

+PROJECT REPORT



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1. Overview

+Project is a collaborative project between different institutions and companies, both industrial and academic, aimed at advancing sustainability strategies in future residential buildings.

It is organized in three parts: +U, +House and +Labrarry. +U is concerned with creating a network of collaborators and experts, bringing collaboration and inovation around sustainability, design and production in architecture, circular business models, etc. +Labrarry aims at creating a library of 3d printing bio-based materials, both in the digital as well as physical space. SP Processum, a research institute and biorefinery is supporting this branch of the project. +House focuses on a discussion on the future of residential. Questions such as maker communities, additive manufacturing technologies, digital interiors and control of energy flows are addressed within the group.

Although +Project consists of a number of different subprojects, for the purpose of this report more detailed information will focus on the Hangprinter technology created by Torbjörn Ludvigsen at the Sliperiet and the structure that was built with it.

2. Institution and development

2.1. Institution overview

+Project headquarters are at Sliperiet workshop and fablab. This is on the grounds of Umeå University, strategically placed in proximity to the Architecture and Design campus.

2.2. Project overview, size and development

The focus of the project is developing sustainable and innovative construction in the Norrland region of Sweden. Specifically investigating large scale 3d printing possibilities with cellulose based materials.

2.3. Target market

Since it is an academic project, the +Project target is research and development rather than commercially targeted. Regarding the Hangprinter, it is an open source design, wich can be realised with around 260 USD.

2.4. Past, current and future projects

The largest structure realized with the Hangprinter is *The Tower of Babel* which measures 4.5 meters in height, with a tapered horizontal section varying in diameter from around 500mm to 200mm. There are plans to unveil a 3d printed house in 2018; however besides the tower there was no large scale structure visible at the time of the visit.

3. Technology



3.1. Additive manufacturing technology and printing procedure

The type of technology is FDM, which stands for fused deposition modelling. The printhead deposits thin layers of heated thermoplastic which bind as they cool down. Then the printer moves up one layer in height and then deposits the material according to the next horizontal section of the geometry.

3.2. Form freedom

The printer has full three dimensional form freedom, with the limitation of the material with regards to overhangs. Since the speed of the material being deposited hardens as it cools down, it is more difficult to print where there is no material underneath. The limitations are similar with other FDM plastic desktop 3d printers.

3.3. Fabrication location and approach

The fabrication of the *Tower of Babel* took place on the grounds of Sliperiet, in the void of the

spiral stairwell. This was a good choice as it is a difficult space for any other type of printer to work. The Hangprinter could easily fit and reach the desired build volume. The fixing points were placed on the ceiling above, one on a nearby steel column and the other two on the concrete staircase (see image below).



Source: <http://www.fabbaloo.com/blog/2017/3/7/the-hangprinter-a-frameless-3d-printer>

4. Printer

4.1. Overview

Hangprinter is of the delta type. However, instead of the rods that connect to three evenly spaced columns in a typical delta 3d printer, this printer literally hangs from wires connected to adjacent supports, whose position can be customized entirely. There are three sets of wires which secure the position of the central moving unit, according to the motors placed on it.

One of the strongest points of this type of 3d printer, besides its adaptability to basically any print site is the scalability. The fact that it's not built with fixed restpoints means that these can be placed anywhere, and the printer will be able to build within the volume defined by these, after being calibrated.

4.2. Movement

The movement is done in a similar manner with a 3d printer of the delta type. There are three motors that define the xyz position. Due to the varying length of each of the cables that is pulled by the corresponding motor, calibration needs to be done after installation on site, so that it proportionally corresponds to the absolute xyz positioning.

4.3. Material feeding

The feeding is identical to any standard FDM desktop printer.

4.4. Printer accuracy

The printer has a resolution of less than a millimetre.



Resolution detail

5. Material

There have been various material tests done at Spliperiet. These are concerning different ratios of cellulose and lignin from different sources. Different types of binders have also been explored, such as PVA, which stands for Polyvinyl alcohol – it is a water soluble synthetic polymer, used among many things as wood glue, which makes it a possible solution for wood based elements.



Material tests.

5.1. Material properties

There have been some problems in managing the extrusion with wood pulp. When the mix is directed through the printhead, it tends to compress and block the nozzle. A number of extruders have been broken this way, even when handled manually.



Extrusion tests with different material mixes.

5.2. Material possibilities

Because of this, a prefabricated solution has been chosen for building the large scale structure. This is a PLA based wood composite filament. These are commercially available, consisting in a mixture of 30-40% wood fibres and the rest is PLA which binds them together and makes the material printable.

5.3. Useful links and sources

<http://sliperiet.umu.se/en/making-and-thinking-start/plusproject/>

<http://www.3ders.org/articles/20170308-frameless-hangprinter-reprap-turns-an-entire-room-into-a-3d-printer.html>

<http://reprap.org/wiki/Hangprinter>