A review of runout analysis models for tailings dam breach

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EXTENDED ABSTRACT
Breaches of tailings dams are destructive man-made geohazards. It is estimated that there are, at least, 3500 active tailings dams worldwide (Kossoff et al., 2014). These dams retain mine tailings, and together the storage system comprises a complex mixture of water, unconsolidated tailings slurry and compacted dam materials. When a failure occurs, large volumes of this material flow out and may travel over substantial distances with potential for extensive damage to the environment and people. Several catastrophic events have been recorded within the past 100 years. The fluorite tailings dam at Stava, Italy failed in 1985 and released a total volume of 185,000 cubic meters of muddy debris. As a result, the Stava and Tesero villages were completely destroyed and 243 people lost their lives (Pirulli et al., 2017). The 2015 Fundão tailings dam failure in Brazil resulted in the release about 43 million cubic meters of tailings materials. This disaster killed 19 people and caused long-lasting environmental damage to several water channels in the basin of the Doce River (Carmo et al., 2017). The 2014 Mount Polley disaster in British Columbia resulted in the release of about 25 million cubic meters of water and tailings into Polley Lake, Hazeltine Creek and Quesnel Lake (Golder Ltd., 2015). The methods that are used to predict the consequences of such events (e.g., the velocity, distance and direction of the discharged tailings materials) do not account for the compositional variety of tailings and its potential influence on downstream flow behaviour. Due to this issue, hazard maps based on these techniques are potentially unreliable. In this study, we present a comprehensive review of the empirical and numerical runout models that are currently available and describe the main limitations of these methods that are being addressed by our research program.

Rico et al. (2008) proposed a set of empirical correlations that relate tailings flow characteristics (e.g. released volume and runout distance) to the geometric parameters of tailings dam (e.g. dam height and total tailings volume before released). Due to the incompleteness of the worldwide database for tailings dam breaches, only 28 case histories (from 1965 to 2000) that contained information on tailings outflow volume and flow runout distance were considered in their study. They found good correlations between 1) total volume of the tailings in the impoundment at the time of failure and the tailings outflow volume, and 2) the outflow volume of tailings and the tailings runout distance. However, the uncertainties in their database and limited sample size suggest that the results need to be treated with caution (Rico et al., 2008).

A large number of numerical models have been developed for water dam-break runout analysis. In contrast, no models have been developed specifically for the runout analysis of tailings dam breaches. As a result, the dam breach analysis methods that are currently carried out in practice do not accurately account for the unique behaviour of flowing tailings. In this study, we have compiled information about 33 numerical models that have been developed for water dam-break analysis and/or that have specific features or capabilities that may make them adaptable for tailings dam breach analysis. Ten of the most promising and widely used models were reviewed in detail. The capabilities and limitations of these 10 numerical models were systematically assessed and the following preliminary conclusions were reached:

- Current available numerical models for runout analysis are not capable of simulating the rheological behaviour of a variety of tailings materials
- Current available numerical models for runout analysis are not capable of simulating the multi-stage flows of water and saturated tailings for cases where the tailings are capped by water

The development of a numerical model that addresses these limitations is the subject of our ongoing work.

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