Effect of stratigraphic model uncertainty at a given site on its liquefaction potential index: Comparing two random field approaches

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Presenter: Hoai-Han Le
Advisor: Prof. Jia-Jyun Dong
Co-Advisor: Dr. Yu-Chen Lu
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Abstract

The geological model is indispensable in geotechnical, petroleum and mining engineering projects. There are many methods to simulate the spatial variability of geo-material boundaries and properties, but different theories return very different random field generation outcomes. In this paper, conditional random field (CRF) and Markov random field (MRF) were used to construct the geological model based on the cone penetration test (CPTs) result in the study site area, in Taiwan. The derived CRF-based and MRF-based stratigraphic models are realized in a series of geological profiles. Then, with a simulated geological profile and associated soil parameters, the liquefaction potential index (LPI) is calculated. The mean and the coefficient of variation of LPI are then calculated by repeating the analysis for all realizations of random stratigraphic models. Meanwhile, the information entropy is a measurement and expression of the uncertainty of the stratigraphic models produced by CRF and MRF approaches. The correlation between LPI variation and stratigraphic model uncertainty is expressed as entropy is established. The results show that: (1) the generation of the stratigraphic model is affected by the chosen random field approach, and the distribution of MRF-based strata is more continuous compared with that of CRF-based strata; (2) due to this effect, the strata uncertainty of CRF simulation is more uniform compared with that of MRF; (3) the information entropy and LPI uncertainty obtained using CRF exhibit moderate correlation, while these parameters obtained using MRF exhibit a strong positive correlation.

Keywords: Liquefaction potential index, conditional random field, Markov random field, stratigraphic model uncertainty.

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Wan-Ying Chien [a], Yu-Chen Lu [a,b,*], C. Hsein Juang [a,d], Jia-Jyun Dong [c,e], Wen-Yi Hung [a,d]

[a] *Department of Civil Engineering, National Central University, Taoyuan City 32001, Taiwan*

[b] *Institute of Materials Science and Engineering, National Central University, Taoyuan City 32001, Taiwan*

[c] *Graduate Institute of Applied Geology, National Central University, Taoyuan 320, Taiwan*

[d] *GeoRisk Engineering and Advanced Technologies Center, National Central University, Taoyuan City 32001, Taiwan*

[e] *Earthquake-Disaster & Risk Evaluation and Management Center, National Central University, Taoyuan 320, Taiwan*

A R T I C L E I N F O

Keywords:
Liquefaction potential index
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information entropy

A B S T R A C T

Random field theory is often used to model spatial variability of geo-material boundary and property. The results of random field generation based on different theories are quite different; however, few studies discuss the effects of adopting different random field approaches on the established stratigraphic models and their influence on engineering analysis. This article compares two random field approaches for evaluating liquefaction potential at a selected site. Here, based on the results of cone penetration tests (CPTs) at the study site, stratigraphic models are constructed using a continuous random field (conditional random field, CRF) and a discontinuous random field (Markov random field, MRF). Note that the MRF parameters were calibrated with the statistical parameters used in CRF. A series of geological profiles representing realizations of the derived CRF-based and MRF-based stratigraphic models are generated. Then, the liquefaction potential index (LPI) is calculated using the simplified procedure with a simulated geological profile and associated soil parameters. Finally, by repeating the analysis for all realizations of random stratigraphic models, the mean and the coefficient of variation of LPI are determined. Meanwhile, the uncertainty of stratigraphic models generated by CRF and MRF approaches is quantified and expressed as information entropy. Next, the relationship between stratigraphic model uncertainty (as an entropy) and LPI variation (or uncertainty) is established. The results show that: (1) the generation of the stratigraphic model is affected by the chosen random field approach, and the distribution of MRF-based strata is more continuous compared with that of CRF-based strata; (2) due to this effect, the strata uncertainty of CRF simulation is more uniform compared with that of MRF; (3) the information entropy and LPI uncertainty obtained using CRF exhibit moderate correlation, while these parameters obtained using MRF exhibit a strong positive correlation.