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RELIABILITY ANALYSIS OF SEISMIC STABILITY OF UNSATURATED SOLDIER PILED-EXCAVATION

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Soldier piles are widely used in urban and industrial areas as a temporary or permanent retaining system for constructing subway or multi-story buildings (Sáez and Ledezma, 2012; Saez et al. 2015). The key advantages of soldier piles are that it provides unobstructed open excavations (Sert et al, 2016). As the socio-economic implications of excavation failure are irreparable, stability problem is a demanding branch in geotechnical engineering (Tsiampousi et al., 2013). On the other hand, Evaluation of the stability of the retaining system under the earthquake conditions is integral part of retaining system design in seismically active regions. The most popular and simple method for computation of seismic earth pressure is Mononobe-Okabe (Kramer, 1996) that is a Limit Equilibrium (LE) based method. These simple design procedures are straightforward, but they do not provide directly any indication of structural internal force and deformations under the design earthquake load. However, during an earthquake, movements of both the soil and the structure will occur under seismic loading, regardless of how over-designed the structure may be. To get an estimate of the seismically induced movements, the LE methods are usually combined with a sliding block type of analyses, which have been shown to be very sensitive to the seismic coefficient obtained by the LE analysis (Crespellani, 1998). On the other hand, time domain analysis, using acceleration time histories, provides a rigorous tool for the safe and economic seismic design of a geotechnical structure, as it can give predictions of the performance of a structure under any given seismic scenario. However, this type of analysis requires the use of computational codes (Finite Element (FE)/Finite Difference) which encompass advanced constitutive models capable of simulating the response of soils to seismic loading and boundary conditions specifically formulated for dynamic analysis. Such advanced tools are not usually readily available in engineering practice and the calibration and analysis of the computational models can be time consuming. The use of finite element pseudo-static analysis can be a good compromise between simplified methods of analysis and time domain analysis and consequently is widely used in engineering practice. The pseudo-static FE approach can accurately model the in-situ internal force and deformation prior to seismic loading (when it follows a static analysis simulating the construction sequence) is relatively simple and not as computationally expensive as the time domain approach.

Recent studies show the insufficiency of traditional deterministic assessment of stability problems in which stability is evaluated only based on Factor of Safety (FS) (Cai and Ugai, 2000). Due to the inherent variability associated with soil properties, a reliability-based approach is present as a complementary measure to the FS to aid geotechnical experts to make acceptable designs (Duncan, 2000).

To address these issues, this paper provides a probabilistic framework with random finite element-based program coded in MATLAB to evaluate the reliability indices of seismic stability of soldier-piled excavation with consideration of inherent uncertainty of soil properties and unsaturated state. Numerical results of a case study show that reliability indices of all failure modes and safe distance from the edge of the excavation deteriorate and improve with implementation seismic and unsaturated state respectively.

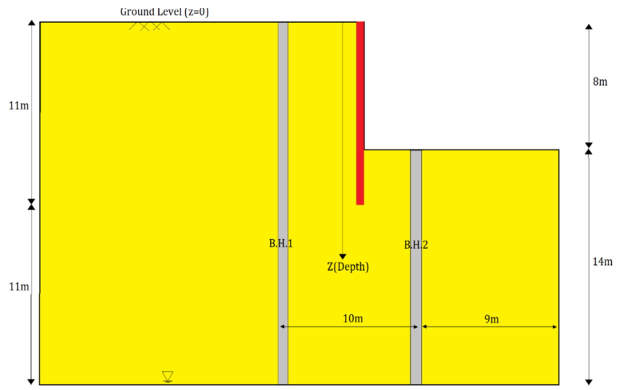

Figure 1. Soldier piled-excavation geometry and borehole location.

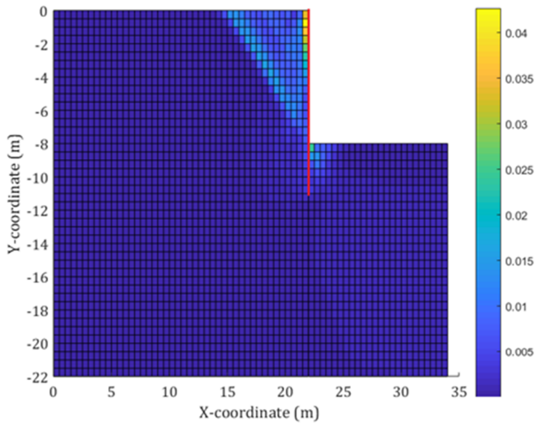

Figure 2. The shear strain of soldier piled-excavation.

Table 1. Soil properties Applied in deterministic analysis.

Poisson's Ratio	Modulus of Elasticity (kPa)	Cohesion (KN/m^2)	Friction Angle (deg)	ω_{mean} (%)	γ_{mean} (KN/m^3)
0.35	30,000	23.10	17.20	9.80	17

Table 2. Sensitivity analysis of input parameters.

Studied Parameters	Cohesion	Friction Angle	Unit Weight	Poisson's Ratio	Modulus of Elasticity
Change in FS (%)	5.8	4	8.8	0.2	0.2

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