PhD fellowship

Title : Discrete element modeling of concrete under impact; influence of mesoconstituents

Context of proposed research

The topic concerns the vulnerability analysis of reinforced concrete (RC) protective structures subjected to severe dynamic loading due to accidental or terrorist risks (aircraft crash, missile impact,…). The proposed research project aims at developing a numerical tool able to predict the response of the impacted structure and to describe associated damages. Several studies have already been carried out (see references), the PhD candidate will focus on the case of impact by a non-deforming projectile ("hard impact") that may cause perforation and fragmentation within the reinforced concrete structure.

The main developments will be numerical and carried out at Grenoble but the work will also include experimental developments conducted at Haifa in the Israel Institute of Technology (Technion). So some long stays will have to be spent at Haifa.
The PhD candidate will have the possibility to be engaged into a dual PhD program between UJF and Technion but this condition is not mandatory to get the fellowship from UJF.

Because the aim is the development of a numerical tool for the structural analysis of an industrial structure, the project will also be carried out in collaboration with EDF R&D at Clamart and CEA Saclay

Research project

When subjected to severe loading such as an impact, concrete material presents specific damage mechanisms (cracking, fragmentation, crushing, compaction). The classical continuum mechanics methods like FEM can hardly model the occurrence of discontinuity surfaces. The discrete element (DE) method (DEM) has shown its ability to model complicated phenomena in concrete such as penetration, spalling and scabbing. The correct prediction of RC structural response requires the experimental characterization of concrete under quasi-static and dynamical loading (3SR-UJF database) and the validation of the numerical tool requires the simulation of tests performed on full scale RC slabs (collaboration with NBRI-Technion).
In the practical cases of building structures, reinforcement, either conventional or in the form of fibers, is another challenge that needs to be considered in this project.

The mesoscopic modelling of concrete will be carried out in order to investigate the influence of mesoconstituents (cement matrix, aggregates, pores, free water). The FEM/DEM coupling (Rousseau et al. 2008 and 2009) will allow limiting the size of the DE model.

Main goals of the PhD

- Improvement of an existing DE model implemented in the explicit code Europlexus for accounting compaction under high triaxial loading.
- Development in Europlexus of existing coupled FE/DE model for the simulation of impact tests performed on RC slabs.
- Complementary tests (at 3SR Grenoble and NBRI Haifa), influence of mesoconstituents (aggregates, ciment matrix, free water)
- Validation of the model by the macroscale simulation of impact tests performed on RC slabs.
- Mesoscopic modeling of tests, influence of mesoconstituents.

PhD scolarship : Funded by the university Joseph Fourier (UJF), doctorate school IMEP2

Host laboratory in France : 3SR lab UMR 5521 (CNRS, UJF, INPG)

Supervisor : Laurent DAUDEVILLE, Prof. UJF

http://people.3sr-grenoble.fr/users/ldaudeville/

Collaborations in France : EDF R&D (Serguei POTAPOV) and CEA (Vincent FAUCHER)

Host laboratory in Israel : National Building Research Institute (NBRI), Technion – Israel Institute of Technology http://tx.technion.ac.il/~nbri

Co-supervisor in Israel : Avraham DANCYGIER, Ass. Prof. Technion

Skills

Advanced knowledge in structural dynamics, proficient user level of English language (speaking and writing)

References

Potapov S., Faucher V., Daudeville L. 2012. Advanced simulation of damage of reinforced concrete structures under impact. *European Journal of Environmental and Civil Engineering.* 16(9): 1090-1101.

Daudeville L., Malecot Y. 2011. Concrete structures under impact. *European Journal of Environmental and Civil Engineering.* 15(S1): 101-140.

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Rousseau J., Frangin E., Marin P., Daudeville L. 2008. Damage prediction in the vicinity of an impact on a concrete structure: a combined FEM/DEM approach. *Computers and Concrete*. 5(4): 343-358.

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Contact

Candidates should send a full CV and a motivation letter to Prof. Laurent DAUDEVILLE

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