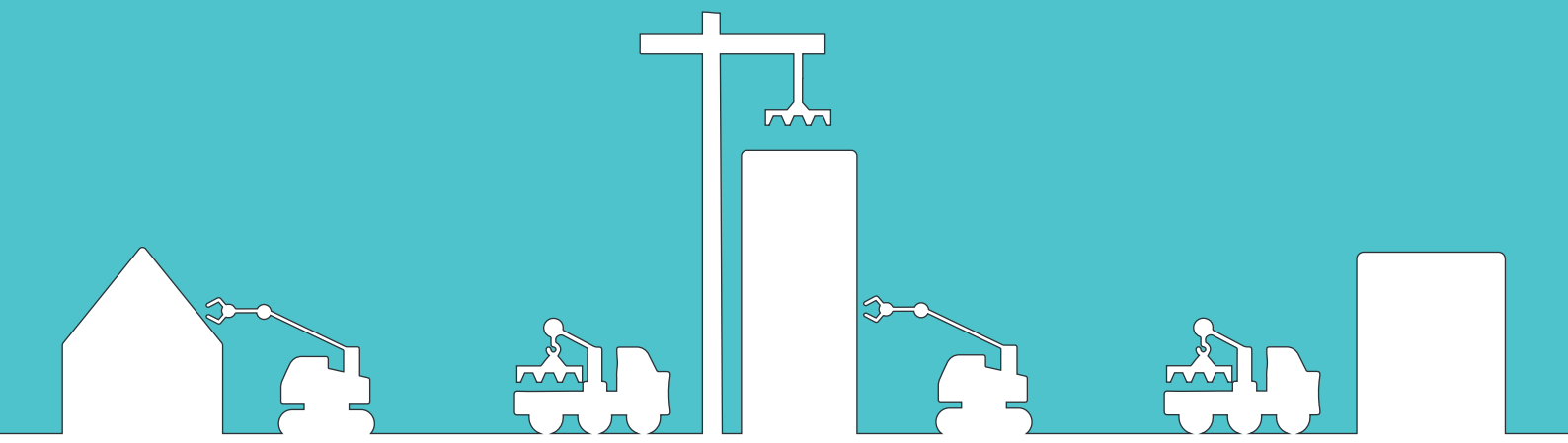
PROJECT MANAGEMENT IN CIRCULAR BUILDING PROJECTS

Developing a framework supporting the re-use of components



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Abstract – The environmental pressure on the planet and its limited capacities has resulted in the need for new building methodologies that respect this limited capacity. Building methods based on the principles of the Circular Economy could pose an answer to this problem. However, limited knowledge and tools are available to bring this into practice. This research focuses on circular building from the perspective of re-using building components upfront and its relation with the project management of non-residential building projects in The Netherlands. The study aims to clarify the role of the project management and obtain more insight into the briefing, the project organization, and the selection of the project team, in relation to the re-use of building components. By conducting qualitative research, consisting of a literature study and empirical research, including multiple expert interviews with people involved in re-use projects and case study of a renovation and a newly built office project, a better understanding has been achieved. The research suggests that the management of the initiation phase is of great importance in setting a good starting point for re-use projects. The briefing could help in this by defining clear ambitions and goals. These can guide the team throughout the process. Besides, the way projects are organized could facilitate the inclusion of re-use. This includes the extension of the initiation phase, in which an inventory of reclaimed components is started. Throughout the process better integration between activities is needed to align the reclaimed components with the design, this comes with additional iteration. Lastly, the project team selection is found to have an impact on re-use. The composition of an interdisciplinary team is proposed to integrate planning and design activities and conduct them earlier in the process. This includes (new) collaborations with re-use experts. It is also found that the motivation of the team members could impact the amount of re-use. These findings are translated into a project management framework and in the visualization of the re-use process in a flow chart. These can be used by project managers in future re-use building projects.

Keywords
Circular building projects, project management, re-using building components, briefing, project organization, project team selection

PREFACE

My ambition to make the building sector more sustainable developed throughout my studies at the Faculty of Architecture. The notion of the significant impact of the building sector on the environment has motivated me to contribute to focus on this topic. This has resulted in an exchange programme with the Technical University in Stockholm, where I further explored sustainability and its application on the building sector, and eventually the focus on sustainability in my graduation research. The concept of circularity is rapidly evolving and many goals have to be reached within only a few years. To achieve these goals on a very short term, I was wondering how the building sector could contribute to this. That's why the concept of re-use came across, as it deals with building products that are already in use and thereby overcomes the need for virgin resources as well as the production of waste. In combination with my interest in organizing processes, my research topic was born.

This graduation research is documented in this report and represents the study to "Project management in circular building projects". The research presents my master graduation project for the track Management in the Built Environment of the MSc. Architecture, Urbanism, and Building Sciences at the Delft University of Technology. A study on the impact of three project management activities during the early stages of building projects, on the re-use of building components. For me, the research confirms the potential of improving the environmental impact of building projects by aligning the re-use concept with appropriate management. I hope to provide interested parties with a better understanding of the impact of management of the initiation phase in re-use projects, and provide guidance on how one could tackle this. Besides, by describing the potential of the implementation of re-use in building projects, I aspire to reduce the reluctance and ignorance concerning implementing circularity in the building sector and to inspire those who are willing to accelerate the road towards a circular building sector.

Acknowledgments

Conducting my graduation research has been very instructive, I have learned a lot concerning the re-use topic, conducting research as well as project management practices. This would not have been possible without the support of several people. Therefore, I would like to express my sincere gratitude to my mentors, John Heintz and Herman Vande Putte. Your guidance and criticism throughout the entire graduation process have been truly valuable. Your critical questions have resulted in many interesting discussions that have contributed to a better understanding and reflection on my research. Also, I would like to thank Brink Management/Advies and in particular Birgit Hopff and Housni Chaibi for their supervision. Our meetings have been very motivating and I appreciate your effort to provide me with constructive feedback and interesting opportunities to improve my research. Furthermore, I many thanks to all interviewees. Your inspiring stories have been of great importance in the data collection and enabled me to gain insight into the practices of re-use. Finally, special thanks to my family and friends, for their unconditional support throughout this journey.

I am very happy to share my graduation research with all who are interested. Enjoy reading!

Lotte Meijers
June, 2020

EXECUTIVE SUMMARY

Introduction

Problem statement

The building sector is known for being responsible for the use of high amounts of resources, energy, and water and is acknowledged to be in need of improvement (The Ministry of Infrastructure and the Environment and the Ministry of Economic Affairs, 2016; van den Berg, 2019; Ghisellini, Ji, Liu & Ulgiati, 2018; Pomponi & Moncaster, 2017; Ghisellini, Ripa & Ulgiati, 2018; Nasir, Genovese, Acquaye, Koh & Yamoah, 2017).

The principles of the circular economy have been proposed to address this problem. Multiple strategies to apply the principles of the circular economy to the building sector are known. This research focuses on one of these strategies, being the re-use of components. This includes the integration of reclaimed building components in building projects. The strategy is found to have a (short term) environmental advantage and is seen as an effective strategy to reduce the environmental footprint of the building sector, however currently little components are re-used (Rakhshan, Morel, Alaka & Charef, 2020; Stichting Economisch Instituut voor de Bouw & Metabolic, 2020).

Project management during the initiation phase is mentioned to have a major impact on project success and plays an important role in circular building projects (Morris, 1998; Leising et al., 2017). During this phase, amongst others, a vision regarding circularity should be created, market parties are involved and the process is organized.

Research aim and question

The research aims at obtaining better insight into the briefing, the project organization, and the selection of the project team in circular building projects. Understanding the relationship between those management activities and the re-use of building components, should help in the management of circular building projects and thereby minimize the resource intensity of the building sector. The following research question is addressed in the research:

In what way can the briefing, the project organization, and the selection of the project team, contribute to re-using building components?

To provide an answer to this main research question, several sub-questions are to be answered. The sub-questions are categorized based on two themes:

Re-using building components and circularity

- *What is the re-use of building components?*
- *How do circular (re-use) building projects differ from linear projects?*
- *What are the project management barriers/constraints for re-using building components (a) and how could they be resolved (b)?*
- *What is the role of project management in the initiation phase of circular building projects?*

The briefing, project organization & selection of the project team

- *What are standard practices concerning the briefing, the project organization, and the selection of the project team?*
- *How are the briefing, the project organization, and the selection of the project team carried out in re-use projects, and does this contribute to re-using building components?*

Research methods

The research has an explorative and explanatory nature. Besides, little data is available and only little re-use projects are known. Therefore a qualitative research approach has been adopted, including empirical research. The research is divided into three phases: (1) literature study, (2) empirical study, and (3) the synthesis. The research design, including how the different phases have led to answering the research question is visualized in Figure I.

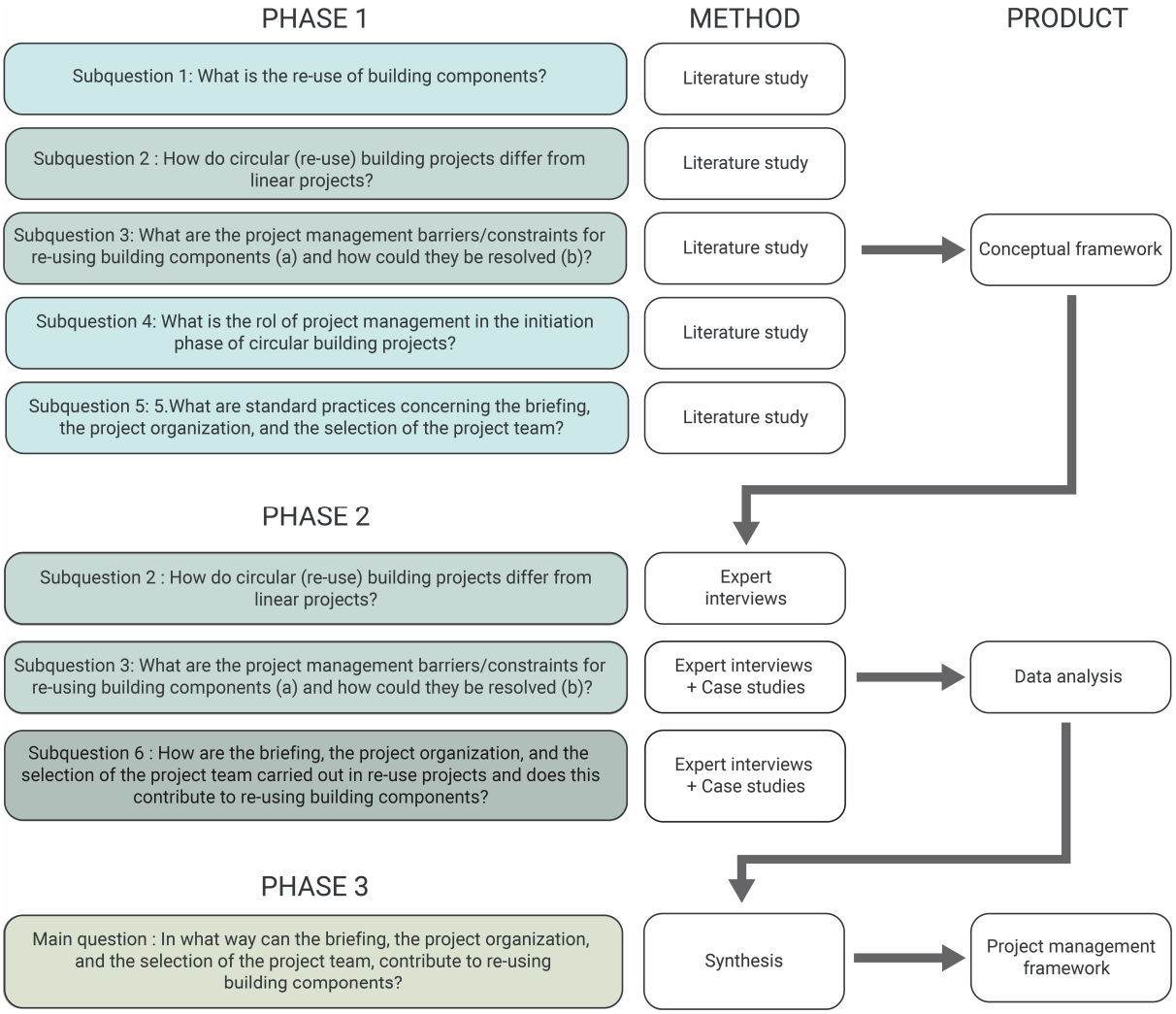

Figure I. Research design

Findings from the literature study

Re-use of components

The literature points out that re-use could take place on several levels as shown in Figure II. On the component level, also multiple ways re-use can be found. Within this research, re-use includes using a component again either for its original purpose or a familiar purpose, as well as component re-use for a different purpose, with a minimum of operations of recovery (Van den Berg, 2019; Ghisellini, Ripa & Ulgiati, 2018; Rakhshan et al., 2020).

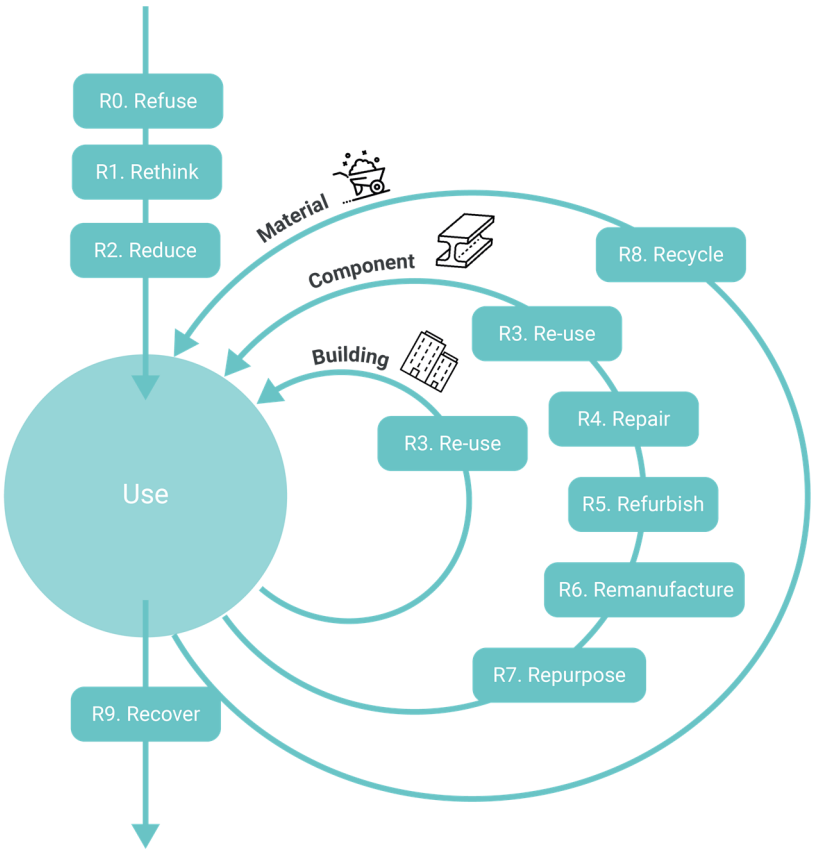

Figure II. Application re-use to the building sector (After PBL Netherlands Environmental Assessment Agency, n.d.; Van Haagen, 2018)

Differences linear and circular

Re-use projects significantly differ from traditional projects (Gorgolewski & Morretin, 2009; Kozminzka, 2019; Van den Berg, 2019; Addis, 2006). Major differences can be found in the project delivery process (Figure III). The literature describes the need for an interdisciplinary and flexible process to integrate activities and deal with uncertainty. To enable additional identification and research activities concerning reclaimed components, it is also suggested to extend the initiation and conceptual design phase in re-use projects. These adjustments also impact the supply chain.

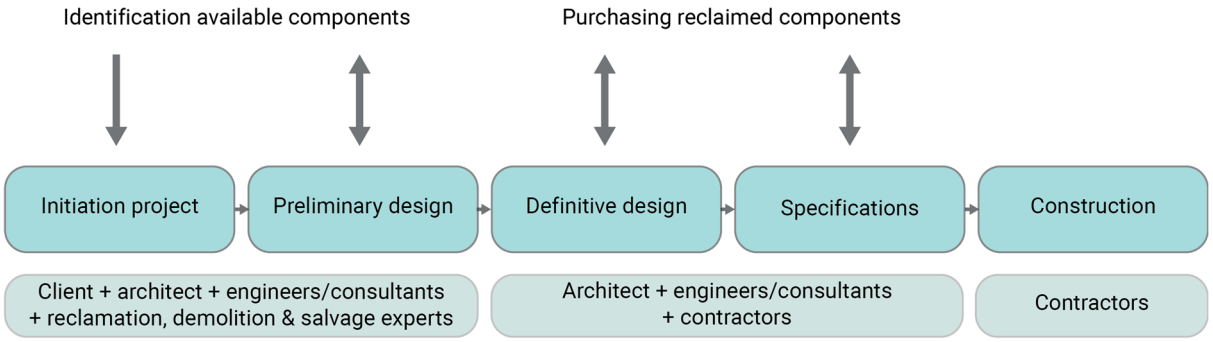

Figure III. Re-use project delivery (After Kozminska, 2019 and Addis, 2006)

Barriers

Challenges are seen in sorting, transporting, and recovering components. This leads to the lack of an established market and results in difficulties in the management of re-use projects. Timing and scheduling are mentioned to be a big issue, as well as the availability and sharing of information regarding the reclaimed components. Besides, regulatory standards are limiting the re-use of components and poses an additional challenge during the early project stages. In addition, people aren't experienced and educated to build with reclaimed components and often have a negative attitude towards the re-use concept.

Project management initiation phase

The management of the Front-End Loading is stressed to be of importance in maximizing the project's success (Project Management Institute, 2016). Project sponsors and project management consultants are actors fulfilling project management activities during the initiation phase. For re-use projects, an organic approach is suggested due to the innovative character, uncertainty, and complexity (Ossipova & Eriksson, 2013). Several management activities related to integration in circular building projects are also stressed (Leising et al., 2017; Van der Wijk, 2018).

The briefing, project organization and project team selection

During the initiation phase the briefing takes place, the project organization is developed and the selection of the project team is started. The briefing is the evolutionary process of understanding an organization's needs and resources and matching these to its objectives. To unite the team and guide them through the process the definition of a clear re-use vision and related targets during the initiation phase is of particular importance in re-use projects. A dynamic way of the briefing is suggested. The project organization, the structure of the process that facilitates the coordination and implementation of project activities, also plays an important role (PM4DEV, 2016). Adjustment of the traditional way of organizing projects is advised to enable the inclusion of reclaimed components. This includes a more cyclic way of planning, the extension of the initial phases, and the facilitation of integration. The selection of the team that forms the collation of firms that are deployed to realize the project mission, is also of importance (Winch, 2010). Due to the innovative character, the project team is of particular importance (Thurm, 2005). It is suggested to form an interdisciplinary team and establish the early involvement of varying actors (Leising et al., 2017; Kozminska, 2019). The team should also share the re-use ambition and work closely together (Rakhshan et al., 2020; Leising et al., 2017).

Findings from the empirical study

The empirical study included multiple expert interviews with actors involved in re-use projects as well as the study of two cases of re-use projects. Case A included a renovation of a municipal office with the ambition to re-use 95% of the demolition materials. Case B included a newly built office with “reduce, re-use, recycle” as one of the main themes.

Briefing

The briefing is of great importance, as it could help to steer the team. A vision and related targets regarding re-use should be defined early in the process. This could be done by, for instance, organizing workshops as seen in Case B. Well defined and measurable targets are mentioned to provide guidance to the team. Case A demonstrates this by defining re-use Key Performance Indicators. To not limit to only one source of reclaimed components, targets should include multiple types of re-use. However, a lot of uncertainty due to the limited market is experienced. This leads to challenges in specifying clear re-use targets. Therefore other ways to specify targets is mentioned, for example, setting an effort obligation.

Project organization

The empirical study indicates that one should start with identifying reclaimed components before commencing the design. This was however not the case, in both cases. The interviewees indicated that the earlier the inventory takes place, the better the reclaimed components could be aligned with the design. Uncertainty concerning timing and availability of components is said to be a key issue, therefore an iterative process that leaves room to revisit the plan is needed. It is stated that additional attention should be spent on the initiation phase. In particular, in Case B there was limited time reserved for the initiation phases, due to the strict schedule. This is experienced to have limited re-use potential. Adjustments of the supply chain are also mentioned. A major implication is the early purchasing of components, which is particularly needed due to the limited availability of reclaimed components.

Project team selection

The expert interviews indicate that in re-use projects integral decisions should be made. Therefore an interdisciplinary project team that closely collaborates and shares responsibilities from early in the project is needed. The cases demonstrate ways of shaping such project teams by deploying a consortium or a contractor with an in-house architectural firm. Both cases stress the contribution of knowledge and skills of demolition, re-use market, and reconditioning experts. The interviews pointed out that often some stakeholders have a negative attitude towards re-use. It is suggested to select the team based on their motivation and experience and to include re-use project champions. The positive impact of including intrinsically motivated team members is experienced in both cases.

Lastly, the empirical study pointed out the important role of the client and project manager in re-use projects in supporting re-use targets and extending this to the team.

Synthesis

The briefing is of importance in giving guidance to the project and involved actors. Therefore the initiation of a vision, related to re-use, should take place early in the process and clear goals should be developed. However, mainly due to uncertainties, these goals should be

further developed and revisited throughout the project. Keeping track on this ambition and goals is found to be needed to avoid falling back on traditional approaches.

The project organization should be adopted in re-use projects. This should include starting with the identification of reclaimed components during the initiation phase, which implies that the initiation phase is extended, afterward more integration and iteration in the process is needed.

An interdisciplinary project team that closely collaborates from early on in the project is needed. This also includes new expertise, such as re-use market parties or reconditioning experts. These team members should be motivated, share the re-use ambition, and having a good relationship and trust is of importance in achieving this ambition.

The imagination of scenarios showed that types of re-use, as well as the layer to which component belong come with varying moments of decision making and have varying impact on the process. Combining those options would optimize the inclusion of re-used components and how this process would look like is visualized in a flow chart that is shown in Figure IV.

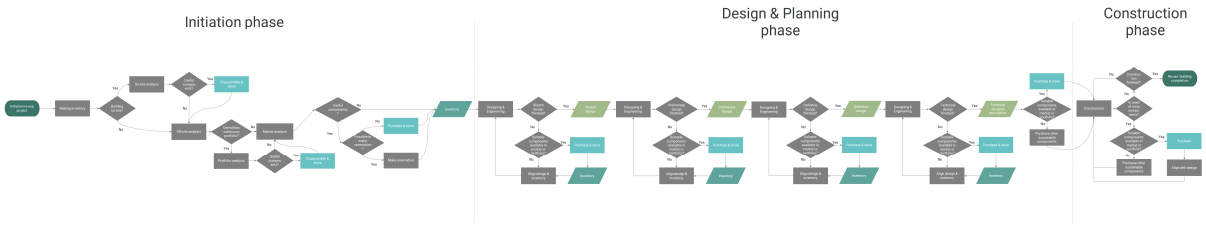

Figure IV. Flow chart re-use process

Conclusions and recommendations

The briefing, project organization, and selection of the project team contribute in setting positive boundary conditions for the re-use of components. Appropriate management of these aspects gives guidance to the process and team, provides timely opportunities for identification, analysis, and implementation of reclaimed components and establishes a motivated team that has knowledge, skills, and means to integrate reclaimed components.

The project management framework in Figure V reflects the main recommendations related to the three activities that are taking place in the initiation phase. This framework should guide project sponsors or project management consultants in setting up building projects that facilitate the re-use of building components.

Briefing	Project organization	Project team selection
- Define re-use ambition during initiation phase - Define clear and realistic re-use goals *Specify the goals and measurement based on the availibity of information* *Distinguish between layers and types of re-use* - Maintain re-use ambition and goals throughout the process *Keep track on the re-use ambition and goals and revisit or specify when more information comes available*	- Expand the initiation phase *Include extra time for defining the re-use ambition and goals, careful selection of the project team and additional re-use tasks* - Start with the identification, analysis, and ordering of components and repeat this iteratively - Integrate activities *Let design, planning and engineering activities run in parallel and streamline the information flow* - Design an iterative process including milestones *Systematically assess the opportunities and determine decision moments*	- Create an interdisciplinary project team with shared responsibilities *Establish (new) relationships with i.e. re-use market, demolition, and reconditioning experts* *Involve a contractor during design phase to enable early ordering of components* - Select a team based on experience and willingness regarding re-use - Include project champions *Team members that are intrinsically motivated to re-use*

Figure V. Project management framework

The re-use of building components can be seen as a radical innovation. The re-use innovation is still in its infancy, therefore, time and energy should be invested in the front end of the project. Project managers should also be aware of the need to adapt and revisit the plan.

Clients should strongly support the re-use ambitions and goals and play a determining role in taking initiative in identifying reclaimed components and steering the team to achieve them. This also implies an important role that potential project management consultants should play in assisting clients to implement their ambitions in building projects.

The research also indicated the importance of distinguishing between types of re-use and the layers to which components belong. Taking this into account could help in optimizing the scope, setting clear goals, and structuring the process.

Discussion

Research design and outcome

The empirical study supplemented the literature study by providing a better understanding and practical insights. It revealed some challenges, such as the conflict between flexibility and the

project schedule. Besides, the empirical study pointed out the importance of some aspects that were only briefly discussed in the literature, such as the motivation of the project team, the maintenance of the re-use ambition and goals, and the early inventory of components.

The need for identification and securing of reclaimed components from early on in the project has a far-reaching impact on the entire building process. It requires an adjusted way of thinking for architects, earlier conduction of planning and engineering activities, and comes with the need for early involvement of actors such as re-use experts and contractors to timely identify, analyze, and purchase the components.

Research implications

Some aspects are still restraining the development of the re-use concept. Including the need for additional activities, comparable or higher costs of re-use, a limited market, and restricting regulations. However, upcoming developments such as re-use platforms contribute to re-use and some indicate that suppliers might eventually provide certified reclaimed components similar to new products. Nevertheless, in the current stage, innovative clients and construction parties should invest time and energy to further explore the concept and subsequently diffuse the re-use innovation.

Limitations and further research

The explorative research is based on a limited amount of literature and dependent on empirical study. Besides, the study was limited to three project management activities during the initiation phase. Several other topics of interest are not addressed. Therefore, further research is suggested in the following topics:

- Development of the re-use market. This would enable identifying components easier.
- Business models that better facilitate re-use. As costs are found to play a restriction for re-use and investments in purchasing components has to be done early, which causes difficulties in the involvement of actors and causes risks.
- Regulatory standards that would better allow for re-use.
- Contractual facilitation of an interdisciplinary re-use project teams.

Broader context

A mind-shift beyond the project team might be needed to scale op the re-use concept. However, further development of the re-use market and growing experience, knowledge, and acceptance of the re-use concept are expected. Some of the suggestions of the research, including the need for early investments and the selection of a motivated team, are closely related to this and will, therefore, become less relevant once the concept has been further developed. In addition, the development of the re-use concept goes hand in hand with the design for disassembly strategy. Once buildings are easier to be disassembled, re-using them would become less difficult which would accelerate the re-use concept.

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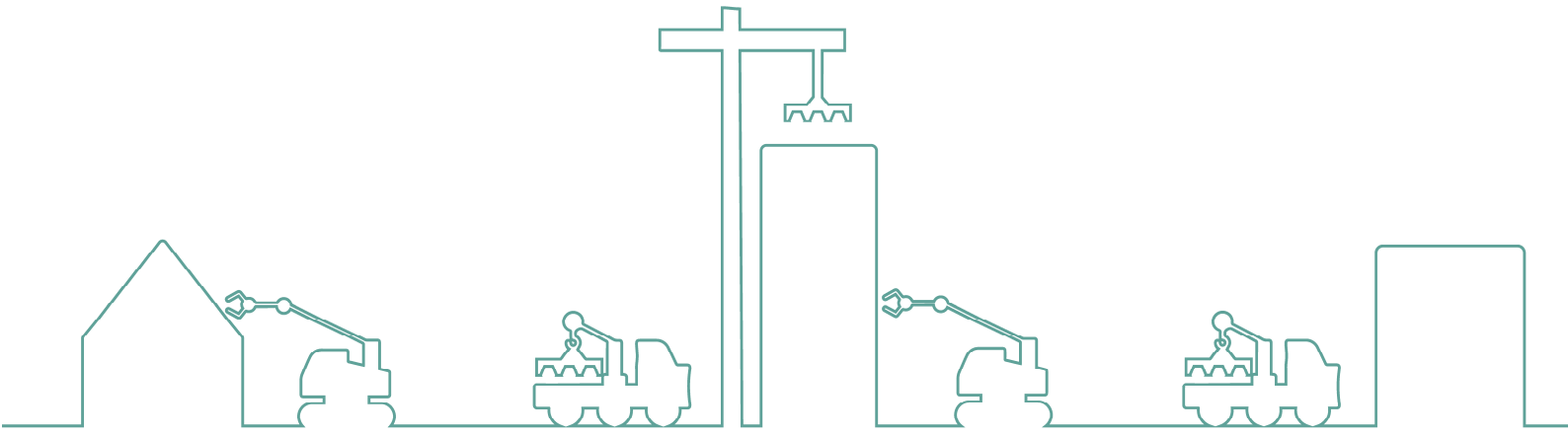
CHAPTER 1

INTRODUCTION



1.1 Problem statement

“A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems.” (Ellen MacArthur Foundation, 2017). This concept is proposed to change the current consumption and production patterns, as they put high pressure on the planet and its capacity, and is recently getting momentum in multiple fields including politics and business (Leising, Quist & Bocken, 2017).

In the last decades growing concerns about the planet’s resources are seen, leading to the development of more sustainable strategies that are crucial to sustaining human activities in the coming years (De los Rios & Charnley, 2017). In 2015, to achieve a better and more sustainable future, the United Nations (UN) adopted the Sustainable Development Goals (SDG) (UN, 2015). One of these goals includes to “Ensure sustainable consumption and production patterns” (UN, 2015). The UN mentions the need for reducing the use of natural resources and has set targets that aim for sustainable management of resources and substantially reducing waste by 2030. As mentioned, the principle of circular economy aims at minimizing waste and therefore the principles of the circular economy (further referred to as CE) could be adopted to contribute the achievement of the goals as set by the United Nations.

The Dutch government has set a goal concerning circularity as well: achieving a circular economy in the Netherlands by 2050 (The Ministry of Infrastructure and the Environment and the Ministry of Economic Affairs, 2016). A 50% decrease in the use of primary resources by 2030 is set as an interim goal. In addition, the Netherlands aims at a 49% decrease in greenhouse gas emissions in 2030 compared to 1990 (Rijksoverheid, n.d.). One of the described priorities is the construction sector, as the construction industry is responsible for the use of high amounts of resources (The Ministry of Infrastructure and the Environment and the Ministry of Economic Affairs, 2016). “The construction industry is estimated to account for 50% of the raw materials used, 40% of total energy consumption, and 30% of total water consumption in the Netherlands. Also, a large proportion of waste in the Netherlands (approximately 40%) involves construction and demolition waste, while the sector is responsible for approximately 35% of CO2 emissions.” (The Ministry of Infrastructure and the Environment and the Ministry of Economic Affairs, 2016, p. 58). It is even stated that the construction sector is globally the largest consumer of natural resources with about 40% of all resources extracted from nature (van den Berg, 2019). The significant impact of the construction sector on the environment and the need to improve this position is confirmed by several scholars (Ghisellini, Ji, Liu & Ulgiati, 2018; Pomponi & Moncaster, 2017; Ghisellini, Ripa & Ulgiati, 2018; Nasir, Genovese, Acquaye, Koh & Yamoah, 2017; van den Berg, 2019). This underpins the importance of making the building sector less resource-intensive. The principles of the circular economy have been proposed for more effectively approaching and evaluating the sector, and thereby minimizing its environmental impact. For example, a case study comparing a linear and circular supply chain demonstrates that the circular supply chain has led to significantly lower emissions than the linear supply chain (Nasir et al., 2017). It is also found that emissions, resulting from waste, could be avoided by re-using products (Nasir et al., 2017). However, more research on how to prevent waste and close resource loops on a building level is required (Ghisellini, Ripa & Ulgiati, 2018; Leising et al., 2017; Pomponi & Moncaster, 2017).

In the Netherlands, several buildings are promoted as examples of circular construction. One example is the temporary courthouse in Amsterdam. Because of its temporary nature, this

building is designed and constructed to easily be disassembled and re-used for another function (CFP Green buildings, 2019). Another example of a circular building is the renovated Alliander office in Duiven. Here, the focus was on re-using materials, and this building is made out of 83% recycled material (CFP Green buildings, 2019). This way of re-using existing building materials in building projects is clearly visible in the façade of the Europa Building as shown in Figure 1.

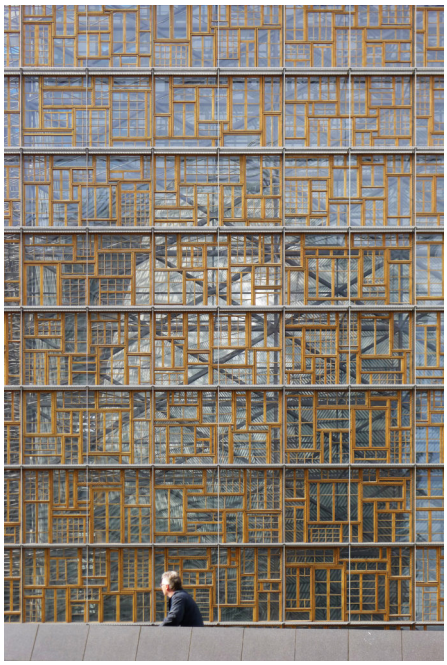


Figure 1. Europa Gebouw (Henrard, 2017)

These examples show two different perspectives of approaching circular building methods. Firstly, by designing buildings based on such principles that it is possible to disassemble and re-use products afterward. This design method is often called “Design for Disassembly”, and integrates waste prevention into the design process (Gorgolewski, 2008). This method results in benefits only after the building is taken out of service and dismantled.

Secondly, designing buildings with the intention to re-use existing building materials upfront. This perspective offers benefits sooner, as it deals with products that are already in use. Especially within the built environment, this is an important dimension, as buildings have a long life span of, on average, at least 60 to 90 years (Pomponi & Moncaster, 2017). Excluding maintenance and replacement of interiors, that occur throughout a building’s lifespan, a project that is built for disassembly now, would not result in any material savings for 60 to 90 years, while the goals concerning the reduction of raw materials are already to be achieved in 10 to 30 years. Additionally, it is suggested that older cities have a high potential for re-use, firstly because of the potential to re-use the existing building elements, but also due to many demolition projects and little need for new infrastructure (Gorgolewski, 2019). Brunner (2011) even suggests that for cities in steady-state, mature cities in which import and export of resources are in balance, it is supposable that 80% or more of the primary resources could be replaced by secondary resources. Although the Netherlands consists of many older and developed cities, where both demolition and new construction projects are ongoing, this number seems to be too opportunistic. Research into the waste streams and expected demand for new residential and non-residential buildings in the Netherlands suggest that there is a higher need for materials for new buildings than the amount which comes available from demolition and disassembly (Cirkelstad, 2020). This report indicates that a difference

will remain, however, it will become lower over time. It is suggested that this would mean that in 2030, in theory, 59 percent of the building materials and elements could originate from secondary resources (Cirkelstad, 2020). Much is recycled, but only little demolition waste re-used at this moment, this suggests a significant potential to improve re-use in the Netherlands. Several studies and institutes support the stimulation of re-use of reclaimed components (Stichting Economisch Instituut voor de Bouw & Metabolic, 2020; Rakhshan, Morel, Alaka & Charef, 2020).

It is also important to mention that re-using components is considered to be more beneficial than recycling (Van den Berg, 2019; Gorgolewski, 2008). Re-use can generate savings in energy and greenhouse gas emissions compared to recycling. These savings are described to be estimated to be about 60% greater, as re-use preserves the embedded energy of the products (Environmental Protection Agency, 2006; Gorgolewski, 2008). Recycling is also less preferable as it generally reduces the object's quality, its opportunities for future use and its economic value. Therefore recycling is also called, "downcycling". The preference of re-use over recycling is also supported by Korhonen, Honkasalo and Seppälä (2017) by stating that in line with the principles of the circular economy, materials should first be re-used, refurbished and repaired, before remanufactured, only later be recycled. It should, however, be mentioned that re-use is not always more preferable as it also depends on the component characteristics, which might not contribute to the environmental impact of re-use. For example, the energy efficiency of the component or the use of toxic materials in the component are often an exception.

It is stated that, instead of developing specified building requirements, in circular projects, one should start with the creation of a vision for the product as well as the process (Leising et al., 2017). The creation of a vision is ought to be key in the transition towards a circular building sector and is of particular importance during the early stages of the circular economy where pilots and demonstration projects are taking place (Leising et al., 2017; Venselaar, Heintz & Lousberg, 2019). These visions help in providing an image of a possible future, but also provide coordination among actors, and guidance and orientation for joint action to achieve that future by setting shared goals and alternative guidelines (Leising et al., 2017). This suggests the significant role of the initiation phase in circular building projects where this shared vision could be shaped, market parties could be involved and the process is organized.

Integration is mentioned to be key to achieve circular building projects (Leising et al., 2017). Van der Wijk (2018) also states that circular building asks for a high degree of integration throughout the building process. Therefore, van der Wijk states that an integral manager is required and suggests that the general contractor might fulfil this role. However, the idea of the general contractor as an integral manager is only addressed in one thesis and is not entirely consistent with the collaboration tool developed by Leising et al. (2017). Therefore, it is desirable to get more insight into the role of integration in circular building projects.

The fact that there is a connection between innovations and project management is obvious and is discussed by several researchers over the last decades (Brady & Hobday, 2010). Although circularity in the building sector could be seen as a current innovation, there still limited research on how this concept affects the project and its management (Van den Berg, 2019). Besides, it is found that, although the concept of the circular economy is gaining momentum, knowledge and tools to put it into practice still need to be developed (Leising et al., 2017).

Above suggests the importance of project management during the initiation phase of circular building projects. The briefing is a substantial task during this phase and could play an

important role in the creation of a good starting point. In addition, the determination of the project organization and selection of the project team take place during this early stage and might play a role in the suggested integration. A better insight into the role of these aspects in circular building projects is therefore interesting.

1.2 Research aim

The role of the early stages is found to be of great importance in circular building projects. This research aims at obtaining more insight into the managerial tasks in these stages in circular building projects. It seeks at identifying the role of three project management aspects related to the early stages of a building project; the briefing, the project organization, and the selection of the project team, in relation to the degree to which building components are re-used. Understanding how these aspects could impact the degree to which building components are re-used, should help in the management of circular projects and make them better executable. This should contribute to the minimization of the resource intensity of the building sector.

1.3 Research questions

The main research question to be answered with this research is:

In what way can the briefing, the project organization, and the selection of the project team, contribute to re-using building components?

To answer this main research question, several sub-questions need to be answered. The sub-questions are categorized within two main themes:

Re-using building components and circularity

1. *What is the re-use of building components?*
2. *How do circular (re-use) building projects differ from linear projects?*
3. *What are the project management barriers/constraints for re-using building components (a) and how could they be resolved (b)?*
4. *What is the role of project management in the initiation phase of circular building projects?*

The briefing, project organization & selection of the project team

5. *What are standard practices concerning the briefing, the project organization, and the selection of the project team?*
6. *How are the briefing, the project organization, and the selection of the project team carried out in re-use projects, and does this contribute to re-using building components?*

1.4 Scope of the research

Circular building methods

As mentioned, one could have different perspectives on circular building methods, such as the perspective of design for disassembly or the approach of re-use upfront. This research focuses on the perspective to re-use building components upfront since this approach is supposed to have the potential in improving resource efficiency sooner. In addition, the research focusses on re-use rather than recycling, as re-use is considered to be more beneficial, but comes with bigger challenges in the building process (Gorgolewski & Morettin, 2009).

Re-using building components

Scholars distinguish different types of re-using upfront in the building sector (Rakshan et al., 2020). Firstly, adaptive re-use, which is defined as extending the life of a building or part of a building at the end of its useful life. It could also include building material recycling which includes the use of building materials in the production of new building products. Lastly, building component re-use is mentioned. This is defined as bringing back a reclaimed component with a minimum (or zero) treatments. Due to its potential to improve the environmental impact of the building sector, the need for specific management, but limited research on this topic, this research focuses on the latter, building component re-use (Van den Berg, 2019; Gorgolewski 2009; Pomponi & Moncaster, 2017).

When looking at the built environment, different scales can be considered. De Jong & Van der Voordt (2002) discuss the programming of building construction on the smaller scales (<100 m radius) and describe differences in life span, which relates to the dimension time, and easiness to move, that relates to dimension location. These dimensions are of particular interest in circular buildings, as location plays a role in the potential for re-use from site to site, and time is, in particular, an important dimension in the idea of closing loops.

Building components are constituent parts of a building that are manufactured as an independent unit, subsystem or subassembly, that can be joined or merged with other components to form a more complex product (Designing Buildings Ltd, 2019). In general, components are “self-contained” and distinguish themselves from materials in that way.

Brand (1995) describes buildings could be divided into several layers. These layers are shown in Figure 2 and come with varying lifespans. The 6 layers that are described include the following:

- Site, the geographical setting, or the external context.
- Structure, which includes the foundation and load-bearing elements.
- Skin, exterior surfaces.
- Services, including installations and moving elements like elevators.
- Space plan, the interior layout, including e.g. floors, walls, ceilings, and doors.
- Stuff, which includes furniture and all objects that move daily to monthly.

It is stated that one should distinguish between these layers as the lifespan of components impact the circular approach and should be considered when setting circular ambitions (Platform CB’23, 2019; Van der Weerd & Levels-Vermeer, 2018). For instance, the structure is hard to replace and , therefore, requires another approach than chairs and tables, as these are easier to replace. This also comes with different needs for project management, for example,

the process of building a concrete structure would require specific management, while placing a table doesn't necessarily require a responsible manager. This results from the characteristics of the process and the related requirements and risks of the components.

It is believed that the re-use of components within the layers stuff and site can be taken out of the scope of this research, as stuff can be easily re-used and replaced independent from the design and construction process, and the site, the external context, is beyond the control of the project manager.

Therefore, this research focuses on the building components within the layers structure, skin, services, and space plan as visualized in Figure 2. These layers have lifespans varying from 3 to 300 years. As visualized in Figure 2, examples of building components within these layers include beams and columns (structure), window frames (skin), radiators (services), and interior doors (space plan). Components within the layers site and stuff are excluded.

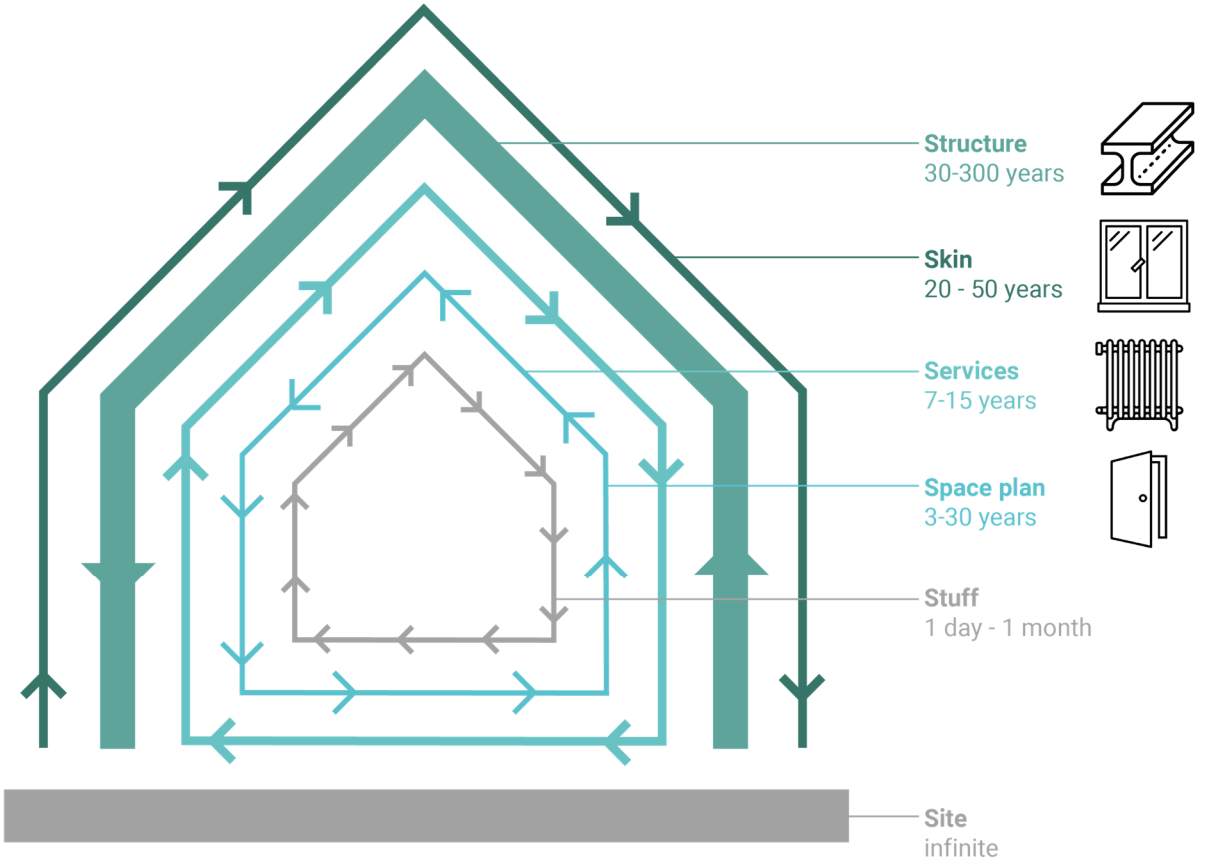


Figure 2. Layers of building as described by Brand (After Brand, 1995)

The re-use of building components has environmental benefits and is seen as an effective strategy to reduce the environmental footprint of the building sector (Rakhshan et al., 2020). Multiple articles are in line with this and mention the potential of re-using building components for improving the environmental impact of the building sector. Markus (2018), for example, states that most benefit will be achieved with the re-use of system elements such as façade panels, window frames, and columns. Besides, several circular building platforms are developed or in development which aim at stimulating circularity in the building sector by offering and selling second-hand building components (De Leeuw, 2017; Vissers, 2018; Verheijen, 2019). Rankings of circular waste prevention strategies, such as the 3-R principle, The Delft Ladder, and the 10-R model, also describes steps that should be considered, in

sequence, in each stage of the life cycle to prevent and slow down the degradation of products (Platform CB'23, 2019; Van den Berg, 2019; Addis, 2006). The re-use of components is ranked relatively high, which suggests its importance. In addition, it is stated that, in terms of Energy Saving Potential, re-use is considered to be the best option for several components, as well as an acceptable option for components such as wall finishes, internal walls, and partitions (Ghisellini, Ripa & Ulgiati, 2018). This suggests the potential of re-use on the component level and will, therefore, be the focus of this research.

Building types

It is of interest to differentiate between building types since different types of buildings have different characteristics. For example, non-residential buildings pose an extra difficulty concerning re-use, as they are heterogeneous, which makes standardization more complex compared to residential buildings (Werkgroep verduurzaming utiliteitsbouw, 2018). Non-residential and residential building projects differ significantly, both in the organization as by content. Therefore, the project manager's role might also vary between building types and organizational context. Although non-residential building projects might also vary in content and organization, it is chosen to limit the scope of this research to these type of projects to limit variations in context.

Project management in the early project stages

In the identification of the different stages of the delivery of a building project, multiple terms are used and a variation in the number of phases can be seen. However, in principle, the phases include the same activities. Winch (2010) distinguishes the phases of briefing, design, planning, and execution. The briefing phase includes the initiation of a project with the development of an idea for a new building and specification which results in the brief. To refer to this early stage of the project's life cycle, different terms are used, e.g. briefing, initiation and planning, proposal and initiation, exploration, and initiation and definition (Ibbs & Kwak, 2000; Bosch-Rekveldt, 2011; De Wit, 1988). For this research, the term initiation phase will be used to describe the early stages of a project.

The management of the early stages is stated to have a major impact on project success (Morris, 1989). It is also stated that, in circular building projects, the activities that are taking place in the early stages of the project are of great importance (Leising et al., 2017). Therefore it is chosen to study the briefing, the project organization, and the project team selection.

Several roles that carry out project management tasks during the initiation phase are known. Firstly, a project sponsor, who acts in the interest of the client in the day-to-day management of the project and is considered to be crucial for the project's success (Bryde, 2007; Helm & Remmington, 2005). The project sponsor is usually an experienced manager, from within the client's organization or, if the project is undertaken by another organization on behalf of the client, from within that organization (Bryde, 2007). Since this actor represents the client and is responsible for the management, he/she is supposed to play a significant role in the management of the early stages of a circular building project (Ibbs & Kwak, 2000). Secondly, project management consultants could also be involved from these early stages of a building project (Nikumbh & Pimplikar, 2014). They are often involved in a project when there is no qualified (project) manager available at the client's organization and performs could be involved from the early stages of the project (Nikumbh & Pimplikar, 2014; Gooding, 1993).

Multiple roles of project management during the initiation phase are known, including those of the project sponsor and project management consultants. The briefing, project

organization, and selection of the project team are management tasks that should be conducted during this phase. This research focuses on the role of the project manager related to these aspects.

Context

This research will focus on the status quo of the building sector in the Netherlands, assuming the current state of availability of reclaimed building components and current experience concerning the circular building concept. Reviewing the current building sector by exploring the concept of re-use, is stated to be needed to increase the demand for, and effective implementation of, re-used building components (Gorgolewski, 2019). This should accelerate the road to a stage where re-using building components has become the standard. Although it is found that the legal environment, including standards, regulations, and contracts are barriers for the transition towards a circular building sector, the contractual relationships and legal environment are beyond the scope of this research (Van den Berg, 2019; Gorgolewski & Morettin, 2009; Gorgolewski, 2019). This research adopts the idea that a better insight into the role of the project management in circular building projects could help in improving the success of re-using building components, independently from the regulations and technical aspects related to the re-use of components. Besides, the financial aspects and business model, which are also discussed to be a restraint in re-using building components, are out of the scope of this research (Leising et al., 2017).

1.5 Research relevance

Societal relevance

As mentioned in chapter 1.1 the environmental impact of the construction sector is closely related to societal problems. Therefore the focus of this research to make this sector less resource-dependent by minimizing resource intensity through re-using components that are already in use implicates its societal relevance.

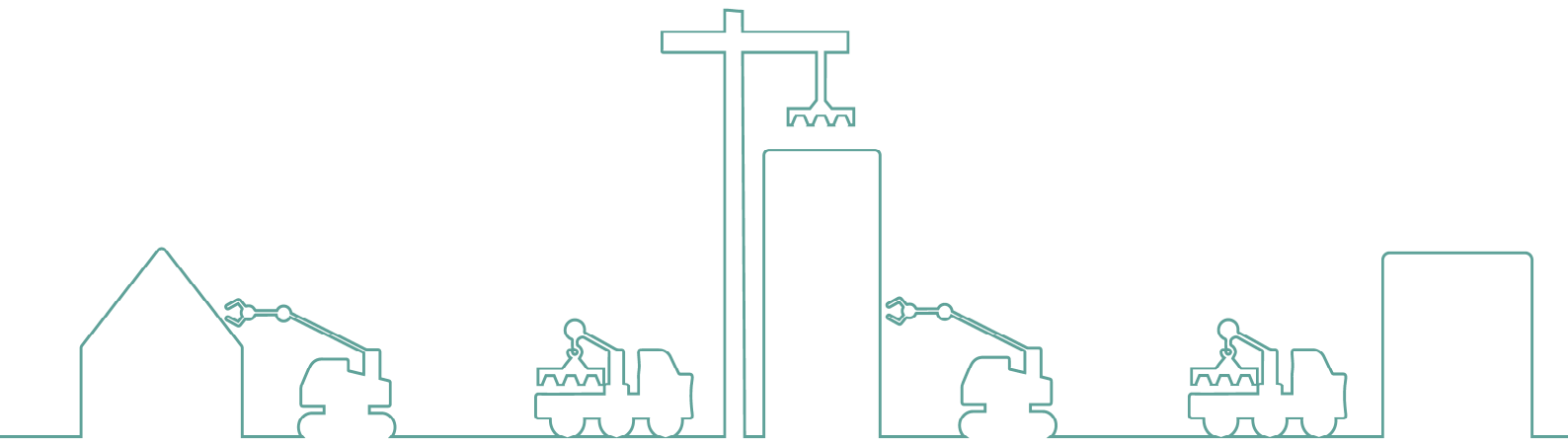
Scientific relevance

The concept of the circular economy is currently gaining momentum in several fields, including the construction sector (Pomponi & Moncaster, 2017). However, the literature on CE in the built environment is still in its early stages. Interdisciplinary research is found to be crucial for understanding and practicing the CE principles to the built environment, but there is a lack of this kind of research. Especially on the component level, where extremely few research has been conducted and these few studies mainly focus on a technical approach, rather than adopting an interdisciplinary approach. Exploring the re-use of building components from a management perspective would therefore contribute to the academic field of CE in the built environment.

Although this topic is rapidly developing and gaining momentum in academic research, limited research on the relation between the concept of the circular economy and its application in the built environment exists (Leising et al., 2017; Van den Berg, 2019). Especially the perspective of re-use in the building sector is hardly addressed and research tends to overlook the potential to close material loops by means of re-using components (Ghisellini, Ripa & Ulgiati, 2018; Van den Berg, 2019). Investigating the practice of project management in relation to the concept of re-using building components would, therefore, supplement to the existing academic collection.

CHAPTER 2

RESEARCH METHODS



2.1 Type of research

The research aims at addressing how project management tasks including the briefing, the organization of the project, and the selection of the project team could contribute to the re-use of building components. The idea of building with significant amounts of re-used components and its management is a relatively unexplored concept (Van den Berg, 2019; Leising et al., 2017).

Based on objectives, the research is exploratory, as little research has been done before, and explanatory, as it aims at understanding the relationship between project management aspects and the degree to which building components are re-used (Kumar, 2011). There is little data to be found concerning project management of re-use projects, and relatively few building projects have been completed where re-use was a central ambition from the beginning. The exploratory and explanatory nature and the limited availability of data suggest that a qualitative approach suits this research. As literature has not been sufficient to answer the research questions, and many barriers relating to the re-use of building components are of a social nature, the research also included social research (Bryman, 2012; Gorgolewski, 2008). In specific empirical research, which means that conclusions are based upon evidence gathered from information from real-life experiences or observations (Kumar, 2011). This type of research is of particular interest in this study as experiences and observations of people in the field and existing cases are the main source of information, due to the explorative nature of the research.

2.2 Methods and techniques

To be able to answer the research questions, the research has been split into three phases. The first phase consisted of the exploration of literature to specify the current state of knowledge about the re-use of building components and project management during the initiation phase, relating to the first four sub-questions and the theoretical insights related to the management activities. This created the base for understanding the nature of re-using building components (1) and some insight into how re-use projects differ from linear projects (2). It also pointed out barriers relating to re-using building components (3) and has defined the role of project management in the early phases of (circular) building projects. Lastly, it provided knowledge concerning standard practices of the briefing, the project organization, and the selection of the project team (5). This has been done by focusing on two areas of interest. Firstly, re-use of building components within the context of circularity in the built environment. Secondly the briefing, project organization, and selection of the project team. This phase aimed at generating an understanding of the role of the project management tasks during the early phases and has set the basis for grasping the nature of re-use building components and related barriers. This has offered a good starting point for the following phases. Phase 1 concluded with the development of a conceptual framework that identifies the concepts that had to be further investigated in the following phases. The following phase, which included empirical research, has led to a better understanding of the in the literature identified topics and supplemented them with additional practical insights.

The empirical research has taken place in phase 2 and included expert interviews and an in-depth study of two cases. This second phase aimed at getting a deeper understanding of how re-use projects differ from linear projects (2), what the management barriers and constraints of re-use projects are and how these could be resolved (3), what the role of project

management in the early stages of a re-use project is (4) and if, and how, the briefing, project organization, and the selection of the project team, influence the degree to which building components are re-used (6). People active in the field of re-used building components, including project managers and other actors, have been interviewed on the, in literature identified, differences and barriers, as well as on project management related topics and tasks. The interviews have helped in exploring the practices of re-use projects and their management. The subsequent in-depth study of the cases has revealed the identified concepts and processes within a certain context, the cases. This has given specific insight into how the briefing, the organization of the project, and the selection of the team have contributed or restricted the extent to which building components are re-used in these practices.

The last phase included a synthesis of the previous phases. This included the merging of the findings from the literature and the empirical study. This resulted in the answering of the main research question, and the development of a project management framework and a re-use process flow chart.

A visualization of the research design can be found in Figure 3. The methods and techniques of the conducted research are described in the following paragraphs. It should be mentioned that, although the phases followed each other, the research had an iterative character. This means that the concepts and ideas that have popped up in the early phases were reconsidered once new information came available.

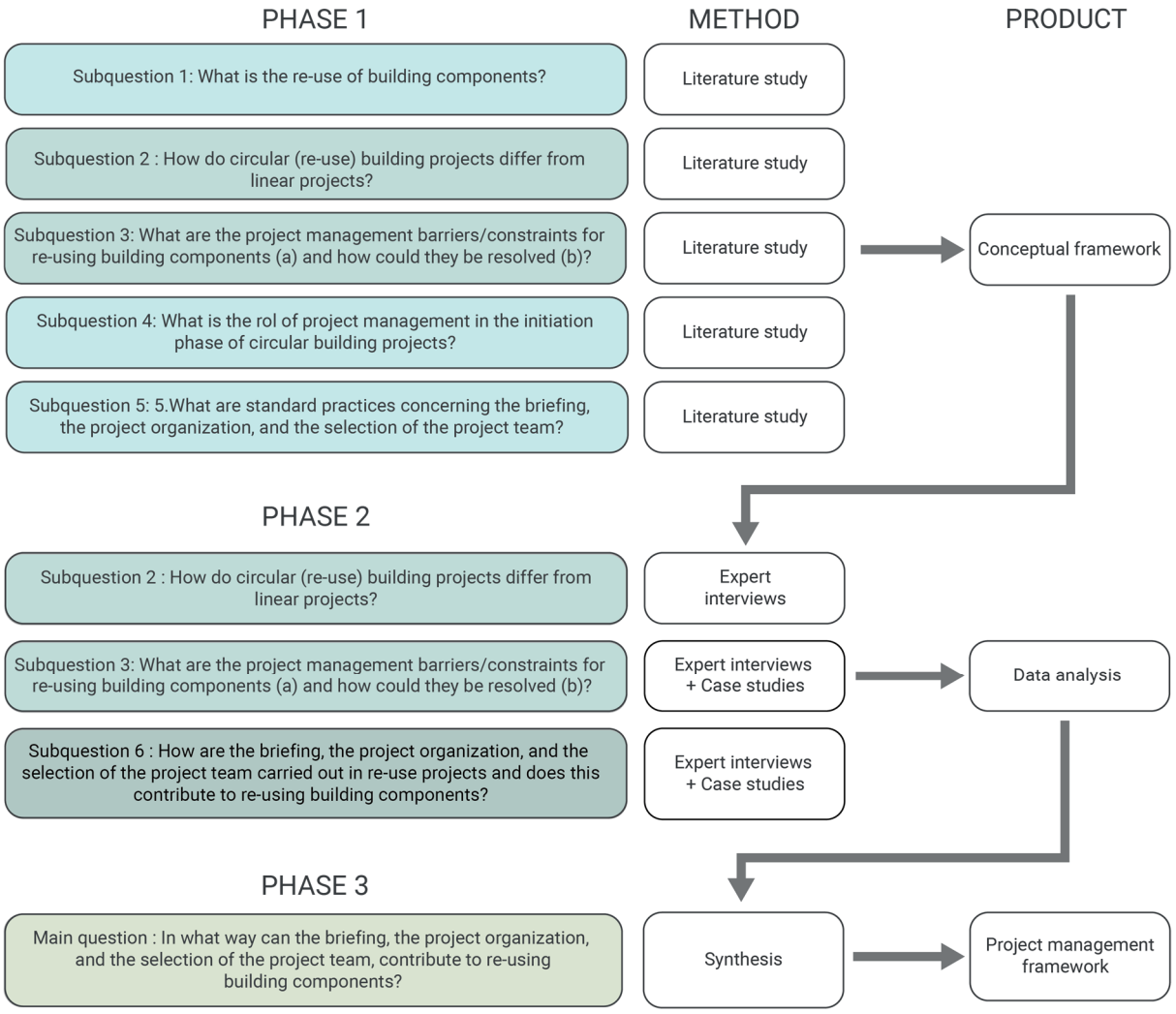


Figure 3. Research design

2.3 Literature study

As mentioned, a literature study has been conducted in the first phase of this graduation research and has formed the basis for the phases to follow.

This phase aimed at answering the following sub-questions:

1. *What is the re-use of building components?*
4. *What is the role of project management in the initiation phase of circular building projects?*
5. *What are standard practices concerning the briefing, the project organization, and the selection of the project team?*

And setting a substantial basis in answering the following questions:

2. *How do circular (re-use) building projects differ from linear projects?*
3. *What are the project management barriers/constraint for re-using building components (a), and how could they be resolved (b)?* – sub-question 3a is the main focus of this phase.

The literature study aimed at defining what is meant with the re-use of building components and defining the different project management tasks, the briefing, the organization of the project, and the selection of the project team. It also pointed out some suggestions for these activities in re-use projects. Also, it had sought to identify how re-use projects differ from linear projects and what barriers are related to this.

The topics that have been looked at in the literature review included:

1. Re-using building components and circularity
2. The briefing, project organization & selection of the project team

The literature study has been used to develop a conceptual framework that has been built upon in the subsequent empirical study. The framework has been developed once the literature study has been completed and contained concepts to be further investigated in the empirical research.

2.4 Empirical study

The empirical study aimed at exploring the practices of re-use projects, based on the in literature identified topics, as visualized in the conceptual framework. It could be seen as making a puzzle based on several starting points, but without knowing the full image that the puzzle should form (Figure 4). By questioning the starting points, in this case, these starting points included the in literature identified topics, a better understanding of these starting points has been created and new starting points have been identified. Moreover, analysis of the data and the mind experiment has helped in connecting the different starting points. The aim of the empirical research was not to complete the puzzle, but to create a better understanding of the identified concepts and to be able to connect them.

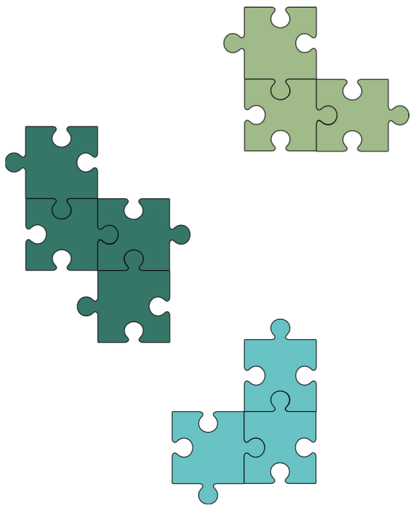


Figure 4. Empirical puzzle

Expert interviews

The concept of re-used building components was only little discussed in the literature and little information is available online. However, several projects are known for having re-used building components or are currently in development. The research aims at understanding how project management could contribute to the re-use of components, therefore it was needed to get a better insight into how re-use projects are taking place. Therefore qualitative data had to be collected. As mentioned, there are only a few projects that include a significant amount of re-used building components. This means that the group of experienced people is limited, but these people, the experts, had experiences that helped in achieving an understanding of re-use practices.

Interviewing is a very widely employed method in qualitative research and is advantageous as it is flexible and could be accommodated relatively easily (Bryman, 2012). An interview includes "a verbal interchange, often face to face, though the telephone may be used, in which an interviewer tries to elicit information, beliefs or opinions from another person" (Burns, 1997, p. 329). Thereby it has helped with collecting the data that was needed to answer the research questions based on the expert's experiences and has helped in achieving a better understanding of re-use projects and their management within a limited period. There are several types of qualitative interviews. One common type is the semi-structured interview (Bryman, 2012). Semi-structured interviews include the interviewer preparing a list of questions or relatively specific topics, that have to be covered and are discussed in each interview. However, the order of questioning is flexible and the interviewer could also respond to things brought up by the interviewee itself. Thereby this type of interviewing leaves room for concepts and theories to emerge during the interviews. The interviews followed the literature study which has concluded in the identification of several concepts relating to sub-question 2 and 3(a) and could, therefore, be used as input for the interviews. Besides, the interviews sought to gather information relating to the "how" of sub-question 3(b) and identifying concepts relating to sub-question 6. Therefore, semi-structured interviewing was chosen to be used to gather qualitative data. Next to answering research questions, the interviews have been helped to identify one of the cases that was worth to be studied in depth.

The experts that have been interviewed included, amongst others, people that have been involved in project management tasks in non-residential building projects that either have the ambition to, or have re-use(d), a significant amount of building components. These experts could give insight into the practices of these projects and could also compare them with linear building projects, as most of them have been involved in those projects as well. In addition, they have experienced management barriers during these projects and could describe them. Other experts included people that have experience with re-use projects as well but don't necessarily have project management responsibilities. The input from these experts also helped in obtaining a better understanding of re-use projects, the actors involved, and the related challenges. The study aimed at continuing with the conduction of interviews until no new themes will be discovered, which is known as the point of saturation (Lowe, Norris, Farris & Babbage, 2018).

Guiding themes and questions interviews

The following questions have been the focus of the interviews:

1. What is the interviewee's background and experience with re-used building components?
2. How are building projects with re-used building components taking place and does, and if yes, how, this differs from linear projects?
3. How did the brief, project organization, and project team selection take place, and did this impact the degree to which components are re-used?
4. What are management barriers experienced in re-use projects and how are they, or could they be resolved?

A detailed interview protocol can be found in Appendix A. Due to the semi-structured way of interviewing this protocol only served as a guideline and the interviewer followed the interviewee based on the course of the conversation. Therefore, based on the interviewee's expertise and response the interviews varied between interviewees. The interview protocol also has been adapted after conducting some interviews to optimize the content of the protocol and reflect important themes.

The questions have been discussed in an open way, but the concepts identified in the literature relating to the differences in re-use projects and the barriers related to them, have been included in the protocol and have been questioned to see whether or not these aspects are also experienced by the interviewees, as well as seeking a better understanding of them.

Data collection

The interviews included face to face, telephone, and online interviews. For the interviews, an interview protocol has been set-up in advance. The interviews have been recorded and transcribed unless the interviewee objected.

Data analysis

The interviews have been analyzed by following the concept of thematic analysis (Nowell, Norris, White & Moules, 2017). This includes a method for identifying, analyzing, organizing, describing, and reporting themes that are found within a data set. This methodology is described to be accessible and relatively easy. It is also useful in examining the perspectives of different research participants, highlighting the differences and similarities, and generating insights. Also, this method could help with summarizing key findings of large data sets and produce a clear and organized report, by forcing the researcher to adopt a structured approach in handling the data. As this research involved multiple interviews, this methodology has been insightful in structuring the findings.

According to Nowell et al. (2017) thematic analysis includes the following steps. The generation of initial codes, subsequent translation into themes, a reflection of the themes, and lastly an analysis of the coded data set.

At first, one should get familiar with the data and follow this by generating initial codes. Which is seen as reflection and interaction that makes one think about the data. The generation of codes includes both deductive codes, arisen from literature, and inductive codes, that have

appeared during the interviews. Once the initial codes are developed, they are analyzed and translated into themes.

Themes include concepts that stand on their own and are seen as a significant concept that links data. The themes mainly resulted from the topics included in the conceptual framework, however, some additional themes were developed based on additional topics that have been discussed in the interviews. Again, the themes are reviewed afterward, by reviewing the coded data for each theme and checking whether a coherent pattern is seen and whether the codes reflect the data set in its entirety. The analysis concludes with a detailed analysis of themes, including identifying relations between them.

This has been done by using the software ATLAS.ti, a workbench for qualitative analysis of large bodies of textual, graphical, audio, and video data and includes software that is intended to support social researchers with the interpretation of a text (ATLAS.ti, 2020; Muhr, 1991). The tool is specifically intended for qualitative research such as the analysis of interviews and discussions.

Themes and codes, based on the topics that were to be researched with the expert interviews, have resulted from the literature study (deductive codes). In addition, new themes and codes have arisen throughout the analysis of the interviews (inductive codes). An overview of the themes and codes that are used to analyze the expert interviews are shown in the table below. These themes and codes are used as a starting point for the analysis of the case study interviews and have been further developed.

Group	Deductive	Inductive
Differences	- Differences linear vs circular	
Briefing	- Dynamic briefing - Definition of clear goals - Initiation re-use vision	- Importance - Maintenance throughout process
Project organization	- New project delivery approach - Adjusted supply chain - Cyclic phasing - Extended initiation phase	- Start identifying components - Milestones
Project team selection	- Interdisciplinary project team - Early involvement - Collaboration and shared vision	- Motivation - Project champion
Barriers	- Attitude towards re-use -Lack of experience and education - Information - Market - Sorting, transporting & recovery - Regulatory standards - Timing	- Building specifications - Quality and characteristics components - Costs
Client	- Role client	

Table 1. Coding expert interviews

Case studies

Case studies are useful when exploring an area where little is known or where one wants to have a holistic understanding of a situation or phenomenon (Kumar, 2011). Case study research is of relevance when the focus of a study is on extensively exploring and understanding, rather than confirming and quantifying. This research is exploratory and aims at achieving a better understanding of re-use practices and its management. Studying specific cases in depth has helped in achieving a holistic understanding of those practices and explore how certain project management tasks are carried out and whether or not they have contributed to the re-use of building components. In addition, it helped in verifying preliminary findings and conclusions. This has helped in answering sub-questions 3(b), and 6.

According to Yin (2002), a case includes: "a contemporary phenomenon within its real life context". A case study includes an empirical inquiry that investigates a case or cases by addressing the "how" or "why" questions concerning the phenomenon of interest. Within this research, the phenomenon includes building projects with re-used building components. The sub-questions that had to be thoroughly answered through case studies included what project management barriers are experienced and in specific, "how" they are to be resolved (3b) and if and "how" briefing, the project organization, and the selection of the project team influence the degree of re-used building components (6). Studying two cases in-depth has led to additional and more extensive knowledge, which enables to answer how many of the experienced barriers are or could be resolved (sub-question 3b). It has also led to a more thorough understanding of the relationship between project organization, selection of the project team, and briefing and the re-use of building components (6). The knowledge concerning the barriers, found in literature and interviews, and the discussed concepts relating to project organization, selection of the project team and briefing, have been the starting points for the case study.

However, synthesis has been needed to answer the research questions as it required analysis of the different cases and reflection on whether or not certain tasks indeed contributed to the re-use of building components.

Guiding themes and questions case studies

As mentioned, the literature study and interviews pointed out several aspects that had to be further investigated in the case studies. However, to make sure that the research questions were addressed the following questions were key:

1. What management barriers and constraints are experienced and how could they have been overcome?
2. How was the project organized and did this impact the degree to which building components are re-used? If so, how?
3. How did the selection of the project team take place and did this impact the degree to which building components are re-used? If so, how?
4. How did the briefing take place and did this impact the degree to which building components are re-used? If so, how?

Case study criteria and selection

As mentioned before, the re-use of building components is not carried out extensively in practice. This means only a limited amount of cases with re-used components have been fully carried out.

In the setup of a case study selection process, it is of importance to construct a set of criteria that guarantee a well thought out and structured decision-making process. However, as there are only limited cases, it should be mentioned that the criteria could not be too strict and that the main aim of the criteria was to secure that the cases were selected in line with the scope of the research (as described in chapter 1). This is required to decrease the differences in the context between the chosen cases and thereby to allow better comparisons. Besides, the aim was to study cases that include high ambitions related to re-use, as re-using very few components probably doesn't significantly alter the process. The process also aimed at selecting projects that are (almost) realized, as this allows for reflection on the actual degree of implemented re-used components. The case study criteria are shown below.

Case study selection criteria:

- It includes a non-residential building project in The Netherlands.
- The project must include the ambition to make significant use of re-used building components.
- The cases must at least involve one project that is in a stage where the project organization is defined and a project team is shaped, and, if possible the construction phase has been completed.

Data collection and analysis

Multiple types of data collection in case studies are described (Yazan, 2015). These include documentation, archival data, interviews, observations, and physical artifacts. This case study research has collected data by conducting two of these types: documentation and interviews. Case study documents have been studied by focusing on the, in the literature and expert interviews identified topics and study what components have been re-used. In addition, semi-structured interviews with people involved in the studied cases have been conducted. These have also helped in obtaining more information to be able to understand the related case study documents. As mentioned, semi-structured interviews are specifically chosen as the approach leaves room for theories and concepts to develop throughout the interview, while guiding the interview on major topics to be discussed (Bryman, 2012). For the case interviews, similar procedures and guidelines have been used as used in the expert interviews, as mentioned earlier. The general interview protocol that has been used in the case interviews can be found in Appendix B. Again the interview protocols have functioned as a guideline and the exact content of the interviews was based on the expertise and response of the interviewees. The protocol was also adapted throughout the interview process when more information comes available or specific topics required some clarification.

In line with the concept of thematic analysis, the themes and codes that have been used in the analysis of the expert interviews were again organized and further developed. Due to relevance and some new codes relating to the cases have arisen, some codes are left out in the analysis of the cases. The codes have been grouped, where applicable, based on main themes. The list of themes and codes that have been used and whether or not the code arose from literature or during the interviews, is shown in Table 2.

Group	Deductive	Inductive
Cases		- Info Case A/B - Re-use Case A/B
Briefing	- Dynamic briefing - Definition of clear goals - Initiation re-use vision	- Importance - Maintenance throughout process
Project organization	- New project delivery approach - Adjusted supply chain - Cyclic phasing - Extended initiation phase	- Start identifying components - Milestones
Project team selection	- Interdisciplinary project team - Early involvement - Collaboration and shared vision	- Motivation - Project champion
Barriers	- Attitude towards re-use -Lack of experience and education - Information - Market - Sorting, transporting & recovery - Regulatory standards - Timing	- Building specifications - Quality and characteristics components - Costs - Guarantees
Client	- Role client	

Table 2. Coding case study

2.5 Data and ethical considerations

The earlier described interviews have only been recorded and transcribed if the interviewees gave permission. During the interviews, personal data has been collected. Therefore, it was of high importance that the privacy and data protection requirements according to the General Data Protection Regulation (GDPR) are adhered. This has been done by following the guidelines that are set up by the Human Research Ethics Committee of the Delft University of Technology and included the use of an accepted informed consent form and data management plan.

This research has also respect the FAIR guiding principles by taking into account the following aspects (Wilkinson et al., 2016). The research identifies sources, when not confliction with privacy issues, in accordance with APA 6 referencing, has been written in English and will be uploaded on the repository of the Technical University of Delft, once completed and approved by authorized employees of the Technical University of Delft. This results in the data to be Findable, Accessible, Interoperable, and Re-usable (FAIR).

2.6 Synthesis

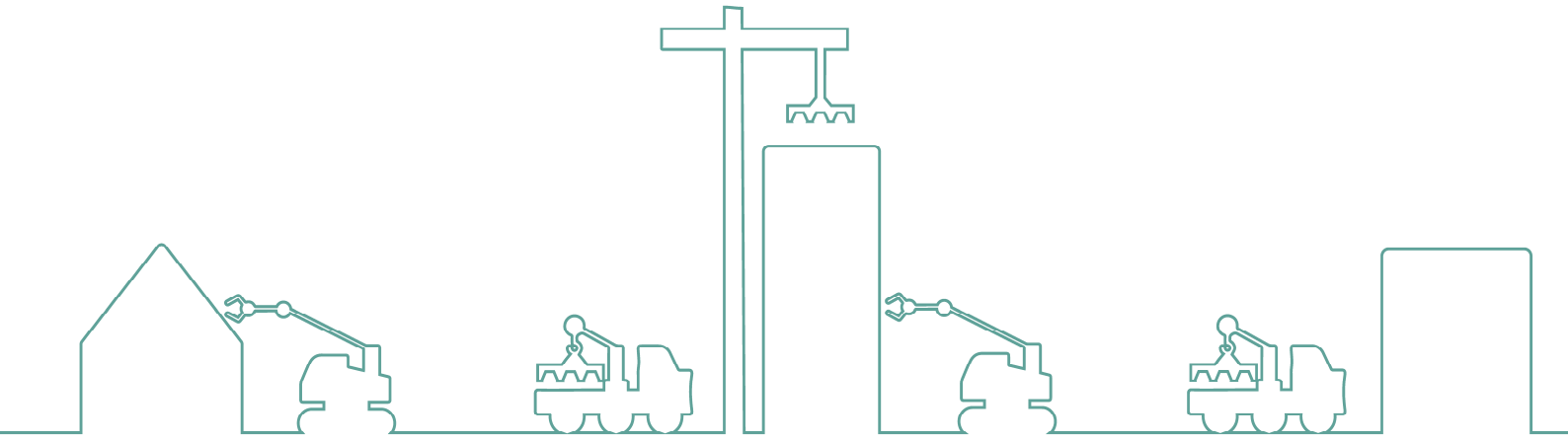
After conducting the literature study, interviews, in-depth case studies, and related analysis the findings and conclusions have been integrated.

An imaginary experiment has been conducted to synthesize the data. This included the imagination of the process from the start of the project, the idea to build with re-used components, until the construction. This imagination has helped in creating an overview of the impact of re-use on the building process. The steps and decisions that could be followed when re-using components are registered and visualized in multiple routes and subsequently combined.

The merging of the research steps and related data have been used to define a project management framework that describes project management aspects to be considered by the project manager to support the ambition to re-use building elements in future projects. The project management framework describes several recommendations related to each aspect, the briefing, the project organization, and the selection of the project team. In addition, a combination of the potential routes that could be followed to achieve re-use has been visualized in a flow chart of a re-use process. The preliminary findings and recommendations have also been discussed with some experienced project managers, to reflect on the clearness and incorporate feedback from practitioners.

CHAPTER 3

LITERATURE STUDY



3.1 Circularity in the built environment

Multiple definitions of the term circular economy are known. Rather than coming up with a new definition, this research takes on the widely accepted definition by the Ellen MacArthur Foundation: “A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the ‘end-of-life’ concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models” (Ellen MacArthur Foundation, 2013, p. 7). According to the Ellen MacArthur Foundation (2013) in a circular economy, one should “design out” waste to minimize the use of primary resources.

Recently the concept of circularity has received a serious boost (Leising et al., 2017). However, it is stated that this concept goes way back to 1966. By then, Boulding already wrote about a “cyclical ecological system that is capable of continuous reproduction of material form even though it cannot escape having inputs of energy” (as cited in Leising et al., 2017, p. 976). It is also stated that some scholars trace back the concept of circularity back to a model for circularity developed by Pearce and Turner in 1989. This concept is rooted in Industrial Ecology, as it focuses on the analysis and optimization of industrial systems, and developing a production and consumption models with closed material loops. The concept of Cradle to Cradle is also mentioned to be linked to the concept of CE because of its biomimetic approach in designing products, where biological and technical cycles are distinguished.

As mentioned, this research focusses on the contemporary idea of the CE as defined by the Ellen MacArthur Foundation. The basic principles of the CE as specified by the Ellen MacArthur Foundation are shown in Figure 5. This shows that products should be designed in that way that materials can be disassembled and re-used and only later be recycled or disposed. In addition, it distinguishes between biological (consumable) that can be returned to the biosphere and technical (durable) products, that can last in industrial cycles. Lastly, it is proposed that renewable energy is used. These principles are translated into four value propositions: minimize material usage, maximize the number of consecutive cycles, diversify re-use across the value chain, and avoid contaminated materials (Ellen MacArthur Foundation, 2013). Cheshire applied these principles to buildings, which lead to the following ideas (as cited in Van den Berg, 2019, p.6). Firstly, refurbish rather than demolish and rebuild. Additionally, aim at refurbishing, adapting, and refitting for a longer period. Replace virgin resources with waste from other industries. Lastly, try to keep materials pure, as this enables re-use, recycling, or composting at the end-of-life. The need to deal carefully with resources is stressed by several scholars including Ghisellini, Ripa & Ulgiati (2018, p. 636) by stating that “a resource-limited world cannot afford to throw away still usable resources, because of environmental challenges, of the shortage of strategic materials as well as the lack of land for landfill and treatment purposes.”

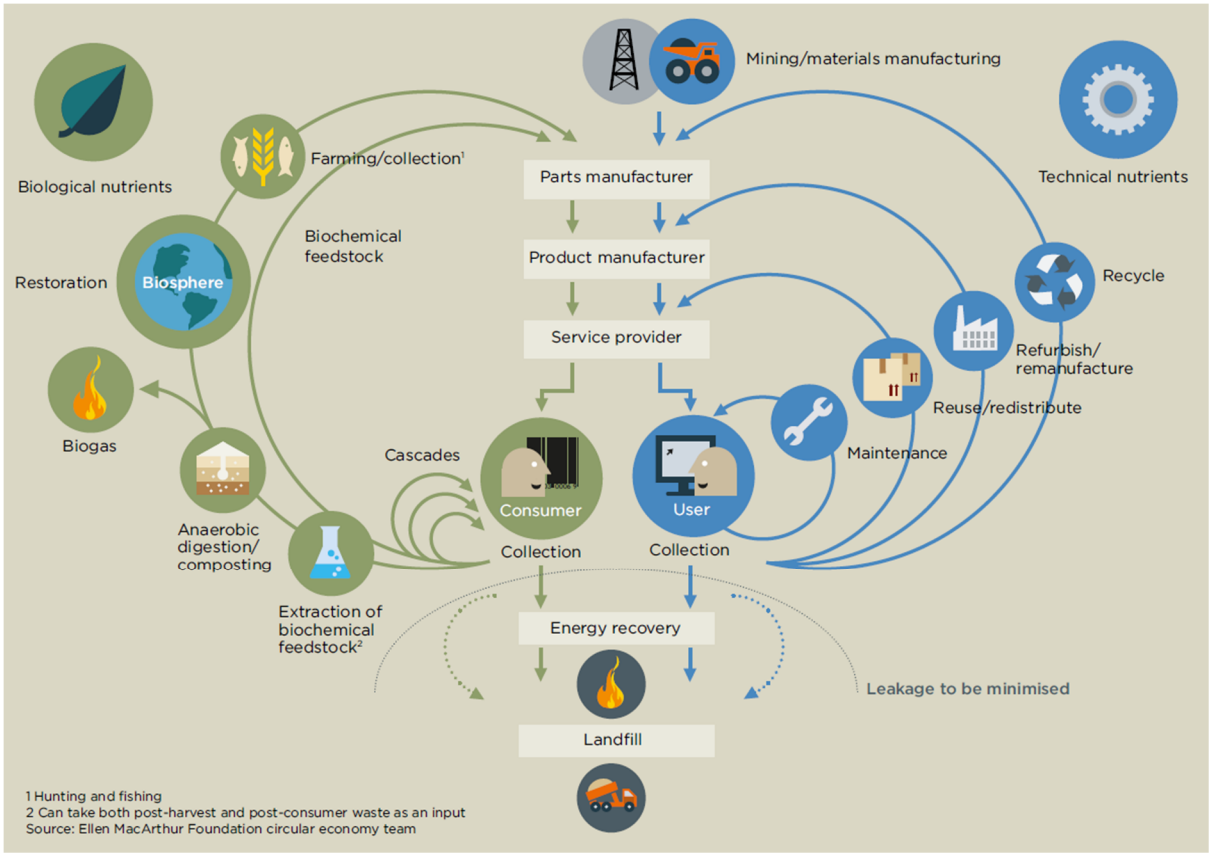


Figure 5. The circular economy visualized (Ellen MacArthur Foundation, 2013)

Knowledge and tools to put the concept of CE into practice still largely have to be developed (Leising et al., 2017). Especially within the building sector, where the main focus has been on energy use and efficiency. However, the construction sector is the world's largest consumer of virgin resources and causes 25-40% of carbon dioxide emissions globally (Pomponi & Moncaster 2017). As the building sector puts significant pressure on the natural environment, its role in the transition towards a CE is crucial and should be considered. Although there have been several attempts to improve the position of the building sector in the last decades, it is found that only focusing on the operations of buildings is not sufficient to reduce its impact on the environment. The most recent numbers of construction demolition waste in The Netherlands origin from 2010 and shows that most of the waste is recycled (about 95%), and little is used for energy recovery or landfill, but less than 1 kiloton per year is prepared for re-use (Figure 6) (Rijkswaterstaat, n.d.). Recycling only includes the outer circle of the CE scheme (Figure 5), while re-use is found to be more in the inner circles of CE. The small amount of re-use of construction and demolition waste in the Netherlands suggests the potential to make the construction sector more circular and significantly reduce the use of primary materials, by increasing the re-use of construction waste.

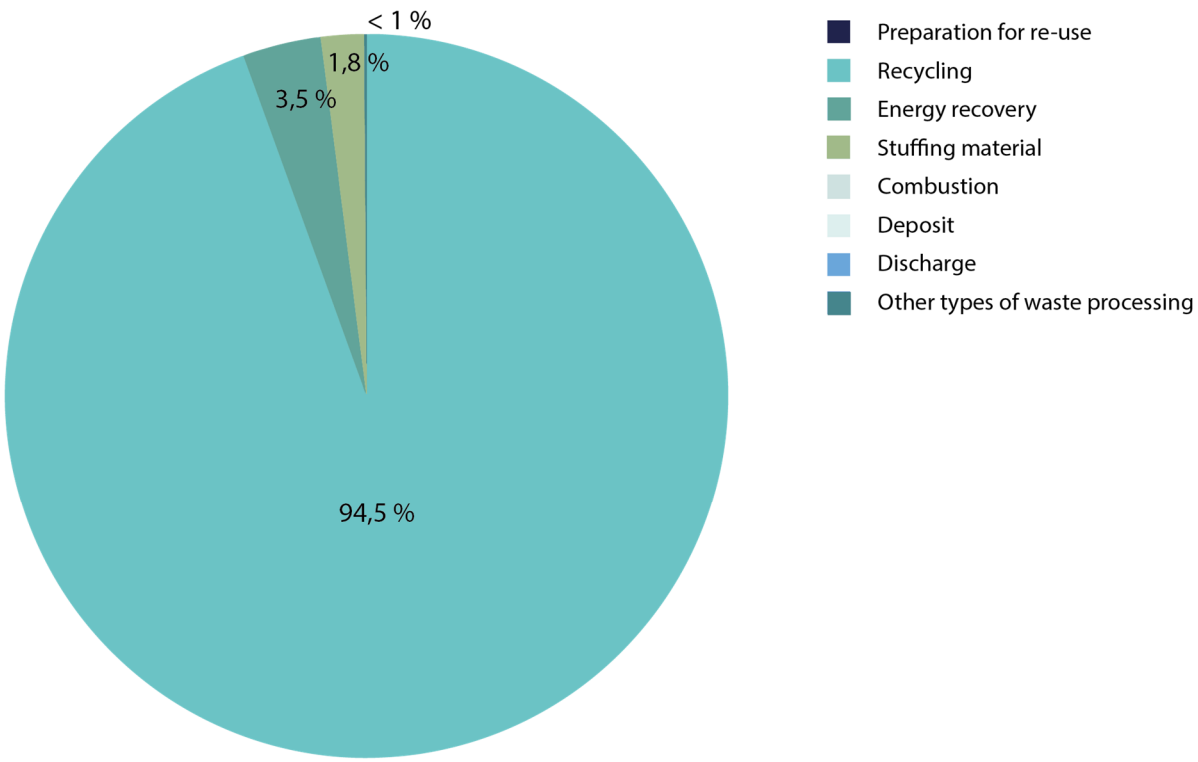


Figure 6. Visualization construction and demolition waste The Netherlands 2010 (After Rijkswaterstaat, n.d.)

Re-use of building components

As mentioned, both re-use and recycling of construction and demolition waste could contribute to lower the induced impacts in the end-of-life phase (Ghisellini, Ripa & Ulgiati, 2018). The balance could even become negative. The benefit results from the fact that the components return in future life cycles and thereby avoid the production of building components from raw materials.

Different models and ladders related to the degree of circularity and the strategies to prevent waste are known, e.g. the 3-R principle, the Delft ladder, the Ladder van Lansink and the 10-R model (Platform CB'23, 2019; Van den Berg, 2019; Addis, 2006). In general, the higher the strategy is ranked on the ladder, the lower the need for resources and the pressure on the environment, and thereby more circular. This research adopts the ideas of raking circular strategies as described in the 10-R model by "Planbureau voor de Leefomgeving" (PBL) as this model distinguished between types of circular measures and associated strategies (Platform CB'23; 2019). This is shown in Figure 7.

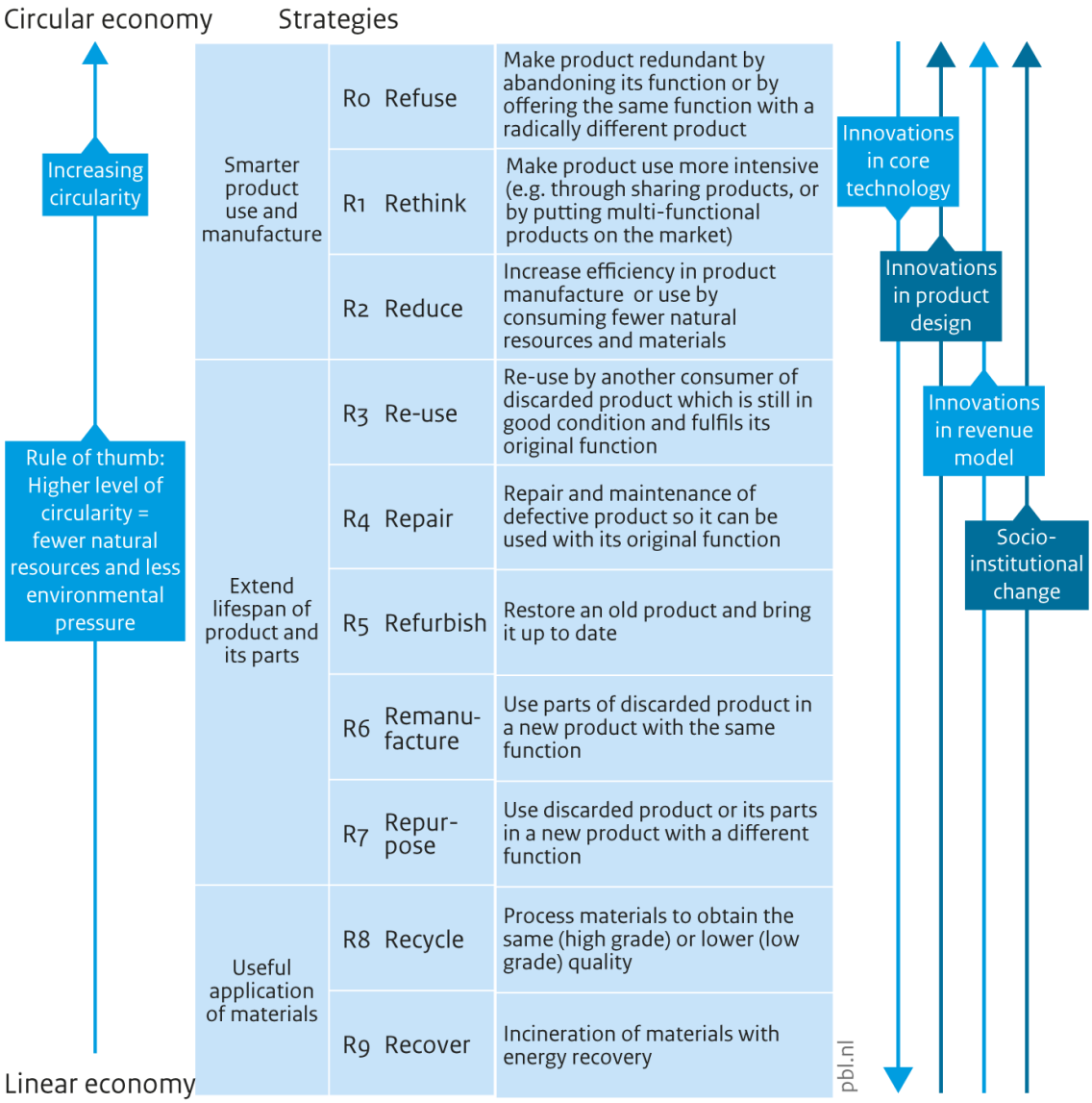


Figure 7. 10 R-model (PBL Netherlands Environmental Assessment Agency, 2017)

The R's within the category "extension of the lifespan of products and elements", R3 – R7, are seen as re-use in this research. However, it should be mentioned that it aims at achieving the highest possible R within this category, as this results in the lowest need for resources and lowest environmental pressure (Platform CB'23, 2019). It is also stated that higher circular strategies come with innovations that affect the whole supply chain and could lead to changes in rules, habits, and views. Which suggests the impact of re-use on building practices. The application of the 10 R's on the building sector is visualized, inspired by the model of the circular economy by the Ellen MacArthur Foundation (2013), and is shown in Figure 8.

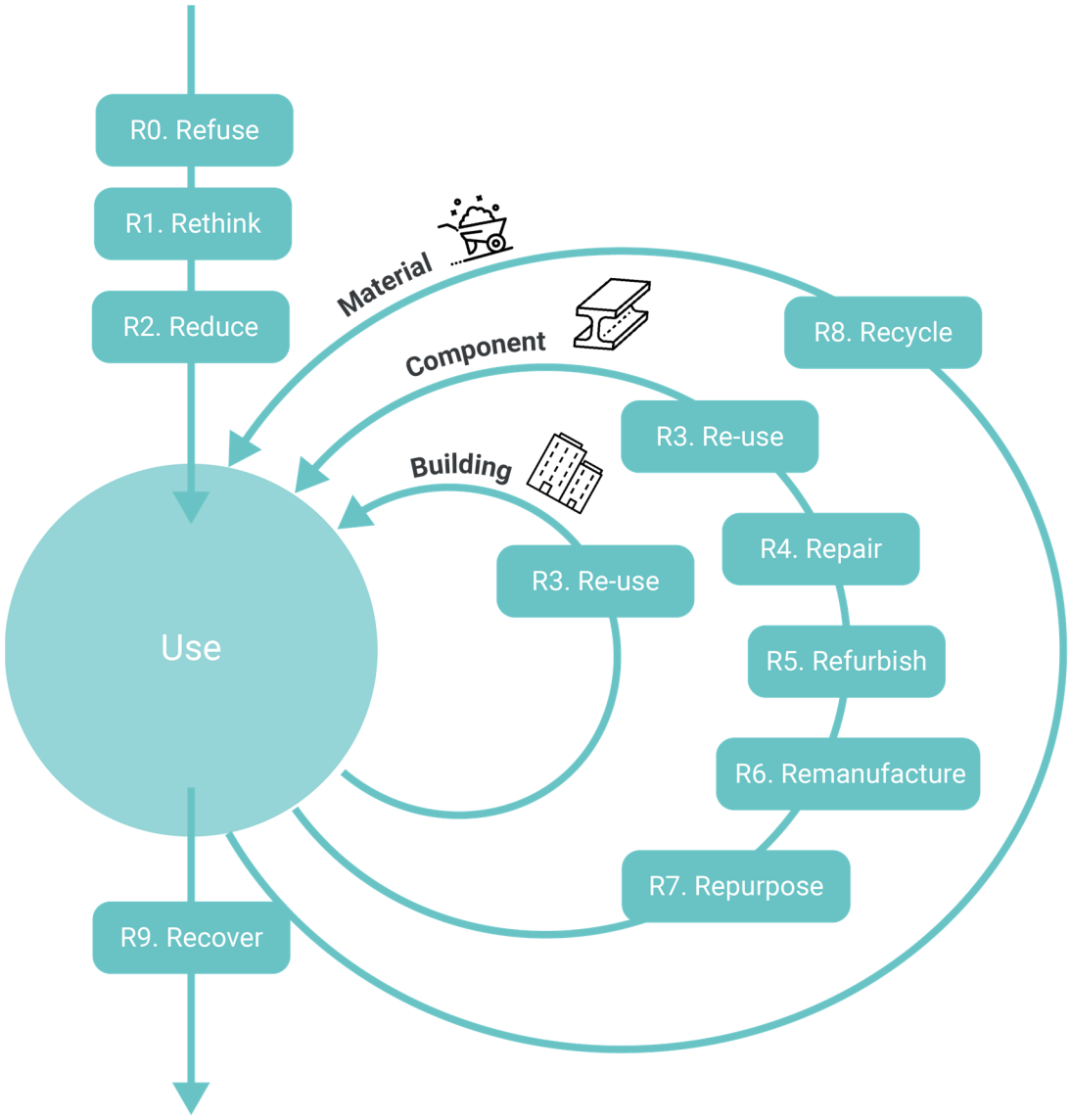


Figure 8. Application 10 R's to the building sector (After PBL Netherlands Environmental Assessment Agency, n.d.; Van Haagen, 2018)

For this research this means re-use includes both using a component again either for its original purpose or a familiar purpose, without significantly modifying its physical form and a minimum of operations of recovery, and component re-use for a different purpose, with a minimum of operations of recovery (Van den Berg, 2019; Ghisellini, Ripa & Ulgiati, 2018; Rakhshan et al., 2020). It doesn't include recycling, reprocessing recovered materials with manufacturing, and making a new building component of it (Van den Berg, 2019; Rakhshan et al., 2020). It also doesn't include re-use on building level.

In addition to the 10-R model, the literature describes different types of re-use on the component level within the scope of this research (Gorgolewski & Morettin, 2009). Firstly, on-site re-used components. This includes re-using components that are available on the site of the new building, as shown in Figure 9. Secondly, re-using building components salvaged from other sites (Figure 10).

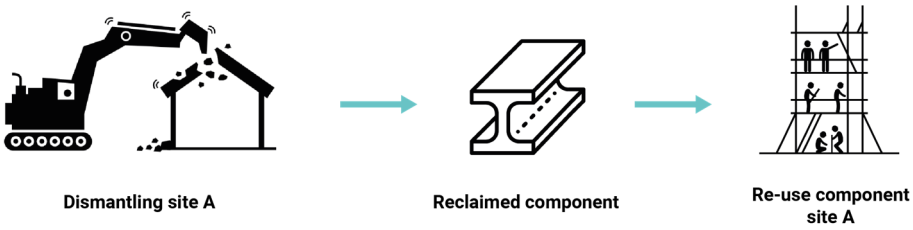


Figure 9. On-site re-use

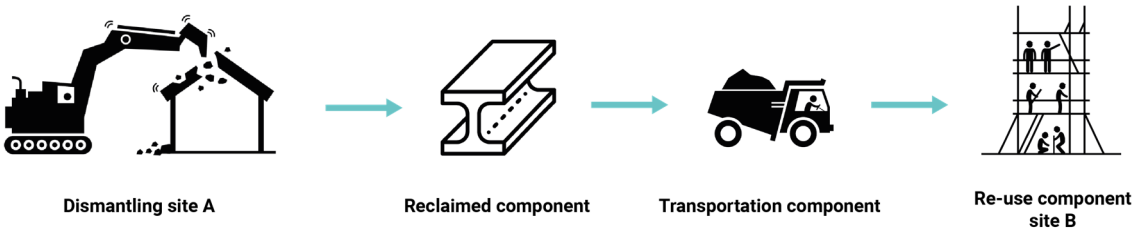


Figure 10. Off-site re-use

Gorgolewski and Morrettin (2009) also describe reconditioned components, components that are taken from a demolished building, and are in need of some improvement to be used in a new project (Figure 11 & 12).

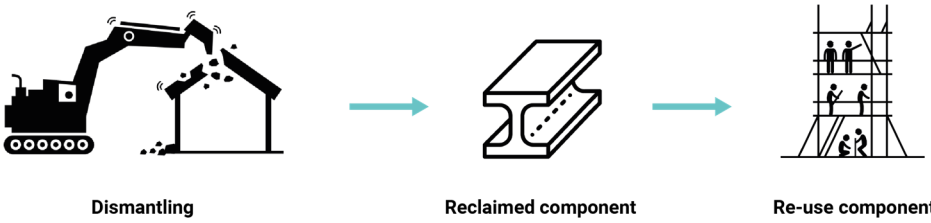


Figure 11. Re-use without reconditioning

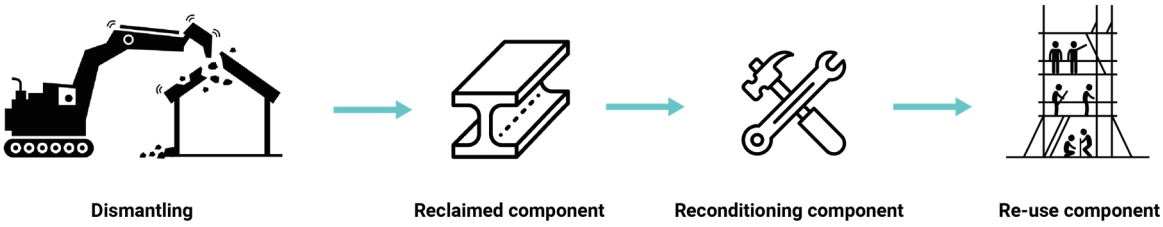


Figure 12. Re-use with reconditioning

In addition, it is of interest to distinguish between re-use from components that are already owned by the client and components that have to be acquired in the market. This is shown in Figures 13 & 14.

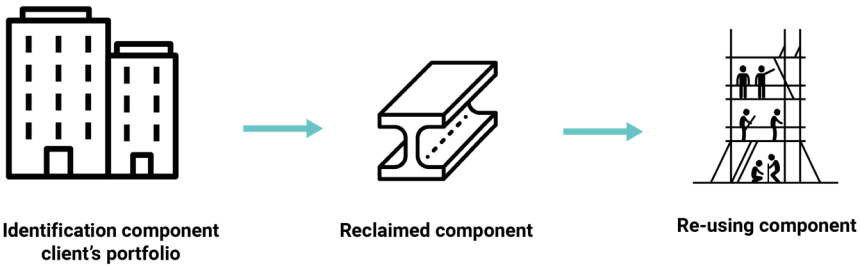


Figure 13. Re-use from the client's portfolio

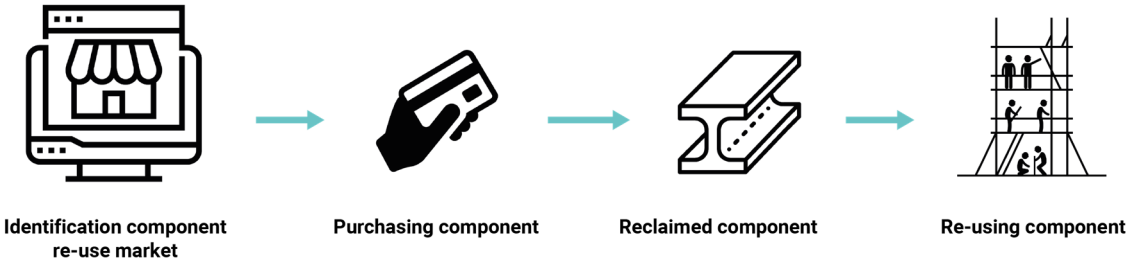


Figure 14. Re-use from the market

The type of re-use plays a role in environmental benefit. Re-using on-site results in lower energy use and Green House Gas emissions due to minimized transportation (Ghisellini, Ripa & Ulgiati, 2018). The environmental impact of off-site re-using strongly depends on the transportation distance. However, overall it is stated that re-using on-site has less impact than off-site, because of minimized transportation emissions. Both options are however better than landfilling, since re-using replaces primary recourses, and potentially leads to a reduction of concentrations of Green House Gas emissions, energy consumption, and costs of mitigation of air pollution and elimination of environmental impacts and health risks as a result of litter. Besides, as the 10-R model also implicates, the less reconditioning activities are conducted, the lower the environmental impact (PBL Netherlands Environmental Assessment Agency, 2017).

It also mentioned that the different types of re-use require different tasks and strategies, during different phases of the project (Gorgolewski & Morettin, 2009). In addition, differences in re-use types and availability in the market are seen. For example, reclaimed components from the market are often the most difficult to be integrated. These components have to be identified and sourced at the right time. On-site use offers opportunities to re-use what is already at the site. This issue of different patterns of availability and ownership has a great impact on the design process, as well as the planning and cost estimations. This requires a different approach to the project management as well.

As mentioned, different ways of re-use come with different barriers and processes, therefore, this research follows Table 3 to categorize the type of re-use. The main categorization includes whether or not the components are available at the site. Beside it will be distinguished based on the need for reconditioning and the need to acquire them in the market or not.

		No reconditioning	Reconditioning
On-site	Owned	Identification component client's portfolio → Dismantling site A → Reclaimed component → Re-use component site A	Identification component client's portfolio → Dismantling site A → Reclaimed component → Reconditioning component → Re-use component site A
	Market	Identification component re-use market → Purchasing component → Dismantling site A → Reclaimed component → Re-use component site A	Identification component re-use market → Purchasing component → Dismantling site A → Reclaimed component → Reconditioning component → Re-use component site A
Off-site	Owned	Identification component client's portfolio → Dismantling site A → Reclaimed component → Transportation component → Re-use component site B	Identification component client's portfolio → Dismantling site A → Reclaimed component → Reconditioning component → Transportation component → Re-use component site B
	Market	Identification component re-use market → Purchasing component → Dismantling site A → Reclaimed component → Transportation component → Re-use component site B or Dismantling site A → Reclaimed component → Identification component re-use market → Purchasing component → Transportation component → Re-use component site B	Identification component re-use market → Purchasing component → Dismantling site A → Reclaimed component → Reconditioning component → Transportation component → Re-use component site B or Dismantling site A → Reclaimed component → Identification component re-use market → Purchasing component → Reconditioning component → Transportation component → Re-use component site B

Table 3. Categorization type of re-use

3.2 Differences traditional and re-use projects

Traditional building projects

As mentioned before, different terms are in the identification of the different stages of the delivery of a building project. However, in principle, the phases include the same activities. Winch (2010) distinguishes the phases of briefing, design, planning, and execution. The briefing phase includes the initiation of a project with the development of an idea for a new building and specification which results in the brief (initiation phase). This phase is followed by the development of a design concept (design phase). Once the design is finished, the construction will be planned and building materials will be purchased (planning phase). The final stage includes the execution of the construction and concludes with the building being put into use (execution phase). This traditional process and relation with the inclusion of building components are visualized in Figure 15.

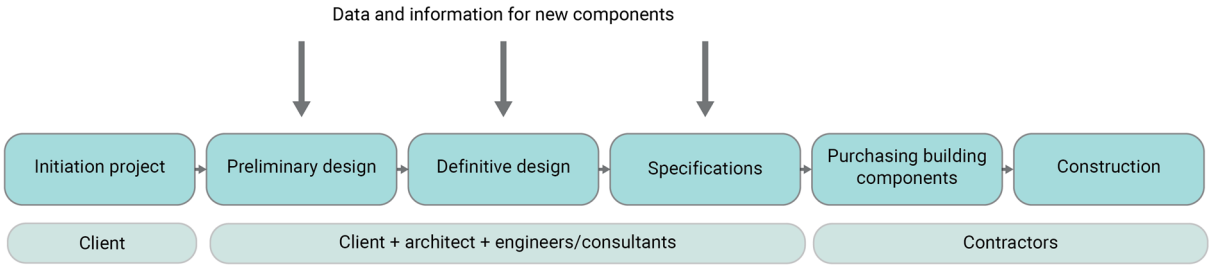


Figure 15. Traditional project delivery (After Addis (2006) and Kozminska (2019))

Different actors are involved throughout the process. Internal stakeholders are the ones in legal contract with the client, and include, among others, the client, architects, engineers, contractors, and material suppliers (Winch, 2010). In traditional project delivery, the client is the main actor during the initiation phase, which is followed by the involvement of an architect and potentially engineers and/or consultants for performing the design phase, afterward contractors, engineers, and material suppliers are involved to plan and execute the construction.

However, in the early nineties, besides this traditional model, new models for project delivery developed (Zeegers, 2013). These models include more integrated forms of project delivery that shifted responsibilities to different actors, which also came with new contractual moments. Although the context of contractual models is out of the scope of this research, it is closely related to the project organization and it should be mentioned that these developments did not significantly alter the traditional building process, in a sense that the sequence of the different steps and phases remain the same. However, it did lead to new moments of involvement of different actors, for example, contractors that become involved in the design phase. According to Chao-Duivis (2019), the shift to more integrated project delivery mainly resulted in a shift of the moment of price determination, which is nowadays reflected to be one of the weak points of integrated project delivery.

Re-use projects

"The building design community needs to review and adapt conventional practices to increase demand for, and effectively integrate, reclaimed materials and components." (Gorgolewski, 2019, p.2)

Several scholars (Gorgolewski & Morretin, 2009; Kozminska, 2019; Van den Berg, 2019; Addis, 2006), state that building with re-used materials and components significantly differs from a traditional project trajectory and requires an adjusted way of organizing information (Van den Berg, 2019). Different suggestions to improve project delivery processes to support the re-use of components are described. Van den Berg (2019) proposes a new order of life-cycle stages for building projects to improve the management of circular building projects. Starting with the demolition and followed by design, construction, and operation stages in a continuous cycle. Gorgolewski (2019) also suggests that a the approach to project management stages needs to be adapted to facilitate a process that is more applicable to circular strategies. Kozminska (2019) found that successful developments of projects with re-used components appeared in a non-traditional and iterative design and construction process (Kozminska, 2019). Addis (2006) states that design is always an iterative process, however, re-using components adds to the number of iterations. To be able to make the design, the reclaimed components should be identified early, already during the initiation phase of the project (Kozminska, 2019). The implications of re-use on the process are described and translated into the visualization of a customized re-use trajectory which is shown in Figure 16. Such visualization of the process is described to be a valuable tool to communicate the project team about how the sequence of activities differs from a traditional process (Addis, 2006).

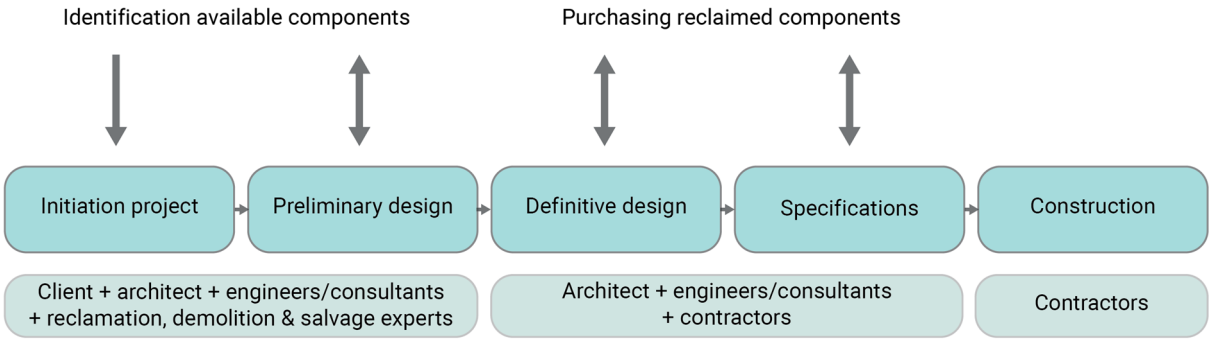


Figure 16. Re-use project delivery (After Addis (2006) and Kozminska (2019))

The main implications of this re-use project delivery include the need for an interdisciplinary, and a flexible design process that facilitates the collaboration between experts from diverse disciplines (Kozminska, 2019). This is in line with other scholars that discuss the implications of circular building projects and suggest the importance of integration (Leising et al., 2017; Van der Wijk, 2018; Pomponi & Moncaster, 2017). Leising et al. (2017) state that, related to integration, several things are needed in the development of circular buildings. Firstly, an adjusted process design whit the early integration of a variety of disciplines in the supply chain. Besides, the co-creation of an ambitious vision. Lastly, the extension of responsibilities to actors along the entire building supply chain.

This is also suggested in the collaboration tool, developed from the perspective of the initiating party, which also describes adjustments in the different project phases and is shown in Figure 17 (Leising et al., 2017). It should, however, be mentioned that this tool doesn't particularly focus on the re-use of building components, but adopts a broader perspective on circular building. Pomponi and Moncaster (2017) state that (new) partnerships and

collaborations, and a wider engagement of all involved stakeholders, are considered to be key in achieving a circular building sector. In particular related to re-use projects, Iacovidou & Purnell (2016) even state that a wider collaboration between all actors involved in the planning, construction, maintenance, renovation, or deconstruction of a building is required.

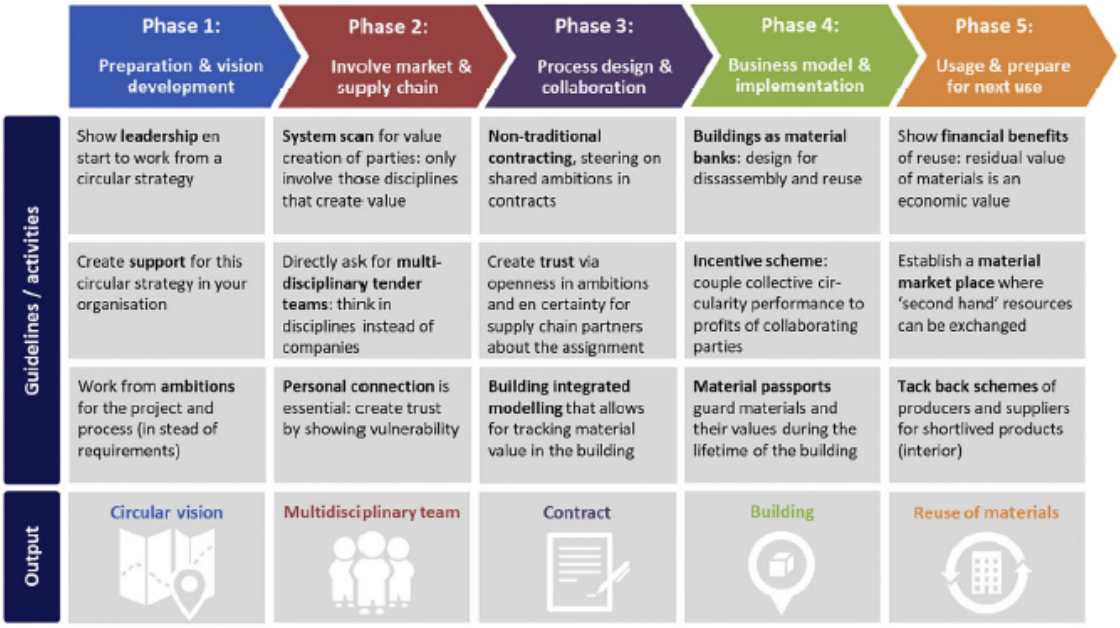


Figure 17. Collaboration tool circular building projects (Leising et al., 2017)

In addition, an extension of the initiation and conceptual design phase is suggested to enable the inclusion of research activities, consultation of specialists, conduction of material tests and experiments, and the integration of the activities and information by the design team, construction engineers, demolition companies, future contractors and other experts in re-using components (Kozminska, 2019). Collaborations between the, before mentioned, stakeholders should start early in this conceptual phase as this would enable a better understanding of priorities and decisions. The participation of demolition and re-use experts and contractors in the early stages facilitates the assessment of construction waste, and provides information concerning material sourcing, processing, assembly, disassembly, and finishing. The potential of involving a contractor in the design phase is also mentioned by Gorgolweski and Morettin (2009) and Leising et al. (2017), who suggest a multidisciplinary design approach. This is in line with the studies by Castelein (2018) and Van Haagen (2018) that suggest working with consortia and integrated contracts in circular building projects. This way of collaboration could help in minimizing the borders between different actors (Hopff, 2018). Besides, it is stated that collaboration between designers and academics in the initiation and design phase may lead to an environmentally and economically efficient and effective application of re-used components in building projects (Kozminska, 2019).

According to multiple scholars, the architect plays a big role in the process of re-use building design and construction, the design team should, however, be more integrated and expanded (Kozminska, 2019; Gorgolewski, 2019). Suggested collaboration partners include salvage material brokers or consultants, demolition experts, construction managers, material scientists, specialist trades, and product developers. This could help with estimating the right characteristics and amounts of the reclaimed components which are required early in the design phase, and would therefore contributes to promoting re-use (Rakhshan et al., 2020).

The importance of the definition of, and commitment to environmental goals by the design team and client in the initiation phase, and the inclusion of these goals in the brief and specifications are also emphasized (Kozminska, 2019; Gorgolweski & Morettin, 2009; Gorgolewski, 2019). This could help to unite the project team, to avoid conflicts, and to guide the design throughout the process towards more detailed specifications. Studies to circular contracting and tendering (Van Haagen, 2018; Castelein, 2018) suggest to specify the project and define these goals in an open, functional and performance-based manner, rather than a closed technical manner.

In addition, re-using building components often comes with a longer and more expensive design and construction process, and a unique cost breakdown structure (Kozminska, 2019; Gorgolewski, 2019). It is stated that a flexible approach to process and timing is needed. This means that the design team should be prepared to revisit decisions when new opportunities concerning materials arise. Besides there is a need for coordination of the timing between deconstruction and reconstruction, and the exchange of deconstruction information with designers, including lead times and availability of products (Kozminska, 2019; Gorgolewski, 2019; Van den Berg, 2019; Addis, 2006). It is also the advised to include a flexible cost plan that takes into account, the split between labor and materials, additional design team costs, deconstruction, and the unpredictability of the re-used materials' market, due to limited availability, challenges with purchasing, and the absence of regulated processes and methods. Besides, the early commitment of funds is needed to enable purchasing products that become available during the early stages and subsequent transport and storage. Storage will be needed in case components are identified and purchased before construction. Depending on whether or not a component are to be reconditioned, two moments of storage might even be needed.

The phases as proposed by Leising et al. (2017) and other adjustments in the building process are expected to impact the supply chain of circular building projects. De Los Rios and Charnley (2017) also emphasize a change in the supply chain, by stating that the industries that are joining the CE can create greater value when designers and engineers collaborate at different stages of the value chain. According to Nasir et al. (2017), a holistic view of the whole product supply chain is needed to achieve sustainable production systems. The development of sustainable supply chain management has taken place in parallel to the concept of the CE. Processing, transportation, and storage in circular supply chains are playing a bigger role than in linear cases and should, therefore, be taken into account (Nasir et al., 2017; Gorgolewski, 2019). This includes the understanding of the project manager that components should be acquired early and therefore might need to be stored. Careful planning and collaboration with contractors could help with this.

To conclude, the built environment could improve its position as one of the biggest consumers of resources by re-using building components. This idea is in line with the principles of the circular economy. The re-use approach will lead to significant adjustments to the traditional approach to building projects and requires changes in the project delivery process. Major changes include the extension of the initiation and early design phase, the need for an interdisciplinary project team from early on, and a more flexible approach to the time and process.

3.3 Management barriers and constraints in re-use projects

As explained, the re-use of building components comes with major changes in the project delivery process. Several barriers and constraints related to the management of this type of building projects and its deviations from traditional projects are described.

The challenges experienced with the re-use of components are twofold, on the one hand, the difficulties on the supply side, related to sorting, recovery, and transportation of components, and on the other hand the demand side, that faces challenges which impact the project management of building projects.

Sorting, transporting and recovering

Related to the recovery of components difficulties are experienced due to the fact that most buildings are not built to be disassembled, which leads to limitations in the ease and speed of deconstruction (Iacovidou & Purnell, 2016). Deconstruction sometimes takes longer due to several issues including a lack of space, complexity of the design, or the geographic location (Rakhshan et al., 2020). Other barriers related to sorting, transporting and recovering include difficulties with the large size of some of the reclaimed components, and the uniqueness of buildings (which leads to a difficulty in standardization) (Van den Berg, 2019).

No established market

Especially the lack of an established market of re-used components results in issues such as components not being available at the right time or with the right amounts which is discouraging of contractors/demolishers to offer their components for re-use (Van den Berg, 2019; Gorgolewski, 2008; Rakhshan et al., 2020). This negatively influences the establishment of the re-use market. Due to this limited market, components might have to be stored, however, it is hard to correctly estimate the space that is required to store recovered components and there might be a lack of space for storage.

Amongst others, the limitations on the supply side, result in difficulties for managers in new building projects. The lack of a properly managed supply chain leads to the limitation of a consistent supply of re-usable building components and can lead to higher costs and even higher environmental impacts (Van den Berg, 2019; Gorgolewski, 2008; Rakhshan et al., 2020). Therefore, supply chain management is considered to be of high importance to overcome these problems. This includes a clear division of responsibilities concerning the identification and purchasing of reclaimed components (Gorgolewski & Morettin, 2009). However, trust in the purchasing process is mentioned to be a major obstacle (Hopff, 2018). Close cooperation between construction and demolition companies and systems thinking are mentioned to address these barriers (Rakhshan et al., 2020).

Time and scheduling

The difficulties on the supply side are closely related to one of the main barriers to re-use. The time that is needed for disassembly and re-use, and the consequent project scheduling, while dealing with the usually high pressure to complete construction as early as possible (Rakhshan et al., 2020; Van den Berg, 2019). This results in a tight project planning and this has a negative effect on deconstruction and re-use. Moreover, designing with re-used components requires to remain flexible, to be able to incorporate alternative dimensions of the re-used component, as well as due to the earlier mentioned uncertainty of availability in

the market (Rakhshan et al.,2020; Kozminska, 2019). This might conflict with the tight project schedule.

Information availability and sharing

As the management of circular building projects is very dependent on information and new ways of organizing this information are suggested (Van den Berg, 2019). An extra difficulty is posed due to the fact that, in re-use projects, the characteristics of available reclaimed components have to be the starting point for the design (Gorgolewski & Morettin, 2009). A major challenge includes the lack of data about availability, amount, and quality of reclaimed components, and ways of sourcing or processing (Kozminska, 2019). In addition, limited knowledge on how managers could use information to reduce, re-use, or recycle materials exists and is mentioned to be an issue (Van den Berg, 2019). Improved communication between demolition contractors and designers is mentioned to be needed to improve this process of exchanging information concerning the re-use of components. The availability of sufficient information about the characteristics, details, and drawings of the reclaimed components can contribute to increase re-use (Rakhshan et al., 2020). It is suggested that the management of circular building projects should include organizing demolition and design information to reduce material use and optimize re-use activities (Van den Berg, 2019). Suggested ways to organize this include the use of a reclaimed components management coordinator, and the presence of a list with the reclaimed components, from early in the design phase (Rakhshan et al., 2020). However, this doesn't happen very often. To address the information challenge, smart technologies, such as a knowledge base with locally available resources and the use of Building Information Models, are mentioned to be valuable tools for improving the information process (Iacovidou, 2016; Gorgolewksi, 2019).

Regulatory standards

It is also found that regulatory issues, such as standards and specifications often limit the potential to re-use components (Gorgolewski, 2019; Kozminska, 2019). It is stated that this leads to additional tasks during the early stages of the project. Unlike a traditional process, in which obligations with respect to meeting regulatory standards are within the responsibility of producers and suppliers of building products, in re-use projects architects are often required to obtain standards and permits.

Lack of experience and education

Designers and contractors are rarely experienced or educated to design and build with re-used materials, as well as project managers aren't experienced with these projects, which negatively influences the re-use of components and therefore education concerning this topic is needed (Rakhshan et al., 2020; Kozminska, 2019; Pomponi & Moncaster, 2017; Van den Berg, 2019).

Attitude

Lastly, people's attitude and mindset toward re-used components is mentioned to be a barrier (Pomponi & Moncaster, 2017; Gorgolewski, 2019; Iacovidou, 2016; Rakhshan et al., 2020). One of the reasons for this is the esthetical appearance of re-used components, that could be seen as lower quality in comparison with new components. Another reason includes the fear for potential risks when using re-used components. It is assumed that the project manager could play a significant role in this issue, by convincing people to change their attitude, shaping a positive mind-set to re-use within the project team and minimize the potential risks. This

attitude differs between the material into consideration (Pomponi & Moncaster, 2017). Re-use of e.g. steel, which might not even be visible, is mentioned to be seen as unattractive, while the aesthetics of reclaimed wood are seen as one of the most important reasons to re-use wood. Although, this attitude towards re-use is gradually changing it is still mentioned to be an important barrier (Pomponi & Moncaster, 2017; Rakhshan et al., 2020).

It is stated that an opportunistic view on the re-use of components and creative thinking about how to deal with the components available is needed (Gorgolewski, 2019). Project managers might help in shaping a process that supports this view and steering the team to this approach.

Several management barriers are thus experienced when building with re-used components. Many challenges result from the lack of an established re-use market. The limitations on the supply side lead to challenges in timing and scheduling. In addition, significant difficulties are seen with the exchange of information concerning potentially re-used components, collaborations and tools such as databases might solve this problem. Difficulties in dealing with regulatory standards are also mentioned. Furthermore, lack of experience and education is stated to limit re-use, as well as a negative attitude towards re-use. These challenges require better collaboration between demolition and initiation actors, and an opportunistic view.

3.4 Project management and roles

Van den Berg (2019) states that the root causes of social-environmental problems related to construction projects can be traced back to the management of building projects. Although this is quite a statement, the literature indicates that the role of project management can be crucial in circular building projects. The following chapter describes the literature on project management during the initiation phase of building projects. It will also describe literature on how project management is described for re-use projects. This chapter focusses on the project management function and two roles that are known to be responsible for carrying out project management tasks during the initiation phase. The main definitions are first described.

Project management: The establishment of an organizational function concerned with the delivery of the system to the client (Winch, 2010).

Project sponsor: The person that acts in the interest of the commissioning organization (client) in the day-to-day management of the project (Bryde, 2007).

Project management consultant: An external person that provides management tasks to the client or owner of the project by using tools and skills (Ismail, Zin & Latif, 2006).

Project management

Over time ideas about the project manager's role have evolved (Morris, 2010). Nowadays project managers are not only seen as managers of time and costs but are also believed to be the guardians of quality, risks and opportunities, health, safety and environment, and strategy and governance at the front-end. The contemporary idea focuses on the “management of a project”, rather than “project management”, and is described as management of execution or the management of projects as whole entities. This comes with a wide variety of tasks that may differ between projects and their phases.

The traditional idea of project management is more about the contractor's, or middle management (Morris, 1989). However, the responsibility of the project manager to aligning the project strategy with the client's strategy has evolved and the importance of the project sponsor is emphasized (Morris, 2010). It is argued that many people are concerned with management tasks to set up the project, by defining its (technical) content, financial and commercial requirements, and its organizational structure (Morris, 1989). This suggests the relevance of project management during the initiation phase, which is stated to have a major impact on the project's success.

The Project Management Body of Knowledge (PMBOK) also describes the role of project management in the construction sector and mentions the importance of project management to avoid problems in construction projects (Project Management Institute, 2016). Due to the complex nature of construction projects, construction project managers are expected to be adaptive and in some cases have a good knowledge base concerning construction developments.

Five project management process groups are described, the initiating process group, the planning process group, the executing process group, the monitoring and controlling process group, and the closing process group (Project Management Institute, 2017; Project Management Institute, 2016). These are described to be applicable on construction projects as well. The initiating process group is described as the processes that are performed to define a new project. Thereby this group is clearly related to the initiation phase of building projects. The planning process group includes the processes that are needed to determine the scope of the project, refine the project objectives, and define the required methods to achieve those objectives (Project Management Institute, 2017). This also relates to the initiation phase of a project and is therefore of relevance in this research. Several project management tasks are described to be performed within these process groups and to be related to multiple project management knowledge areas as shown in Figure 18 and Figure 19.

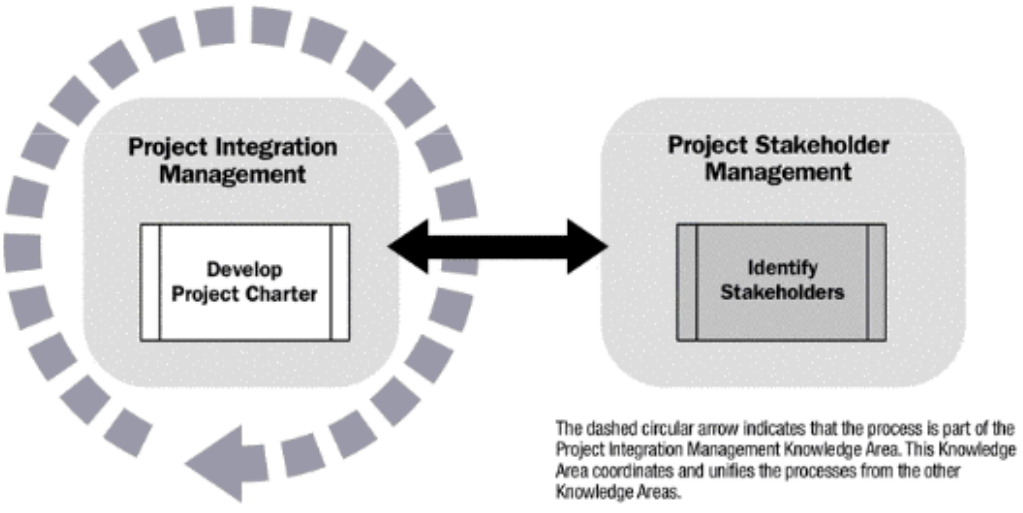


Figure 18. Project management tasks and knowledge areas initiation process group (Project Management Institute, 2017)

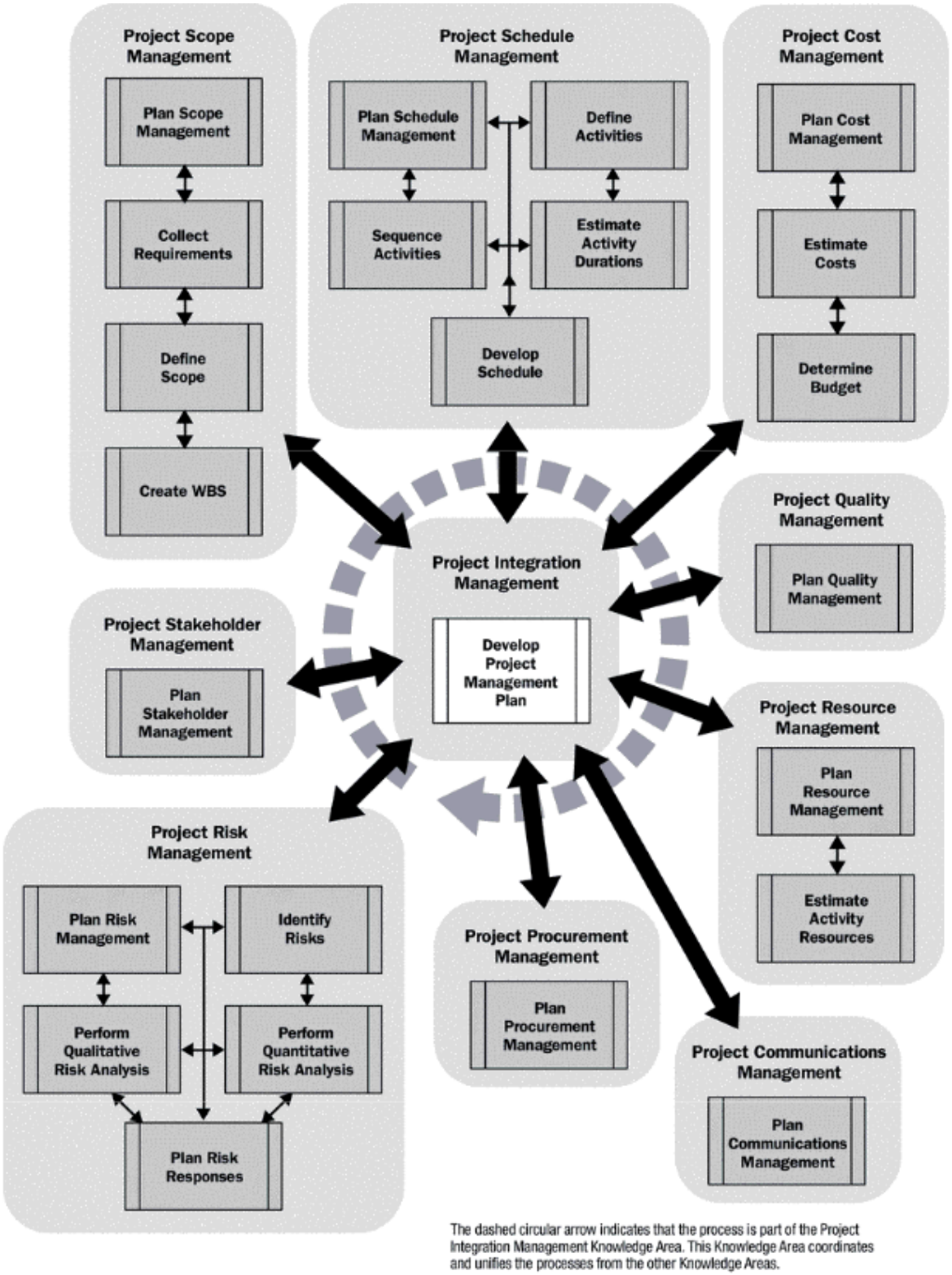


Figure 19. Project management tasks and knowledge areas planning process group (Project Management Institute, 2017)

The PMBOK construction guide indicates that much is established during the early stages of the project when uncertainty is greatest (Project Management Institute, 2016). This also confirms the importance of project management during the initiation phase. The Front-End

Loading, performing solid planning and design in early stages, is mentioned to reduce risks and maximize the probability of the project's success. This concept is based on the idea that in early staged one has a higher ability to influence changes with lower costs. Although the idea of Front-End Loading requires additional time and cost in the early stages, it is believed that the overall risk is reduced and that it leads to more information which results in better project decisions.

It is believed that effective management is contingent, meaning that certain contingencies influence the choice for a particular form of management over another (Provan & Kenis, 2008). Two contrasting ways of management are described, mechanistic and organic (Osipova & Eriksson, 2013). A mechanistic approach includes a high level of control. Each actor focuses on its own specialism and the importance of individual knowledge and skills is key, this takes place within a hierarchical structure. A mechanistic approach is appropriate in stable environments. In less stable conditions, with a lot of uncertainty, an organic approach is more appropriate. This approach is known for a network structure, shared commitment, and informative communication. These approaches are also described to affect project management. For example, two project management approaches that reflect this control and flexibility are known (Koppenjan, Veeman, Van der Voort, Ten Heuvelhof & Leijten, 2011). Firstly, a predict-and-control approach, which has its main focus on planning and controlling, and aims at minimizing uncertainty and complexity. Contrary, a prepare-and-commit approach. This approach aims at shared and constant management of complexity and uncertainty and remaining flexible, by close collaboration between actors.

Project sponsor

The project sponsor is described to play an integral role in organizational project management (Bryde, 2007). In addition, its relation with the project executive manager is stressed, stating that they should foster a partnering and effective relationship (Zwikael & Meredith, 2017; Bryde, 2007). The project sponsor is seen as the interface between the client and the project delivery (project organization) and is therefore believed to play an important role in the initiation phase of projects (Bryde, 2007).

As a representative of the client in the day-to-day management, the project sponsor is responsible for providing resources and support to the project, and guiding and facilitating the implementation of project management (Bryde, 2007; Zwikael & Meredith, 2017). Several responsibilities during this phase are described, including determining a project strategy and its priorities, agreeing on the project definition and its objectives, and defining the project success criteria. In general, the client mobilizes a coalition of firms, defines the project organization structure, and charters the project coalition, in order to deliver the project mission (Winch, 2010). As a representative of the client, the project sponsor thus plays a role in the briefing, the organization of the project, and the selection of the project team.

Project management consultants

As mentioned, project management consultants are also known for being involved in the project management of the initiation phase of building projects and are often involved when no qualified manager is available at the client's organization. Although there is no specific definition for project management consultants, most of the writers described a management consultant by their roles and responsibility and services that they provided to the client, by using tools and skills (Ismail et al., 2006). Therefore a project management consultant can be seen as the person from an external party that is carrying out project management tasks to

deliver the project to the client. This can include project management representatives of e.g. project management companies, developers, and contractors.

Nikumbh & Pimplikar (2014) also describe the role of the project management consultants and its responsibilities in different stages of construction projects, including the initiation phase. During this phase, several tasks relating to the briefing, project organization, and selection of the project team are described to be within the project management consultant's role. Examples include their responsibility to prepare the design brief, finalize a project organization chart, prepare a project schedule, and identify and suggest consultants and designers.

Depending on the project and its organization different project management consultants come involved in different stages, within this research the focus is on the project management consultants that are involved during the initiation phase.

Project management in re-use projects

The circular economy is seen as an innovative economic and production model (Ghisellini, Ripa, Ulgiati, 2018). Within this context, the management of building projects with re-used components is taking place. As effective management is believed to be contingent, in this context of innovation certain project management approaches and tasks might be needed.

It is described that mechanistic control-oriented approaches to project management hinder flexibility and innovation (Osipova & Eriksson, 2013). Therefore more organic approaches to project management might suit innovative projects better. This requires to be more flexible throughout the process and establish close cooperation to be able to achieve this flexibility.
This relates to the fact that innovation increases the level of mission uncertainty, as doing something different reduces the availability of information for the cost and schedule estimations (Winch, 2010). Therefore, it is suggested that innovation requires additional investments. However, these investments are frequently underestimated. In addition, re-use specific uncertainty is also described and mainly results from a limited re-use market (Van den Berg, 2019; Gorgolewski, 2008; Rakhshan et al., 2020). This confirms the idea of an organic approach in re-use projects.

Stevens & Burnley (2003) describe the importance of the project manager during the early stages of radical innovative projects. It is even stated that a key individual, which often includes the project manager, often plays a key role in the project's outcome. This suggests the importance of the project manager in the initiation phase of re-use projects.

The diffusion of innovations usually takes off slowly, with only a few adopters, which slowly increases (Widén, 2006). After a while, it increases faster until most have adopted the innovation and then the diffusion slows down again. The slow start of the diffusion is described to be related to the relatively low advantages at the moment the innovation is first introduced. Wamelink & Heintz (2015) discuss process integration innovations in the construction sector and mention its relation to Roger's innovation diffusion theory. It is stated that until a particular demand is created, there is only little to gain from process integration innovations as the short-term advantages to individuals are not clear and, resulting from high initial costs, economic advantages might even be negative. Clear guidance by clients and regulations is described to be key in diffusing the process integration innovation.

According to Wamelink & Heintz, (2015) the principle of integration in the building sector has had many advocates, including both scholars and practitioners. These advocates see

integration as an innovation in itself, as well as a means to stimulate other innovations, as integration could provide a network for communication that helps in realizing change. Relating to the innovation of circular building, process integration is also discussed by multiple scholars. Leising et al. (2017) and Van der Wijk (2018) for instance suggest the use of interdisciplinary tender teams and propose the need for an inter-firm network, supply chain management, and the idea of an integration manager. Concerning re-use Kozminska (2019) also suggest integrating project activities. This suggests the link between process integration innovations and a need for integration in circular building projects.

3.5 Initiation phase and its activities

This chapter described the initiation phase and the briefing, project organization, and project team selection which are determined during this phase. The main concepts are first defined. The role of these aspects in re-use projects are also explained.

Initiation phase: The initiation of a project with the development of an idea for a new building and its specification, which results in a document including the specification of the demand, this document is known as the brief (Winch, 2010).

Briefing: “An evolutionary process of understanding an organization’s needs and resources, and matching these to its objectives and its mission” (Blyth & Worthington, 2001, p. 3).

Project organization: The structure of the process that facilitates the coordination and implementation of project activities (PM4DEV, 2016).

Project team selection: The selection of “the coalition of firms deployed to realize the project mission” (Winch, 2010, p. 429).

Initiation phase

The initiation phase includes the initiation of a project with the development of an idea for a new building and its specification, which results in a document including the specification of the demand, the brief (Winch, 2010). Therefore, the initiation phase is often called the briefing phase. It is stated that the project initiation should include the following issues (Morris, 1989):

- the assurance of the technical basis and the related uncertainties and risks
- the structuring of the project and its financing
- the assessment of the political and local community of the project and management of the related risks
- the management of the process that is needed to obtain planning and permit approvals
- the development of an applicable organization structure and contracting strategy

Several of the aspects are directly related to the briefing, organization of the process, and selection of the project team. However, as the contractual relations, legal environment, and financing are beyond the scope of the research, the issues of structuring the finance, obtaining permits, and organizing the contracting strategy will not be addressed in this research.

Briefing

It is stated that briefing is about the formulation of a problem, solving it, and managing change (Blyth & Worthington, 2001). This comes with evolving ideas, that are analyzed, tested and

gradually lead to a specific set of conditions, the “brief” or “programme of requirements” (Blyth & Worthington, 2001; Van der Voordt, 2004). This document serves as a means of communication between client and other stakeholders, based on certain guiding principles and takes into account the conditions, needs, requirements, wishes, and expectations of both the client and end-users in a coherent way, in order to collect, edit, evaluate and share the information phased, as a starting point for the design phase (Van der Voordt, 2004).

Savanović and Zeiler (2006) describe the idea of “dynamic briefing”. The continuous feedback between the design team and the client is described to be the main aspect of this concept which is referred to as iterative. Van Meel & Størdal (2017) also describe a dynamic briefing process by stating that the briefing process is more than producing a list of requirements. It is a gradual and iterative development process, with a strong social component that requires specific management.

This process is seen as a combination of several processes (Van Meel & Størdal, 2017). Firstly, a stakeholder process, as a variety of stakeholders are involved in most projects. These should be taken into account by getting to know their interests, managing their expectations, building a relationship, and offering them the opportunity to share their ideas and concerns, which would lead to a more comprehensive brief. It also includes a decision-making process. This means several decisions should be made that will shape the process. Gathering data is mentioned to be important in making these decisions. In addition, it includes a learning process and as identifying the needed knowledge often comes with research it is also seen as a research process. Lastly, the process includes a communication process. This includes talking with several audiences. Probably most of the time during the briefing process is spend on this topic.

Blyth & Worthington (2001) describe a distinction between two types of project managers. Firstly a building project manager who is responsible for achieving success by fulfilling the client’s expectations within time and cost. Secondly, the client’s project manager that is responsible for managing the client’s needs and expectations and could also be seen as the “design brief manager”. This role is more mediatory than the role of the strict construction manager and includes listening, unravelling the user demands, good communication and a more soft approach. The latter is in line with the role of the project manager in the initiation phase and relates to the different processes included in the briefing process, as described by Van Meel & Størdal (2017).

The early stage of the briefing process is described to be crucial in ensuring a clear definition of the project objectives (Blyth & Worthington, 2001). This helps in making sure that the client gets what it wants. This suggests the importance of briefing during the initiation phase.

Briefing in re-use projects

Literature suggests that in circular projects one should start with the creation of a vision (Leising et al., 2017). This vision could help in providing an image of a possible future and the coordination, guidance, and orientation for the project team by achieving that future. This suggests the importance of defining a vision for the re-use project as part of the briefing process.

Degrees of re-use and the type and amount of it, are advised to be specified in at least three ways at different phases of the project (Addis, 2006). Firstly, for the building as a whole in the project brief, which is also underpinned by several scholars (Kozminska, 2019; Gorgolweski & Morettin, 2009; Gorgolewski, 2019). Later during the design process, component by

component (Addis, 2006). And lastly, in the building specifications as employer's requirements. It is also mentioned to be of importance to be able to measure the type and degree of re-used components, to make sure that the requirements are delivered. Integrating re-use in contractual requirements is also stated to increase re-use rates (Rakhshan et al., 2020). In addition, it is stated that the definition of clear goals with defined targets early in the project could help in uniting the project team and guiding the team through the process towards more detailed specifications (Gorgolewski & Morettin, 2009). This suggests the importance of the briefing process in re-use projects. However, some studies to circular contracting (Van Haagen, 2018; Castelein, 2018) suggest to specify the project and define circular goals in an open, functional and performance-based manner, rather than a closed technical manner. This allows for a more dynamic form of briefing.

Project organization

Related to the structure of the process that facilitates the coordination and implementation of project activities, some argue that the project management process could be seen as an incremental decision-making process in which, step by step, in a certain order, alternatives are compared and chosen (PM4DEV, 2016; Vande Putte, 2009).

Amongst other tasks, the project manager is responsible for the planning of the project. Different types of planning are known. Firstly linear phasing, where different steps follow each other, is most common in building projects (Vande Putte, 2009). Parallel phasing is mentioned to be used in complex and/or major projects where subprojects could be designated. In that sense, the subprojects could take place parallel to each other to save time. However, in projects with uncertainty and/or complexity, cyclic phasing could be considered. This includes an iterative process in the sense that the different steps will be reconsidered when more information has become clear. This is in line with the before mentioned principles of "dynamic briefing". The continuous feedback between the design team and the client is referred to as iterative but is rather similar to the concept of cyclic phasing.

The organization of the project also comes with a certain process delivery method (Project Management Institute, 2016). Several methods for construction are known, for instance, design-build, self-performance, or integrated project delivery, and are closely related to the contracting strategy.

Project organization in re-use projects

As mentioned, different approaches to project management have evolved. An approach to project management that is based on a predictable, relatively simple, and rational model, is especially not suitable for projects with an uncertain environment, where the costumers' needs are difficult to be specified in advance and the success of a project requires learning among the different actors that are involved in the project (Brady & Hobday, 2010). As mentioned, it is also suggested that a mechanistic form of organization is more applicable in stable conditions, while less stable conditions require a more organic form of organization. This confirms and is in line with the suggested project organization for re-use building processes by Kozminska (2019) and the cyclic planning process as described by Vande Putte (2009).

This cyclic planning process is suggested when projects are uncertain and/or complex. These aspects are both applicable to projects with re-used building components. Firstly, as it is less clear which building components will be available. Secondly, as designing with re-used building components also poses an extra difficulty, since it limits the architects' freedom and

requires them to design differently. Chapman and Simmonds (as cited in Gorgolewski, 2008, p.179) confirm this by stating "using reclaimed materials adds a whole new level of complexity to the project". Lastly, the organization and planning of the building process could be more complex as it is dependent on the time that building components become available.

Related to this, Rakhshan et al. (2020) describe a way to organize the process by making a decision-making framework. This could help in informing stakeholders when alternative re-use options should be investigated and helps in making informed decisions and maximizes the potential of re-use by identifying the steps that should be taken by the involved stakeholders.

Although the contractual arrangements are out of the scope of this research, studies to circular contracting identify interesting aspects that are related to the project organization. Some studies suggest that more integrated forms of contracting would better suit circular building projects (Castelein, 2018; Van Haagen, 2018). The need for integration in circular building projects is also mentioned by Leising et al. (2017) and Van der Wijk. This suggests a need for the incorporation of integration in the project organization in re-use projects.

Project team selection

The project team includes "the coalition of firms deployed to realize the project mission" (Winch, 2010, p. 429). This team is often consisting of people that usually don't work together (Project Management Institute, 2020). Project teams distinguish their selves from other types of teams, as they have a temporary nature (Winch, 2010).

The responsibility of the client towards the project team is stated to be acting as (Winch, 2010):

- a promoter, by defining the need for the project and making sure that this is met,
- a financier, by acquiring the capital needed to finance the project,
- a decision-maker, by making the required decisions to push the project throughout its process
- a recruiter, by mobilizing the most convenient and capable actors to execute the project

The latter is even a legal obligation under European health and safety legislation (Winch, 2010). It is mentioned to be vital that the project sponsor is engaged with the development of the project, including the shaping of the project team. From the perspective that the project sponsor is responsible for providing the resources needed to execute the project, the selection of the project team, which includes firms that provide their resources to execute the project, falls within the project sponsor's responsibilities. As mentioned a project management consultant could also be involved in the process of selecting the project team by identifying and suggesting team members.

Project team selection in re-use projects

"Innovation is a team sport" (Thurm, 2005, p. 126). Therefore it is important to take special care in compiling a good team, including architects, engineers, contractors, and developers (Thurm, 2005). Each member has a special perspective and skillset, and the power of these team members will be greater if the project manager has taken the effort to choose sensibly to create a good team dynamic. This underpins the significant role that project managers could play in shaping the team, especially when building with re-used building components. However, in many projects, project managers do not take this special care and in most cases,

the hiring of a contractor takes place when the design process is already started. This results in a lack of a third party that can provide a reality check for the design. This sequence of activities is in line with the traditional building process as described in chapter 3.2. and the suggestion to involve a variety of disciplines in the early stages of a project that is taking place in a context of innovation is also described to apply to projects that re-use building components (Kozminska, 2019).

After assembling a project team, it is stated to be of importance that a feeling of freely exchanging and challenging each other is created between the team members (Thurm, 2005). Important is that this collaborative mindset is also extended to the people within the client's organization. This idea is also included the previously mentioned collaboration tool for circular building projects by Leising et al. (2017) by proposing the creation of trust via openness in ambition and uncertainty among the supply chain partners during the initiation phase. Besides, Rakhshan et al. (2020) mention that the willingness of stakeholders to integrate re-used components into their projects is determining, which underpins the importance of creating a certain mindset within the project team. Especially the perception of clients, contractors, and designers are found to have a high impact on the successful integration of reclaimed components. However, if the client is not motivated to re-use components, the chance is much lower that the architects and contractors would introduce this idea. But if the client is motivated, the unwillingness of a designer or contractor can be handled effectively, although unevenly distributed risk might remain a challenge for designers and contractors. Concerning the project team, it is also stated that an informal atmosphere and good relationships among the team members could help in promoting re-use.

To conclude, as mentioned, the project sponsor is in charge of several management tasks during the initiation phase of a building project. Project management consultants are also found to potentially be involved during this phase. The project sponsor's and project management consultant's involvement in the early stages of the project fits within the contemporary ideas of project management, and is ought to be key for the success of building projects. The briefing and its dynamic process, the organization of the project and determining the shape of this process, and the selection of the coalition of firms that are going to realize the project, are within the responsibilities of the project sponsor and/or project management consultant and should, therefore, be considered to increase the success of a circular building project.

3.6 Conceptual framework

Literature highlights several aspects that are considered to be of importance in the initiation phase of a building project with re-used building components. Related to the briefing it is found that one should define the re-use ambition and clear re-use goals from early on and adopt the idea of dynamic briefing. This is closely related to the organization of the project. Hereof it is suggested to adopt new approaches to the project delivery process. This includes the extension of the initiation phase and a more iterative trajectory. The project delivery is closely related to adjustments to the supply chain. The importance of the selection of the project team is also stressed. This project team should include a variety of disciplines from early in the project and might come with the development of new relationships. Collaboration within the project team is mentioned to be key and should include the development of a shared vision. These aspects are visualized in a conceptual framework which is shown in Figure 20.

Several barriers are also described in the literature. On the supply side difficulties are seen with the sorting, transporting, and recovering of building components. This results in a limited

supply market of reclaimed components. Many barriers can be found in the process of matching the supply of re-usable components with the demand. This comes with challenges with the sharing of information about potential components and the division of responsibilities concerning the sourcing of components. It also leads to difficulties with timing and scheduling. On the demand side difficulties with the regulatory standards, a lack of experience and education in building with re-used components by the project team, and the attitude towards re-used components are also described. These barriers are included in the conceptual framework as well.

The following research phases have built on this framework and aimed at achieving a better understanding of the identified concepts and their relations to the re-use of building components.

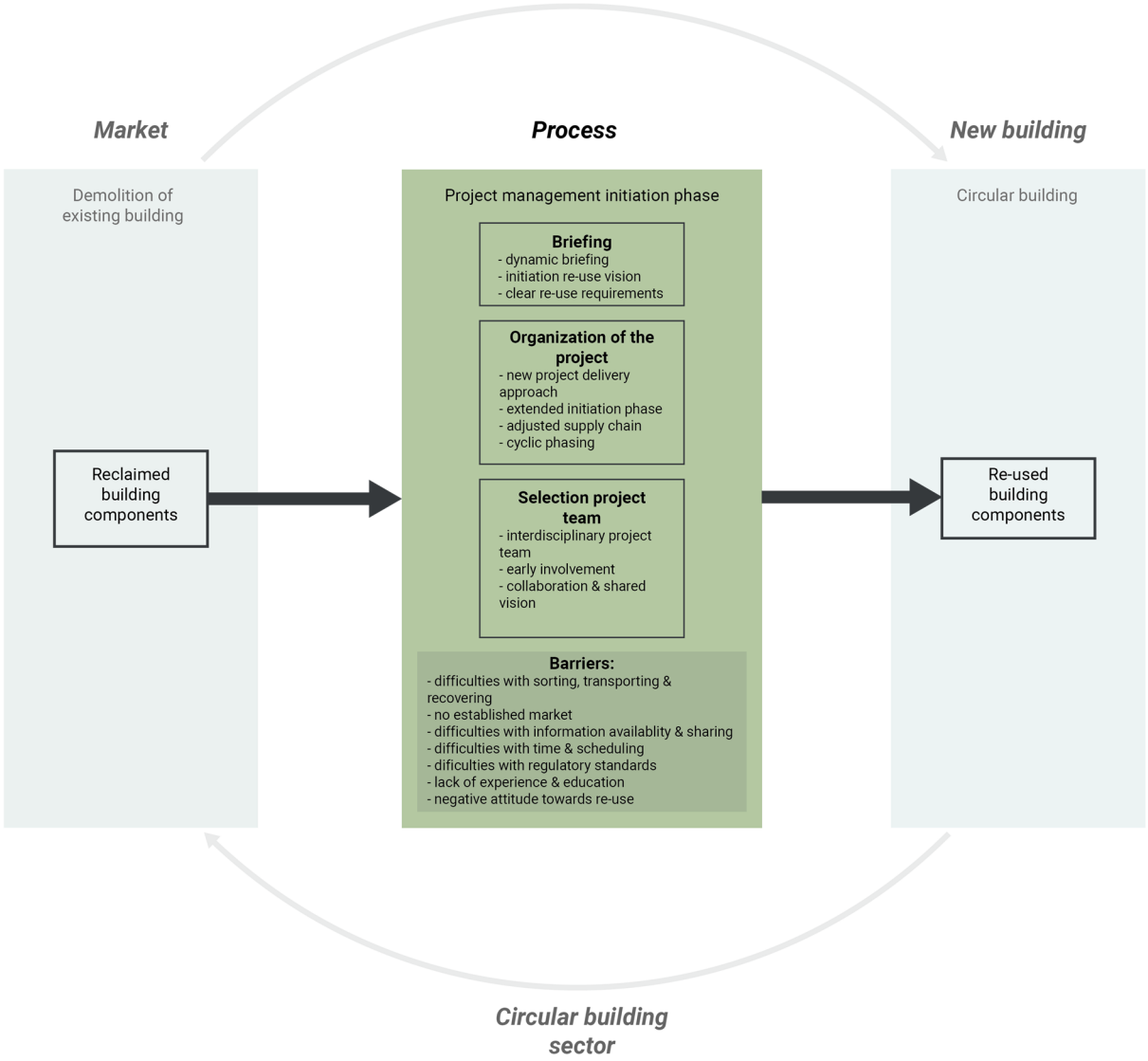
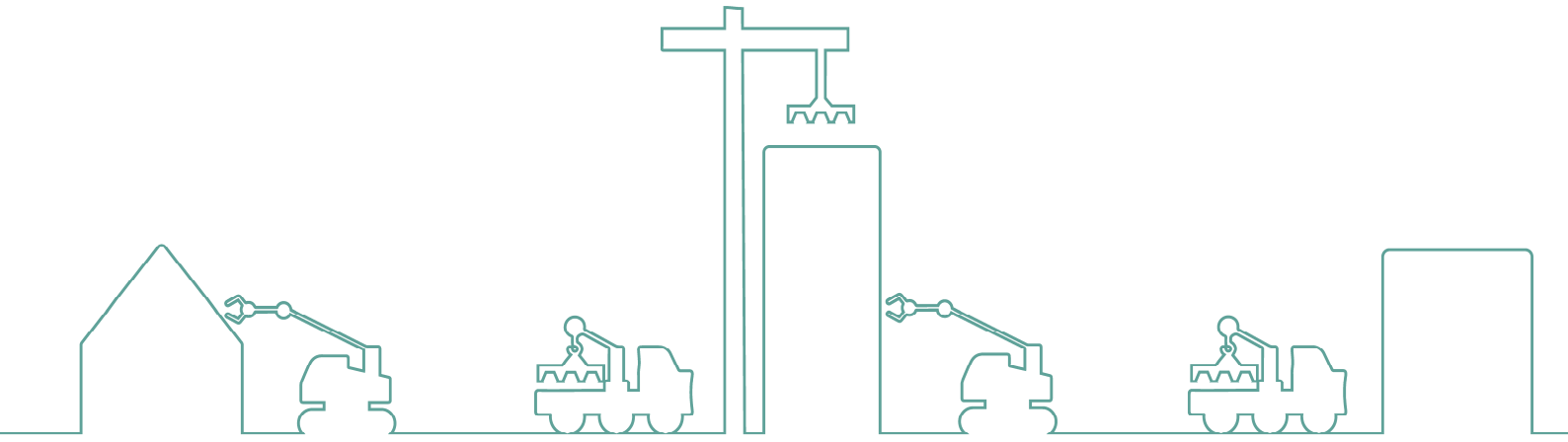


Figure 20. Conceptual framework

CHAPTER 4

EXPERT INTERVIEWS



4.1 Data collection

To gather more insight into the practices of re-use projects, 7 interviews have been conducted a range of individuals that have been involved in projects where components have been re-used. The interviews were conducted in February and March 2020. The interviewees included Dutch experts with various roles in various projects, including project management consultants, developers, demolishers, re-used component suppliers, and sustainability consultants. Due to limited experience with the re-use of components, newly built and renovation projects are discussed. The degree to which re-used components were used also varied. Based on an interview protocol that can be found in Appendix X, the interviewees have been interviewed in a semi-structured way. The interviews are analyzed with ATLAS.ti on the identified themes.

Interviewee A: Circular development manager, involved in several circular building developments in the Netherlands. The main focus was on the development of a temporary circular building that also included the re-use of some components.

Interviewee B: Experienced program manager at a project management consultant in the building sector. Involved in multiple building developments and responsible for the program management of a cluster of circular renovation projects with the ambition to re-use.

Interviewee C: Experienced project manager, working for a project management consultant in the real estate sector. The interview had responsibility for the project management of the realization of a circular renovation project, including an ambition to re-use demolition waste.

Interviewee D: Development manager, working for a real estate developer for a few years. Involved in the building of a circular office building.

Interviewee E: Program manager at a non-profit organization that aims at accelerating the circular building sector. The organization focusses on the market of reclaimed materials and components and includes an online platform.

Interviewee F: Consultant at relatively young real estate consultancy, management, and development firm with a focus on sustainability and circularity.

Interview G: Director of circular materials at a demolition company. Involved in multiple demolition and disassembly projects and the sale of circular materials and components.

4.2 Interview findings

The interviews gave insights into the practices of re-use projects and the extent to which components are re-used. In addition, the interviews showed various ways of how the briefing, the project organization, and project team selection could take place, and what is believed to be of relevance within these aspects in re-use projects. The findings are structured in relation with the themes, which are closely related to the research questions.

Briefing

Initiation of re-use vision

The interviews indicate the importance of defining a vision related to re-use early in the project to give guidance to the team. Multiple interviewees state that the ambition of the client concerning circularity, including re-use, should be discussed and shaped during the initiation phase of the project. One interviewee, for instance, indicates that the vision to re-use was only discussed later in the project and this has led to difficulties.

Clear re-use requirements

In line with the literature, several interviewees mentioned the importance of the incorporation of targets and requirements related to this re-use ambition, in the early stages of the project, for example in the brief or programme of requirements. Corresponding with Leising et al. (2017) the interviewees suggest that this early definition of goals and ambitions related to re-use helps in putting a dot on the horizon and this would provide coordination between actors and in guidance and orientation for joint action to achieve the re-use ambitions. To be able to realize a high degree of re-use and overcome uncertainties, some state that really clear requirements, including the definition and degree of re-use, and how it will be measured need to be described.

"Als je het juist concreet maakt dan weten ze ook waar ze naar toe moeten werken." (Project manager)

Vague requirements, such as "strive for maximum re-use measured in kilos" are mentioned to result in diverse interpretations. This specification might, for instance, suggest that re-use of the construction, which would lead to high scores based on its weight, is preferred. However, this might not be the actual ambition and this vague specification of the goal would therefore not contribute to achieving the aspired goals related inclusion of re-used components.

"[Je moet] ook goed meegeven op welke wijze je dat gaat toetsen of beoordelen." (Circularity consultant)

Several interviewees also underpinned the idea that the client should really support the re-use targets and that this actor plays an important role in the specification of the ambition and goals related to the re-use theme. One interviewee even suggested that an assessment of the potential re-usable components should be part of the tender request and should be conducted by the client.

Dynamic briefing

Due to the limited availability of re-usable components, it is, however, mentioned to be hard to specify the amount of re-use in advance. Therefore, it is stated that one should be careful in making performance claims at the time there is still a lot of uncertainty concerning potential components.

One interviewee suggests that an effort obligation could be imposed, but such a measure is not a very strict requirement in procurement law. In addition, it is suggested to specify these targets in relation to quality management, rather than only as quantifiable targets.

"Ja misschien meer een inspanningsverplichting … dat je een bepaalde inventarisatie, dat je de websites of de platforms, waar je de materialen kunt toetsen, dat je die volgens methode X beoordeelt." (Circularity consultant)

Maintenance

The importance of repeating the earlier defined ambitions and goals relating to re-use is suggested. Because re-use requires a really different way of approaching the project which people aren't used to, it is important to prevent the team forgetting these ambitions and fall back on the traditional approach.

It is the role of the project manager to make the team aware of the idea of re-use and extending this mindset within the team. Scheduling time for creating this mindset, which is mentioned to be needed to change the traditional way of building, is suggested.

"Ja dus de project manager moet eigenlijk organiseren en faciliteren dat het gedachtegoed van hergebruik bij iedereen goed tussen de oren komt." (Project manager)

Project organization

The projects discussed in the interviews were mainly traditionally organized and not specifically adapted to facilitate the re-use of components. However, the interviewees suggest that this might not have stimulated the incorporation of re-use and describe several aspects that are of importance in re-use projects related to the organization of the project.

New project delivery approach

In line with the importance of incorporating re-use in the brief, the idea of re-use should be incorporated in the project organization right from the start and the project organization and assessment criteria/framework should be set up to support this idea. Some managers stated that, to secure the re-use ambition, it is the role of the project manager to embed the principles in the organization, guard the principles, and spend time on convincing the project team of these principles.

Several interviewees stated that designing with re-used components differs in the sense that one should start with making an inventory of what is available, after which designing with what is available can be started, while in traditional projects the choice of components follows the design. This is in line with the earlier described differences in the process delivery as suggested by among others, Kozminska (2019) and Addis (2006).

"Ja dat is gewoon, wat is er beschikbaar? Op het moment dat je iets beschikbaar hebt dan ga je kijken hoe je je detaillering en hoe je je ontwerp daar op aflegt, dus daar mee volgt het ontwerp veel meer de materialen die je hebt. Terwijl in een voorbeeld waar circulariteit niet in het hergebruik op component niveau zit, daar zie je dat de materiaalkeuze juist het ontwerp volgen." (Project manager)

Besides, much more information will be needed in the early stage of the project which is needed to make decisions concerning material choices. In line with literature by Van den Berg (2019), the interviewees explained that sufficient information about for instance the quality and dimensions of reclaimed components is needed to be able to make decisions.

This is also in line with the ideas as explained by some project managers, who state that the planning is different, not necessarily more complex, but some tasks should be done earlier in the process. This includes engineering, making technical drawings, taking decisions on material usage, and making tradeoffs that take into account the pros and cons of components that are planned to be (re-)used.

However, many interviewees describe difficulties in the project organization that relate to the lack of an established re-use market. An often mentioned barrier is the timing and availability of components. This is mainly related to off-site re-use of components that are not owned by the client but could also include off-site re-use of components within a client's portfolio. The interviewees mention that it is often hard to find the components they are looking for on marketplaces and the internet, as a lot of platforms are still in development.

"Vaak kijken ze eerst op de marktplaats en dan kunnen ze iets niet vinden." (Program manager online platform reclaimed buliding products)

The limited availability of components leads to difficulties related to matching supply and demand. The technical conditions and information that is needed to determine whether or not components meet the requirements is one aspect that is mentioned to be important. In addition, time is identified to be an important dimension related to this. This relates to the time that is needed to identify suitable components, the moment these components will become available, and the alignment with the schedule of the building process. It is suggested to take this into account from the early stages of a project.

"Dus in [de] planning wanneer kozijn A, wanneer is die beschikbaar hoe weet je wanneer die beschikbaar is?" (Circularity consultant)

It is suggested to organize re-use projects differently to better facilitate the re-use of components. When projects are organized in a traditional way and a final design is made before identifying and purchasing components, interviewees mention that it is extremely hard to find suitable components to replace the specific new components that are included in the design. This leads to only limited amounts of re-used components. Box A describes an example of a situation where reclaimed components were identified once the design was already finished.

Box A

"Dat zijn er heel interessante discussies geweest omdat we hadden bijvoorbeeld, nou het gebouw is heel organisch en we hadden een soort van zo zo'n terras heb je daar en heb je zo. Je hebt er een soort van ronde vlonder heb je lopen als een soort van rondgang. Dat was allemaal perfect natuurlijk want mooie lijnen, super organisch. Wij kwamen dus die vlonders tegen en dat moest gesloopt worden dat pand, maar dat was nog gewoon een hele mooie houten vlonder die daar lag, ook als looppad. Maar dat zou dus betekenen dat we dat allemaal moesten gaan segmentere. … Dus daar moesten we wel esthetisch een soort van dingen gaan afkalven van wat het origineel was. De opdrachtgever zei toen ja prima, maar het moet wel nog binnen de normen passen. Zoveel kieren en whatever en laat het even door de architecten checken. Je raadt het al, dat is natuurlijk een no go bij die architecten. Om hun mooie perfect organische vlonder om die allemaal te gaan segmenteren. Dus daarom is hij er ook niet gekomen." (Development manager)

Extended initiation phase

The interviewees stress the importance of defining the vision and goals related to re-use early in the project and suggest starting with making an inventory before commencing the design. Therefore the initiation phase in re-use projects requires more attention and includes additional tasks and might, therefore, be extended.

Adjusted supply chain

Due to the limited availability of re-usable components in the market, identifying the right components in the re-use market is mentioned to often takes more time than ordering new ones. Within a limited schedule, offering new ones is therefore often chosen.

"Een aannemer krijgt zeg maar 10 minuten om 300 euro te bestellen voor zijn nieuwbouwproject. Ja en dan moet hij nu 20 websites voorbij." (Program manager online platform reclaimed buliding products)

These difficulties regarding limited availability are in line with the literature stating that there is a lack of an established re-use market (Rakhshan et al., 2020) and make it hard to maximize the search for re-usable components. Once a suitable re-use component is found, it might take some time before the component will actually be used, as it needs to be investigated and implemented in the design, before it can be realized. In addition, there is no constant supply of reclaimed components and suitable reclaimed components should therefore be secured at the moment of identification. Therefore, components have to be purchased earlier than traditional, already during the initiation or design phase. From the design phase until the construction phase might take more than a year, therefore the components might have to be stored for a while, a barrier that is also mentioned in the literature (Kozminska, 2019; Gorgolewski, 2019; Van den Berg, 2019; Addis, 2006). Related to this need for storing, some interviewees mention that storing results in extra costs and therefore stakeholders try to avoid taking this responsibility.

Cyclic phasing

It is interesting to hear that multiple projects that were intentionally traditionally organized, later shifted to a more integral, design and build/engineering model (Interview B + Interview D). The interviewees state that this has helped in making sure that the contractor became involved in the definitive/technical design and therefore was able to align with the engineering/build aspects and take over responsibilities before moving to construction. It also helped in working with building specifications in a more flexible way, which is mentioned to be completely different from traditional projects. This suggests the need for respecification of the process in uncertain circumstances.

"Ook al waren alle contractstukken en alle bestek tekeningen gereed, we hebben nog steeds met elkaar afgesproken, mocht het zo zijn dat er nieuwe materialen of dat er materialen beschikbaar komen die we een tweede leven kunnen geven in het project, dan staan we daar altijd voor open." (Development manager)

In traditional developments, a detailed design and building specifications are made and, based on these, a price is proposed by the contractor, who subsequently will execute exactly what is in those documents. There is no room for deviations without cost deviations. However, when working with re-used components, which are not always known at the moment the building specifications are made, or might have deviating dimensions, this would not support to re-use.

This would mean that the design should be iteratively revisited throughout the process. To facilitate this iteration throughout the process, another way of collaborating with the contractor is discussed. This includes a way in which the contractor is preferably earlier involved and is also involved and responsible for design and engineering activities.

The interviewees also stress that other topics than re-use also require a lot of attention. This results in a certain contradiction in the process between the need for freedom and a flexible approach that is needed to experiment with re-using components, and the strict planning. This leads to difficulties in the schedule or might even result in penalties if decisions are postponed and the building won't be delivered in time. To make sure that this won't happen the interviewees advised to still schedule certain milestones that secure timely decision making while moving on and guarding the planning. This idea of experimentation and freedom is in line with the in the literature described need for a flexible approach of time (Kozminska, 2019; Gorgolewski, 2019).

"Je moet af en toe ook gewoon door zeg maar. Het is leuk hobbyen, om zeg maar die materialen te gaan hergebruiken maar het project moet er ook gewoon komen." (Development manager)

To deal with difficulties in organizing the building projects and in decision-making, a few suggestions are discussed. They are mainly related to structuring the process to be able to make decisions at the right moment. The layers of Brand, as described in Chapter 1, are mentioned several times, to systematically assess the building and opportunities for re-use. In addition, decision matrices are advised, and working with the coding of components, such as NL-SfB or Stabu, are mentioned to be a good way to work with components and identifying its re-use potential. This is in line with the ideas of Rakhshan et al. (2020), stating that a decision-making framework could help in organizing the process. However, according to the interviewees, multiple types of coding and structuring are currently used which obstructs standardization.

Selection of the project team

Interdisciplinary project team

A circular development manager stated that, in essence, the circular projects are comparable to traditional projects, meaning that every actor should make its tradeoffs based on their craftsmanship. However, when building circular, one should integrally justify certain decisions and include all disciplines. For instance, the interviewees state that especially when re-using components, it is of importance to take the maintenance phase into account from early on. Re-using a certain component might initially seem less expensive and a circular choice, but when approaching it from an integral perspective it could be the wrong choice.

"Het hergebruik van je gevelelement, vanuit circulariteit vanuit het MPG, vanuit CO2 reductie, zou ik zeggen altijd doen, maar mijn collega adviseur installatietechniek die zegt ja leuk bedacht, maar door dat wij die gevel handhaven, zakt de RC weg, waardoor we energetisch dit verlies hebben." (Circularity consultant)

Besides difficulties with contractor collaborations are discussed, stating that, in general, contractors find it difficult to change their traditional way of working. One interviewee suggests working with medium-sized contractors, as they are most flexible in their process. This flexibility is claimed to be crucial when working with re-used components due to the difficulties to match supply and demand.

To improve the efficiency of identifying components available in the market, it is suggested to collaborate with parties that have a better insight into the re-use market. However, some of these companies are not willing to collaborate if there are also collaborations with their competitors. Some suggest the development of one marketplace combining all information of the separate platforms concerning available re-use components. Some also suggest collaborating with (service) suppliers and manufacturers. However, these are not always willing to change their current way of working.

Early involvement

The interviewees also suggest to involve expertise such as re-use experts, demolition companies, (sustainability) consultants, and contractors earlier in the project than normally. This enables them to include their knowledge to be able to make integral decisions and integrate re-used components from early in the process.

"Die kennis wil je eigenlijk gebruiken om het ontwerp op mee te nemen." (Development manager)

Collaboration and shared vision

Related to the need for integral decisions the interviewees state that there is a need for an adjusted way of collaboration. This comes with collaborations for a longer period, closer collaboration between different actors, and the need for better alignment between them. According to one of the experts, this should also be incorporated in the project management plan.

In line with the literature, the attitude of the project team towards re-use is also mentioned to be important in re-use projects. According to the interviewees, this attitude varies between stakeholders and results from diverse ideas. One reason for a negative attitude includes for example architects that do not like the esthetical appearance of "second hand" components. Therefore, components that are in good technical conditions are not re-used due to esthetical aspects. Other stakeholders might have a negative attitude due to the difficulties related to responsibilities and guarantees and the risks related to this. Due to the second-hand character and unknown origin, contractors are reluctant to provide quality assurances for reclaimed components or would therefore even refuse using them. This leads to difficulties with taking responsibility for quality assurance or would result in avoiding the use of reclaimed components. Surprisingly even innovative clients, that circularly demolish their own buildings, are mentioned to be reluctant to re-use components in their new buildings.

"Ik zei daar zitten fantastisch mooie toiletpotten in die kunnen we hergebruiken. Ja daarvan zei de eindgebruiker, ja dat is leuk bedacht maar dat gaan we echt niet doen." (Circularity consultant)

A good working relationship and trust between the project team members are mentioned to be of importance in re-use projects, which is in line with the ideas of Rakhshan et al. (2020). This is mentioned to be needed to take guts and experiment with the relatively new concept of re-use.

"Juist zeg maar door die goede samenwerking en die goede verhoudingen hebben we ook met z'n allen wel wat lef durven nemen. Van ja, het kan fout gaan maar dan draaien we er ook met zijn allen voor op." (Development manager)

Motivation

Several interviewees mentioned the importance of the motivation of the project team to work with re-used components. They mention that intrinsically motivated team members contribute to building with re-used components. Team members and involved parties should also be selected based on stakeholders' motivation and experience with re-use. This would help in creating a shared ambition and to avoid falling back on a traditional approach.

"Mensen moeten bijna letterlijk voor leven inderdaad, anders ga je toch snel ja die traditionele kant in." (Program manager)

Several interviewees even mention the need for the inclusion of extremely motivated team members, who motivate and lead the team in re-using components during the initiation and design phase. Such members are sometimes referred to as "project champions" and are mentioned to be needed to secure the circularity ambitions.

Other

The interviews also pointed out some other aspects, that are not directly related to the identified themes.

Interviewees state that, due to the fact that the re-use market is still under development and therefore the choice of reclaimed components is very limited, concessions related to quality or costs are often to be made.

"Ja dan kun je twee dingen doen, je kunt hem niet toepassen of je doet concessies op de kwaliteit of de euro's." (Circularity consultant)

This also results from the fact that most buildings are not built to be deconstructed and because the quality standards and regulations are developing. Reclaimed components often don't meet the current standards or come with non-standard dimensions. This leads to difficulties related to the implementation of the reclaimed components.

Also, the current building stock is consisting of large amounts of concrete and steel. These materials are particularly mentioned to come with difficulties for re-use as these materials have to deal with regulations and safety issues and are therefore often recycled rather than re-used. This results in lower percentages of re-use.

"Het zorgt er wel voor dat de gebruiksmogelijkheden minder goed zijn of dat er heel veel kosten moeten worden gemaakt om die veiligheid te toetsen." (Director circular materials at demolition company)

According to the interviews re-use of components is therefore not cheaper and due to additional tasks to meet the desired quality, it might even become more expensive than using new components.

Some interviewees also suggest that re-use has more potential and is more obvious, in renovation and transition projects of existing buildings, than in new building projects. This seems related to the difficulties of acquiring components off-site and in the market, but could also result from the differences between regulation for renovation and new construction.

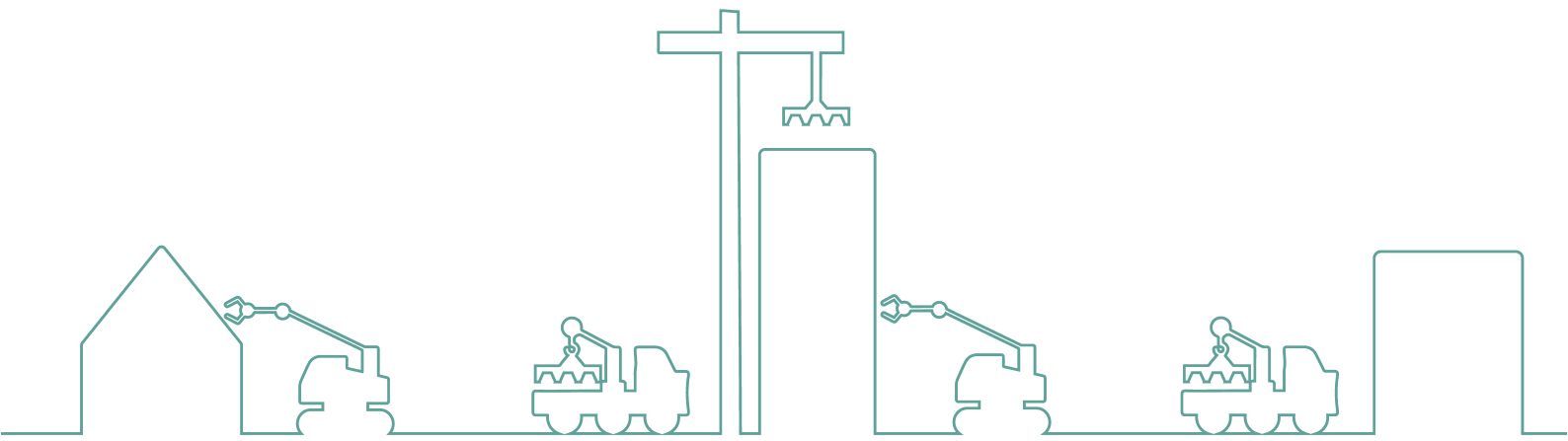
Besides several interviewees talked about the potential for “donor buildings”, the use of larger shares of building components originating from one building, to achieve high degrees of component re-use. Others mention the potential for re-use within the portfolio of larger clients, such as municipalities or universities. These clients have some generic components within its porfolio and have the opportunity to re-use components originating from their own projects.

The opportunities and potential of project management in stimulating re-use from the initiation phase onwards are stressed. It is mentioned to be of importance in defining the ambition, aligning it with the project management plan, and thereby having the most impact and steering the project towards re-use. The earlier the idea of re-use is integrated into the project management approach, the more impact it can have.

In line with the findings of Rakhshan et al. (2020) about the crucial role of the client, most of the interviewees stress the important role of the client. The willingness of the client to re-use components, and its role in inspiring the project team to do so, is mentioned to be crucial and helps in facilitating a spirit within the project team to do the best they can.

CHAPTER 5

CASE STUDY A



This chapter will discuss a case by describing how the project has occurred and what the role of the briefing, project organization and project team selection was in relation to the re-use of components, including barriers that have been experienced. This case includes a renovation of a non-residential building in the Netherlands and is chosen based on the case study selection criteria as described in Chapter 2.4.

5.1 Data collection

To collect data on the case several articles and documents have been studied. Including both publicly available articles as well as internal project documents. Besides, 4 stakeholders have been interviewed in a semi-structured setting. The interviewees included the client, an architect, and two project management consultants.

Interviewee B: Experienced program manager at a project management consultant in the building sector. Involved in multiple building developments and responsible for the program management of a cluster of circular renovation projects.

Interviewee C: Experienced project manager, working for a project management consultant in the real estate sector. The interviewee was responsible for the project management of the realization of the renovation project.

Interviewee J: Working at the client and responsible for the project management of the renovation project. Involved from the early stages of the project.

Interviewee N: An architect at an architectural firm that is experienced in working with re-used components. Responsible for project management at the architectural firm.

5.2 Introduction

The case includes a recent, large scale renovation project in The Netherlands. The building is located in the city center of one of the larger municipalities and includes more than 7.000 m2 and multiple floors, with a relatively simple, straightforward design. The building originates from 1960 and after construction, several small scale maintenance/renovation tasks have been undertaken. The building is used as a municipal office.

The goal of the recent large scale renovation was twofold, on the one hand making the building more sustainable and energy-efficient and on the other hand rescheduling functions into one building.

The renovation project is part of a larger project that involves several municipal buildings and which focusses on upgrading sustainability. These projects are awarded and carried out by a consortium in alliance with the municipality (client), the consortium is also responsible for 15 years of maintenance after completion of the renovation. The consortium consists of architects, a contractor, a project management consultant, a sustainability consultant, and an installation consultant. Other stakeholders were also involved, including a consultancy company specialized in re-using materials and components.

The goal was to realize a maximum of sustainability within the available renovation and maintenance budgets. Guiding themes included, amongst others, efficient use of space and

several aspects concerning sustainability; improving liveability and health, 50% energy neutrality, 95% re-use of demolition material, reducing CO2 emissions, increasing green and water, attention for people at a disadvantage in the labor market, and sustainable work and living traffic.

The principles of “The Natural Step”, a non-profit organization that stimulates sustainable development, were used as guiding principles. As a result of the renovation project, the energy label of the building significantly improved from G to A.

Re-use

Related to several themes Key Performance Indicators (KPIs) have been set. These themes include: Energy, Materials, Water, Biodiversity, Mobility, Comfort, Social Impact, and visibility. The re-use of materials fits within the theme “Materials”. Related to this theme, five KPI’s have been developed.

Eventually, around 95% of the materials and components that became available from demolition were used again. This was done in several ways. Recycling materials, making components and materials available for others to re-use via an online platform, and lastly, in line with the scope of this research, re-using components within the renovation project. About 10 percent of the demolition materials and components are re-used within the building itself. The components that became available from the demolition of the client’s buildings were the main source for second-hand components in this project. In addition multiple components are repurposed. The identified re-used components are described below and visualized per layer in Figure 21.

	No reconditioning	Reconditioning	
On-site		- Mineral fiberboards as façade insulation - metal plats as façade finishing - Closets are made from wooden interior doors - Door locks and hinges are re-used - Rails of blinds are used for finishing floors - Doors are re-used in central walls - Wooden fences are re-used in walls - Ceramic toilets - Ceramic washbasins - Fluorescent tube luminaires - Cable trays	**Owned**
			Market
Off-site		- Interior walls from another municipal project	**Owned**
			Market

Table 4. Re-use case A

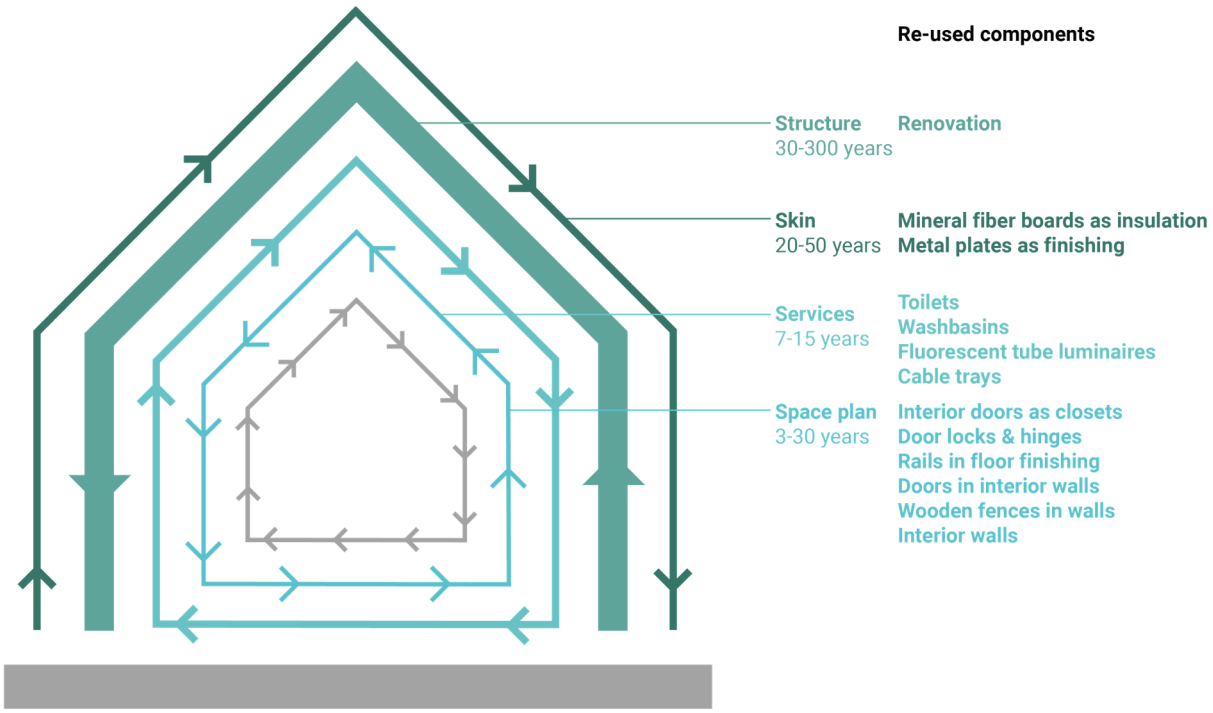


Figure 21. Re-use of components divided per layer

5.3 Findings

This chapter will describe the main findings of the study of Case A, by describing the briefing process, the project organization, the project team selection and the experienced barriers and tools to overcome them during the project. It will conclude with some other findings.

Briefing

The client was willing to improve their municipal buildings and make them sustainable and has asked the market to come with ideas for making their real estate sustainable. The client defined the budget for a total of 7 buildings and asked market parties to come with an offer including renovation and 15 years of maintenance. This resulted in an extensive tender procedure, that took several years. During this process, even before a consortium was awarded and a contract was signed, the consortium together with the client started to develop and define the programme of requirements according to the interviewees.

The municipality initiated the idea to re-use demolition waste, as they had a successful experience with the concept of re-using components in a previous project. This has been incorporated in a document that defined the project in two main pillars. Firstly, during the demolition, the several steps, based on The Natural Step, should be followed to use the demolition waste as a resource. In the document, it is described that it will first be determined whether or not materials are suitable for re-use, after which it will be determined whether or not they could be re-used within the client's scope or region. If this is not the case, the components will be offered through an online platform. The remaining materials will be processed and recycled. Secondly, it was stated that new used building products are defined

to be required to achieve a defined sustainability score and should not be on a list of non-sustainable materials as defined by The Natural Step.

The definition of the earlier mentioned KPI's was also a result of this process of translating the ambition of the client into requirements. The KPI's were defined by the consortium and applicable for all 7 buildings. Afterward, the KPI's were translated into specific KPI's for this project.

"En een van de opdrachten die de gemeente aan ons had meegegeven was eigenlijk zo veel mogelijk hergebruik bewerkstellingen." (Project manager)

One of those KPI's was related to material use and come with five more detailed sub-KPIs. For newly used products the KPI's stated that they should achieve a certain score according to BREEAM standards and none of the new products should be on the "red list" as defined by The Natural step. With respect to the use of the products that become available from demolition, it included three KPI's that together would result in 95% of the demolition waste to be used again rather than become waste, measured in units of mass throughout the project lifecycle. These KPI's and the sum are visualized in Table 5.

Definitions	Percentage
Re-use: The part of the released materials that is re-used within the municipal region.	> 40
Redistribute: The part of the released materials that is re-used **or** offered on a digital platform.	> 80
Recycle: The part of the released materials that is re-used **or** redistributed **or** recycled.	> 95

Table 5. Re-use KPI's (After case documentation)

Due to the fact that it was known from the start that the source for second-hand building products is the building itself, an estimation of the re-use could be made.

The interviewees suggested that the role of the client in this process of translating the client's demand into certain goals and requirements related to re-use was crucial. According to the interviewees achieving the re-use goals wouldn't have been possible if the client wouldn't have embraced the re-use ambition.

During the tender procedure, the client was very clear in its ambitions concerning re-use. This resulted in the beforementioned KPI's and confirmation of the consortium to these goals. According to the project manager and architect, these clear goals helped the consortium to guide the team through the process, and keep track on the re-use ambition. In that sense, the briefing was of importance in achieving this degree of re-use. The interviewees also stated that the definition of the KPIs related to re-use was tangible and therefore easy to measure and steer on. This is mentioned to have helped in achieving the defined goals.

"Dat heeft er voor gezorgd dat dat gewoon gedurende het hele bouwproces iets is waar je met elkaar scherp in moet zijn en moet proberen vol te houden." (Architect)

Several interviewees stressed the importance of sharing the idea of re-use with all people that became involved throughout the process. This relates to the fact that the approach is really

different from traditional projects and should, therefore, be repeated throughout the process. The role of the project manager was mentioned to be important to be able to achieve this. In addition, a communication team was created to inform stakeholders about the development of the project. To create an understanding of the re-use ambition by the complete team, several workshops have been organized. This has resulted in the initiation of re-use ideas throughout the process. However, it was still experienced to be difficult to extend this ambition to everyone that got involved in the project. While the project was progressing, the core of the team, the actors involved in the consortium, started to understand the re-use concept. However, when new actors became involved, especially during construction, it was experienced to be more difficult to share the concept. An architect proposed the idea to make a re-use ambition movie that could be shared with all involved stakeholders to share the re-use story and ideas behind.

"Dat op een gegeven moment een bouwvakker op de bouwplaats zei ja waarom moet ik dit slopen? Want volgens mij kan ik het daar eigenlijk net zo goed weer gebruiken. Dan laat ik het gewoon zitten." (Project manager)

Including re-use from other sources was not included in the requirements. This seems to be one of the reasons that the team didn't widen their scope for including re-used components from other sites or the market. Therefore, including multiple types of re-use in the requirements might have stimulated the team to focus on a wider scope for reclaimed components and might have lead to higher amounts of re-use.

Project organization

In essence, the project delivery steps traditionally followed each other. However, since the consortium, including both architects, consultants, and a contractor, was involved from the initiation of the project and is responsible for maintenance as well, it can be seen as a more or less integrated project organization. The steps and involvement of actors are visualized in Figure 22.

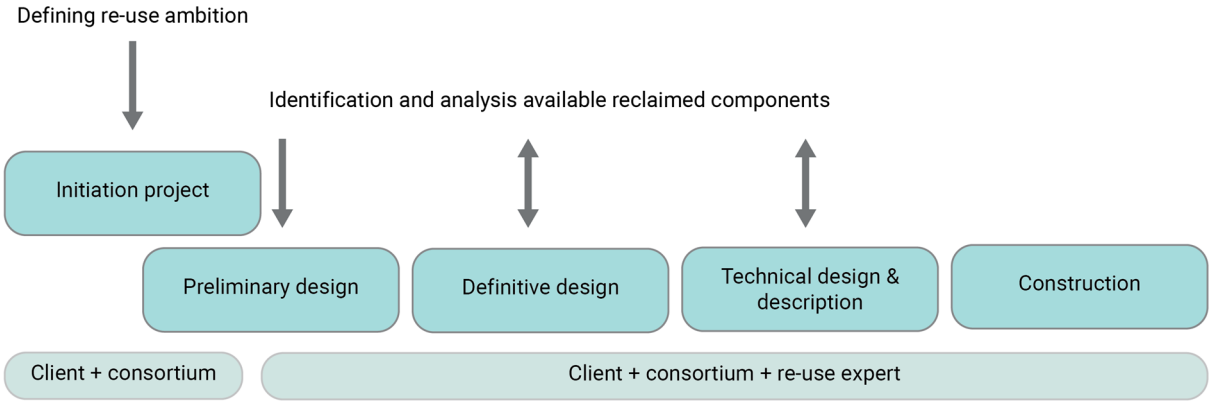


Figure 22. Project organization Case A

The initiation of the project, including the tender procedure, was extensive and took about three years. This is in line with the literature (Kozminska, 2019), stating that one should extend the initiation phase in re-use projects. However, the long duration of this phase is probably caused by the scope of the tender, as it included 7 projects in one tender.

It was stressed several times that a major difference in this process, compared to traditional processes, related to the inclusion of information concerning demolition materials which

acted as input from early on in the design process. This was done after a design vision and sketch design were developed, but before a detailed design was made.

"Ja heel erg in het beginstadium van het proces is inderdaad geinventariseerd wat is er dan aanwezig? Hoe kunnen we in hoofdlijnen de gedachtegang en de ambities die we hebben voor dit gebouw, hoe kunnen we die vormgeven? Daar is die inventarisatie van hergebruik natuurlijk onderdeel van geweest." (Architect)

More re-use could have been achieved if components originating from other projects would have been included. The difficulties to include components from other projects than the building itself are mentioned several times. According to the interviewees, this was mainly related to timing, the other buildings were still in use at the time the components would have been needed for construction. To be able to realize more re-use from other projects, the schedules of the projects should have been aligned early in the project.

According to one of the interviewees, the way the project is organized doesn't necessarily influence the amount of re-use that is achieved, but the greatest gains can be made in sharing the re-use story with all the people that become involved throughout the process. The challenge and importance of including everyone in this story is also stressed by all case interviewees.

Project team selection

As mentioned, the project team was selected through an extensive tender procedure and included a consortium with several companies with varying expertise. The different companies that formed this consortium already knew each other through their network and bundled together as they were like-minded and had shared ambitions related to circularity and re-use. This group has also worked together on a competition before the tender of this renovation project. According to an interviewee, based on their shared ambitions and the relationship and trust that they had built, they were very enthusiastic to work together on this project, as a private limited liability company, and spend a lot of time to win the tender.

The good relationship and shared responsibilities within the consortium resulted in a natural way of collaboration between the team members, which according to an interviewee might have convinced the client to select this consortium.

"Dus in de hele keten van bedenken, ontwerpen, adviseren tot aan het bouwen zelfs tot aan het onderhouden, dat zit allemaal onder een vlag. Dat zijn allemaal mensen die elkaar kennen ... Dat zijn geen collega's, maar die werken natuurlijk wel op een hele makkelijke manier samen. [Ik] denk dat dat een van de succesfactoren is geweest. (Program manager)

Besides the importance of the motivation and mindset of the team members related to re-use and their experience with re-use is stressed several times to have been of importance. As mentioned, the ambition and motivation of the client concerning re-use was of importance and has contributed to being able to integrate re-use throughout the process.

Several actors within the consortium had high ambitions and previous experience related to re-use. These people are mentioned to play a big role in steering the team in the process of re-using components and could be seen as the project champions of the project.

"[Er] zijn echt wel een paar aanjagers nodig, een paar letterlijke en figuurlijk steunpilaren, die dit echt helemaal omarmen." (Program manager)

However, for some of the team members, including the contractor, it was more difficult to embrace the ambition to re-use components. This was mainly related to the (perceived) extra time, risks, and costs related to re-use. This mainly results from the additional activities that should be undertaken to use reclaimed components, such as disassembly and recovery tasks. Difficulties with providing quality assurance and guarantees on reclaimed components are also mentioned to play a role in this.

The architect also suggests that the overall positive vision concerning re-use within the consortium has been one of the reasons for winning the tender. Besides, it was mentioned to be of importance that the consortium shared responsibilities and risks concerning design, construction, and maintenance. The architect indicated that this made them think differently and feeling more responsible for considering the consequences of the overall project. This is mentioned to be different for them as architects, as they are traditionally only involved during design.

The consortium, in collaboration with the client, can be seen as the basis for the project and other parties and experts became involved where needed. In addition, the close and equivalent collaboration, in an alliance between the client and the consortium, was stressed by several interviewees.

Besides, to enable and maintain the earlier defined ambitions concerning re-use, some interviewees mentioned the need for continuity in the team throughout the project.

Other

Throughout the process, multiple difficulties related to re-use were experienced by the interviewees. Some of them are closely related to the briefing, project team selection and the project organization, while other barriers seem less related to these topics.

It was, for instance, stated that some components that were planned to be re-used were eventually not suitable due to damages that only became clear later on in the construction process.

“Alleen kwamen we er helaas achter dat tijdens de bouw dat er zoveel water en viezigheid, die vloeren worden voor niets afgedekt. Die platen zagen er niet meer uit, dus dat zijn helaas wel nieuwe platen geworden.” (Architect)

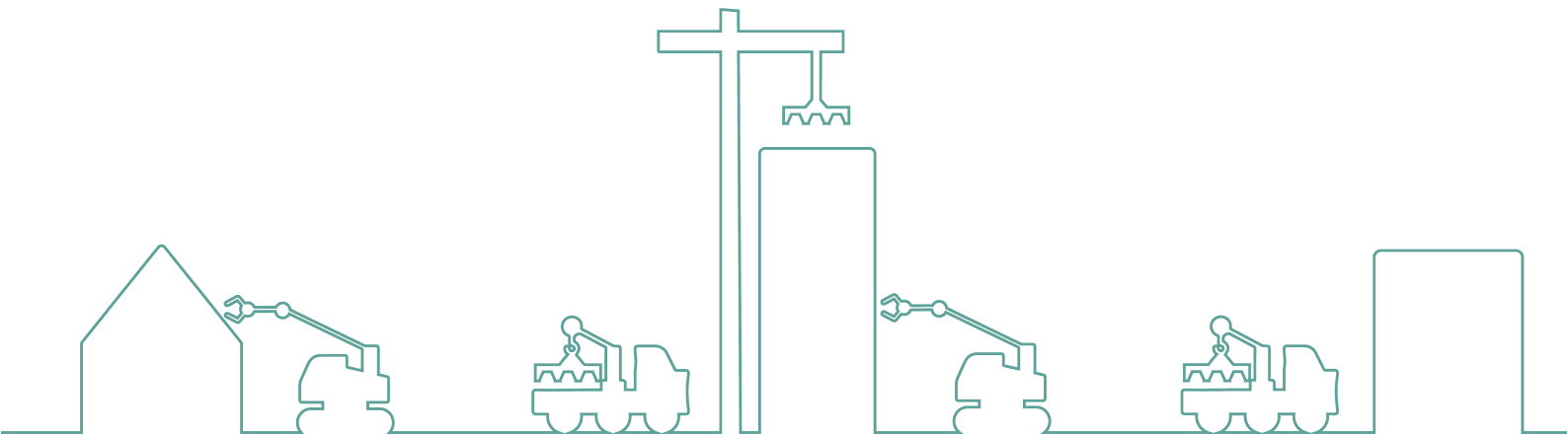
According to the interviewees, the degree of re-use could have become higher. Within this project, a lot of recycling was done, rather than re-use. This is mentioned to result from the limitations imposed by requirements and standards relating to quality and safety issues such as fire resistance. In addition, difficulties were experienced since the building was not built to be disassembled.

“En dan komt het toch heel vaak er op uit dat je wel gecertificeerde, nieuwe producten moet gebruiken, dat je daar eigenlijk geen keus voor hebt.” (Architect)

According to the interviewees, one of the barriers that has limited the amount of re-use also included costs. At a certain moment, there was no budget left to invest more in re-using components, and buying new components was then a cheaper choice as no additional activities should be undertaken.

CHAPTER 6

CASE STUDY B



This chapter will discuss a case study by describing how the project has taken place and what the role of the briefing, project organization and project team selection was in relation to the re-use of components, including barriers that have been experienced. This case includes a newly built non-residential project in the Netherlands and is chosen based on the case study selection criteria as described in Chapter 2.4.

6.1 Data collection

To collect data about the case several articles and documents have been studied. Besides, 4 semi-structured interviews have been conducted, of those interviews one interview included multiple interviewees. The interviewees included the client, a construction project manager, a plan developer, and both interior and exterior architects.

Interviewee I: This is the client of the project, the director of a Dutch contractor with different subgroups. The client has worked for multiple other (civil) engineering parties and contractors before working at this contractor.

Interviewee K: The project manager of the realization of the construction of the project. Working within the group that is responsible for the realization of office projects.

Interviewee L: Interviewee works as a plan developer at the contracting party. Responsible for the development of the project plan from the initiation phase up to the start of the construction.

Interviewees M: This interview included multiple interviewees, all working within the architecture department of the contractor. One of the interviewees was responsible for the exterior design, one for the interior design, and the last interviewee was involved in the modelling of the design.

6.2 Introduction

The case includes the construction of a new circular office building (> 1500 m2), situated on a business parc in The Netherlands, which has recently been completed. The project was initiated as a result of the need for a new office. The initial idea was to renovate a building, however, no suitable building in the preferred region was found. Therefore, a new building was developed.

The project was initiated by a client, which was closely involved in the project due to the fact that the client is the owner of the contracting company that is responsible for the realization. The team included a “design and contracting” company. In addition, a demolition company, installation consultants, and material suppliers have been involved.

“Health and wellbeing” and “sustainability”, in particular circularity, were identified as the main themes in the development of the new office building. The measures that were taken related to material usage have resulted in a 45% lower Milieu Prestatie Gebouwen (MPG) score compared to the previous office building. A score that indicates the environmental performance of the materials that have been used in the building.

Re-use

Based on the three R's, "reduce", "re-use" and "recycle", re-use was considered from the start of the project. The re-use of components only included off-site re-use, as the site included an empty lot. Reconditioning of the components played a role, however, this sometimes included only minor cleaning and recovery activities. Due to the fact that the client was involved in several ongoing projects, including demolition projects, there was an opportunity to re-use components originating from those projects. Besides, components available in the market have been re-used. The following components are found to be re-used (Table 6).

	No reconditioning	Reconditioning	
On-site			**Owned**
			Market
Off-site		- Glass sliding door, originating from the previous office - Walls and doors from previous office project - Baseboards, originating from another project of the client - Glass partition walls and sliding doors, origination from another project of the client	**Owned**
		- Lamps from a shopping district - EPS roof insulation - Plastic roof covering - Terrace tiles - Grass tiles - Wood paneling of the stair from scrap wood - Drywall - Ceiling plates - Cable trays - Floor covering	**Market**

Table 6. Re-use Case B

As visualized in Figure 23, the components that are found to be re-used fall within the layers services, skin, and space plan. No re-use of components is seen within the layer structure.

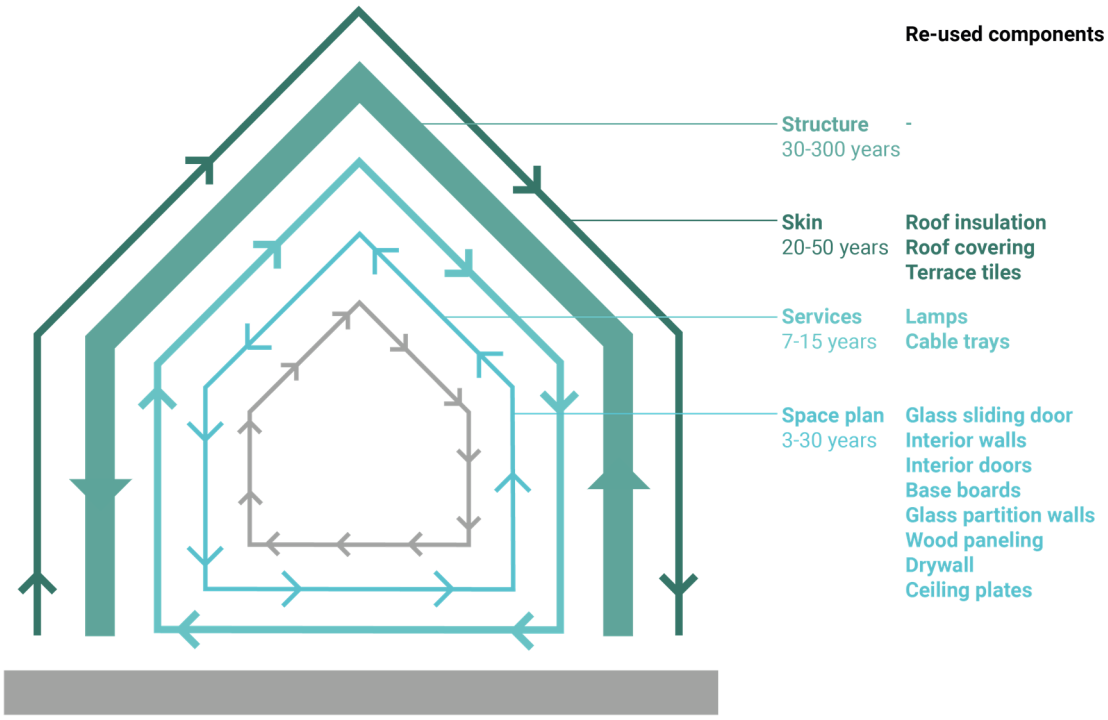


Figure 23. Re-use of components divided per layer

6.3 Findings

Briefing

Already, from the initiation phase of the project, the client has set high ambitions related to two main themes, “health and wellbeing” and “sustainability”. The ambition of the client related to re-use originated from two reasons. On the one hand, the client mentioned to be intrinsically motivated and on the other hand the client, as a company, desired to improve the position of the building sector and express this ambition with their new office. The high ambitions and the trust of the client related to the potential of re-use are mentioned to have played a big role in the amount of re-use that is achieved.

“Die bevlogenheid bij de klant was ook echt aanwezig.” (Plan developer)

By organizing workshops with the client’s representatives and the contracting party, a better definition of these ambitions was developed. According to the plan developer, it was an extensive process to make sure that the ambition of the client was understood and translated into project-specific targets and characteristics. This was sometimes difficult as the main themes, health and wellbeing and circularity, were sometimes contradicting each other. Using fewer materials, which is a circular decision, might, for example, impact the indoor climate which might not contribute to the wellbeing of the office users. Therefore it has to be made clear which of the themes had priority. It was concluded that health and wellbeing had the most priority and circularity was the second most important.

Related to re-use, this process of discussions and workshops with the client, resulted in the development of the concept “reduce, re-use, recycle”. This meant that during the project one should first consider whether is it possible to reduce material usage, if not, look for re-usable components and only if the previous options are not possible, use recycled materials. These three pillars are mentioned to be used as a starting point to base decisions on throughout the entire process.

“Dan wordt het ook een soort kapstok waar je eigenlijk elke beslissing op maakt.” (Client)

This resulted in the ambition to achieve the lowest possible MPG score. However, next to this and the concept of reduce, re-use, recycle, no clear goals or targets have been defined related to re-use. This might have been due to the limited experience and knowledge, which is mentioned to have made it difficult to develop more concrete targets. According to the architects, this was, on the one hand, positive, as it left room for the team to experiment with material usage throughout the process with little restrictions, but on the other hand, clear goals would have helped the team to determine the Red Threat to steer the process and take decisions.

During the briefing process, it also became clear that components originating from ongoing projects of the client could potentially be re-used. An inventory of the potential components was done and the client has instructed the team to take this into account and try to incorporate these components in the design. This also meant that those products had to be analyzed, measured and had to be stored for a while.

“In één van onze andere projecten kwamen natuurlijk tegen van he maar dit kantoor wordt gesloopt, dan moeten we direct alles aan elkaar koppelen. We hebben eigenlijk toen we nog niet eens wisten hoe onze nieuwe kantoor eruit zou komen te zien. Hebben we wel helemaal gezegd wat er ook gebeurt, dat spul wat we er daar uit halen, moet er wel in komen.” (Client)

These ambitions and concept of re-use were thus initiated by the client during the initiation phase. However, it was stressed several times that it was very important that this concept was repeated throughout the process. The client had almost weekly discussions with the team, to make sure that the concept of re-use and the reason behind the concept was understood and incorporated and the team members would not fall back in their traditional way of thinking. Posters with the message to re-use as much as possible were even hanging on the walls of the construction shack.

Project organization

The project started with the initiation of the project by the client. Once the new location was identified the contracting party organized workshops to identify the wishes and ambition of the client. Due to limited time, the process of translating the client's ambitions ran in parallel with the development of a sketch design. During this process, it became clear that the client wanted to re-use components and had potential components within its portfolio. After the sketch design was made, an inventory of those components and how these could be incorporated in the design was executed. During this phase, the contractor was also involved and several activities ran parallel to each other, including the further investigation of the components to be re-used and storing them, finalization of the design, and ordering of (new) components. The construction phase followed these steps based on a technical description. This process is visualized in Figure 24.

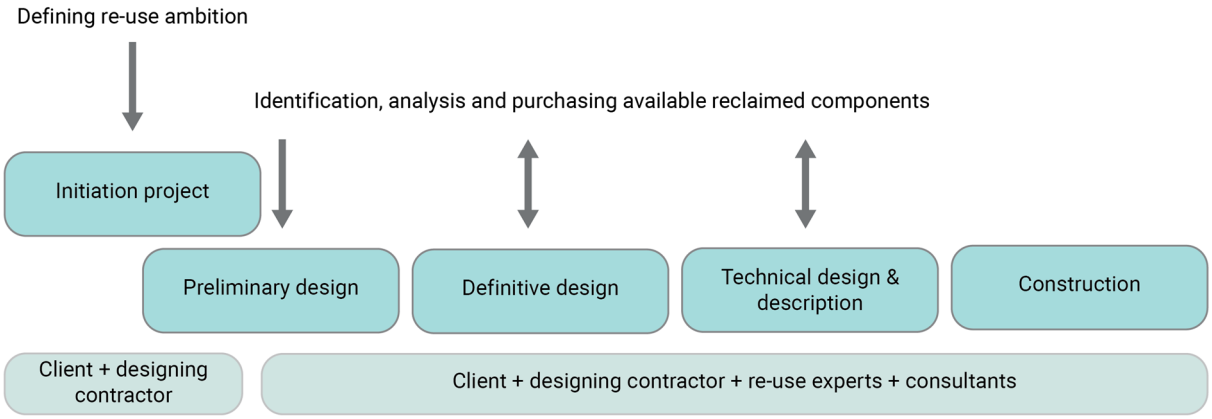


Figure 24. Project organization Case B

The planning of the project was very tight and only limited time was available. The team members first believed it was not impossible to achieve the high ambitions of the client within this short period. Resulting from this very limited time frame, no extra time was reserved to implement re-use. The architects indicate that if more time would have been available re-use opportunities could have been better investigated and the sketch design could have been revisited at the moment the re-use opportunities became clear. In the backward planning (calculating back from a fixed end date) however, certain milestones related to materialization decisions were included.

"Als we dan klaar willen zijn, dan moeten we op dat moment dit besluit nemen. En zo maken we dat inzichtelijk voor alle componenten die we hebben in onze hele gebouw." (Client)

The contractor was already involved during the early stages of the design. This early involvement was related to this very short period that was available, but it also helped in giving technical input in the design with re-used components and improved constructability. The contractor has, for instance, helped in analyzing the impact of re-using partition walls and had the lead in measuring and stickering at the location of harvesting, making calculations, and providing the architects with the right information concerning reclaimed components.

Multiple interviewees mention the benefits of working as a "designing contractor" when working with re-used components. This has enabled them to have a less fragmented process and let activities run in parallel, which enabled them to secure information and give input to each other related to the re-use of components throughout the process. In addition it has offered the opportunity to work flexibly and avoid the use of strict building specifications. Instead of those strict specifications, the intentions were described as a certain desired quality level that should be met.

The interviewees mention the impact of designing and building with re-used components on the project organization. They believe that one should first make an inventory of potential components and base the design on that. This requires a different way of designing and an adjusted mindset of the architects. They indicate that re-using components takes extra time and energy during the initiation phase, where components are to be identified and research has to be done, before being able to incorporate the components in the design.

"Waar je normaliter een ontwerp maakt en vervolgens krijgen wij die en met die tekeningen gaan wij naar een leverancier van dit product zoeken we op deze afmeting, ga je hier zeggen van nee, we moeten eerst het product zoeken, welke afmeting heeft dat en hoe past dat dan in het ontwerp. En waar moeten we dan het ontwerp aanpassen om het passend te krijgen." (Project manager)

Most of the identification of re-usable components has happened during the early stages of the design phase. Therefore, these components had to be stored for a while. This happened both in the workshop of the company, as well as in rented containers on an external location. This process of transportation and storage is mentioned to be quite difficult and has resulted in some damage, which led to some of the components having become unusable. Next to the early identified components, few space plan and service components are identified and purchased later on, when construction already had started. The interviewees mention that they have worked with a systematic approach that was based on the earlier mentioned layers of Brand. According to them, most of the re-used components are used within the layer "space plan" as this offered the most opportunities and allow for integration until later on in the process.

"Omdat het één: zo makkelijk is en en twee: niet heel veel impact heeft op de rest van het proces….. Het is niet onwijs kostenverhogend, het duurt niet heel veel langer, je kan wat langer de tijd nemen om het goed uit te zoeken et cetera." (Plan developer)

Re-using components within the layer structure is mentioned to be way more difficult as this should be decided on early in the design phase and is determining for the dimensions of the building. Therefore, less time is available to analyze structural re-use opportunities.

As mentioned, there was only a limited period available for the realization of the office. This restricted the team to spend enough time on the identification, research, and integration of second-hand components during the initiation phase. According to the interviewees, in future projects, they would better integrate the re-use concept in the project organization. This would mean that more time during the initiation phase would be reserved to conduct a thorough investigation of re-use opportunities, by identifying, measuring, and analyzing re-usable components before the design is started, and more specific re-use activities and milestones would be included. For instance, by setting a concrete milestone for a design proposal that should be accorded by the client within two weeks and afterward the proposed components could be purchased and further investigated to enable for the inclusion of the components within time.

The limited market for re-used components is also discussed to restrain the potential of re-use. The interviewees indicated that suppliers do not always have the right amount of products available at the right time. Therefore new components still have to be purchased. In addition, it was difficult to get insight into second-hand products that are available, due to the limitations of the still developing online platforms. A database with available components at the start of the project would have helped to integrate higher degrees of re-used components. As the re-use market is developing, better insight into the availability of certain components will become more clear. The interviewees also advise making clear agreements with the suppliers of second-hand components to make sure that the re-used components will be available at the right time.

"Dat was een aanbod van een sloopaannemer en die zeiden van jullie kunnen hergebruikte gipsplaten van ons krijgen. En uiteindelijk toen we ze nodig hadden, waren ze niet voorradig op de markt." (Project manager)

Project team selection

The project team included a “designing contractor” who covered several in house disciplines, including project developers, architects (both interior and exterior), modelers, and a contractor. This company also collaborated with several other companies including a demolition company, installation consultants, and suppliers.

The selection of the design and construction company was obvious as this company is part of the client’s company. Subsequently, the project development team designated colleagues to form the project team. Afterward, the team realized that these internal team members were not selected based on their motivation to re-use. Therefore, team members were not all motivated to re-use from the beginning of the project, especially the ones that were in charge of the construction. One of the team members was intrinsically motivated to re-use and this has resulted in a lot of initiative from her side in the identification of components in the market, for instance, the identification of streetlights. This team member could be seen as a re-use project champion. The interviewees experienced the importance of the willingness of the team members to spend time on identification and analysis of re-usable components. The plan developer suggests to include this motivation in the selection of team members, especially the architects, in future re-use projects. It is also mentioned to be hard to keep motivated about the re-use concept when team members express their selves negatively.

“Op zoek, op bouwmarkten, handels online en bellen met leveranciers, hebben jullie toevallig nog iets staan of zijn jullie in een sloopproject. … dat moet echt wel iets zijn wat je past ook als mens, je moet dat het leuk vinden.” (Plan developer)

Besides it is mentioned to be difficult to incorporate re-use in the process since people are inexperienced with the topic and have to deal with additional information and tasks that are needed to implement reclaimed components. For example, more technical information is needed to implement a reclaimed component in the design. Therefore they suggest collaborating with actors that are more experienced with these tasks and include their expertise early in the process.

“Alleen nog steeds merk je dat dat best wel moeilijk is om dat bij elkaar te krijgen zeg maar, van wat heb je nou gemeten, komt dat profielletje er om heen of heb je alleen maar de glasmaat gemeten. .., waar zit dat profiel, … moet daar nog een versterking in die metal stud wand? Het wordt dan best wel heel snel technisch.” (Plan developer)

Several interviewees stressed the importance of close collaboration between the internal team members. This is closely related to the previously described project organization and results from the way the designers and contractor are integrated into one company. Next to the benefit of working closely together, the sharing of the same goals, transparency, trust, and having the same interests and shared responsibilities within one team is mentioned to have contributed to realizing the re-use ambition. This has helped in organizing the re-use process and being able to purchase second-hand components while the design was still in development. The integration of design and construction is suggested to be needed to build circular and make integral decisions. The interviewees indicated that when working in a traditional way, difficulties would be experienced when components have to be captured already during the design phase. This would mean the architect has to capture these components and somehow invoice the client. This is mentioned to be conflicting with normal practices of architects and therefore early involvement of a contractor would be a logical way to resolve this issue.

Next to the internal team members, other companies were involved in the building process as well. A partner demolition company, that also developed a platform with second-hand building products, is mentioned to have been of importance related to re-use. This company has helped by sharing their knowledge and network of re-use activities and in identifying components that could potentially be re-used. It has also resulted in getting in contact with market parties and a reconditioning company. This reconditioning company was involved in the project that helped with reconditioning certain components before implementation. The interviewees suggest that they would have involved this company in an earlier stage if they would have known the company before. This could have helped in streamlining and improving the process of re-using components.

"Wij zijn met een bedrijf in contact gekomen die dit soort wandjes, dus heel vaak demonteert, en weer hermonteert. Die hebben dus ook precies de kennis van alle profieltjes en de rubbertjes en de systemen." (Project manager)

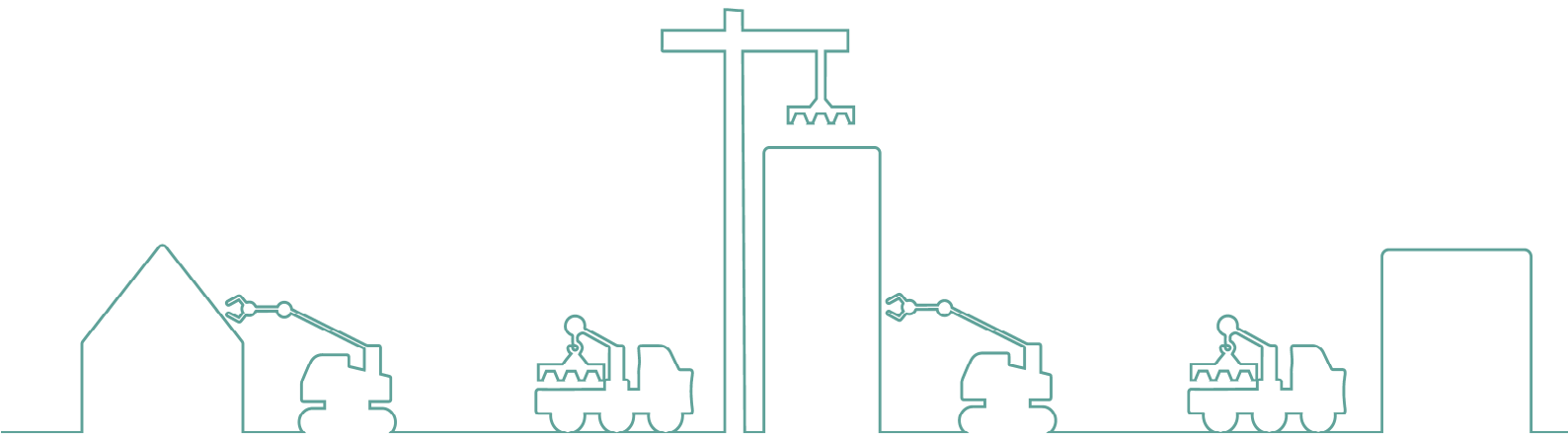
In general, the contracting company often works with partners or well-known suppliers, therefore, other companies were mainly selected based on previous experience. In addition, their motivation and opportunities concerning re-use were taken into account. The previous experiences have resulted in good trust between the suppliers and contractor and is mentioned to have resulted in a good working relationship, which is mainly based on this previous experience and only little on contractual agreements. Besides, the contractor states to embrace the advice from suppliers and that this has helped in optimizing the implementation of reclaimed components.

Other

As mentioned, the team members were not all positive about the re-use idea from the start, and did not understand the "why" behind the re-use and the potential of the approach. This could also include future clients. The interviewees suggest that people's mindset should change to be able to scale up the re-use concept. One potential way to show potential clients the opportunities of re-use is mentioned to be taking them to this office and showing them what circular building could look like.

CHAPTER 7

SYNTHESIS



After the literature study and the empirical study has been conducted, the synthesis of the findings has been performed. It included further analysis of the empirical findings and connecting them with the literature, imagining re-use processes and the implications of re-use on the process, and discussing the preliminary findings and recommendations with professionals to gain reflect on the clearness and understanding, and achieving additional practical insights.

7.1 Lessons learned empirical study

The empirical study has resulted in a better insight into the practice of the in literature identified topics. Based on the conceptual framework and supplemented with additional themes that were revealed in the empirical study, the main findings from the empirical study are described and reflected on in combination with the studied literature.

Briefing

The briefing is found to be of great importance in re-use projects. The role of the client in this is often mentioned, stating that the client can really make a difference and should support the re-use ambitions and targets defined in the brief or programme of requirements.

Dynamic briefing

The empirical study stresses the potential of the, in the literature identified, concept of dynamic briefing in re-use projects (Savanović and Zeiler, 2006; Van Meel & Størdal, 2017). Due to the uncertainty concerning the availability of reclaimed components during the initiation phase, it is stated to be hard to estimate the amount of re-use that could be achieved. This suggests that a more dynamic form of briefing would suit better, to be able to get more detailed specifications throughout the process. The expert interviews also suggest imposing an effort obligation, rather than strict requirements for the contracting party to be able to deal with this uncertainty. The case study also showed the potential of dynamic briefing. It showed that in Case A, the scope for re-use was very limited since the requirements, that were defined during the initiation phase, only focused on re-use within the tender projects. Dynamic briefing would have left room to include other types of re-use throughout the process, which could have led to higher degrees of re-use. Case B showed a more dynamic form of briefing, as the concept “reduce, re-use, recycle” was defined early in the process, but the team was free to experiment with this concept. This enabled them to add reclaimed components throughout the process and have a more complete scope for re-use. However, according to the interviewees, some more clear targets would have helped them to steer the process and take decisions related to material usage.

Initiation re-use vision

As suggested in the literature (Leising et al., 2017) the early definition of the ambitions concerning re-use are mentioned to be of high importance in the empirical study as well. Leising et al. (2017) state that the early definition of a circular vision could help in providing an image of a possible future and the coordination, guidance, and orientation for the project team by achieving that future. The empirical study shows that this is also the case in re-use projects and that the definition of the re-use ambition during the initiation phase has helped the teams to guide them through the process and develop re-use related goals. Case B demonstrated that it could be difficult to define a client’s ambition concerning re-use since

the topic is relatively unknown. Workshops are mentioned to help with figuring out the ambitions of the client and defining the vision with regards to re-use. This re-use vision is however found to sometimes be in conflict with other ambitions of a client and this should also be taken into account to make decisions that are in line with the client's priorities.

Clear re-use requirements

Closely related to this literature (Addis, 2006; Kozminska, 2019; Gorgolewski & Morettin, 2009; Rakshan et al., 2020) suggested the need for the development of clear re-use targets. These clear targets would unite the project team and guide them through the project to be able to specify more detailed specifications. The importance of setting clear targets and goals, early in the process, in documents such as the brief or programme of requirements, is also stressed in the empirical research. This should also include the definition of re-use, as varying interpretations of this concept are seen. The cases also showed the importance of clear re-use targets. Case A, for instance, showed that the early definition of re-use related KPIs helped the team in having a fixed point on the horizon. Because the KPIs were easy to measure, they helped the team to keep track on them.

However, as mentioned before, due to the uncertainty caused by the limited re-use market, it is not always possible to define such clear targets. The empirical study suggests that this uncertainty may differ depending on the type of re-use, which was also mentioned by Gorgolewski & Morettin (2009). In Case A, for instance, it mainly included on-site re-use, and all components originated from the client's portfolio. Therefore insight in the availability of components could have been achieved early in the process. With respect to off-site re-use, especially originating from the market, the empirical research suggests that it is more difficult to have a good insight into what will be available, due to the limitations of the current re-use market platforms and the lack of a constant flow of available components. This suggests that, depending on the type of re-use and availability of information concerning potential reclaimed components, the requirements will become more clear on different moments throughout the process. This also underpins the potential of the beforementioned dynamic briefing.

This also suggests that, as soon as the re-use market will be more developed and one could rely on a steady flow of certain components, the re-use targets could become more specific in the early stages of the project.

Besides, interviewees indicated that difficulties with developing clear re-use targets might also result from the lack of experience with re-use, which confirms the challenges that result from a lack of education and experience as suggested in the literature (Rakhshan et al., 2020; Kozminska, 2019; Pomponi & Moncaster, 2017; Van den Berg, 2019).

Maintenance

The empirical study suggests that the development of a clear re-use ambition and related targets early in the project are of high importance. However, due to the disruptive nature of the idea to re-use components, setting these goals is not enough to achieve the implementation of re-use. Both the expert interviews and the case study demonstrate the need for certain maintenance of these ambition and goals during the project to avoid falling back on a traditional approach. Throughout the process, the ideas behind the re-use concept should be repeated and extended to all actors that become involved. The case study shows that this could, for instance, be done by organizing workshops. It is suggested to be the role of the project manager to guard the re-use idea and make sure that the team sticks to and keeps track on the early identified ambition and goals. In particular, the case study demonstrates the

role of clients in maintaining this ambition, which suggests an important role of the project sponsor in stimulating and steering towards re-use. However, a project management consultant could also be designated to fulfil this task.

Project organization

New project delivery approach

Literature states that e new project delivery approach is required when building with reclaimed components (Gorgolewski & Morretin, 2009; Kozminska, 2019; Van den Berg, 2019; Addis, 2006). This was confirmed in the empirical study. The expert interviews indicate that a major difference between re-use projects and traditional projects can be found in the sequence of the project delivery activities. The interviewees state that one should start with making an inventory of potential reclaimed components during the initiation phase, and commence designing afterward. Some interviewees even suggest that the client should make this inventory. In both cases, the inventory and identification of components that are to be re-used took place in the early stages of the design phase. However, in both cases, a sketch design was already made before this took place. This is mentioned to have limited the amount of re-use. One of the cases suggests that identification and analysis of the components before the design has started could have improved this.

Besides, the empirical study underpins the idea of iteration throughout the process (Kozminska, 2019; Addis, 2006). The interviews suggest the need for more information about the components that are going to be re-used and making more integral decisions related to material usage. Therefore more integration of expertise is suggested. This is confirmed by the case studies. Case A, for instance, demonstrated a quite traditional process and the interviewees indicated that better integration of activities would have helped to align the components in the process. In Case B amongst others, due to the limited available time, some activities ran parallel to each other instead of sequential. The interviewees mention that this has helped in streamlining the exchange of information related to re-usable components and integrating them into the design. The empirical study suggests that this also comes with a different way of collaboration and the use of documents such as building specifications. Therefore the interviewees suggest that, to align the integration of second-hand components in the design, and to be able to take over responsibilities during construction, the contractor should become involved in the design and engineering process. The cases confirm this by demonstrating the integration of design and construction by contracting design and construction to integrated teams, for instance, a consortium (Case A) or a contractor with an in house architectural firm (Case B).

Extended initiation phase

Kozminska (2019) suggested the extension of the initiation and conceptual design phase to enable the inclusion of research activities, consultation with specialists, material tests and experiments. The empirical study also confirms this idea. Several interviewees mentioned the importance of the initiation phase for setting a good starting point and defining a re-use vision and related targets and being able to make an inventory before the design phase has started. Case A, also demonstrates an extensive initiation phase of about 3 years. During this phase, the re-use ambitions could be defined in clear targets and a first identification of the potential components could be done. In Case B, due to limited time, the initiation phase was not extended. However, the interviewees mention that the extension of the initiation phase would have helped to be able to spend more time in the identification and analysis of second-hand components and integrate higher degrees of re-used components.

Adjusted supply chain

Literature suggests the impact of re-use on the supply chain and the importance of the management of this supply chain in re-use projects (Leising et al., 2017; De Los Rios & Charnley, 2017; Nasir et al., 2017; Gorgolewski, 2008; Gorgolewski & Morettin, 2009; Gorgolewski, 2019; Rakhshan et al., 2020). The adjustments in the project delivery are stated to influence the supply chain and processing, transportation and storage are mentioned to play a bigger role in re-use projects. The limited re-use market also plays a role in this supply chain. The empirical study confirms this. The beforementioned idea of starting with an inventory of components has a major impact on the supply chain. Traditionally, components are purchased after the design has been finished, however, this idea of starting with an inventory suggests that in re-use projects the purchase of components should take place already during the initiation phase of the project. The cases show that the ordering of reclaimed components started earlier in the process than traditionally. In Case A, the components were already owned during the initiation phase. In Case B, the moment of identification and purchasing differed between component, but started early in the design phase. This meant that in both cases reclaimed components had to be stored. The empirical study pointed out the importance of early identification of reclaimed components. Firstly, as much difficulty is experienced in the timing and availability of components. This results from the fact that the re-use market is still in development and therefore it is hard to identify suitable components. Therefore it is suggested to order components as soon as they are identified, as they might not be available later on in the process. Secondly, since multiple activities should be undertaken before being able to implement the reclaimed components. Including for instance, measuring, tests, and reconditioning. This also results from the fact that most buildings are not built to be deconstructed and quality standards are developing.

In addition, the empirical study confirms the ideas of the early involvement of engineers, contractors, and demolition companies (De Los Rios & Charnley, 2017; Rakhshan et al., 2020). The interviews demonstrate the establishment of cooperation between these actors in the early stages of re-use projects. Both cases also point out the importance of the early involvement of these actors.

Cyclic phasing

Literature suggests that in re-use projects, with a lot of uncertainty and complexity, a more organic form of organization suits best (Vande Putte, 2009; Brady & Hobday, 2010). The empirical study emphasizes this in multiple ways, which are closely related to the above described aspects relating to the project delivery. The interviews confirm that a more flexible approach to time is needed due to the uncertainty about time and availability of reclaimed components, as suggested by (Kozminska, 2019; Gorgolewski, 2019; Van den Berg, 2019; Addis, 2006). The cases also demonstrated that one should reconsider the plan throughout the process. For instance, the cases showed that components that were intended to be re-used turned out to be unusable, or unavailable throughout the process and therefore the team had to adapt. Related to this, the interviewees suggested that one cannot work with strict building specifications as this type of documentation does not leave room for deviations. It is suggested to work with a more flexible way of specifying. This is also described in the literature to circular contracting, that suggest to specify in a performance base matter, rather than using closed technical specifications (Van Haagen, 2018; Castelein, 2018). The cases confirmed this and showed how one could work with a “technical description” that is less strict than building specifications and allow for deviations. In addition, the interviewees suggested

that the client should also be more flexible in re-use projects, as the exact definition the process and details might not allow being specified in advance.

However, the empirical study shows that the suggested flexibility is not that easy in practice, as it is experienced that this flexibility leads to difficulties with strict planning. Therefore, it is advised to still incorporate certain decision moments. This is in line with the idea of Rakhshan et al. (2020) who describe a way to organize the process by making a decision-making framework. This could help in informing stakeholders when alternative re-use options should be investigated and helps in making informed decisions and maximizes the potential of re-use by identifying the steps that should be taken by the involved stakeholders. The empirical study suggests different tools that could be used to organize this process, however, no uniform method to address the project in a systematic way exists. This might be helpful in structuring re-use projects.

Selection of the project team

Interdisciplinary project team

The in the literature suggested need for an interdisciplinary project team (Kozminska, 2019; Leising et al., 2017; Iacovidou & Purnell, 2016) is also stressed in the empirical study. The expert interviews indicate the need for integral decisions related to material usage, and the need for information concerning reclaimed components. The collaboration of disciplines is stated to be required to be able to achieve the necessary information and make these decisions. In addition, the cases showed two examples of interdisciplinary project teams as in both cases the project was executed by a team in which architects and the main contractor were involved from the initiation phase and shared responsibilities. In Case A this was the result of the establishment of a private company that includes multiple companies with varying expertise. In Case B this resulted from the in house architectural and construction firm at the contracting party.

Besides the empirical study confirms the idea of new collaborations with for instance salvage material brokers or consultants, demolition consultants, construction managers, material scientists, specialist trades, and product developers as suggested in the literature (Kozminska, 2019; Pomponi & Moncaster, 2017). Several interviewees suggest the collaboration with re-use experts, that have insight into the re-use market. In addition, both cases demonstrated the importance of collaboration with re-use experts. The reason for collaboration with re-use experts, however, differed between the cases. In Case A, this actor mainly helped in mapping the available components and making them available on their online platform. In Case B the inventory largely has been executed by the architects and main contractor. The re-use actor mainly helped in identifying re-usable components outside the portfolio of the client. Besides, another re-use company helped with the reconditioning of components. The cases underpin the potential of collaboration with re-use actors and some interviewees mention to be willing to collaborate more with this kind of experts and earlier in the process.

The cases also demonstrate that, although the teams were interdisciplinary in theory, one should guard the collaboration between the team members. Case A, for instance, stated that closer collaboration between the team members and closer involvement of the client would have helped in better sharing of the ambition and information concerning re-use. This would also have contributed to the integration of activities in the iterative process as mentioned before. Case B demonstrates the importance of the close collaboration within an interdisciplinary project team. The case showed how good relationships and trust between

the team members in combination with the ability to work in parallel and streamline design and engineering activities, could contribute to the implementation of reclaimed components.

Early involvement

Closely related to the interdisciplinarity of the project team, literature (Kozminska, 2019; Gorgolewski & Morettin, 2009) has suggested the need for involvement of actors from the early stages of the process. The participation of demolition or re-use experts and contractors in early stages facilitates the assessment of construction waste, provides information concerning material sourcing, processing, assembly, disassembly, and finishing, and enables realistic cost calculations. The early involvement of contractors is also suggested in studies to circular ways of contracting (Castelein, 2018; Van Haagen, 2018). This idea is also stressed in the empirical research. The expert interviews indicate that including experts, such as construction, demolition, and re-use experts, earlier in the process could help in stimulating re-use by identifying potential components, analyzing their potential, and reconditioning them. Also, both cases demonstrate the involvement of a contractor and re-use actors such as demolition companies early in the project.

Collaboration and shared vision

In innovative projects, the project manager should take special care in compiling a good team and relationships and trust between team members is mentioned to be even more important (Thurm, 2005; Leising et al., 2017). The empirical study also suggests this and stress the importance of investing time and energy in shaping the team. A good relationship and a high level of trust between the team members is, for instance, mentioned to be needed in re-use projects. This is also stressed in Case B, several interviewees mention how previous experience and good relationship within the internal team, as well with suppliers and consultants has positively impacted the integration of re-used components. It helped to quickly switch between disciplines, sharing knowledge, and thereby taking integral decisions and streamline the inclusion of reclaimed components.

The empirical study suggests that another way of collaboration is needed in re-use projects. This includes sharing responsibilities and interests, and long term involvement. This is in line with the beforementioned idea of an early established interdisciplinary team, and literature suggesting that integrated contracts or consortia would suit circular projects better (Castelein, 2018; Van Haagen, 2018).

The literature points out that in circular building projects one should start with the co-creation of a shared vision (Leising et al., 2017). Especially during the early stages of the circular economy where pilots and demonstration projects are taking place (Leising et al., 2017; Venselaar, Heintz & Lousberg, 2019). This is also stressed in the empirical study which demonstrates the importance of the creation of a re-use ambition that is understood and supported by the project team. This is found to be difficult due to the mind shift that is needed as re-use is not yet widely accepted.

Motivation

Although it was also mentioned by Rakhshan et al. (2020), the empirical study, in particular, suggests that the willingness of stakeholders to integrate re-used components is determining. An often mentioned barrier includes the attitude of people towards re-use. This is mentioned to be either because of the esthetical appearance of re-used components or because of the difficulties and risks related to responsibilities and guarantees. The empirical study suggests

that the motivation of actors to work with re-used, along with their experience, should be, taken into account when selecting the project team. Some interviewees even state that “project champions”, in this case, team members that are intrinsically motivated to re-use, are needed. It is however experienced that it is quite difficult motivating the whole project team to work with re-used components, especially contractors, are mentioned to find it difficult to change their traditional approach. It is advised to select contractors that can be flexible in their planning and approach. In addition, only limited experience with re-use currently exists. More experience should be gained by conducting more re-use projects. This will also help in achieving more insight in the re-use opportunities, for instance, which reclaimed components are often available and which components suit best for re-use.

The cases clearly demonstrate the difficulty with, but the importance of the team members' motivation to re-use. Although some of the team members in Case A were more (intrinsically) motivated, the overall team, eventually understood the idea and concept. Some of the team members are mentioned to be very ambitious concerning re-use and this helped in actually incorporating re-use in the project. These team members could be seen as the project champions in this case. In Case B motivation was also mentioned to be of importance. One particular team member was mentioned to be intrinsically motivated and could be seen as the project champion. This team member was responsible for the interior design and it is found that within the layer space plan, most re-use is realized. This motivation, in combination with the responsibility for the interior design, as space plan is mentioned to have the greatest potential for re-use due to the limited consequence on the process, suggest the impact of the motivation of team members on the incorporation of reclaimed components.

Other

The importance of the client is mentioned in both the expert interviews and the case study. These indicate that the willingness and motivation of the client to re-use is crucial. In both cases, the client was really willing to re-use and worked hard-and-fast to achieve this goal. The interviewees underpin that this had a major impact on the success of integrating reclaimed components. Moreover, both clients stressed the importance of the understanding that clients in re-use projects should be more flexible. This includes being more flexible in the expectations and ideals and being open for deviations from a traditional process. The importance of the client’s motivation was also mentioned by Rakhshan et al. (2020), stating that if the client is not motivated, this would result in much lower degrees of re-use. In addition, the empirical study suggests that clients could play a role in making an inventory of potential re-used components. The cases demonstrated two projects with clients that have experience with building projects. In those cases, the project sponsor has an important role in steering the project towards the client's re-use ambition. However, often clients are less experienced with building projects. In that case, project management consultants could play a significant role in supporting the project sponsor in these tasks and the overall management of the project.

The empirical study indicates that component re-use is more obvious in renovation or transition projects. This might be related to better insight into the availability of components at the start. With respect to that, the interviewees state that the use of “donor buildings” or re-using components from the client’s portfolio also have the potential for new building projects. This also relates to the different types of re-use as described in the literature (Gorgolewski & Morettin, 2009). On-site re-use of components that are already owned by the client is for example seen in Case A, which included renovation. Case B was developed on an empty plot and therefore included only off-site re-use.

The empirical study also pointed out some other challenges, resulting from the recovery of components from buildings that aren't built to be disassembled and don't meet the current quality standards, as well as challenges with transporting them without causing damage. These barriers were also described in the literature by Iacovidou & Purnell (2016) and Van den Berg (2019). Both cases showed examples of damaged components due to recovery and transportation acitivities. Beside, the costs of re-using components are mentioned several times to have restricted the re-use potential. The interviewees indicate that re-use won't safe costs due the currently limited market as well as the costs related to reconditioning and storing of the components and within a strict schedule and limited budget, new components are therefore often chosen.

7.2 Designing the re-use process

An imaginary experiment has been conducted to combine the findings from literature and the empirical research and create a better understanding of the process that is needed to realize the re-use of components.

"Imagine one would like to re-use components in the building of an office building…".

This was the starting point for the experiment. The idea was to imagine the process that would result from this idea and track the steps that are to be taken to achieve this ambition.

First of all, this would mean that at the start of a project, a client has the idea to build a new office and one of the requirements is to include reclaimed components in this building. At that very beginning of the project, the empirical research suggests that the client has two options related to this ambition. Firstly to specify the already identified components that are to be included, for example from demolition within the client's portfolio, and handing this inventory over to the contracting party. And secondly, to ask the contracting party to specify and identify second-hand components.

These options, at the initiation of the project, already suggests that multiple routes could be followed to implement re-used components in the project. Literature also describes different types of re-use and the different layers reclaimed components could belong to, and the empirical research indicates multiple moments of including re-used components. It is therefore decided to follow the steps of several potential routes. Depending on the moment of identification of reclaimed components, type of re-use, and layer to which the components belong. These potential routes are imagined and visualized in step-by-step schemes as shown in the figures.

Inventory in advance or during the process

Traditionally a project starts with the initiation of an idea for a new building by the client and is followed by contracting an architect that subsequentially starts the design. It seems this is often also the case in projects where re-used components are to be included. The empirical study identifies varying moments that the contracting party consults the re-use market, such as online market places for building components or demolition companies that offer reclaimed components. The literature (Addis, 2006; Kozminska, 2019; Van den Berg, 2019) suggested the importance of aligning the information about the re-used components with the design process and the need for iteration throughout the process, which is also stressed in the empirical study. In addition, the cooperation with re-use actors and contractors during the design process is found to be of importance. This route is visualized in Figure 25.

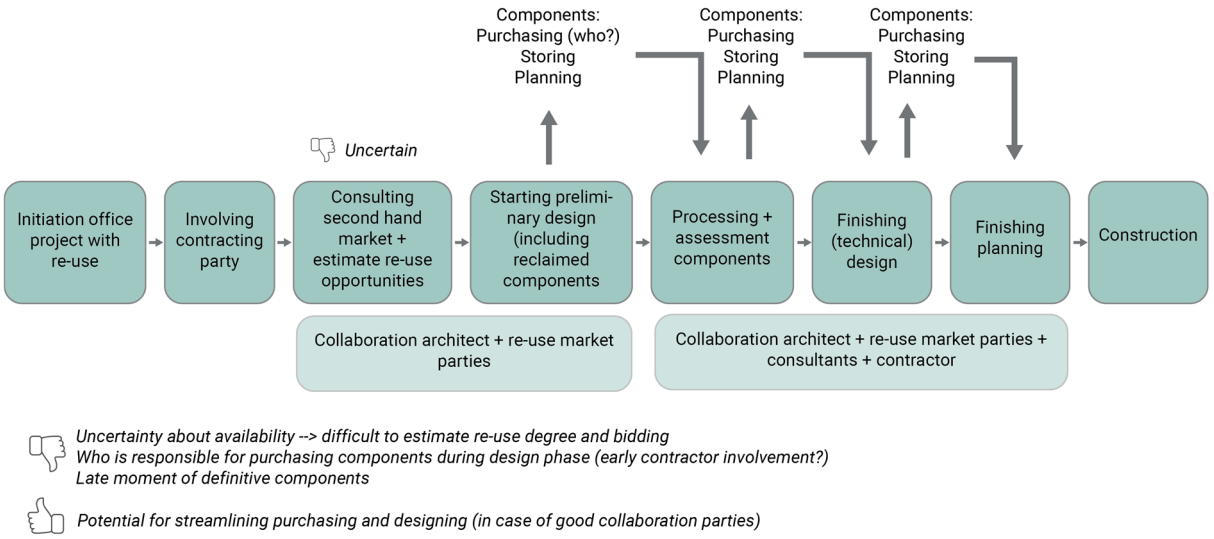


Figure 25. Route without making an inventory beforehand

The empirical study shows the importance of identifying re-usable components as early as possible and suggests that the client could play a role in this by identifying potential components before handing over the project to the contracting party. This early inventory process is visualized in Figure 26. Several opportunities to identify re-usable components are found. Firstly within the client's portfolio, for instance when the client has multiple buildings and demolition/renovation projects are planned, which could serve as resources for the new projects. Secondly, identifying components on the market. This could include the identification of a "donor building" that serves as a source of reclaimed components. It might also include the identification of components on a building component marketplace or by collaborating with for instance demolition contractors. This early identification of components forms the starting point for the contracting party that subsequently starts designing and incorporates the identified components in the design. This idea is in line with the in the literature identified extension of the initiation phase (Addis, 2006; Kozminska, 2019). Extension of the initiation phase enables the identification, specialist consultation, and testing of components which is needed to implement them in the design.

Based on the learnings from the literature study and the empirical research, it is clear that the earlier an inventory of potential second-hand components is done, the better the components could be integrated into the design. However, this would also imply that the components should be purchased or reserved even before the design is finished. This is very uncommon in building projects, as traditionally one starts purchasing components after the design is finished. Purchasing during the design phase might come with difficulties since the architect, who is traditionally involved during the design phase, normally doesn't purchase components. This could be resolved by doing investments as a client in purchasing and storing components beforehand, or involving a contractor earlier in the process that starts purchasing components during the design phase. The early involvement of a contractor is also mentioned by Kozminska (2019) and would also help with aligning the engineering of the components early in the design. However, these early investments might come with additional costs and risks.

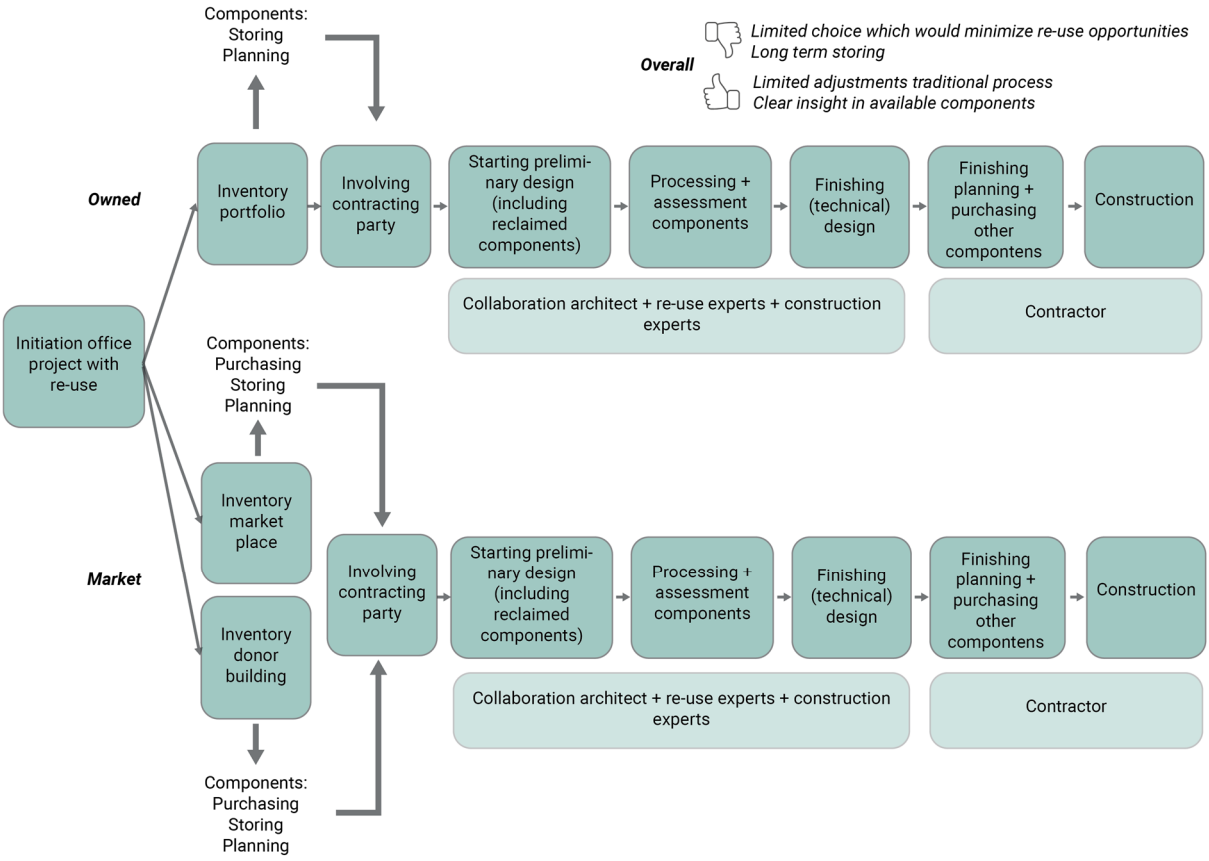


Figure 26. Route based on doing an inventory beforehand

In case components are identified later on in the process, when the design is already started or even finished both literature (Kozminska, 2019; Gorgolewski, 2019; Van den Berg, 2019; Addis, 2006; Rakhshan et al., 2020) and the empirical research suggests that it would be difficult or even impossible to find reclaimed products that fit within the design and are available at the right time. Although the identification of second-hand components in a later stage might solve the problem of ordering and storing the products, it would probably lead to a lower degree of re-use in the currently limited re-use market. Besides, it comes with difficulties in setting a budget by contracting parties.

Type of re-use

Next to the opportunity to decide to make an inventory beforehand or not, one could also distinguish between on-site and off-site re-use. The inventory and on- and off-site re-use are, however, closely related as, for instance, on-site re-use offers obvious opportunities for identification of components beforehand.

In case the new building will be developed on a site where another building is already located one could re-use the components that come available from the dismantling of the building at the site. The potential routes are shown in Figure 27 Depending on whether the building will be renovated or demolished and newly built, the amount of components will vary. On-site re-use offers opportunities as it clear which components could be re-used early in the process. Barriers that were also mentioned in literature and the empirical study include the difficulties with transporting and storage (Kozminska, 2019; Gorgolewski, 2019; Van den Berg, 2019; Addis, 2006; Ghisellini, Ripa & Ulgiati, 2018). With on-site re-use, these barriers could be

overcome, as the components do not have to be transported and might be stored on the site, as seen in case A.

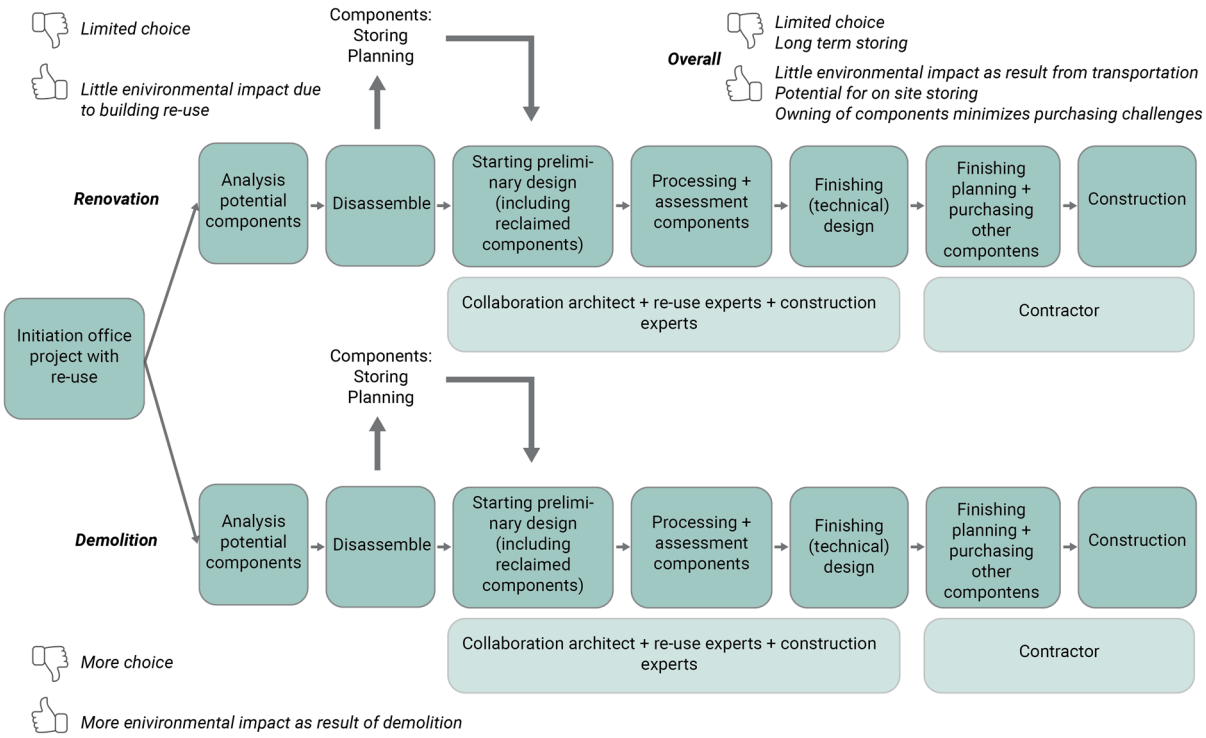


Figure 27. On-site route

In addition, components could originate from other locations. As mentioned, one could identify components within the client's portfolio or consult the second-hand re-use market. The identification of components within a client's portfolio offers potential due to the fact that one already owns the components and therefore, does not have to do early investments. It also has the potential to identify components early in the project as the client could have quite a good insight into its portfolio and the demolition and renovation projects that are taking place or are planned. However, not every client has the opportunity to identify components within its portfolio and the portfolio would also be limited. The other option is to consult the market by consulting online platforms and/or collaborating with parties that have insight into the components that become available from disassembly. Due to the fact that the re-use market is still very limited, one cannot rely on a constant supply of certain components. Therefore, the interviewees suggest purchasing or reserving components at the moment they are identified and seem to be suitable. Also, both literature (Addis, 2006; Kozminska, 2019) and the empirical study suggest the iterative character of the identification of components and aligning them with the design and engineering activities. These off-site options are visualized in Figure 28.

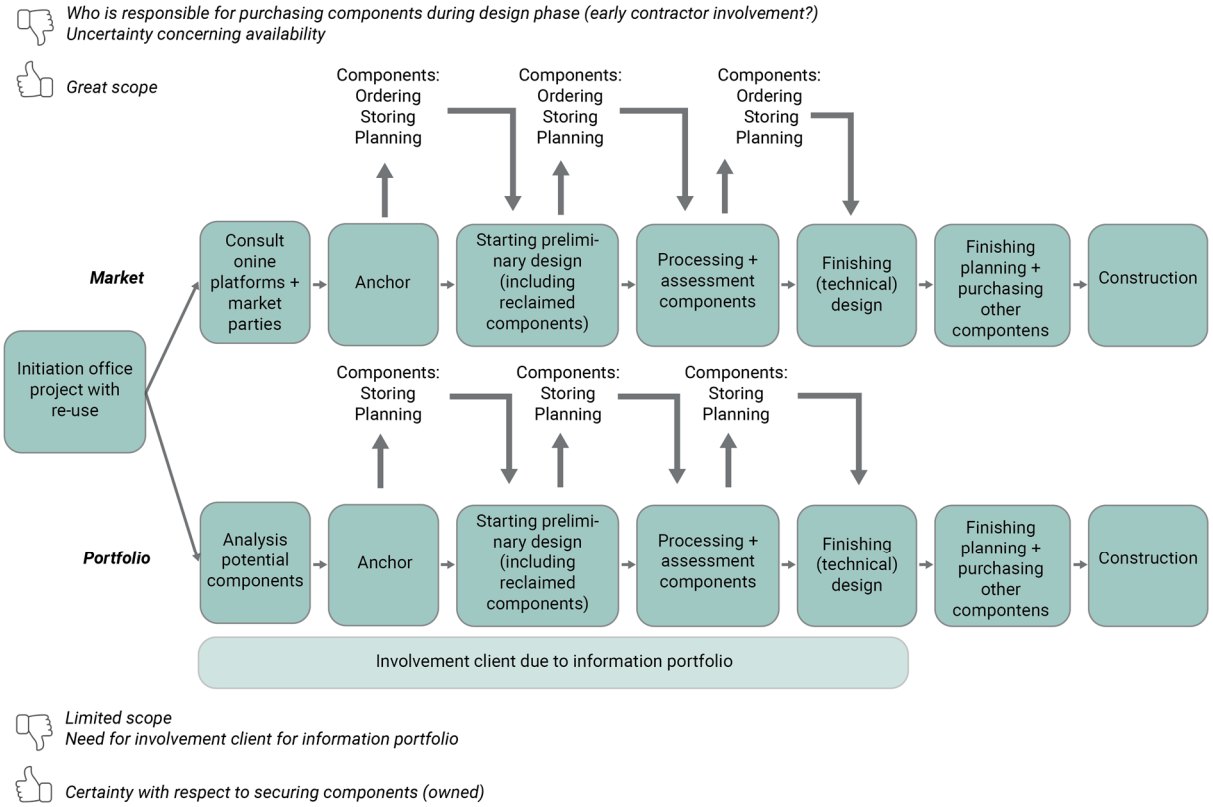


Figure 28. Off-site route

Major differences are seen between on-site and off-site re-use, and between whether or not the client owns the components.

The empirical research suggests that reconditioning of disassembled components is almost always needed when re-using components. However, the nature of the reconditioning determines whether or not an external company should be involved and whether or not it would include minor reconditioning that could take place on-site or actual remanufacturing. With on-site re-use, major reconditioning activities might cause extra transportation, but in off-site re-use, this wouldn't significantly alter the process. Therefore it is chosen not to include this in distinguished routes.

The varying types of re-use come with their own pros and cons. The empirical study suggests that the scope of re-use is often limited to just one type of re-use and this could lead to limited degrees of re-used components. To optimize the amount of re-use including multiple types of re-use would, therefore, contribute to increasing the amount of re-use.

Different layers

The literature describes different layers of a building (Brand, 1995). Differences between the layers structure, skin, services, and space plan are described in the literature and empirical research. The study shows that different aspects play a role in the implementation of reclaimed components within certain layers and these influence the process. This is visualized in concept in Figure 29.

Re-use within the layer structure would require the biggest adjustments in the process. Due to the nature of these components, an extensive process of research and tests is mentioned to be needed before being able to re-use structural components. These regulations are imposed to minimize the serious consequences that imperfection of the layer structure can cause. In addition, the construction would start with structural components and therefore the design of the structure should be finished first. Therefore, identification and analysis of structural components should happen at the very beginning of the process. Re-use within the layers skin and services comes with less strict regulations. However, the interviewees discuss multiple requirements that still play a role, especially when taking into account the energy efficiency dimension of components within these layers. To be able to measure their performance, these components should also be identified on time. Although requirements for space plan components also exist, components within this layer are mentioned to have the fewest restrictions. Also, according to the earlier described interviews, adjustments in the design of the space plan can take place even in the final stages of the design phase. In line with this, the case study also demonstrates that the majority of component re-use took place within the layer space plan.

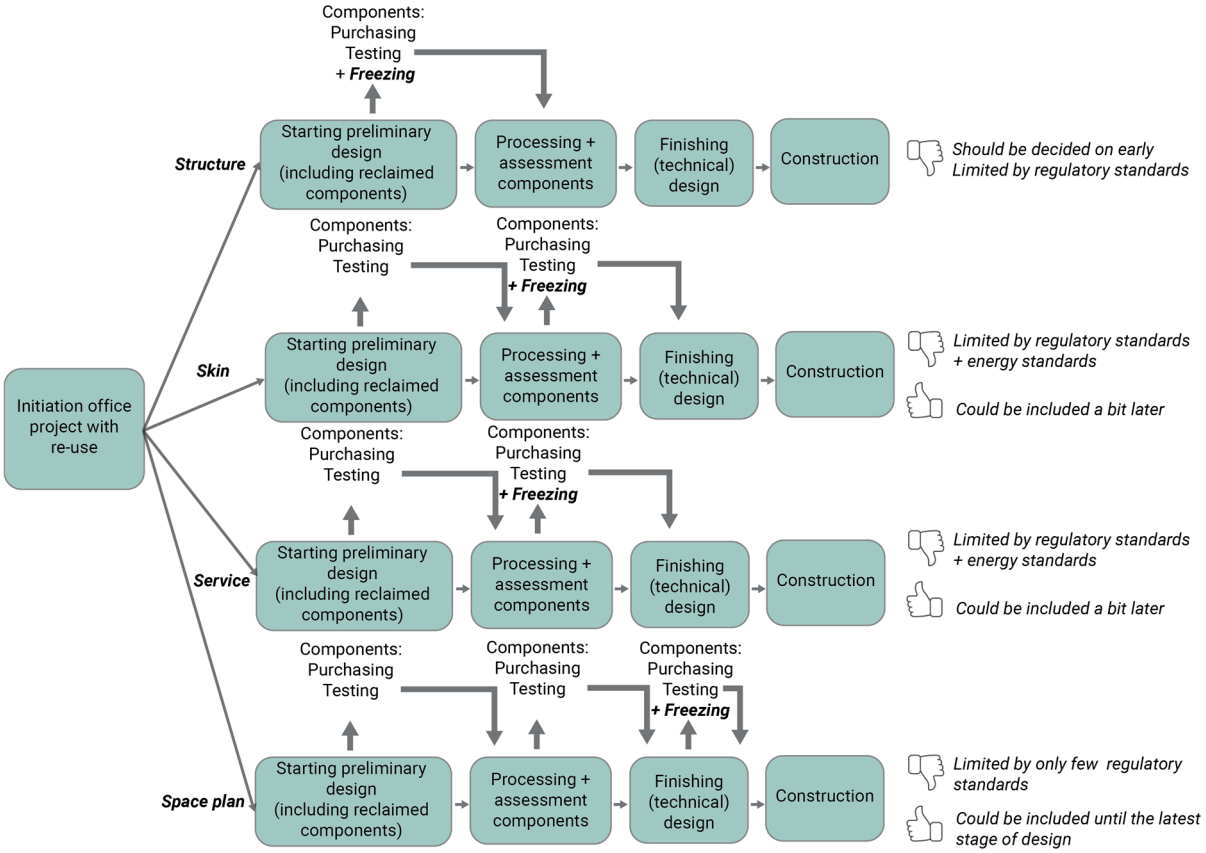


Figure 29. Route for each layer

Combining the routes

While following the steps of the multiple routes, several benefits and challenges related to particular routes are demonstrated. As mentioned, the combination of multiple routes could contribute to the degree of re-used components that will be implemented. A combined route has therefore been developed and is visualized in a flow chart in Figure 30. The illustration at the original size can be found in Appendix C.

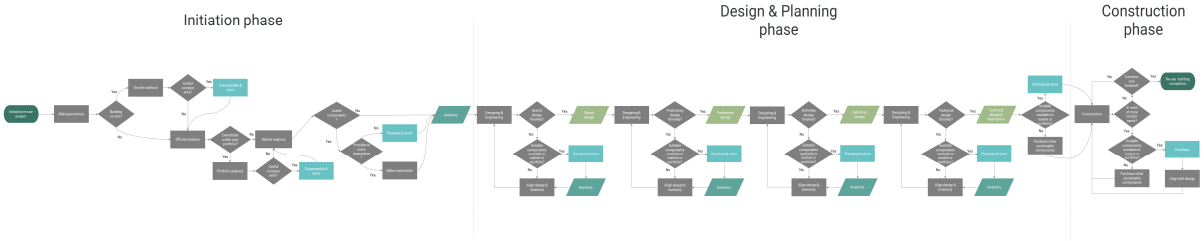


Figure 30. Flow chart

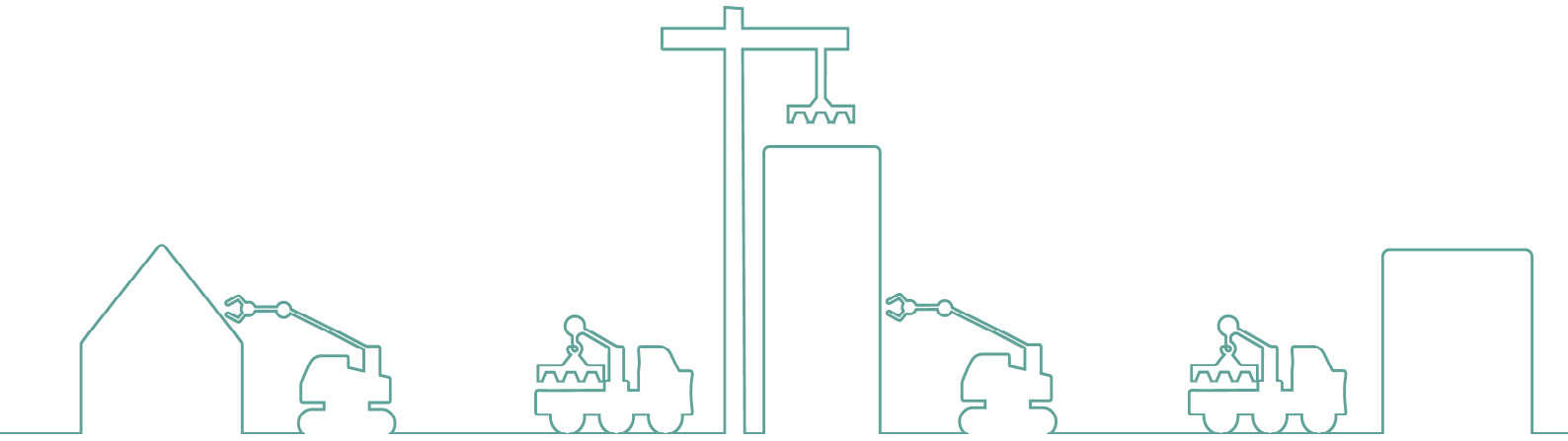
The flow chart visualizes that one should start with the identification of reclaimed components during the initiation phase. In case there is a building located on the site of the project, one should analyze this building, determine which components could be re-use and secure them by adding them to the inventory. In addition, or in case of an empty lot, one should identify off-site opportunities for re-use. If the client has more buildings in its portfolio, it should check if demolition or renovation projects are taking place and analyze them to secure potentially useful components. These should also be added to the inventory. Besides, the market should be consulted, if potential components are identified, these should be reserved, or in case that is not possible, purchased and again added to the inventory.

This inventory is the starting point for the design. The design should include the already identified components and throughout the design process an iterative check of the potential building portfolio and market should be conducted and purchased, stored, and added to the inventory. The inventory and should be aligned with the design iteratively as well. This can be seen throughout each stage of the design process, from sketch design until detailed and technical design. It should, however, be mentioned, that depending on the layer, some components have to be frozen at a certain point in the design phase.

After the design has been finished again the market and portfolio should be consulted and suitable reclaimed components should be purchased. Other components that are not available in the re-use market, but necessary to start construction, should be replaced by other sustainable components. Afterward construction is started and when components have to be purchased, one should again first try to purchase reclaimed components, and if not include other sustainable components. This repeats iteratively until construction is finished and a building with as much as possible re-used components is delivered.

CHAPTER 8

CONCLUSIONS & RECOMMENDATIONS



The research has resulted in a better understanding of the relevance of the briefing, the project organization, and the project team selection in re-use projects. This chapter will answer the research question by describing the main findings of the study and making recommendations for project managers in re-use projects, concluding with a project management framework.

The research included a literature study, expert interviews, two case studies, and related analysis. These research components aimed at answering the sub-questions. The synthesis of the multiple research components aimed at answering the following main research question:

In what way can the briefing, the project organization, and the selection of the project team, contribute to re-using building components?

Several aspects related to the briefing, project organization, and selection of the project team are found to contribute to the re-use of building components. For each of the three aspects, it is described in what way they could contribute to re-using building components.

Briefing

The briefing is the process of understanding the client's needs and resources and aligning them with its mission and objectives. This process helps to define the client's ambition related to re-use and translating this ambition into clear goals, from early in the project. Based on the literature and the empirical research it is believed that the early definition of a re-use ambition and goals helps to unite the team, to avoid conflicts, and to guide the team throughout the process. The ambitions and goals also contribute to organizing the project, and making decisions, especially regarding material usage.

The current re-use market comes with a lot of uncertainty concerning the timing and availability of reclaimed components and next to that there is only very limited experience with re-use. Therefore, at the start of the project, it might be difficult to define specific goals and a more dynamic form of briefing would, therefore, suit better. However, especially with this relatively new concept, clear targets from the early stages of the project are needed to steer the team. Although this might seem to be contradicting, it is believed that clear goals could still be developed while remaining flexible to adapt to these uncertainties. For example by specifying the targets in a more functional and performance-based way, rather than a closed technical way.

To optimize the development of clear and comprehensive re-use goals, it is advised to take into account the following aspects:

- Specify the definition of re-use. This would minimize varying interpretations of the goals and contribute to achieving the aspired ambitions.
- Consider multiple types of re-use, this could help in having more complete goals and achieving higher degrees of re-use.
- Distinguish between the layers as defined by Brand. Specify targets related to each of the layers, as each layer offers its own opportunities for re-use, due to the requirements that they have to meet and the moment of inclusion in the design.

- Start identifying and investigating potential re-use opportunities, including on-site opportunities, the client's portfolio as well as the market of reclaimed components already in the initiation phase. This could help in having a better grip on the availability of components and this should be used in defining measurable and realistic targets. Ideally experienced clients with a larger building portfolio would make an inventory of the components and use this as a starting point for the project. However, this would only suit a limited group of experienced clients.
- Define how the goals will be measured. Depending on the information that is available in the initiation phase, realistic goals and ways of measuring should be developed and supplemented when more information is available. When limited information is available, an effort obligation might be a reasonable compromise. While in the case the availability of components is clear, the goals could be specified more detailed in, for instance, percentages of the mass of the total construction. The definition of goals can be seen as a certain feedback process, as throughout the process the goals could become more concrete when more information comes available.

Due to the disruptive nature of the requirement to re-use components, the study suggests that repetition of the re-use ambition and related goals and a regular review on the achievements of these ambition and goals is needed to avoid falling back on the traditional approach. Therefore, it is of great importance to use these re-use ambition and goals as a clear starting point and maintain them during the process. Throughout the process the project manager should make sure that this ambition and goals are understood and supported by the project team. This could be done by for example organizing workshops and having regular conversations. In addition, these goals should be at foundation for the decisions that are made throughout the entire process.

Project organization

The study demonstrates that the way projects are organized could contribute to the re-use of components if the process facilitates the opportunity for the alignment of reclaimed components with the design. Several aspects related to the project organization are identified to have the potential for facilitating the inclusion of reclaimed components in building projects.

To create positive boundary conditions for the re-use of components, the research suggests adjusting the traditional project delivery approach in multiple ways.

Firstly, it is found that the extension of the initiation phase would be useful in re-use projects. This enables the definition of the client's ambition with regards to re-use and related targets. It also provides room for the identification and analysis of reclaimed components early in the project. This is found to be of importance to be able to use the information of specific recovered building components in specifying more detailed targets and using the component specific information as a starting point for the design. In that sense the reclaimed components can be seen as preconditions for the design. The early identification of components is therefore of particular importance when the re-use market is limited, as one cannot count on a constant supply of reclaimed components and is dependent on the limited amount of available components. Later identification would obstruct the inclusion of reclaimed components as the available components would not match a design that is based on new components. The early identification of components also allows for timely analysis, research, and reconditioning of the reclaimed components. This is required to obtain sufficient

information that is required to integrate the components and meet the desired quality standards.
Besides, it is advised to organize the project in a less fragmented way, let identification, research, engineering, and design activities run in parallel, and develop an iterative process. This enables for revision of the plan throughout the process, which is mentioned to be of importance in re-use projects as these have to deal with a lot of uncertainty. In re-use projects, this could, for instance, mean revisiting the planning when components turn out to be not available at the right time, or adapt drawings when more detailed information about the reclaimed components comes available. This way of organizing the project also helps in facilitating the process of integration of the components by enabling the team members to streamline the information concerning identification, research, engineering, and design aspects. In addition, it facilitates the team to perform activities, such as making decisions related to material usage, purchasing building products, and performing engineering tasks, earlier in the process. This implies that design, planning, and engineering tasks become more integrated.

The study demonstrates that these adjustments to the project delivery process also lead to an adjusted supply chain. This includes early ordering or purchasing of components, analysis of the components, potentially transporting and reconditioning of the components, and the need for storage of the components until construction. In the currently limited re-use market, it is in particular advised to invest in purchasing and storing components early in the project, to make sure that suitable reclaimed components are secured and will be included. This, however, requires early involvement of actors that are in the position to make these investments, such as contractors. Besides these early investments come with additional risks.

The in the literature identified adjustments of the project delivery approach in re-use projects have been further developed based on the empirical study and a suggested project delivery approach for re-use projects is visualized in Figure 31. It reflects the expansion of the initiation phase, the need for identification, analysis, and purchasing of reclaimed components from early in the process and its repetition throughout the process, the need for iteration throughout the process, as well as the early involvement of actors to enable early design, planning, and engineering activities to be conducted in parallel.

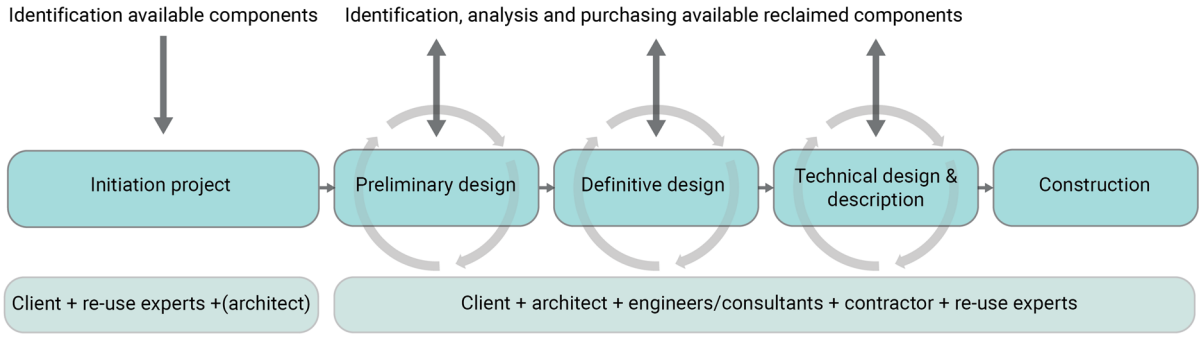


Figure 31. Re-use project organization

While a more flexible approach to the planning is suggested to be needed to deal with the uncertainties of the current re-use market, it is found to be of importance to include certain milestones in the planning. These milestones could define the moments that decisions related to re-use (at the latest) are to be made. It is found that, depending on the type of re-use and the layer to which components belong, different decision moments are needed. On-site re-use should be determined early in the process, as it is clear what is available on the site. This is also the case for re-use from within the client's portfolio. Off-site re-use, where components

are acquired in the market, should start early in the project but can be included until later in the process as the market might develop throughout the process. Besides, decisions related to the structure should be made very early in the design phase, as the structure is determining for the dimensions of the design and requires additional attention and potential tests and reconditioning to meet high standards with respect to quality and safety. Skin and service decisions could take place a bit later in the process, but should also meet certain regulatory standards. Space plan decisions can even be made until a late stage of the design phase, as these have minimal impact on the design and only have to comply with a minimum of standards. To incorporate the concept of re-use in planning, a systematic approach is found to be useful. The use of the layers of Brand to systematically assess the building and re-use opportunities, the development of decision matrices, coding of components using, for instance, NL-SfB or Stabu, and using Building Information Modelling, are useful tools that could help in systematically approaching the project and identifying appropriate milestones.

Project team selection

The selection of the project team is also believed to play a role in the contribution to re-using building components. Several aspects related to the project team are found to play parts in this and should, therefore, be taken into account when selecting and shaping a project team for a re-use project.

Closely related to the project organization, the collaboration between actors is stressed to be of high importance. Close collaboration between architects, re-use experts such as demolition, re-use market, and reconditioning actors, consultants, and contractors is needed to let activities run in parallel and share information concerning the characteristics and availability of reclaimed components. This is required to align the reclaimed components with the design and helps in making integral decisions, taking into account multiple perspectives on the circularity of the reclaimed components and the potential for re-use. This is of particular importance when working with re-used components, due to the specific characteristics of reclaimed components and the uncertainty about timing, availability, and condition. The integration of multiple disciplines in one team, an interdisciplinary project team, from early on in the project also enables performing tasks, such as making technical drawings and purchasing components, earlier in the process.

The collaboration between architects and contractors from early in the process is specifically found to be of importance. This collaboration helps in the alignment of design and construction, which enables a better implementation of re-used components that come with non-standard dimensions and are often in need of some reconditioning. In addition, it allows for the early purchasing of reclaimed components by the contractor, which is needed to secure suitable components in a limited re-use market. It could also overcome the difficulties related to the transfer of responsibilities, which are traditionally based on closed technical documents such as building specifications. These closed specifications do not contribute to re-use, as this won't leave room for deviations, which are often needed when using reclaimed components due to the unpredictable re-use market and potential deviating dimensions or conditions of the component. When design and construction are integrated and responsibilities are shared, this way of transferring responsibilities is unnecessary and one could work with less strict specifications that more functional and allow for such deviations.

Besides, the benefits of collaboration with disciplines that have particular knowledge relating to re-use, such as demolition experts, re-use market parties, reconditioning experts, and sustainability experts, is stressed. This would help in gaining insight into the re-use market, estimate the re-use possibilities, and obtaining information concerning the characteristics and

condition of reclaimed components. It can also help in the process of reconditioning and thereby improving constructability.
Multiple ways of shaping this kind of interdisciplinary project teams are seen, which is closely related to contractual relationships. This could be done by using integrated contracts, for instance by appointing a consortium or a contractor with in-house architects. Including actors during the initiation and design phase on an advisory basis, and including their knowledge in that way, might also work. However, to be able to purchase reclaimed components already during design, it is advised to involve a contractor in a risk-bearing manner already during design.

Apart from their substantive roles, the study suggests that an adjusted way of collaboration between team members is needed. The team should have shared ambitions, interests, and responsibilities. In addition, a good relationship and trust within the project team contribute to re-use. This should express itself in close cooperation and exchanging of knowledge and thoughts. This would help to unite the team and steer the team to achieve the, sometimes very ambitious, re-use goals. This is also needed to deal with the innovative character of re-use and enable to take some guts to experiment with this relatively new concept.

Lastly, it is found that the motivation and experience of team members regarding the re-use topic are of importance in achieving high degrees of re-use. Therefore, it is advised to select team members based on their understanding of, experience with, and willingness to work with re-used components. Including project champions, in this case, team members that are intrinsically motivated to re-use components, is found to contribute to achieving higher degrees of re-use. They could help in taking initiative in identifying reclaimed components, motivating, and steering the team to secure and accomplish the ambition to re-use building components.

In line with the earlier mentioned ideas concerning the extension of the initiation phase, in re-use projects, one should invest time and energy in compiling a good project team. The above mentioned ideas concerning project teams are advised to be taken into account when selecting a project team. Related to the need for maintaining the re-use ambition and goals, it is of great importance to create awareness among the team members throughout the process. This could be done by, repeating and discussing the concept of re-use, or training, such as organizing workshops.

Overall

The re-use of building components is found to be an innovation that has a great impact on the traditional approach to building projects. The limited experience with re-use and the currently limited market for re-used components, which is rapidly developing, indicates that this radical innovation is currently in its infancy. During these stages of innovation, one should realize that the advantages might still be relatively low, but investments are needed for further development of the innovation. Project management and innovations are described to be closely related and project management during the initiation phase of innovative projects is particularly found to be of great importance in achieving projects' success. Project managers in re-use projects should, therefore, realize the impact of the ambition to re-use components and the importance of the initiation phase. They should be aware of the need to invest time and energy in this front end of the project and should be aware of the importance of the careful selection of project team members. In addition, it is found that radical innovations are experienced to come with a need for flexibility throughout the process and project managers in re-use projects should, therefore, be open to revisiting issues. These aspects related to the project management of innovative projects are also described to play a role in re-use projects

and are reflected in the recommendations for re-use projects. This includes the expansion of the initiation phase and the iterative character of the proposed project organization, as well as the importance of the careful selection of the project team members.

Literature to circular building projects also suggests the need for integration. This is, however, not surprising, as literature also indicates that process integration is seen as a means to stimulate innovations. This idea of process integration is confirmed by this research on the re-use of components with regard to several aspects. Firstly the suggestion to form an interdisciplinary team that includes close collaboration between clients, architects, engineers/consultants, re-use experts as well as contractors. This is closely related to the integration of designing, engineering, and planning activities, including, for instance, making drawings, purchasing of components, and assessing them. In general, the innovation of process integration in construction is slowly developing and is in need of strong guidance by clients and regulations. Besides, better insight into the benefits of process integration should be achieved to stimulate the further diffusion of the innovation. As mentioned, several recommendations for re-use projects are related to this innovation, therefore further development of process integration would also contribute to the management of re-use projects.

The research demonstrates the importance of the client in achieving re-use. The client should be really motivated to re-use, should translate this into an ambition and related goals, and should make sure that these are well understood and incorporated in the entire project. Experienced clients, managing larger building portfolios, could even play a role in providing an internal inventory of potential re-usable components. This suggests the important role that the project sponsor, as representative of the client, has in the project management of re-use projects. However, not every client has the opportunity to appoint a project sponsor that is experienced with building projects. That’s when project management consultants, could also play an important role in supporting a client during the initiation phase in setting up a project that supports re-using components and managing this throughout the process.

The project manager should also be aware of the differences that are seen between the different types of re-use (particularly on the site, or originating from other sites and owned, or acquired in the market) and to what layer (structure, skin, service plan, or space plan) components belong. The study shows that the different types and layers relate to varying tasks and decision moments. The project manager should take this into account from the early stages of the project and systematically include it in the project plan, to make sure that all types and layers are taken into account before it is too late. Distinguishing between types of re-use and layers also helps in setting complete and clear targets. This would thereby contribute to achieving a maximum amount of re-use.

Project management framework

The findings of the research related to the aspects briefing, project organization, and project team selection, have been translated into a project management framework (Figure 32). The framework describes multiple aspects that are believed to support the ambition to re-use components in building projects. This framework could be used by project managers that are involved in future building projects with the ambition to include reclaimed components.

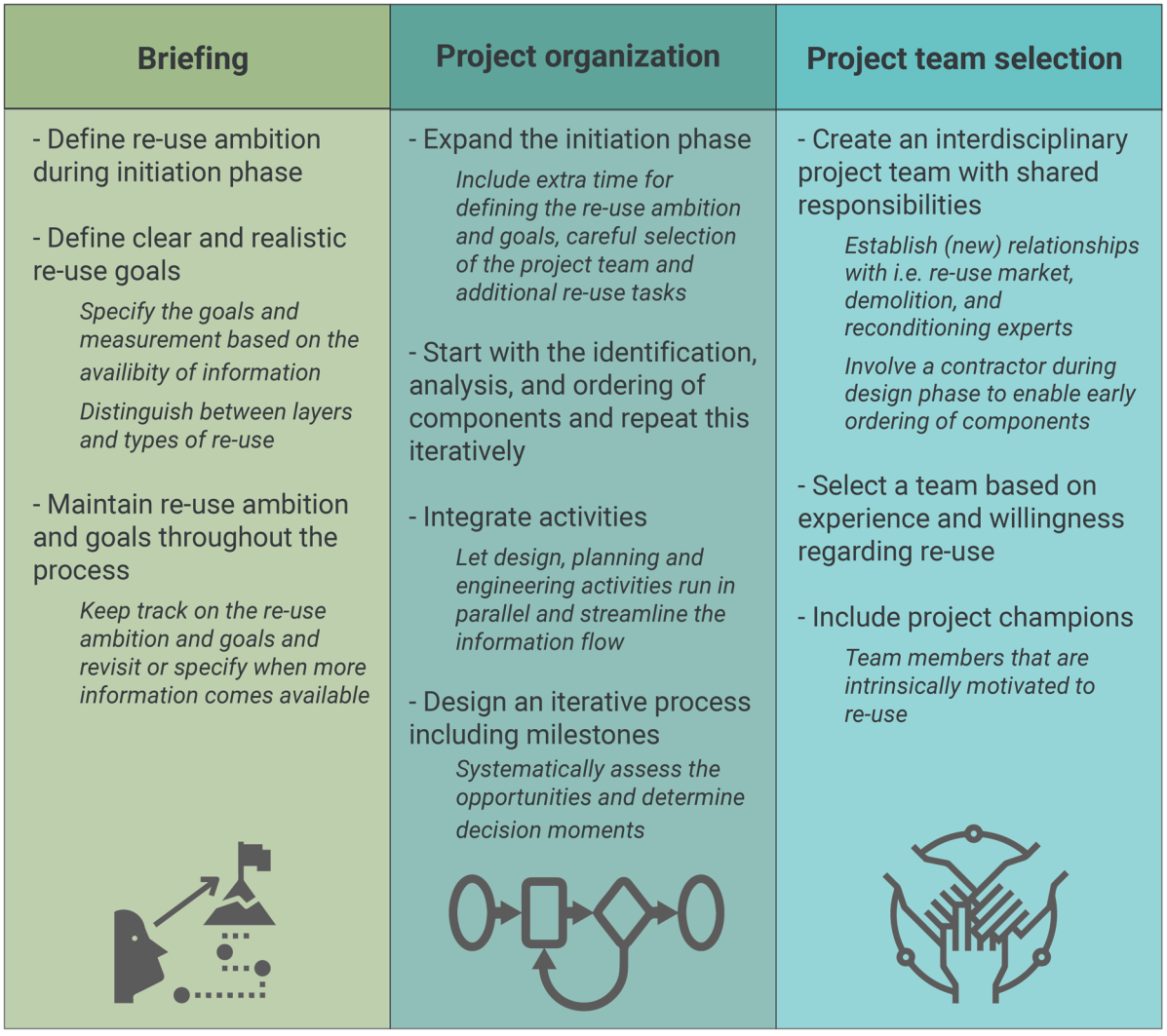


Figure 32. Project management framework

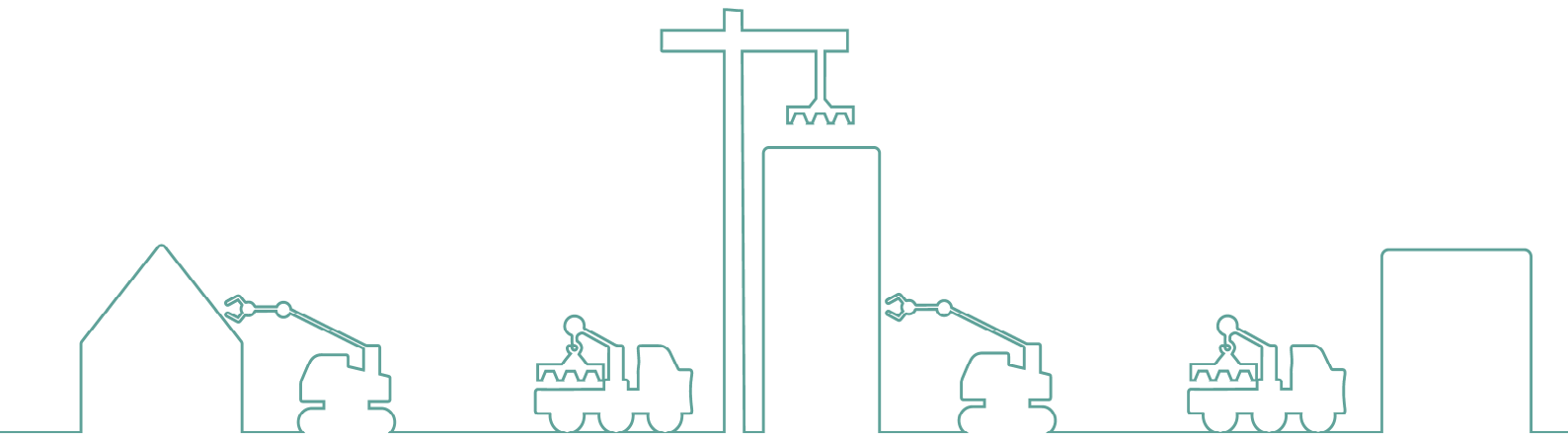
The most striking suggestion for project managers in re-use projects is to start with the identification of reclaimed components already during the initiation phase and align the design with the identification, ordering, and analysis of reclaimed components iteratively.

The flow chart that has been developed describes the process that should be followed to optimize the inclusion of reclaimed components. It indicates the starting inventory during the initiation phase and suggests considering multiple types of re-use from the start. As the process is progressing, fewer opportunities for re-use arise. On site re-use can only be considered during the early stages, in addition the layers determine the last possible moment

for inclusion. It is advised to study this flow chart and use the flow chart as a starting point for designing the project organization. The flow chart can be found in Appendix C.

CHAPTER 9

DISCUSSION



Research design and outcome

During the early stage of the research process, a research design was developed. This design aimed at being able to answer the research question and to develop a project management framework for building projects that include re-used components. The methods that were planned to be used are eventually implemented and there was no need to deviate from criteria that have been set up in advance. This meant that multiple experts have been interviewed and two cases, that meet the criteria, have been studied. Although it was taken into account that only limited re-use projects are known in the Netherlands, it was experienced to be challenging to identify suitable cases. However, eventually, a renovation and newly built office case that complied with the pre-set case study criteria have been studied. It turned out that the planned methodologies were useful and helped to achieve the research aim, as they have provided enough information to answer the main research question.

The findings of the empirical study confirmed most of the suggestions in literature and mainly contributed to a better understanding of the importance of the suggestions and how these could be carried out in practice. The empirical study, however, did point out some practical difficulties regarding some of the suggestions described in the literature. For instance, the literature suggests having a flexible approach to time. This is found to be in contradiction with other aspects that also fall within the project manager's responsibility and should be executed within an often restricted time. Therefore, some nuance of the flexible approach is needed and incorporating milestones could help in this.

In addition, some aspects are described only briefly in literature, while the empirical study indicates them to be of significant importance. For example, the motivation of project team members was only mentioned as a barrier for re-use in literature. The empirical study supplemented to this and clearly demonstrates that selecting actors that are (intrinsically) motivated could really make a difference in the inclusion of re-used components. Both literature and the empirical study also clearly point out that including the ambition to re-use in the brief and requirements is of importance in achieving re-use. However, the empirical study suggests that it is as important to repeat and keep track on the re-use ambition and related targets throughout the process. The empirical study also suggests that the identification of reclaimed components during the early stages of the project is more crucial than the literature indicates. A comprehensive analysis of potential components of different types and the capturing of the components already from the initiation phase is believed to have a major impact on the degree of re-used components that will eventually be achieved. The empirical study shows that the need for early ordering of purchasing of components mainly relates to the current limitations of the re-use market. However, the need for information concerning the characteristics and dimensions of the reclaimed component from the early stages of design will remain.

The need for early identification and ordering of reclaimed components is a striking outcome as it has a far-reaching impact on the entire building process. Firstly, it results in very specific components becoming a precondition for the design, which requires another way of thinking of the architects. It requires to conduct planning and engineering activities a lot earlier in the process, which influences the project delivery process and schedule, and requires adjusted moments of involvement of actors, including actors that are normally not involved such as re-use market, demolition or reconditioning experts. It also implies the need for early involvement of suppliers of reclaimed components, which goes hand in hand with a need for early investments in the ordering and purchasing of components. These early investments require

the need for involvement of an actor that has the ability to make these investments. Traditionally an architect, who is the main actor during the design phase, doesn't have this ability. Therefore other actors, such as a contractor should already become involved during this early stage. Besides, these early investments also come with additional risks. Once the design further develops certain components might not fit the design and the question arises what will happen with those already purchased components by then. This requires clear agreements on how to deal with that and suggests the need to reconsider the traditional business models.

Research implications

The research is believed to be relevant since the re-use of building components and its management are currently little explored in research and practice but is gaining in momentum. Multiple interviewed professionals have indicated that they are seeking their approach to re-use projects and would be interested in developing a better idea of how one could approach this kind of projects. The outcomes of the research contribute to the current experience and knowledge and supplements to the literature as it provides additional practical insights and makes recommendations for the implementation of reclaimed components. The study gives guidance to project managers that are willing to manage building projects where reclaimed components are used. It also gives a better insight into the effects of the ambition to re-use components on the process. This should be useful for ambitious clients that seek to shape their circular ambitions in building projects.

The study suggests that the traditional way of building should be adopted to enable the integration of reclaimed components. Some interviewees are skeptical concerning the re-use topic and see more potential in other circular strategies as they require fewer adjustments to the traditional process. For instance, design for disassembly requires another way of designing but has less impact on the project delivery process, as new components still can be purchased after the design has finished. Besides, building with reclaimed components is not yet cheaper than using new components, which limit the stimulation of using reclaimed components. As with other innovations, the development of standards and regulations that stimulate the innovation, and in this case better allow for re-use, is also mentioned to be crucial for further development and standardization of the re-use concept. In particular related to the re-use of components within the layers structure and skin, that have to meet high standards related to safety and quality. Subsidies could also contribute to the further development of the concept, currently few subsidies that support re-use are known. Re-use projects might, for instance, be eligible for a subsidy for Dutch pilot and demonstration projects that focus on recycling, re-use, or the use of biobased materials (Rijksdienst voor Ondernemend Nederland, n.d.).

However, the study also implies the potential of building with reclaimed components. Ongoing developments such as a proactive online platform that match reclaimed building products with building projects, other re-use marketplaces, and the establishment of construction product brokers confirm this and would contribute to the further development of the concept. A constant supply of reclaimed components would offer more opportunities to use second-hand components. Some interviewees indicated that the identification, reconditioning, and qualification of reclaimed components might even develop as standard practice and, over time, suppliers would sell certified reclaimed components similar to selling new components. This would result in less need for early identification and securing of reclaimed components. Project managers that have been interviewed believe that the suggested recommendations for re-use projects are realistic and that this way of construction would offer a nice way to implement circularity in the building sector.

As the concept of re-use is currently still in its infancy, it requires clients and actors involved in building projects to be ambitious and invest time and energy in experimenting with re-use and getting this concept of the ground. This would help in developing knowledge and experience with the concept, convincing other actors of the opportunities of re-use, and, together with the developments of regulations and standards, subsidies, the re-use market, and re-use business plans, would lead to the diffusion of the innovation of re-using building components.

Remarkable is that the study points out several aspects that are in line with suggestions for circular building innovation or innovations in the construction sector in general. Including the need for more integration by the establishment of multidisciplinary project teams, supply chain integration and the integration of project activities (Orstavik, Dainty & Abbot, 2015; Hart, Adams, Giesekam, Tingley & Pomponi, 2019; Leising et al., 2019; Van der Wijk, 2018). In re-use projects, these suggestions mainly result from the need to have the specific reclaimed components as input for the design.

Limitations and further research

Due to the explorative nature of the research, the research is based on themes that are identified in a limited amount of literature that exists on the re-use topic. Besides, only limited interviews and two case studies have been conducted. Due to the large share that the empirical study has played in the research, the outcomes are also very dependent on those experiences and opinions of the interviewees, the quality of the interview technique, and the specific cases that are studied. Therefore one must realize that the research has given important insights into the topic that could be applied to future re-use projects, but the outcomes of the research should not be generalized.

It is found that many of the barriers for re-use could be reduced by an appropriate briefing, project organization, and project team selection. However, multiple barriers seem not to be addressed by focusing on these three aspects and relate to topics that are out of the scope of this research. These include for instance challenges on the supply side, which currently leads to a very limited supply of reclaimed components. Relating to this the fact that most buildings aren’t built to be disassembled, is causing fundamental issues. Besides, regulatory aspects are described to limit the supply of reclaimed components. Although the expansion of the initiation phase and the iterative character, as suggested in this research, would help in taking into account these difficulties and leaving room to respond to the uncertainties on the supply side, these suggestions won’t solve the problems at the supply side. Therefore, research on the development of a more established re-use market and regulatory standards that better allow for the re-use of components is suggested.

The study also shows that re-using components doesn’t save costs and might even be more expansive, than using new materials. This results from the additional recovery, research, and reconditioning activities that should be undertaken to include reclaimed components. In addition, the study suggests that early investments in purchasing reclaimed components at the moment they come available should be done. This implies that business models should be adopted to facilitate re-use. Further research into these financial aspects of re-use projects would, therefore, be interesting. In addition, as mentioned before, subsidies might contribute to financial challenges.

In addition, the contractual relationships are out of the scope of this research. The study points out the need for interdisciplinary teams that share responsibilities. Some studies to

circular contracting in general, show links to these findings by suggesting the use of integrated contracts or consortia. However, including additional expertise concerning re-use or realization on a consulting basis, might also help to provide the design team with additional knowledge and information relating to re-use. This would nevertheless not lead to shared responsibilities and lead to difficulties with purchasing components already during the initiation or design phase. Therefore more research into the contractual facilitation of this kind of interdisciplinary project teams would therefore be interesting.

The research focuses on only three aspects during the initiation phase of building projects from the perspective of the project manager. The aspects briefing, project organization, and selection of the project team relate to multiple project management knowledge areas as identified by the Project Management Institute (2017), but doesn't touch all knowledge areas. As mentioned cost management and procurement management aren't dealt with in this research, and risk, communication, and quality management are also little touched upon in this research. Therefore it would be interesting to also study these topics. In addition the research was limited to the role of project management during the initiation phase, however other phases and actors obviously also play a role in the implementation of re-used components in the building sector. According to Kozminska (2019) and Gorgolewski (2019), for instance, the architect plays an important role in re-use projects and the study by Van den Berg (2019) implies to start with demolition in circular building projects, which indicates the importance of demolition contractors which is also stressed by the empirical study. Research into the role of varying actors during the other phases of re-use projects would, therefore, be useful. This would help in optimizing the understanding of the entire re-use process and how to manage it.

Circularity in the built environment has multiple dimensions that come with different strategies as described in for instance the 10-R model by PBL Netherlands Environmental Assessment Agency (2017). This research was limited to using reclaimed components as input for building projects. However, the different dimensions of circularity are closely related and the building sector will not become fully circular by focusing on only one aspect of circularity. In addition the research showed that, depending on the layer to which components belong, the re-use strategy comes with its own challenges. The study suggests that most potential for re-use is currently experienced within the layer space plan and services. Therefore this research to one strategy, the re-use of components, should be placed within a wider context of circular building strategies and better inside in how a project manager could combine multiple circular strategies would be very useful to create a more complete idea of how building projects could become circular. Distinguishing between the building layers might help in this.

The study demonstrates that a systematic approach would be useful to organize re-use projects. Using the layers as defined by Brand (1995) would help in structuring the project. Several tools such as the use of BIM, coding of components, and the development of decision matrices are described to be helpful. However, no standardized method is known. Further development of these tools and including them in a uniform circular building method would help in achieving a circular building sector.

Broader context

Although it is found that project management could contribute to improving the mindset of team members regarding re-use. The empirical study suggests that a mind-shift of a much wider audience, besides the people involved in building projects, future clients and users should adapt their attitude with respect to using reclaimed components. This would create

greater demand for and acceptation of re-use and this might be needed to scale up the concept of building with reclaimed components. Many people state that they first have to see the successful realization of re-use projects, before they believe it. This is in line with Roger's innovation diffusion theory, which describes that innovations require pioneers to show the potential of the innovation (Widén, 2006; Wamelink & Heintz, 2015). Although only limited examples are still known, some cases already show the potential of the concept of re-use. Therefore, it might be time that people start to believe it. This would lead to acceleration and upscaling of the concept and growing demand would also contribute to the development of the re-use market.

The study relates to the status quo of the building sector in the Netherlands, assuming the current state of availability of reclaimed building components and current experience with the re-use concept. Many of the outcomes are related to the fact that the re-use concept is still in infancy. The study, however, suggests that this concept is rapidly developing, including a growing market with upcoming developments such as online marketplaces and excess material exchange (EME), a platform that matches supply and demand of material and product flows (Excess Material Exchange, n.d.). Once the concept and market has been further developed some of the suggestions of this research will be less significant. For example, the need for purchasing of components during the initiation and design phase might not be needed when a constant flow of reclaimed components is established. Besides, people's understanding, motivation, and experience will change over time, which will make it less complex to shape a project team that contributes to the realization of buildings with re-used components. For the time being, this is, however, wishful thinking.

Moreover, the development of the re-use concept also goes hand in hand with the development of the concept of design for disassembly. When more buildings are built to be disassembled, it will become be less difficult to re-use components. In addition, standardization in building components, by using, for instance, modular dimensions, would also ease the re-use of components. Although it would take some time before these components will be disassembled, due to the long lifespan of buildings, these developments would cause an acceleration of the re-use concept.

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strict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C06THRU10%5CTXT%5C00000000%5C60000AVO.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=2#

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APPENDIX A

Interview protocol expert interviews

Technische Universiteit Delft: Faculteit Bouwkunde
Geïnterviewde : Naam + Achternaam + Functie
Interviewer: Lotte Meijers

A. Introductie en achtergrond
B. Hergebruik van gebouwcomponenten en projectmanagement
C. Afsluiting

Hergebruik van gebouwcomponenten en projectmanagement

A. Introductie en achtergrond

Voorstellen

Mijn naam is Lotte Meijers en ik volg de masteropleiding Management in the Built Environment aan de faculteit Bouwkunde aan de Technische Universiteit Delft. Al tijdens de bachelor was ik geïnteresseerd in hoe de bouw duurzamer zou kunnen en tijdens mijn master ben ik een half jaar naar Zweden geweest om hier meer vakken in te volgen. Daarom wist ik al dat ik tijdens mijn afstudeeronderzoek hier mee aan de slag zou willen. Uiteindelijk heb ik gekozen om onderzoek te gaan doen naar een aspect van circulair bouwen. Namelijk het hergebruiken van gebouwcomponenten en welke rol project management hier in heeft.

- ➔ Toevoegen in samenwerking met Brink Management/Advies indien van toepassing
- ➔ toevoegen via wie in contact gekomen indien van toepassing

Protocol en permissie audio opname

In verband met het maken van aantekeningen die ons gesprek correct representeren zou ik graag een audio opname van ons gesprek maken en deze achteraf transcriberen. Als u dit liever niet geeft hoop ik dat u dat aangeeft en is er ook de optie om geen opname te maken.

Voorlezen informed consent.

Ik verwacht dat het interview ongeveer 60 minuten zal duren. Hierin zou ik graag verschillende onderwerpen met u bespreken.

Interview inhoudelijk

Ik heb u gevraagd om met mij te spreken gezien het feit dat u ervaring heeft met bouwprojecten waar gebouwcomponenten zijn of worden hergebruikt. Zoals ik aangaf richt mijn afstudeeronderzoek op het projectmanagement van dergelijke projecten en in het specifiek utiliteitsbouw. Voorafgaand aan deze interviews heeft een literatuurstudie plaatsgevonden en hieruit kwamen verschillende dingen naar voren met betrekking tot het proces van bouwprojecten waar componenten worden hergebruikt.

Maar wat bedoel ik hier dan eigenlijk mee, het hergebruiken van componenten? Ik heb hier drie verschillende schalen waarop we over gebouwen kunnen spreken. Materiaal, component, gebouw zelf. Als ik het heb over het hergebruiken van gebouwcomponenten heb ik het over, die schaal en vaste onderdelen van een gebouw, dus geen interieur, bijvoorbeeld, kozijnen, deuren, radiatoren etc. Ook heb ik het over het hergebruiken van die componenten zonder grootse aanpassingen, zoals hersmelten of hervormen, wat ik recycling noem.

De focus van mijn onderzoek ligt verder op de rol van het opstellen de nota van uitgangspunten en programma van eisen, het samenstellen van een projectteam en het organiseren van het project. Hier zal ik dan ook graag over spreken en naar vragen gedurende het gesprek.

Met dit interview hoop ik meer inzicht te krijgen in de praktijk van bouwprojecten met hergebruikte componenten en waar de voordelen en uitdagingen hiervan liggen zonder een bepaalde richting in te sturen. Zoals ik aangaf zijn een aantal onderwerpen waar ik graag over wil spreken, maar de opzet van het interview zal open zijn dus voelt u zich vooral vrij om te praten over ervaringen en voorbeelden te noemen.

Achtergrond geïnterviewde

1. Zou u wat meer over uzelf kunnen vertellen?

2. Wat is uw professionele achtergrond?

3. Voor welke organisatie werkt u?

4. Wat is uw rol binnen de organisatie?

5. Als ik het goed heb begrepen bent u betrokken geweest bij projecten met hergebruikte componenten, is dit zo en bij welke projecten dan?
a) Welke rol?

6. Waarom betrokken bij dit soort projecten, wat is motivatie?

Achtergrond organisatie

1. Kunt u vertellen hoe uw organisatie betrokken is in hergebruik projecten?

2. Hoe komt het dat jullie hierbij betrokken zijn geraakt?
a) Door wie is het idee om her te gebruiken geïnitieerd?

B. Hergebruik van gebouwcomponenten en projectmanagement

Hergebruik projecten in de praktijk

Overkoepelende vraag: Hoe vinden bouwprojecten met hergebruikte elementen plaats en hoe wijkt dit af van "normale" projecten?

1. Als we spreken over projecten met hergebruik, hoe zou u uw rol daar in beschrijven?

2. Kunt u vertellen over uw/je ervaringen met bouwprojecten waar gebouwcomponenten zijn hergebruikt?
a) Wat is er **bijzonder** aan deze projecten?
b) Waar liggen de **verschillen** met andere projecten?
c) **Waarin** dan?
d) Wat waren **belangrijke taken** die u op zich hebt genomen?
e) Zijn dit **andere taken** dan normaal?

3. Op wat voor manier zijn er componenten hergebruikt?
a) Waren deze al op de **locatie** aanwezig? Was er een **donor gebouw**? Kwamen van **andere locaties**?
b) Moesten er **aanpassingen** gedaan worden?
c) Zijn de componenten ingezet met **dezelfde functie**?
d) Indien verschillende vormen van hergebruik: **verschillen** tussen deze vormen? En wat dan?

4. Organisatie betrokken geweest in meerdere projecten met hergebruik?
a) Evaluatie tussen projecten?
b) dingen anders tussen projecten?

Project management: Opstellen van uitgangspunten tot PVE, project organisatie en selectie project team

Overkoepelende vraag: Heeft, en zo ja, hoe, het opstellen van de uitgangspunten, project organisatie en selectie van het project team bijgedragen aan het hergebruiken van gebouwcomponenten?

Als **project manager:**
Bekend met projectmatig werken? GOTIK? TGKIO?
1. Kunt u uitleggen hoe hergebruik van componenten effect heeft op de verschillende beheers aspecten?

Algemeen:
1. Hoe zijn projecten normaal **georganiseerd**? (gebruik pen papier)
a) Hoe was dit bij **hergebruik** projecten?
b) Wat is er dan **anders**?

c) In literatuur heb ik gevonden dat de (**volgorde van de) project leveringsfases** in een project afwijken, bent u het hier mee eens? En hoe ziet dat er dan uit? (O)
d) Ook wordt er gesproken van een meer **flexibele benadering van de planning en tijd**. Was dit van toepassing? (T)
e) Heeft het ook gevolgen gehad op de **supply chain/toeleveringsketen** en hoe zag de **inkoop** er dan uit? (O) (G)
f) Denkt u dat de manier waarop project is georganiseerd heeft **bijgedragen** aan het hergebruik van componenten? Zo ja, op wat voor manier? (K)

2. Hoe ziet normaliter het proces van het opstellen van de uitgangspunten er uit? (K)
a) Hoe zag dit er uit in de projecten waar hergebruik een rol speelde?
b) Is dit **anders**? Op wat voor manier?
c) Is er een **nota van uitgangspunten** opgesteld?
d) **Wat** werd hier gezegd over hergebruik?
e) **Wanneer** werd hergebruik geïntroduceerd in specificaties en door **wie**?
f) Denkt u dat dit heeft **bijgedragen** aan het hergebruik van componenten? Zo ja, op wat voor manier? (K)
g) Was er een **gedeelde visie**? Was deze ergens gespecificeerd? Hoe hiertoe gekomen?
h) In hoeverre zijn er **doelen** opgenomen in de nota van uitgangspunten of PVE? Wat houden deze dan in?
i) Wie heeft hier **leiding** in genomen? Waar kwam **initiatief** vandaan?
j) Wat voor rol had de **project manager** hier in genomen? Veel initiatief?

3. Hoe ziet normaal gesproken de **selectie van het project team** er uit?
a) Hoe is het project team geselecteerd in **hergebruik project**?
b) **Wie** waren er allemaal betrokken en **wanneer**?
c) Is dit **anders** dan normaal?→ Zijn bepaalde actoren op **andere momenten** betrokken in het proces dan normaal? Zijn er **andere partijen** benaderd die normaal niet betrokken zijn?
d) Was de **samenwerking** tussen verschillende partijen anders dan normaal? Zo ja hoe?
e) Was er sprake van een **interdisciplinair ontwerpteam**? Hoe zag dit er uit?
f) Denkt u dat dit heeft **bijgedragen** aan het hergebruik van componenten? Zo ja, op wat voor manier?
g) Welke **actoren** zijn relevant? Welke hebben de meeste invloed?

Management belemmeringen

Overkoepelende vraag: Wat zijn de project management belemmeringen en beperkingen in circulaire projecten en hoe kunnen deze verholpen worden?

1. Wat ging er **goed**, wat was opmerkelijk?
a) **Wat** heeft er aan bijgedragen om het te bereiken en **wie**?
b) Hoe kan dit in de toekomst worden benut en uitgebreid?

2. Wat ging er **minde**r/wat waren de obstakels?
a) Wat waren de management belemmeringen en **beperkingen** die zijn ervaren, specifiek gerelateerd aan project management?
b) Hoe zouden deze **opgelost** kunnen worden? Zijn er specifieke **tools** die hiervoor gebruikt kunnen worden?

c) In literatuur wordt gesproken over moeilijkheden met de **informatiestromen.** Heeft u daar ook ervaring mee en op wat voor manier? Zijn er specifieke **tools** die hiervoor gebruikt kunnen worden? Hoe zou dit verholpen kunnen worden ? (I)
d) **Houding van mensen** ten opzichte van hergebruik, ook ervaren, hoe verholpen?

3. Vond u het l**euk** om te doen en zou u het graag **nog een keer** zo willen doen?
a) **Waarom**?
b) Denkt u dat het iets heeft **toegevoegd?** Denkt u dat uw rol **waardevol** was? (K)
c) Wat zou u **anders** doen in volgende projecten?
d) Wat zou er anders moeten om het **beter** te doen?
Tot slot

1.Zijn er nog **andere aspecten** die niet aan bod zijn gekomen die u wel graag wil vermelden m.b.t. projectmanagement en proces van projecten met hergebruikte componenten?

2. Met **wie** zou ik volgens u **nog meer** in gesprek moeten gaan over dit onderwerp?

C. Afsluiting

Ik wil u graag bedanken voor uw tijd en moeite voor het uitgebreid beantwoorden van mijn vragen. Ik hoop dat u het interview als prettig hebt ervaren. Als er nog vragen of opmerkingen zijn kunt u mij altijd mailen of bellen.

APPENDIX B

Interview protocol case interviews

Technische Universiteit Delft: Faculteit Bouwkunde
Geïnterviewde : Naam + Achternaam + Functie + Case
Interviewer: Lotte Meijers

A. Introductie en achtergrond
B. Hergebruik van gebouwcomponenten en projectmanagement
C. Afsluiting

Hergebruik van gebouwcomponenten en projectmanagement

A. Introductie en achtergrond

Voorstellen

Mijn naam is Lotte Meijers en ik volg de masteropleiding Management in the Built Environment aan de faculteit Bouwkunde aan de Technische Universiteit Delft. Al tijdens de bachelor was ik geïnteresseerd in hoe de bouw duurzamer zou kunnen en tijdens mijn master ben ik een half jaar naar Zweden geweest om hier meer vakken in te volgen. Daarom wist ik al dat ik tijdens mijn afstudeeronderzoek hier mee aan de slag zou willen. Uiteindelijk heb ik gekozen om onderzoek te gaan doen naar een aspect van circulair bouwen. Namelijk het hergebruiken van gebouwcomponenten en welke rol project management hier in heeft.

- ➔ Toevoegen in samenwerking met Brink Management/Advies indien van toepassing
- ➔ toevoegen via wie in contact gekomen indien van toepassing

Protocol en permissie audio opname

In verband met het maken van aantekeningen die ons gesprek correct representeren zou ik graag een audio opname van ons gesprek maken en deze achteraf transcriberen. Als u dit liever niet geeft hoop ik dat u dat aangeeft en is er ook de optie om geen opname te maken.

Voorlezen informed consent.

Ik verwacht dat het interview ongeveer 60 minuten zal duren. Hierin zou ik graag verschillende onderwerpen met u bespreken.

Interview inhoudelijk

Ik heb u gevraagd om met mij te spreken gezien het feit dat u betrokken bent geweest in project X en ik heb begrepen dat hier gebouwcomponenten zijn hergebruikt. Zoals ik aangaf richt mijn afstudeeronderzoek op het projectmanagement van dergelijke projecten. Voorafgaand aan dit interview heeft een literatuurstudie en interviews plaatsgevonden en hieruit kwamen verschillende dingen naar voren met betrekking tot het proces van bouwprojecten waar componenten worden hergebruikt.

Maar wat bedoel ik hier dan eigenlijk mee, het hergebruiken van componenten? Ik heb hier drie verschillende schalen waarop we over gebouwen kunnen spreken. Materiaal, component, gebouw zelf. Als ik het heb over het hergebruiken van gebouwcomponenten heb ik het over, die schaal en vaste onderdelen van een gebouw, dus geen meubels, maar bijvoorbeeld, kozijnen, deuren, radiatoren etc. Ook heb ik het over het hergebruiken van die componenten zonder grootse aanpassingen, zoals hersmelten of hervormen, wat ik recycling noem.

Met dit interview hoop ik meer inzicht te krijgen in het project X en hoe het hergebruik van componenten hier heeft plaatsgevonden. Ook hoop ik beter inzicht te krijgen in hoe de eisen en uitgangspunten zijn opgesteld, het project is georganiseerd en het project team is gevormd.

Ik wil dus verschillende onderwerpen graag bespreken, maar de opzet van het interview zal open zijn dus voelt u zich vooral vrij om te praten over ervaringen en voorbeelden te noemen.

Achtergrond geïnterviewde

1. Wat is uw professionele achtergrond?

2. Wat is uw rol binnen de organisatie en het project?
a) Wat voor taken?

3. Waarom betrokken bij dit soort projecten, wat is motivatie?

Achtergrond organisatie

1. Kunt u vertellen hoe uw organisatie betrokken is in hergebruik projecten?

2. Hoe komt het dat jullie hierbij betrokken zijn geraakt?
a) Door wie is het idee om her te gebruiken geïnitieerd?

B. Hergebruik van gebouwcomponenten en projectmanagement

Hergebruik projecten in de praktijk

Overkoepelende vraag: Hoe heeft het project plaatsgevonden en wat is er aan componenten hergebruikt?

1. Kunt u vertellen hoe het project heeft plaatsgevonden?

a) Wat was de opdracht?
b) Wie waren betrokken?
c) Hoe was het project georganiseerd?
d) Wat was het aandeel aan hergebruik? → ambitie hergebruik?

2. Als we spreken over het hergebruik van componenten in project X, kunt u dan vertellen hoe dit van toepassing is geweest?

a) Kunt u voorbeelden noemen van hergebruikte componenten?
b) Wanneer is er besloten om bepaalde dingen her te gebruiken? → van tevoren geanalyseerd? → lukte dit altijd? → hoe zijn beslissingen genomen? → Wie nam die beslissingen?
c) Op wat voor manier zijn ze opnieuw ingezet? Zelfde functie?
d) Waren deze al op de **locatie** aanwezig? Was er een **donor gebouw**? Kwamen van **andere locaties**?
e) Uit de **markt** of **portfolio**?
f) Waren er nog **aanpassingen** nodig?
g) Als verschillende manier is geweest, zit daar een **verschil** in? Wat is dat dan?
h) Was het **lastig** om geschikte componenten te vinden? → waar lag dat aan?
i) Hoe is er omgegaan met de **timing** van het hergebruiken?
j) **Samengewerkt met andere partij** met kennis van hergebruik/markt?
k) Is ergens **opgeslagen**?
l) **Hoeveel** is er uiteindelijk hergebruikt? → percentages?

Project management: Opstellen van uitgangspunten tot PVE, project organisatie en selectie project team

Overkoepelende vraag: Heeft, en zo ja, hoe, het opstellen van de uitgangspunten, project organisatie en selectie van het project team bijgedragen aan het hergebruiken van gebouwcomponenten?

Briefing:
1. Bent u **betrokken** geweest in het proces waar **eisen en uitgangspunten** zijn opgesteld?
a) Hoe zag dit er uit? Wat voor document? Specifieke doelen?
b) Wat is er in opgenomen wat betreft **hergebruik**? → bepaalde ambitie? Doelen?
c) **Wanneer** is dit gebeurd?
d) Wat was **uw rol** hier in?
e) Wie nam hierin de **leiding/initiatief**?
f) Zijn doelen **behaald**? → Waarom wel/niet?
g) Hoe heeft dit **invloed** gehad **op het hergebruik** in het project?

Project organisatie:
1. Hoe was het project **georganiseerd**?
a) Project leveringsfases anders?

b) Flexibele **benadering van de planning en tijd**. Was dit van toepassing? → Werkte dit goed? → bepaalde beslismomenten in opgenomen?
c) Eerst inventarisatie gemaakt van **componenten**?
d) Actoren eerder betrokken? → Aannemer betrokken tijdens ontwerpen?

2. Hoe zag de **supply chain/toeleveringsketen** en hoe zag de **inkoop** er dan uit? → wanneer bepaalde dingen "ingekocht"

3. Hoe is er omgegaan met **bestek**? → Hoe met **garanties** leveren en **verantwoordelijkheden**?

4. Denkt u dat de manier waarop project is georganiseerd heeft **bijgedragen** aan het hergebruik van componenten? Zo ja, op wat voor manier?

Project team:
a) Hoe is het project team geselecteerd in dit project?
b) **Wie** waren er allemaal betrokken en **wanneer**?
c) Hoe was de **samenwerking** tussen verschillende partijen? → hoe is dat zo gekomen?
d) Was er sprake van een **interdisciplinair ontwerpteam**? Hoe zag dit er uit?
e) Waren de mensen gedreven om dingen **her te gebruiken?** → sprake van bepaalde actoren die hier leidende rol in hadden?
f) Wat was de rol van de **opdrachtgever**? → bepalend voor hergebruik?
f) Denkt u dat de selectie van het project team heeft **bijgedragen** aan het hergebruik van componenten? Zo ja, op wat voor manier?

Management belemmeringen

Overkoepelende vraag: Wat zijn de project management belemmeringen en beperkingen in het hergebruiken van gebouwcomponenten in circulaire projecten en hoe kunnen deze verholpen worden?

1. Wat ging er **goed**, wat was opmerkelijk?
a) **Wat** heeft er aan bijgedragen om het te bereiken en **wie**?
b) Hoe kan dit in de toekomst worden benut en uitgebreid?

2. Wat ging er **minde**r/wat waren de obstakels?
a) Wat waren de management belemmeringen en **beperkingen** die zijn ervaren, specifiek gerelateerd aan project management?
b) Hoe zouden deze **opgelost** kunnen worden? Zijn er specifieke **tools** die hiervoor gebruikt kunnen worden?
c) Er wordt gesproken over moeilijkheden met de **informatiestromen.** Heeft u daar ook ervaring mee en op wat voor manier? Zijn er specifieke **tools** die hiervoor gebruikt kunnen worden? Hoe zou dit verholpen kunnen worden?
d) **Houding van mensen** ten opzichte van hergebruik, ook ervaren, hoe verholpen? → waar kwam vandaan?
e) Zijn er moeilijkheden ervaren met het **bestek**? Hoe is daar mee gewerkt?
f) Zijn er moeilijkheden met de **planning** ervaren door het hergebruiken?

3. Vond u het l**euk** om te doen en zou u het graag **nog een keer** zo willen doen?
a) **Waarom**?
b) Wat zou u **anders** doen in volgende projecten?

c) Wat zou er anders moeten om het **beter** te doen?

Tot slot

1.Zijn er nog **andere aspecten** die niet aan bod zijn gekomen die u wel graag wil vermelden m.b.t. projectmanagement en proces van projecten met hergebruikte componenten?

2. Met **wie** zou ik volgens u **nog meer** in gesprek moeten gaan over dit onderwerp en project?

C. Afsluiting

Ik wil u graag bedanken voor uw tijd en moeite voor het uitgebreid beantwoorden van mijn vragen. Ik hoop dat u het interview als prettig hebt ervaren. Als er nog vragen of opmerkingen zijn kunt u mij altijd mailen of bellen.

APPENDIX C – Flow chart re-use process