

Seminário Técnico Internacional sobre Barragens de Rejeitos e o Futuro da Mineração em Minas Gerais

International Technical Seminar: Tailings Dams and the Future of Mining in Minas Gerais State

ORGANIZAÇÃO



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INSTITUTO BRASILEIRO DE MINERAÇÃO
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Tailings Dam Safety and the Future of Mining in MG Brazil Guidelines, Regulation and Decommissioning

Paul W. Ridlen, PE
April 17, 2019

Outline

- International Guidelines for Tailings Dam Design and Operation
 - Existing
 - In Progress
- Improved Governance
 - Continuity of the Engineer of Record
- Evaluating, Stabilizing, & Decommissioning

Guidelines

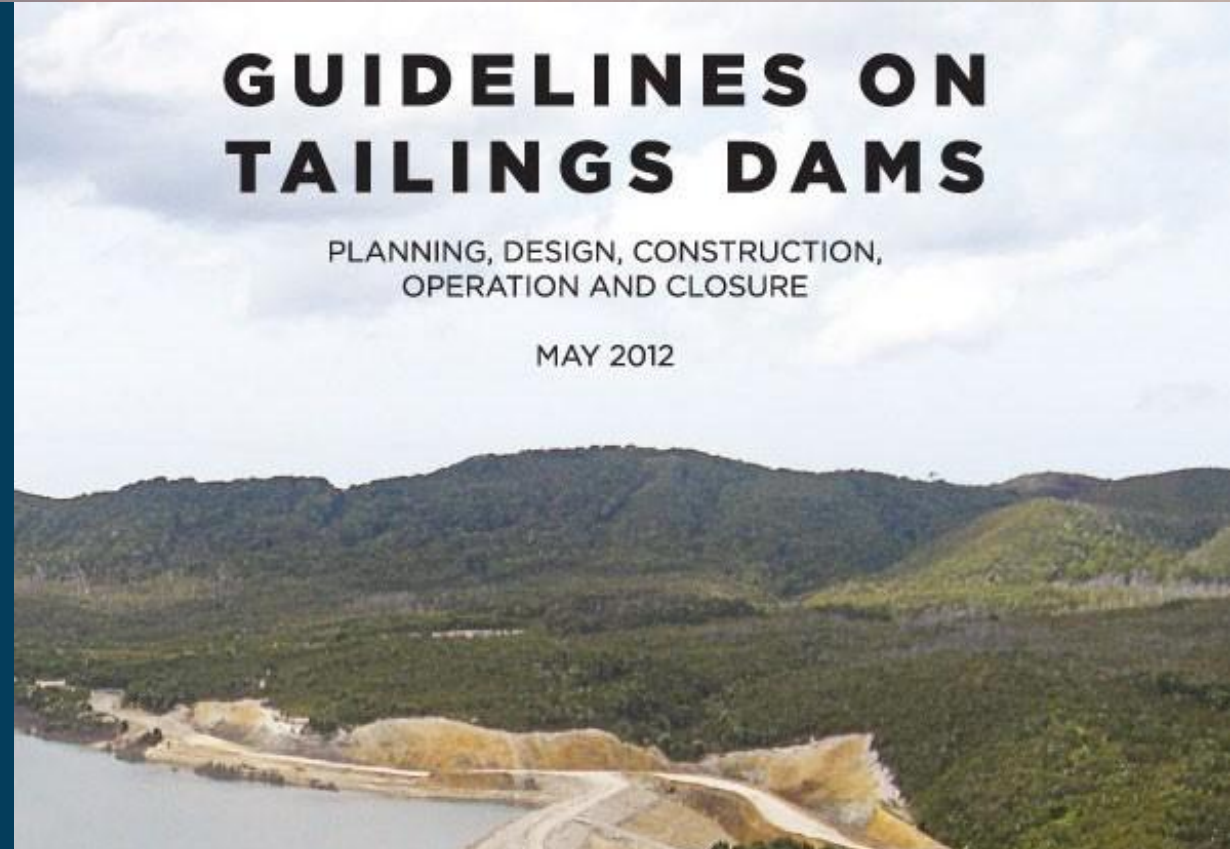
A Guide to the
**Management of
Tailings Facilities**

VERSION 3.1

GUIDELINES ON TAILINGS DAMS

PLANNING, DESIGN, CONSTRUCTION,
OPERATION AND CLOSURE

MAY 2012



Guidelines for Tailings Design

- There is currently no International Standard for tailings dams
- There is also no single guideline for tailings dam design, operation and construction that applies universally to all types of tailings storage facilities in all locations.
- However, there are some very good guidelines focused on tailings dams that can be used carefully for projects around the world
 - Canadian Dam Association (CDA) – 2007, 2013, and 2014 dam safety documents
 - Australian National Committee on Large Dams (ANCOLD) – 2012
 - International Committee on Large Dams (ICOLD) – multiple documents
 - Numerous others
- There is no “how-to” manual anywhere

Policies vs Standards vs Guidelines

- **Guidelines** are intended to provide non-mandatory/recommended guidance, especially when interpretation of standards and policies is needed.
- **Standards** are mandatory actions or rules that give formal policies support and direction.
- **Policies** are high-level, formal statements that define the objectives of a program. They are:
 - Driven by business objectives and convey the amount of risk that is acceptable to the entity issuing the policy.
 - Easily accessible and understood by the intended reader
 - Created with the intent to be in place for the long-term, regularly reviewed, with approved changes made as needed



The existing Guidelines contain some gaps

- The existing guidelines were usually written with a specific geography in mind (typically by a national organization specific to that nation)
- Usually influenced by common and accepted practices in each country
- ICOLD guidelines are generally broad. It is sometimes difficult to gain consensus – committee members may be representative of a narrow spectrum (i.e., one representative per nation)
- The guidelines do not always address all the technical issues that must be addressed in designing safe tailings dams
- The guidelines are sometimes conflicting.
- Significant judgment and experience are required to apply them properly in some cases.

Works in Progress

- Canadian Dam Association – updates in progress since the 2014 Mt. Polley failure
 - Proposed revisions to Engineer of Record responsibilities issued in October 2018
 - New guidance on factors of safety to be presented at ICOLD conference in June 2019
- ICOLD
 - New Bulletin on Tailings Technology updates to be issued in near future
 - New Bulletin establishing overall guidelines for tailings dam design, construction, operation and closure is in progress.
- US Society of Dams
 - Proposal to the US Federal Emergency Management Agency (FEMA) under consideration to develop a Tailings Dam Safety guideline for US
- ICMM
 - New initiative to develop a Standard for tailings management

CDA Guidance on Factors of Safety

- The new guidance acknowledges that a factor of safety is a means of managing risk due to uncertainty in material behavior and loading conditions. The selection of a minimum factor of safety should be based on considerations of both **probability** (*high uncertainty requires a higher factor of safety*) and **consequence** (*high consequence requires a higher factor of safety*).
- The selection of a suitable factor of safety for slope stability requires consideration of the potential variability in materials and site conditions and is based on the accumulated experience of the design engineer with respect to dam design and the soils considered for the dam and its foundation.
- Targets for initial evaluation are provided, but the guidance allows that higher factors of safety may be required, or lower factors of safety may be allowable in some instances.

CDA Guidance on Factors of Safety

- Selection of “screening-level” minimum target factor of safety values should be based on the following assumptions:
 - Appropriate consideration of the variability of the soils during the construction and operating conditions;
 - Suitable site investigations and understanding of the variability of the material properties and subsurface conditions;
 - Recognition of soil response (contractive/dilative) and its variation with confining stress and stress level, including the potential for brittle failure mechanisms, creep failure, etc.
 - Historical performance of the dam or similar dams.

CDA Guidance on Factors of Safety

- Undrained Loading and Potential for Flow Liquefaction
 - Tailings dams often contain contractive elements (e.g., loose hydraulically-placed tailings) or may contain sensitive clays in the foundation.
 - The application of undrained or drained strength parameters depends on the state (contractive or dilative) and rate of failure. Most tailings dam failures have occurred in undrained or partially undrained/drained conditions.
 - If there are contractive elements in the dam or foundation, then the designer should assume that the dam can fail in an undrained manner and should design/analyze accordingly.
 - The undrained strength is the strength available at the time of failure and is not to be considered a “lower bound” strength to be used in a factor of safety calculation.
 - For static undrained loading condition, it is assumed that the shear strains that are mobilized to the peak strength are initially small.

My Take on “The New Normal”

- For designs of new tailings dams, we must strive to avoid relying on contractive materials for stability
 - Design in drainage features
 - Compact embankment materials
 - Use rockfill, non-sensitive clays, well-draining sands whenever possible.
 - Remove unsuitable foundation material
 - Learn from water dam experience and practice
- For new facilities, initial factors of safety should be relatively conservative, reflective of the amount of information on the materials that is actually available at the time. Start higher than the minimum.
- If it is not practical to eliminate contractive elements or designs based on conservative FS, then:
 - The bar should be set very high in terms of material characterization, design analysis, and operational controls
 - The burden is to prove that undrained behavior or flow liquefaction will NOT occur – not prove that it must
 - Design will be controlled by the residual (post-peak) undrained shear strength

My Take on “The New Normal”

- For evaluation and remediation of existing facilities:
 - Thorough characterization is required
 - Field investigations (CPT, shear wave velocity measurement, drilling and sampling, piezometer installations)
 - Laboratory investigations (triaxial – possibly anisotropic consolidation, direct simple shear, cyclic DSS)
 - Numerical modelling will frequently be required.
- Evaluate brittleness (e.g., Robertson, 2016)
 - Residual strength
- Understanding of trigger mechanisms is very complicated
 - Assuming a trigger from an unknown or uncontrollable mechanism is prudent
 - Some of the profession’s smartest minds do not understand all of the triggers
 - Risk/reliability analysis may be helpful
- Factors of safety are limited, imperfect, oversimplified tools – better to err on side of caution than to push the envelope too closely.

Governance



Better Governance Required

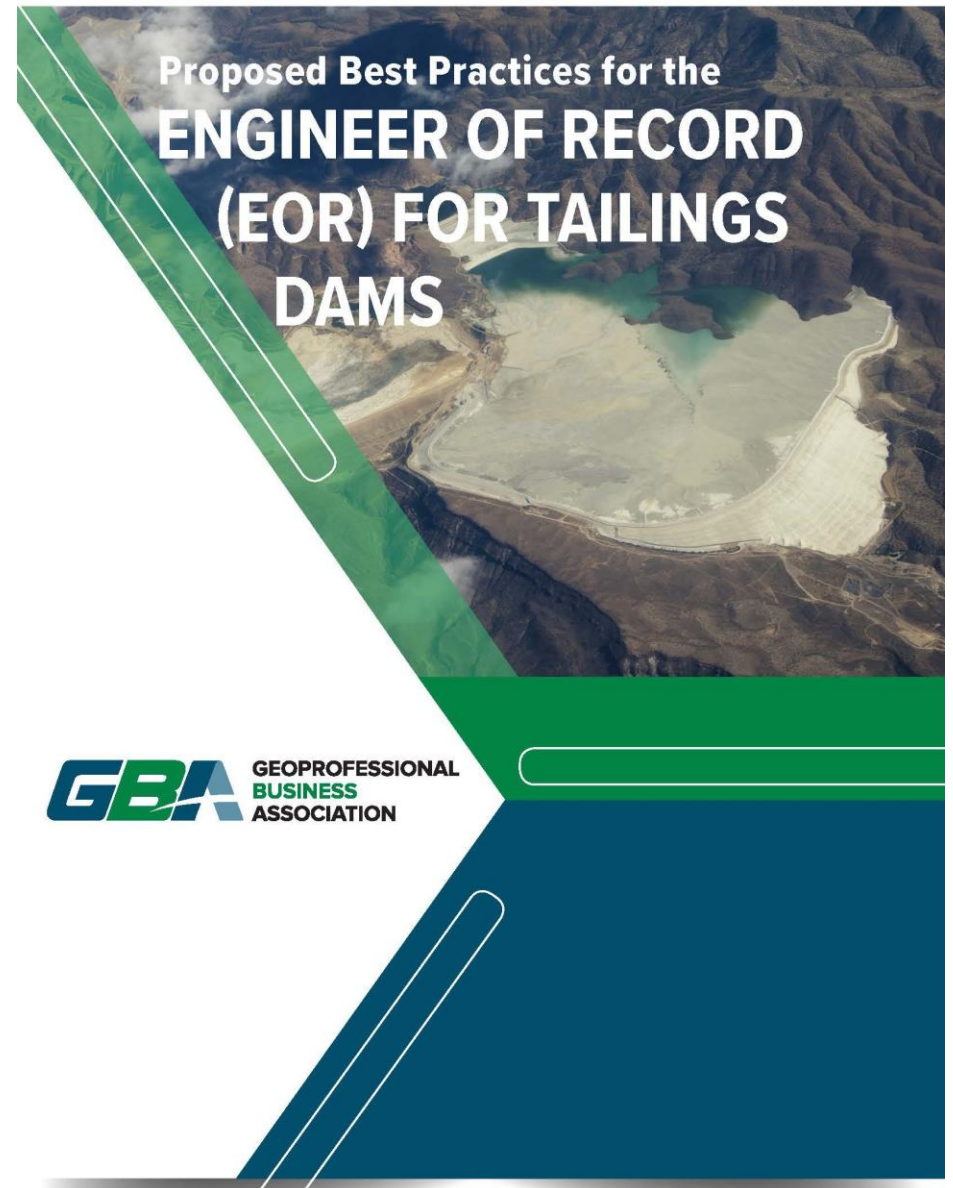
- Mining Association of Canada (MAC) provides excellent framework
- Several members of International Council on Mining and Metals (ICMM) have excellent internal governance/stewardship programs
- Key components of Governance
 - Accountability to Highest Level of Management – should engineers be added to Boards of Directors?
 - Independent Reviews
 - Continuity of the Engineer of Record
 - Whistleblower Protection
 - Use of Best Available Technology and Best Available Practices
 - Design and Operate with Closure in Mind
- The new ICOLD bulletin will emphasize governance.
- The ICMM initiative is an important undertaking.

Continuity of the Engineer of Record

- The current practice of cycling through engineers every year must stop.
 - This is not a business development ploy.
 - When a change is required, a formal handover with due diligence process should occur.
- Engineering services are not equal to goods and products. Procurement departments at most mining companies often undermine even the best governance programs.
 - The cost of a failure will be many times greater than the minor cost savings made on engineering fees.
- Engineers of Record should be enabled and empowered to report to management if they are being pressured into making bad decisions
- Engineers should return to following a Code of Ethics
 - Lawyers follow ethical and professional rules better than engineers do

Engineer of Record

- Developed by Geoprofessional Business Association (www.geoprofessional.org)
- Supported by:
 - *Alberta Dam Integrity Advisory Committee (DIAC)*
 - *Association of State Dam Safety Officials (ASDSO)*
 - *Canadian Dam Association (CDA), Mining Dams Committee (MDC)*
 - *United States Society on Dams (USSD)*



Evaluating, Stabilizing, & Decommissioning



What does the future hold?

- There will be no easy answers.
- There will be no cheap answers or quick answers. The current problems were developed over a long time. It will take time to solve them.
- Answers can be found.
 - There will be much to learn from the Feijão failure investigation/analysis.
- Tailings dams are not inherently dangerous – there are many successful case histories.

Some approaches to stabilizing Upstream Dams

- Downstream buttressing
 - Waste rock
 - Filtered tailings
 - Cycloned sand
 - Imported fill
- Vertical and/or Horizontal drains (but, obviously, installed with extreme caution)
- Removal
 - Hydraulic mining
 - Excavate and haul
- In-situ stabilization
 - Deep soil mixing
 - Grouting

Closing Remarks

- Complete paradigm shift is needed in order for mining to survive in Minas Gerais

The definition of insanity is doing the same thing over and over again and expecting a different result.

-- *misattributed* to Albert Einstein

- In order for mining to survive in Minas Gerais, we must make certain we don't fall back into old practices.
- Honor the memories of those who lost their lives at Samarco and Feijão by making sure it never happens again.



**THANK
YOU**

Paul W. Ridlen, PE

+1 303.629.8788

pridlen@knightpiesold.com

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