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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	Marilse Nouws
Student number	4585623

Studio		
Name / Theme	Building Technology Graduation Studio	
Main mentor	Olga Ioannou	Chair of Façade & Product Design
Second mentor	Andy Jenkins	Chair of Climate Design
Argumentation of choice of the studio	I am very interested in sustainable and nature-inclusive design and how we can fight climate change with new, innovative designs and techniques.	

Graduation project	
Title of the graduation project	**A Circular Façade Cladding System from waste materials which fosters biodiversity** *[working title]*
Goal	
Location:	Urban areas that lack biodiversity in the Netherlands
The posed problem,	Currently the residential building stock in the Netherlands consist of more than 8 million buildings and this stock grows each year with approximately 1%. It is very likely that this trend continues, which means that more than 80% of the buildings in 2040 exists today. Making our existing building stock futureproof is therefore one of the biggest challenges in the building industry to reduce CO_2 emissions and meet the EU climate goals. The transition from a linear to a circular economy plays a key role in these challenges. One of the four circular principles states that waste equals food. As mentioned in the background information, the building industry is a great contributor to waste materials and with the current rapid development of technologies the door is open towards more innovative strategies of using waste as a material source. Another cause for the worldwide rising temperature is the urban heat island (UHI) effect. The number of people living in

	urban areas is still increasing and this leads to several issues for our planet and our own health. Nature-inclusive buildings reduce the UHI effect and furthermore enhance biodiversity in cities. However, fostering biodiversity in cities requires a lot of attention, since a proper implementation is site specific, reliant on many factors and therefore hard to achieve.
research questions and	In response to my problem statement, the main research question can be defined as follows: *"How can waste materials be used to design a multifunctional, modular, three-dimensional circular façade panel which fosters biodiversity in urban areas in the Netherlands?"* In order to fully answer the main question, some sub-questions are proposed: 1. Which production techniques are available to create a three-dimensional façade cladding component? 2. What types of waste materials are suitable for a three-dimensional façade cladding component? 3. What are possible circular production and processing methods for turning waste materials into a cladding component? 4. What types of waste materials are suitable for the application of biodiversity in a cladding component? 5. Which factors influence the biodiversity in urban areas and which of those are considered for this study? To gain more knowledge for the research of this thesis some background questions are investigated during the literature study. ➢ What are important aspects to consider when designing one façade panel which has various options for infills? ➢ What is the effect of biodiversity in urban areas? ➢ How and where is biodiversity currently present in urban areas? ➢ What are possible application methods of biodiversity in building envelopes?
design assignment in which these result.	At the end of this thesis, it is expected that this results in the following objectives:

	(1) an overview of suitable waste materials to use as the façade cladding panel or as one of its parts, (2) a fixing system for the panel which is applicable to existing building façades and is designed for disassembly (DfD), (3) a diagram with a mapping of considered biodiversity species present the Netherlands, which serves as a design tool for the customization-aspect of the façade element, (4) experimenting with and testing of the design through (digital) models and prototypes which then results in the main objective of a multifunctional, modular, three-dimensional façade cladding panel, which is made from waste materials, fosters biodiversity and that considers all the mentioned aspects.

Process

Method description

The research starts with performing literature studies for all three divisions simultaneously. For circular design the research is all in relation to three-dimensional façade cladding. Looking at the four domains of circularity, this thesis focuses on the domains of design and manufacturing and with the literature study the aim is to find circular production techniques and a modular cladding system which is designed for disassembly (DfD) and can be attached to existing building envelopes.

These production techniques however should be suitable for the waste materials that are selected through literature review. From looking into waste streams in the Netherlands a few materials will be chosen for the next phases of this study. As mentioned earlier on, the term waste in this thesis is about two of the three circular approaches and the focus lies with the R-strategies Recycle and Repurpose. However, if a discarded material with a primary function as a façade element is one of the outcomes of the literature study, the other strategies from the second circular approach “Extend lifespan of product and its parts” will also be explored.

For the biodiversity section of the literature study building reliant animal species and various plant species from the Netherlands will be analyzed. Additionally, the factors that influence biodiversity in urban areas are explored, wherefrom a set of parameters is chosen to guide the decision-making for which biodiversity species will be implemented in the design. These species then will be mapped into a diagram which will serve as a design tool for the customization of the final design.

Furthermore, analyzing several case studies for the three divisions is part of the literature review and additionally the option of getting in touch with façade manufacturers, companies which give waste a second life is highly considered. These approaches will help to get a better understanding of the topic and will provide inspiration, but also focal points.

The second phase of the thesis, which will overlap in the time schedule and furthermore interacts with the literature study, is all about Research by Design. From the literature study of the three

divisions the development of the shape of the panel can be established. Through experimenting and testing with sketching, physical and 3D modelling, the shape will be finalized into the final design. Concluding, the design will be placed in a chosen context and according to the created biodiversity diagram a design example will be presented.

Literature and general practical preference

Literature retrieved from Scopus, Elsevier and Google Scholar.

List of some of the literature that will be consulted:

Bridgens, B., Powell, M., Farmer, G., Walsh, C., Reed, E., Royapoor, M., Gosling, P., Hall, J., & Heidrich, O. (2018). Creative upcycling: Reconnecting people, materials and place through making. *Journal of Cleaner Production*, *189*, 145–154. https://doi.org/10.1016/j.jclepro.2018.03.317

Designing for reuse and circulation of products and materials. (2019, maart). Ellen Macarthur Foundation. https://www.ellenmacarthurfoundation.org/our-work/activities/circular-economy-in-cities

Faragalla, A. M. A., & Asadi, S. (2022). Biomimetic Design for Adaptive Building Façades: A Paradigm Shift towards Environmentally Conscious Architecture. *Energies*, *15*(15), 5390. https://doi.org/10.3390/en15155390

Fernández-Cañero, R., Pérez Urrestarazu, L., & Perini, K. (2018). Vertical Greening Systems. *Nature Based Strategies for Urban and Building Sustainability*, 45–54. https://doi.org/10.1016/b978-0-12-812150-4.00004-5

Gorgolewski, M. (2019). The architecture of reuse. *IOP Conference Series: Earth and Environmental Science*, *225*, 012030. https://doi.org/10.1088/1755-1315/225/1/012030

Gulck, L. V., Leenknecht, E., Debusseré, E., Steenkiste, J. V., Steeman, M., & Bossche, N. V. D. (2021). Development of a circularity assessment method for facade systems. *IOP Conference Series: Earth and Environmental Science*, *855*(1), 012008. https://doi.org/10.1088/1755-1315/855/1/012008

Gunnell, K., Murphy, B. and Williams, C. (2013) Designing for biodiversity: a technical guide for new and existing buildings. Second edn. London: RIBA Publishing, 1.

Hop, M. E. C. M., & Hiemstra, J. A. (2013). Ecosysteemdiensten van groene daken en gevels: een literatuurstudie naar diensten op het niveau van wijk en stad. In *Wageningen UR* (DLO-PPO-67). https://library.wur.nl/WebQuery/wurpubs/446146

Kabisch, N., Korn, H., Stadler, J., & Bonn, A. (Reds.). (2017). Nature-Based Solutions to Climate Change Adaptation in Urban Areas. *Theory and Practice of Urban Sustainability Transitions*. https://doi.org/10.1007/978-3-319-56091-5

MA, M. (2011). Green facades and building structures. *Delft: Delft University of Technology*.

Mayrand, F., Clergeau, P., Vergnes, A., & Madre, F. (2018). Vertical Greening Systems as Habitat for Biodiversity. *Nature Based Strategies for Urban and Building Sustainability*, 227–237. https://doi.org/10.1016/b978-0-12-812150-4.00021-5

Meier, L., Raps, J., & Leistner, P. (2020). Insect Habitat Systems Integrated into Façades-Impact on Building Physics and Awareness of Society. *Sustainability*, *12*(2), 570. https://doi.org/10.3390/su12020570

Mommers, V., Dekker, G., & van de Leemkolk, W. (2021). Analyse knelpunten natuurinclusief bouwen. In *Rijksoverheid*. Rijksoverheid. Geraadpleegd op 23 januari 2023, van https://open.overheid.nl/repository/ronl-99962b1f-b0de-42c2-ac8f-9bc2b6fdb79f/1/pdf/analyse-knelpuntenonderzoek-natuurinclusief-bouwen.pdf

Munaro, M. R., Tavares, S. F., & Bragança, L. (2020). Towards circular and more sustainable buildings: A systematic literature review on the circular economy in the built environment. *Journal of Cleaner Production*, *260*, 121134. https://doi.org/10.1016/j.jclepro.2020.121134

Ottelé, M., Perini, K., Fraaij, A., Haas, E., & Raiteri, R. (2011). Comparative life cycle analysis for green façades and living wall systems. *Energy and Buildings*, *43*(12), 3419–3429. https://doi.org/10.1016/j.enbuild.2011.09.010

Pérez-Urrestarazu, L., & Urrestarazu, M. (2018). Vertical Greening Systems. *Nature Based Strategies for Urban and Building Sustainability*, 55–63. https://doi.org/10.1016/b978-0-12-812150-4.00005-7

Platform CB'23. (2021). *Leidraad Circulair Ontwerpen* [Presentatieslides]. https://platformcb23.nl/images/leidraden/PlatformCB23_Leidraad_Circulair-Ontwerpen_versie1.pdf

Sandak, A., Sandak, J., Brzezicki, M., & Kutnar, A. (2019). State of the Art in Building Façades. *Bio-based Building Skin*, 1–26. https://doi.org/10.1007/978-981-13-3747-5_1

Sandak, A., Sandak, J., Brzezicki, M., & Kutnar, A. (2019a). Designing Building Skins with Biomaterials. *Bio-based Building Skin*, 65–97. https://doi.org/10.1007/978-981-13-3747-5_3

Verdonck, O. (1988). Composts from organic waste materials as substitutes for the usual horticultural substrates. *Biological Wastes*, *26*(4), 325–330. https://doi.org/10.1016/0269-7483(88)90138-3

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)?

With the design of a nature-inclusive façade cladding element the focus lies in the smaller, detailed scale of the build environment, namely the façade, which has a strong relation with the Building Technology track. However, the bigger picture won't be forgotten in this thesis since the design will be well integrated in its surrounding area and furthermore this study considers not just humans as future users, but mostly animals, insects and plants and therefore is a great fit for the master programme.

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

This thesis is part of the movement towards a healthy and sustainable living environment in urban areas of the Netherlands and contributes to the global transition from a linear to a

circular economy. Additionally, the proposed modularity and customization of the design, makes a broad implementation feasible, whereas the analysis of biodiversity species and its resulting diagram contributes to the success probability of the nature-inclusive façade panel on multiple locations.