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# Mine Tailings Deposition Practices, Liquefaction Potential and Stability Implications

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**SYNOPSIS:** Typical mine tailings characteristics resulting from different deposition practices are discussed. The potential for liquefaction of the tailings during seismic events is presented. A discussion of how the tailings deposition method can affect the liquefaction potential is included. Tailings dam construction techniques are reviewed and evaluated with respect to the tailings deposition method and liquefaction potential. A case history is presented to illustrate how the tailings dam construction method must be coordinated with the method of tailings deposition.

## INTRODUCTION

This paper presents an overview of typical metalliferous ore tailings properties, tailings deposition methods and tailings dam construction practices. In situ tailings characteristics and the potential for liquefaction during seismic loading which may result from the various disposal methods are discussed. The potential economic impacts on tailings dam construction which may result from the disposal method follows. A case history is presented to illustrate how the tailings dam construction method and tailings disposal practices must be compatible.

## TAILINGS CHARACTERISTICS

Tailings are the waste product resulting from the milling and beneficiation of ore for mineral extraction. The tailings consist of rock particles which have been crushed and ground to sand, silt and clay sizes. Typical tailings from metalliferous ore consists of angular particles ranging from 1-2 mm to 0.001 mm, or finer, in size. The finer tailings are commonly referred to as "slimes" while the coarse component is simply "sand". Although consisting of a high percentage of silt or clay sized particles, the tailings consist of finely ground rock and typically exhibit marginal plasticity, if any at all. Figure 1 depicts a grain size curve envelope typical of tailings from base or precious metal mining operations. Tailings from base metal operations tend to plot toward the left side of the envelope whereas those from precious metal operations tend to fall to the right.

The tailings are generally transported from the mill to the disposal area as a slurry. The slurry is discharged into the disposal area where the solid particles settle out of suspension and the liquid component collects in a "free water" pool where it is recycled back to the mill. As the settling particles consolidate, additional fluid bleeds from the tailings surface and migrates to the pool.

Due to their fine size, tailings particles have a slow settling velocity which can result in a low density tailings deposit upon initial settling. The fine particle size also results in a relatively low permeability mass which consolidates slowly. The end result can be large deposits of relatively loose saturated tailings, which are highly susceptible to liquefaction.

## TAILINGS DISPOSAL

As the tailings slurry is discharged into the disposal area, a progressive decrease in the flow velocity as the flow spreads results in a

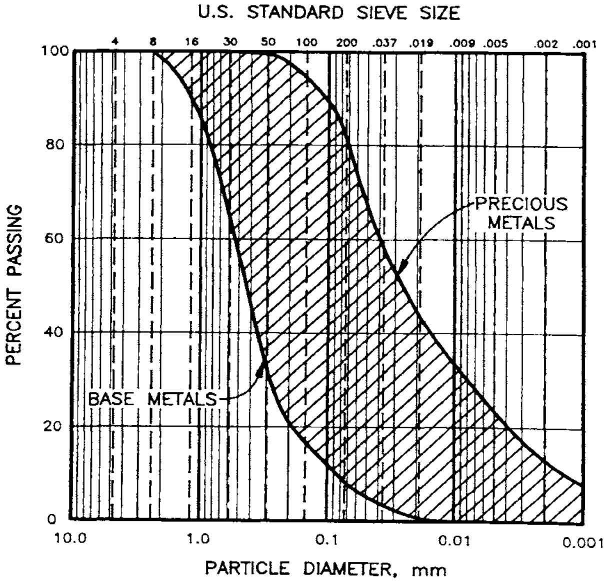


FIGURE 1
METALLIFEROUS MINE TAILINGS
GRADATION ENVELOPE

tendency for the coarsest particles to settle and deposit first with progressively finer particles deposited with increasing distance from the point of discharge. Thus, the hydraulic placement method results in some segregation of the tailings by grain size. The degree of segregation and sorting by grain size can be quite high to nearly nonexistent. The amount of sorting which occurs is influenced by the gradation and specific gravity of the tailings, and the initial slurry density and specific flow rate (i.e. the volume discharged per unit flow width). Well graded tailings tend to exhibit a greater degree of segregation than poorly graded tailings. High specific gravity tailings also tend to exhibit a greater degree of sorting. The tailings slurry density also affects the sorting processes with lower slurry densities tending to result in greater separation.

Segregation of the tailings typically results in a "beach" of relatively free draining tailings sand near the point of discharge which grades to tailings slimes and a free water pool distant from the discharge point. The tailings beach profile is generally parabolic and concave upward with the steeper portions nearest the point of discharge. The tailings beach generally slopes towards the solution pool at an average grade of 0.5 to 2 percent.

Tailings near the point of discharge are generally deposited at higher initial densities than those more distant due to the mechanics of deposition in the higher energy environment and the greater degree of particle impingement. Tailings deposited in the fluvial environment of the beach are typically deposited at significantly higher densities than those deposited within the lacustrine environment of the free water pool. For most metalliferous mine tailings the void ratio for beach tailings typically ranges from about 0.6 to 1.0 while the slimes deposited in the solution pool may exhibit a void ratio on the order of 1.0 to 1.6 or higher. Following settling, tailings typically exhibit a moisture content in the 50 to 100 percent range. Sandy beach tailings may exhibit a permeability as high as $10^{-3}$ cm/sec while the slimes can be as low as $10^{-8}$ cm/sec.

The formation of a dense sandy tailings beach can be facilitated by discharging the tailings from a series of closely spaced multiple discharge points or spigots located around the periphery of the disposal area. By operating groups of spigots in an alternating sequence, thin layers of tailings can be progressively deposited, drained and desiccated to maximize the tailings density. This type of tailings operation is commonly referred to as managed, thin-lift, sub-aerial deposition. Typically, layer thicknesses range from 4 to 6 inches and deposition, drainage and consolidation can take several hours to several days.

As each thin layer of tailings deposited under managed thin-lift conditions drains and is subject to evaporation, negative pore pressures develop due to capillary action in the fine grained material. These negative pore pressures can lead to overconsolidation of the tailings and considerable densification. The resulting densification can exceed the ultimate self weight consolidation in many instances. Desiccation of the tailings may take several days to several weeks. After draining and desiccation, the moisture content may be in the range of 15 to 30 percent.

During deposition of the next layer of tailings the surface of the desiccated tailings will absorb moisture to some degree. However, the depth of re-wetting is not great as the densified tailings will typically exhibit a permeability which is much lower than in the overlying freshly deposited tailings. In addition, the hydraulic gradient is low and the desiccated tailings are not in contact with slurry flow for any appreciable length of time. Thus, the desiccated tailings are not generally resaturated unless ponding occurs over the area due to seasonal increases in the free water pool or prolonged wet weather.

Idealized laminar sheet flow across the beach frequently does not occur, and the tailings depositional regime may be upset. Instead, the depositional processes may resemble natural deltaic sedimentation whereby meandering braided channels control deposition. This type of flow mechanism can result in very thin alternating layers of slightly finer and coarser particles or micro-stratification. Finer grained tailings can be deposited between individual spigot points if the spacing is too wide. Encroachment of the solution pool onto the beach can also cause layers of slimes to be deposited within the beach. The inclusion of even a small amount of slimes in the tailings beach may have a serious negative impact on stability of the tailings dam.

Variation in slurry flow rates, solids content, grind characteristics, ore hardness, ore weathering, the presence of clay minerals, etc., during operations, can also have a large impact on the character of the tailings mass.

For tailings deposited by single point discharge methods, in rapidly accumulating layers or in extremely wet climates, consolidation and desiccation cannot occur and the tailings are generally underconsolidated and remain saturated during and sometimes long after operation of the facility. These conditions generally exist for tailings slimes and tailings in the vicinity of the free water pool even when well developed sub-aerial deposition is occurring in the beach area.

## TAILINGS LIQUEFACTION

Since mine tailings typically consist of cohesionless particles deposited in a saturated state by hydraulic methods they can be quite susceptible to liquefaction during earthquake loading. Liquefaction of the tailings deposits retained by a tailings dam can have severe consequences on the stability of the dam. In terms of liquefaction characteristics, tailings differ from natural soils in several key ways. These differences can have a significant affect and must be considered when evaluating the potential for liquefaction of tailings deposits.

In marked contrast to natural soil deposits, fines present in tailings deposits are generally non-plastic, very fine, rock particles or "rock flour". Thus the tailings slimes generally behave as a cohesionless soil while at the same time exhibiting some of the properties of a silt or clay soil. The presence of a small amount of plasticity in the tailings tends to increase the resistance to liquefaction. Ishihara et al. (1980) report significantly higher cyclic strengths for slimes with a plasticity index (PI) of 15-30 versus slimes with a PI <10 even though the high plasticity slimes were tested at a much higher void ratio. Ishihara et al. (1981) report that the cyclic strength for slimes with a PI of 40 is approximately 50 percent higher than for slimes with a PI of 10.

Laboratory testing of tailings materials has demonstrated that at equal void ratio, non-plastic tailings slimes are more susceptible to pore pressure build-up and liquefaction than are tailings sand (Ishihara, et al., 1980, Troncoso, 1986). Tonscoso (1986) indicates that silty sand tailings with 15 percent fines have one half the liquefaction resistance of clean sand from the same tailings dam at the same density. Since the slimes are generally deposited at higher void ratios than the sands and consolidate slower, they can be extremely prone to liquefaction during an earthquake. Laboratory testing of tailings slimes has shown a much quicker rise in pore pressure ratio versus the number of stress cycles than is observed for sand (Moriwaki, et al., 1982). Thus, even in the absence of liquefaction, the rapid development of high pore pressure ratios in the slimes can lead to drastic strength reductions.

In order to prevent or limit the potential for liquefaction of tailings deposits, they must be unsaturated and/or dense enough to be dilative during shearing i.e. denser than the "critical state" of the particular material. The angular and irregular shape of individual tailings particles can result in a high degree of interlocking causing the tailings to be highly dilative at low to moderate confining pressures when in a medium dense to dense condition.

The "critical state density" can be exceeded by mechanical compaction of the tailings or through well controlled, thin-layer, sub-aerial deposition techniques. With well developed sub-aerial deposition, the desiccation processes can result in densities which are 50 to 100 percent greater than the density that can be achieved when settling in water (Blight and Steffen, 1979; Knight and Haile, 1983). This can result in relative densities of 60 to 70 percent. The sub-aerial deposition technique can also lead to substantial overconsolidation of the tailings which will increase the lateral earth pressure coefficient and therefore, the liquefaction resistance (Moriwaki, et. al., 1982).

The cost for methods of increasing the tailings density or reducing the phreatic surface should be evaluated with respect to the dam construction costs. In some instances it may be more economical to reduce the potential for liquefaction of the tailings, whereas in others, it may be more economical to assume the tailings will liquefy and construct a dam which is sufficient to retain the liquefied tailings.

## TAILINGS DAM CONSTRUCTION

Tailings disposal structures must be designed to fully contain all tailings solids and supernatant solution in a stable <u>and</u> cost-effective manner. These two criteria are frequently at odds and requires careful evaluation of many factors to arrive at the optimum solution.

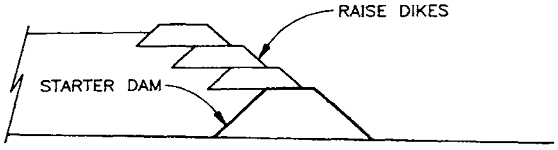
In order to be cost-effective, early tailings dams were frequently constructed in an upstream fashion using mine waste rock, or most often, the tailings themselves. For this type of structure, a small starter dam is constructed from which tailings are deposited. As the tailings level approaches the dam crest, a small dike is constructed on the tailings beach to raise the crest height of the dam and then tailings deposition continues and the process is repeated. Figure 2a depicts a cross section of a tailings dam constructed in this fashion. As shown on this figure, as the height of the dam increases, the crest progressively moves upstream. Hence, this method of dam building is referred to as upstream construction. As evident in Figure 2a, upstream construction of the dam results in a thin shell of material which retains the impounded tailings.

The upstream construction method offers major advantages in terms of the cost and simplicity of dam construction. A small volume of mechanically placed fill can be used to create relatively high embankments. The fill can be obtained from the beach sand at minimal cost and placed in an incremental fashion to distribute construction costs over the life of the facility. Dike construction can be routinely performed by the on-site personnel utilizing available mining equipment. In some instances, the raise fill may be placed hydraulically with minimal or essentially no compaction.

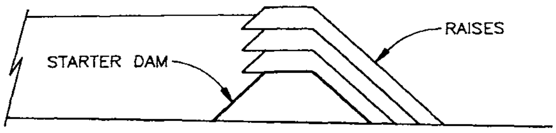
Upstream raise methods are limited to projects with a beach capable of supporting the construction of the raise dikes. The ability for the beach tailings to support the raises may be severely compromised by the inclusion of even a small amount of slimes or poorly consolidated layers of tailings. Liquefaction of tailings beneath the upstream raises can lead to gross instability of the structure and a flow slide failure which can release a large volume of tailings to the environment.

In order to provide adequate stability for the structure, control of the phreatic surface within and adjacent to the structure is generally necessary. Thus, the beach tailings should be relatively free draining, the free water pool must be well removed from the dam, and the ability to store a large volume of water is limited.

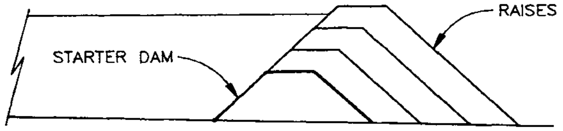
Review of the performance of tailings dams constructed by upstream methods indicates that they are prone to failure under seismic loading conditions due to the inability of the thin embankment shell to restrain extensive zones of liquefied tailings. Due to their poor performance record under seismic loading, the present use of upstream raises is only justified when



A. UPSTREAM CONSTRUCTION



B. CENTERLINE CONSTRUCTION



C. DOWNSTREAM CONSTRUCTION

FIGURE 2
SCHEMATIC ILLUSTRATION OF
TAILINGS DAM CONSTRUCTION METHODS

all of the design criteria can be thoroughly investigated and appreciated.

In order to alleviate concerns associated with upstream dam construction, the tailings facility can be constructed to full height as a conventional water retention dam. While this approach eliminates much of the performance concerns, it imposes significant economic impacts on the project. The dam construction costs must be included as initial capital costs for development, the embankment typically involves a significant volume of fill material, and mine waste material such as waste rock or tailings are unavailable for use as fill material.

To reduce the initial capital expenditures while maintaining the high level of protection offered by a conventional water retention dam, the tailings dam may be built as an incrementally raised structure constructed with downstream or centerline raise methods. Figures 2b and 2c depict schematic cross sections of each of these types of tailings dams.

The downstream raise method of construction results in a massive trapezoidal embankment section which increases in size over time. As the name implies, the crest of the dam progresses downstream as the height of the structure increases. Construction costs for a dam constructed in a downstream fashion can be distributed over the life of a project as in the upstream raise method, yet the method is suitable for a wider range of operating conditions.

The embankment can be constructed with impervious zones and drains for positive control of the phreatic surface to further enhance embankment stability. The major disadvantages with this type of construction are that the toe of the dam advances downstream as the height increases and may encroach on other critical facilities, and embankment construction involves a large amount of fill. Waste rock production from the mine and/or the quantity and quality of tailings beach sands may be insufficient to meet the raise schedule. Thus, borrow sources may be required to meet the fill placement schedule. Downstream construction may cost 9 to 16 times the cost of upstream raise construction (Caldwell and Smith, 1985).

The centerline raise method of tailings dam construction represents a compromise between the upstream and downstream raise methods. The centerline raise method offers the reduced fill volume advantages of the upstream raise method while exhibiting much greater stability. Centerline raise construction may cost 1/3 to 1/9 of downstream construction (Caldwell and Smith, 1985).

The method of tailings dam construction must be evaluated in conjunction with the tailings characteristics that are anticipated to result from the disposal method adopted. The increased cost associated with carefully controlled sub-aerial deposition may be more than offset by reduced dam construction costs if the upstream or centerline methods can be utilized. Conversely, on some projects it may be more economical to construct the dam using the downstream method while depositing the tailings by uncontrolled single point discharge. Other factors such as the ultimate reclamation of the tailings impoundment or the need for subaqueous disposal of the tailings to control acid generation may also affect the optimum tailings disposal method.

## CASE HISTORY

In order to illustrate how tailings dam construction practices must be coordinated with the tailings deposition method, the following case history is presented.

The project consists of a historic lead mine located in southeast Missouri which operated from 1906 to 1965. Mining activities at the site resulted in the construction of two tailings dams. This case history focuses on one of these two dams.

Although little design or operation documentation was available, a technical paper describing the original construction of the dam and personal interviews with a mine employee present throughout construction and operation of the dam provided valuable insight into the operating and deposition procedures for the dam. This information was supplemented with subsurface explorations to determine the internal composition of the dam and tailings for the purposes of evaluating the dam's stability under current dam safety regulations.

Construction of the dam commenced in 1942 as a valley fill structure. Mine waste rock was used to construct a starter dike to a height of approximately 30 ft (792 ft elevation). A concrete weir structure located at the abutment of the starter dike was used to decant base stream flows and supernatant from the impoundment area.

Tailings were spigotted from the dam crest and as the tailings level rose, perimeter dikes constructed of sand tailings obtained from the beach were used to raise the structure in an upstream fashion. The dam was constructed with a steep downstream slope which varies from 1.25H:1V to 1.4H:1V. As the tailings dam reached an elevation of approximately 820 ft, a decant tower was constructed approximately 250 feet from the embankment for decanting water from the impoundment. As the tailings dam reached an elevation of approximately 830 feet, a second tailings pipeline was put into service for dump discharge of tailings into the extreme upstream reaches of the impoundment. Presumably this was done to prevent tailings beach development from encroaching upon the decant tower. As will be shown, this practice had a drastic effect on the stability of the dam.

At about this same point in time, perimeter dike construction was changed to mine waste, although the upstream construction method was continued. With rear impoundment discharge and the associated accumulation of slimes near the dam face, the quantity of sand at the embankment was probably insufficient to meet dike construction needs. Discharge of tailings from the dam was continued in an intermittent fashion to provide a foundation for support of the embankment raises. Tailings were reportedly discharged from the embankment for about a month prior to each semi-annual embankment raise to create a beach of tailings sufficient to support the dikes and trucks hauling the mine waste.

The practice of predominantly rear impoundment discharge with minimal discharge from the dam embankment followed by upstream raises of mine waste rock was continued until the facility was closed in 1965. At this point the dam had reached its maximum height of approximately 136 ft at an elevation of 898 ft.

According to these descriptions, the tailings deposition practices were expected to have resulted in predominantly sand tailings in the vicinity of the embankment below an elevation of approximately 830 feet and a thin zone of sand directly adjacent to the embankment which transitions rapidly into tailings slimes above this elevation. Extensive subsurface exploration consisting of Standard Penetration Tests (SPT), Cone Penetrometer Tests (CPT) and associated piezometer installations confirmed this general internal configuration and provided in situ strength data and information on piezometric levels within the tailings. The subsurface exploration indicated greater encroachment of tailings slimes toward the dam above elevation 860 and indicated that the relative proportion of tailings discharged from the embankment crest was probably reduced during the final stages of operation. Slimes zones were found to be saturated and loose, whereas the tailings sand was generally moderately dense with saturated zones restricted to the lower levels of the deposits. Figure 3 presents an idealized cross section of the maximum dam section which was developed from the available information.

The sand tailings typically contain 10 to 30 percent fines while the slimes contain 40 to 80 percent fines with occasional zones or layers of extremely fine "rock flour" with 90 percent fines or more. The saturated sands in the lower portion of the tailings were found to exhibit an average $(N_1)_{60}$ value (SPT N-Value normalized to 1 tsf overburden pressure and 60 percent of theoretical hammer energy) of 16. The 3-4 ft thick slimes layer at approximately elevation 825 (lower slimes layer) was found to exhibit an average $(N_1)_{60}$ value of 8 and the upper slimes exhibited an $(N_1)_{60}$ value of 2. The very low average $(N_1)_{60}$ of 2 for the upper slimes illustrates the soft nature typical of many slimes deposits and the long time period necessary for appreciable consolidation and densification of such deposits. It should be noted that 20-25 years elapsed since tailings deposition ceased and the subsurface explorations were conducted.

The State of Missouri Dam and Reservoir Safety Program stipulates that for the dam location and downstream hazard classification a horizontal acceleration of 0.20 g should be

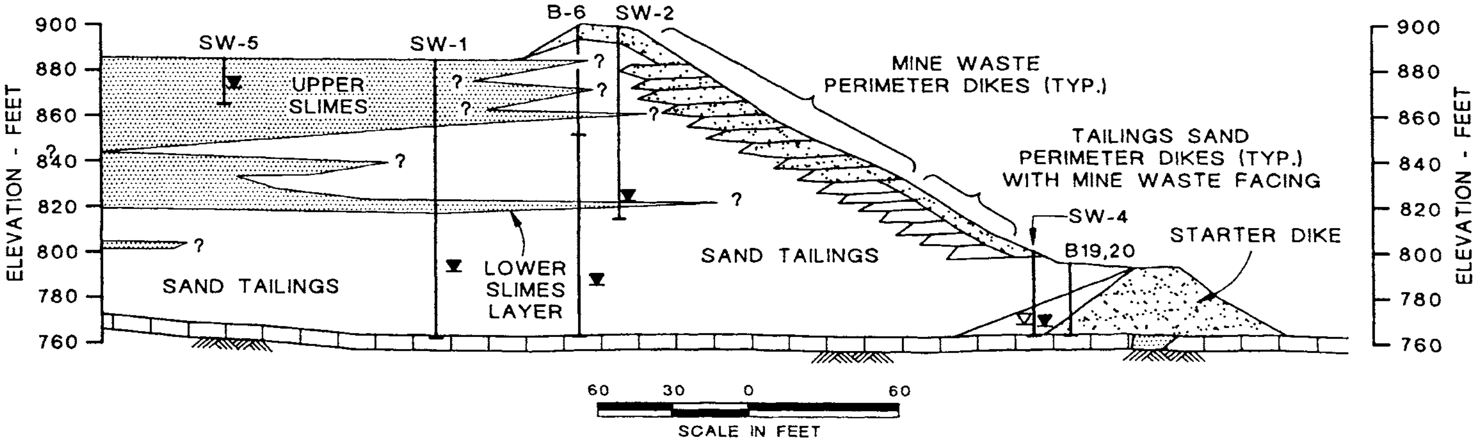


FIGURE 3
CASE HISTORY - IDEALIZED EMBANKMENT SECTION

used to determine the seismic stability of the structure. Specifically, a minimum post-earthquake factor of safety of 1.0 under ground motion levels corresponding to a peak ground acceleration (PGA) of 0.20 g and MMI=VIII-IX was specified. This level of ground motion is estimated to have a 90% probability of non-exceedance in 250 years and is consistent with a seismic event with a body-wave magnitude ($m_b$) of 7.4 with an epicenter near the 1811-1812 New Madrid earthquakes.

The TARA-3 finite element computer program developed by Finn et. al (1986) was utilized to evaluate the static stress conditions in the dams and to conduct a dynamic effective stress analysis to identify the distribution of tailings, if any, which would liquefy. The S69°E component of the 1952 Kern County earthquake (M=7.7) recorded at the Taft-Lincoln School tunnel and scaled to a PGA of 0.2 g was utilized as the input motion. The triggering analyses indicated liquefaction of all slimes zones relatively quickly in the earthquake time history and the development of dynamic pore pressure ratios of 20-30 percent in the bulk of the saturated sand tailings.

Subsequent to the liquefaction triggering analyses, the finite element computer program TARA-3FL (Finn and Yogendrakumar, 1989) was utilized to estimate the post-liquefaction deformation of the dam. For the deformation analyses, the liquified slimes layers were assigned residual, or steady-state, strengths and included adjustments for fines contents as per Seed and Harder (1990). As the pore pressures rose in the slimes layers the shear strength was assumed to progressively degrade to the residual strength. The deformation analyses using TARA-3FL indicated large lateral deformations along the lower slimes layer, prior to the shear strength actually dropping completely to the residual strength, and an uncontrolled flow slide failure would be initiated. Static limit equilibrium stability analyses incorporating residual strengths for the slimes indicated a minimum factor of safety on the order of 0.5 - 0.6, thus confirming that large uncontrolled deformations were likely under the design earthquake loading.

As a result of these analyses, a seismic dam remediation program was initiated for the site. A large berm to buttress the downstream slope of the dam was designed to limit dynamic displacements to acceptable levels and raise the post-earthquake factor of safety to 1.0 or higher.

## SUMMARY AND CONCLUSIONS

Tailings deposition practices can have a profound influence on the potential for liquefaction during earthquakes. Practices such as dump discharge versus carefully controlled, sub-aerial, thin-lift deposition can result in wide variations in the behavior of the tailings. This, in turn, can have a dramatic affect on the stability of the tailings dam and may control the method of dam construction which can be safely adopted.

The case history presented illustrates the consequences of a tailings dam which was not constructed by a method which considered the type of deposition which would be practiced over the life of the project. Conversely, the tailings disposal practices were not compatible with the type of dam construction adopted.

## REFERENCES CITED

Blight, Geoffrey E. and Steffen, Oskar K.H., 1979; "Geotechnics of Gold Mining Waste Disposal." Current Geotechnical Practice in Mine Waste Disposal, ASCE, pp 1-52.

Caldwell, Jack A. and Smith, Adrian, 1985; "Material Considerations in the Design of Downstream Embankments for Tailings Impoundments." Mining Science and Technology, Vol. 3, pp 35-49.

Finn, W.D.L., and Yogendrakumar, M., 1989; "TARA-3FL - Program for Analysis of Liquefaction Induced Flow Deformations." Dept. of Civil Engineering, University of British Columbia, Vancouver, B.C., Canada.

Finn, W.D.L., Yogendrakumar, M., Yoshida, N. and Yoshida, H. 1986; "TARA-3: A Program for Nonlinear Static and Dynamic Effective Stress Analysis." Soil Dynamics Group, University of British Columbia, Vancouver, B.C. Canada.

Ishihara, K., Troncoso, J., Kawase, Y., and Takahashi, Y., 1980; "Cyclic Strength Characteristics of Tailings Materials." Soils and Foundations, Journal of the Japanese Society of Soil Mechanics and Foundation Engineering, Vol. 20 No. 4, pp 127-142.

Ishihara, K., Yasuda, S. and Yokota, K., 1981; "Cyclic Strength of Undisturbed Mine Tailings." Proceedings of the International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, University of Missouri - Rolla, Rolla, Missouri, April 26-May 3.

Knight, R.B. and Haile, J.P., 1983; "Sub-Aerial Tailings Deposition." Proceedings of the 7th Panamerican Conference on Soil Mechanics and Foundation Engineering, Vancouver, Canada, June. Vol. II, pp 627-639.

Moriwaki, Y., Akky, M.R., Ebeling, R., Idriss, I.M., and Ladd, R.S., 1982; "Cyclic Strength and Properties of Tailing Slimes." Dynamic Stability of Tailings Dams, ASCE National Convention, New Orleans, October.

Seed, R.B. and Harder, L.F. Jr., 1990; "SPT-Based Analysis of Cyclic Pore Pressure Generation and Undrained Residual Strength." Proceedings of the H. Bolton Seed Memorial Symposium, J. Michael Duncan (ed.) BiTech Publishers, Vancouver, B.C., May, pp 351-376.

Troncoso, Jorge H., 1986; "Critical State of Tailings Silty Sands for Earthquake Loadings." Soil Dynamics and Earthquake Engineering, Vol. 5, No. 3.