UNIVERSITÉ D'ARTOIS

UNIVERSITE LIBANAISE
Ecole Doctorale
Sciences et Technologie

Development of a Sustainable Construction Material for 3D Printing: Rheology, Printability, Mechanical Properties, and Durability

1. Context and state of the art

3D printing, also referred to as additive manufacturing, is an automated process that produces objects from digital models by successively depositing layers of material. In Civil Engineering, this technology offers great potential, particularly regarding architectural freedom, reduced construction time, and optimized prefabrication processes. It allows complex shapes to be created and is particularly useful for producing repetitive or custom-made elements that are integrated into structures.

However, the materials used in 3D printing, particularly concretes and mortars, must meet strict requirements regarding workability, dimensional stability, mechanical performance, and durability. Current formulations largely rely on high Portland cement content and natural resources such as sand, resulting in a significant environmental impact.

In a context where reducing the carbon footprint is a key challenge for the construction sector, this thesis aims to develop a new 3D-printable concrete formulation that meets technical requirements and environmental performance standards. The objective is to design a sustainable material that is suitable for 3D printing. The study will also examine how the material's properties evolve over time in relation to its microstructure to ensure durability and long-term performance.

2. Methodologies and techniques used:

- Begin with an extensive literature review covering various aspects of 3D printing, including materials, components, properties of constituents, mechanical performance, durability, and more.
- Define the key parameters and properties of a 3D-printed cement-based material, with appropriate justification and qualification.
- Study the influence of formulation parameters on the material's properties in both fresh and hardened states (e.g., durability, fire resistance). An optimization process will be conducted.
- Reduce the carbon footprint by replacing conventional constituents (cement, sand, etc.) with alternative materials. This part will also include an optimization study.
- Investigate the durability of the printed material, including its fire resistance and long-term performance.

3. Thesis Supervisors:

Pr. Emmanuel ANTCZAK, Professeur des Universités à l'Université d'Artois, France (emmanuel.antczak@univ-artois.fr)

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Dr. Nicolas YOUSSEF, Associate Professor at Junia-HEI, France (nicolas.youssef@junia.com)

4. Study duration and locations :

This Ph.D. thesis is for a period of 3 years starting in October 2025. The selected student will be integrated within the LGCgE of the University of Artois, the Centre de Modélisation of the Lebanese University, and ACTS laboratory. The Ph.D. student will have access to numerical and experimental resources to carry out his/her PhD.

5. Funding:

This Ph.D. thesis will be funded by Advanced Construction Technology Services ACTS.

6. Candidate profile :

We are looking for motivated candidates to carry out their PhD thesis at the University of Artois and the Lebanese University. The candidate must hold a master's degree in research in civil engineering, materials engineering, or any related discipline.

The candidate must demonstrate communication skills and an interest in conducting research in a collaborative and multidisciplinary environment.

7. Scientific valorization and perspectives :

The results of this work will be the subject of participation in national/international conferences and/or scientific publications in international journals.