Additive manufacture in the construction industry

Micheal Walsh

Aim of the Project

The Aim of the project is to find the advantages and disadvantages of using 3D printed concrete as opposed to traditional methods of construction. the process of 3D printing concrete was mimicked using FDM printing

Objectives

- Research papers about additive manufacture in the construction industry.
- To understand the design procedure involved to allow for 3D printed concrete.
- Create a model of a house, generate the Gcode and 3D print the house using an FDM printer.
- To research the future of this technology.
- Understand the advantages and disadvantages of 3D printed concrete.

Background

Additive manufacturing is a rapidly growing technology that can be used for the construction industry. 3D printed concrete works by pumping concrete through a nozzle into a predetermined path using Gcode. The nozzle will move upwards once a layer is complete 3D printed concrete needs to have reinforcements. These can be implemented manually, with a robotic arm or by adding fibers into the concrete mix. Standards and building regulations need to be worked on for the future of 3D printed concrete in construction.

Figure 1 concrete printing of a section of a pedestrian bridge

Modeling + Gcode

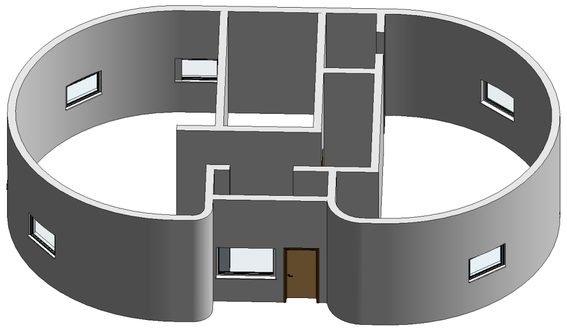

Figure 2 House modeled in Revit

The model that was used was based on an existing house that was made by the 3D printed concrete company ICON. This house was used to show the design capabilities of 3D printed concrete. The walls are rounded which would be difficult to make with traditional methods. The model was made using Autodesk Revit.

Below is a simulated Gcode path that was made using Rhico3D with the Grasshopper plugin. The Gcode was made by using parameter nodes. The nodes were able to change parameters such as the resolution, print speeds, layer height and so on. After the Gcode was generated, it needed to be pasted into a notepad file and from there it was saved as a .Gcode file.

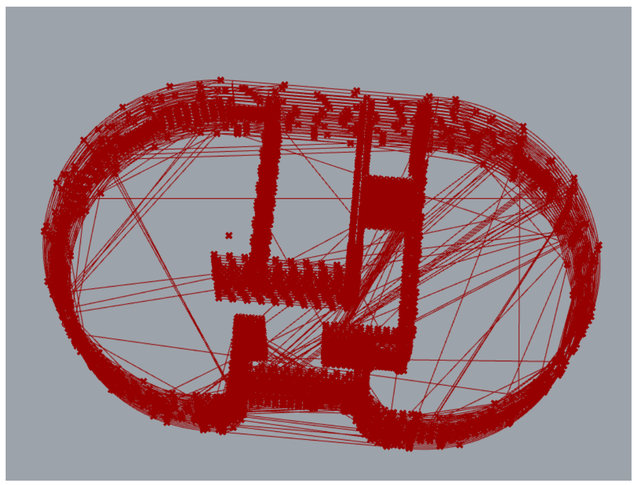

Figure 3 Gcode path for the house.

FDM printing

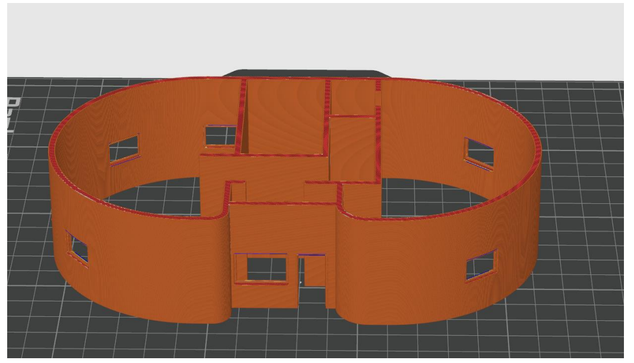

Figure 4 FDM slicer Bambu studio

A Bambu lab P1S was used to print the model. This printer was used because it was a core XY printer, this type of printer is like the gantry style printers which are commonly used to print concrete. A .Stl file from Revit was needed to start slicing the model in Bambu lab studio. The file was scaled down to 1% of its original size to fit on the build plate. Supports were not added to the model as the printer can bridge the gaps. This would be like concrete printing as supports are not made during concrete printing. The materials used for this print is Sunlu grey PLA. The print took 1 hour and 54 minutes to print and used 71.72g of filament to print.

Some of the print settings were as follows:

Table 1 print settings

Printer settings	
Nozzle diameter	0.4mm
Layer height	0.2mm
Wall loops	2
Infill type	grid infill
Infill density	15%
First layer speed	50mm/s
Outer wall speed	200mm/s
Infill speed	270mm/s
Supports	N/A

Advantages + Disadvantages

Some advantages of 3D printed concrete are:

- Lower costs.
- Lesser environmental impact.
- Less labor needed.
- Lower chance of injuries.
- Less wastage of materials.
- More design freedom.

Some disadvantages of 3D printed concrete are:

- High initial cost.
- Limited material selection.
- A deep understanding of materials is needed.
- Public perception, increased job automation can be seen as a threat to job security.
- Limited print speed .

Conclusion

In conclusion additive manufacturing has a bright future and will only continue to improve as more research is done. From a survey of 7 respondents all of them believe that 3D printed concrete will revolutionize the constructing industry. More work needs to be done with building regulations and standards. by creating the Gcode for a printed house it gave a better understanding of the process involved with 3D printed concrete. 3D printed concrete can reduce the cost and environmental impact associated with the construction of a house compared to traditional methods.

References

Xu, W., Gao, Y., Sun, C., Wang, Z., Burry, J., Sabin, J., Sheil, B., & Skavara, M. (2024.). *Chapter Title: FABRICATION AND APPLICATION OF 3D-PRINTED CONCRETE STRUCTURAL COMPONENTS IN THE BAOSHAN PEDESTRIAN BRIDGE PROJECT Book Title: Fabricate 2020 Book Subtitle: Making Resilient Architecture*.