China Scholarship Council / Université de Lyon
Scholarships for doctoral mobility

Call for Thesis subjects: 2025

RESEARCH SUBJECT TITLE: Multi-Scale Numerical Approach for Predicting the Mechanical Behavior of Textile Reinforced Concrete Structures

Name of the laboratory: LTDS, TRIBOLOGY AND DYNAMICS OF SYSTEMS LABORATORY
Website: http://ltds.ec-lyon.fr/spip/

Name of the research team: Géomatériaux et Constructions Durables
Website: https://ltds.ec-lyon.fr/

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Doctoral School (name and number): ÉCOLE DOCTORALE 488 - SCIENCES INGÉNIERIE SANTÉ SIS (https://edsis.universite-lyon.fr)

Lab Language: English

Minimum language level required:

- English : B2
- French :
- Other :

Expected duration of the thesis: (36 or 48 months): 48 months

Keywords : Composites structures, Multiscale methods, Textile reinforced concrete, Finite element method

Abstract :

General context:
Textile Reinforced Concrete (TRC) has gained significant prominence in various fields, especially in civil engineering, where it offers an efficient solution for reinforcing deteriorated concrete structures. Consisting of multi- or uniaxial textile reinforcements embedded within a fine-grained cementitious matrix, TRC presents itself as a compelling alternative to conventional Fiber Reinforced Polymer (FRP) composites. This material boasts excellent mechanical properties, superior fire resistance (compared to polymer-based composite materials), and contributes to sustainable development objectives. TRCs, characterized by their highly anisotropic nature and nonlinear hardening behavior, rely on complex multiscale mechanisms to determine their macroscopic performance. Extensive research has been dedicated to modeling TRCs using numerical simulations (Djamai et al., 2017; Truong et al., 2016).

Given the inherently multiscale nature of TRCs, developing numerical multiscale approaches has become a practical method for simulating their behavior. These approaches aim to integrate information from microscale constitutive behavior, mesoscale properties, and macroscopic structural responses into a unified model, enabling rapid and cost-effective simulations compared to conventional fine-scale methods. This research will focus on the development of a multiscale Finite Element Two-Scale (FE2) approach to accurately predict the mechanical behavior of highly nonlinear composite structures.

Description of the work:
The research will be based on the existing LAGAMINE code (Pardoen et al., 2020). The first phase will involve modeling representative mesostructures of textile-reinforced concrete (TRC) by defining a Representative Volume Element (RVE). Homogenization studies will be conducted on these RVEs to capture microscale behavior, and the resulting data will be integrated into macroscale models. Parallelization techniques will be employed to optimize computational efficiency and reduce simulation time. The resultant code, will be applied to simulate the response of textile reinforced concrete structures with highly nonlinear and anisotropic damage behavior. Comparative analyses with experimental results will validate the numerical predictions, ensuring the robustness and accuracy of the developed multiscale approach. This research not only advances the understanding of TRC behavior but also holds the potential to transform the design and analysis of such composite structures in practical engineering applications. Strong programming skills, especially in finite element modeling, will be crucial for the successful completion of this work.

References:
Djamai, Z.I., Bahrar, M., Salvatore, F., Si Larbi, A., El Mankibi, M., 2017. Textile reinforced concrete multiscale mechanical modelling: Application to TRC sandwich panels. Finite Elements in Analysis and Design 135, 22–35. https://doi.org/10.1016/j.finel.2017.07.003

Truong, B.T., Larbi, A.S., Limam, A., 2016. Numerical modelling of reinforced concrete beams repaired by TRC composites. Composite Structures 152, 779–790. https://doi.org/10.1016/j.compstruct.2016.05.071

Pardoen, B., Bésuelle, P., Desrues, J., Dal Pont, S., and Cosenza, P. (2020). Accounting for small-scale heterogeneity and variability of argillite in homogenised numerical micromechanical response and microcracking. Rock Mechanics and Rock Engineering.