Stabilization Measures For An Existing Tailings Dam

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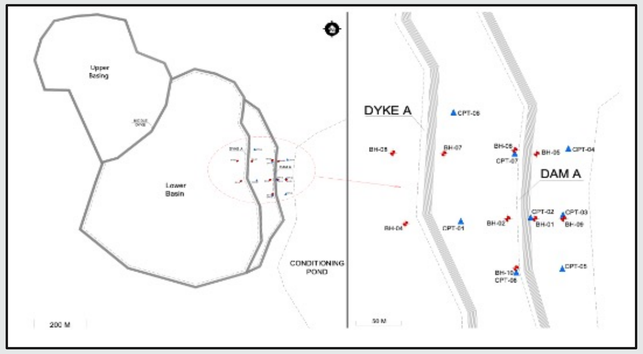
Project Description

The project involves the assessment of an existing tailings dam based on the CDA Dam Safety Guidelines with a primary focus on slope stability performance of the dam under normal and extreme loading conditions.

Site Photograph

Site Layout

- Project Location: Northern Ontario, Canada



Design Process

Identify Unknown Soil Layers and Its Properties → Steady-State Analysis and Pseudo-Static Analysis → Apply Remediation Measures → Cost Estimation

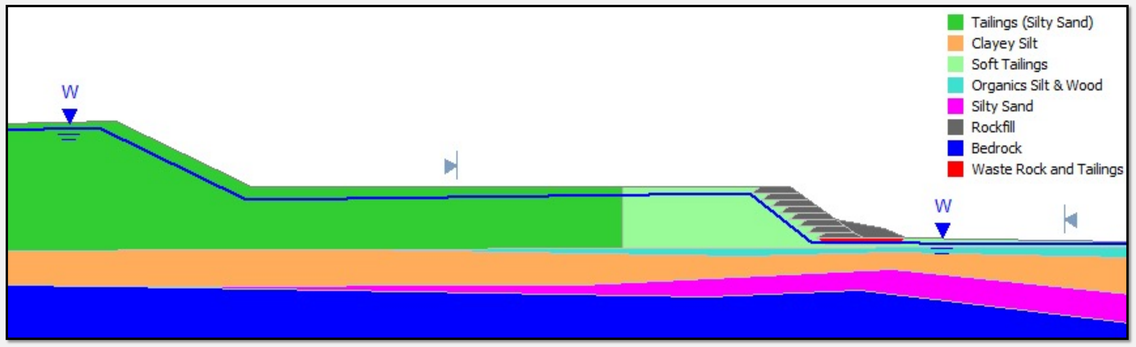
Strength Parameters

Soil Layer	Thickness (m)	Dry Unit Weight (kN/m³)	Saturated Unit Weight (kN/m³)	Friction Angle ϕ (Degrees)	Cohesion c (kPa)
Rockfill	0.0 - 2.2	18.0	21	32.0	-
Waste Rock and Tailings	0.0 - 2.3	18.0	20.5	33.0	-
Soft Tailings	0.0 – 11.0	15.5	18.1	25.0	39.0
Organic Silt and Wood	0.5 – 6.0	-	18.0	28.0	38.0
Tailings (Silty Sand)	1.0 – 24.0	15.0	17.4	27.0	-
Clayey Silt	4.5 – 6.0	16.1	18.1	35.0	41.0
Silty Sand	1.5 – 4.0	15.0	18.0	27.0	0

Dam Cross-Section

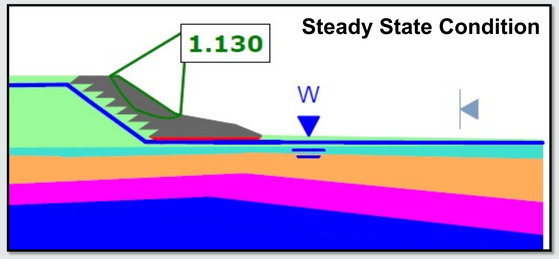
The picture below presents the dam's cross-section along with the different layers identified through the group's analysis.

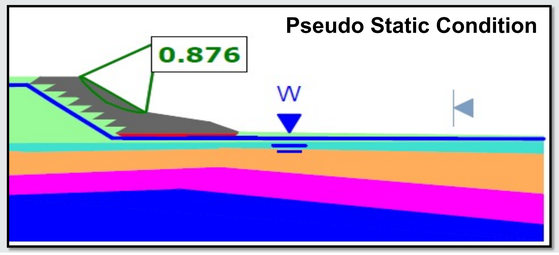
- The group was able to identify 5 different strata.



Loading Conditions

- Two applicable loading conditions:
  - Stead-state seepage (long-term sustained use at maximum retaining capacity).
  - Pseudo-static earthquake (seismic activity summarized as a constant force).
- Loading condition factors of safety (pre- remediation):
  - Steady-state seepage: 1.13 (target: 1.5)
  - Pseudo-static earthquake: 0.876 (target: 1.0)
- Pseudo static force with seismic activity - Peak Ground acceleration (PGA) value: 0.099 (g).
  - Estimated as a function of the annual exceedance probability of a seismic event.
  - Annual exceedance probability of 0.099 corresponds to 1 in a 100-year seismic event.
- Result: remediation measures required

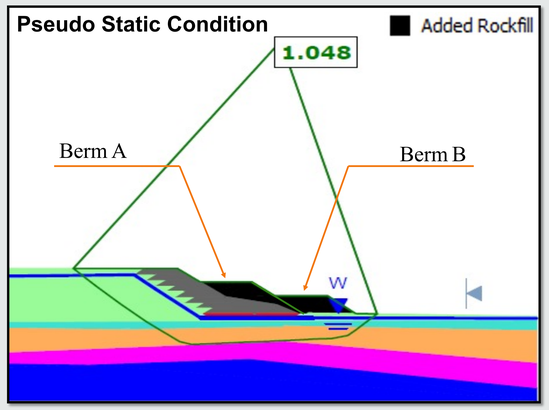


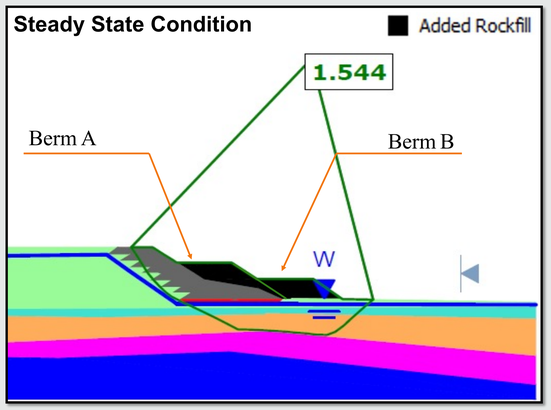


Proposed Solution

- Proposed solution: Implement stabilization berms along dam slope.
  - Reduce the angle at which driving forces act, reducing their effect.
  - Additional strength applied to weaker soil layers against seismic effects.

Factors of Safety (Post Remediation)

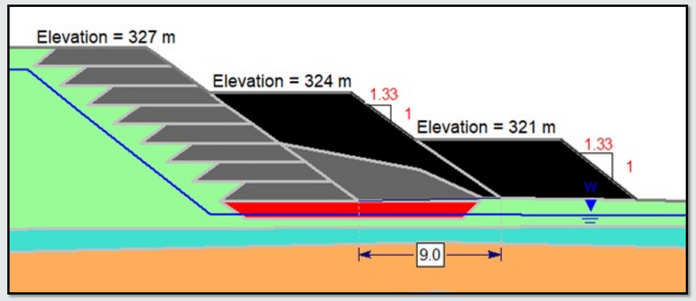




Detailed Design

The figure below presents the detailed design of the two berms proposed.

- The berms proposed are to extend along the dam with a length of 825 meters (into the page)
- Fill amount: 34,100 m³ (Berm A), 27,100 m³ (Berm B)



Cost Estimate

$ 4,000,000

Project Cost

Riprap, Grubbing and Toe Drain Materials	Access Road Construction	Rockfill	Mobilization & Demobilization	Excavation
$ 425,000	$ 90,000	$ 2,700,000	$ 200,000	$ 70,000

Conclusion and Recommendations

- Two berms, an upper berm and a lower berm, have been proposed to meet the current Canadian Dam Association guidelines for tailings dams slope stability.
- The berms will consist of rockfill and will be placed on the dam's downstream slope.
- The factor of safety for each loading condition has been achieved;
  - Steady-state seepage: 1.544 (Target: 1.5)
  - Pseudo-static earthquake: 1.048 (Target: 1.0)
- The project solution will cost $4 million, with a 20% contingency.
- The berms should be constructed in stages to minimize the volume of material while the minimum required stability is achieved at the least cost.

References and Acknowledgements

- Industry Advisors: Ilia Wainshtein, Matthew Davidson, Ahmed Mahgoub
- Academic Advisor: Hany El Naggar
- Ormann, L., Zardari, M. A., Mattsson, H., Bjelkevik, A., & Knutsson, S. (2013). Numerical analysis of strengthening by rockfill embankments on an upstream tailings dam. Canadian Geotechnical Journal, 50(4), 391-399.
- Dam Safety Guidelines 2007. (2013). Canadian Dam Association.