AR3AH105 Graduation Studio Adapting 20th Century Heritage

Renovation with reused materials as feasible alternative to reconstruction

Research Plan

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1.A Introduction

Key concepts:

Application of used building materials. Renovation of existing residential buildings as alternative to demolition and rebuilding propositions. Housing shortage. Embodied carbon. Virgin raw material use. Waste production. Feasibility.

Globally, the building industry accounted for 34% of energy demand and around 37% of energy and process-related CO_2 emissions in 2021 according to the '2022 Global Status Report for Buildings and Construction'. These numbers are only expected to go up following the current trajectory. This way the sector will fail to decarbonize by 2050 as agreed in the Paris agreements. (*UNEP - UN Environment Programme, 2022)* Of the 37% CO_2 emissions, 40% is accounted for by the production of building materials, the so-called embodied carbon. This means that 5.6 Gigatons of carbon is released in our atmosphere for the production of building materials every year. *(Architecture 2030*, n.d.)

Apart from the pollution that results from producing new building materials, there is another urgent reason to drastically lower the production rate: resource scarcity. Ever since 1970 we have been extracting more resources from the earth than it can regenerate and every year we extract even more than the year before. (*Earth Overshoot Day*, *2023*) The result of this is rather simple, it will not take long before there are no more resources to extract: the earth will have run dry.

The building sector is also responsible for 35.9% of all solid waste in Europe. (*Weghmann & Public Service International Research Unit*, 2023) Drastically lowering the production rate of new building materials will make a positive impact on the building sectors' share of embodied carbon emissions, resource depletion and waste generation.

In the meantime, the Netherlands is coping with a housing shortage. Recent reports by the Dutch Government state that approximately 900.000 additional dwellings will have to be built by 2030 to accommodate its inhabitants. Also, a large part of the current housing stock in the Netherlands is unfitting to modern standards of energy efficiency and spatial quality. There is both a legal as societal need for the upgrading of this current stock. *(Ministerie van Algemene Zaken, 2023)*

This means that the construction industry faces a seemingly paradoxical challenge. Much of the current housing stock must be renewed and a large number of homes must be added. At the same time, the production of new building materials must decline. How to do that?

Two strategies are available for this. In the context of renewing the current housing stock, preservation of current structures is necessary to meet both ambitions. Why demolish everything and thereby automatically having to produce a lot of material when much of the current construction is still adequate? For all the material you need to add and what you need to build to meet the housing demand, the application of reused material can offer a solution. After all, these products do not have to be newly produced. Technically, both strategies are possible. In practice, there are plenty of examples of both successful renovation projects and projects realized with reused materials. *(Superuse Studios, 2023) (Popma ter Steege Architecten, 2021) (Wessel van Geffen architecten, 2017)* Still, the application of these strategies is very limited compared to demolition and new construction and the use of conventional new materials. The developments in Amsterdam New West are a good example of this. Much of the housing stock in Amsterdam New West is owned by housing corporations. This housing stock is outdated and in need of renewal. Nineteen neighbourhoods are up for renewal in the coming few years. Apart from some partial renovation plans, most of the stock is up for demolition in order to build brand new construction. (*NUL20, 2021*)

The housing corporations relevant to these development plans: Eigen Haard, Stadgenoot, Ymere, Rochdale, De Alliantie en De Key, promote their renewal plans on their websites. The arguments for demolition and new construction are all very similar and can be summarized as follows: new construction allows them to guarantee the best thermal insulation and therefore energy efficiency and new construction allows for realizing more dwellings. *(Eigen Haard, 2021), (Stadgenoot, 2022), (Rochdale, 2021), (De Alliantie, 2018).* With these arguments, they say they are responding to two key issues: sustainability and housing demand.

Sustainability however is about much more than energy efficiency in the use-phase. All environmental issues mentioned before are not addressed by only looking at this factor. Also, is it really true that a high energy efficiency in the use phase can only be achieved in new construction? There is no doubt that conventional renovation (with newly added material) is able to insulate a structure well and thereby substantially improve energy efficiency. When we start looking at renovation with reused materials, there is still insufficient evidence for this. Does reused insulation perform as well? If not, how does the performance compare to new material? Such questions challenge the obviousness of the sustainability of reuse.

This research seeks to connect the preservation of built structures with the application of used building materials. Mainly because they are the same strategy at heart. Both are about re-use, refraining from demolition and disposal. Specifically, they are about minimizing carbon footprint in a current construction project. This is where preservation and applying used building materials differ from their overarching theme 'circularity'. A lot of circular building solutions focus on re-use in the future, like Design for Deconstruction (DFD) and spatial flexibility. A study on how such strategies can be implemented by housing corporations to renovate their stock circularly has been conducted by Anne van Stijn for the TU Delft in her dissertation 'Developing circular building components – between ideal and feasible' published in April 2023. This research formed the foundation for the handbook 'Woningcorporaties aan de slag met circulair renoveren', a toolbox on circular renovations for housing corporations. (*van Stijn, 2023*) Although these are very valid strategies, their positive ecological impact will only happen when the need for a new construction or function arises. They are still built with new material and still contributing to an ever growing ecological problem. Using less new material, so not only reassuring that material can be reused in the future, is also part of the ambitions by the municipality of Amsterdam. The report 'Amsterdam Circulair 2020-2025', clearly states the ambition to use 50% less new resources by 2025. *(City of Amsterdam, 2020)* This ambition in combination with the large amount of demolition and new construction in Amsterdam New West shows the difference between ambition and action. Vincent van der Meulen, architect and partner at Kraaijvanger Architects, addresses this call for action in his workbook 'Building with a positive footprint' published in November 2022. He states that buildings (in the current industry) always have a negative impact on our planet and the health of its users. Making buildings that make a positive impact, is not even complicated, Vincent states, as long as the whole industry works together. *(van der Meulen, 2022)* A beautiful idea, but practice shows that such an idealistic attitude is rarely capable of making a large scale impact. It calls for a more pragmatic approach. This research seeks to formulate a pragmatic valuation of renewal plans in dwelling. It will try to mediate between two forces. It will challenge the arguments by the established order (housing corporations and developers) by making a fair and complete estimate of the environmental burden of construction (not just the use phase). On the other hand it will challenge the idealistic attitude of radical sustainability by weighing environmental impact against feasibility.
This way the research seeks to find a valid answer to the following research questions:

1.B Research questions
Main research question

"How can renovation with reused materials become a feasible alternative to demolition and new construction plans of the current housing stock?"

Sub questions

What are the interests of the stakeholders in a renewal task of existing housing?
What are the barriers to choosing renovation in a renewal task of existing housing?
What is the relative ecological impact of renovation versus newly built construction?
What is the relative ecological impact applying reused materials in a renovation project?
What are the technical challenges for applying reused materials in a renovation project?
What are the logistical challenges for applying reused material in a renovation project?

2. Methodology

2.A Theoretical Framework
Loriane Icibaci, a researcher and architect for Superuse North America, published a book in 2019 called 'Reuse of building products in the Netherlands'. The research "positions the object of study from an evolutionary perspective where relations condition the action of reuse" where "relations are dynamic and contextually bounded defining the commercial feasibility of products to be reused rather than wasted". *(Icibaci, 2019)* For her research she describes the theoretical framework which is based on Industrial Ecology. Industrial Ecology is a scientific discipline that takes a systemic approach to sustainability problems. In basis it looks at industrial processes from a perspective of metabolism and ecology since it emulates the natural process of loops and interrelations. In other words, 'circularity' is natural; ecosystems operate in constant loops and are disrupted by linear activity. *(Kapur & Graedel, 2004)* How to mimic these natural loops in industrial processes in order to reduce waste, resource-use etcetera is the basis of Icibaci's research. This research operates in a similar framework. The feasibility of applying reused materials depends heavily on industrial ecology. This research will however leave this macro scale of systems. It will look more into the current state of practice and the graspable interventions needed to make an impact in the current building industry, one that is still very non-ecological, and will try to frame how a diffractive approach to the macro complexity of the industry's challenges can help shift towards a more ecology based system.

2.B Methods
This research consists of a literature review, case studies and a design research in which the design research functions as a case study when finished. The literature review has mostly been done already in preparation of constructing the research design.

On March 2023, Superuse Studios designed a renovation proposal as an alternative to the demolition and new construction plan for Complex 70 in The Hague, an ensemble of residential blocks from the 1930s. *(Jongert, 2023)* Haag Wonen, the housing corporation that owns the properties, is scheduled to start the new construction plan designed by Architektenkombinatie and to be developed by AM in 2025. Due to protests by current local residents in cooperation with heritage association Heemschut, the plans are now temporarily on hold. The renovation proposal by Superuse is being considered by the municipality of The Hague. Initially a renovation was declared unfeasible by Haag Wonen, as can be read on their website. (Haag Wonen, 2022)

For this research, a study of this case will follow in collaboration with Superuse Studios. In preliminary discussions with Jan Jongert, partner and architect at Superuse Studios, the status of the current knowledge about the case and the need for more research was established. This is how the research plan came about, which will be explained below. This research combines academic interests with practical needs.

In fact, the research consists of three case studies:

1. Demolition and new construction plan (Architectenkombinatie, AM).

2. Renovation proposal Superuse (new renovation material).

3. Renovation proposal Superuse (reused material).

Case study 1, is the original proposal by Architectenkombinatie and AM in which the entire existing building is demolished and replaced with new construction.

Case study 2, is Superuse's proposal which they presented on March 2023. This is a renovation proposal where the vast majority of the buildings remain intact and where through insulation packages and minor interventions in the residential floor plans, the homes are improved and restored in quality. This proposal uses new building materials to renovate.

Case study 3, is a design task which is part of the study. The starting point is a second alternative to the demolition and new construction plans in which the Superuse proposal is taken as a basis. This proposal then looks at the possibilities of implementing Superuse's design with reused materials. Herein, the focus is on identifying the materials needed for this and the processes involved in obtaining these materials and applying them in the renovation plan. For this design study, Superuse Studios has shared Complex 70's project files. A study of all the information released will be the first step in the design research.

These three case studies will then be assessed against three attributes. These attributes are: environmental impact, cost and feasibility. How these terms are interpreted in this study and how they will be tested is outlined below.

Ecological footprint
Ecological footprint is a broad term. Due to the limited time to conduct the study, ecological footprint is defined by combining the embodied carbon of the structure, energy efficiency in the use phase, waste production and nitrogen emissions during construction and demolition to arrive at a score. The higher the score, the larger the ecological footprint of the proposal. The embodied carbon is calculated using an LCA (Life Cycle Assessment). This looks at production of the material, transportation and the installation process. This LCA will be calculated with the software Granta Edupack and will be based on Gibbons method as described in 'How to calculate embodied carbon'. *(Gibbons, 2020)* The energy efficiency in the use phase, when climate systems are not taken into account, mainly depends on the physical properties of the building envelope. The thermal resistance of the façade and roof packages will therefore be calculated using Rc value calculations. Waste production will be expressed in kilotons and is a product of all material that is removed from the current construction in order to realize the proposal. Nitrogen emissions during construction and demolition activities will be calculated with aid of Bureau Bouwkunde. This is the firm that has made previous nitrogen calculations for Superuse's renovation proposal. They are willing to provide assistance in making an estimate for Case Study 3.

Costs

To make a cost comparison of the three case studies, the cost of materials and labour costs will be considered. For labour costs, the amount of labour required to execute the proposal in the construction phase will be considered. Also considered will be costs incurred by unconventional processes due to the need for research and a higher level of expertise. Subsidies and taxes are excluded from this because they are political means and have no architectural basis. This cost estimate will be made on the basis of previous calculations by Bureau Bouwkunde that already did a cost estimation for Casestudy 1 and 2.

Feasibility

To test the feasibility of the proposal, scenarios will be created. They describe the roles that different parties have in the construction process. Interviews with representatives of these parties are used to test whether they are willing to take these steps and, if not, what they believe needs to be done to make these steps feasible. In this, subsidies and taxes may be tools that can be used. It is important to test cost and feasibility separately but always be aware of how they are intertwined in practice.

By performing the methods above, both quantitative and qualitative data will be collected. The quantitative data will then be used to score the three case studies on environmental impact and cost. How much more sustainable is renovating with reused materials? How do the costs compare? Next, the qualitative data will be used to test the proposals against practice. Is the proposal feasible? What are the preconditions?

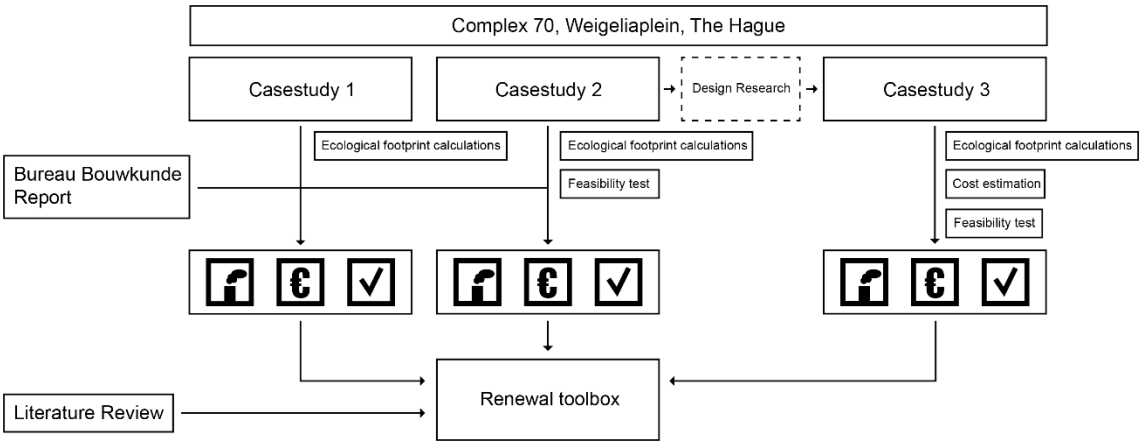

Figure 1: Research Structure

2.C Timeline

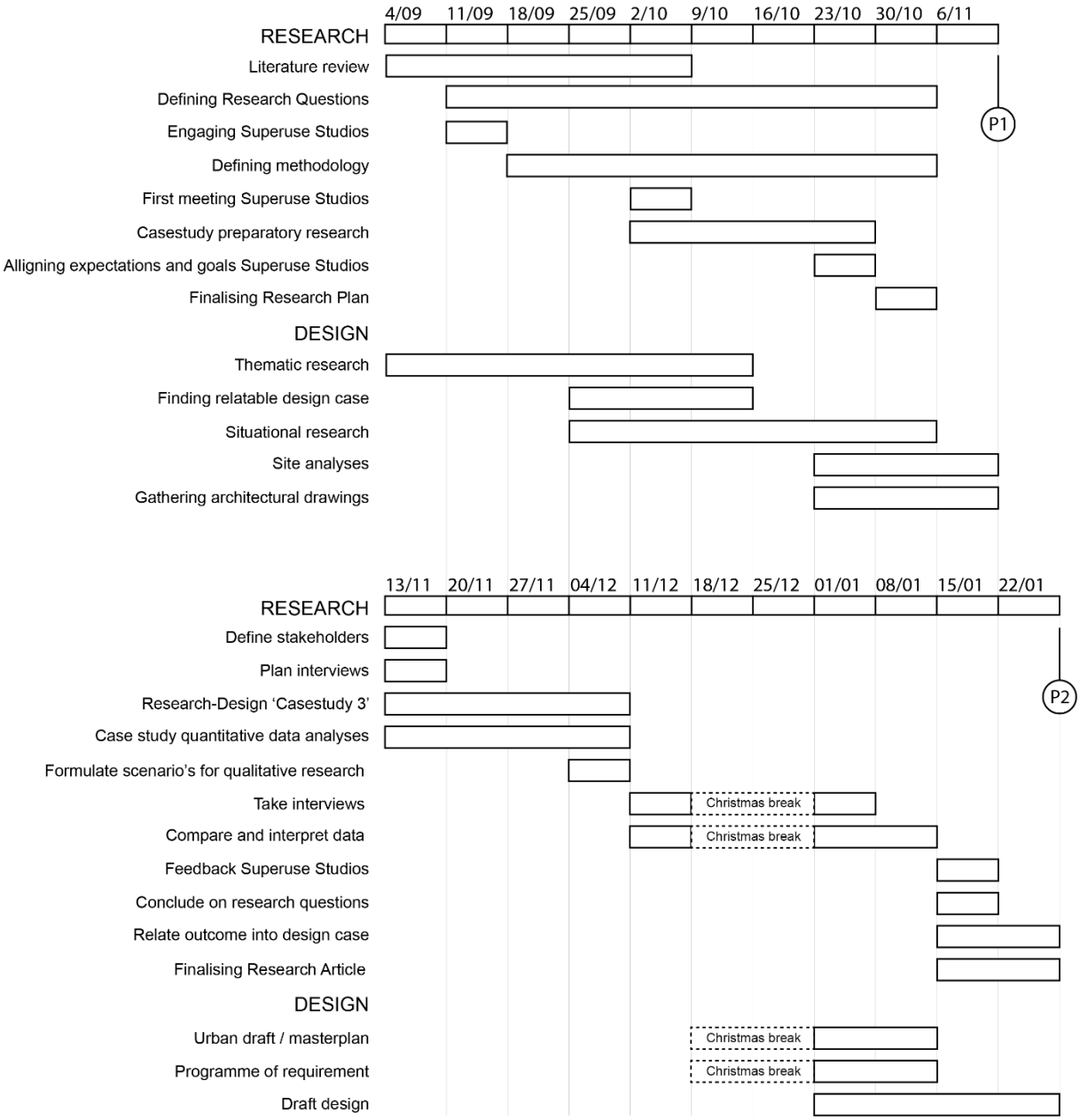

Figure 2: Research Timeline

2.D Risks & Mitigation

An important part of testing the feasibility of the different proposals relies on conducting interviews with parties involved. Unwillingness of such parties to cooperate is a risk. Ideally, the stakeholders will be interviewed that are currently involved in the original demolition and newly built proposal for Complex 70. It is however understandable if such parties refuse to cooperate because of the critical attitude this research takes towards their initial efforts. When these stakeholder refuse, similar parties will be approached. In case all efforts to take interviews fail, the expertise and experience of Superuse Studios will be used to frame the feasibility of the proposals. To maximize the probability of success, parties will be approached in the first week of the research to already plan interviews for later. This means interviews will be planned before the scenarios that the interviews will test, are created.

3. Expected Results

It is expected that the results of this research can be used to develop a strategy in which renovation with as many reused materials as possible becomes a viable alternative for demolition and new construction plans of existing housing complexes. In this, the results of the study can provide support in the justification for choosing renovation and then provide insights into how this renovation can be carried out as sustainably as possible. The expected product that this research will lead to can be described as a 'Renewal toolbox'. This toolbox will provide insights for the roles of the parties involved in renewal tasks and show how design can maximize the feasibility of the proposal through carefully chosen interventions and materials.

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Graphs & Figures

Figure 1: von Barnau Sythoff, T. (2023). Research Structure
Figure 2: von Barnau Sythoff, T. (2023). Research Timeline