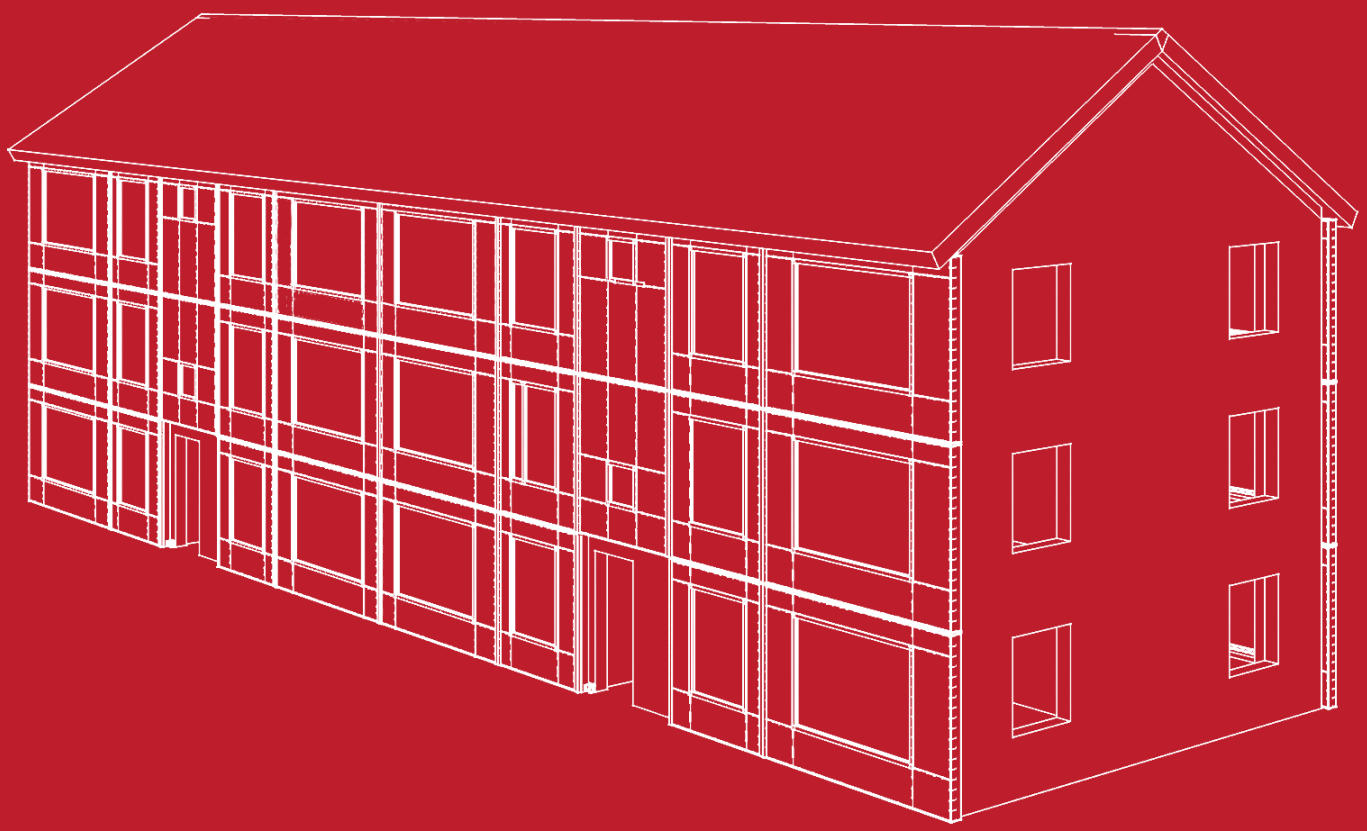
08

REFLECTION

This final chapter presents the author's reflection on the graduation project and process.



Reflection

In this section, the graduation project will be reflected on two aspects: the graduation process and the societal impact. The reflection will give an answer to the main question: *How and why did the used approach work or did not work and to what extent?* This first part will focus on the used research methodology. The second part focusses on the research within the wider social context.

Graduation process

The graduation project started with the existing research project 2nd Skin Façade Refurbishment of Thaleia Konstantinou and Tillmann Klein. In this existing research project a refurbishment strategy for post-war residential buildings was developed, in which the residential building is wrapped in a second layer of exterior insulation with integrated ventilation ducts and photovoltaics on the roof, in order to reach energy neutrality of the building. The aim of the graduation project was to further develop the façade refurbishment system in terms of circularity. The end result would be the redesign of the Circular 2nd Skin Façade Refurbishment Facade Refurbishment system, that creates no waste. The hypothesis leaded to the use of recycled and bio based materials in the redesign, that could be disassembled at the end of the functional lifetime of the refurbishment.

The following methodology was used for the research. First, based on intensive literature research, the definition of the Circular Economy and its application in the built environment was determined to get familiar with the concept. Then the accommodating frameworks around the Circular Economy, were analysed to be able to identify the coherence. Next, the design strategies for circular building were developed, based on literature research and analysed precedents. The second step was the assessment of the level of circularity of buildings. A complete circularity assessment tool didn't yet exist, so several sustainability assessment methods were analysed. The two methods in which most of the principles of the Circular Economy were integrated, were chosen and the exact assessment criteria were defined. These assessment criteria were then used to evaluate the level of circularity of the 2nd Skin Façade Refurbishment system. To be able to make a comparison, two variants of the 2nd Skin Façade Refurbishment system were analysed: the Prefabricated variant, that consists of prefabricated modules connected to the existing façade with a substructure, and the Exterior Insulation variant, that consists of exterior insulation board glued to the existing facade. Originally, also the existing façade of the case study building was planned to be evaluated, but that appeared not to be useful for the research, because the existing façade would be maintained during the refurbishment process. The redesign of the 2nd Skin Façade Refurbishment system was based on the comparison results of the two refurbishment systems. To be able to make the redesign of the 2nd Skin Façade, a Roadmap was created to help making decisions for the redesign. This wasn't incorporated in the initial research methodology, but appeared to be necessary for the translation of the research results into a new design proposal.

The chosen research methodology did work out to a certain extent, because the comparison of the assessment results of the two variants did lead to practical points of improvements that needed to be implemented in the design in order to increase the level of circularity of the 2nd Skin Façade Refurbishment system. However, important to mention are the limitations of the chosen methodology. As stated in the research framework, the assessment focusses on the technical aspects of the implementation of the Circular Economy in the built environment. The proposed methodology can be used to assess the level of circularity of the materials the 2nd Skin Façade Refurbishment system consist of, and the Disassembly Potential of the connections between the façade components and materials. What the approach doesn't take into consideration, is the analysis of the supply chain and business model around the refurbishment process of the post-war residential building, while this is also of high importance when implementing the Circular Economy into practice. Next to that, the embodied energy of the materials and the transportation distances from the factory to the building site isn't incorporated into the methodology, while these aspects also have an impact on the level of circularity of the system. Originally planned was to incorporate also the embodied energy of materials into the methodology. However, this aspect was considered to be more related to the level of sustainability than the level of circularity of the system. For these reasons, the research can't state that the redesign of the 2nd Skin Façade Refurbishment system should be considered as 100% circular, because not all aspects of the Circular Economy were taken into account. The graduation process has shown the complexity and the widespread definition of the Circular Economy, that has an effect on many fields of study within the wider socio-economic system, leading to a concept difficult to grasp completely within the timeframe of the graduation process.

This methodology enabled the connection between research and design. All decisions for the redesign of the façade system were based on the research results, in which the two variants of the 2nd Skin Facade Refurbishment system were assessed in terms of circularity. The decision-making process was facilitated by translating the research results into a Roadmap, that explains with questions step by step how to design a circular façade. This roadmap can be seen as an additional result of the graduation project, that can be used by architects, contractors and material suppliers. The conducted literature research showed the necessity to implement the principles of the Circular Economy into practical guidelines that can be applied in practice. This proposed Roadmap should be seen as a way to communicate these.

The relationship between the theme of the graduation lab, Sustainable Design Graduation studio, and the chosen subject, Circular Façade Refurbishment, is clear. Circularity is strongly interlinked with sustainability, because the Circular Economy is seen as a new approach towards sustainability. Next to that the research had to fit within two of the four tracks of the master Building Technology: Façade, Structural, Climate and Computational design. The chosen tracks for this graduation project were Façade and Climate design. In terms of Façade Design the graduation project delivers a detailed façade system, that can be used to refurbish different typologies of post-war residential buildings. In terms of Climate design, the focus lays on sustainability; providing a system to improve the energy efficiency of residential buildings within the framework of the Circular Economy.

Societal impact

The results of the graduation results are applicable in practice, because the project provides a practical Roadmap for circular façade design, that can be used by architects, contractors and material suppliers during the design process. The roadmap can be used for the design of a façade refurbishment system, which was the topic of this research, but also for the design of the façade of new buildings. The proposal for the redesign of the 2nd Skin Façade Refurbishment system can't yet be applied to practice, because the design needs to be elaborated further. During the graduation project the system is applied to two case study buildings. However, to make the system feasible, more case study buildings with different typologies should be examined in detail.

The projected innovation, however, has been achieved. The aim of the project was to develop a new circular façade refurbishment system, that has the potential to be brought to the market. From the feedback of the contractor, that was involved in the project of the 2nd Skin Façade Refurbishment system, clearly emerged the necessity of a universal façade refurbishment system, that can be applied to any post-war residential building. Because of the currently low refurbishment rate of post-war residential buildings, the ambition of the Paris climate agreement to reach energy neutrality of the built environment in 2050 can never be reached. These developments in the building industry ask for an innovative solution, that would give a helping hand in increasing the refurbishment rate of the high number of post-war residential buildings with bad energy performance.

The project has a clear impact on sustainability, because it offers a practical solution to the problem of the current linear take-make-dispose model that is prevailing in the current building industry. During construction, demolition and refurbishment of buildings a high amount of valuable material waste is accumulated on-site. Due to the inflexibility of the building envelope the refurbishment of the residential building is complicated and demolition and reconstruction is often the preferred option. The developed façade refurbishment system can be disassembled and reassembled to enable refurbishment of multiple residential buildings with the same system. The system will be applied from the outside, to avoid disturbance of the inhabitants. With the 2nd Skin Refurbishment system the building will become energy neutral, creating a comfortable interior climate in the building. Next to that, the proposed redesign increases the flexibility of the façade, so the façade is able to go along with the changing demand of the people living in the building. Consequently, the project has made an effort to translate the concept of the Circular Economy in practical building guidelines, that can be applied to the building industry.