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	Laura Romano
Student number	5623480

Studio		
Name / Theme	Building Technology Graduation Studio (AR3B025)	
Main mentor	Olga Ioannou	Building Product Innovation
Second mentor	Michela Turrin	Design Informatics
Argumentation of choice of the studio	-	

Graduation project	
Title of the graduation project	Three-Dimensional Cladding with Bio-based Materials: a parametric design following the *seamless tiling* [1] concept
Goal	
Location:	No location is needed
The posed problem,	Global greenhouse gas (GHG) emissions are mostly caused by the extraction and processing of raw materials typically used for three-dimensional cladding.
research questions and design questions	**Research Question:** *"How can external **three-dimensional** cladding be realized using **circular strategies**, **bio-based materials** and being manufactured with **moulding**?"* **Subresearch Questions:** *"What is the relevance of three-dimensionality in external claddings?*

	"How does circularity affects the final product realization? *"What are the available bio-based materials that can be used for external cladding?"* *"What are the relevant moulding processes for such bio-based materials?"* **Design Question:** *"How can the external three-dimensional cladding be **parametrically** designed to **minimize** the number of **modular** moulds while allowing **flexibility** in diverse façade configurations?"* **Subdesign Question:** *"Which will be the design variables that allow flexibility in different façade configurations?"* *"What are the limitations and opportunities of the final product?"*
design assignment in which these result.	This thesis aims to explore and provide a new design system that takes care of an innovative design while respecting and enhancing circular strategies. Having stated the impact that usual materials used for three-dimensional cladding are causing on the earth, the intent is to show how these geometries can eventually be realized, diminishing global gas emission with more circular solutions. This principle is innovative regarding materiality and design; therefore, only some

	bio-based bas-relief configurations have been developed so far. Consequently, at the end of this journey, it is expected to have a good knowledge of bio-based materials and cladding products, understand their differentiations, properties, and limits, and, finally, understand their behavior during the prototyping process. Furthermore, it is expected to recognize and understand the molding processes in general but, above all, the manufacturing process considered most appropriate, understanding its facets, premises, and any differences caused by external agents. Knowing these two areas makes it possible to create the design and, therefore, fully understand how the selected materials respond to the three-dimensional boundaries, given the process of making it. Following an in-depth study of parametric design, it will be possible to differentiate the design and the possibilities to make this product more of a system and springboard for understanding how more circular results can be distinguished and used rather than the usual products typical of the 20th century.

Process

Method description

Literature Research

The process starts with the literature research, understanding and selecting the frame of interest.
The following topics were studied by looking at different research, articles, books, journals, conference papers, presentations, and websites.
The subjects taken into account in the literature research are various:

- Skin as shearing layer, three-dimensional claddings scenario;
- Environmental Impact of extraction and production of used materials for 3d cladding realization
- Computational Design Theory for scripting and minimizing material use
- Bio-based products and their manufacturing processes

The literature research will be implemented simultaneously with the first part of the conceptual design.

Research by Design
The research by design starts with the **conceptual design**.

This phase explores sketches, maquettes, and abstract ideas to develop an ideal 3D cladding product and the corresponding mold.
During the conceptual design, parameters, boundaries, and guidelines will be settled. Through sketches and draft maquettes, there will be an understanding of the potential design and how to translate it into a digital design further.

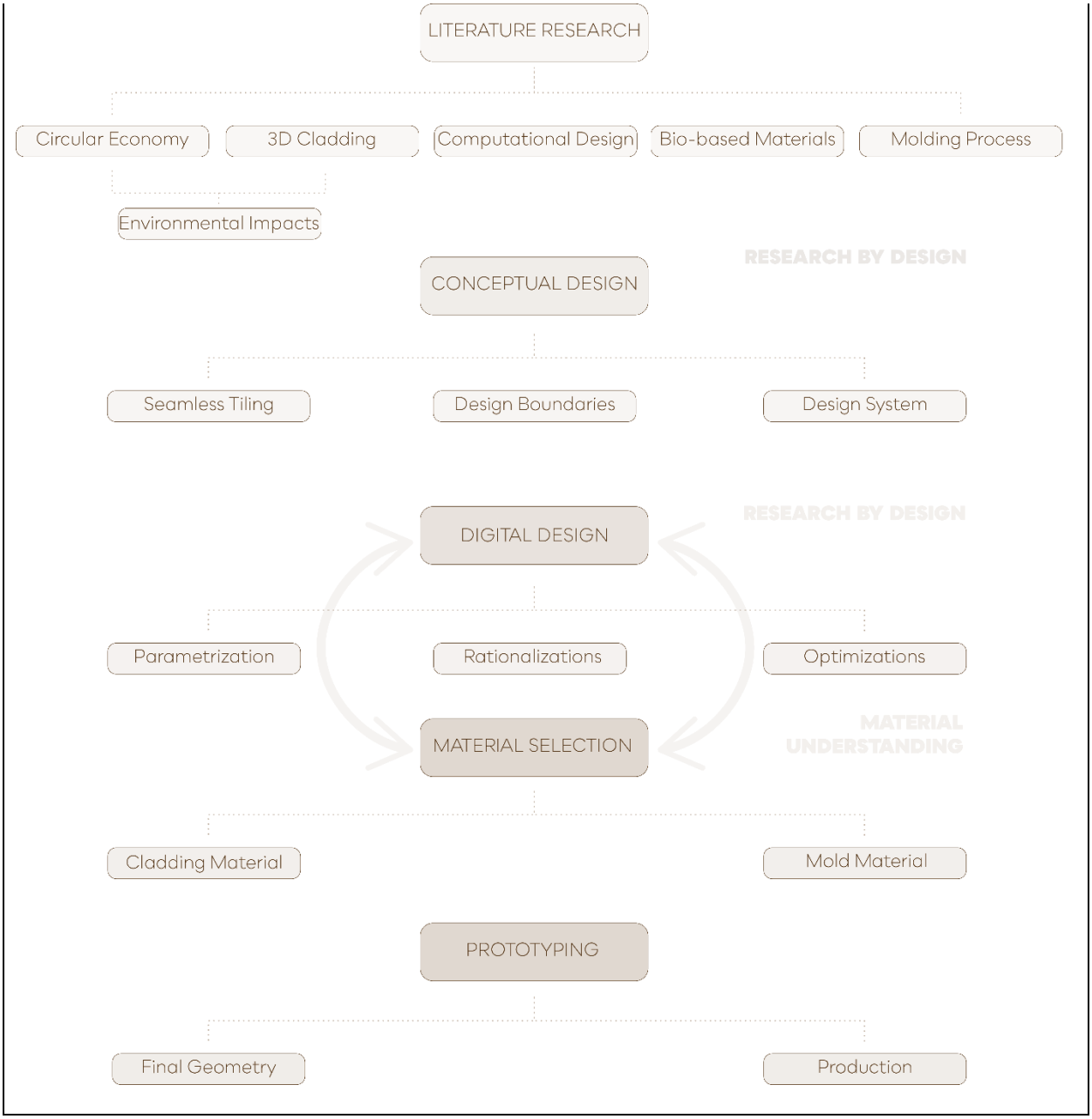
Research by Design  **Material Understanding**

The third part of the project involves a synergistic approach, combining **research by design** with a **theoretical understanding** of cladding and mold materials. On the one hand, the selected design undergoes parametrization, enabling a more refined exploration: the panels will be designed in such a way as to match the façade by having different three-dimensional configurations.

On the other hand, thorough consideration is given to the properties of the available bio-based cladding materials in the market. This mutual interaction allows for identifying the most suitable cladding material that aligns with the design objectives and vice versa.

Design Outcome

Finally, there will be the design outcome, where the realization of the panel is actualized. All the design strategies will be compared and evaluated in relation to the results and scale.



Literature and general practical preference

1) *Seamless tiling* definition:

It refers to a continuous and infinite pattern through separate and finite elements.

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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 graduation project *Three-Dimensional Cladding with Bio-based Materials: a parametric design following the seamless tiling concept* combines two main fields:

· Façade and Product Design
· Design Informatics

These topics are two of the main four fields of the Building Technology track, one of the several available tracks in the MSc Architecture, Urbanism, and Building Science program.
These two fields give technical and practical knowledge when there is a willingness to design the skin of a building.
On one side, it is possible to understand the elements that compose a façade - both from a technical and circular point of view - on the other, it is possible to create numerous configurations and optimizations, making them performing according to the requirements. These two fields have been chosen for the perfect personal combination of creative and practical flair.

Therefore, it was possible to create a peculiar configuration of a façade, starting from the practical resolution of a panel considering its materiality, design, and manufacturing process, for producing the new innovative circular product.
Moreover, it has been possible to create a design system from which the parameter of macro-geometry could provide infinite design configurations. Thus, an innovative designed has been realized both in terms of circularity and design strategies.

By pointing out these performances, building technology provides the knowledge to create a performant project considering all the fields provided in that track. In my case, the aim is to create a three-dimensional system that follows circular strategies and can withstand different configurations.

In realizing a design project, it is possible to see a connecting point with the Master of Architecture, Urbanism, and Building Science.
The central core where all the tracks meet is the willingness to improve the built environment quality. However, the way to achieve this goal changes from track to track: in the case of my thesis, the project is not starting from the bigger scale of the whole essence realization, but from the single element, which will then compose what is mentioned.
It is a different mindset than the usual compositional projects that are part of my cultural background, as the initial question in realizing a building technology project is how and then why, not vice-versa.
I believe that showing me a different mindset than how I was used to let me understand a different perspective which, mixed with what I learned before this master's, can give me a 360-degree view of the composition of a building, taking into account not only the compositional and cultural aspects but practical, sustainable and performing ones.

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

The proposed design system has considerable social, professional, and scientific relevance.

As a start, the primary purpose of the thesis is to provide a possible realization and applicability system that can be translated into a product. Therefore, it has acted within the cognitive scope and created an innovation based on secure - not experimental - aspects.

Indeed, there is knowledge of bio-based products with excellent mechanical strength and bending stiffness; however, the three-dimensionality in a facade is implicitly socially defined as the solution of a specific materiality – namely metals, concrete, ...
From this point of view, this thesis connects the dots that were so far separated, aiming at creating a system whose final design is directly applicable and included in the construction market.

This new vision enormously contributes to shifting the construction market towards the circular economy.
In fact, proposing a new system to those currently applicable, which considers the material, energy, and waste used in the manufacturing process, implicitly shows more sustainable variants for our planet.

However, the material defined and most feasible to produce is not fully circular. It is a bio-based material with partially bio-based resin, and the filler is non-renewable.

When the will is to design a feasible system, decisions have been made to exclude experimental products composed of renewable and more sustainable materials.

Furthermore, there is a significant social impact in the proposal of this project thesis. As mentioned before, there is a common indirect association between materiality and shape, considering that a sharp or exuberant form can be uniquely made with specific materials.
Instead, with this design system, this indirect association is interrupted with an emphasis on different materiality, showing the provided bio-based mechanical capabilities significantly with an extreme and complex design solution.

Moreover, the social impact is created when the material's importance and life cycle are shown rather than only the material at the time of use.
When it starts to compare the environmental impacts of two materials that, mechanically speaking, can reproduce that same geometry, an effect is created in directing common thought towards a more circular design for the good of the environment.

However, this transition process is still ongoing and challenging to change drastically. Therefore, given that the circular economy approach is not

universally adopted across industries, the production of more circular products can often incur higher expenses than conventional ones. These increased costs are primarily due to the requirement for specialized machinery and processes to facilitate resource reuse or remanufacturing, which can be time-consuming and result in high prices.

Thus, the task that designers can have to facilitate this transition is to show the possible dynamics and variations while considering its circular aspect, as in the case of this project thesis.

What has just been mentioned has a social but also an architectural impact.

The architecture and transmission of the concept are now influenced and conditioned by the life and impacts of the material.

Therefore, the material will be soon seen as a tool for concept expression – as traditional perceptions - and a translation of a caring for the future environment. Consequently, aims vary, and ideas tend to be accompanied by the constant thought of making the project more circular: but can't this vision be the initial step of a concept itself?
This question has been indeed the starting point of the project realization.

After showing the thesis project's social, scientific, and professional impacts, further steps are needed to finalize the design system.

As mentioned, the chosen material is not fully circular. Therefore, given the foundations of this thesis, it would be interesting to help create and provide more circular materials in the construction market to emphasize and improve the proposed concepts.
Some more experimental materials will soon be provided in the construction market. Therefore, more research on the innovative material properties and solutions could be helpful for the a more circular design.

Subsequently, the use and amount of the material and the waste are fundamental aspects of this research: to create more performing panels from this point of view, structural optimizations would be formative to make the panel and mold with the least amount of material possible.
Although it is possible to use reused materials or waste streams, there are resources that can be deteriorated or run out – the non-renewable ones as the calcite filler.
Therefore, the attention to the quantity of material used confirms the premises.

Finally, given the attention to modifying the usual materials for creating three-dimensional claddings, it would be advisable to give this same accuracy in understanding how to make the elements behind the facade in a circular way, such as substructure and wall.

The substructure has a fair amount of metal connection in the proposed design. This choice, as mentioned in Chapter 5, was taken to maintain the integrity of mold production while providing the designer with flexibility in their options, but above all, as a springboard for future connection developments given a flat surface that does not influence other designs.

These three further steps would respond adequately to the problem statement initially posed, creating a system that would improve the building market towards a circular economy.