GEOTECHNICAL CONSIDERATIONS FOR SOLAR PANEL INSTALLATION ON MINE TAILINGS[1]

Srikant Annavarapu[2], Terril Wilson, Moe Momayez, and Alex Cronin

Abstract. Geotechnical stability considerations are important for the installation of solar panels on mine tailings areas. Active tailings deposition areas consist of coarse-grained, free-draining relatively stable particulate mass at the perimeter with fine-grained, low shear strength mass around the supernatant pond in the deposition area. An evaluation of the geotechnical stability of the supports for the solar panels constructed, which will have their foundations placed on mine tailings, is essential so that the orientation of the solar panels can be maintained within suitable limits. An assessment of the forces imposed on the solar panel supports, including the distributed weight of the solar panel arrays and effect of wind loading on the flat array surfaces, also need to be considered in the design of suitable foundations for these supports. This paper enumerates some of the geotechnical issues related to the installation of solar panel arrays on active and inactive mine tailings areas.

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[1] Paper was presented at the 2009 National Meeting of the American Society of Mining and Reclamation, Billings, MT, ***Revitalizing the Environment: Proven Solutions and Innovative Approaches*** May 30 – June 5, 2009. R.I. Barnhisel (Ed.) Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

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Proceedings America Society of Mining and Reclamation, 2009 pp 37-43
DOI: 10.21000/JASMR09010037

http://dx.doi.org/10.21000/JASMR09010037

Introduction

The mineral industry is a worldwide business which in many countries accounts for a large proportion of their Gross National Product (GNP) (Ritcey 1989). The increasing demand for base and precious metals has resulted in the exploitation of many low grade ore deposits around the world. The valuable minerals in these deposits are locked within the rock, and advances in mineral processing technology allow lower grade ores to be exploited, generating higher volumes of waste rock that require safe disposal. The waste ground rock and the spent processing water and reagents from the plant are commonly referred to as tailings.

Though tailings can be disposed of and stored using a variety of methods, the most conventional method for the disposal of tailings worldwide is a large surface impoundment which sometimes incorporates individual cells laid adjacent to each other. While early mine tailings were often deposited in valleys as slurry from the processing plant, the impacts of such uncontrolled tailings disposal were recognized (Fig. 1) and, by about 1930, a complete cessation to this type of tailings disposal was enforced in the western world (Martin, 2002).

Figure 1. Early 20th Century tailings disposal at an abandoned gold mine in Nevada, USA (Martin et al, 2002)

Current practices in tailings deposition use perimeter spigots to emplace a slurry containing about 50 percent solids over a raised embankment, which results in a relatively flat surface with coarse-grained, free-draining relatively stable particulate mass at the perimeter and fine-grained, low shear strength mass around the supernatant pond. This flat surface, which is normally free from shade forming vegetation during and after construction (Fig. 2), forms an ideal location for the installation of solar panel arrays. The availability of power lines to the site of the mine tailings deposition areas make these areas uniquely beneficial for the installation of solar panels since the generated power can be effectively transmitted to power grids, which supply power to the mine areas. The synergy between the requirements for the solar panel installations and the conditions on the mine tailings deposition areas make the areas suitable for development as large solar energy farms. The concepts are explored in greater detail in the paper by Wilson et al (2009).

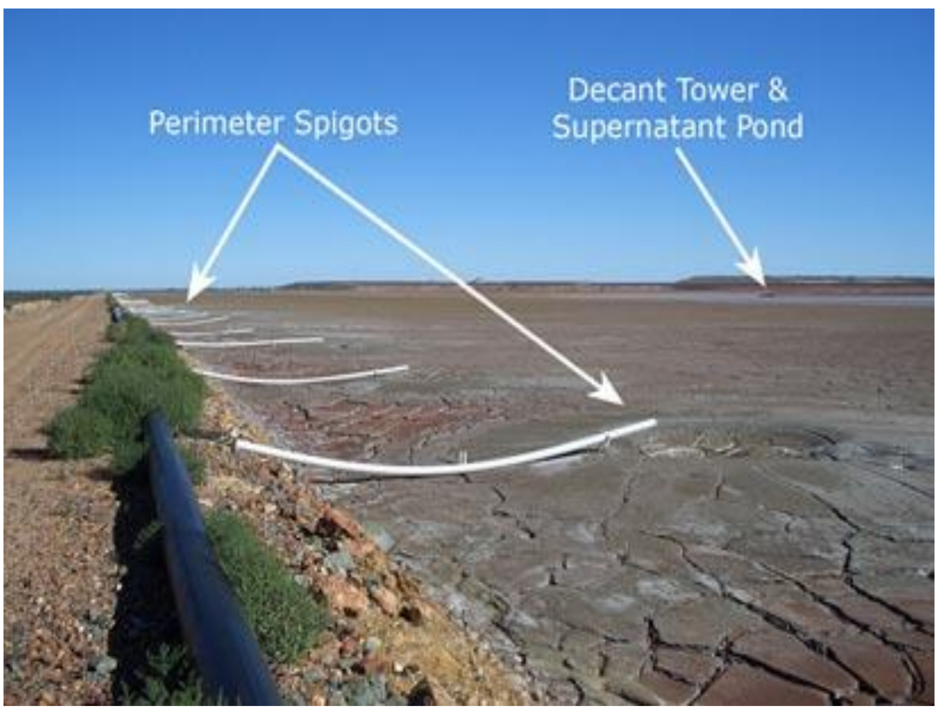

Figure 2. Tailings deposition in Jundee Gold Mine, NT, Australia (www.tailings.info/deposition.htm)

The installation of a large number of solar panels on mine tailings areas require a thorough understanding of the geotechnical properties of the mine tailings for the design of appropriate systems for the erection of supports for the panels. Though the panels by themselves do not weigh much, and there are consequently no significant bearing capacity issues, the supports for the solar panels need to be designed to adequately resist the forces acting on the panels in large open areas. The evaluation of the geotechnical properties of the mine tailings is necessary for the success of such installations.

Geotechnical properties of mine tailings

The geotechnical properties of mine tailings are dependent on the composition of the tailings, which typically consist of crushed and ground rock ranging from coarse sands to fine silts. Several authors have reported the results of geotechnical evaluation of mine tailings including Shamsai et al (2007), and Rassam and Williams (1999). Common geotechnical parameters tested for mine tailings include grain size distribution, Atterberg limits, dry densities, shear strength parameters, consolidation coefficient and bearing capacity. Figure 3 shows grain size distributions from copper mine tailings reported in Shamsai et al (2007).

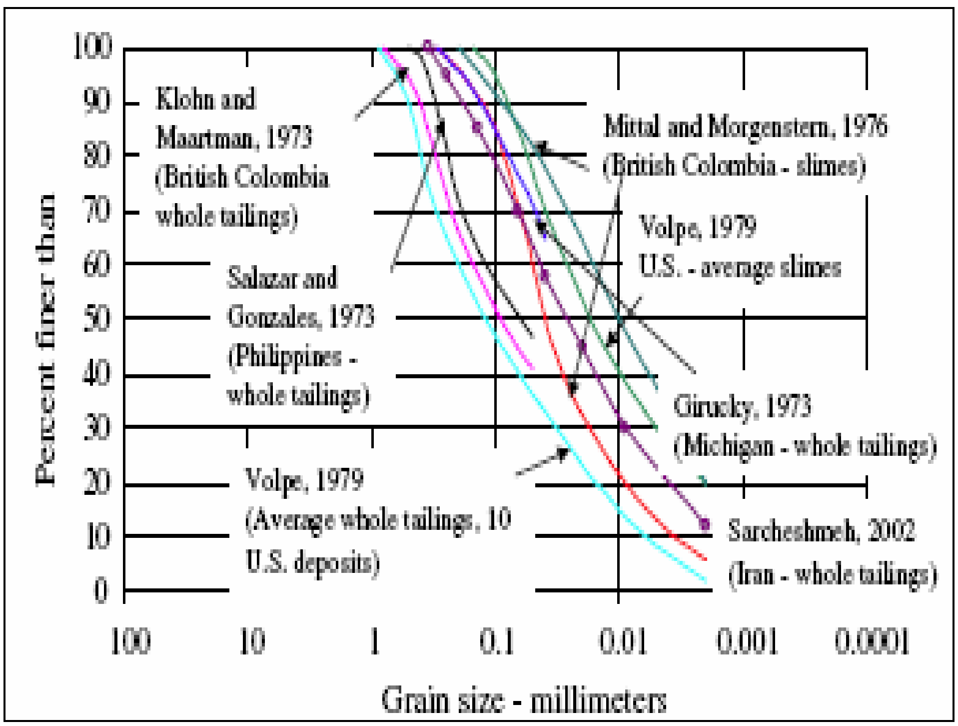

Figure 3. Grain size distributions for mine tailings from different copper mines (Shamsai, 2007)

Typical values for the other parameters are shown in Table 1.

Table 1. Geotechnical parameters for mine tailings

Parameter	Range
Liquid Limit	25-40 %
Plastic Limit	4-15 %
Dry density	1.5-2.7 g/cm^3
Friction Angle	13-18 degrees
Cohesion	0-0.98 kg/cm^2
Coefficient of consolidation	0.001-0.4 cm^2/s

The engineering characteristics of the mine tailings in the deposition area can vary greatly and are dependent on the composition of the ore and the process of mineral extraction used. Ritcey (1989) reported that even tailings of the same type may possess different mineralogy and therefore may have different physical characteristics. Some of the geotechnical properties outlined above are dependent on the water content in the fill and the grain size distribution at the location of the measurement. Since the water content is dependent on the evaporation time, the authors suggest the development of site-specific curves for the variation of the different geotechnical properties with water content or evaporation rates (Fig. 4) to help identify the zones most suitable for the installation of the solar panel arrays.

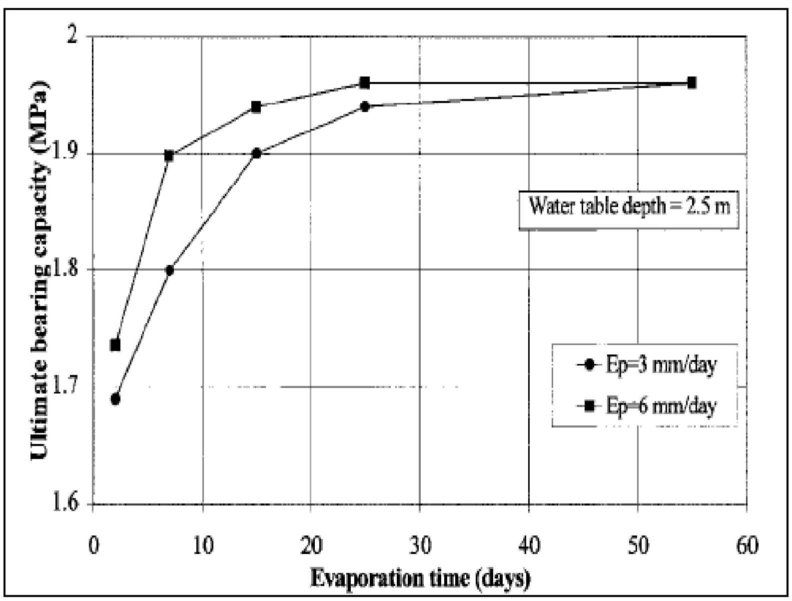

Figure 4. Ultimate bearing capacity versus evaporation time (Rassam and Williams, 1999)

Field testing using piezo-cones and vane shear tests can help develop relations between moisture content and shear strengths in different zones in the tailings area. The installation of the solar panels arrays on mine tailings that are not completely dried out create an additional challenge since the shade provided by the panels may reduce the evaporation rate and increase the drying time for the tailings. This can be of importance during large storm events since there is an increased possibility on water flow through the "wet" areas. Furthermore, any storm water trapped below the solar panel arrays will take more time to dry out. Good storm water drainage around the solar panel arrays may be necessitated to reduce the possibility of eroding the supports for the arrays.

Forces acting on supports for solar panels

The design of supports for solar panel arrays on mine tailings areas requires an understanding of the forces that these supports would be subjected to and how these forces are transferred to the mine tailings. A research program has been proposed to evaluate the performance of large solar array installations on mine tailings areas near Tucson. Under this program, the researchers propose to study the geotechnical, environmental and atmospheric conditions in the area along with the structural and electrical performance of the solar panels. While no studies have as yet been undertaken, the authors estimate that the weight of the panels and the wind forces are likely to be the main forces acting on the supports for the solar panels.

Weight of panels

The weights of the individual panels depend on the output wattage of the solar panels and vary from a few kilograms to more than 15 kilograms (for a 1500 mm by 1000 mm panel producing 205 W). Additional weights need to be added to panel structures to increase the resistance of the installation to wind forces. The total weight of the installation for a 205 W panel can be expected to be more than 40 kilograms for which a suitable footing can be designed.

Wind forces

The availability of large flat plains on the mine tailings areas without wind breaks can result in high velocity winds across the solar panel array installations. The forces generated on the supports for the solar panels will need to be estimated for different atmospheric conditions so that the necessary ballasting weights can be added to the solar panels and the supports can be designed to withstand such wind forces.

Conclusions

Mine tailings areas can provide the large, flat areas without significant vegetation required for the installation of solar panel arrays. The solar panels are light enough not to result in major geotechnical stability challenges, though adequate drainage facilities need to be considered to eliminate ponding around the solar panel installations. The support structures need to be designed to withstand high wind forces which are possible on the top of tailings deposition areas. Field studies need to be undertaken to evaluate the forces acting on the supports for the solar panels on an actual tailings area with geotechnical and environmental monitoring so that the systems for installation of solar panels on mine tailings areas can be suitably designed.

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www.tailings.info – The website all about tailings.

www.kyocerasolar.com/pdf/catalog/catalog.pdf