Proceedings of the 10th World Congress on Civil, Structural, and Environmental Engineering (CSEE 2025)
Barcelona, Spain - April, 2025
DOI: 10.11159/icgre25.001

Slope Stability Analyses: From Factor of Safety to Quantitative Risk Assessment

Professor Jinsong Huang, PhD
Discipline of Civil, Surveying and Environmental Engineering
College of Engineering, Science and Environment
The University of Newcastle
Callaghan NSW 2308, Australia
E-mail: Jinsong.huang@newcastle.edu.au

Slope failures or landslides occur annually in various countries. Despite advances in recognizing, predicting, and mitigating landslide hazards, as well as improvements in warning systems, global landslide activity continues to rise. Uncertainty is a prevalent feature in all landslides, arising at various stages—from climate data like rainfall, to infiltration rates, site characterization, material properties, analysis, design, and consequence assessment.

Traditional geotechnical analysis often fails to account for these variabilities directly. Instead, "average" or "pessimistic" properties are assumed across the entire region of interest, leading to the calculation of a factor of safety that is commonly used to quantify slope stability. This single factor of safety encompasses all uncertainties.

The primary aim of this plenary lecture is to advocate for quantitative risk assessment approaches in slope stability analyses. These approaches utilize site investigation data directly in stability analysis, rather than converting the data into parameters for use in traditional methods. By integrating finite element methods, random field theory, Monte Carlo simulations, and machine learning algorithms, these approaches provide more data-informed, quantitative assessments of slope stability risks.

Keywords: quantitative risk assessment; slope stability; spatial variability; machine learning.

References

[1] Yang, R., J. Huang and D. V. Griffiths (2022). "Optimal geotechnical site investigations for slope reliability assessment considering measurement errors." *Engineering Geology* 297.

[2] Yang, R., J. Huang, D. V. Griffiths, J. Meng and G. A. Fenton (2019). "Optimal geotechnical site investigations for slope design." *Computers and Geotechnics* 114(103111).

[3] Huang J., Lyamin AV, Griffiths D. V., Krabbenhoft K, Sloan SW. (2013). Quantitative risk assessment of landslide by limit analysis and random fields. Computers and Geotechnics, 53, 60-67

[4] Huang, J., D. V. Griffiths and G. A. Fenton (2010). "System reliability of slopes by RFEM." *Soils and Foundations* **50**(3): 343-353.

[5] Griffiths, D. V., J. Huang and G. A. Fenton (2009). "Influence of spatial variability on slope reliability using 2-D random fields." *Journal of Geotechnical and Geoenvironmental Engineering* **135**(10): 1367-1378.