Simulation of stochastic soil consolidation using Dynamic Variability Response Functions

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ABSTRACT

In this study, the consolidation phenomenon of soils exhibiting spatial variability of permeability k and Young's modulus E is considered. The uncertain soil properties are incorporated into the analysis though the use of dynamic mean and variability response functions (DMRF, DVRF), established in [1, 2]. It is very difficult if not impossible to derive closed form formulas of the DMRF and DVRF functions and therefore, a numerical finite element method-based fast Monte Carlo simulation procedure is used. Spatial discretization of the consolidation equations is based on the coupled u-p finite element formulation and a generalized Newmark (GN11) time integration scheme is used to carry out the time integration. A test case of a rigid strip footing resting on a consolidating soil layer and loaded with a ramp type load, is used to demonstrate the accuracy and efficiency of the proposed formulation. Statistical quantities of the footing-soil response calculated via the DMRF-DVRF functions are compared with the results obtained by the globally applicable direct Monte Carlo simulation (MCS) method, for various correlation structures of the underlying soil properties. It is shown that the DMRF-DVRF based stochastic analysis is more efficient in terms of computational cost. Furthermore, the results obtained by the proposed method are spectral and probability distribution free, i.e. the time dependent variance and mean of the response quantities can be easily calculated for any correlation structure with known spectral density, without resorting to additional finite element analyses. Finally, the DMRF-DVRF functions provide valuable insight into the mechanisms governing the variability of the studied response and are a valuable tool for sensitivity analysis.

Acknowledgements

The first author acknowledges support from the Bodossaki Foundation. This work has also been supported by the European Research Council Advanced Grant "MASTER - Mastering the challenges in numerical modeling and optimum design of CNT reinforced composites" (ERC-2011-ADG_20110209).

REFERENCES

[1] Papadopoulos Vissarion and Kokkinos Odysseas. Variability response functions for stochastic systems under dynamic excitations, *Probabilistic Engineering Mechanics* (2012) **28**:176–184.

[2] Papadopoulos Vissarion and Kokkinos Odysseas. Transient response of stochastic finite element systems using Dynamic Variability Response Functions, *Structural Safety* (2015) **52A**:100–112.