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A new look at the statistics of tailings dam failures

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ABSTRACT

Tailings dams are commonly built incrementally to increase the storage capacity of the Tailings Storage Facility (TSF), usually without interrupting the mining activities. Dam management practices, lack of knowledge on tailings behaviour and the poor performance of monitoring and management processes have resulted in disastrous tailings dam failures with human and economic losses, as well as huge environmental consequences to ecosystems and local communities. In the literature, correlation analyses have been carried out considering different variables: stored volume, released volume, runout distance, dam height, peak discharge. Several databases of tailings dam failure are available online, each with different levels of detail. This paper computes the statistics of tailings dam failures using an up-to-date database on failures and a catalogue of existing TSF. The existing correlations between stored and released volumes have been verified using a larger database. The new proposed regression analysis considers the functional relationship between released volume and characteristics of the dam such as height and stored volume (i.e., dam factor). The effect of construction type, fill material and failure mode on the released volume has also been evaluated as well as the frequency of tailings dam failure as function of the construction method. Tailings dams built using the upstream construction method turn out to be more prone to failure, and more susceptible to static and dynamic liquefaction. The new correlation provides more reliable estimates of the expected released volume as a function of dam height and stored volume and should prove useful for runout analyses and risk assessment of tailings dam failure. Finally, the analyses carried out show that there is no correlation between the water pond extension and the released volume.

1. Introduction

Tailings are the waste result of mining processes. They are a mixture of sand and silt with high content of unrecoverable metals, chemical reagents and process water employed during raw materials extraction. Tailings are usually discharged as a slurry to a storage area commonly known as Tailings Storage Facility (TSF). Usually dams or embankments are used to retain the stored tailings. Tailings dams are built and raised to increase the stored capacity, often without interrupting the mining activities. This construction approach differs from the one used for water-retaining dams, which are completely built before becoming operational. Most of the tailings dams were built several decades ago and about 45% have been constructed with the upstream method, which is considered the least stable among the tailings dam construction methods (Wei et al., 2013).

The advances in mining technology over the past 100 years have made it economically feasible to mine lower grades of ore and to increase the excavated volumes (Bowker and Chambers, 2016). On the

other hand, until recently, there has been little change in practices related to management of the increased tailings volumes. The uncertainties on physical and chemical characteristics of tailings, together with dam management practices, are of growing concern (<https://www.tailings.info/basics/tailings.htm>). The lack of knowledge on tailings behaviour and the poor performance of monitoring and management processes can be considered as the main predisposing factors of dam failures.

Tailings dam failures have resulted in disastrous environmental and human tragedies. The different tailings dam databases considered in this study (ICOLD, WISE, [World Mine Tailings Failures](#), n.d, CSP²) indicate that since 1915, a total of 257 failures have been recorded with circa 2'650 fatalities and 250 million m³ of contaminated residues released to the environment. Almost 50% (115 million m³) of the released volumes have been recorded after 2000, with circa 640 fatalities. These data highlight that the challenge of safely storing mine waste is growing in scale and complexity (GRIDA, 2016). The threat is further complicated by the increased severity and frequency of extreme weather events due

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