Proposal of a PhD subject

Years: 2020-2023
Title: Modeling of vertical rigid inclusions subjected to seismic loading
Laboratory: GeM, Institut de Recherche en Génie Civil et Mécanique (UMR CRNS 6183)
https://gem.ec-nantes.fr
Team : MEO (Matériaux Environnement et Ouvrages)
Where: École Centrale de Nantes
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Period: October 2020 – September 2023
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Description of the subject
Proposal's context
The technique of reinforcement of compressible soils by vertical Rigid Inclusions (RI) is very widespread in France and abroad. It was the subject of a French National Project (ASIRI) in the mid-2000s, leading to the development of recommendations (1) for mainly monotonic and vertical loads. This composite foundation technique, combining deep and superficial elements (Figure 1), was originally developed for embankment-type structures (for transport infrastructure), but now extends to wind turbines and to industrial buildings (e.g. logistic platforms), housing or offices (up to 4-5 floors), schools, hospitals, etc. It covers the whole territory, urbi et orbi, impacts the choice of the foundations of construction and linear transport works (roads & railways), thus affecting citizens in their living environment and for their mobility.

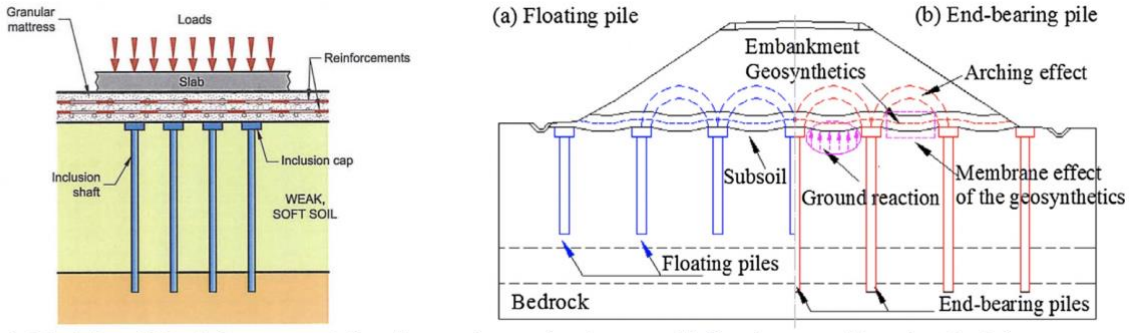

Figure 1 Principles of RI reinforcement, left, scheme of an embankment with floating or end-bearing RI, right

The new ASIRI+ project, comprising a "PN Project" (ASIRI+) and an "ANR Project", is part of a global approach to adapting land use planning to the requirements of sustainable development and it aims to study the behaviour of soft soil reinforced by RI subjected to seismic loading (inertial and kinematic effects). EC Nantes is the leader of the Topic B Numerical modelling and of the Work Package 5: Topic B: Numerical Modelling of soft soil reinforced by rigid inclusions, subjected to seismic loading of the ANR ASIRIplus-SDS. Within, this project, the following PhD doctoral position is available at EC Nantes (GeM Laboratory).

Workplan of the PhD

A comprehensive numerical study will be made (using the general purpose finite element code Cast3M and the supercomputer LIGER - 280 TFlop/s) of the failure envelope (i.e. horizontal force H, bending moment M and vertical force V) of a shallow foundation on a soft soil reinforced by RI. In order to find the 3D failure envelope, the radial displacement method and swipe tests will be numerically performed (3). The behaviour of the foundation subjected to different load combinations will be simulated using a large number of 3D finite element numerical calculations and constitutive laws based on plasticity or hypoplasticity, accounting also for fluid flow through the porous network. Then, a novel hypoplastic macroelement for soil-structure interaction will be developed (4) to simulate the behaviour of RI foundations submitted to cyclic and dynamic (seismic) loadings. A calibration procedure of the macroelement's parameters will be defined and validation will be provided using the experimental data of the dynamic centrifuge facility of University Gustave Eiffel and in situ data of the ASIRI+ project. Applications will be made on real cases. The PhD candidate will closely collaborate with the other PhD and Post-Doctoral students of the ASIRI+ project.

Necessary skills: Finite element method, geotechnics, continuum mechanics, constitutive laws

(1) ASIRi (2012) Recommandations pour la conception, le calcul, l'exécution et le contrôle des ouvrages sur sols améliorés par inclusions rigides verticales (Recommandations Projet National ASIRi), PressePont IREX Paris ISBN9782-85978-462-1.

(2) https://www.irex.asso.fr/le-projet-asiri-labellise-projet-national/

(3) Li Z., Kotronis P., Escoffier S. 'Numerical study of the 3D failure envelope of a single pile in sand'. Computers and Geotechnics, October, volume 62, pages 11–26, 2014.

(4) Li Z., Kotronis P., Escoffier S., Tamagnini C. 'A hypoplastic macroelement for single vertical piles in sand subject to three-dimensional loading conditions'. Acta Geotechnica, 11(2), 373-390, 2016.