THE INFLUENCE OF DEPOSITIONAL METHODS ON THE
ENGINEERING PROPERTIES OF TAILINGS DEPOSITS

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SYNOPSIS

During the past two decades there has been a considerable advance in the understanding of the physical and chemical processes which are active in tailings deposits. It has been recognized that alternative placement methods and impoundment operating procedures result in deposits with substantially different engineering properties. Advantage has been taken of these differences to develop alternative tailings impoundment construction methods suited to different tailings types, impoundment sites, climatic conditions and impoundment performance requirements. In this paper the most significant processes are reviewed and their effect on the engineering properties of the tailings impoundment discussed. The significance of the engineering properties relative to appropriate methods of impoundment construction, abandonment preparation and pollution control are briefly mentioned.

INTRODUCTION

Tailings may be produced in either a dry or slurry form.

Dry tailings, in the form of ash, is produced in large quantities from thermal coal fired powerstations. Other sources of dry tailings are the coarse rejects from some coal, metal and mineral recovery processes. Methods of handling such dry tailings are essentially similar to many other dry earth or overburden moving exercises. Excellent descriptions of large dry handling and stacking operations for ash tailings are provided at this conference by Boswell, 1987.

Dry tailings, depending on their geochemical properties, may be subject to leaching of contaminants, acid generation or spontaneous combustion. They are also subject to weathering and the development of destabilizing pore pressures as demonstrated by the Aberfan coal tip failure in Wales in 1966. Control of these effects are, in many instances, similar to the controls required for tailings deposited in a slurry form as discussed in later sections of this paper. They differ from slurry deposited tailings in two fundamental respects:

(i) interim stability is usually of less concern and a retaining embankment or wall is not usually required, and

(ii) the surface of the tailings are usually trafficable during placement permitting compaction to be applied, such as that described at this conference by Gifford and Coetzee, 1987.

This paper addresses primarily tailings which are in a slurry form prior to disposal. Because of the economics of transportation and placement, tailings which are initially dry are often slurried prior to disposal. Tailings which are initially in slurry form but are then subjected to a dewatering process, using a mechanical device to produce "dry" tailings, are referred to as dewatered tailings.

Almost all tailings impoundments are constructed with four primary objectives in mind. These are:

(i) to serve as a liquid:solids separating basin in which the tailings settle out allowing the excess process water to be decanted;

(ii) to contain or control excess process water contained in the tailings pore spaces and in the surface pond until it is decanted or seeps away in a controlled manner;

(iii) to contain the tailings solids in the long term (including soluble contaminants) to a level consistent with environmental protection requirements, and

(iv) to achieve (i) to (iii) at the lowest possible cost.

The tailings solids are usually earth like materials and are often suitable for either embankment and pile construction which meets these objectives, provided they are placed in a manner which enables them to achieve a required "set of engineering properties".

CONSTRUCTION METHODS

Before reviewing how the engineering properties of the deposited tailings, can be influenced by the depositional method it is appropriate to consider which tailings properties are most important in influencing construction methods and costs.

Three primary containment facilities are defined

(i) No Embankment Facilities

Such facilities do not require the construction of an embankment. Examples are under sea or in-lake disposal as practiced in Canada and New Guinea, and in-pit disposal. Since the containment basin is natural there is no need for constructed embankments. The primary properties of interest for under water disposal are:
angle of deposition slope and hence deposit geometry.

liquid effluent quality and hence the impact on receiving waters.

turbidity from discharges and flows.

susceptability to liquefaction.

An excellent text on marine disposal of tailings is provided in Ellis, 1982.

For in-pit disposal the following properties are also of interest:

- average tailings density at closure and hence the mass capacity of the pit.
- consolidation following closure hence cover deformations.
- permeability and leachate quality hence operational and post closure leachate yields and quality.

(ii) Central Discharge Facility

A central discharge cone deposit is illustrated in Figure 1 and is described by Robinsky, 1975 and 1978. No embankments are required for tailings retention. The tailings property of most critical interest is the angle of the beach slope that will form since this determines the angle, location and volume of the cone. Tailings thickening is employed to increase the beach angles requiring an understanding of the relationship between the slurry density and beach angle. Additional parameters of interest are:

- the density of the tailings deposit for mass capacity determination.
- the relative density of the tailings below the saturated zone and hence its susceptibility to liquefaction.
- erosion characteristics of the cone slope.

![Figure 1 Central Discharge Cone Deposit (Robinsky, 1979)](image)

consolidation, permeability and leaching characteristics for long-term seepage qualities and rates.

(iii) Embankment Retained Deposits

It is customary to divide tailings retention embankments into one of three classifications (ICOLD, 1982). These methods of construction are illustrated in Figures 2, 3 and 4.

1. Upstream Construction

The impoundment crest is advanced upstream by periodically constructing small embankments on the tailings deposit immediately upstream from the previous embankment. The small embankments may be constructed of tailings and/or borrow materials, and are not usually critical in the overall embankment stability. What is critical is that the embankment is raised over previously deposited tailings and this requires that the underlying tailings have sufficient shear strength to be stable. Stability is achieved by one of two methods.

(a) By constructing a graded beach deposit, as shown in Figure 2(a), by spigoting from the embankment such that the phreatic surface is drawn down low near the embankment and the embankment zone is consolidated. The basis for drawdown is clearly described by Blight, 1987 in his paper to this conference.

(b) By constructing an outer zone in which the tailings have been compacted and drained by air drying. This system is referred to as either the paddock system or irrigation method as described by Gowan and Williams, 1987 and Gowan, 1987, at this conference. Since the air drying is required to both dewater the tailings (preventing pore pressure generation) and to develop the negative pore pressures required to compact the tailings (Blight and Steffen, 1979) the rate of rise is limited by the slurry settling density and net evaporative conditions. Maximum rates for Witwatersrand gold tailings and climatic conditions are provided by Wates et al. 1987 at this conference.

![Figure 2(a) Upstream Construction by Spigot Discharge](image)

![Figure 2(b) Paddock System Upstream Construction](image)

Both the above methods usually include a system of underdrains under the embankment zones to assist in the drawdown of the phreatic surface.

Engineering properties of critical importance to these construction methods are:

- the segregation and hence grain size distribution along the beach and its variability, hence the potential deposit permeability from the pond to the embankment face.
- the density and compressibility of the tailings under the embankment crest which, together with the permeability (including...
effects of layering) and rate of embankment rise, determines the pore pressures developed under the embankment and hence its stability.

Ice lensing in the beaches (in severe cold climate areas) and its effects on drainage.

the compressibility and consolidation of the soft slimes zone in the centre of the deposit and its effect on cap deformation and long term seepage releases.

permeability and leaching characteristics of the deposit and its effect on long term seepage quality.

2. Centreline Construction

With centreline construction the impoundment crest is raised vertically upwards as the embankment is constructed, as illustrated in Figure 3. The embankment downstream from the centreline is constructed of materials over which some control can be exercised as to its permeability and compaction. Both borrow materials and cyclone sands are often used. The individual lifts can be constructed in horizontal layers or layers parallel to the downstream slope of the embankment. An example of construction using compacted cyclone sand is provided by Griffin et al., 1983. Control of the downstream embankment properties permits stable conditions to be achieved in the embankment. The suitability and cost effectiveness of the method is dependent on there being sufficient coarse materials in the total tailings to enable a sufficient split to be obtained. The degree of compaction and drainage required is dependent on the relative density achieved by the cycloned sands in the saturated zones.

Engineering properties of critical importance to this construction method are:

- the percentage of coarse material that can be split from the tailings for embankment construction.
- the relative density of the embankment sand and hence its susceptibility to liquefaction.
- the potential for ice lensing and its effect on drainage in the embankment.
- the consolidation and long term settlement of the slimes in the impoundment and its effect on reclamation covers and long term seepage.
- the permeability and leaching characteristics of both the embankment sands and the fines and the resultant quantity and quality of long term seepage.

3. Downstream Construction

Downstream construction is essentially a variation of centreline construction, in which the crest of the impoundment is advanced downstream as successive lifts are added, as illustrated in Figure 4. Such construction is normally used only where the tailings materials are extremely weak and provide little support to the upstream face of the embankment; where the water pool is impounded against the embankment; or where severe climatic, seismic or toxic tailings conditions warrant the additional security and costs.

Engineering parameters of interest are essentially similar to those for centreline construction.

ENGINEERING PROPERTIES OF PRIMARY INTEREST

Grain Size, Type and Permeability

Grain size distribution and type is normally determined by the ore type and the milling process and is beyond the control of the impoundment design engineer. It is the most fundamental property of the tailings, controlling the basic engineering property of permeability. A first estimate of permeability can be made from the grain size distribution using Hazen's formula as described by Bight, 1987. This is modified substantially by the density of the tailings as illustrated in Figure 5 after Vick, 1983.

Of greater importance in any tailings impoundment is the variation in permeabilities resulting from grain size variations caused by segregation during tailings placement. Variations in permeability between the sand and slime zones of a tailings impoundment may be as much as three orders of magnitude. Thus the sand zone from a cyclone split tailings, or at the top of a well segregated spigot discharge placed beach, may be one to two orders of magnitude greater than the average (unsegregated) tailings.

Layering of beach deposited tailings is highly anisotropic with permeability parallel to the layering being one to two orders of magnitude greater than normal to the layering. Such layering is adversely oriented for drainage purposes and is therefore undesirable. Where ice layers are included in the beaches (as occurs in northern Canada) they are barriers to drainage.

Consolidation Characteristics and Density

During consolidation, the effluent in the pore spaces is squeezed out resulting in a closer spacing of the grains. Consolidation under an increase of stress results in a decrease of the void ratio and an increase in the dry density of the tailings. Consolidation is stress history dependent and for each tailings sample there is a void ratio, effective stress relationship as described by Bight and Steffen, 1979, and illustrated in Figure 6. Effective stress increases causing consolidation can result from any of the following:

(i) Additional layers of incumbent tailings

Figure 7 illustrates some typical increases in density with increased depth of tailings impoundments. Generally the higher the initial void ratio the greater the density increase under
increased loading. Thus slimes tend to consolidate more than sands for the same stress change. Full consolidation occurs only after all excess pore water pressures have dissipated allowing the maximum effective stress to be felt by the tailings grain structure. Excess pore pressure dissipation is time dependent, depending on the permeability and the drainage path length. Recent studies have indicated that the time rate of consolidation in a tailings impoundment is not well represented by classical (Terzaghi) consolidation theory. Instead consolidation according to finite strain theory as described by Schiffman 1980, Carrier and Bromwell, 1983, Geocon, 1986, provides a more realistic model. This latter model results in considerably increased estimates of drainage and consolidation rates.

(ii) Drawdown of water table due to underdrainage.

Should drawdown of the water table occur, the effective stresses in the tailings increases resulting in very substantial settlements, particularly in the region of the slimes pond. For highly segregated tailings deposits, differential settlements may be large, and should they occur after the tailings impoundment surface has been contoured and covered, will disrupt drainage patterns and crack cover layers. The increased density resulting from consolidation due to drainage increases the capacity of the impoundment.

(iii) Pore suction due to evaporative drying

The high pore suction resulting from evaporative drying at low moisture contents is well documented and results in the consolidation and cracking of surficial tailings layers. This method of dewatering and consolidation is exploited to advantage for the creation of the consolidated drained zone of the outer portion of the retaining embankment in the paddock construction system. The large increases in effective stress and the resulting void ratio reductions have been documented by Blight and Steffen, 1979, and are illustrated in Figure 6.

(iv) Frost action

The effect of freezing tailings is to prevent consolidation and drainage for as long as the tailings are frozen. In northern Canada large accumulations of frozen tailings have occurred under the beach areas of annually layered tailings impoundments. The zones under the pond tend to not freeze. On thawing the low density frozen tailings will consolidate resulting in large surface settlements. Such settlements would disrupt surface drainage and capping layers. Cycles of freezing and thawing have two effects. On freezing the water is drawn from the tailings pores and forms ice crystals and lenses which separate the tailing solids. Thus the tailings solids are consolidated between ice filled channels. On thawing these channels permit the rapid drainage of fluids resulting in an increase in the tailings mass permeability. Some of these channels close as the thawing tailings slump under the incumbent loads. Knight and Piesold, 1986, have demonstrated that for gypsum rich tailings, the frost induced consolidation may exceed the evaporation induced consolidation, while overall tailings permeability remains considerably higher than for equivalent unfrozen load stress consolidated tailings.

Frost effects on surficial layers of tailings (and cover soils) results in an increase of the surface permeability and consequently an increased infiltration rate. This has considerable significance if surface infiltration is to be minimized to reduce leaching and contaminated seepage.
Shear Strength

The shear strength of tailings is generally of importance only where tailings are used for embankment construction, or for trafficability on the surface of the tailings.

Tailings are characterized by low cohesion and high frictional strength parameters. To develop frictional strength requires the dissipation of excess pore pressures resulting from imposed loads.

Sand sized tailings are usually sufficiently rapidly draining so that they may be used for embankment construction by any of the construction methods.

Silt sized tailings are generally so slow draining that they cannot be used for embankment construction by any of the conventional methods except the paddock system in which dewatering

![Figure 7 Increase in Average In-Place Density with Depth](image)

(drainage) is achieved by evaporative drying. Some silt sized tailings can be mechanically dewatered to a sufficient extent to permit "dry" placement.

Si typically or predominantly clay sized tailings can usually not be used for embankment construction, except by the paddock system. Where silt and clay sized tailings have been dewatered it is necessary that they remain so, by effective drainage, if additional embankment construction is to proceed over them.

To achieve trafficable conditions on silt and clay sized tailings they must be dewatered to a partially saturated state for 0.4 to 0.6 m below the surface.

Liquefaction Potential

Hydraulically placed tailings sands and silts are usually in a state of low relative density (less than 60%) and if saturated are susceptible to liquefaction under dynamic (seismic) loadings. In areas subject to seismic risk, it is usually necessary to design to allow for the potential for liquefaction. This means the avoidance of upstream construction methods (where embankment sands cannot be compacted) or, if used, the installation of sufficient under drainage and a sufficiently secure placement method to prevent the build up of saturated uncompacted zones in the embankment.

Cycloned tailings sands and borrow materials can be compacted to relative densities above the approximately 65% value required for dynamic stability.

Acid Generation and Leaching

Where tailings leachates are such that they cannot be released to the environment, seepage prevention or interception and control becomes necessary. Under these circumstances the permeability of the tailings and tailings embankment is of considerable concern. These can be modified to some extent by the tailings placement and management method. In this respect drainage to promote stability generally serves to increase seepage, both in the short and long term. It is noted that after abandonment, that seepage will stabilize at the level of infiltration. Thus long term seepage control requires control of the rate of infiltration by drainage from and sealing of, the surface of the tailings impoundment.

Where tailings are acid generating it may be necessary to control the ingress of oxygen and/or water. Methods of such acid generation control have been reviewed by Robertson, 1987. The most successful control is a water cover which is generally not feasible for embankments constructed using tailings. Little is achieved for acid generation control through alternative placement techniques except where the percentage of tailings maintained in a saturated state is increased.

PLACEMENT FORMS

Tailings placement can be in one of the following forms; dewatered tailings, cycloned tailings or slurried tailings.

Dewatered Tailings

Methods of dewatering tailings and for the handling and placement of the resulting products have been reviewed by Robertson et al, 1982.

Equipment for tailings dewatering includes centrifuges and a range of filters including disk, drum and belt vacuum filters, belt presses and filter presses. The degree to which dewatering can be achieved is dependent on both the nature of the tailings and the equipment used. Tailings products may range from a sloppy semi-slurry to a product which behaves essentially as a "dry" granular material.

The handleability, trafficability and stability of the dewatered product is critically dependent on the degree of dewatering achieved. Sloppy semi-slurry cannot be travelled on and requires containment embankments for its retention. It therefore requires specialized placement equipment such as conveyors. 'Dry' granular tailings can be handled by conventional earth moving equipment and handled and placed in a conventional manner. By co-disposing sloppy tailings and other dry mine wastes, it is possible to achieve 'dry' pile conditions.

The only significant difference between a deposit of sloppy dewatered tailings and a slurry placed tailings is the uniformity (lack of segregation)
that results in the denser tailings deposit. Moisture contents, at placement, are so high that large consolidation settlements are required to expel excess pore water before consolidated densities and strengths are achieved. Thus the engineering properties of interest are essentially similar to those for tailings slurry deposits except for the uniformity and isotropy of the deposit. Similar containment facilities are required with similar seepage controls and abandonment measures.

Uniformity and isotropy of engineering properties can be achieved with a "dry" tailings product. However, since the tailings are placed in a partially saturated state, they can be compacted to achieve desirable densities, consolidation or shear strength characteristics. Further consolidation and settlement can occur instantaneously under the placement of additional incipient layers and there is very little pile deformation after the end of construction. There is little restriction on the shape of pile that can be constructed. This allows the development of a tailings pile which is consolidated, stable and reclaimed at the end of its construction period. The long term infiltration leaching and seepage quality remains a concern.

Cycloned Tailings

Where there is a sufficient portion of the tailings with an average grain size in the sand fraction (plus 200 mesh) for it to be split out and used as a construction material, consideration may be given to cyclonic classification. The relatively free draining characteristics of the sand fraction makes it suitable for use as a construction material, when placed in a slurry form. Underdrains may be required to assist in the collection and removal of drainage and seepage waters.

Methods of cycloning and placement, and constraints on construction, are reviewed in both ICOLD, 1982, and Vick, 1983.

The sand fraction in the embankment is relatively isotropic, consolidates rapidly, and develops a low water table. If placed without compaction, portions of it will be at relative densities susceptible to liquefaction under dynamic seismic loading.

The slimes fraction, placed behind the tailings embankment is placed by conventional spigotting techniques at a low slurry density. The properties of these fine grained slurry deposits are as discussed in the next section.

Slurred Deposits

Engineering properties of tailings deposits placed as a slurry are essentially dependent on:

the degree of grain size classification and segregation that has occurred within the deposit, and

the degree of consolidation the deposit has achieved.

The grain size classification that occurs along the beach of a tailings deposit has been examined by a number of workers including Blight, 1987, Wates et al., 1987 and Williams and Morris, 1987, at this conference. It is apparent that a number of different mechanisms are effective in producing the classification that is observed in tailings deposits.

(i) Slurry Density

The first basic mechanism is dependent on slurry density. At very high slurry densities there is interference with the settling out of coarse particles during flow, reducing the amount of classification and segregation along the flow path.

(ii) Flow concentration

The second basic mechanism is dependent on depth of flow. It is observed that if slurry of a given density is discharged to flow as a shallow wide flow it tends to develop steeper beaches, with less segregation than if discharged as a concentrated flow.

Both mechanisms can be used to advantage to promote or restrict segregation along the beach. The least segregation is achieved by discharging thickened tailings through a system of spray bars with closely placed small spigots. This method is described by Knight and Haile, 1983, and Gowan and Williamson, 1987, as the sub-aerial technique. The greatest segregation is achieved by employing a single spigot discharging point and a low slurry density. Thus good segregation is anticipated during the initial deposition from any central disposal system (Robinsky, 1975).

For low density slurry deposits, the tailings beach angle may be calculated from the Master Profile concept as described by Blight, 1987 and the grain size distribution along the beach by the relationship proposed by Blight, 1987 or Williamson and Morris, 1987, at this conference. Beach angle determination for thickened tailings may require field trials. A typical beach angle versus slurry density relationship is illustrated in Figure 8 (after Robinsky, 1975).

![Figure 8 Laboratory Tailings Deposition Test Results. Magma Copper Company, Superior Division](image-url)
the slurry flows as a density stream at shallow angles (a few degrees) for long distances, with segregation along the flow path. Where a shallow distributed flow enters a tailings pond, tailings are deposited rapidly with little segregation to produce much steeper slopes.

PLACEMENT METHODS AND THEIR EFFECTS ON ENGINEERING PROPERTIES

Sub-Aqueous Discharge

Where sub-aqueous discharges are moved about or distributed, a deposit of fairly uniform grading (little segregation) results. Since deposition is below water, consolidation is due to the load of incumbent layers only, resulting in a very low density normally (or under) consolidated deposit, particularly near the upper surface of the tailings. Such deposits are typical of the pond area of many tailings impoundments, which also represent a concentration of the finest grained tailings. Such deposits are characterized by a high void ratio, high compressibility index and a low isotropic permeability. If, following decommissioning, there is a drawdown of the water table and air drying, such deposits are subject to large consolidations and settlement. Because of the water cover they are normally ice free. Estimates of the consolidation settlement for a typical deposit of this type has been made by GEOCON, 1986, who indicate that settlements may approach 20 to 30% of the deposit depth.

Should water cover be preserved then the large additional consolidation settlements will not occur; oxygen entry and oxidation (acid generation) is prevented and long term seepage and stability are a concern.

Paddock System Deposits

In the embankment zone of the paddock system, the thin layered nature of deposit results in a fairly homogeneous, though anisotrophic, distribution of engineering properties. Partially saturated tailings conditions can be achieved provided the rate of rise, during construction, is sufficiently low and re-saturation is prevented by an effective underdrainage system. Desiccation compaction resulting in relatively high densities compared with incumbent load consolidation only. Little or no additional settlement is anticipated after impoundment abandonment. Drainage from the underdrains must be maintained for embankment stability and this may be a cause for concern for long term seepage control. It is not usually feasible to develop a water cover for acid generation control and the partially saturated deposit conditions are favourable for acid generation.

The engineering properties of the interior zone is essentially similar to that for spigoted discharges discussed below.

Spigot Discharges

(i) Thickened Layered Tailings

Thickened tailings placed through closely spaced spigots result in a deposit in which the segregation is minimized. Since segregation is minimized it is usually necessary to install an extensive underdrainage system to assist drainage and dewatering. Rates of rise must be kept sufficiently low that either drainage or air drying will be sufficiently great to achieve pore pressure dissipation to ensure embankment stability.

Embankment zones are of necessity drained and consolidated. For finer grained tailings this consolidation may depend on desiccation compaction and thus on the rate of rise. In wet and cold climatic conditions, this desiccation compaction may be seasonally poor. Permeability is usually high anisotropic and may on balance of magnitudes or more greater parallel to the layering than normal to it. This may be further complicated by ice inclusions in the beach areas resulting from deposition during severe winter conditions. This results in poor lateral drainage towards the perimeter drains and may result in perched water tables near the outer slopes. Permeability is reduced in the partially saturated zones by both desiccation compaction and partial saturation. Density is not increased and permeability is not reduced in the zones where desiccation has not occurred (in the pool zone, frozen zones or zones where wet climatic conditions prevented significant evaporation). Zones of low density may be susceptible to liquefaction.

Large consolidation settlements are anticipated in the pond area and where included ice exists in beaches.

Where upstream construction is used, drainage of the embankment zones must be maintained in the long term and may be a cause for concern, if seepage cannot be discharged. The partially saturated deposit conditions are favourable for acid generation, and control of acid generation by a water cover is usually not feasible.
(ii) Unthickened Layered Tailings

Unthickened (low slurry density) tailings placed through spigots onto wide beaches will result in segregation along the beaches. The uniformity of segregation will depend substantially on the uniformity of the placement conditions. Variations in the density of the slurry or discharge method will result in variations in the grain size layering. Development of a coarse drained outer zone for upstream construction is dependent on a well graded tailings with a substantial coarse fraction (plus 200 mesh) and uniform placement conditions.

Grain size and permeability distribution estimates may be made in accordance with the methods described by Blight, 1987. Perimeter underdrainage is required to ensure drainage and consolidation of the embankment zones. The permeability will be anisotropic depending on the variations in tailings discharge conditions. Beach deposition is conducive to ice development and included ice layers, as reported by GEOCON, 1986, would considerably increase the anisotropy of permeability.

Some desiccation consolidation may occur but this may not be a major contributor to densification. Embankment zones are expected to be normally consolidated under a drained condition. The low density embankment sands are susceptible to liquefaction if saturated. In view of the layered, some saturated perched table zones would be anticipated. The interior of the embankment would be under or normally consolidated under a high water table. The pond zone is expected to be fine grained, ice free with a high void ratio.

Following abandonment, the water table drops as a result of drainage, surface desiccation occurs and entrapped ice melts, and large surface settlements could occur as demonstrated by GEOCON, 1986.

Where upstream construction is used, drainage must be maintained in the embankment zone, after abandonment, to ensure stability. Long term seepage is a concern if the water quality is such that it cannot be discharged. The partially saturated conditions in the embankment are conducive to acid generation and control cannot be achieved by a water cover.

Central Discharge Cones

Placement using a controlled discharge to form a cone deposit is essentially a variation of the spigot discharge. The same range of engineering properties and concerns exist. Some primary differences are:

- there is no need to maintain an underdrainage system to ensure embankment stability.
- the post-closure settlement is such that drainage patterns will be preserved.
- susceptibility to liquefaction is reduced by the low slope angle.
- erosion of the tailings surface is a long term concern.
- the ability to achieve the highly thickened tailings required for economic operation is often not practical.

REFERENCES


Steffen Robertson and Kirsten, 1987, Frost Action Study for CANMET, Canada, National Uranium Tailings Program

