Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan

Personal information	
Name	Marije de Ruijter
Student number	4595394

Studio		
Name / Theme	Design for change	
Main mentor	Stijn Brancart	Structural Design
Second mentor	Hans Hoogenboom	Design Informatics
Argumentation of choice of the studio	Due to the increasing material shortage, it becomes more important that we increase the lifespan of components and buildings. By creating demountable structures, the materials can be reused when the building is disassembled, increasing the lifespan of the components. Furthermore, the buildings become more adaptable by being able to change the structure more easily, thereby increasing the lifespan of the building.	

Graduation project	
Title of the graduation project	Compute - Demount - Adapt
Goal	
Location:	Netherlands, more specific location is not applicable
The posed problem,	Currently material is becoming increasingly scarce. The construction sector is the largest consumer of raw material, as well as the largest producer of waste. By creating more adaptable buildings both this consumption of material and production of waste can be decreased. However, at the moment buildings are often made more adaptable by oversizing the building components. This leads to an increase in material usage, thereby focusing just on the environmental issues of the future and discarding the current environmental problems. Instead, material usage should be minimized while finding a balance to create more adaptable buildings.
research questions and	Main question: How can a building structure be designed to have more adaptability with the use of a computational workflow and demountable connections, while minimizing material usage? Sub-questions: - "How are buildings currently being designed to be demountable and adaptable?"

	- "How are computational tools currently used to design reconfigurable structures?" - "How can a computational workflow be designed to aid the design process of creating an adaptable building?" - "How can a computational workflow be designed to minimize the material usage of a structure?" - "How can demountable connections be applied to create more adaptability?"
design assignment in which these result.	The design assignment is to create a computational workflow and relating demountable connections. The workflow should aide the process of designing an adaptable building. Based on a provisional design the workflow should lead to multiple design options, which are evaluated based on their adaptability and material usage. The connection should be demountable and should aid the adaptability of the building. By making sure the connection can be disassembled easily without disrupting the further structure, the adaptability of the building can be increased.

Process

Method description

During the research project 4 methods will be applied, being literature review, semi-structured interviews, research by design, and case-studies.

Literature review

At the start of the research a literature review has been conducted to create a base knowledge on the topic and to research the current state of the art.

For the literature review scientific papers were selected using the scopus database. Firstly, sets of keywords were created relating to the main questions of this research project. Of the resulting papers the title and abstracts were scanned to determine whether these papers did indeed relate to the topic.

In some cases, if the found papers related very well to the main topics and were very helpful in the research, connected papers were found by looking at the sources. The suitability of these papers was then also checked by reading the title and abstract.

Interviews

A set of semi-structured interviews were conducted to gain insight in some of the current practices in regard to designing demountable and adaptable buildings. Semi-structured interviews follow a set of predetermined questions, but also offer flexibility to veer off these questions to gain the required information.

The choice of companies to contact depended on four aspects. Firstly, all companies were based in the Netherlands, to allow the possibility to conduct an in-person interview. Furthermore, the external factors, such as policies and demand for demountable products, will remain consistent by limiting the research to one country. Secondly, all companies have experience designing at least one demountable building. The companies were also selected to have experience with different structural materials

and buildings systems, to get an overview of different approaches. Furthermore, companies with dissimilar roles in the design process have been selected, to gain a better understanding of the entire process.

In the end, 10 companies were contacted to determine whether they would be willing to be part of this research. The six companies which responded positively include one structural engineering firm, one building system factory and four architectural firms.

Case studies

Case studies will be done to create an understanding of the current building systems and connections, and the possibilities to design such a connection.

To start the case studies, first appropriate projects will have to be chosen. Only demountable connections will be looked at, since the connection that will be developed during this project will be demountable as well. Furthermore, the projects to be studied should have the same base material as the connection to be designed. Connections often greatly differ based on the building material, looking at connections for other materials will therefore not produce useful information.

Research by design

For both the demountable connection as the computational workflow research by design will be done. Through the act of developing or designing these products, knowledge is gathered. This information could be used to design a similar type of product.

Because the two products are so dissimilar, the exact process of developing the product will differ. The design of the connections will include designing by making drawings, and computational and physical modelling. The design of the computational workflow on the other hand will solely focus on programming, using Rhino, Grasshopper and Karamba.

However, both products will be developed following an iterative process of design and testing phases. For the computational tool, this testing will focus on the functionality of separate parts of the workflow. Especially since the workflow will consist of multiple steps that will have to work together in the end. While for the connections these testing phases will typically be used to reflect on the connection as a whole. In both cases the products will be assessed based on requirements set at the start of the process.

The design phase can have multiple approaches. For instance, it is possible to create multiple options and to choose one or combine multiple options based on the evaluations. However, it is also possible to instead continue developing just one option. A combination of these approaches will probably be applied.

Literature and general practical preference

During the project, several companies that have experience in designing demountable buildings will be consulted. This will offer valuable insight into how professionals currently design these buildings, as well as what difficulties in designing these buildings still exist. More research can then be done into these current difficulties to try to solve some of the problems.

Besides the interviews, information will be gathered during a literature review. At the moment, there is already quite some research into demountable and adaptable buildings, as these stem from the introduction of prefabrication. However, it has more recently become a tool for creating sustainable buildings. Silva et al. (2020) provide an overview of the history of circular economy as well as providing three demountable building typologies. Rahla et al. (2021) give an overview of circular economy strategies that can be applied to buildings, as well as during which of the building's life stages these should be applied.

In contrast Arisya & Suryantini (2021) and Anastasiades et al. (2021) focus on specific aspects of demountable building, modularity and standardization respectively. They research the benefits of these strategies in relation to demountable structures.

There is however less literature available on how to use computational methods to increase the adaptability of a structure. Brütting et al. (2019; 2021; 2022) have written multiple papers on this topic, which form a valuable source of information. Among others, they have developed a method to create a kit of parts that has been optimized to create three predetermined structures with the least number of components. Nadir et al. (2004) have also done research into the adaptability of a structure. They have researched the reconfigurability of a truss to be able to adapt to a change in load.

Reflection

What is the relation between your graduation topic, the studio topic, your master track, and your master programme?

This research project focuses on increasing the adaptability of a structure. This is done by creating a computational workflow to create design options and evaluate these on the amount of adaptability. Furthermore, a connection that can easily be disassembled will be developed. This is part of the bigger topic of creating more adaptability to increase the lifespan of buildings.

As part of the Building Technology track, the project focusses on innovative solutions to create more sustainable buildings. However, it also extents beyond Building Technology, as this workflow could be used to offer more insight into the creation of adaptable buildings for all actors in the design process.

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

Currently there is an increasing shortage in building materials. By creating demountable buildings, the buildings' materials can be reused at the end of the building's use. Furthermore, demountable buildings are more adaptable, as it's easier to make changes to the building. Both of these aspects increase the lifespan of the building itself or its components, reducing the need for material usage in the future.

Even though there is already research on creating demountable buildings, it is not often applied in practice yet, due to the higher costs. The computational workflow is meant to encourage the creation of more adaptable and demountable buildings, by showing which components would benefit the most from being demountable.

Furthermore, not a lot of research is done in the use of computational design to create adaptability in buildings. This project will add to the information that is already available and could be used for further research.