IMPERIAL
Grantham Institute

Grantham Institute-funded PhD studentship

Project title: Physics-based and data-driven discovery of governing laws for next generation energy-storing geomaterials

Lead Supervisor and Department: Dr. Angela Casarella, Department of Civil and Environmental Engineering

Co-Supervisor(s) and Department(s): Prof. Domniki Asimaki, Department of Civil and Environmental Engineering, in collaboration with Dr. Filippo Masi (Université Grenoble Alpes)

Project Description:

The transition to renewable energy presents a major energy-storage challenge. Wind and solar generate electricity according to weather conditions, while electricity demand varies independently. Meeting large-scale storage needs through conventional batteries alone would require substantial quantities of critical raw materials. The solution might be hiding beneath our feet: what if the ground itself could store energy?

Recent advances suggest that natural clay-based materials can be engineered to support infrastructure while storing electrical energy, creating an entirely new class of multifunctional geomaterials. In the future, the ground beneath roads, railways and buildings could become part of the energy grid, forming a distributed storage infrastructure embedded in the built environment. By harnessing abundant natural resources, this approach could reduce dependence on critical raw materials and contribute to more sustainable energy systems.

Realising this vision requires a fundamental understanding of how energy-storing geomaterials behave. No established governing framework can currently describe the fully coupled behaviour of these new materials. Their response emerges from complex interactions between electrical, hydraulic, chemical and mechanical processes, which govern their ability to store energy, deform and undergo progressive damage or self-healing. These processes are also strongly history-dependent: the behaviour of the material evolves according to the sequence of mechanical loading, electrical charging and environmental conditions experienced over time.

Developing predictive governing laws using conventional approaches presents an extraordinary challenge. The number of interacting variables and possible loading histories is so vast that exploring the full range of material responses experimentally would require an impractically large number of tests. At the same time, experimental observations are inevitably limited, and the underlying relationships between physical processes remain poorly understood.

This PhD project will develop a physics-based and data-driven framework to discover the constitutive laws of energy-storing geomaterials. The research will combine numerical modelling and machine learning to investigate how these coupled processes govern material behaviour across different environmental conditions and over time. By integrating fundamental principles of continuum mechanics and thermodynamics with data-driven approaches, the project aims to

uncover previously unknown constitutive relationships and develop predictive models that remain physically consistent despite limited experimental data.

The student will engage in the associated PhD training and activities of the Grantham Institute – Climate Change and Environment and the Department of Civil and Environmental Engineering.

How to apply:

Please email Dr. Angela Casarella (a.casarella@imperial.ac.uk) and include in your application:

- Statement of Purpose
- Your CV
- Transcript of record
- At least two references to be sent directly to a.casarella@imperial.ac.uk from the referees.

Informal enquiries are welcomed.

Funding and eligibility:

Studentships are for **3.5 years** and include:

- London weighted UKRI stipend (£23,805 per annum for 26/27)
- Home fees at UKRI indicative fee level (£5,238 per annum for 26/27)
- £5,000 research expenses associated with the project (for consumables, conference attendance and travel associated with the research)

The studentships are eligible for Home and Overseas students. For overseas students, the difference between home and overseas fees would need to be organised and sourced separately.

Funding will be available for a studentship to start in October 2027 (or earlier depending on candidate availability).