



Micromechanical modelling of damage propagation

A 4 to 6 months research internship is offered at LMA (Laboratoire de Mécanique et d'Acoustique, <https://laboratoire-mecanique-acoustique.fr/>) in Marseille (France) in spring 2026, under the supervision of Julie Triclot and Sébastien Brisard.

Context: Brittle fracture is a failure mechanism that affects many materials of engineering interest: ceramics (including concrete) at all temperatures, but also metals below their brittle/ductile transition temperature. At the microscopic level, failure is initiated by the formation of multiple microcracks that form at the macroscopic level a damaged zone. These cracks grow and eventually coalesce into one (or several) macroscopic crack(s), causing failure.

Modelling of the first stage (damage) raises several questions: **(1)** How is damage to be quantified? **(2)** How are the macroscopic material properties affected by damage? **(3)** How does damage evolve with the stress history?

The first two points have been widely studied in the past through the lense of homogenization. In particular, in simple situations, a unique, scalar damage variable can be identified, that is related to the local number density of cracks, and that univoquely defines the effective stiffness of the cracked material.

The present project is focused on the third point, namely modelling of damage propagation. Damage will be assumed to remain “small enough” so that homogenization theory can be used (length scales are separated) to infer macroscopic damage propagation laws. This investigation will be carried out within the framework of micromechanics, where elliptical cracks are constrained to propagate as ellipses, and interactions between cracks are accounted for in an approximate manner. Under these drastic assumptions, it becomes possible to derive damage models that result from a true multiscale approach. These models (and the underlying assumptions) can then be assessed through confrontation to experimental evidence.

Outline of the project: The first step of the project will be the definition of the mechanical problem to be considered (initial distribution of defects, load-path, etc.). Then, various micromechanical models will be implemented to estimate the macroscopic properties of the cracked material (damage being prescribed). Finally, damage evolution will be modelled in the spirit of the work by Dormieux, Kondo and Ulm (2006, DOI:10.1016/j.crme.2006.05.007). The model will then be enriched through the introduction of multiple propagation scenarii and an energy-based selection criterion that will be the novelty of the project.

Applications: cover letter, transcripts and references to be sent to julie.triclot@univ-amu.fr and sebastien.brisard@univ-amu.fr.

Profile of the applicant: master's (M2) or final year engineering student with strong background in continuum mechanics (linear elasticity). Notions of homogenization theory, micromechanical (mean field) models and/or linear elastic fracture mechanics would be appreciated.

Keywords: homogenization, micromechanics, mean-field models, linear elastic fracture mechanics