COMPUTING CRAFT

Manufacturing Cob Structures Using Robotically Controlled 3d Printing

Concluding remarks


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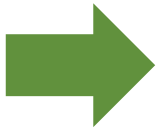
Introduction

Material exploration

3D printing equipment

Material extrusion system

Geometry and performance explorations



Future work

Cob

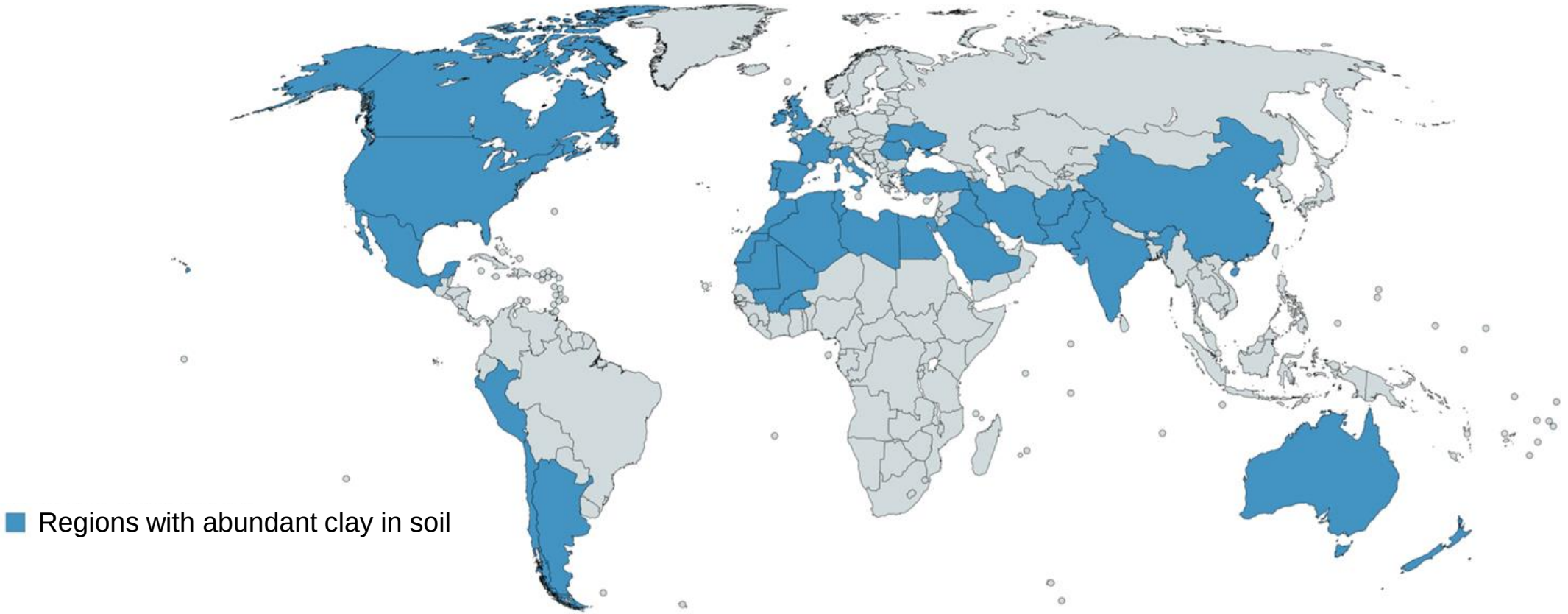
Subsoil

Straw

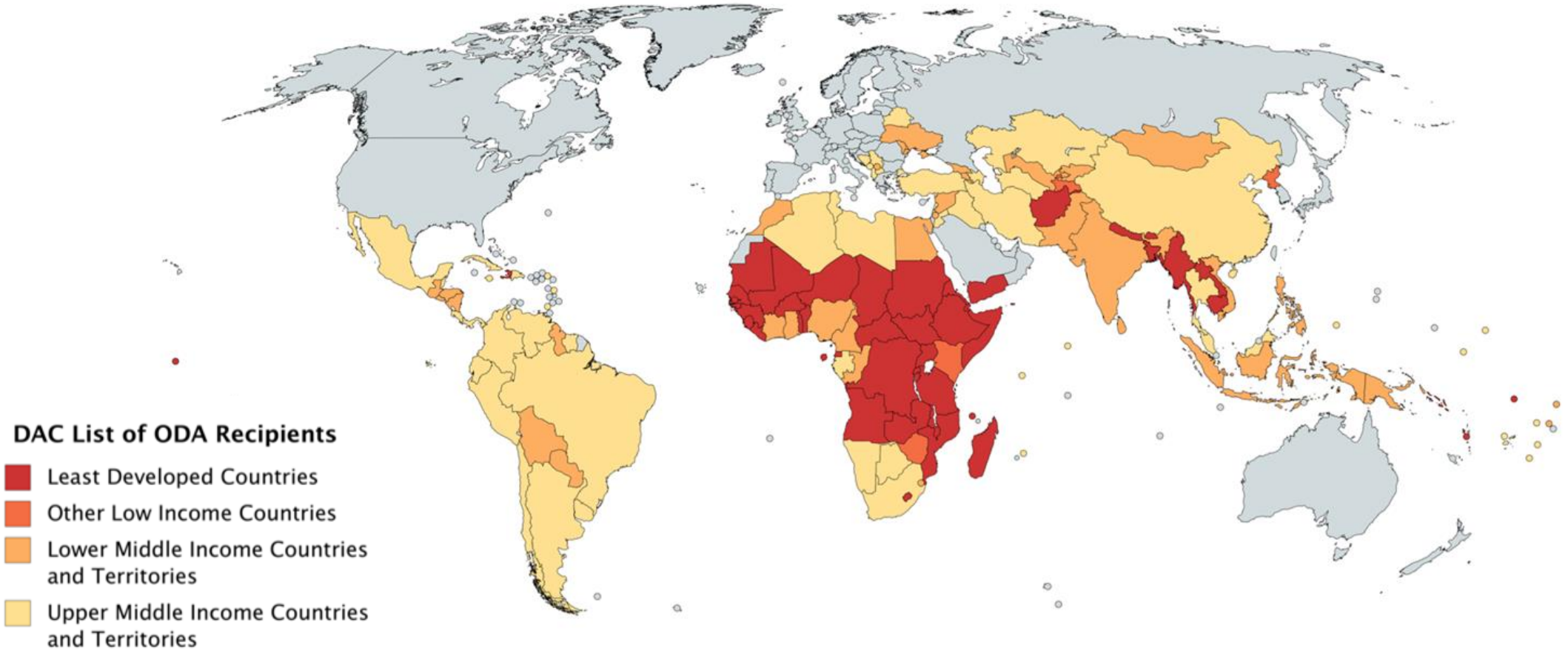
Water

Cob house in Dartington village in England. (CobBauge, 2018)

Where Can You Build with Cob?

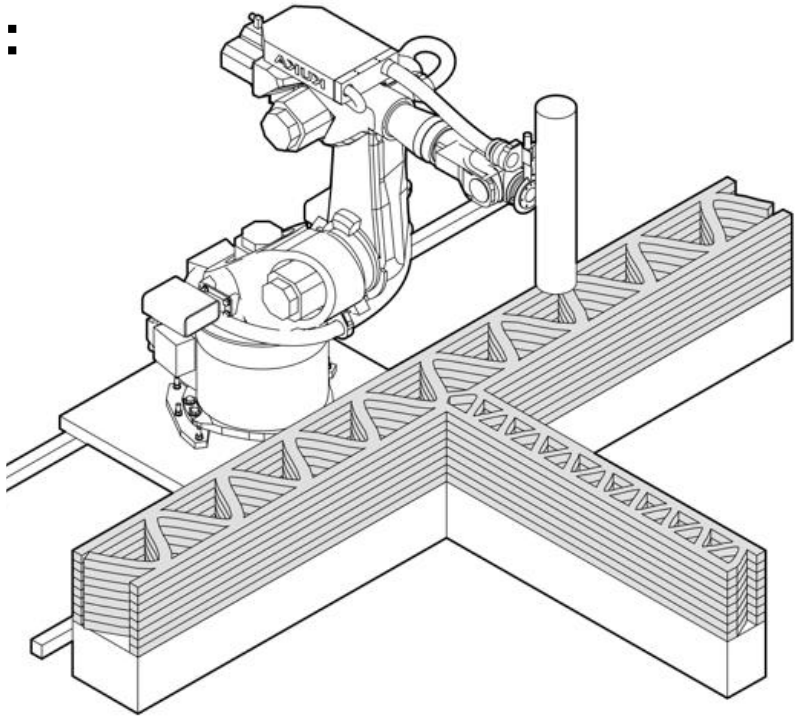


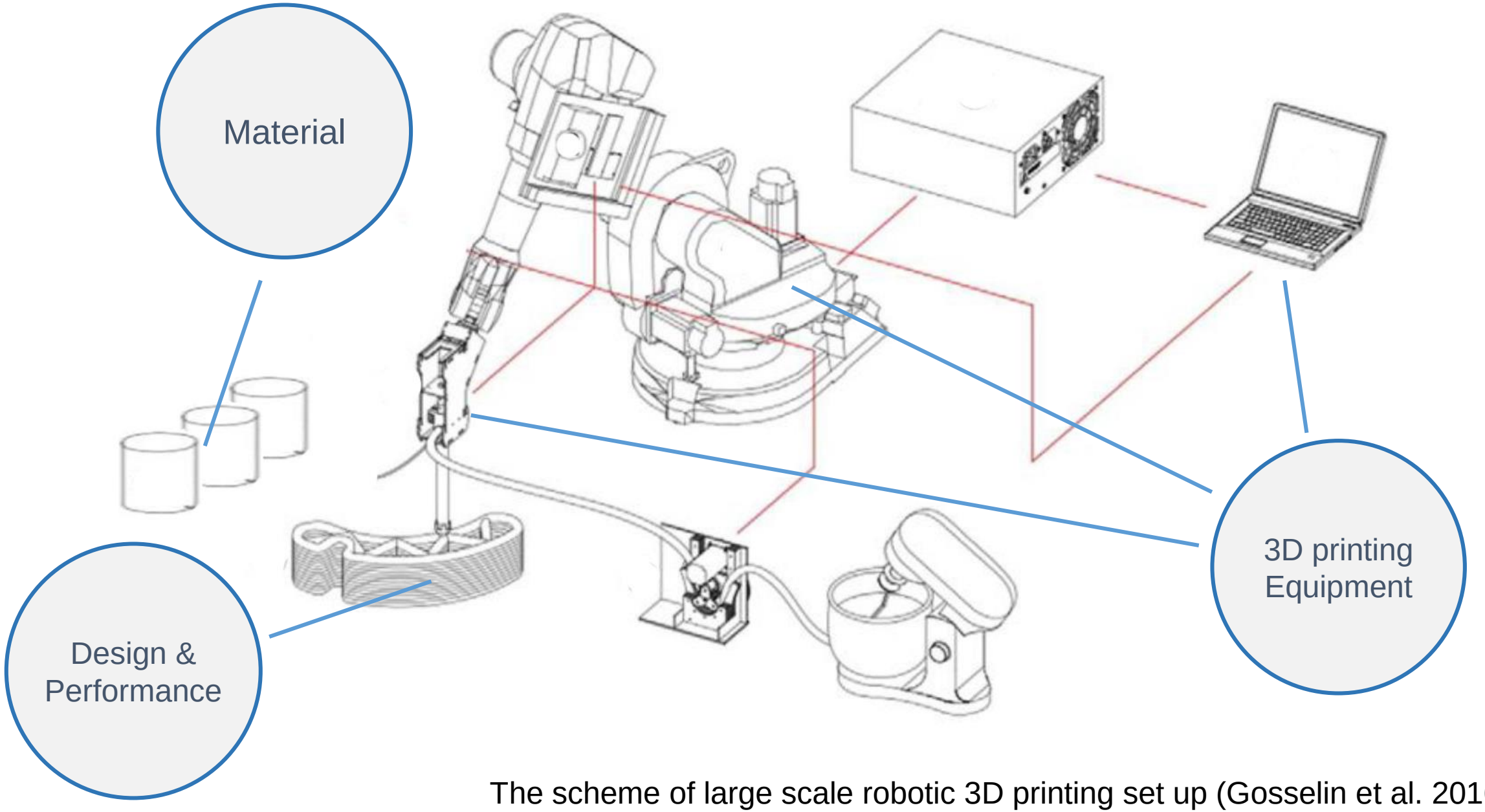
ODA Countries and Territories



The investigation was conducted in three stages:

- Investigate the current knowledge base of craft-based cob-construction.
- Conduct initial geometrical and performance exploration through small-scale modelling.
- Conduct a full-scale feasibility test for a cob building element (building a wall/module).





The scheme of large scale robotic 3D printing set up (Gosselin et al. 2016)

Material Exploration

Subsoil properties

Cob recipes are location-dependent.

On-site testing is always required.

80 % fine aggregate (sand, silt) + **20** % Clay

Cob recipe (by weight)

Subsoil **78**% + water content **20** % + Straw **2** %

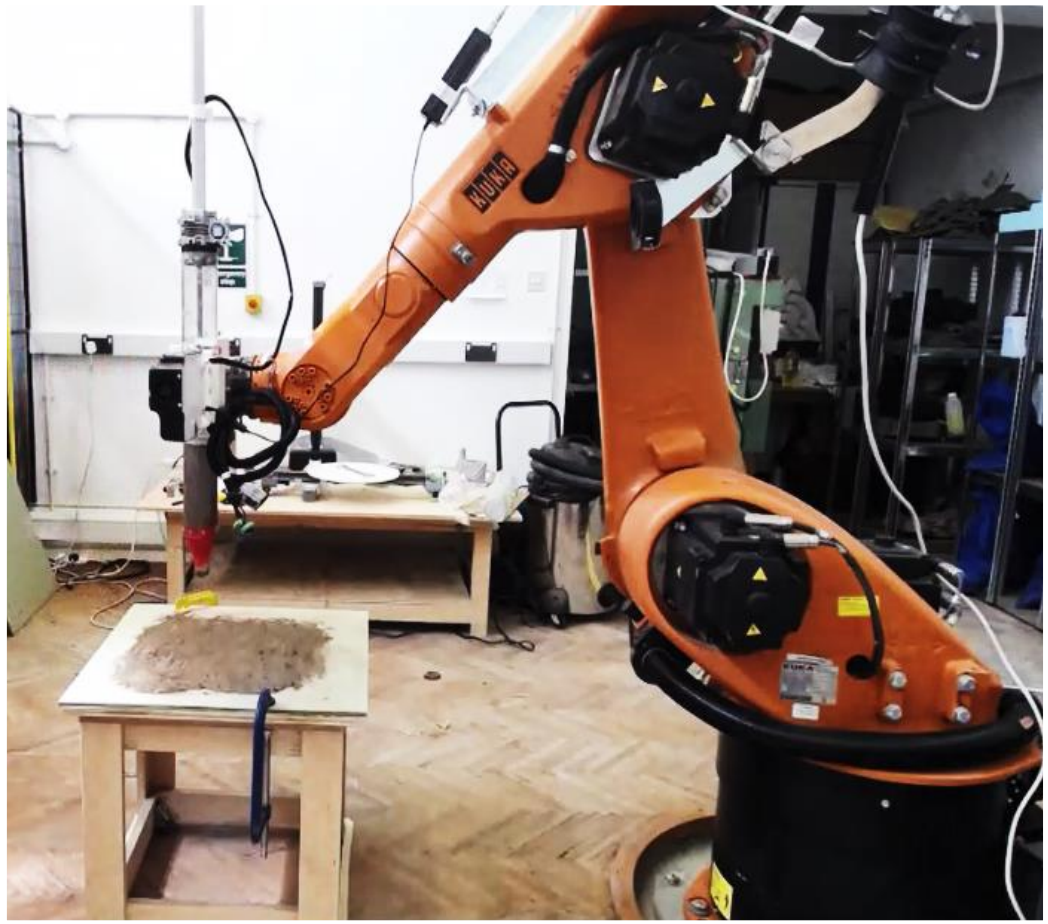
Weismann, Adam and Katy Bryce. *Building with Cob: A step-by-step guide*, 40 – 65. Devon: Green Books Ltd, 2006.

3D printing Equipment

Rhinoceros

grasshopper

KUKA|prc
parametric robot control for grasshopper

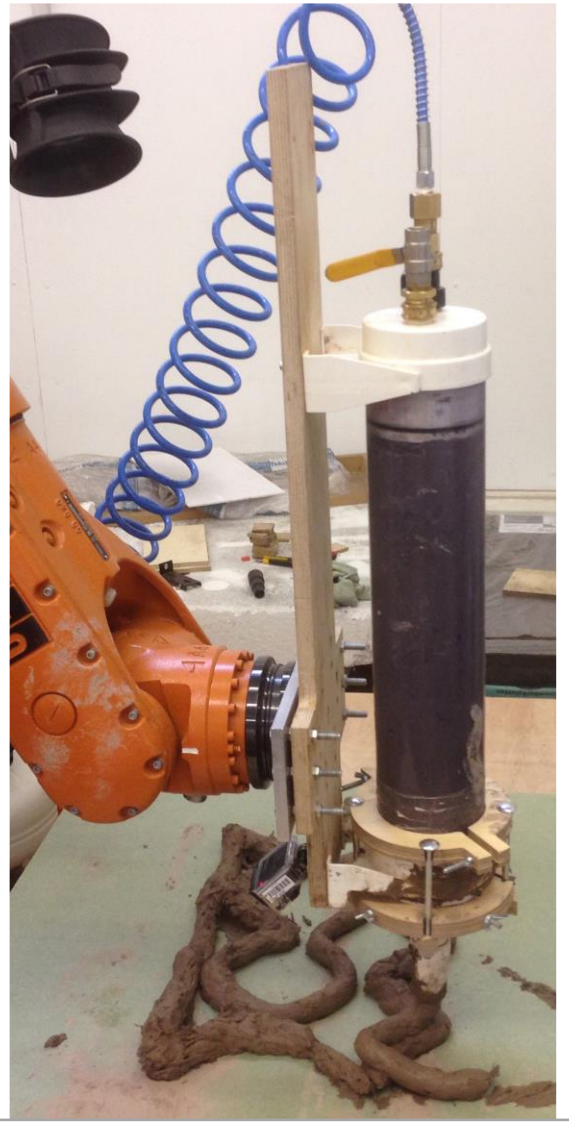


3D printing Equipment

Material extrusion system

A

Air-assisted Extrusion system



3D printing Equipment

Material extrusion system

B

Mechanical Extrusion system
(3D potter 7- Linear ram extruder)

3D printing Equipment

Challenges

Constant extrusion

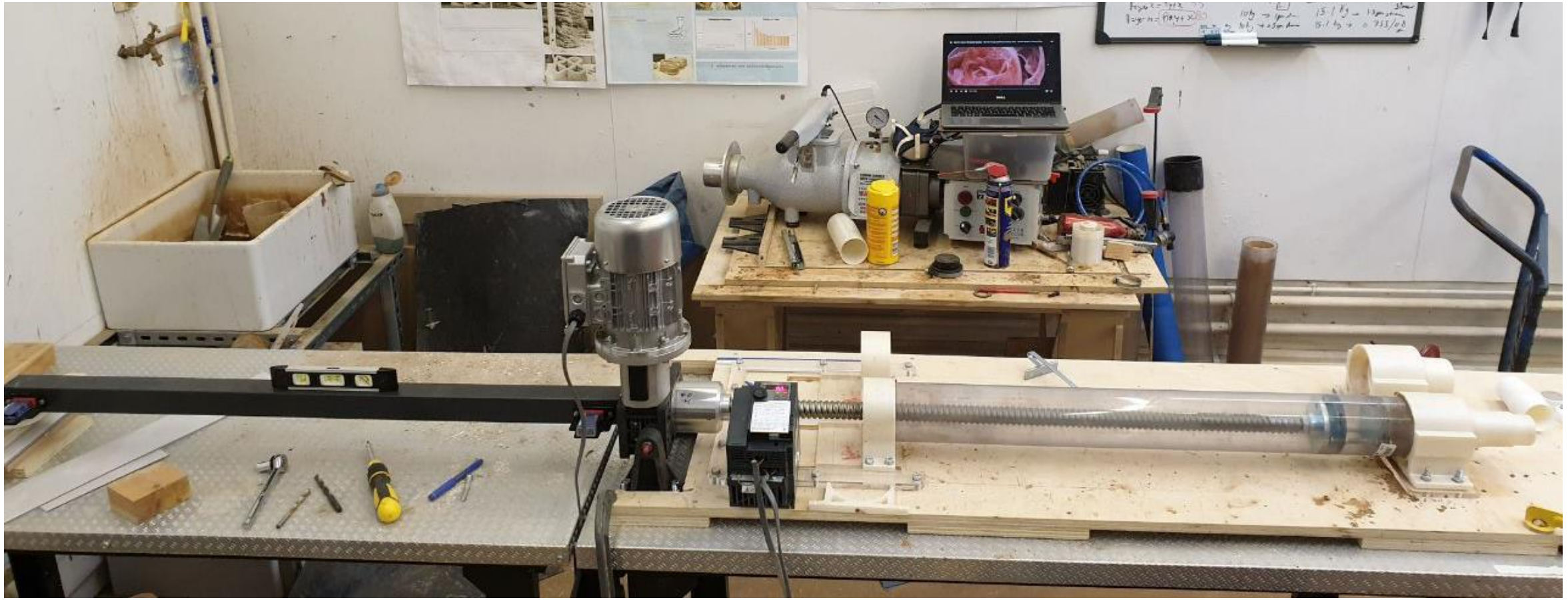
Continuous flow

Higher speeds

Larger scale

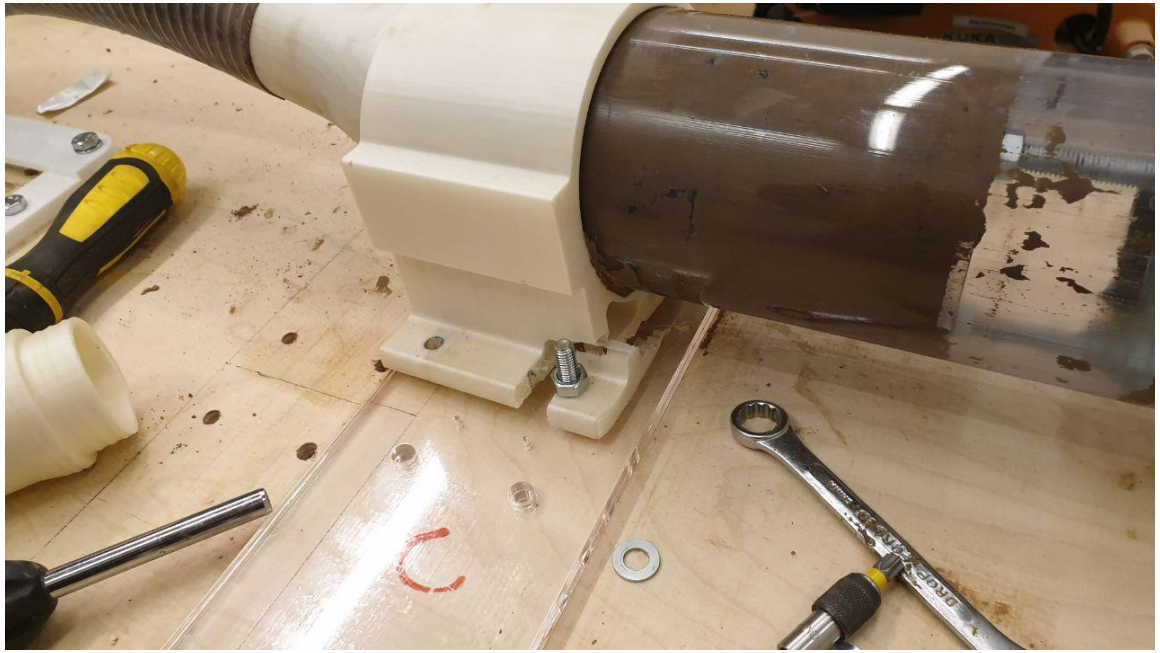
Freedom of movement

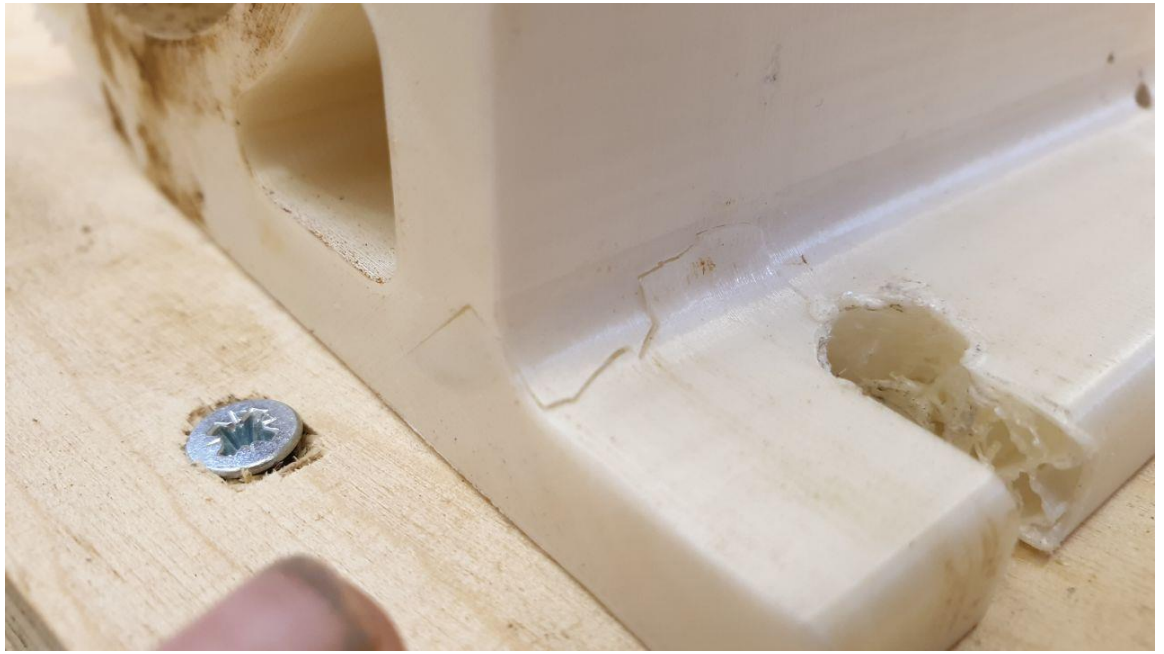
Material extrusion system



Material extrusion system

Material extrusion system





Geometry and performance explorations

Geometry exploration

Small scale (1:4)

Simple geometries

Geometry Exploration

Small scale (1:4)

Complex geometry A

Geometry Exploration

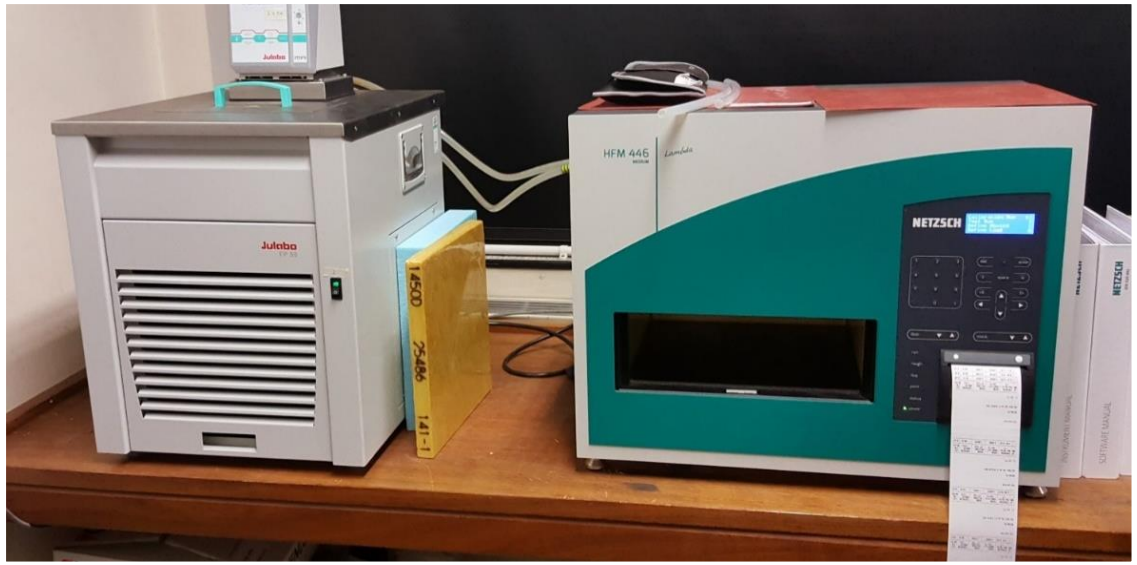
Small scale (1:4)

Complex geometry B

Performance Exploration

Thermal conductivity (W/mK)

- The heat flow rate through a material.
- Lower thermal conductivity is normally desired. Good practice: 0.6 W/mK.
- The heat flow meter used is a Netzsch HFM 446.

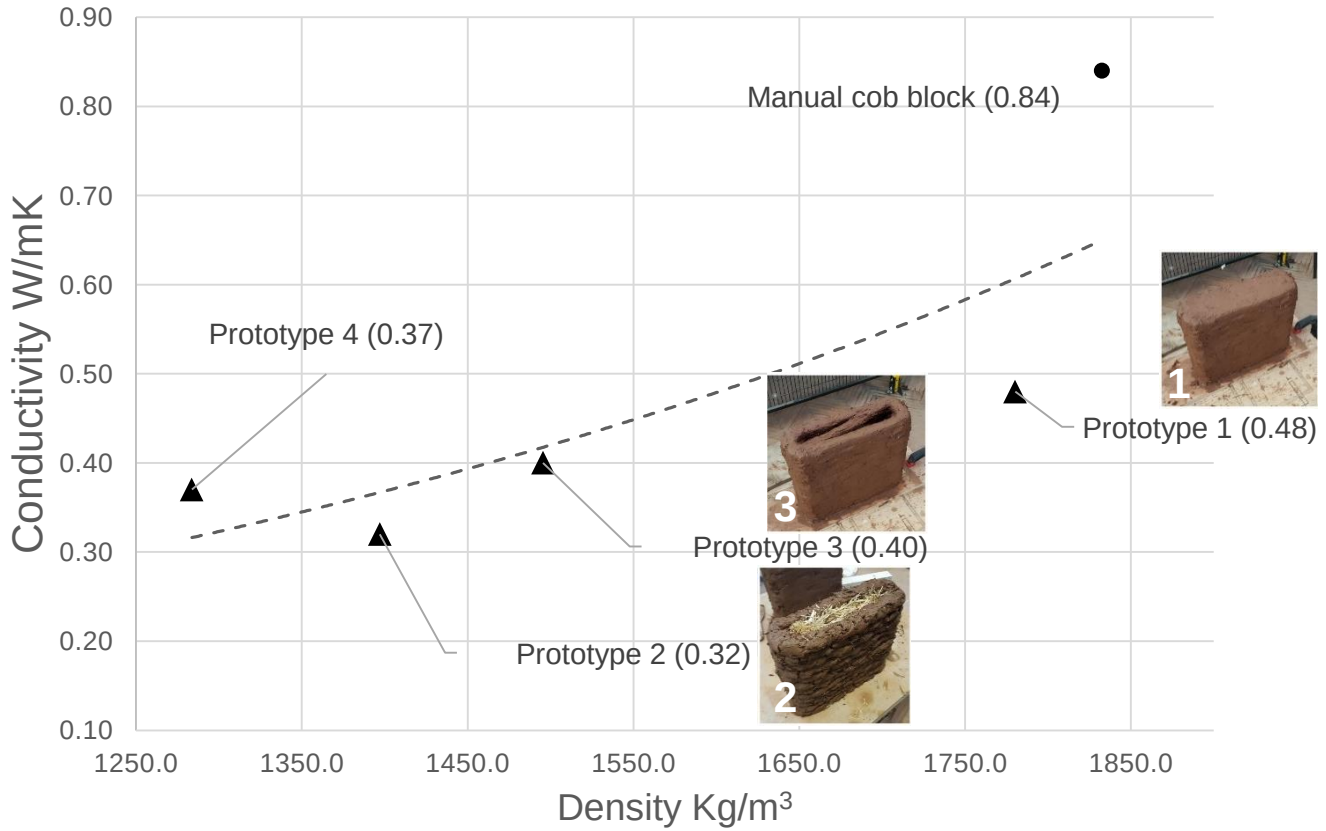


Performance Exploration

Thermal conductivity

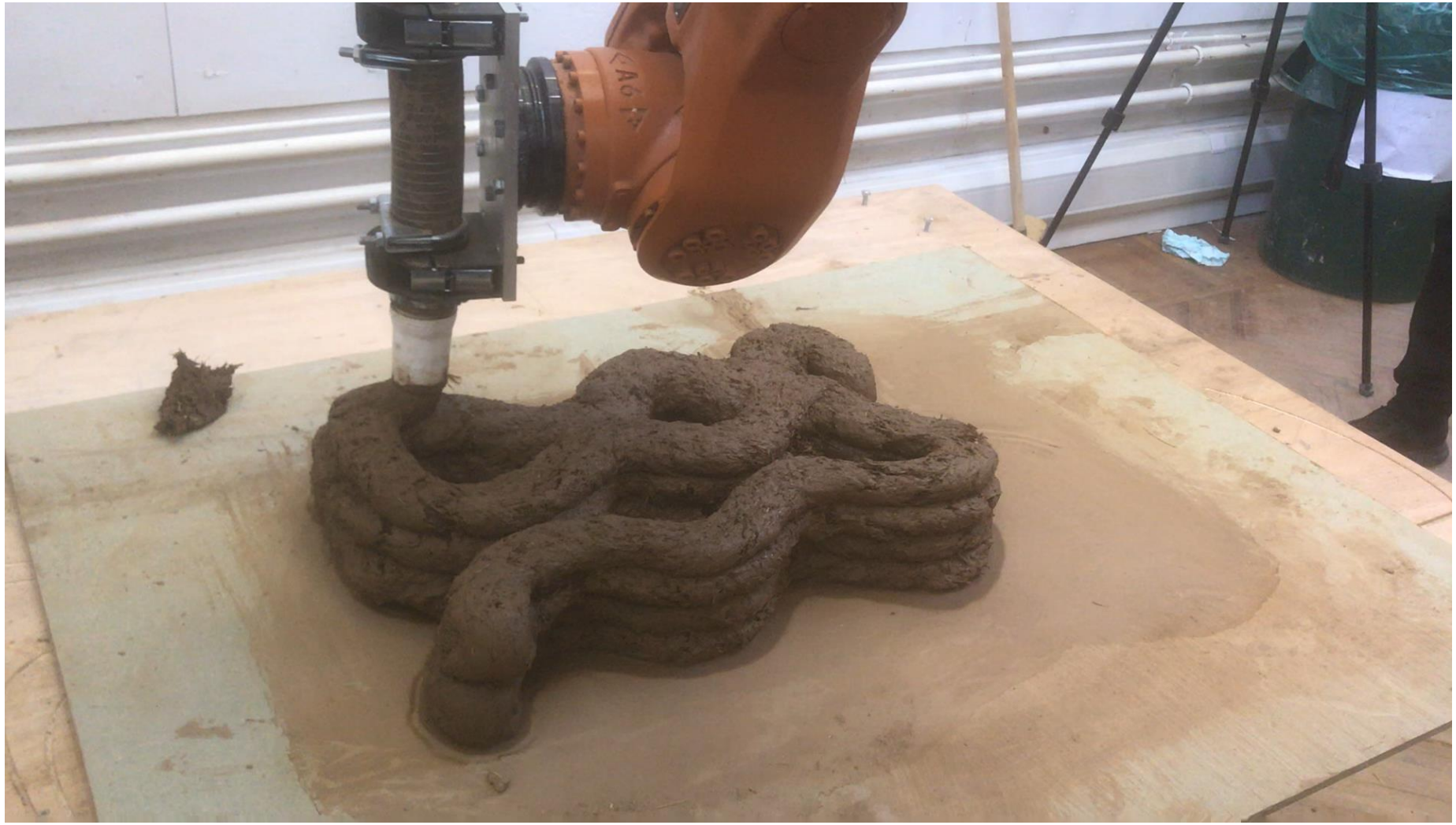
- Presence of air gap(s) lowered the conductivity of the solid 3D printed cob samples.

- Straw filling in the air gap(s) further lowered the thermal conductivity



Geometry Exploration

Bigger scale (1:1)



Geometry Exploration

Bigger scale (1:1)

Publications

- Veliz Reyes, A., Jabi, W., Gomaa, M., Chatzivasileiadi, A., Ahmad, L. and Wardhana, N.M. 2019. Negotiated matter: a robotic exploration of craft-driven innovation. In Press. *Architectural Science Review Journal.*

- Gomaa, M., Carfrae, J., Goodhew, S., Jabi, W. and Veliz Reyez, A. 2019. Thermal performance exploration of 3D printed cob. *Architectural Science Review* 62 (3).

- Veliz-Reyes, A., Gomaa, M., Chatzivasileiadi, A., Jabi, W. and Wardhana, N. 2018. Computing craft: development of a robotically-supported 3D printing system for cob structures. Presented at: *36th annual Education and research in Computer Aided Architectural Design in Europe (eCAADe) 2018*, Lodz, Poland, 17-21 September 2018.

Future work

- Apply the technology in developing countries.
- Explore new material configurations.
- Explore new design and geometric opportunities.
- Conduct further performance testing (e.g. structural etc. on 1:1 scale).

Thank you!

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