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Joint analysis of epistemic and aleatory uncertainty in stability analysis for geo-hazard assessments

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Uncertainty analysis is an unavoidable task of stability analysis of any geotechnical systems. Such analysis usually relies on the safety factor SF (if SF is below some specified threshold), the failure is possible). The objective of the stability analysis is then to estimate the failure probability P for SF to be below the specified threshold.
When dealing with uncertainties, two facets should be considered as outlined by several authors in the domain of geotechnics, namely "aleatoric uncertainty" (also named "randomness" or "intrinsic variability") and "epistemic uncertainty" (i.e. when facing "vague, incomplete or imprecise information" such as limited databases and observations or "imperfect" modelling). The benefits of separating both facets of uncertainty can be seen from a risk management perspective because:
- Aleatoric uncertainty, being a property of the system under study, cannot be reduced. However, practical actions can be taken to circumvent the potentially dangerous effects of such variability;
- Epistemic uncertainty, being due to the incomplete/imprecise nature of available information, can be reduced by e.g., increasing the number of tests (lab or in site survey), improving the measurement methods or evaluating calculation procedure with model tests, confronting more information sources (expert opinions, data from literature, etc.).
Uncertainty treatment in stability analysis usually restricts to the probabilistic framework to represent both facets of uncertainty. Yet, in the domain of geo-hazard assessments (like landslides, mine pillar collapse, rockfalls, etc.), the validity of this approach can be debatable. In the present communication, we propose to review the major criticisms available in the literature against the systematic use of probability in situations of high degree of uncertainty. On this basis, the feasibility of using a more flexible uncertainty representation tool is then investigated, namely Possibility distributions (e.g., Baudrit et al., 2007) for geo-hazard assessments.
A graphical tool is then developed to explore: 1. the contribution of both types of uncertainty, aleatoric and epistemic; 2. the regions of the imprecise or random parameters which contribute the most to the imprecision on the failure probability P. The method is applied on two case studies (a mine pillar and a steep slope stability analysis, Rohmer and Verdel, 2014) to investigate the necessity for extra data acquisition on parameters whose imprecision can hardly be modelled by probabilities due to the scarcity of the available information (respectively the extraction ratio and the cliff geometry).

References

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