TU Delft
MSc Architecture, Urbanism & Building Sciences
Building Technology Track

3D PRINTING CLAY FACADE WALLS

Integrating Ventilation Systems Into Printing Process

Reflection

Student | AmmarTaher Ibrahim
Tutors | Dr. S. Asut
| Dr.ir. WH van der Spoel

Delegate examiner | Dr.ir. G. Bracken MPhil

Reflection

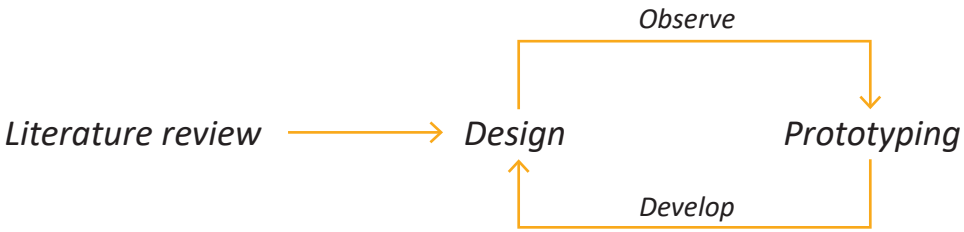
1. Relationship between Research & design

The main objective of this research was to answer the question of:
“What are the printing techniques and tools that can help integrate the clay as an environmentally friendly material, into the 3d printing of building components,while maintaining the required indoor and outdoor performance quality?”. This required dividing the research into four main aspects, firstly the explored material, clay. Secondly, ventilation systems and their effect on the indoor quality. Then, the design and generation of a facade wall that integrates the ventilation system. And lastly, the robotic printing where prototyping is exploring the effects of the process limitations on the design process.

Hence, the research had three major approaches where two of them were sequential in the first period of the project. Starting with literature review which was providing the base for each aspect of the previously mentioned research aspects. Then, the digital design where the literature concluded results were used to generate the design and verify it. Lastly, the prototyping and making iteratively informing and informed by the design requirements that are based on the literature review.

To be more specific, literature review informed the material choice of what type of clay suits the architecture applications and its properties. That choice affected the calculations for designing the ventilation system according to the thermal resistivity and conductivity of the material as the thermal performance in a facade. While, in the same time literature review was conducted for the ventilation system calculations and their verifications. This designed ventilations system generated the wall morphology which then was detailed in respect to the requirements of the prototyping and building process.

In brief, the research by design and design by research where both implemented in this project and differentiated from the first period of the project to the last ones. This showed how relevant each step of an architectural product is to the available production techniques.



2. Relationship between graduation topic & studio theme.

Named “Sustainable graduation studio” the main theme of the graduation studio in building technology program is the sustainability and its integration within the architecture applications. Sustainability was integrated and could be observed in this research in the three main points of the material, production technique and integrated ventilation system. Firstly, the base for the research is exploring a sustainable and environment friendly alternative material within the architectural new fabrication technologies. This material is bio-degradable and the resultant product can has an end of life back to the same place where it was extracted from as a primary material. In addition, additive manufacturing or 3d printing as an explored technology and fabrication technique, it was promoted in this research as a better sustainable solution for the complex geometries production. As 3d printing has less wasted material than in -for example- molding or CNC cutting techniques. Lastly, the chosen designed and integrated function within the printed product is the displacement ventilation system. This kind of ventilation consumes less energy than the conventional mixing ventilation while also insures better indoor air quality.

To summarize, the sustainability aspect was the main drive or the core of this research project and achieving it was the real challenge.

3. Relationship between graduation methodology & graduation studio method

According to the requirements of the graduation studio and the building technology track for a master thesis to be integrating two at least of the chairs of structure design , facade design, building physics or design informatics. The latest two chairs were integrated in this project in which design informatics is designing and verifying the building physics requirements. While prototyping it and exploring the effect of the production limitations on the design requirements.

However, this research goes also further to explore the sustainable material clay, which is less researched or explored in the architecture new fabrication context yet. The honors master program research was integrated to represent a main part of the thesis project where the material is being explored and material experiments were conducted to conclude a final recipe for clay to be used in the thesis research prototyping. Integrating material science, design informatics, and building physics enhances the interdisciplinary approach recommended by the graduation studio.

4. Relationship to the wider social framework

Societal Relevance

Being an affordable material and low cost, clay represents a promising building material that suits the current economical approaches where there is a need for more affordable housing for more people in need. Pushing the limits of this material by research and continuous innovation, introduces the community to a better sustainable affordable material. Moreover, the research emerges from the sense of the social responsibility for architects towards the sustainability of the built environment. As architect's decision on a certain material or system to be used in his design has an effect on the environment, not only as a building operation performance but even more on the embodied energy within these materials and systems. Consequently, by promoting the clay as an environmentally friendly and affordable material helps to reduce the footprint of the buildings. Not to mention also that pushing the boundaries of the large-scale 3d printing - especially with such a sustainable material- helps the continuous development of environment-oriented performative designs and more sustainable architecture.

On the other hand, designing a displacement ventilation system provides more exposure for that kind of ventilation which assures more indoor quality to the users of the buildings. In addition, it consumes less energy which reduces the operation costs, energy and footprint of the building over its lifetime.

This investigation of clay and displacement ventilation helps in changing the way we observe these less exposed and used materials or systems even though they have high potential for the community and the environment in parallel.

For that social responsibility for architects lies not only in building interaction with society, but rather more the integration with the whole environment.

Scientific Relevance

Further development in the growing field of digital fabrication in architecture is considered one of this research's objectives. Since the field of digital fabrication in architecture is still relatively new, introducing sustainable materials into it enhances the possibilities of future developments that are more sustainability oriented. The research might introduce a reference for those who are interested in the sustainable materials -clay specifically- in additive manufacturing. Unfortunately, resources about clay as a printing material or even as an architectural material and its thermal properties or performance, these resources were very few to be found. Therefore, this research might help in giving insights on its performance in terms of printability and properties while adding to its referenced knowledge and documented data.

TU Delft Relevance

Due to the growing interest in clay and earth materials in the design informatics chair, a new extruder for clay was provided recently. Previous research on earth extrusion was conducted by Tommaso Venturini, and a new masters course “Earthy” for digital optimization of the clay and earth related building designs is introduced. Thus, this research by using and operating the clay extruder for the first time will provide a good base reference and data for the possible future clay printing related research projects. This also assures that this will help to continue developing clay as an environment friendly material. Even further innovate more on the alternative materials to concrete to help shape a better sustainable built environment.

5. Ethical relationships to the graduation topic

The main ethical dilemma in every project that implements or using robots in architecture scale or production industry is always how is it expected to affect the human labor in the future? This integration of robots according to some opinions- on one hand- will create more un-employment not only in the building production industry but in general. On the other hand, different perspective argues that the development of technology always shifts the jobs into another level of instead of removing it in general too. This means that as for every machine that always had been made, workers had to move to a different level of jobs within the same field or even within a different related field. Also, by replacing humans tasks which requires repetition or hard labor work, replacing by robots or machines has always helped in the development of the civilization. This is by integrating more minds in the process of innovating and creating instead of hard laboring.

Lastly, the dilemma of whether we should replace concrete by clay or other materials or should we only reduce it? This argument is based on the fact that concrete has a very strong potential structurally, and so far there is no other material that can replace it, hence, ignoring clay or not would not make a difference. This can be argued against by clarifying that we didn’t find a sustainable alternative till now because there is less action or interest to actually find it. Moreover, if concrete is highly performative in structure, it would be wise to not use it in all architecture applications that might not require this high structural properties and rather explore the other sustainable materials as clay and how to implement them in these non structural products.