TERRA EX-MACHINA

Impact Printing with biopolymer improved soil mixes

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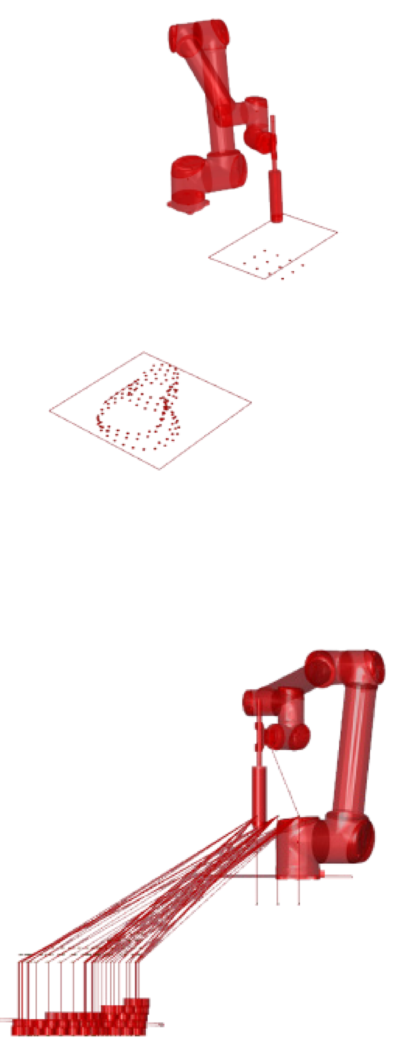
INTRODUCTION

The construction of soil buildings is still a prevalent practice around the world, with more than a third of the population still living in structures comprised mainly of soil, built in many cases according to long existing vernacular building practices. These practices, though effective to some extent, produce structures that are not resistant to earthquakes and/or flooding, which highlights their need for improvement, especially in the context of populations living in locations vulnerable to such events.

On the other hand, recent years have seen a lot of development in the digital fabrication and biological material exploration industry, with manufacturing methods being developed to build with diverse construction materials and techniques. Robotic fabrication methods using discrete unit assembly, like impact printing, have been developed and researched using earthen materials, but not enough research has gone into the possibilities that biologically based polymers could bring into the improvement of heterogenous soil mixes for the application of additive manufacturing methods, and the improvement of existing earthen construction technologies.

This work strives to explore how these bio polymers could be applied in the context of contemporary fabrication technologies, as well as how these new fabrication processes could point us in the way of new possibilities for earthen architecture and construction practices.



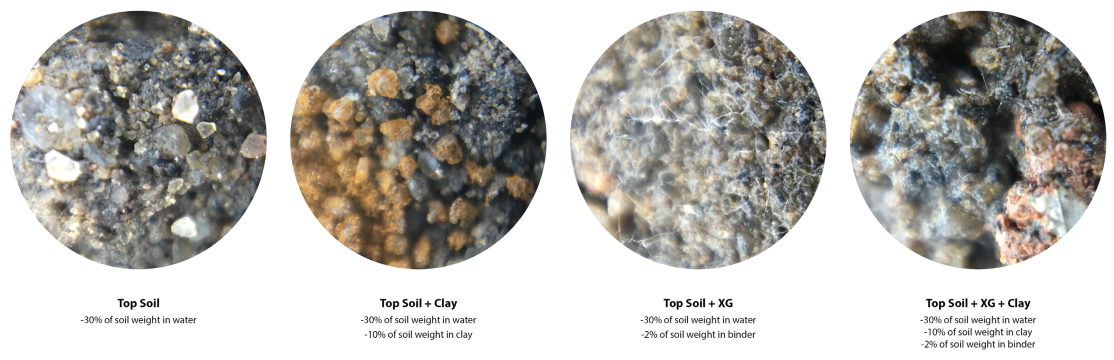
METHOD

Fabrication tests were conducted using a UR-10 robotic ar equipped witha pneumatic end effector, which would pick up the units one by one and impact them into position in the workspace.

Taking a different approach from the impact printing method used on recent research papers by Dörfer, Gramazio, Kohler, Ming, et al., where the units were thrown into place, and the impact would come from the throwing speed and/or gravity (Dörfler et al., 2014; Ming et al., 2022), this setup was designed to place the units in the target workspace and impact them into place by mechanical force. The end effector itself is comprised of an acrylic tube that picks up the prepared units by the pressure exerted by them on the walls of the tube, as well as a pneumatic plunger that performs the impact.

The toolpath of the robot was programmed to perform 3 basic actions:

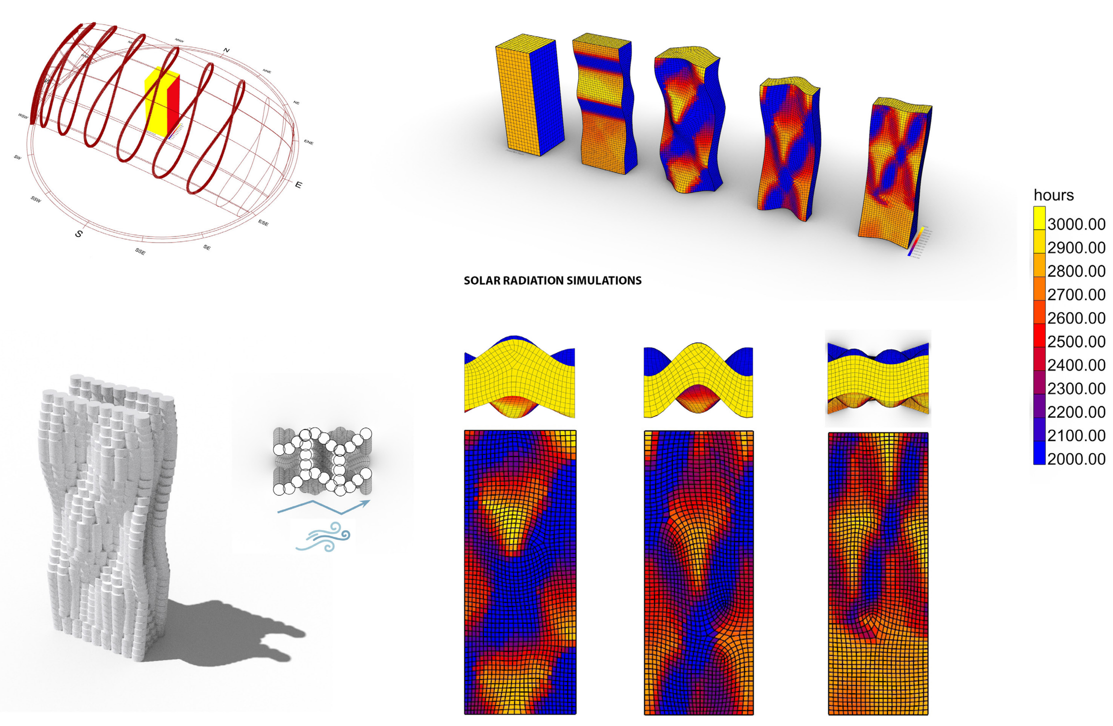
- Pick up units from a calibrated pick-up plane.
- Place said units on a calibrated workspace in a pre-determined manner.
- Impact said units into place with a specific amount of pressure.

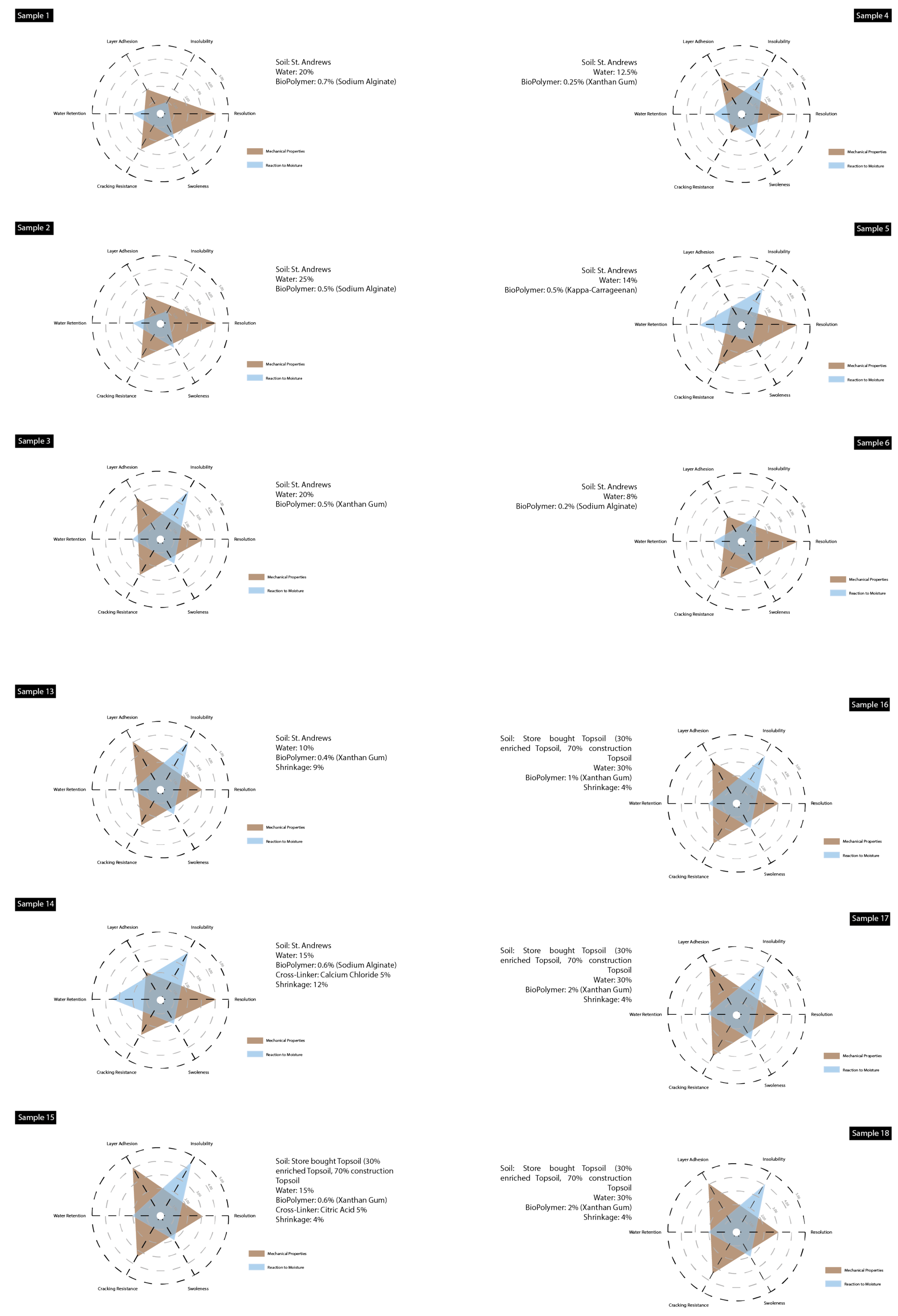


With the purpose of testing the geometrical possibilities of the material and the fabrication method, different wall iterations were produced to obtain a geometry that could project shadowns on itself, as well as increase the surface area to augment windflow interaction, with the purpose of managing the thermal performance of the structure.

To inform this design process, solar radiation and structural stress simulations were conducted on a double layered wall structure.

Different material mixes were tested, to find the optimal material composition to balance printability and structural integrity.





CONCLUSIONS

The use of biologically based binders could represent an alternative to other more pollutant methods of soil improvement in the context of large-scale construction, and it could also represent a contribution to existing earthen construction practices.

These biopolymers have the potential of improving the rheological properties of heterogenous soil mixes for their use with additive manufacturing methods, as well as improving on the mechanical properties of the resulting structures.

Impact printing is an interesting fabrication method that circumvents some of the complications related to 3D printing with soil based materials, usually related with the continuous extrusion of heterogeneous soil mixes.

The large-scale application of these biopolymer binders could broaden the scope of possibilities for earthen construction with contemporary fabrication techniques and improve on existing earthen construction methods.