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Submarine slope instabilities in gas hydrate-bearing sediments: peak strength versus strain softening

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Existing laboratory geo-mechanical data show that gas hydrates content can significantly increase the peak shear strength of hydrate bearing sediments while developing its strain softening. On the other hand, some recent publications have reported the occurrence of slope instabilities within the gas hydrate stability zones suggesting a mechanical cause for the failure rather than a thermodynamic one. The purpose of this work aims to examine, through a computational numerical approach, the potential link between gas hydrate content, strain softening behavior and slope stability in gas hydrate-bearing sediments.
The strain softening of gas hydrate-bearing sediments was implemented in a 3D slope stability model (SAMU-3D). This was done by adding to the classical limit analysis method a shear strain field compatibility equivalent to the velocity field compatibility. Examples of slope failures related to strain softening behavior documented in the Literature were used to validate the model formulation. The developed model was then used to assess the slope stability of two well studied examples from the literature. Numerical simulations show that the formation of gas hydrates in shallow sedimentary layers could considerably affect the Factor of Safety (FoS) of the studied slopes which strongly depends on the depth at which hydrates were formed and on the degree of hydrate saturation.