Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Track: Building Technology

Graduation Plan: Building Technology

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	Pragya Chauhan
Student number	5319110

Studio		
Name / Theme	Circular Building Design	
Main mentor	Thaleia Konstantinou	Façade and Product Design / Building Product Innovation
Second mentor	Atze Boerstra	Climate Design / Building Services Innovation
Argumentation of choice of the studio	While working as an architect prior to opting for Masters – I had the chance to work on a renovation project of a modern heritage building. The project aimed to make sustainable improvements to a 40-year-old structure and inspired me to pursue this subject in greater detail. Much of the building stock that would exist in the next few decades is already built – and as architects we face the challenge to refurbish it sustainably, while making it comfortable for users and meet the safety standards of today. I have keenly explored this through various studios in the Building Technology Master's program, especially in the façade domain – since the building envelope has a direct effect on the wellbeing of the users. Moreover, I have researched this theme in my Honors program 'Second Life' where I am currently investigating how buildings can undergo circular renovations.	

Graduation project	
Title of the graduation project	Circular Façade Systems
Goal	
Location:	The Netherlands
The posed problem, research questions and the design assignment in which this result.	Problem Statement - There is no clear and strategic approach to designing a circular façade due to many factors such as a general lack of awareness and methods to implement, lack of collaboration between the actors, fragmented market, lack of market readiness, and the complexity of the process due to many aspects constituted.
	Research Question - How can the actor network be aided to implement circularity during the planning and design process of a façade renovation in a non-residential building in the Netherlands? Sub Questions – - What are the main challenges and barriers to circular designing in the built environment? - What are the renovation goals for office buildings in cold countries like the Netherlands?

	- What is the state of the art in facade systems being used in building renovations? - What strategies of circular building design are applicable for facade design and can be incorporated in the early design phase of a building renovation?
	Design Assignment - Using the existing literature to study the circularity principles related to building design and develop a framework which can help us undergo more circular renovations. - Applying this knowledge to practical examples and formulating how they can be improved in the future. This can bridge the gap between theory and practice and can act as a benchmark for similar projects.

[This should be formulated in such a way that the graduation project can answer these questions. The definition of the problem must be significant to a clearly defined area of research and design.]

Process

Method description

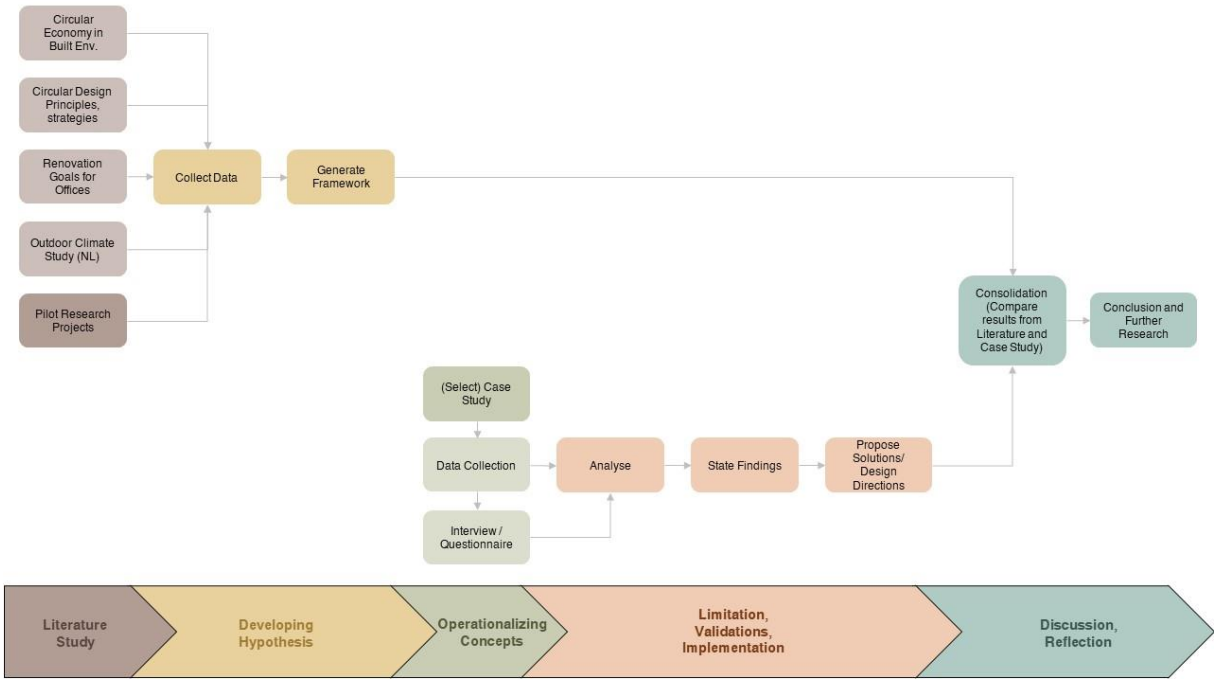

Figure – Methodology of Research

Phase 1 - Literature Study

- Climate and Energy
  - Outdoor climate study
  - Renovation goals for office buildings
  - Energy renovations
- Facades

    - Façade systems
    - Façade components
    - Façade renovation and redesign
- Circularity
    - Circular Economy in the Built Environment
    - Circular design principles, strategies
    - Challenges to design a circular facade
    - Pilot projects

Phase 2 - Developing Hypothesis

- Generate a framework using collection information
- Answer 'how can we undergo circular renovations in facades'

Phase 3 - Operationalizing Concepts

- Select a case study example
- Data collection
- Conduct interview / questionnaire for remaining information

Phase 4 - Limitations, Validations, and Implementations

- Analyse and state the findings
- Propose design solutions *or* suggestions in process to make solution more circular

Phase 5 - Discussion, Reflection

- Consolidate information from the literature study and case study
- Conclude research and give further steps to research

Literature and General Practical Preference

Research Papers

Adams, K. T., Osmani, M., Thorpe, T., & Thornback, J. (2017). Circular economy in construction: Current awareness, challenges and enablers. *Proceedings of Institution of Civil Engineers: Waste and Resource Management*, *170*(1), 15–24. https://doi.org/10.1680/jwarm.16.00011

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Durmisevic, E. (2018). *Reversible Building Design Guidelines*. *March*, 22. https://www.bamb2020.eu/wp-content/uploads/2018/12/Reversible-Building-Design-guidelines-and-protocol.pdf

Foster, G. (2020). Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts. *Resources, Conservation and Recycling*, *152*(October 2019), 104507. https://doi.org/10.1016/j.resconrec.2019.104507

approach. *Cleaner Engineering and Technology*, *4*, 100239. https://doi.org/10.1016/j.clet.2021.100239

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Books

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Others

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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 program (MSc AUBS)?

The topic of 'circular façade systems' is directly related to the studio topic of 'Circular Building Design', the master track of 'Building Technology' and the master program of 'Architecture, Urbanism and the Built Environment'.

The theme of the *master's track* 'Building Technology' focuses on the design and engineering of smart buildings that are sustainable, comfortable, and environmentally intelligent. It integrates both the architectural design and the technical disciplines related to the built environment. In this context, the graduation project aims to achieve a more sustainable built environment and reduce the material and energy consumption in a resource intensive industry. This can be done through new innovations in the technical design of a building, so that it can be refurbished or demolished, reused or disassembled – while making sure that the social and spatial challenges are being tackled. Within the field of building technology, there is a great need for these kinds of innovations to mold the current built environment to be more sustainable.

The world is fast transitioning from a linear economy to a circular economy. This change is very visible in the automobile and fashion industry - people are using refurbished phones, machines and recycled clothes. Soon, this change will also come to the larger commodities such as homes, buildings etc. In the building and construction industry, this process has already started, where academicians and practitioners are finding ways to reduce the impact that the built environment has on the natural environment. Many approaches have been taken so far – earthen construction, biomimicry, zero energy design, etc. One theme that has remained constant within these is to reduce the amount of resources consumed, whether materials or energy. The circular economy in the built environment approach encompasses this theme thoroughly. New 'circular' buildings such as the Circl Pavilion in Amsterdam, Venlo Municipal Office in Venlo, and Green House in Utrecht have come up which incorporate many aspects of circularity – on a

building level but also on an urban level. Circularity touches upon both the detail level and the bigger picture. The graduation project aims to incorporate this wide range – investigating the detailed technical design as well as the industry/market. Hence, it is also directly related to the *master's program* of 'Architecture, Urbanism and the Built Environment'.

The building stock that exists today has a long physical lifespan. However, they are designed for short term predictions of building use and do not offer flexibility to maximize their functional lifespan. Therefore, they need to be adapted to meet the changing standards of human comfort, safety regulations, climatic requirements, apart from catering to the different functional needs and occupancies. To be able to make these changes, layers within a building need to be modified as per their lifespans and requirements. The layer 'building envelope' affects most of these aspects directly and will be explored in detail in the project 'Circular Façade Systems'. Hence the graduation project has a strong connection to the *studio topics* of 'Façade and Product Design' and 'Climate Design'.

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

The buildings and construction sectors together consume 40% of all the materials entering the global economy (Khasreen et al., 2009), and accounts for 36% of global final energy use (UN Environment & International Energy Agency, 2017). It has a major impact on the environment. More than 220 million building units, representing 85% of the EU's building stock, were built before 2001. 85-95% of the buildings that exist today will still be standing in 2050 (European Commission, 2016). With an increasing global urban population, there is a growing need to both construct new sustainable buildings, but more importantly, retrofit old structures (Eline et al., 2018). This means that these buildings will require extensive renovation, to meet future energy and performance goals in the building sector. Therefore, it is important to innovate towards a circular construction economy incorporating ideas such as less resource use, more recycling, etc. Building retrofit, a growing research area during the last decade, finds its fundament on the urgency of decreasing the harmful effect of buildings in the environment, and improving them as healthier places for occupants. For these reasons, façade retrofit is rapidly expanding as a research area (Martinez et al., 2015). Moreover, with the principles of circular economy, ideas such as modular and regenerative design, material passports, buildings-as-a service, design for disassembly and material banks are being brought up in the building and construction sector (Leising et al., 2018) (Holland Circular Hotspot, 2018).

The graduation project is a major step towards a circular built environment. This is important because a circular built environment can only be a success if it becomes tangible and measurable. Only then can people implement it in everyday life. However, there are still no clear steps to undertake this. *Socially,* the built environment is directly connected to humans and touches all aspects of our lives – including wellbeing. This transition will be a learning process that will progressively teach us how to live sustainably, not just because it is ethically correct but also because it will open new opportunities.

Professionally, the results of the graduation project can be used for innovators, entrepreneurs, researchers, and designers. The project aims to understand all the aspects related to making of a circular façade – from the market level to the technical design, and hence can be used by further research, project teams in the industry to design and plan for more circular building facades. The project will focus on the renovation aspects but can be applied to for new buildings as well. The project also focusses on non-residential buildings – such as offices, public and commercial buildings, as there is a knowledge gap for them. It will investigate real life examples of circular projects which are executed and relate them to the theoretical literature, so that the construction of such facades and structures can be improved.

Scientifically, this research brings together renovation goals, energy goals, circularity in the built environment. So far, there is a lack of research which has combined all these aspects. The research attempts to find business models, applicable strategies in theoretical research and real-life projects to support this knowledge gap. Also, it does so while looking at literature and case studies of practical applications in so far, trying to find connections and gaps in both aspects. Existing frameworks express principled and philosophies but fail to offer specifics on how built environment assets and services must be

developed procured designed constructed operated maintained and repurposed. Scientifically, the graduation project will be a step to remedy that.

Time Planning