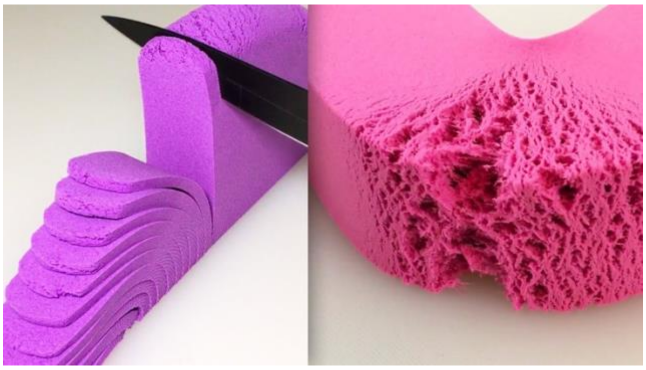
INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: LPENS
CNRS identification code: UMR 7636
Internship director'surname: Andreotti
e-mail: andreotti@phys.ens.frr Phone number:
Web page: https://www.phys.ens.psl.eu/~foldingslidingstretchinglab/Membres.html
Internship location: ENS

Title: ***Bridging Micro-Dynamics and Macro-Rheology of Soft Cohesive Granular Media.***

Bridging Micro-Dynamics and Macro-Rheology of Soft Cohesive Granular Media. Within the urgent framework of the transition toward a circular economy, the construction industry faces a major technological bottleneck caused by the inherent irreversibility of traditional cementitious materials.



Conventional concretes, based on hydration chemistry, lock matter into a permanent state, effectively preventing the direct disassembly and reuse of components without destructive crushing. To meet the emerging requirements of Design for Disassembly and the Buildings-as-Material-Banks concept, it is crucial to explore new bonding pathways based on controllable physical interactions rather than permanent chemical fusion. This fundamental research project investigates the physics of model granular media composed of grains coated with thin polymer films, systems analogous to commercial kinetic sand. These hybrid materials sit at the intersection of granular mechanics and soft matter physics, offering a pathway to reversible concretes capable of restructuring or disintegrating under specific stimuli.

The study of these soft cohesive granular materials is scientifically driven by their complex rheological behaviour, particularly their compressibility. While dry granular media are also compressible, their packing fraction typically behaves as a slave variable dependent on shear rate and confinement pressure. In contrast, soft cohesive systems follow evolution laws where the volume fraction acts as a critical, independent determinant of viscosity. These behaviours diverge fundamentally from those of compressible Newtonian fluids and often exhibit significant flow localization at low velocities, complicating the modelling of the transition from static load-bearing structures to dynamic fluid-like states. To characterize these phenomena, a series of fundamental experiments will be conducted, including modified inclined plane tests with a mobile upper boundary, tube discharge analysis, and studies of the visco-plastic flow of grain layers through circular orifices. The central scientific challenge lies in solving the inverse problem to determine constitutive stress-strain laws outside of the long-term asymptotic state. This requires a model that accounts for the evolving microstructure, specifically compactness and other potential internal state variables. To bridge the gap between microscopic interactions and macroscopic behaviour, the project will employ discrete element method simulations using a cohesive-frictional model. This numerical framework will be directly derived from rheological experiments performed on the polymer coatings and grounded in established polymer physics models, ultimately aiming to identify the constitutive laws necessary for engineering next-generation reversible building materials.

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: NO Soft Matter and Biological Physics: YES
Quantum Physics: NO Theoretical Physics: YES