Physical modelling of tailings dam overtopping and effect on breach outflow hydrograph

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EXTENDED ABSTRACT

Recent tailings dam failures in Canada and around the world have increased requirements to conduct tailings dam breach studies in British Columbia and throughout Canada (Martin et al., 2015). Understanding of dam breach failure processes is crucial for mine infrastructure planning and management, and protection of communities and the environment downstream.

The behavior of tailings dams during breach events is not well understood; breach models for tailings dams currently used in practice were developed for water storage dams and have not been properly validated or calibrated for the simulation of flowing tailings (Rico et. al 2008). Further, the geotechnical aspects related to dam breach have been oversimplified or neglected in available models (Al-Riaffi and Nistor 2010).

A number of laboratory experiments have been carried out to investigate the parameters that control the breach rate for prototypical water retaining dams (e.g. Morris et al. 2007; Al-Riffai and Nistor 2010; Walder et al. 2015). The proposed work will extend these types of experiments to investigate prototypical tailings dam configurations and material behaviour, with the objective of developing a new empirical-parametric model that is suitable for tailings-specific breach analysis. The addition of tailings to the dam reservoir effects the volume and location of water stored in the reservoir (Figure 1). The first phase of research aims to create novel experimental data required to investigate the geometric effects of retained tailings on the breaching process.

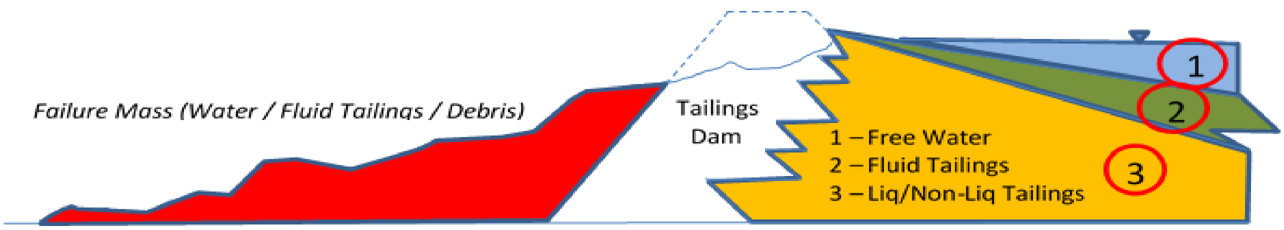

Figure 1: Tailings Dam Sketch

A key input for downstream flood inundation modelling is the outflow hydrograph (Figure 2a). This is a measure of outflow of a dam throughout the breach event. The effect of adding tailings to the dam reservoir will be quantified in the outflow hydrograph. This can then be utilized in debris flow modelling to predict runout and deposit thickness (Figure 2b).

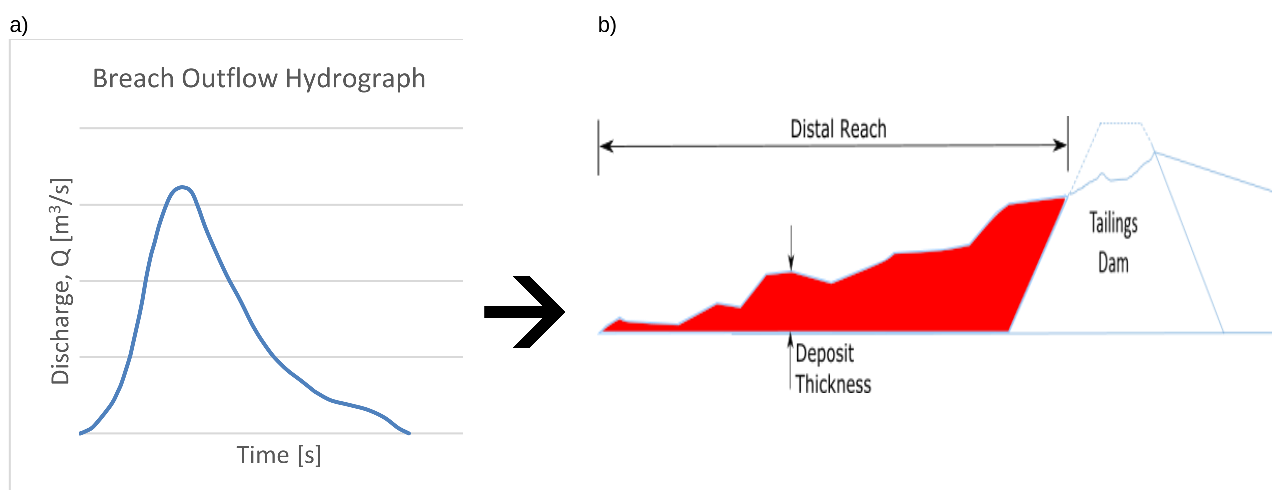

Figure 2: Dam breach outflow hydrograph utilized as an input for debris flow modelling

Experimental dams will be constructed in the existing large flume facility at Queen's University. The flume is 2.1 m wide and 1.2 m tall, with a 35 m long horizontal runout section. Dams will be constructed from fine sand in the middle of the runout section, permitting an upstream reservoir and downstream depositional zone each of approximately 15 m in length. A toe drain will be included to reduce the likelihood of seepage failure. Dams will be on the order of 1 m in height. Initially, clear water tests will be conducted to serve as a calibration exercise to compare outflow hydrographs to known results published in the literature to test and optimise sensor layout. Next, a wedge of material will be added next to the upstream face of the dam to simulate the presence of tailings. A series of experiments will be carried out using different tailings volumes to investigate the sensitivity of the breach results to the depth of water, D, above the tailings (Figure 3), producing a continuum of results that can be directly compared with previous clear water breach models. To avoid mixing of different materials and facilitate post-test cleanup and material reuse, the same fine sand used for dam construction will be used for the tailings; however, it will be placed in a looser state. The dams will be failed by overtopping, initiated by cutting a v-notch in the dam centre. Instrumentation will include capacitance water level sensors to record upstream water level and calculate outflow, synchronised high speed cameras to permit measurement of breach outflow velocity with Particle Image Velocimetry (PIV) and breach crest width with Structure from Motion photogrammetry (SfM) throughout the breach event. Underwater videography will record breach crest growth. Laser (LiDAR) scans will be completed pre and post failure for the analysis of post-event deposit morphologies. A schematic drawing of the experimental design is presented below.

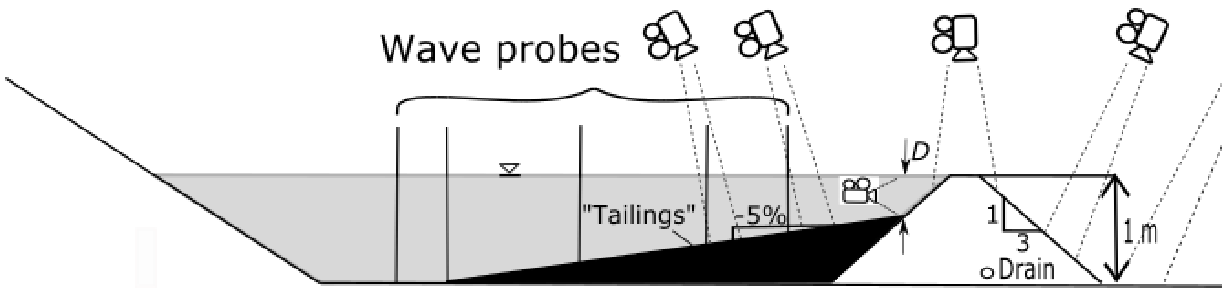

Figure 3: Proposed breach experiment design

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