2019-2022 PhD Thesis : Multi-scale numerical modelling for hydraulic works under severe loadings (Aix-en-Provence, France)

Research Topic

Multi-scale methods (e.g. Miehe et al., 2010 ; Nguyen et al., 2014 ; Liang & Zhao, 2019) constitute a recent and promising modelling approach in geotechnics. Owing to the discrete nature of soil materials, a phenomenological description of their constitutive behavior is indeed highly challenging (e.g. Duriez & Vincens, 2015), which hinders an optimal design and assessment of geo-structures. On the other hand, multi-scale modelling approaches rely on a direct simulation of the interacting soil particles at the material's scale, which is exported to the structure scale through classical continuous approaches, such as the Finite Element Method (Miehe et al., 2010 ; Nguyen et al., 2014) or, more recently, the Material Point Method (Liang & Zhao, 2019).

The present PhD thesis is devoted to develop such an approach, with a special interest into large deformations and failure conditions at the structure scale, following Liang & Zhao (2019). Applications lie in the field of hydraulic earth works, such as dams and dikes.

Tasks to perform and expected skills

The PhD project aims to develop, and eventually conduct, multi-scale numerical simulations of hydraulic earth structures. As such, the PhD student is expected, at the end of the project, to proficiently use both the Discrete Element Method (DEM) code YADE (http://yade-dem.org) and one Material Point Method code, coupled one with another, for hydro-mechanical simulations.

As such, candidates are expected to hold a Master Degree in (Geo-)Mechanics with a Numerical Modelling component. Ideal candidates would show very good theoretical knowledge in (soil) mechanics as well as demonstrated, high level, computer skills.

English language skills are expected. French communication skills would help a global integration in the host team, but won't be necessary for direct interaction with the supervisors.

Host team

The PhD student will be enrolled at Aix-Marseille University, in the Doctoral School 353, in Engineering (https://ecole-doctorale-353.univ-amu.fr/).

The PhD thesis will be co-directed by Pierre Philippe (Research Director) and Jérôme Duriez (Research Associate, http://www.irstea.fr/duriez), with a co-supervision by Stéphane Bonelli (Research Director), in the G2DR team of RECOVER research unit (Irstea, Aix-Marseille University), in Aix-en-Provence, France (http://www.irstea.fr/en/research/research-units/recover).

Collaboration with international research teams are probable. As such, the PhD thesis may include mobility periods overseas.

Perspectives for the PhD students

The project will take place in a research team having close ties with academic partners in (geo)mechanics, as well as private companies in the field of dams engineering.

Once graduated, the PhD will be a proficient computer scientist, with a first-hand expertise in two promising numerical modelling approaches and two open-source codes such as, for the DEM part, the YADE code that has a significant community worldwide.

Funding for this PhD is guaranteed, with a monthly gross income of 1874 € (net income in the order of 1500 €).

How to apply

Applications should be submitted between February, 4 2019 and May 17, 2019 through the dedicated web interface : https://pasi.irstea.fr/en. Selection procedure may last until mid-July 2019 for short-listed candidates.

Previous informal inquiries (see the **Contact** section below) are welcome.

Contact

- Jérôme Duriez : jerome.duriez@irstea.fr
- Pierre Philippe : pierre.philippe@irstea.fr
- Stéphane Bonelli : stephane.bonelli@irstea.fr

References

Duriez, J. and Vincens, É. (2015) Constitutive modelling of cohesionless soils and interfaces with various internal states: An elasto-plastic approach, *Computers and Geotechnics*, 63: 33-45

Liang, W. and Zhao, J. (2019) Multiscale modelling of large deformation in geomechanics, *Int. J. Numer. Anal. Meth. Geomech.*, 43(5): 1080-1114

Miehe, C. , Dettmar, J. and Zäh, D. (2010) Homogenization and two-scale simulations of granular materials for different microstructural constraints. *Int. J. Numer. Meth. Engng.*, 83: 1206-1236

Nguyen, T.K., Combe, G., Caillerie, D. et al. (2014) FEM × DEM modelling of cohesive granular materials: Numerical homogenisation and multi-scale simulations. *Acta Geophys.* 62(5): 1109-1126