

3D PRINTED MORTAR: INVESTIGATING RHEOLOGY AND SUSTAINABLE MATERIAL INTEGRATION

Bao Minh Phuong TA, Luc COURARD

University of Liège, Urban and Environmental Engineering - GeMMe Building Materials

1. INTRODUCTION

- 3D printed mortar is a type of printable mixture that can be extruded through a 3D printer. This technology divides component into layers and prints them one by one.
- To design a 3D printable concrete mix, it is essential to understand the rheological properties of the material: **pumpability, extrudability, and buildability**. These characteristics are controlled by two key rheological parameters: **yield stress and viscosity**.

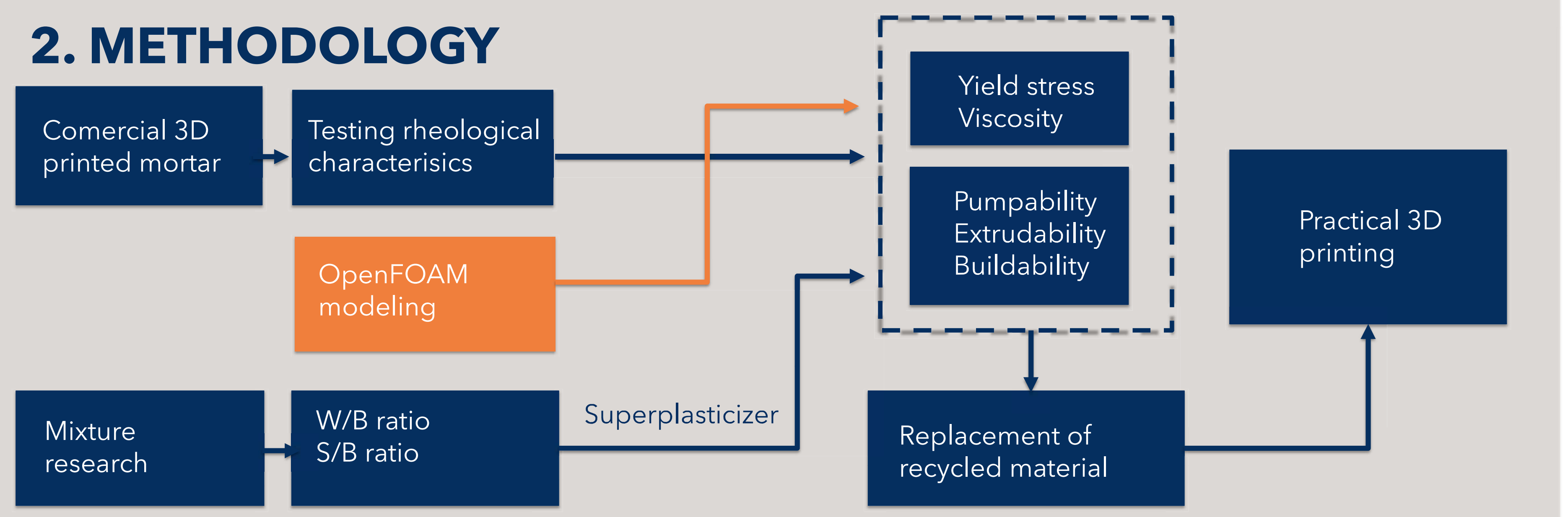
OBJECTIVES :

- Develop a 3D printable mortar mix incorporating recycled sand, using a commercial product as the baseline.
- Create a rheological modeling to predict the mortar's behavior without operating the printer, aiming to save time and resources.

PROBLEM STATEMENT

- The global population is continuously growing, leading to an increasing demand for housing. Traditional construction methods take a long time to build a house (an average of 9 months), which can result in housing shortages.
- The application of 3D printing technology in construction can help address this issue, offering several benefits such as cost savings, faster construction, reduced waste, and improved safety during execution.
- However, to ensure sustainable development and an environmentally friendly approach, construction waste materials (such as recycled sand) need to be incorporated into this promising technology.

2. METHODOLOGY



3. RESULTS

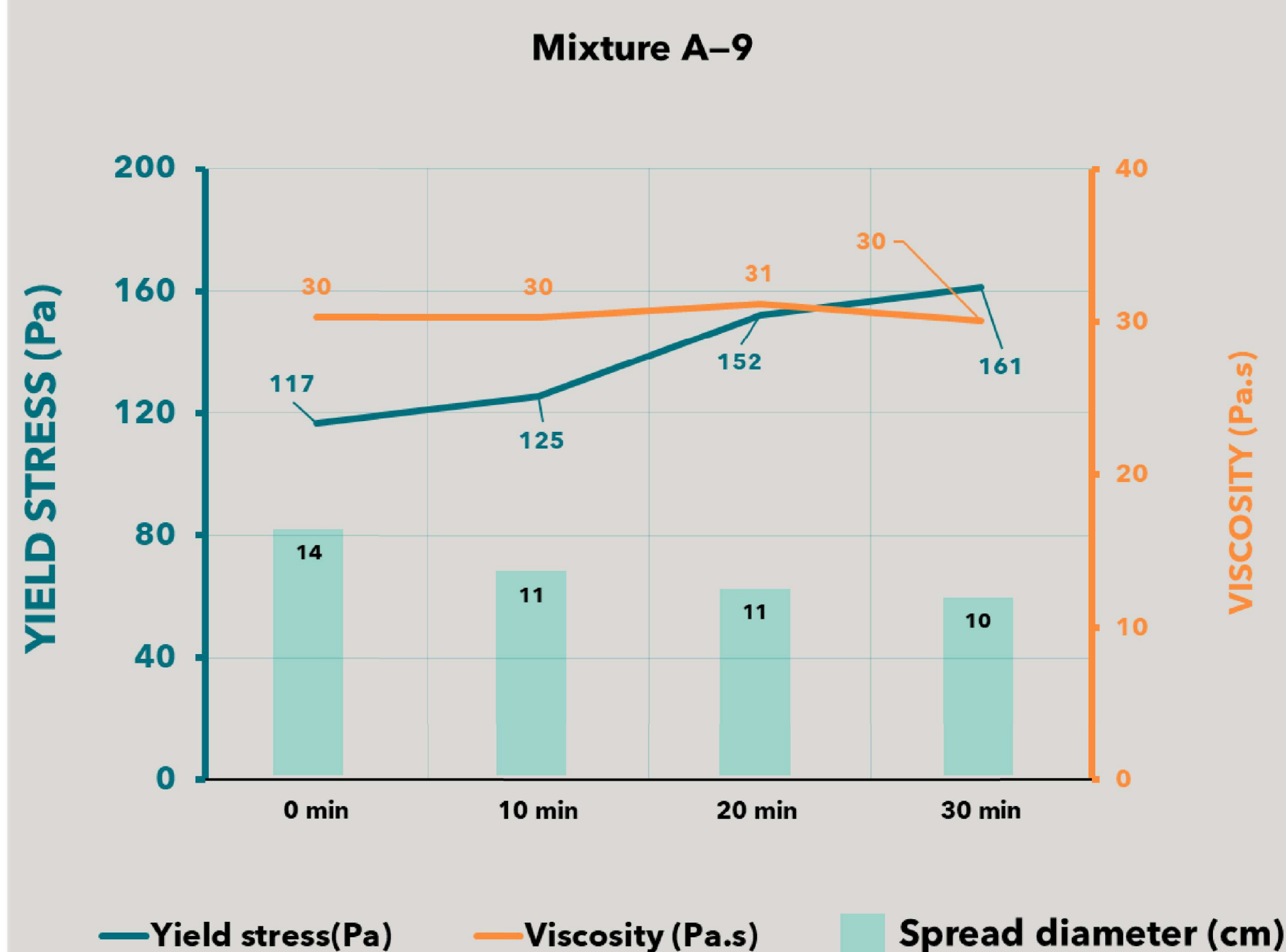


Fig. 1. Optimal rheological range of a commercial 3D printable mortar



Fig. 3. Openfoam simulation to predict mortar flow behavior based on yield stress and viscosity of a 3D printable mixture

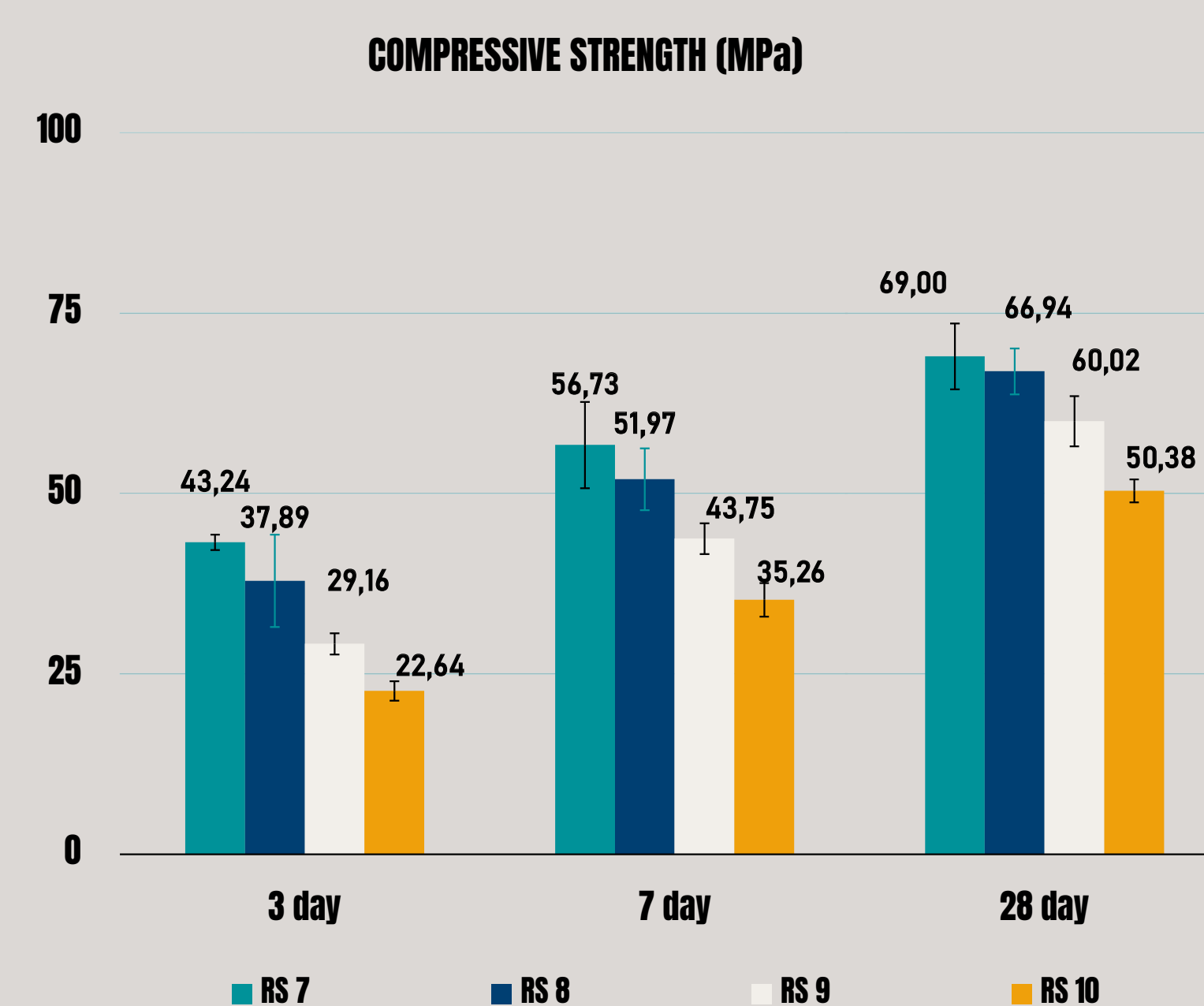


Fig. 2. Compressive strength of 3D-printed mortar mixtures containing 25%, 50%, 75%, and 100% recycled sand.

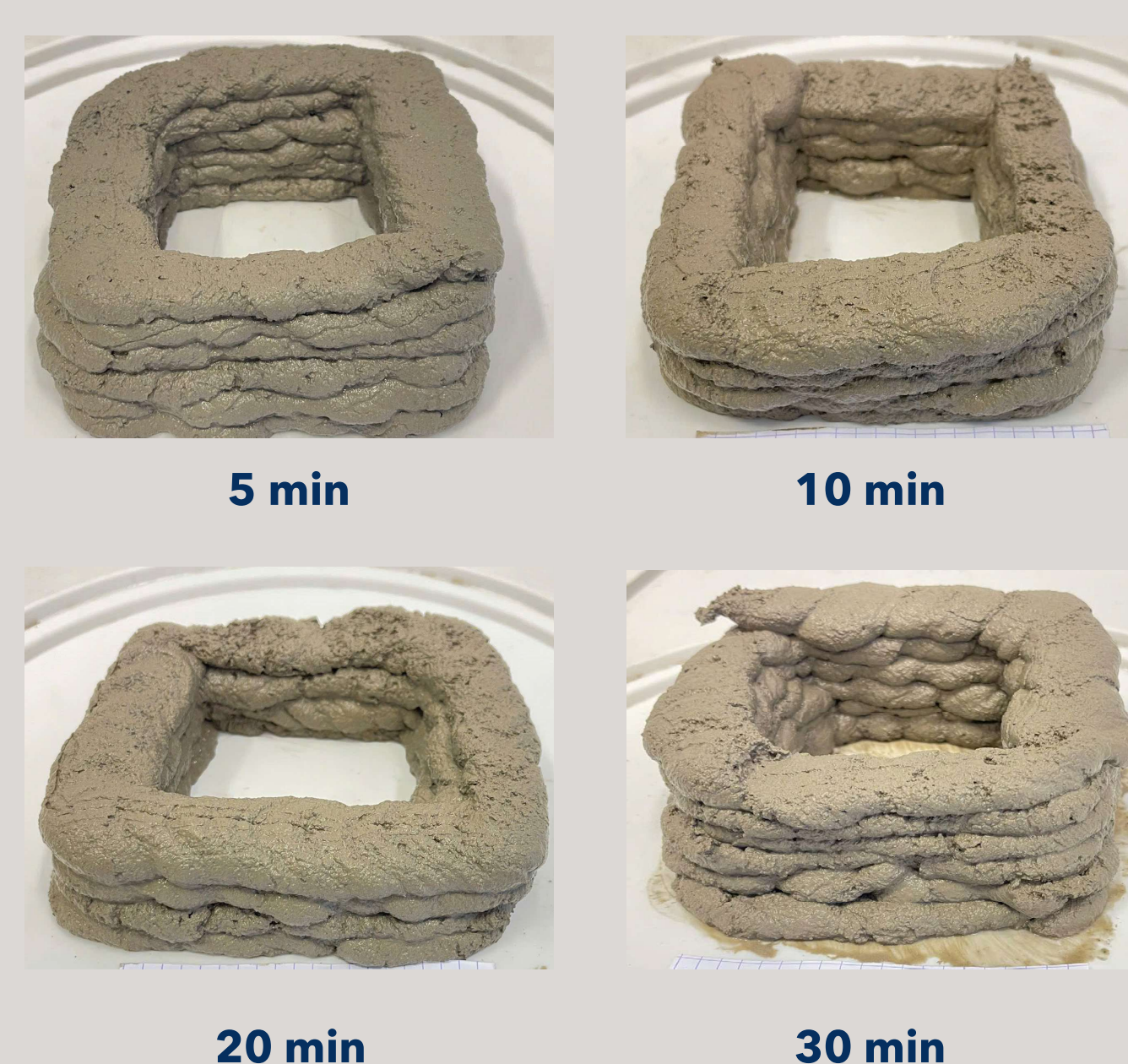


Fig. 4. Printability of a mortar mix containing 75% recycled sand, assessed 30 minutes after mixing.

DISCUSSION

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The **rheological properties** will first be determined using a **rheometer** and several tests such as the **flow table test** and **pistol test**, in order to evaluate the viscosity, yield stress, and printability of the mixtures.

According to global research on printable mortar mixtures:

- the **water-to-binder** ratio : **0.30 - 0.40**
- the **sand-to-binder** ratio : **1.0 - 1.5**

2

- The **potential** for using **recycled sand** in 3D printed mortar is **highly promising**, as it can achieve a high 28-day compressive strength of up to 50 MPa when using a mix with 100% recycled sand.
- Furthermore, **mixtures incorporating recycled sand** can still meet the **required viscosity and yield stress** values necessary for successful extrusion through the printer nozzle.
- In addition to recycled sand, future research could explore the use of **crushed concrete fines** as a **partial replacement for cement**. If these fines no longer contribute significantly to compressive strength, they could alternatively be used as a filler material—similar to the role of limestone powder.

3

- With the **OpenFOAM modeling**, we can clearly examine the **flow velocity** of the printed mortar within the nozzle.
- Additionally, the **buildability** of the printed mortar can be assessed by modeling the **shear stresses generated by the gravitational forces** acting on the layers immediately after they have been printed.