Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Doris van Uffelen
Student number	4587995

Studio		
Name / Theme	Additive Manufacturing (AM) for the Circular Built Environment (CBE)	
Main mentor	Paul de Ruiter	Design informatics
Second mentor	Olga Ioannou	Building Product Innovation
Argumentation of choice of the studio	The combination of AM and CBE is a new and interesting one. AM has the potential to contribute a lot to CBE, but how these two relate has not been extensively researched. Personally I am really interested in these topics and I think I can extend this field of research.	

Graduation project	
Title of the graduation project	Design for disassembly of façade element connections made from PET through Fused Deposition Modeling
Goal	
Location:	Europe
The posed problem,	The built environment needs to shift towards a circular economy in order to achieve sustainability goals. Building through FDM has the potential to help reach these goals, since it allows for building on location with waste materials, modular mono-material components with integrated functionalities and connections Designed for Disassembly (DfD). Although there are designs that proof the concept of mono-material façade elements, FDM PET connections are underexplored, and only few examples can be found, that still show limitations. In this thesis research is conducted into DfD connections through FDM with PET. Prototypes will be tested on their functionality for a circular design.
research questions and	RQ: How to design mono-material reversable connections for a circular façade system using PET through Fused Deposition Modeling?

	SQ1: What is the state of the art of Additive Manufacturing for the Circular Built Environment? SQ2: How can the connection design be optimized for building speed in relation to its accuracy? SQ3: How can the connection design be optimized for disassembly? SQ4: How can the connection design be optimized for strength? SQ5: How can the connections be designed to be watertight? (SQ6: What are the material properties of recycled, printed PET)
design assignment in which these result.	Design for disassembly of a modular panel-to-panel connection, based on the Spong3D façade element. The design should be rationalized for fabrication by optimizing printing speed vs accuracy. It should also be optimized for reversibility and strength and should also be watertight. A preferred design goal would be the option to take out individual panels for maintenance or replacing.

Process

Method description

Theoretical

- Analysis of case studies
    - 3D printed façade elements
    - Thermoplastic circular building products
    - Circular/reversible connections
- Literature review (sources filtered on relevance of keywords and abstract and on date)
    - Circular built environment
    - Additive manufacturing
    - AM for CBE
    - PET material properties
- Define design criteria based on the theoretical framework and the Dutch building regulations
- Setting design boundaries based on
    - The printer
    - The material
    - Circular design method

Practical

- (recycled material testing
    - Strength after recycling once, based on different printing directions
        - Simulate regression by uv radiation?)
- Concept design through sketching
- Variants testing on the 40x40x40 cm printer based on these variables:
    - Printing speed vs accuracy
    - Strength
    - Reversibility
    - Water/wind tightness

- Prototyping integrated design on the robot printer
- Testing prototype to design criteria
    - If not sufficient → iterations

Literature and general practical preference

- Case studies
    - 3D printed thermoplastic façade elements
    - Circular thermoplastic building products
- Literature on
    - Circular Built Environment
        - Circular design strategies
        - Connection design
    - Additive manufacturing for building elements
        - PET as printing material
        - Printing methods
        - State of Art
    - AM for CBE

Reflection

1. What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?

   The topic of this graduation focusses on façade product design, circular design of a façade system, building through additive manufacturing and with recycled materials, these are all topics specifically taught in the Building Technology track. This circular façade system will re-introduce a form of living that inspires for sustainability, which is greatly valued in the master programme.

2. What is the relevance of your graduation work in the larger social, professional and scientific framework.

   In a social framework this graduation is related to the need for more housing in the Netherlands, and a shift towards a circular economy. This graduation can provide a step in the right direction, by making a design for façade element connections that can easily be assembled and disassembled. If successful, 3D printed circular housing is one step closer to realization. This is also the relevance of the professional framework, it has the ability to bring knowledge of novel and circular building methods to the industry.

   The use of Additive Manufacturing for the Circular Built Environment is an underexplored topic within the scientific framework. Until now additive manufacturing of thermoplastics for the built environment mostly focused on multi-functional façade elements, which can be promising for circular design, but research does not yet extend into the connection of these elements. This graduation project will build on existing designs of additively manufactured façade elements and focus on designing circular connections.