Ph.D. project for Fall 2021
"Risk of early-age shrinkage cracking of cement-based slabs"

Plastic shrinkage cracking designates the apparition of cracks in concrete slabs before setting (see Fig. 1), i.e., at an early age, when concrete is still in a plastic state [1]. Plastic shrinkage cracking occurs mainly on horizontal surfaces and is favored by high rates of evaporation. When conducted properly, internal curing (by adding admixtures directly to the mix [2,3]) reduces the cracking of the material. Presently, the risk of plastic shrinkage cracking of slabs and curing agents' efficiency to reduce this risk are assessed in a rather phenomenological manner. Such a phenomenological approach presents its limits, as it makes it difficult to assess the risk of cracking in environmental conditions other than the tested ones, and it provides only a limited understanding of the physical reasons why a given curing agent works or not.

Figure 1: Early-age cracks in concrete slab (from [1]). Space between cracks is around 1m.

Significant work on plastic shrinkage cracking has already been performed in collaboration between LafargeHolcim and Laboratoire Navier at Ecole des Ponts ParisTech, through several M.Sc. projects. Based on the experience gained in those previous projects, **the objective of the proposed Ph.D. is to 1) identify what physical properties of hydrating cement-based materials govern the risk of plastic shrinkage cracking, 2) propose specific experiments to assess those physical properties, 3) identify the physical properties that internal curing agents modify, 4) propose a model that predicts the risk of plastic shrinkage cracking of a hydrating slab (with or without curing agents) as a function of the environmental conditions.**

The Ph.D. project will comprise both modeling and experiments. Modeling the risk of plastic shrinkage cracking in given environmental conditions will consist in concatenating a model for water evaporation with constitutive laws of hydrating cement-based materials at an early age. Those laws will be derived in a chemo-poro-mechanical framework, in the continuity of works already performed at Laboratoire Navier [4, 5]. Specific attention will be devoted to the cracking criterion, which is a point still debated in the literature [6]. We will develop experiments on hydrating materials (mortars) to assess the physical properties that intervene in the model and how curing agents impact them. Those experiments will be inspired from experiments classically performed in geomechanics and soil mechanics (oedometer testing, determination of air entry pressure…). The model, fed with inputs obtained with those geomechanical experiments, will be confronted to results from drying shrinkage experiments and slab cracking experiments to assess its validity domain.

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Locations: Laboratoire Navier at Ecole des Ponts ParisTech (Champs-sur-Marne, just outside Paris) and LafargeHolcim Innovation Center (Saint-Quentin-Fallavier, just outside Lyon)

Advisors at Laboratoire Navier: M. Vandamme, S. Ghabezloo

The project will take place as a CIFRE Ph.D. project between LafargeHolcim Innovation Center and Laboratoire Navier at Ecole des Ponts ParisTech.

To apply, send CV, transcripts and motivation letter (all in English) to matthieu.vandamme@enpc.fr and siavash.ghabezloo@enpc.fr, preferably before 25 April 2021.

Do not hesitate to contact us for further information.

References

[1] Slowik, V., Schmidt, M., Fritzsch, R., 2008. Capillary pressure in fresh cement-based materials and identification of the air entry value. Cement and Concrete Composites 30, 557–565. https://doi.org/10.1016/j.cemconcomp.2008.03.002

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[6] Man, W.N., Russel, W.B., 2008. Direct measurements of critical stresses and cracking in thin films of colloid dispersions. Physical Review Letters 100, 198302. https://doi.org/10.1103/PhysRevLett.100.198302

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