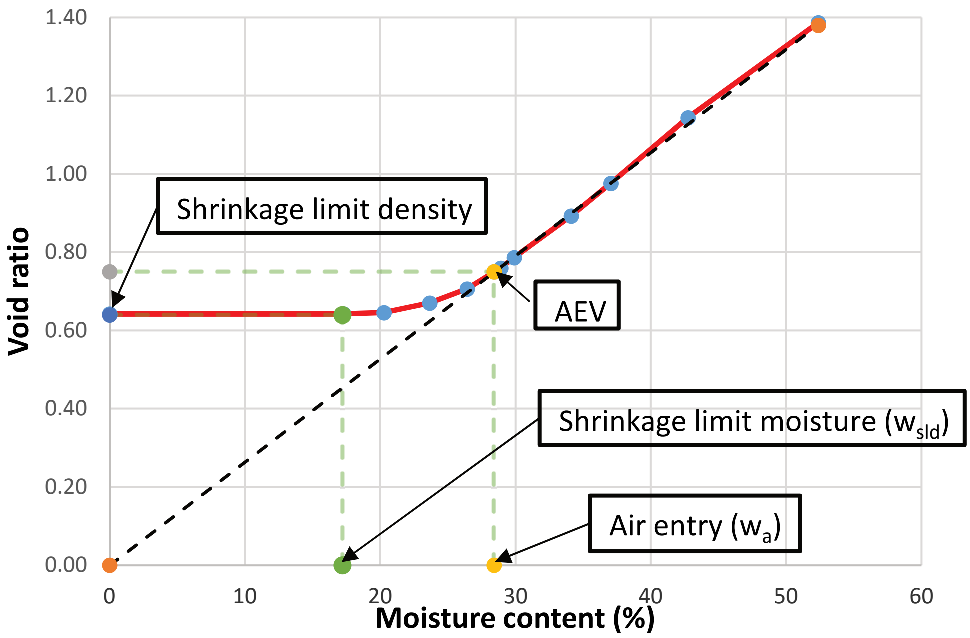


**Figure 4 Shrinkage limit density test results (moisture content versus void ratio)**

It is apparent that the shrinkage limit is related to suction effects and the maximum suction pressure that can apply as the sample desaturates. It is of interest that experience has shown that finer grained/higher plasticity tailings typically have higher shrinkage limit densities than coarser grained products. This is consistent with finer grained materials having a higher air entry value (and higher limiting suction).

Variations exist on the method of inducing evaporation. In some cases, incandescent lights or heat lamps are applied to speed up the process, and the final reading is taken at oven dried temperature. Sometimes, the test is run at site ambient conditions in an attempt to directly predict actual drying rates. However, it is probably better to use the shrinkage limit test to establish the limiting density, and predict site/climatic effects and drying rates by subsequent modelling.

## 3.6 Consolidation

### *3.6.1 Introduction*

All tailings materials undergo self-weight consolidation as individual layers are progressively covered. In some conventional deposits, it is not uncommon to encounter under-consolidated conditions (excess pore pressures) particularly under the slimes pond in cases of lower permeability material. This is less common in thickened tailings deposits for the following reasons: (a) for non-segregating tailings, a slimes pond should not form, and hence lower permeability zones are avoided, (b) the rise rate of thickened tailings deposits is typically lower than for conventional tailings deposits, giving more time for consolidation, and (c) if there is any evaporative drying effect, some of the entrained moisture is removed by desiccation before the consolidation process begins.

### *3.6.2 Testing*

Consolidation testing is most commonly done in a Rowe cell. These have typical diameters in the range 100–250 mm. Testing typically commences from material placed as a slurry, which is allowed to settle (to the initial settled density) at the start of the test. The sample is therefore in a normally consolidated condition throughout the test.

Other test methods are possible but are generally inferior. The practice of drying a sample to a thick paste and moulding this into a conventional oedometer is a poor alternative; it may change the structure of the deposited tailings, and in addition, results at the lower stress ranges are essentially over-consolidated. Results obtained from the over-consolidated range may be misleading.

Similarly, it is considered that results obtained from 'long tube' consolidation tests will introduce serious side friction effects unless load cells are included in the sample. This applies to both laboratory-scale equipment, and to column type pilot-scale tests. The author is aware of at least one case where wall friction was sufficient to cause the sample in a small pilot-scale test to 'hang up' to the extent that continuous horizontal cracks developed through the full diameter of the sample, and therefore, calculations of effective stress based on sample depth were meaningless.

### *3.6.3 Results*

The Rowe cell consolidation test (in common with the conventional oedometer tests) is a relatively straightforward test, but which yields a quite sophisticated set of results. These are typically a compression curve (e versus log p plot), as shown in Figure 2, and a relationship showing permeability versus density, and/or coefficient of consolidation (Cv) versus density/effective stress.

The compression test results can be used to calculate a normally consolidated density profile in the deposit, as shown in Figure 4. In the example case, the calculation is based on the phreatic surface being at the surface, but the calculation can be undertaken for a phreatic surface at any desired depth. At any given depth, the normally consolidated density is the highest density that can be achieved in a tailings deposit under self-weight consolidation.

In some conventional deposits, the combination of high rate of rise and low permeability is such that the tailings remain under-consolidated throughout the life of the storage, and the normally consolidated density is not achieved. In the case of thickened tailings, rise rates are typically lower, and under-consolidated conditions rarely occur. However, this should be checked on a case-by-case basis, particularly for (a) start-up configurations where higher rise rates may apply, and (b) for cases where the method is used for lower permeability tailings (e.g. red muds, oxide gold tailings, oil sand tailings, and coal tailings).

The test results for the example tailings for initial settled density and shrinkage limit density are also shown on Figure 5. The initial settled density values apply at very shallow depths at the surface of the deposit. In this case, the shrinkage limit density is equivalent to a depth of 10 m at the normally consolidated profile. If the tailings have been dried back to this density during placement, the in situ density will exceed the normally consolidated density (down to 10 m depth), and the tailings above this depth will be over-consolidated (with higher strength and density compared to the normally consolidated material). This is the most significant influence on the advantages of thickened tailings disposal.

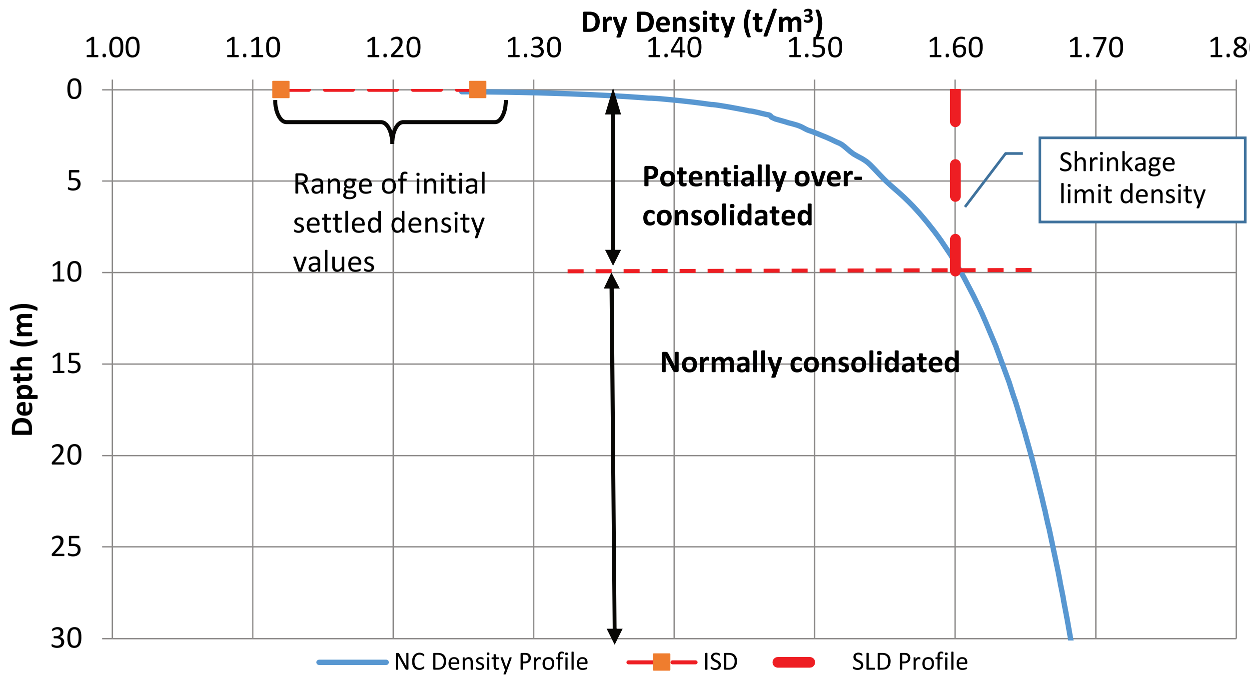


**Figure 5 Calculated normally consolidated density profile**

At greater depths, the effect of increasing vertical stress overrides the shrinkage limit density, and the tailings revert to being normally consolidated.

It should be noted that the depth to which the shrinkage limit influences the tailings density is strongly material dependent. Finer grained materials typically can have (a) higher shrinkage limits and (b) lower normally consolidated densities. In these cases, the shrinkage limit density effect may be the controlling influence to much greater depths.

# 4 Site-specific effects

## 4.1 Overview

The effect of evaporation from the tailings beach is the factor which really distinguishes thickened discharge storages from conventional storages. Evaporation increases density and strength, and may reduce the degree of saturation. However, the end effect is a result of the interaction between evaporation and rate of rise.

## 4.2 Effect of rise rate

An order of magnitude indication of the interaction between rise rate and evaporation can be obtained using the water loading rate (WLR) (Williams et al. 2008). If the evaporation rate exceeds the WLR, then as a first approximation the deposit may be unsaturated. The calculation is framed in terms of daily rates, but it is more logical to use (daily) values averaged over a longer time interval. This calculation ignores the effect of rainfall, assuming that the majority of rainfall simply runs off the inclined beach, and does not significantly influence the in situ moisture content. It also ignores bleed water runoff over areas of previously deposited tailings.

$$WLR = \frac{1000R(w_{isd} - w_{sld})}{A} \tag{1}$$

where:

WLR = water loading rate, mm/day.

$w_{isd}$ = the moisture content at the initial settled density, w/w.

$w_{sld}$ = the moisture content at the shrinkage limit density, w/w.

R = tailings production rate, t/day.

A = stack area, m².

In the example case, if we take:

$w_{isd}$ = 42% = 0.42 w/w.

$w_{sld}$ = 18% = 0.18 w/w.

R = 90,000 t/day.

A = 600 ha = 600 × $10^4$ $m^2$.

then WLR = 3.6 mm (equals 1,300 mm/year if taken as an average).

In the hotter, more arid parts of the world, annual evaporation can exceed 3,000 mm/year, and an unsaturated beach would be expected for this example. In more temperate climates at higher latitudes, evaporation rates of less than 1,000 mm/year can be experienced, and the beach would be expected to remain saturated.

## 4.3 Modelling evaporative drying

The effects of evaporative drying are dependent on:

- Rate of placement of tailings (rise rate) (= R/(A × density).
- Climate (available evaporation, plus precipitation).
- Material characteristics: $w_{isd}$, $w_{sld}$, soil moisture characteristic curve (SMCC), and unsaturated soil permeability function.

These parameters can be incorporated into one of the commercial unsaturated soil models to generate a profile of suction versus depth (including seasonal effects if desired) (e.g. Williams et al. 2008).

In using these types of models, it is important to recognise that most models assume that the material remains at a constant volume and that increasing suction simply results in partial saturation. Better modelling results can be obtained by adoption of an SMCC that includes the effect of volume change in the tailings (Mbonimpa et al. 2006), and by adjusting the soil permeability function in the unsaturated zone to match (Zhang et al. 2018).

## 4.4 Permeability

The saturated permeability of tailings is usually obtained from Rowe cell testing, either indirectly from the Cv results, or directly from constant head permeability tests carried out between loading stages. The results for the example tailings were obtained by direct constant head testing, and are shown in Figure 6. The results show a variation in excess of one order of magnitude of permeability across the likely vertical stress range. Variations of this order of magnitude are typical. If an accurate estimate rate of settlement is required, finite strain methods should be used to be able to accommodate the spatial variation of parameters.

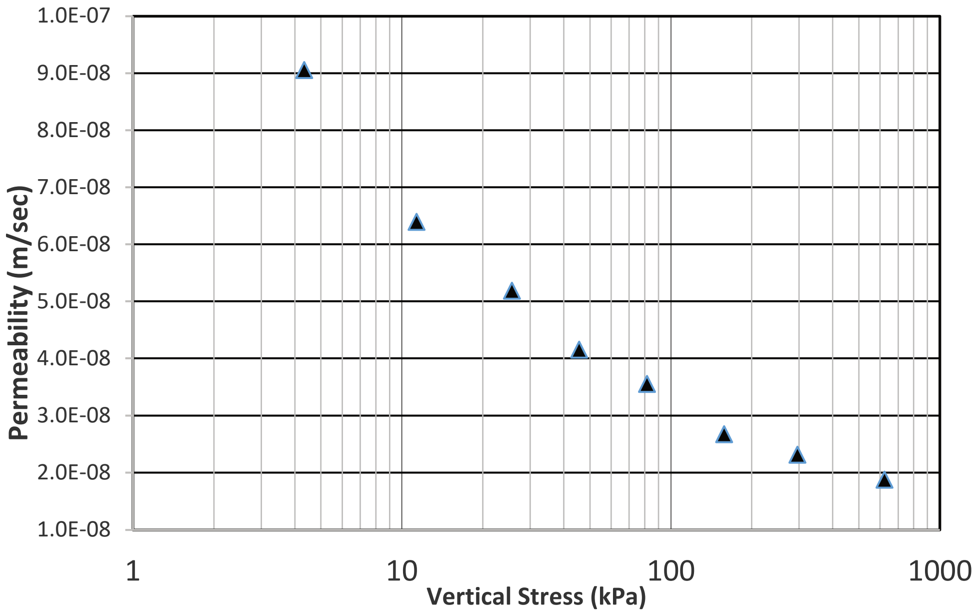


**Figure 6 Variation of permeability with pressure**

Modifications (reductions) to the permeability must be incorporated in zones that are determined to be unsaturated (Zhang et al. 2018).

## 4.5 Shear strength

The strength of tailings may be evaluated in terms of either drained (effective) strength, or undrained parameters; although, most emphasis is placed on the undrained strength, as this is usually lower than the drained strength. Often, the effects of suction due to partial saturation do not apply or are neglected.

For the case of thickened tailings, significant depths of the total deposit may be partially saturated, and it may be desired to investigate the resulting strengths. The degree to which these strengths are adopted in design may be dependent on the risk profile associated with the design outcomes.

The operational strength of unsaturated tailings (i.e. the actual strength in the deposit at a given time) can be assessed using the procedure proposed by Khalili & Khabbaz (1998) in which:

$$\tau = (\sigma - \chi u) \tan \phi' \quad (2)$$

where:

$\tau$ = shear strength.

$\sigma$ = normal (vertical) pressure.

u = suction (negative pressure).

$\chi$ = a correction value (applies at suctions > AEV, i.e. for u > u AA).

The correction value is estimated by: $\chi = (u/u\ AA)^{-0.55}$

The variation of $\chi$ and the calculated unsaturated shear strength ($\tau$) for the example tailings is shown in Figure 7, using the suction at AEV, u AA = 15 kPa. The results indicate that relatively high strength may be developed, depending on the suction that applies.

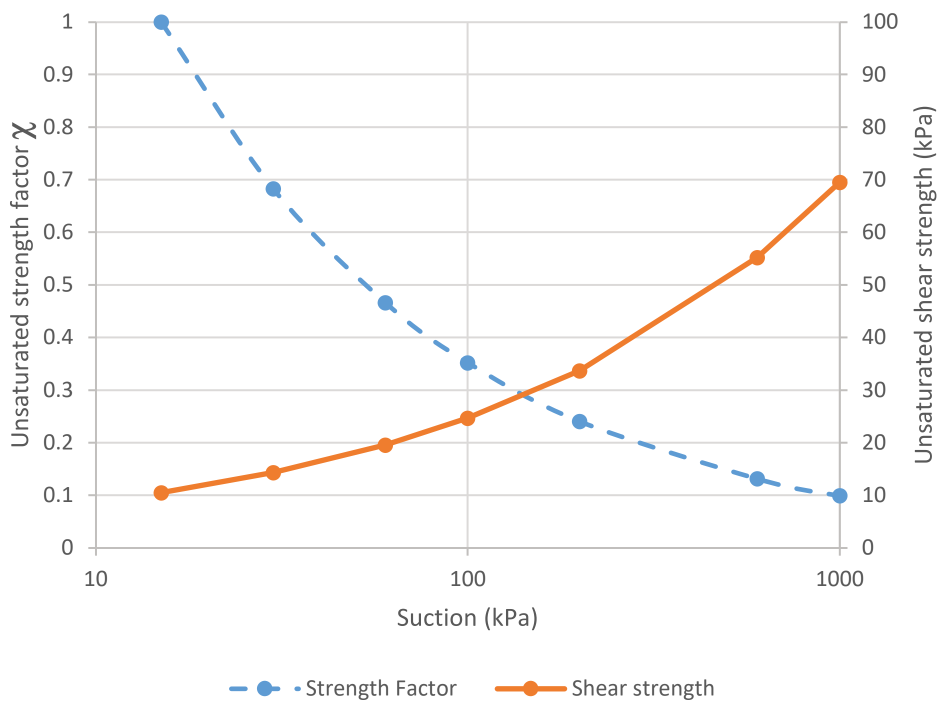


**Figure 7 Unsaturated shear strength**

The suction profile that develops in a tailings beach is site-specific. However, as an example, modelling for a site in northern Australia (Williams et al. 2008) showed maximum suction values in the range 200 kPa to 1,000 kPa for a rise rate of 2.4 m/year, increasing to well in excess of 1,000 kPa for a lower rise rate of 1.2 m/year. In these conditions, the example tailings can be expected to have an unsaturated shear strength of at least 30 kPa, and potentially much higher.

Similar results were reported by Seddon & Albee (2015) based on cone penetration test (CPT) results from a thickened tailings beach (in a different material). In that case, the lower bound strength was also 30 kPa over the upper 5 m of the deposit.

At shallow depths, these values are significantly in excess of the undrained strength that would apply to saturated normally consolidated tailings. As an example, the undrained strength (assuming saturated tailings and hydrostatic pore pressure from the surface) can be calculate by taking:

- Effective density $\gamma'$ = 8 kN/m$^3$.
- Undrained strength ratio (su/$\sigma'$vo) = 0.30.
- Depth = 2 m.
- Undrained strength (at 2 m) = 8 × 2 × 0.3 = 4.8 kPa.

These results show why the strength of a thickened tailings beach will generally be significantly higher than for a conventional deposit. This has particular application to access to the beach for management purposes (if required), and for trafficking as part of closure operations, and may also be applicable to post-seismic stability (but see following section).

## 4.6 Liquefaction

Liquefaction assessment of tailings deposits must consider both static and seismic liquefaction.

The assessment of static liquefaction is typically informed by approaches based on critical state theory (Jeffries & Been 2015). This may be based on laboratory testing and/or CPT results. Much of the work on static liquefaction is based on results for sands, which may not be applicable to tailings (which are typically silts with some sand fraction). An extension of the critical state theory to silt tailings has been proposed by Shuttle & Cunning (2007) but requires careful and advanced triaxial testing to derive all the necessary modelling parameters.

The analysis of seismic liquefaction is typically based on CPT methods (e.g. Boulanger & Idriss 2015), which have been calibrated against an empirical database of liquefaction case histories. The assessment of seismic liquefaction includes an allowance for the magnitude and intensity (peak surface acceleration) of the design event, which are site-specific.

In principle, if a site is not at risk of static liquefaction, it should not be at risk of seismic liquefaction. However, because of the different overall approaches, it remains possible that the seismic assessment may indicate liquefaction while the static assessment does not. Conversely, it is quite possible that a site could be assessed as being subject to static liquefaction but not subject to liquefaction for the design seismic event.

For the purposes of liquefaction assessment, it may be considered prudent to make conservative assumptions regarding the location of the phreatic surface and hence the extent of saturated tailings that are subject to the liquefaction event. However, for post-liquefaction stability assessment, it is considered that post-liquefaction strengths should be assessed on the basis that the upper part of the deposit will be over-consolidated (due to desiccation), and will have a higher strength than normally consolidated tailings.

# 5 Discussion

Proper design of a thickened tailings scheme requires careful testing of representative samples of tailings. Once established, the geomechanical properties of deposited thickened tailings are effectively a 'given' until there is a change in ore type and/or processing (although these should be checked periodically). Because the tailings are non-segregating, these same properties can be considered to apply over the whole of the deposit.

Two factors impact on the achieved strength and density of the deposited tailings. Evaporation off the exposed (sub-aerial) beach is the defining mechanism. Sites in hot, arid climates can be expected to experience high surface suctions year round, and a deep partially saturated tailings deposit will be the outcome. On the other hand, in higher latitudes with reduced evaporation, or tropical areas with extremely high rainfall, there may be considerable portions of the year where evaporation is not sufficient to result in desaturation. This may be further complicated by freezing conditions in winter. This is clearly a site-specific factor, and must be considered on an individual site basis.

Site depositional practices may also influence the outcomes. For a central thickened discharge scheme, deposition may occur relatively randomly over the full surface of the beach, and in thin layers. Once established as a mature scheme, the annual rate of rise may be relatively low. In general, significant drying can be expected to have occurred before deposition of the next layer. In addition, surface-applied suction will generally generate a suction profile deep into the tailings beach, and even if some individual layers are still wet when covered, further drying is possible.

Conversely, some sites adopt practices where thicker deposition over more limited areas is managed in a cyclic fashion. The base of these layers may never dry to the same degree as achieved by thin layer deposition, particularly in the case of finer grained tailings where the unsaturated permeability values can be very low, effectively locking in the moisture at depth. The results from this practice may fail to achieve the full benefits available to a thickened discharge scheme.

# 6 Conclusion

The properties and behaviour of deposited thickened tailings are an interplay between (a) the intrinsic material properties, (b) site climatic characteristics, and (c) site-specific management practices.

In the first instance, if the tailings do not segregate, it is likely that better packing and settled densities will result. In favourable conditions, evaporative drying induces partial saturation and a suction profile through the deposited tailings. This results in the top part of the tailings deposit achieving a higher density (over-consolidation) compared to conventional deposition.

Similarly, the partially saturated tailings will exhibit significantly higher strengths compared to saturated, normally consolidated tailings.

Design of a thickened tailings scheme should be based on a comprehensive set of tailings test results, and site climatic conditions, so that the benefits of the method can be maximised.

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