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Considerations for Effectively Using Probability of Failure as a Means of Slope Design Appraisal for Homogeneous and Heterogeneous Rock Masses

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Abstract : Probability of failure (PF) often appears alongside factor of safety (FS) in design acceptance criteria for rock slope, underground excavation and open pit mine designs. However, the design acceptance criteria generally provide no guidance relating to how PF should be calculated for homogeneous and heterogeneous rock masses, or what qualifies a ‘reasonable’ PF assessment for a given slope design. Observational and kinematic methods were widely used in the 1990s until advances in computing permitted the routine use of numerical modelling. In the 2000s and early 2010s, PF in numerical models was generally calculated using the point estimate method. More recently, some limit equilibrium analysis software offer statistical parameter inputs along with Monte-Carlo or Latin-Hypercube sampling methods to automatically calculate PF. Factors including rock type and density, weathering and alteration, intact rock strength, rock mass quality and shear strength, the location and orientation of geologic structure, shear strength of geologic structure and groundwater pore pressure influence the stability of rock slopes. Significant engineering and geological judgment, interpretation and data interpolation is usually applied in determining these factors and amalgamating them into a geotechnical model which can then be analysed. Most factors are estimated ‘approximately’ or with allowances for some variability rather than ‘exactly’. When it comes to numerical modelling, some of these factors are then treated deterministically (i.e. as exact values), while others have probabilistic inputs based on the user’s discretion and understanding of the problem being analysed. This paper discusses the importance of understanding the key aspects of slope design for homogeneous and heterogeneous rock masses and how they can be translated into reasonable PF assessments where the data permits. A case study from a large open pit gold mine in a complex geological setting in Western Australia is presented to illustrate how PF can be calculated using different methods and obtain markedly different results. Ultimately sound engineering judgement and logic is often required to decipher the true meaning and significance (if any) of some PF results.

Keywords : probability of failure, point estimate method, Monte-Carlo simulations, sensitivity analysis, slope stability
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