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Risk Management and Reliability Analysis in Civil Engineering

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Recently the feasibility of non-deterministic methods for solving civil engineering problems is highlighted in the literature. Although, still deterministic methods are implemented in practice, non-deterministic methods can be seen as a complement to deterministic methods. In fact, failures of several important projects with relatively high factor of safeties underlined the importance of reliability analysis in Civil Engineering projects. High factor of safety does not necessarily mean high reliability more specifically in Geotechnical Engineering where soil behavior is complex [1]. For example, in a deep excavation problem or slope stability problem, since soil behavior may vary from a place to another place within the soil mass, one can not suggest the high reliability (or low probability of failure) based on a high factor of safety obtained from a deterministic analysis. There are several methods for performing reliability analysis, including random set (RS) method, random field method, Monte Carlo simulation, to name a few. Nevertheless, after obtaining the probability of failure, P_f , for a specific project using the aforementioned methods, the risk of a project can be estimated by multiplying the project P_f by the cost of the project failure (failure consequences of the project). Due to the increasing importance of the reliability analysis concept, this thematic issue is aimed to shed some light on the risk management and reliability analysis of Civil Engineering problems. The thematic issue comprises four papers which are briefly summarized in the following paragraphs. The implemented methods in the following papers can be used in other civil engineering problems (or other case studies) for further research.

The first paper entitled “Risk-based Decision Making Method for Selecting Slope Stabilization System in an Abandoned Open-pit Mine” suggests the implementation of RS-based Finite element method (FEM) for reliability analysis of a real case study, a 50-meter-deep abandoned open-pit mine. In essence, as mentioned by authors, the paper is focused on

determining the most appropriate method of stabilization using RS-FEM as well as risk-based decision making approach. The authors used PLAXIS 2D software for their reliability analysis. The RS-FEM suggests two upper and lower bounds for probability of failure or excessive displacement. The obtained probabilities of failures or excessive displacements (lower and upper bounds) can then be checked against the acceptable probability of failure or acceptable probability of excessive displacement [2]. The paper is an interesting study and readers are encouraged to get more into details regarding the reliability analysis and risk assessment of a real case study.

The second paper entitled “ARMA models to measure the scale of fluctuation from CPT data” suggests implementation of Auto-Regressive Moving Average (ARMA) model for estimating scale of fluctuation. As mentioned earlier, the variability of soil behavior is the reason behind shifting from deterministic analysis to non-deterministic analysis. As illustrated by authors, “this variability is primarily characterized by the scale of fluctuation which describes the distance over which the parameters of a soil or rock are similar or correlated; soil properties sampled from adjacent locations in the soil profile tend to have similar values and as the sampling distance increases the correlation decreases”. Nevertheless, the authors compared the fluctuation values from the ARMA model with two other methods and concluded that the ARMA model outperforms other considered methods. However, the authors highlighted that a considerable amount of research is required before the model can become established in the geotechnical sphere.

The third paper entitled “An Overview of the Reliability Analysis Methods of Tunneling Equipment” provides a detailed overview of the reliability analyses methods used for tunneling machines and equipment including excavator, shovel, LHD machines, conveyor transport system, mechanized tunneling machine, network ventilation equipment in tunnels and underground mines. The reviewed methods in their study include statistical analysis, failure mode and effects analysis, Markov and fault tree methods.

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The fourth paper entitled “A Reliable PSO-based ANN Approach for Predicting Unconfined Compressive Strength of Sandstones” suggests the implementation of an artificial intelligence technique for predicting the unconfined compressive strength (UCS) of sandstones. In this paper, an artificial neural network-based predictive model of UCS is enhanced by particle swarm optimization (PSO) algorithm. The authors highlighted the feasibility and reliability of the aforementioned techniques including PSO-based ANN in solving Geotechnical Engineering problems.

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