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The Use of Random Set Method in Reliability Analysis of Deep Excavations

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Abstract : Since the deterministic analysis methods fail to take system uncertainties into account, probabilistic and non-probabilistic methods are suggested. Geotechnical analyses are used to determine the stress and deformation caused by construction; accordingly, many input variables which depend on ground behavior are required for geotechnical analyses. The Random Set approach is an applicable reliability analysis method when comprehensive sources of information are not available. Using Random Set method, with relatively small number of simulations compared to fully probabilistic methods, smooth extremes on system responses are obtained. Therefore random set approach has been proposed for reliability analysis in geotechnical problems. In the present study, the application of random set method in reliability analysis of deep excavations is investigated through three deep excavation projects which were monitored during the excavating process. A finite element code is utilized for numerical modeling. Two expected ranges, from different sources of information, are established for each input variable, and a specific probability assignment is defined for each range. To determine the most influential input variables and subsequently reducing the number of required finite element calculations, sensitivity analysis is carried out. Input data for finite element model are obtained by combining the upper and lower bounds of the input variables. The relevant probability share of each finite element calculation is determined considering the probability assigned to input variables present in these combinations. Horizontal displacement of the top point of excavation is considered as the main response of the system. The result of reliability analysis for each intended deep excavation is presented by constructing the Belief and Plausibility distribution function (i.e. lower and upper bounds) of system response obtained from deterministic finite element calculations. To evaluate the quality of input variables as well as applied reliability analysis method, the range of displacements extracted from models has been compared to the in situ measurements and good agreement is observed. The comparison also showed that Random Set Finite Element Method applies to estimate the horizontal displacement of the top point of deep excavation. Finally, the probability of failure or unsatisfactory performance of the system is evaluated by comparing the threshold displacement with reliability analysis results.

Keywords : deep excavation, random set finite element method, reliability analysis, uncertainty
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