Evaluating NorSand for Static Liquefaction Prediction in Upstream Tailings Dams: Lessons from Brumadinho

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Keywords: static liquefaction, tailings dam safety, NorSand, CASM, state parameter, PLAXIS 2D, Brumadinho

ABSTRACT

In 2019, Brumadinho Dam I in Brazil collapsed without warning, killing 270 people and releasing 9.7 million m³ of iron-ore tailings. There was no earthquake and no storm. The dam simply lost its strength from within, through static liquefaction, where loose saturated tailings give way under undrained loading. As the mining industry rethinks tailings safety under the GISTM, the question has shifted. It is no longer enough to explain a failure after the fact. Operators need tools that show where static liquefaction is likely to take hold in an upstream tailings storage facility (TSF) while there is still time to act.

Critical-state models are well established for liquefaction analysis, but few studies have put two advanced models head to head on the same upstream TSF failure, or asked what early-warning information each can deliver. This study does exactly that. We implemented the NorSand model in PLAXIS 2D, benchmarked it against the published CASM back-analysis of Brumadinho Dam I by Arroyo and Gens (2021), and examined the extra diagnostic insight it offers. The model uses the Section 3 benchmark geometry, staged construction across 38 phases, and parameters calibrated for coarse, mixed and fine tailings.

NorSand did not just match the benchmark. It went further. It identified the same critical failure zone beneath the upstream crest and captured the pore pressure build-up, crest settlement and spread of liquefied points. Crucially, its state-parameter contours map the contractive zones directly, pointing to vulnerable material before the dam fails rather than after. For an Australian industry managing many operating and decommissioned TSFs, that foresight is exactly what is needed.

REFERENCES

Arroyo M and Gens A, 2021. Computational analyses of Dam I failure at Córrego do Feijão mine in Brumadinho, Final Report for VALE S.A.