Managing circular construction projects

Master Thesis – A.T. Versteeg Conlledo
Managing circular construction projects

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Preface

Before you lies the graduation research report ‘Managing circular construction projects’, written to obtain my master degree in Construction Management and Engineering at Delft University of Technology. This thesis report provides information about the management of construction projects where circular economy principles have been applied. Over the past months I have immersed myself in the world of the circular economy and the management of construction projects. The circular economy is more and more becoming an important topic in the construction sector, therefore I enjoyed diving into this relevant subject.

I would like to thank my supervisors, forming the graduation committee, for guiding and supporting me through the process. I have enjoyed our meetings, where constructive feedback and advice was given (and often jokes were made). This ‘relaxed’ environment made the process very stimulating. Hans, thank you for the constructive feedback during the meetings, which provided me with a clear and precise overview of what I needed to do to improve the quality of my research. Louis, thank you for all the efficient meetings, they were extremely helpful. I would always meet Louis with a list of questions and after 25 minutes I would walk out of the room with a list of clear answers. Daan, I would like to thank you for your feedback, which helped me to look at things I did not think about. Your ambition and enthusiasm about the circular economy was very motivating. Finally, a special thanks goes out to Thomas, for being available to have conversations at the office. I learned a lot about practice during our meetings, which helped a lot to understand the cases I was researching.

I would like to thank Arup for the opportunity the company gave me to do this research. The colleagues at Arup were very supportive, interested and inspiring. This made the process a lot more enjoyable. Moreover, Arup provided me with a great working space and learning environment. I was able to participate in meetings, talk to interesting people and even go to the Madrid office to interview people about my topic. Because of the opportunities given to me by Arup, I will be able to continue learning about this topic and spreading knowledge during my work.

For the research, I had help of many people. I would like to make use of this chapter to thank everyone for their knowledge, interesting insights, contacts and discussions. Your help made my research an enlightening and enjoyable journey. I would like to thank the six interviewees for the explorative interviews at the start of the thesis process. This made me understand the circular economy in detail with its trends, barriers, stakeholders and opportunities. I would like to thank all the 13 case study interviewees for collaborating in my research. You all gave me new knowledge on project management and the management of circular construction projects. Finally, I would like to thank the four validation interviewees, for validating my findings and recommendations. The interviews were all very interesting and it helped in increasing the quality of my conclusions and recommendations.

To finalize, I would like to thank my friends and family for the support. Thanks to their motivation and enthusiasm, the process was very enjoyable. I am very satisfied with the outcomes and the process of this research.

Ana Versteeg Conlledo

Amsterdam, December 2019
Executive summary

The construction sector has been the world’s largest consumer of raw materials since years. Construction and building activities together account for 36% of global energy use and 39% of energy-related carbon dioxide (World Green Building Council, 2017). Considering the built environment puts major pressure on the natural environment, a change in the construction sector is crucial. Circular economy is one of the concepts that can be applied to the built environment. The circular economy is based on three principles: design out waste and pollution, keep products and materials in use and regenerate natural systems. This requires a shift in the way of thinking and in the way of executing and planning a construction process. Where traditional projects are executed according to the ‘take-make-dispose’ plan, circular projects work according to a ‘reduce-reuse-recycle’ plan (van Reijn, personal communication, 2019). Research by Van den Berg explains that the new circular construction method requires a radical new approach (Berg, 2019).

The objective of this research is to find out what changes must be made to traditional project management to deliver circular construction projects. This is done by describing the difference in practice in management, between traditional projects and circular projects. Furthermore, the aim of this research is to help project teams to control and implement the circular ambitions in the project. To meet the objective, the following research question is answered:

What changes must be made to the management of projects, compared to traditional project management, to deliver circular construction projects?

In this research, traditional project management is defined with the help of the Project Management Body of Knowledge+ framework, which is the PMBoK framework including two extensions and therefore called the PMBoK+ framework. The framework discusses 12 project management themes, including the different activities for each theme that ought to be executed. Four circular case studies are performed, they are analyzed by interviewing 13 key stakeholders and by investigating project documents. The interviewees are asked about the 12 PMBoK+ themes, to find out if the same themes have been applied and in what way. The degree of circularity of a project is divided into two categories: circular product and a circular process. The four cases are all circular constructions (products), described with the help of the 10R-model. However, it is unclear if the projects used a circular process. The outcomes of the four case studies are compared, by means of cross-case analysis. The findings and recommendations of the research are validated with the help of an expert panel. Based on the validation and the results of the cross-case analysis, the conclusions, discussions and recommendations are composed.

The four projects that are analyzed are (partly) circular construction projects. However, it is unknown whether in the cases circular project management or traditional project management was used. A distribution is made between the four projects, project A to D. For projects B and D, which are projects with public entities as owners, traditional project management is used. This is different for projects A and C. These two projects can be characterized as experimental circular construction projects. The projects were built with the aim to show the sector how circular buildings are delivered, money was not the main criterion and more funds were available due to media attention. For the experimental projects, circular buildings were delivered where circular processes were used. In both projects, alterations were made to the PMBoK+ framework. These alterations were done for the Scope, Cost, Human Resource, Procurement, Integration and Financial Management. For the other themes, traditional project management was applied.
The following conclusions explain what changes must be made to traditional project management to deliver experimental circular construction projects. To start, the aim to develop a circular construction should be an aim at the start of the project. For the scope, the client should define ambitions (instead of detailed requirements) and after the project team is selected, the requirements should be defined. For Project Cost Management, the budget should be accessible to the project team in a transparent way. The project team should consist of people with the same circular economy commitment, vision and philosophy, as part of the Human Resource Management. The procurement process should be different from the traditional process: plan the tender process timely in the project and involve suppliers early in the project. Besides, parties such as suppliers and subcontractors should be selected with the entire project team. Finally, new contract forms should be used to ensure that the building does not get demolished after the life cycle of the building. For project teams non-hierarchical and cooperative organizational structure should be used to ensure team work, shared responsibility and a creative process. With this, project knowledge is shared in a transparent way. Lastly, for Project Financial Management, responsibilities and risks should be distributed among the involved parties.

Based on these conclusions some recommendations can be made. First for practice, for the entire project team, it is recommended to discuss with the entire project team what circularity means and what principles will be used in the project. By using one clear translation for the project, no misunderstandings can arise because of this. Next, it is recommended to make sure the integrated project team has the same mindset and knows the same principles of the circular economy. It is the entire team’s responsibility to verify if everyone has the same commitment, and if not, act. Finally, the involved parties should know beforehand what the circular ambition of the client is and what the structure is of the project team. That way, the organizations can prepare their own organization for this and educated guesses can be made for the opportunities and the risks of the project. The next recommendations are focused on individual project team parties. Clients and main contractors should consider the way contracts are currently set up. Clients should be aware of the type of contracts they choose, what consequences it can have on the circularity of the project. For main contractors it is recommended to reconsider the traditional contract set up when working with secondary material suppliers, so not all the responsibilities and risks are for the secondary material suppliers. Following, for project managers it is recommended to change the type of leadership. The project manager should make people responsible for the problem, instead of telling them what to do. By solving the problems together, better teamwork with creative solutions is assured. New skills are needed to manage circular projects. The focus has to be more on critical thinking, creativity and making connections.
Samenvatting

De bouwsector is al jaren de grootste grondstofverbruiker ter wereld. Bouw activiteiten zorgen voor 36% van het wereldwijde energieverbruik en 39% van energiegerelateerde koolstofdioxide (World Green Building Council, 2017). Hiervan, en omdat de gebouwde omgeving grote druk uitoefent op de natuurlijke omgeving, is een verandering in de bouwsector noodzakelijk. Circulaire economie is een van de concepten die kunnen worden toegepast op de gebouwde omgeving. De circulaire economie voor de gebouwde omgeving leidt tot drie principes: afval en vervuiling uit het ontwerp verwijderen, producten en materialen in gebruik houden en natuurlijke systemen regenereren. Dit vereist een verschuiving in verandering van de manier van denken en in de manier van plannen en uitvoeren van een bouwproces. Waar lineaire projecten worden uitgevoerd volgens het ‘take-make-dispose’ plan, werken circulaire projecten volgens een ‘reduce-reuse-recycle’ plan (van Reijn, persoonlijke communicatie, 2019). Onderzoek gedaan door van den Berg concludeerde dat de circulaire bouwmethode een radicaal nieuwe aanpak vereist (Berg, 2019).

Het doel van dit onderzoek is om erachter te komen welke wijzigingen in traditioneel projectmanagement moeten worden aangebracht om circulaire bouwprojecten te realiseren. Dit wordt gedaan door eerst het verschil in de praktijk te beschrijven in management van traditionele bouwprojecten en van circulaire bouwprojecten. Het doel van dit onderzoek is daarnaast om projectteams te helpen met het beheersen en uitvoeren van circulaire ambities in projecten. Om het doel te bereiken zal antwoord worden gegeven op de volgende onderzoeksvraag:

**Welke aanpassingen moeten in het management van projecten worden aangebracht, ten opzichte van traditioneel projectmanagement, om circulaire bouwprojecten te realiseren?**

In dit onderzoek wordt traditioneel projectmanagement gedefinieerd met behulp van het raamwerk Project Management Body of Knowledge+. Dit is het PMBoK raamwerk inclusief twee toevoegingen waardoor het vanaf nu het PMBoK+ raamwerk wordt genoemd. Het raamwerk bespreekt 12 projectmanagement thema’s, inclusief de verschillende activiteiten per thema die zouden moeten worden uitgevoerd. Er zijn vier circulaire cases onderzocht, die zijn geanalyseerd door 13 belanghebbenden te interviewen en projectdocumenten te onderzoeken. De geinterviewden zijn gevraagd naar de 12 PMBoK+ thema’s, om uit te zoeken of dezelfde thema’s zijn toegepast en op welke manier dit is gedaan. De mate van circulariteit van een project is verdeeld in twee categorieën: circulair product en proces. De vier cases betreffen allemaal circulaire gebouwen, beschreven met behulp van het 1OR-model. Het is onduidelijk of de projecten een traditioneel of circulair proces hebben gebruikt. De uitkomsten van de vier case studies worden vergeleken door middel van een cross-case analyse. De aanbevelingen en conclusies van het onderzoek worden gevalideerd met behulp van een panel van deskundigen. Op basis van de validatie en de resultaten van de cross-case analyse zijn de conclusies, discussies en aanbevelingen samengesteld.

Een onderscheid is gemaakt tussen circulaire bouwprojecten met publieke entiteiten als opdrachtgevers (projecten B en D) en experimentele circulaire bouwprojecten (projecten A en C). Voor openbare circulaire bouwprojecten wordt in project B en D traditioneel projectmanagement gebruikt, gebaseerd op het PMBoK+ kader. Voor experimentele constructies is dit anders. In projecten A en C zijn enkele wijzigingen doorgevoerd in de traditionele projectmanagement aanpak. De aanpassingen van het PMBoK+ framework zorgen ervoor dat de circulaire principes succesvol worden toegepast met het projectteam, wanneer het doel is om een circulair bouwproject uit te voeren. De conclusies van het onderzoek zullen kort worden besproken.

De vier projecten die zijn geanalyseerd zijn (deels) circulaire bouwprojecten. Voor project A en C zijn wijzigingen aangebracht op het PMBoK+ raamwerk. Deze wijzigingen zijn aangebracht op de volgende thema’s: scope, kosten, human resources, inkoop, integratie en financieel management. Voor de overige thema’s werden traditioneel projectmanagement toegepast.
De volgende conclusies leggen uit welke wijzigingen zouden moeten worden aangebracht aan traditioneel projectmanagement om experimentele circulaire bouwprojecten te realiseren. Om te beginnen moet het doel om een circulaire constructie te ontwikkelen een expliciet doel zijn bij de start van het project. Voor de scope moet de klant ambities definiëren (in plaats van gedetailleerde vereisten) en nadat het projectteam is geselecteerd, moeten de vereisten worden gedefinieerd. Voor projectkosten management moet het budget op een transparante manier toegankelijk worden gemaakt voor het projectteam. Het projectteam moet bestaan uit mensen met dezelfde circulaire economie inzet, visie en filosofie, als onderdeel van het Human Resource Management. De aanbesteding moet anders worden ingestoken dan traditioneel: plan het aanbestedingsproces vroeg in het project en betrek leveranciers vroeg in het project. Daarnaast moet de selectie van partijen zoals leveranciers en onderaannemers met het hele projectteam worden gedaan. Ten slotte moeten nieuwe contractvormen worden gebruikt om te voorkomen dat het gebouw wordt gesloopt na de levenscyclus. Voor Project Integration Management moet een niet-hierarchische en coöperatieve organisatiestructuur worden gebruikt waar projectkennis op een transparante manier wordt gedeeld. Ten slotte moeten voor Project Financieel Management de verantwoordelijkheden en risico’s transparant worden verdeeld over de betrokken partijen van het project.

Op basis van deze conclusies worden enkele aanbevelingen gedaan. In de eerste plaats wordt het aanbevolen om met het hele projectteam te bespreken wat circulariteit betekent en welke principes in het project zullen worden gebruikt. Door één duidelijke vertaling van de uitgangspunten voor het project te gebruiken worden misverstanden voorkomen. Daarnaast wordt aanbevolen om ervoor te zorgen dat het geïntegreerde projectteam dezelfde mindset heeft en dezelfde principes van de circulaire economie kent. Het is de verantwoordelijkheid van het hele team om te controleren of iedereen dezelfde toewijding heeft en zo niet, te handelen. Ten slotte moeten de betrokken partijen van tevoren weten wat de circulaire ambitie is van de opdrachtgever en wat de structuur van het projectteam is. Op die manier kunnen de teamleden hun eigen organisatie hierop voorbereiden en kunnen gefundeerde inschattingen worden gemaakt voor de kansen en de risico’s van het project. De volgende aanbevelingen zijn gericht op individuele projectpartijen. Voor hoofdaannemers wordt aanbevolen om het traditionele contract dat is opgesteld bij het werken met leveranciers van secundair materiaal te heroverwegen, zodat niet alle verantwoordelijkheden en risico’s voor de leverancier van secundair materiaal zijn. Opdrachtgevers moeten zich bewust zijn van het soort contracten dat ze aan gaan, welke gevolgen dit kan hebben voor de circulariteit van het project. Vervolgens wordt het voor projectmanagers aanbevolen om het type leiderschap te wijzigen. De projectmanager moet mensen verantwoordelijk maken voor het circulaire resultaat, in plaats van hen te vertellen wat ze moeten doen. Door eventuele problemen in teamwork op te lossen zullen meer creatieve oplossingen tot stand komen. Nieuwe vaardigheden zijn nodig om van een lineaire economie naar een circulaire economie te gaan, zo zal de focus meer moeten liggen op kritisch denken, creativiteit en verbindingen leggen.
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1. Introduction

The construction sector has been the world’s largest consumer of raw materials since years. Construction and building activities together account for 36% of global energy use and 39% of energy-related carbon dioxide (World Green Building Council, 2017). Construction and demolition waste are one of the most voluminous waste streams generated in Europe. It accounts for almost 30% of all waste generated in the European Union (European Commission, 2018). Although buildings are more and more constructed with sustainable features and components, improvements are still not keeping up with the growing built environment and rising demand for energy services (World Green Building Council, 2017).

In 2017, the building and construction sector accounted for 36% of global final energy use and 39% of energy-related carbon dioxide (CO2) emissions (World Green Building Council, 2017). It is generally accepted that something needs to change in the built environment. Together we need to tackle climate change and drive sustainable development. The Paris Agreement is one of the most important international agreements which aims at reducing global warming. Deployment of energy-efficient and low-carbon solutions for buildings and constructions can put the world on a sustainable trajectory (World Green Building Council, 2017). The Paris Agreement brings nations (195 countries) together for the first time into a common cause: combat climate change and adapt to its effects. The aim of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping a global temperature rise in the coming 80 years below 2 degrees Celsius (United Nations Climate Change, 2018).

Most countries are working on their own arrangements to meet the Paris Agreement targets, including the Netherlands. The Dutch government has expressed the aim to decrease 49% of carbon dioxide emissions by 2030 in comparison to 1990. To achieve this goal, the government has set up arrangements with different parties and drafted new policies. In June 2018 a bill has been adopted with plans to decrease 95% of the greenhouse gas emissions by 2050 (Rijksoverheid, 2018). The new laws aim at providing citizens and businesses clarity about the climate goals. The Dutch Climate Agreement (Klimaatakkoord), drafted in 2013 and agreed by the government in 2019, contains agreements with different sectors about how these climate goals should be achieved. The Klimaatakkoord was published on the 28th of June 2019 and the implementation just started. The figure below (Figure 1) shows the agreements made, Dutch agreements as well as international agreements. One of the options to mitigate or limit climate change is by introducing the circular economy. In 2050 the Netherlands needs to have a circular economy, according to the Dutch government (Rijksoverheid, 2016). A lot of definitions of circular economy exist, with different interpretations. The definition by the Ellen MacArthur Foundation (2015) will be used from this point on: A circular economy is an economic and industrial system where material loops are closed and slowed and value creation is aimed for at every chain in the system. Circular economy requires a re-thinking process: looking beyond the ‘take-make-waste’ extractive industrial model and working towards a circular economy with redefined growth while focusing on positive society-wide benefits.

Figure 1 Dutch and International agreements regarding sustainability and circularity (own work)
The circular economy, for which the Ellen MacArthur Foundation is one of the leading parties, is based on three principles: design out waste and pollution, keep products and materials in use and regenerate natural systems. According to the Foundation, circular economy represents a shift that creates long time resilience, generates business and economic opportunities and provides environmental and societal benefits (Ellen MacArthur Foundation, 2015). Circular economy is a hot topic on the political agenda, particularly in Europe. Circular economy is expected to promote economic growth by creating new businesses and job opportunities, saving money on materials, diminish price volatility, improving security of supply while reducing environmental burden and impacts (Kalmykova, Sadagopan, & Rosado, 2018).

The built environment puts major pressure on the natural environment and a change in the construction sector is crucial. Circular economy can be applied to the built environment as well. European politics are not focused on circular economy in the built environment (yet), however, it offers an opportunity to accomplish the agreements and deadlines (shown in Figure 1). Furthermore, the Ellen MacArthur Foundation calculated that 300 billion pounds from primary resource benefits (including energy) could be saved by applying circular thinking to the European built environment (Ellen MacArthur Foundation, 2015).

The large impact of the built environment on the environment offers significant opportunities to reduce the greenhouse gas emissions, energy use and waste production. Buildings are very complex projects, as buildings are unique entities constructed with materials that each have a specific life cycle. These materials all interact dynamically in space and time. The uncertainty on the life-cycles of buildings is increased due to their long lifespan and the changes of use during the service life (Pomponi & Moncaster, 2016). Still, circular economy in the built environment is predicted to bring economic benefits such as the increase of gross domestic product, net material savings, employment growth and reduced risk of material price volatility and supply. Business may benefit from it as well: higher competitiveness, resource security, flexibility and different business models enabling value creation (Tebatt Adams, Osmani, Thorpe, & Thornback, 2017). However, the knowledge and tools for bringing circular economy into practice still need to be developed. This especially holds for the building sector where innovation diffuses slowly (Leising, Quist, & Bocken, 2017).

A circular building process is assumed to be a different process compared to a traditional building process. The circular ambitions need to be formulated beforehand, the parties need to be searched that are willing to work on a circular project and the circular elements (such as materials) need to be found. This all takes much time at the start of a project. The way of thinking changes too, according to researchers of Arup. The stakeholders need to be taught to think in a way that considers the entire life cycle of the asset, from the construction to how it can be disassembled and how the components can be reused (Zimmann, O’Brien, Hargrave, & Morrell, 2016). Where linear projects are executed according to ‘take-make-dispose’ plan, circular projects work conform a ‘reduce, reuse, recycle’ plan (van Reijn, personal communication, 2019).

The root causes of the large environmental problems that the construction industry causes can be traced back to the way in which construction projects are managed (Berg, 2019). Different project management tools and methodologies exist such as PMBoK, PRINCE2, projectmatig werken, Agile and Scrum. Some methodologies define principles or themes, while others define processes and standards (Aston, 2017). What methodology is best suited for circular construction projects has not been investigated so far. This research aims to find out what changes must be made to traditional project management, to deliver circular construction projects.

1.1 Problem description

Even though circularity seems a promising solution, some difficulties appear during the implementation. These difficulties are expected to be related to the process and to a lesser extent to the technicalities (Gerding, 2019). Adams, Osmani, Thorpe and Thornback (2017) analyzed the challenges and barriers of the implementation of circular economy into the built environment. The challenges are related to the change in organization of the building process. The most important identified barriers are the lack of knowledge and awareness of circular building processes of designers and clients, the fragmented supply chain and the lack of incentives at the start and end phase of the buildings life cycle. The biggest challenges on the part of the client for adopting circularity in the built environment is the unclear financial case. Cost and profit was seen to be the dominant factor in any decision-making process (Tebatt Adams, Osmani, Thorpe, & Thornback, 2017). It is noticed that limited research is done on the implementation of the circular way of thinking in construction projects.
Research by Arup and the Foundation suggests the greatest opportunities are realized when a circular economy way of thinking is applied to strategic decision-making (Acharya, Boyd, & Finch, 2018). However, many stakeholders find it hard to realize circular buildings. Most of the stakeholders interviewed in the report, said the barriers for moving towards circular buildings are caused by the fragmented nature of the sector. This fragmentation prevents the development of circular buildings because it separates decision-makers from the long-term consequences of their decisions: these are called split incentive problems. Therefore, the research suggests that there is a need for an increase of knowledge throughout the industry which focuses on the steps that are necessary to make the transition in the long-term (Acharya, Boyd, & Finch, 2018).

No analysis on the available circular economy implementation strategies or the experiences with implementing circular economy in the built environment has been developed so far (Kalmykova, Sadagopan, & Rosado, 2018). Marc van den Berg, assistant professor at TU Twente, concluded that it is unclear how the circular economy could be implemented to manage construction projects (Berg, 2019). Awareness of circular economy applied to the built environment is growing. However, the existing frameworks and tools offer principles and philosophies, which do not demonstrate or explain how stakeholders in the built environment can change the ways to finance, develop, procure, design, construct, operate, maintain or repurpose services or assets. There is a need to translate these principles into workable practices in the construction sector (Acharya, Boyd, & Finch, 2018).

The practice shows similarities and differences compared to research. According to Thomas van Schaick, senior project manager at Arup, sustainable and circular ambitions are more and more prominent on the clients’ agenda. However, until now no client has made it an objective to complete a 100% circular project, in projects where Arup was involved. A few (construction) clients appoint a circular advisor to identify if certain aspects during the process can become circular. These aspects should go hand in hand with functionality, technicality etc., which can be a large challenge (van Schaick, personal communication, 2019). At this moment, clients balance the projects around three aspects: quality, cost and time. Sustainability or circularity is considered an extra, an improvement in quality more than a necessity in the ambitions. The decision-making on the three aspects (quality, cost and time) are weighed on the consequences on the process, based on the risks. Unnecessary risks are never taken. Introducing high level circular objectives into a project has a high-risk impact on the project compared to projects based on traditional practice. This can lead to a necessary change in project management (van Schaick, personal communication, 2019).

Thus, one of the largest problems is that there is no knowledge on the circular economy implementation strategies or the experiences with implementing circular economy in the built environment, so far. A circular building is often perceived as a high-risk project. Because of the lack of knowledge in workable practices, the re-thinking process into a circular built environment is not yet made by all construction parties.

At this moment, circularity is perceived as overly ambitious. Many people see the circular economy as a transition. A large number of parties all over the world have high ambitions, conferences and meetings are organized to discuss different circularity aspects and organizations try to incorporate these ambitions in projects. However, to complete the transition, actionable strategies and guides are needed to help stakeholders in the built environment to start making changes. Guides are necessary containing lists of actions and processes that companies can use to make the transition towards the circular economy. These guides should be open to everyone to make the transition actionable and accessible for all (Mendiluce, Edgerton, & Giotto, 2017). To obtain the structural change in the system, it is important to translate circularity into project plans. Practice shows that client ambitions are too volatile. The entire building process is based on traditional values and methods. Combining these methods with circular ambitions may give conflicts (van den Nouland, personal communication, 2019). In this research, Dutch circular construction projects will be analyzed to come with actionable and practical recommendations for the future stakeholders of circular constructions.
2. Research objective

Before drafting the research questions, six preliminary interviews were performed to find out what the current situation is for the circular economy in the built environment. The exploratory interview design, interview summaries and most important conclusions are displayed in appendix A. The aim is to find out what the trends are, which stakeholders play an important role and what barriers are perceived which delay the transition towards a circular economy. By merging the results from these interviews and comparing them to literature, a sketch of the current situation is made to further develop, design and strengthen the research. The current situation is defined to make sure the thesis is relevant for the current problems, developments and trends.

Following the introduction, the problem description and the exploratory interviews concerning the current situation, the research objective is described in this chapter.

The objective of this research is to find out what changes must be made to traditional project management, to deliver circular construction projects. This is done by first describing the difference in practice, in project management between traditional construction projects and circular construction projects. Furthermore, the aim of this research is to help clients to control and implement the circular ambitions during the project. This research is vital due to the enormous challenge and uncertainty the circular economy brings to the build environment. Therefore, the objective is to provide actionable knowledge and to advice the project teams on how to manage circular construction projects in the future.

2.1 Research question

To meet the objective, the following research question is formulated:

*What changes must be made to the management of projects, compared to traditional project management, to deliver circular construction projects?*

This research question will be answered with the help of the following sub-questions:

1. *How is circular economy used in the built environment?*
2. *What is traditional project management?*
3. *Is there a difference in management between traditional construction projects and circular construction projects?*
4. *Do these differences warrant a need for change in project management?*

2.2 Scope

The research question includes terms that need definitions and clarification. The research will focus on buildings that are circular. The buildings have been evaluated on their degree of circularity by using the 10R-model by Cramer. The model describes the 10 steps of circularity (Cramer, 2017). The following 10 layers are described, from high degree of circularity to low degree of circularity: Refuse, Rethink, Reduce, Re-Use, Repair, Refurbish, Remanufacture, Repurpose, Recycle and Recover (van der Weerd & Levels-Vermeer, 2018). For the cases that will be analyzed, the different steps of the model used for each case are described.

Additionally, it is decided to only investigate circular construction projects in practice, as case studies. Traditional projects will not be analyzed in practice, since much research is done about this in the past years. It would be redundant to analyze in practice how traditional project management works, since this knowledge exists in literature. For that reason, the second sub-question (“What is traditional project management?”) will be answered with the help of a literature study.

Furthermore, the research will only focus on the project management steps that are taken and will not look at process management. Process management is about managing procedures during the project (Meisel, 2019). It is about initiating and organizing cooperation in uncertain situations to initiate a project or to realign the project to the changed conditions (Leijten, 2018). Process related subjects such as project phases, decision-making and the network approach will not be discussed in this research.
Finally, project management is done for many years and many research is done to investigate it. However, in practice, due to the large complexity, many projects are still not delivered successfully. Often projects are over time and/or over budget. This research does not aim at providing the perfect model to successfully complete circular construction projects. Yet, it aspires to provide some actionable and workable recommendations which can help project teams in the future.

2.3 Research approach

To answer the research questions, a qualitative research will be performed. Qualitative research helps to create in-depth understanding of social phenomena by focusing on the ‘why’ question (rather than on the ‘what’) (Pathak, Jena, & Kalra, 2013). It is suitable whenever there is a lack of empirical evidence or knowledge (Fellows & Liu, 2015). Several methods will be used to answer the five questions. The methods that will be used are literature study and case study research. The figure below shows the steps that will be undertaken during the research (Figure 2).

After completing the literature review, theoretical background is available on traditional project management. The theoretical framework that will be used to analyze the cases will be composed by analyzing project management methods. Three methods are investigated to define what traditional project management is. With the help of the theoretical framework, the interview protocol and case study framework are made which will be used during the case study research. During the case study research, interviews will be held with key stakeholders of the construction projects. With the data that is gathered, a cross-case analysis will be done to analyze the project management themes that emerge from the projects. The results will be validated with the help of experts. Experts from NEN, the Circle Economy and Arup are asked to assess the results and recommendations. In the end, conclusions will be drawn and recommendations will be made for practice and for further research.

Figure 2 Research approach (own work)
3. Literature review

In this chapter the literature review of the research is presented. The aim of a literature research is to assess the knowledge gap between the circular economy and construction project management and to define the literature framework. First the circular economy is explained. The interpretation of circular economy in the built environment is discussed in 3.1. Chapter 3.2 discusses the linear economy in the built environment. To ensure a successful delivery of a project, project management strategies have been developed. The three widely used methods in construction practice, PRINCE2, projectmatig werken and PMBoK, will be elaborated on. The three methods are discussed in chapter 3.4. Finally, a summary is given of the literature review, the three methodologies are compared and the literature framework is presented in the final chapter.

3.1 Circular economy

The circular economy is based on a paradigm shift: from a linear ‘take-make-dispose’ model (which generates a significant amount of waste) to a new model that scrutinizes the role of value conservation and resource efficiency for economies and the environments (Velte & Steinhilper, 2016). For this research one definition of the circular economy will be handled. As mentioned in the introduction, the following definition of a circular economy is used in this research (Ellen MacArthur Foundation, 2015):

‘A circular economy is an economic and industrial system where material loops are closed and slowed and value creation is aimed for at every chain in the system’

The circular economy contains seven pillars. The pillars are listed below (Gladek, 2017):

1. Materials are used in the economy in such a way that they can be recycled at a repeated high value;
2. All energy is based on renewable sources;
3. Water is managed 100% circularly;
4. Biodiversity is fundamentally supported and enhanced;
5. Culture and human society are preserved;
6. Health and wellbeing of humans (and other species) are always supported;
7. Human activities generate value, not only financial value.

In short, renewable materials are always used when possible, all energy is based on renewable sources, natural systems are sustained and augmented when possible and waste and negative impacts are designed out (Acharya, Boyd, & Finch, 2018).

3.1.1 Circular economy in the built environment

As was explained in the introduction, current building practices are insufficiently future proof. The construction industry is worldwide the biggest user of raw materials. The impact of the construction industry on people and the environment is very high. The demand for raw materials and building materials is increasing over time. Because of this, materials are becoming scarcer and therefore material prices become more volatile and more expensive. The current building practices have the effect that the materials are inevitably ‘gone for good’. Given the limited resources, something needs to change at this moment. Circular economy in the built environment is a way to decrease material depletion and reuse materials to decrease waste (Circle Economy, 2017).

For a construction to be circular, all materials (including raw materials) and products are used to deliver value before, during and after use, when creating different life cycles. When virgin raw materials are needed (because no reused materials are available) they must be bio-based (such as wood, hemp and flax). There needs to be a focus on materials that originate in natural cycles or come directly from reuse of complete construction elements or come from recycling materials with high value. The use of materials with toxic substances or non-recyclable materials is avoided. During the design phase, an analysis should be made on how materials can benefit the indoor living environment and how materials can create a positive impact on the indoor climate. This can lead to lower energy consumption and increase the health and safety of the occupants of the building. Knowledge obtained in this design phase is used in the operational phase and the end-of-use phase (Circle Economy, 2017).
At this moment there is a large circularity gap since only 9.1% of the world economy is circular. Closing that gap will not only imply reducing material input by more recycling but will also be about optimizing and extending the lifetime of buildings that are already built (Thelen, et al., 2018).

In more practical terms, Arup in collaboration with the Ellen MacArthur Foundation defined in a study which circular economy principles should be embedded across all its functions in the built environment. The first is support human well-being and natural systems, this should be achieved to improve human living standards and health & wellbeing. Next, decisions in the built environment must be guided by data driven and feedback giving models, to achieve guided systems thinking. Thirdly, developments should be leveraged by digital technology. Besides, the design of space should support resilient and thriving communities to come to holistic urban planning. Buildings should be designed for maintenance, repair, reuse and in the end deconstruction. Buildings should meet their water and energy needs while reducing waste generation. This can be done with circular products, to come to flexible productive buildings. Finally, integrated systems should be made for energy, water and waste to make integrated infrastructure systems (Acharya, Boyd, & Finch, 2018).

There are some barriers for the transition towards a circular built environment. Research by the organization Circle Economy identified five large barriers for the circular economy. The first one is culture and beliefs, which includes company culture and personal beliefs. These two elements decide on the speed of the transition. This can become a barrier when organizations or people are unconvincing or uninformed. The second (potential) barrier is regulations. Regulations and legislation are important drivers for the economy. Because legislation usually follows public opinion, regulations may not account for a fast growing, worldwide trend like circular economy. This could for example cause delays in obtaining permits. The third barrier is the market. Related to market, some of the barriers could be limited subsidies or market incentives for reused materials or lack of market volume or economies of scale for circular products. Next, technology is an important barrier. The transition requires innovation to address technical challenges. Developing new technologies will cost time and money and for that reason need a clear business case. The final barrier mentioned in the report is education and information. Education and information about the circular environment is needed to align and connect the value chain. Limited information sharing is a barrier for acceleration and scaling of the circular built environment (Thelen, et al., 2018). Besides these barriers, research showed that diffusion of responsibility makes it difficult to implement circular economy in existing supply chains (Schraven, Bukvić, Di Maio, & Hertogh, 2019).

Key themes to combat common barriers and to facilitate the transition to a circular built environment are explained below. The first is collaboration. Due to the fragmentation of the construction industry, circular approaches are not widespread in the built environment. Following from this, implementation of circular buildings is blocked by the separation of decision-makers from the long-term consequences of the decisions, called the split incentive problem. By collaboration between organizations, trust can be built which can increase engagements between the supply chain partners of the process (Acharya, Boyd, & Finch, 2018).

Secondly, the use of knowledge. The report concluded that stakeholders in the value chain are unfamiliar with how the circular economy principles could work in the built environment. There is a need for sharing of knowledge in the industry because of the new developments resulting from circularity. Thirdly, a policy environment needs to be created that incentivizes and facilitates circular behavior. Next, leadership is important during a transition; the first movers explore the field and the large group will follow. Lastly, finance can be an enabler of change in the built environment. However, the investment opportunities will have to prove to be profitable (Acharya, Boyd, & Finch, 2018). Besides, obligatory outside influence can give incentives to change. This should be done to counteract the diffusion of responsibility, which is stalling the transition because supply chains are voluntarily changing (Schraven, Bukvić, Di Maio, & Hertogh, 2019).
3.1.2 Circular building
In this analysis the following definition of a circular building is used. This definition is from Kubbinga et al. (2018, p. 7):

‘A building that is developed, used and reused without unnecessary resource depletion, environmental pollution and ecosystem degradation. It is constructed in an economically responsible way and contributes to the wellbeing of people and biosphere. Here and there, now and later. Technical elements are demountable and reusable, and biological elements can also be brought back into the biological cycle’

In other words, in a circular building, each stage of the life cycle should be a continuous closed loop where resources are not lost or wasted (World Green Building Council, 2016). This is done by approaching construction material flows not as waste but as high-quality components, which can be used for new applications. This can be achieved by recycling construction waste, intensifying efforts in maintenance and to extend the life cycle of materials and structures. Operationalizing is within reach, since the construction chain largely takes places within the Netherlands (Vos-Effting, 2018). Important is to keep products, materials and components at the highest value. One of the large barriers is that companies are more focused on how to transport and process old materials from buildings as effectively as possible, instead of how to reuse them. Even though companies are obliged to separate different material flows. This requires the redesign of waste management (Vos-Effting, 2018).

3.1.3 Circular strategies
In the built environment, the most often used strategy is the ReSOLVE framework. This framework was introduced by the Ellen MacArthur Foundation, McKinsey & Co and SUN. The framework shows six different ways how organizations and governments can apply circularity: Regenerate, Share, Optimize, Loop, Virtualize and Exchange. The different elements will briefly be described. The first one is regenerate; this element proposes to regenerate and restore natural capital. In the built environment this can be done by using renewable energy to power buildings, land restoration, resource recovery and renewable production systems such as biogas production. Secondly, the next element is share. By sharing, product utilization is maximized. In the built environment this can be done by residential and infrastructure sharing, appliances and tools sharing, office sharing and water consumption sharing. The third strategy is optimize. The system performance can be optimized by for example lengthening products’ use period or decreasing resource usage. In the built environment, methods used to achieve this are off-site production (prefabrication), smart urban design, energy efficiency optimization, water and material efficiency and reduction in transport. For a construction to be circular, the life cycles of products and materials should be in cycles. In the construction sector this can be done by: optimization of end-of-life of the building/materials, modularity of the building and remanufacturing of materials. Virtualize is done by displacing resource use and delivering utility virtually. In the built environment this can be achieved by teleworking, virtualization of products, virtualization of processes (such as BIM) and smart appliances. The last element is exchange and can be implemented by selecting resources and technologies wisely. In the built environment this can be achieved by using better performing materials, better-performing technologies and new products and services (Ellen MacArthur Foundation, 2016).

3.2 Linear economy in the built environment
In the linear built environment, it is assumed that there is no limit on the availability of resources. Finite primary or non-renewable resources are extracted from nature and used in the built environment as building materials (Ellen MacArthur Foundation, 2013). The materials are used in buildings and after the functional life time expired, the building is demolished. In a linear economy, ownership of a building is transferred from one entity to another. New owners of the buildings take over the responsibility for future social, economic and environmental impacts of the building (Thelen, et al., 2018).
3.2.1 Construction sector supply chain

The transition towards a circular economy requires a different construction sector supply chain. In the current linear built environment, the stakeholder loop in the figure below shows the stakeholders active in the built environment (Figure 3). These stakeholders and their roles will change during the transition (Thelen, et al., 2018).

One of the roles that will change is the role of secondary material suppliers. Urban mining is a new approach for circular constructions that evaluates the value and opportunity for the reuse of materials embedded in so called donor buildings. Ideally, the materials and products are mapped to connect future building needs with the materials in the donor buildings, to make logistical supply chains. In the end, the demand and supply of the material streams need to be connected to ensure qualitative reuse (Blok, 2018). New initiatives are appearing more and more. For example, New Horizon is a well established secondary material supplier and Oogstkaart is a marketplace where supply and demand of secondary products are connected. The construction industry needs to adjust to start working with these types of initiatives.

Secondly, demolition companies are going to play a larger role in the future. This will start at the design phase. To start with, the architect will need to know how the demolition contractor works before designing. Following, the recycling company needs to know what technical requirements the materials have that the constructor uses, to know what recycling technology can be used at the end of the building life cycle. The contractor needs to make sure that the information about the materials is available for the construction client and it is important to ensure that the demolition contractor (maybe a 100 years later) can access that information. At first, a circular construction seems a design and technical challenge, but the even larger challenge is cooperation, transparency and the sharing of knowledge (Schut, Crielaard, & Mesman, 2015).

The construction industry supply chain has some differences compared to other supply chains. To start with, the products that are manufactured are one-of-a-kind. Every construction is different. Secondly, the organizations that are composed for projects are temporary. Consortia with different parties are set up for projects and when the projects are finished, the organizations each go their own way. Last, the supply chain needs to do production on site. Because of this, less attainment of efficient flows (as done in manufacturing) can be achieved (Segerstedt & Olofsson, 2010). These characteristics need to be considered while making the changes for circular constructions.

Figure 3 Key stakeholder loop construction (Thelen, et al., 2018)
3.3 Traditional project management
A project is a temporary endeavor undertaken to create a unique product or service. It has a single and definable goal, which has well-defined end-terms and deliverables. To achieve the goal, the use of resources and coordination is necessary. The project is temporary because it has a definite beginning and end. Project management is the application of knowledge, tools and skills to achieve project requirements (Kerzner, 2017). The tools are used to direct the use of resources in an effective and efficient way to achieve a complex, unique, one-time task within cost, time and quality constraints (Atkinson, 1999). This all should be done within the requirements of the client, which will be different for each client (Kerzner, 2017).

3.3.1 Traditional construction project management
The definition of construction project management is very similar to the definition of project management in general. Walker described construction project management as the following (Walker, 2015, p. 11):

‘The planning, coordination, and control of a project from conception to completion (including commissioning) on behalf of a client, requiring the identification of a client’s objectives in terms of utility, function, quality, time and cost; the establishment of relationships between resources; integrating, monitoring and controlling the contributors to the project and their output; and evaluating and selecting alternatives in pursuit of the client’s satisfaction with the project outcome’

The construction industry is dynamic because of the increasing uncertainties in budget, technologies and development processes (Chan, Scott, & Chan, 2004). Large construction projects could therefore be very risky. A few of the common causes for these risks are the following: changes in scope and the aim of the project, weak project definition and unclear requirements, interfering government and stakeholders, weak contracts, management problems and large uncertainties (Verbraeck, 2018). Moreover, construction projects require the integration of multiple engineering disciplines, such as structural, civil, geochemical, electrical, fire-safety and mechanical. This contributes to more interaction with technology, which demands unique methods and construction techniques (Project Management Institute, 2016).

Project management success is traditionally associated with the ability to deliver scope, cost, quality and time. This is called the iron triangle and is shown in the figure below (Figure 4). A project manager is asked to reach a trade-off in the different constraints (Caccamese & Bragantini, 2012). The four constraints are briefly discussed below.

3.3.2 Scope
The scope is a detailed set of deliverables of a project. The deliverables derive from the client’s requirements. The scope is a clear identification of the required work to complete a project successfully (Monnappa, 2019). The book by the Project Management Institute defines scope as the work that needs to be completed to deliver the product, result or service including the specified functions and features (2017). To divide the scope in deliverables, a Work Breakdown Structure (WBS) is created, which is a hierarchical structure of tasks. By creating this, uncertainty is reduced (small parts are easier to oversee and manage) and complexity is reduced (small parts are easier to understand). A WBS goes as fur until a work task is completed. A WBS can contain different aspects such as engineering, systems, management, facilities and preparing operations (Verbraeck, 2018).
3.3.3 Time
Another project aim is on-time project delivery. A technique often used to manage time is the Critical Path Method (PERT or CPM). Large projects are broken down into several smaller projects. The precedence-relationships (of the work breakdown structure) can be visualized in a network diagram (Babu & Suresh, 1996). The activities are added into a system including earliest start time, latest start time, duration and total float. The CPM determines the minimum time necessary to complete the project. Milestones indicate major events in projects, often these are associated with deliverables. Later, staff is allocated to the work packages. The person allocated is responsible to do the work that is defined by the work package. However, there are some issues with the Critical Path Method, such as: uncertainty of estimations and safety margins of estimations. Estimations can result in wishful thinking and optimism bias (Verbraeck, 2018).

3.3.4 Cost
Managing the project costs is a very important activity. Large construction projects are often over budget. Some of the reasons for this are: underestimation of costs (by lack of experience or by strategically try to win a contract), unclear and inaccurate requirements and change of requirements during project execution. To overcome these risks it is very important to consider change of requirements, prepare a good definition of tasks, involve experienced (cost) managers in the cost estimation and consider a plan for risks and contingencies. The project cost estimation is executed during the project planning phase, in the form of a budget. Cost estimations at an early project stage are proven to be a powerful method to decrease cost overruns (Doloi, 2013).

3.3.5 Quality
Nowadays very competitive market exist where companies compete on price, quality and customer service. The acquirement of adequate levels of quality has been a long-term problem in the construction sector (Mallawaarachchi & Senaratne, 2015). The initial price is a short-term consideration, quality and service determine the long-term success of a product. Quality can be translated to fitness for purpose, which means meeting the client’s requirements. However, this shows some problems: customer requirements must be agreed in a formal way before project start, end-users may not be able to define their needs in exact terms and requirements might change. For that reason, delivering quality is the balance between fixed requirements and dynamic requirements. Quality managements consist of two parts: produce the correct result (quality of the product) and produce it in a correct way (quality of the process) (Verbraeck, 2018).

The figure below (Figure 5) shows the iron triangle with the external relations made by Verbraeck (2018). These external relations such as stakeholders, risks and the environment, influence the project. This influence can be positive as well as negative. These elements should be considered during the management of a construction project. The input for the project is the project goal defined by the client. Based on the goal of the client, the scope and requirements are defined. The requirements influence the organizational structure of the project team, quality that should be obtained and the planning. The project cost is based on these three decisions (Verbraeck, 2018).
3.3.6 Traditional project management methods
The objective of project management is to ensure the goal of the client is accomplished. The role of the project manager is to ensure that the project organization works to achieve the client objectives. The approach to achieve this is to first identify the process to be undertaken to achieve the objectives of the clients, the conditions under which the process should be carried out and the resources available. This analysis results in an organization structure that should be designed for each project. The nature of the project establishes the roles of the parties involved in the project. The project manager’s goal is to resolve conflicts during the process in the interest of the client (Walker, 2015). The project management process often begins with the identification of the requirements of the user, the constraints of the project, the resources needed and the establishment of objectives to meet the goals. This could be an interactive process since new information can become available along the process with input from involved parties, communities, agencies and users (Shadan & Fleming, 2012).

3.3.7 Project management methods comparison
To study what traditional project management is, three well-known methods in the construction industry will be compared. As described by de Jong (2018), PRINCE2 and projectmatig werken are often used methods in construction projects (Jong, 2018). Moreover, PMBoK is another common method to manage construction projects. Based on the research of de Jong, the researcher presumed one of the three methods is used in the cases that will be analyzed and the comparison can be made between the theory and practice. The following methods will be discussed in the next paragraphs: Project Management body of Knowledge (PMBoK), projectmatig werken and PRINCE2. PMBoK defines processes as well as standards. PRINCE2 defines a full methodology framework of principles, themes and processes (Aston, 2017). Projectmatig werken defines themes as well as processes.

3.3.7.1 Project Management Body of Knowledge
The book ‘Project Management Body of Knowledge’ by the Project Management Institute (2017) describes the Project Management activities in detail. The method ensures a set of knowledge principles in project management. The PMBoK is a framework of nine knowledge areas broken down across five stages (Matos & Lopes, 2013). The PMBoK includes proven traditional practices that are applied largely all over the world (Rouse, 2019). PMBoK consist of a knowledge collection of “Best Practices”, techniques and instruments to manage the project. It does not prescribe methods or techniques. Therefore, PMBoK is officially not a method but a framework (Grit, 2015).
The ten management themes of the PMBoK framework are shown in the figure below (theme 1 to 10). Furthermore, the book Construction Extensions to the PMBoK Guide by the Project Management Institute adds two knowledge areas to the ones mentioned above. These are Project Health, Safety, Security and Environmental management (HSSE) and Project Financial Management (Project Management Institute, 2016). PMBoK framework with the extension of Project Health, Safety, Security and Environmental Management and Project Financial Management is from now on called the PMBoK+ framework. More detailed information, including the explanation for each theme, is described in appendix B.1.

**Figure 6 PMBoK+ framework (own summary)**

### 3.3.7.2 Projectmatig werken

Projectmatig werken defines management aspects to delineate when a project is considered successful. The project leader should know on what factors to focus to make sure the project is delivered successfully. Primary management aspects are factors on which the project can be evaluated. These are: budget, scope, quality and time. Secondary aspects are factors on which the project needs to be controlled but are not evaluation criteria. These aspects are goals, organisation, environment and risks. More information about projectmatig werken is documented in appendix B.2.

Other sources state that there are five important management aspects. These are: time, money, quality, information and organization. Compared to the theory by Schouten, environment, risks, scope and goal are missing. The project manager should make sure the result is of sufficient quality. To make sure the entire project team knows what he or she needs to do, the information needs to always be correct. The client needs to receive correct information about the progress. The project leader is responsible for the organization of the project. That concerns internal and external collaboration, decision making and appointing responsibilities and the organizations of meetings (Grit, 2015). The method emphasizes the management of time, money, quality, information and organization, during all phases. It is customary to take decisions during the transition to the next phase. There are no present rules for leading the project, however, collaboration is highlighted (Grit, 2015). Figure 7 shows the management aspects of the method.
PRINCE2, Projects IN Controlled Environments, is a method for project management. It separates the management layer from the work, to achieve the required product the project needs to produce (Turley, 2010). The framework of PRINCE2 increases the likelihood of project success. PRINCE2 cannot be applied when situations take place which are business as usual. For that reason, the project needs to have the following characteristics: change needs to occur during the project, the project is temporary, the project is cross-functional (involved collection of people from different departments/organizations) and the project work is unique. This all increases the uncertainty of the project, where unforeseen threats can occur. This brings more risks to the project (Hinde, 2017).

Project management is described in the four main areas: plan, delegate, monitor and control. The first area is to plan what needs to be made and how this will be made. Next, delegation makes sure that the right work is done by the right people at the right time. To ensure all the delegated work is completed on time and to plan, the project managers need to monitor project work. In the end, the project manager exerts control over the project.

Control ensures that the correct activities occur at the right time to create the correct products. It is also about acting when it looks like the project is going off course (Hinde, 2017). More information about PRINCE2 is documented in appendix B.3. PRINCE2 is usually used in projects of large organizations. The method divides the project into different phases. After each phase, the project team checks whether the original project goal is going to be achieved and the project leader and client decide on the further steps that need to be taken. To make the decisions checklists and directives exist to assist in making the decisions (Grit, 2015).

PRINCE2 management, consist of the following seven elements: Business Case, Organization, Quality, Plans, Risk, Change and Progress. The elements are shown in the figure below (Figure 8) and described in appendix B.3.

3.4 Project management of circular projects

The amount of research done on project management of circular building projects is limited. Marieke Venselaar, a researcher from the TU Delft, is currently analyzing the management processes of circular projects. The study examines work floor experiences of project managers engaged in building projects. The research addresses the question on how to manage projects in the circular economy. Venselaar noticed that the construction sector lacks in the consistency of approach needed to make substantive changes. Therefore, three conclusions were made. First, the project manager must be able to bring expertise from elsewhere in the project. Second, the project manager must be granted room to explore and experiment, to be able to develop new capabilities for circular projects. Third, the project manager needs to encourage learning that forces the factors of time, cost and quality. This all leads to the conclusion that in the two cases investigated, the circular ambition was an extra ambition that is used within the same manner of thinking about project management, instead of making changes in project management (Venselaar, 2019). Venselaar’s study investigates the activities done in the different project phases while the current research will focus on the key project management themes.
Another research in 2017, by Leising, Quist and Bocken focuses on the collaboration tool for developing and operating circular buildings and the supply chain collaborations. The research studies buildings blocks: vision, actor learning, business model innovation and network dynamics. Three cases have been analyzed based on the conceptual framework. The research concludes that circular economy in the supply chain starts with vision development. The cases show that clients have a key role in defining the project requirements. Furthermore, higher order learning is concluded to be essential to use new collaborative approaches. New types of sustainable business models can be enablers for the implementation of a new circular approach for supply chain collaborations (Leising, Quist, & Bocken, 2017).

Finally, Marc van den Berg just finished his doctorate dissertation, which is aimed at developing actionable knowledge on the management of circular building projects. Exploring how information can be used to reduce, recycle or reuse building materials leads to this result. The research is focused on the use of information by the project manager and demolition manager. The subjects are divided in two perspectives: demolition management perspective and design management perspective. The research concludes that demolition managers can empower closed-loop material streams by leveraging the information potentials of later and previous design stages. The managers need to influence the potential of both sorts of design information to close the material loops. Regarding the second part, it is the same for the design manager. Material reduce, reuse and recycle activities can be managed by influencing information potentials during the demolition and design of the project. This research looks at project management as the challenge to efficiently organizing information (Berg, 2019). This is different to the current research. In this research project management is seen as the full spectrum of themes and activities, from communication (where information plays a very small role), to procurement and costs. The research by van den Berg, describes that project managers use information to initiate and manage material streams and every chapter of the research focuses on the management task that is necessary to manage the material strategy. For example, BIM plays a large role in his dissertation (Berg, 2019). In the current research, material strategies and the use of material loops are not evaluated. The research looked at the general term project management instead of at the technical aspects of a building such as material streams.

Information is part of the Project Communication Management theme in the PMBoK framework, called the 'Distribute Information' activity. This is not about the materials but about the communication of project information to internal and external parties. Secondly, it is also a part of the Projectmatig werken strategy. Here they explain that information should be exchanged between stakeholders. This is also about project related information.

3.5 Literature review summary

The framework PMBoK+ and methodology PRINCE2 show a set of project management themes, which should be first tailored to fit the environment and the project. PMBoK+ does not intend to prescribe people what techniques or tools to use. It lays out the processes, which they link to the tools and techniques that can be used. One of the large differences between the two is that PMBoK+ describes a project as a temporary endeavor which is undertaken to create a project, service or result. In PRINCE2, the project is seen as a management environment which is created to deliver one or more products according to a business case. The methodology is also different between the two methods. PMBoK+ can be considered a descriptive methodology, with explanation of the techniques for project management. On the other hand, PRINCE2 details how the tools and techniques should be structured and implemented. Next, PMBoK+ is more oriented towards the processes of the development of projects while PRINCE2 focuses on the final product and the successful delivery and quality (Matos & Lopes, 2013). Projectmatig werken is a method which shows similar elements to the previously discussed methods. However, it is somewhat more simplistic compared to the other two. Little literature and books are available about the method and the method is only used in the Netherlands.

3.6 Literature framework

The three previously discussed project management methods are analyzed and compared to design the theoretical framework. The following figure shows the comparison between the three methods (Figure 9).
The comparison of the three methods shows some differences as well as similarities. Since the PMBoK+ method shows the most overlap with the other two methods, this one is chosen as the literature framework for further research. It shows the broadest framework of traditional project management and is therefore the most detailed framework of the three. The two themes were added based on the construction sector characteristics (Project Finance Management and Project Health, Safety, Security and Environmental Management), which makes it relevant for the research context. One of the aims of this research is to describe a (broad) definition of what traditional project management is, which can be used to compare the cases. The framework PMBoK+ covers most of the themes that are used in the other two models, for that reason it is the most suitable framework to reach the sub-aim of the research. The framework PMBoK+ will be used as the framework to define traditional project management.
4. Company review

The research will be performed at Arup, an independent firm of designers, planners, engineers, consultants and technical specialists working in the built environment. Arup is specialized in solving complex problems and challenges. Sir Ove Arup established the firm in 1946. Arup employs over more than 14000 people in 34 countries. The founder wrote a key speech which defines the values of the company and these are still used in everyday work.

The Amsterdam office of Arup was established in 2000 and is active in commercial, residential and infrastructural projects. The office has worked since then on some high-end projects, such as the renovation of the Stedelijk Museum, Supreme Court of the Netherlands, Nescio Bridge, the Netherlands Institute of Ecology and currently working on the Binnenhof project. Arup has a very large global network of specialists and the team in the Netherlands is capable of applying the global knowledge to local projects. The research is conducted within the Project and Programme management department. The team executes different types of work such as design management for the different disciplines within Arup, client representative project management, external design management, programme and portfolio management and asset management. The department has very little experience in project management of circular projects. The Project and Programme management department is currently small but Arup has the ambition to grow. From their involvement in many disciplines they can oversee the relation and the possibilities between the disciplines. With this they want to make a difference in the Dutch market. Arup has all the disciplines in-house and the disciplines that do not work in the Netherlands can be brought in from other countries. This enormous network of knowledge differentiates Arup from other engineering or project management firms (Thomas van Schaick, personal communication, 2019).

Arup has high sustainability ambitions. Their slogan is ‘We shape a better world’ and sustainability is at the heart of their work. They believe that delivering sustainable projects for stakeholders nowadays, but also for future generations, will make the business stronger on the long run. Arup is determined to realize the long-term ambition to become a frontrunner in the sustainability transition. The fundamental aim of Arup is to serve society and deliver meaningful work for a more sustainable development within the built environment. The company committed itself to the 17 United Nations Sustainability Development Goals (UNSDGs). They do this by adjusting the businesses and doing research on how they can align with the Paris climate agreement sustainable objectives (Arup, s.d.). Therefore, Arup is trying to accelerate the transition by stimulating clients to become as sustainable as possible. Many sustainable projects have been completed in the past years, however the circular transition is starting now.
5. Research design

This section explains the research method. To formulate an answer to the questions of this research, a suitable research strategy must be formulated. At this moment there is a lack of available knowledge on project management of circular construction projects. For that reason, this study aims to contribute to that field of knowledge. The method that is used is a multiple case study research. The study will be descriptive. This chapter explains how the method is going to be used, why the method is chosen and the selection of cases. Also, the data gathering approach is discussed. Finally, the limitations of the research methods are provided.

5.1 Methodology

The research method that is used for this thesis is case study research. With the help of case studies, the problem and complex issues will be explored. A case study research is the best suitable method to use because of the following two reasons: it does not require control of behavioral events and it focuses on contemporary events (Yin, 2003). The case study methodology by Yin is used in this thesis (2003). For this research the unit of analysis is the circular construction projects in the Netherlands, that will be analyzed. Activities regarding project management will be scrutinized. All other information will not be used. In this research, a pattern will be investigated between the different themes in traditional project management compared to the project management used in the cases, to interpret the findings. The decisions taken during the project, related to the traditional themes are analyzed. Based on the decisions made by the stakeholders of the project, the third sub-question can be answered, to investigate whether there is a difference in project management between traditional construction projects and circular construction projects. In the last chapter, the final sub-question is answered with the help of the case study interviews supported by literature.

5.2 Research framework

Based on the literature review, the Project Management Body of Knowledge+ (PMBoK+) framework will be used to review if there is difference in project management between circular and traditional projects. The PMBoK+ research framework will be applied to the case studies by analyzing the twelve project management themes (shown in Figure 10). For each theme will be investigated in detail how this was done at the time of the project. These aspects will be analyzed by questioning whether the activities took place, in what way they took place and with what methods or strategies this was done. The findings of the cases will be compared to the literature review. The steps that are undertaken in traditional project management for each theme in the project management plan is explained in appendix B.1.

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Figure 10 PMBoK+ framework (own work)
5.3 Case study selection

Information and data will be gathered by analyzing the cases. Analytic conclusions arising from more than one case study will be more powerful than those coming from one single case study (Yin, 2003). Moreover, having only one case study may cause doubt about the uniqueness or artifactual conditions around the case. This can lead to skepticism. This skepticism and criticism can be reduced by using 2 cases (Yin, 2003). Moreover, having only one case study may cause doubt about the uniqueness or artifactual conditions around the case. This can lead to skepticism. This skepticism and criticism can be reduced by using 2 cases (Yin, 2003). For this research the aim is to analyze 4 cases.

An important fact about multiple case studies is that it should follow a “replication” logic, instead of a “sampling” logic. This means each case should be selected carefully so that every case predicts similar results or each case predicts contrasting results but for predictable reasons (Gustafsson, 2017). For that reason, a case study selection process will take place. First, selection criteria are defined. The criteria are based on elements such as the type of project, project timeline and availability of information. Based on the selection criteria, different people (within Arup and externally) gave advise on the most suitable projects that could be used as case studies. Some cases have been provided by Arup, while others were found with the help of internet or the researcher’s network. In the next chapter, the case study selection process is described.

5.3.1 Case study selection process

To select the cases, requirements have been set up and based on those, cases are selected. First, since the aim of the project is to analyze circular project management, circular principles must have been applied to the project (as discussed in the scope). The project should show one or more components of the 10R-model. The 10R-model consist of the following elements: Refuse, Reduce, Rethink, Re-use, Repair, Refurbish, Remanufacture, Re-purpose, Recycle and Recover. The model is further elaborated on in appendix E. Secondly, the project should be recently completed. In this research, recently completed is interpreted as from 2016 until today. Next, the researcher should be able to get access to project information and project stakeholders. The interviewer should be allowed to get access to available project information, such as project documents. Information about the project should be available on the internet and the interviewer should be allowed to investigate the project. To be sure of this, permission needs to be asked to project directors or project owners. Besides access to information, access to stakeholders is vital in order to perform interviews. Without being able to interview the relevant stakeholders, the research cannot be carried out. In addition, the fourth criterion for the case study selection, explains that the project should be executed in the Netherlands. Projects from different countries are hard to compare and are therefore not suitable because of the “replication” logic theory by Gustafsson. Laws, permits, culture and way of working can differ between countries. Finally, the projects should be finished to be able to investigate the interviews in retrospective. This is mandatory to scrutinize and compare events and activities from the past.

Possible cases have been analyzed on the above requirements. If the project does not tick off all the above requirements, the project is not suitable for this research. The nine projects that have been further analyzed before the final case study selection took place, are shown in the table below (Table 1). The cases that have been analyzed but have not been selected are documented below as well, to show on what grounds they were not selected.
### Table 1: Available projects and requirements

<table>
<thead>
<tr>
<th>Project reference</th>
<th>Circularity on 10R-model</th>
<th>Delivered in</th>
<th>Access to information</th>
<th>Access to stakeholders</th>
<th>Current status</th>
<th>Suitable</th>
<th>Why not?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project A</td>
<td>Refuse, Reduce, Rethink, Repurpose, Recycle</td>
<td>2017</td>
<td>Yes</td>
<td>Yes</td>
<td>Delivered and disassembled</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Project I</td>
<td>Rethink, Reduce</td>
<td>Ongoing</td>
<td>No</td>
<td>No</td>
<td>Construction</td>
<td>No</td>
<td>No access to information/stakeholders</td>
</tr>
<tr>
<td>Project II</td>
<td>Reduce, Rethink, Reuse, Repurpose</td>
<td>Not started</td>
<td>No</td>
<td>Yes</td>
<td>Procurement</td>
<td>No</td>
<td>Not started, no access to information</td>
</tr>
<tr>
<td>Project III</td>
<td>Reduce, Reuse, Repurpose</td>
<td>Not started</td>
<td>No</td>
<td>No</td>
<td>Feasibility study</td>
<td>No</td>
<td>Not started, no access to information/stakeholders</td>
</tr>
<tr>
<td>Project IV</td>
<td>Rethink, Reduce</td>
<td>Not started</td>
<td>No</td>
<td>No</td>
<td>Design</td>
<td>No</td>
<td>Not started, no access to information/stakeholders</td>
</tr>
<tr>
<td>Project B</td>
<td>Reuse, Repair</td>
<td>2019</td>
<td>Yes</td>
<td>Yes</td>
<td>Delivered</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Project V</td>
<td>Recycle</td>
<td>2018</td>
<td>Yes</td>
<td>Yes</td>
<td>Delivered</td>
<td>No</td>
<td>Not enough similarities with the 10R-model</td>
</tr>
<tr>
<td>Project C</td>
<td>Reduce, Refurbish, Recycle</td>
<td>2017</td>
<td>Yes</td>
<td>Yes</td>
<td>Delivered</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Project D</td>
<td>Rethink, Reuse, Recycle</td>
<td>2016</td>
<td>Yes</td>
<td>Yes</td>
<td>Delivered</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

#### 5.4 Cases

In the end four cases have been selected (A until D). Every case is briefly described by discussing the general characteristics of the project. This is done without giving names, locations and other information that could lead to the project, as they are anonymized. The projects are anonymized to reduce reader bias and to make the best comparison possible. The sources of the project information are known by the writer of the thesis. In view of the anonymity of the projects, the sources are not documented in the report.

**Project A**

Project A is a temporary pavilion, built for only 9 days and demounted afterwards. The building had a floor area of 250 m². The building was designed to promote the closed loop value. This involved thinking beyond the building’s life cycle where no waste is produced. Piles, wooden beams, façade elements, the glass roof, plastic cladding and lighting were amongst others borrowed and given back undamaged after the event to the original owners. Borrowed meant there was no screwing, drilling, glueing or sawing. Because of this, all the materials remained intact. This led to a new vision on sustainable construction: a powerful design language, new collaborations and intelligent building methods (Anonymized reference).

**Project B**

Project B is a transformation project, where the old structure is used with a new interior. The steel structure, some windows, the floor and old railway elements were reused. The building is located in an area where the municipality had large plans to redevelop. The original building dated from 1932. Because of technological development, the building got out of use. The municipality wrote a competition document in 2015 for the new destination of the building. An important aim of the project was to preserve the unique spatial experience of the building and to strengthen this were possible. The building has a floor area of 11,200 m² (Anonymized reference).

**Project C**

This building is one of the first circular buildings in the Netherlands. The building contains three levels, where one is beneath street level. The levels are interconnected with staircases and voids. The building has over 3350 m² floor area. The aim is to be waste free during construction but also during exploitation of the building. For example, the wood supplier can reuse the used wood after the life cycle of 30 years (Anonymized reference).
Project D
The aim at the start of this project is to demount it after five years and reuse all materials and products somewhere else. The client puts great emphasis on preventing waste and the maximization of value during reuse. To make the building as circular and adaptable as possible, it is designed as ‘kit of parts’. Which means it’s easy to assemble and reassemble. The building has a floor area of 5400 m² (Anonymized reference).

5.5 Data collection
The data for this research will be collected by performing interviews and analyzing documents. The interviews were planned from end of June until the start of October. The interviewees are contacted directly. Every interviewee is asked if they know more people that would be willing to do an interview. The aim was to contact different types of organizations and stakeholders: from architects to construction companies and from suppliers to clients. By doing that, thirteen interviewees have been found that were willing to cooperate. The list of interviewees is shown below (Table 2).

<table>
<thead>
<tr>
<th>Interview number</th>
<th>Project</th>
<th>Organization during project</th>
<th>Role in project</th>
<th>Date interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>Client</td>
<td>Project Leader</td>
<td>07-08-2019</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
<td>Client</td>
<td>Intern</td>
<td>21-08-2019</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>Client</td>
<td>Sustainability advisor</td>
<td>26-08-2019</td>
</tr>
<tr>
<td>4</td>
<td>A</td>
<td>Architect</td>
<td>Leading architect</td>
<td>29-08-2019</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>Architect</td>
<td>Leading architect</td>
<td>04-08-2019</td>
</tr>
<tr>
<td>6</td>
<td>D</td>
<td>Project development</td>
<td>Project developer</td>
<td>05-09-2019</td>
</tr>
<tr>
<td>7</td>
<td>B</td>
<td>Engineer</td>
<td>Project Manager</td>
<td>09-09-2019</td>
</tr>
<tr>
<td>8</td>
<td>C</td>
<td>Project manager</td>
<td>Project manager external</td>
<td>11-09-2019</td>
</tr>
<tr>
<td>9</td>
<td>C</td>
<td>Main contractor</td>
<td>Lead engineer</td>
<td>03-10-2019</td>
</tr>
<tr>
<td>10</td>
<td>A</td>
<td>Project manager</td>
<td>Project Manager</td>
<td>23-09-2019</td>
</tr>
<tr>
<td>11</td>
<td>B</td>
<td>Project manager</td>
<td>Project Manager</td>
<td>23-09-2019</td>
</tr>
<tr>
<td>12</td>
<td>C</td>
<td>Project manager</td>
<td>Project manager client</td>
<td>23-09-2019</td>
</tr>
<tr>
<td>13</td>
<td>C</td>
<td>Secondary material supplier</td>
<td>Leading secondary material expert</td>
<td>10-10-2019</td>
</tr>
</tbody>
</table>

Table 2 Case study interviewees (own work)

Yin developed three principles of data collection (2003). Firstly, it is important to use multiple sources of data. For this investigation, several stakeholders for each case will be interviewed. At least two sources are used for data collection, to be able to triangulate the obtained data. Secondly, a database is going to be formed. This is done by making summaries of the interviews and by publishing the summaries in the appendices as case study notes. The database is documented in appendix D. Thirdly, a chain of evidence is made, to increase the reliability of the research. An external observer should be able to follow the derivation of evidence, from research question to conclusions (Yin, 2003). This is achieved by referencing to the database and by explaining every step taken in the research in detail.
5.5.1 Semi-structured interviews
The data will be collected with the help of interviews. Key persons on the selected projects will be interviewed in a semi-structured interview. The semi-structured interview will be used to explore the respondent’s opinions, to clarify interesting and relevant issues, to extract complete information and to explore delicate topics within each interview (Barriball & While, 1994). Via face to face contact, a more trustworthy environment is going to be created where people feel free to speak their minds. This is done by the interviewer by being friendly and polite.

Semi-structured interviews show some form of predetermined order however; they still ensure flexibility in the issues addressed by the interviewee (Clifford, Cope, Gillespie, & French, 2016). During the interview, when obtaining permission, the interviews will be recorded using a mobile phone. This allows the interviewer to fully focus on the interview. A semi-structured interview combines predefined questions with open-ended explorative questions from an unstructured interview (Wilson, 2014). The interview protocol, further elaborated in the next chapter, is used for the structure of the interview and to give the interviewer some guidance on the questions that need to be asked. Furthermore, retrospective interviewing will take place because the observational method is historical observation. Because the analyzed projects have already been finished, no real time observations can be done (Bryman, 2016). Nonetheless, semi structured interviews may have some disadvantages, which are mostly validity and reliability. These threats should be overcome. Research concluded that friendliness, approach and manner towards respondents can help with securing validity and reliability. The research describes that the quality of the information obtained during the interview is for a large part dependent on the interviewer (Barriball & While, 1994). Interview skills are practiced with the aim to obtain the highest quality of data possible. The interview is rehearsed with the help of fellow students. By practicing the entire interview twice, the interviewer is more aware on how the questions are interpreted by other parties. By looking at the effect of the formulation and intonation of the questions on the answers, the questions have been modified accordingly.

5.5.2 Interview protocol
Interviewers during a semi-structured interview approach follow a guide called the interview protocol. The interview protocol consists of four parts including general questions as well as project related questions. The interview protocol is shown in appendix C. The four parts of the interview are outlined below.

1. Introduction of the interview. The participant should be briefed correctly (Wilson, 2014). In this case, this contains the introduction of the interviewer, the goal of the research, the aims of the interview and the confidentiality. The approximated time for this part is 10 min.
2. A list of topics and questions that will be asked during the interview (Wilson, 2014). In this case, topic 1 contains questions about the interviewee. Topic 2 consist of questions about the context and background of the project. Topic 3 is about the project management method used during the project process and topic 4 is about the future of project management of circular projects. This part will take about 50 min.
3. General questions and open dialogue with participant (Wilson, 2014). Interesting topics that were not part of the protocol can be discussed here. This part will take about 10 min.
4. Closing comments (Wilson, 2014). Further questions will be answered here.
5.5.3 Documents

Project documents will be used to analyze the Project Management tools used during the case studies. The received documents will be compared to the data of the interviews. Documents are requested from the interviewees, such as: request for tender documents, project planning, management plans, program requirements, minutes from meetings, health and safety plans, risk registers and cost estimate before tendering. Due to confidentiality of the projects, not many documents were shared. Some project documents were confidential because of the client’s role and function of the building, for other projects the stakeholders switched employees, so they were not allowed to share the documents or, lastly, some interviewees were not willing to look for the documents. In the end, the following documents were collected (Table 3):

<table>
<thead>
<tr>
<th>Project A</th>
<th>Project B</th>
<th>Project C</th>
<th>Project D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sketch design</td>
<td></td>
<td>Report on technical installations</td>
<td></td>
</tr>
<tr>
<td>Health &amp; Safety plan</td>
<td></td>
<td>Report: ‘The added value of circular procurement’</td>
<td></td>
</tr>
<tr>
<td>Final design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building sequence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Note Structures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day planning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawings</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 3 Received documents for each project (own work)*

5.5.4 Triangulation

Data triangulation is used to limit discontinuities during the analysis. To perform data triangulation, different sources of information should be used to increase the validity of a research. The interviews will be used as a primary source of data and as far as possible, the documents will be used to validate the perceived data. If no documents are available, the data is triangulated by the interviews. If there is more than 1 interview, it is possible to triangulate on that as well.
5.5.5 Cross-case analysis

The analysis method that will be used to investigate the obtained data is the cross-case synthesis. This technique applies to the analysis of multiple cases. This method can be applied if the individual case studies have previously been performed as independent research studies (Yin, 2003). The method described by Yin treats each individual case as a separate study. Figure 11 shows the steps that will be taken. There are several analysis techniques possible. In this study, tables will be made that display the data from the separate cases according to a uniform framework. The uniform framework is the PMBoK+ framework. The patterns from the different cases of the table will lead to a conclusion about the data. A down side of this technique is that the cross-case conclusions are drawn on own interpretation. Therefore plausible, strong and fair arguments need to support the data (Yin, 2003).

After the case selection and the designed data collection protocol, the following steps are going to be performed. First, for each individual case a study is done. All the steps of the framework will be compared to the activities that took place during the project. The twelve themes, including the sub-activities, are one-by-one asked to the interviewee. The answer of every interviewee is documented, to first make the comparison between the different interviewees for each project and later compare the projects. This is done with the help of a large Excel spreadsheet. This is documented in appendices F.1 (case A) to F.4 (case D). When this is done, an individual case report is written. These case reports are described in chapter 6.1.1 to chapter 6.1.4. Afterwards, based on the Excel spreadsheet and the individual case study reports, the cross-case conclusions are drawn. The conclusions are used to modify the original PMBoK+ framework for circular construction projects. Subsequently, the cross-case report is written, which is documented in chapter 6.2. Based on this report, the third sub question is answered.

Figure 11 Case study method (Yin, 2003, p. 50)
5.6 Limitations

There are some limitations to case study analysis. To start with, case studies are often perceived as not sufficiently scientific since they are not able to develop checkable generalizations. It is important to use precise language and to create a thoughtful research design (Gustafsson, 2017). Another limitation is that the studied cases can differ from the rest of the population. Thereby the cases cannot lead to conclusions regarding causality. This risk is considered during the discussion. The Hawthorne effect is a large risk for the interviews. This is the effect of being observed, participants might behave differently when being observed. These effects diminish over time when the interviewee feels comfortable (Landsberger, 1959). Thus, during the interviews, an informal and confidential setting is created. Researcher bias is another limitation that can cause a negative effect on the research. The most dangerous form in this case is confirmation bias. It occurs when a researcher forms a hypothesis and uses the interviews to confirm these hypotheses. What can happen is that a respondent uses responses that confirms the hypothesis as reliable and ignoring evidence that does not support the hypothesis (Sarniak, 2015). In this thesis, no hypotheses are used to do the research. However, the researcher could have some preferable outcomes. This should be avoided.

Semi-structured interviews have two main risks. First, experience and practice are necessary to make sure the interviewer does not put words in mouths (Yin, 2003). The interview will be practiced in advance with the help of fellow students, to make sure no words are put into mouths. Secondly, findings may be hard to generalize since the interviews are flexible and not exactly all the same questions are asked (Yin, 2003). For that reason, the interviewer will ask questions that are similar during all the interviews.

5.7 Validation and verification

Validity of a research means the “appropriateness” of the tools, methods and data. In the interest of analyzing whether the research process and results can be assured of being precise and robust, expert validation will be used. Experts from different organizations will be interviewed to determine the level of quality of the findings and recommendations. The validation interviewees are documented in the figure below (Table 4). To do the interviews, a validation interview protocol is set up (appendix H). The summaries of the validation interviews are documented in appendix I. The results are discussed in the discussion chapter. Furthermore, to ensure validity, the summaries of the interviews are sent to the interviewees to make sure the interview is summarized correctly with no misinterpretations. Since little project documents were available, the conclusions are mainly drawn based on the interviews. This implies risks because these cannot be exactly replicated. By writing summaries on all the interviews and adding these to the appendices, this is partly mitigated.

<table>
<thead>
<tr>
<th>Validation interviewee</th>
<th>Organization</th>
<th>Years of experience in circular economy</th>
<th>Date interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Circle Economy</td>
<td>3, 4</td>
<td>17-10-2019</td>
</tr>
<tr>
<td>2</td>
<td>Arup</td>
<td>3, 4</td>
<td>18-10-2019</td>
</tr>
<tr>
<td>3</td>
<td>Arup</td>
<td>2</td>
<td>21-10-2019</td>
</tr>
<tr>
<td>4</td>
<td>NEN</td>
<td>4</td>
<td>18-10-2019</td>
</tr>
</tbody>
</table>

*Table 4 Validation interviewees (own work)*
6. Case study results

A cross-case analysis was done based on the document study and the interview outcomes, structured along the themes of PMBoK+ project management method.

The data received will be analyzed on different levels:

1. First for each interview. The summaries of the interviews are shown in appendix D;
2. After the interviews, an analysis will be done per case (discussed in chapters 6.1.1 until 6.1.4);
3. The results of all the interviews are compared, between projects. This is the cross-case analysis (chapter 6.2).

The chapters of the analysis of the cases are composed of general project information including the circularity of the project, the stakeholders, the lessons learned and the project management. Subsequently, the PMBoK+ framework is used to investigate the cases. At the end of every chapter, a summary of the analysis is shown in the form of a table. The green cells indicate that the step from the framework is executed as described by the method and the red cells refer to the steps that were not done as described in the PMBoK+ framework. When the interviewees or documents give contradictory information, the cell is colored orange and no conclusion can be drawn. The most important color is yellow, these are the activities where the interviewees indicated that something different took place compared to traditional project management, something in their eyes circular. These are the activities that will be further investigated in the cross-case analysis. If several interviewees give the same response, this response is assumed to be more plausible that it actually happened. This has been indicated in the summarizing tables for each case.

Circularity is subdivided into two categories. The first one is a circular product, the circularity of the building. The degree of the circularity of the building is made more quantifiable in the following chapter, based on the circular economy principles of the 10R-model. For every case different circular economy principles have been applied however, it can be concluded that the four cases are (partly) circular constructions. Therefore, whether the four buildings (A until D) are circular constructions will not be disputed in this research. The second category is the circular project process. At the start of the research it is unknown whether for the four cases a circular process was applied or a traditional process. That is going to be analyzed in the following chapters.

6.1 Results

Per project, the results of the case studies are discussed in this chapter. After the analysis, a table is shown where all the themes with the different themes of PMBoK+ are compared to the interview outcomes based on these themes.

6.1.1 Project A

Project A was built to become a temporary exposition and meeting area. Most of the materials and products of the building have been borrowed and given back at the end of the event to the original owners. The building is constructed as a temporary storage of materials. The client had a few central aims. First, the project had to become an iconic and eye-catching building. Another aim was to achieve co-creativity with the audience. The client wanted the neighbors to be able to contribute to the project as well. This was done by letting the public collect plastic to create the tiles of the façade. Thirdly, the project had to become a sustainable example for the construction industry (Interviewee 1). More detailed information about project A is documented in appendix F.1.

Circularity never was a central aim for project A at the start. But it was the most suitable answer to the question. The query of the client was to make the leading pavilion for only nine days. In total 600 people had to fit in the building and it should become the sustainable statement for the coming generation of designers. It should be the precursor on the field of sustainability (Interviewee 4).

6.1.1.1 Stakeholders of project A

For this case, three key stakeholders have been interviewed. The first stakeholder (interviewee 1) interviewed was the project leader of project A. He worked as a program director at the client organization. The second stakeholder (interviewee 4) interviewed for project A was the lead architect.
The third interviewee (interviewee 10) had the role of project manager in project A. He works at an external firm, but in this project he worked as the project manager on the client side. The client, designers and constructors worked in a triangle (Interviewee 1). The client took on the role as contractor. So, the client had three roles; principle, project manager and contractor. The organizational structure of the project was the following (Figure 12):

![Organizational structure of the project team of project A (Interviewee 1)](image)

**6.1.1.2 Circular Economy**

All the interviewees of project A believe project A is a circular construction project. The degree of circularity of the building is analyzed with the help of the 10R-model. An explanation of the 10R-model is shown in appendix E. For this project the following principles of the 10R-model have been used:

- **10 Refuse** – all materials were borrowed. If this was impossible, recycled materials were bought and used. Virgin materials were never applied.
- **09 Reduce** – by borrowing, less raw material was used.
- **08 Rethink** – the building has been designed to dismount it after 9 days, without damaging the materials and products.
- **03 Repurpose** – products were used for other purposes, such as the concrete piles (usually put into the ground)
- **02 Recycle** – the components for the cladding of the façade were made out of recycled plastic. Moreover, the tieraps used to attach the tiles to the façade, were made out of recycled plastic.

The client saw the building as a temporary storage of materials. These materials are in a transit to another destination. Circular economy steps should be made by looking at circularity within different chains, to outreach sectors. It is noticed that various stakeholders and partners in the construction chain keep their traditional work-ethic (Interviewee 1).

**6.1.1.3 Type of project**

The project is a temporary building, which was not a real building. It had no installations, so an indoor climate could not be made. It was very cold on the inside. Besides, the three interviewees believe the project was an experiment. In the end, the experiment worked, because all the materials were given back and afterwards reused (Interviewee 1). After the interview, interviewee 10 was asked what type of contract was used for this project. The reply was ‘mainly DBMR’. It can be assumed that it is more likely a DBMR contract is used. Besides, there was no manual made for the building to be disassembled. However, the interviewee believed the disassembly was common sense (Interviewee 10).

**6.1.1.4 Lessons learned**

Since the project was very innovative and new, the stakeholders shared many lessons learned. A learning of the client was that they realized that this way of completing projects is a style that fits the organization, however, the client realized that it was not the classic owner-contractor situation. In terms of approach you need all hands-on deck, always to think about how to get things done.
As a client they had the same structural risks as the architects. The constructor was not only responsible for the construction calculation but also needed to be flexible because of the dependence of the suppliers the business developers could find. So, the roles were not the same as a traditional construction project. This was very interesting, it resulted in more teamwork between the different involved parties. Here, you cannot just pass on responsibilities to other parties. In these type of projects, the parties are not the owner of the solution, but the owner of the problem. The second learning is that within this mentality, teamwork is very important. As a team worker, you need to rely on each other’s vision and expertise (Interviewee 1). This requires a different mindset.

According to interviewee 4, the project was a success because the commitment was carried by all the different layers involved in the project. In this project all the parties were responsible and committed from the start to the end of the project (Interviewee 4). For interviewee 10, the most important learning of the process was to start on time. This was a very fast project. Therefore, starting on time is very important, because time is the largest enemy for such experimental processes. You need to learn by doing, which takes more time (Interviewee 10).

6.1.1.5 Project Management
The internal project manager was used to keeping tight schedules and deadlines, which did not work in this project. There was one tight deadline and that was the opening of the event. Because the project manager had never done such a project, it was very hard to make estimations on how the process would evolve. The conventional construction planning he had in mind, did not work during this project. It was concluded that such a project requires a new approach (Interviewee 10). Interviewee 1 is fully convinced these types of projects need another approach than classic construction projects. Communication is a very important aspect for these types of projects, as a project manager you need to make sure that every project member is always up to date. The new method that is needed, is a lot more organic and does not follow a certain path. What is noticed, is that it does not work to have a fully conventional work plan, specifications and budget beforehand. Different parties with the same dream should work together by saying, I do not know exactly what I ask for, but this is the budget and this problem needs to be solved. Also, leadership should change, a manager should not make a PowerPoint explaining what should be done and when. You need to make people responsible for solving the problem (Interviewee 1).

6.1.1.6 Project Documents
The project manager provided six project documents. Per document is explained what relevant information has been used for the analysis.

1. Sketch design - This document does not contain relevant information for this research.

2. Safety and Health Plan
The document shows the results of the risk assessment and evaluation (RIE) during the design process. The document reports the Health and Safety Design and Health plan of the design phase. This includes the construction safety plan. The document is drafted after the technical elaboration phase. The works can only start after an analysis of health and safety risks has been done. The document contains a short and brief health and safety plan and discusses some risks. These are used for the summarizing table at the end of this paragraph (Table 4).

3. Building sequence - This document does not contain relevant information for this research.

4. Design note Structures - This document does not contain relevant information for this research.

5. Day planning
This document shows that a project planning is made. The Excel sheet discusses the materials that are needed for the construction and a short (not detailed) planning explaining what material is needed when. The planning is only made for the final three weeks of the project, which are the three weeks of construction. It is not a very structured and clear document.

6. Set of drawings - This document does not contain relevant information for this research.
6.1.1.7 Summary project A

For project A, in terms of project management, it can be concluded that it is more plausible that no traditional project method was used. At first, circularity was not a central aim. This was introduced by the architect during the process. The client set up three very brief requirements to benefit from the creativeness of the project team. The project was part of a larger event and had a tight deadline. Being part of the larger event had some advantages: no permit application needed to be done by the project team and stakeholder management was done for the entire event by the client organization. That is why it was not a part of this project. The project was an experiment. This also had some advantages; for example, parties were more willing to collaborate and less stakeholder management had to be done. However, because it was a very new project, it was very hard to make estimations on time and process. The project had a lot of commitment from the involved parties. The project team learned that it is important to not separate responsibilities, to benefit from each other’s expertise and vision.

The full analysis of project A is shown in appendix F.1. The summary of this analysis is shown in Table 5. Traditional project management was used for the Project Cost Management and Project HSSE Management. For Project Quality Management and Project Stakeholder Management no conclusions could be made. The themes Project Scope Management, Project HR Management, Project Communication Management and Project Integration Management were done minimally. The parts have been done in some way, but no separate document was made and no plans were drafted. This can be explained by the fact that the project was very small and because of that, clear and comprehensible. There are some steps in themes that have been done in a different way compared to traditional, that need clarification. The interviewees say these steps have been done in ‘a circular way’. The first one is that the client defined three short requirements, which were more like ambitions. Interviewee 1 explained that the project was defined together with the project team to come to innovative solutions. This is not how it is done traditionally. Secondly, the project team was acquired and developed, as part of the Project Human Resource Management. However, this is done with only very committed parties that understood the circular economy mentality and were willing to take a challenge. Suppliers were involved that were willing to lend their materials. Besides, project work and knowledge were not really managed during project A. It was a group of enthusiastic professionals working together with the same aim.

The budget was open to everyone, it was managed in a very transparent way. Interviewee 1 did this on purpose, to make everyone responsible for the budget. For risk management, only the costs were managed. However, the interviewees said that the project was very risky. They were never certain about what materials they would be able to borrow and in what amount they were going to get the materials. Next, the Project Procurement Management was done differently than in a traditional project. Parties of the network of the entire project team were requested to collaborate. Suppliers were contacted to see if they were willing to lend their products and materials. These parties have been contracted early in the project. All the parties involved were in the end enthusiastic parties that showed commitment to the idea. Lastly, Project Financial Management was done in a different way as well. Every party involved was responsible for the budget. Moreover, all the risks were for the client, to ensure that everyone would work in the most innovative way.
<table>
<thead>
<tr>
<th>Theme</th>
<th>Traditional project management</th>
<th>Plausible?</th>
<th>Project A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Scope Management</td>
<td>Collect requirements Correct</td>
<td>Yes, but no specific requirements, three short requirements.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Define scope ≠</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Create WBS ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Verify scope ≠</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control scope ≠</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Time Management</td>
<td>Define activities ≥</td>
<td>No, but due to project characteristics.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sequence activities ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Estimate activity resources ≠</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Estimate activity durations ≠</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop schedule Correct</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control schedule ≥</td>
<td>No, but due to project characteristics.</td>
<td></td>
</tr>
<tr>
<td>Project Cost Management</td>
<td>Estimate cost ≥</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Determine budget ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control cost ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Quality Management</td>
<td>Plan quality ≠</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perform quality assurance ≠</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perform quality control ≠</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Human Resource Management</td>
<td>Develop HR plan ≥</td>
<td>No, but due to project characteristics.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acquire project team ≥</td>
<td>Yes, with committed and enthusiastic parties.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop project team ≥</td>
<td>Yes, with committed and enthusiastic parties.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manage project team ≠</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Project Communication Management</td>
<td>Identify stakeholders ≥</td>
<td>No, but due to project characteristics.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plan communications ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distribute information ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manage stakeholders ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Report performance ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Risk Management</td>
<td>Plan risk management ≥</td>
<td>No, only costs were managed in the risk management.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Identify risks ≠</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perform qualitative risk ≥</td>
<td>No, but due to project characteristics.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perform quantitative risk ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plan risk responses ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor and control risks ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Procurement Management</td>
<td>Procurement planning ≥</td>
<td>No, procurement is done by contacting their own network and looking for committed parties that were willing to lend their products and materials.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solicitation planning ≥</td>
<td>No, parties contacted earlier in the project. Before making the design they had to know what materials they could borrow.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solicitation ≠</td>
<td>No, not done the traditional way.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Source selection ≥</td>
<td>No, this was done with the entire project team.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contract administration ≠</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contract closeout ≥</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Project Stakeholder Management</td>
<td>Identify the stakeholders ≥</td>
<td>No, but due to project characteristics.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plan stakeholder ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manage stakeholder ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor stakeholder ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Integration Management</td>
<td>Develop project charter ≥</td>
<td>No, but due to project characteristics.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop project ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct and manage project ≥</td>
<td>No, project work and knowledge was not managed, it was professionals working together with the aim to achieve the same goal.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manage project ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor and control ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perform integrated ≥</td>
<td>No, but due to project characteristics.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Close project of phase ≥</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Project Health, Safety, Security and</td>
<td>Proactive view of health,</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop management plan ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Financial Management</td>
<td>Financial planning ≥</td>
<td>No, but due to project characteristics.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Identify the financial ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contract requirements and risk allocation ≥</td>
<td>Yes, all the risks were for the client. Moreover, everyone was responsible for the budget.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tax planning ≠</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

*Table 5 Project management analysis of project A (own work)*
6.1.2 Project B

Project B is a redevelopment project of an existing building. The building was an industrial monument, owned by a municipality. After the construction, the building got several different functions. More detailed information about the project is documented in appendix F.2.

6.1.2.1 Stakeholders of project B

For this project, three stakeholders have been interviewed. The first one (interviewee 5) was the lead architect of the project. The second interviewee (interviewee 7) was the project manager of the design team, on the engineering side. The third interviewee (interviewee 11) was the project manager of project B. The organizational structures of the design stage and execution stage has been defined and sketched on a paper by interviewee 11 and are displayed below (Figure 13).

6.1.2.2 Circular Economy

There is some disagreement between the interviewees whether project B can be called a partly circular project. Interviewee 5 believes project B is a partly circular project. The architect firm has done several transformation projects, where the reuse of an existing building considered as a circular aspect to the project (Interviewee 5). Interviewee 11 does not think project B is a circular project. The project has a hull and an interior. The hull, which is the shell of the building, is circular because it is a renovation project and the existing structure is maintained. The façade and the floor (as much as possible), the roof, the steel structures, the old crane lanes, the two largest cranes and a little crane and the old train tracks have been preserved. Yet, everything that has been added or replaced to the construction was new, without any circular principle. These were mostly large installations and façade materials (mainly glass). There was not a circular ambition. The building has a very resistant indoor climate concept, which can be called circular. The indoor climate is not user nor area specific, but it is made on building level. The materials that have been applied are new and are not designed with the aspiration to demount and reuse it later. The same for the glass or concrete, this is all new. No new techniques have been used to look at what concrete to use. The glass hall in the building is reused 1 on 1, so this is circular. However, the foundation beneath the glass hall is new (Interviewee 11). The project is analyzed and based on the 10R-model (shown in appendix E) the degree of circularity of building B is:

07 Re-use – an old glass construction from another building was dismounted and mounted in project B.
06 Repair – the structure of the old building was repaired so that the building could be renovated and reused. In addition, the same was done for some glass panels in the roof and the façade, for the floor and for the steel rail systems. Most of the elements were not painted, so the old paint layers are visible.
6.1.2.3 Type of project
The project was a large redevelopment project. The scope of the client was not focused on redevelopment. According to their base scope, the building did not have to be inventoried at the beginning. Because the specification the client made, the aim was to make a new building inside of the old building. However, for the reuse of the existing construction, a lot of research needed to be done. The project team changed this by making several indoor climates in the old building, to improve the sustainability of the building. Moreover, the client made use of an UAV-GC contract, which is not a traditional contract (Interviewee 7).

6.1.2.4 Project Management
As explained by interviewee 5, there were several project managers involved in the project. In the design team, the leading architects were responsible for this. The municipality hired an external project leader (project management company X) and the project leader organization hired another organization that were responsible for the project management (Interviewee 11) between designers and users (Interviewee 5). This is elaborated by interviewee 11, he was responsible for the construction and users and the other company was responsible for the administrative and political side of the project (Interviewee 11).

6.1.2.5 Project Documents
No project documents were available for this project.

6.1.2.6 Summary project B
The organizational structure of project B was based on a very hierarchical structure. Two parties were responsible for the project management. A change, compared to traditional projects, is that users were involved early in the process. They could decide on design decisions, which is unique for these types of projects. Interviewee 5 explains that the hull of the building is partly circular and that the different indoor climates are partly circular. Above of that, as much as possible is preserved from the old building and measures have been applied (thermal system and solar panels) to decrease the energy consumption of the building. But, circularity has never been an ambition in the project. Interviewee 5 explains that a redevelopment project, such as project B in her eyes, takes a lot more time because more investigation needs to be done. In this case, all the structures were controlled and the ground conditions needed to be analyzed. An UAV-GC contract was used in the contract. Interviewee 11 describes that the connection between UAV-GC and circularity are very complex. In this type of contract, conditions and responsibilities are prescribed. One of the conditions is that the client bears less risk in the project. Therefore, extra adjustments are necessary in a circular construction project (Castelein, 2018). Concluding, it can be said that it is more plausible that traditional project management is used for all the 12 management themes of PMBoK+ framework, during the entire project. This is displayed in Table 6.
<table>
<thead>
<tr>
<th>Theme</th>
<th>Traditional project management</th>
<th>Plausible?</th>
<th>Project B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Scope Management</td>
<td>Collect requirements</td>
<td>≥</td>
<td>Yes.</td>
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<td></td>
<td>Define scope</td>
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<td>Create WBS</td>
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<td>Verify scope</td>
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<td>Control scope</td>
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<td>Project Time Management</td>
<td>Define activities</td>
<td>≥</td>
<td>Yes.</td>
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<td></td>
<td>Sequence activities</td>
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<td>Estimate activity resources</td>
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<td>Estimate activity durations</td>
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<td>Develop schedule</td>
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<td>Control schedule</td>
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<td>Project Cost Management</td>
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<td>Determine budget</td>
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<td>Control cost</td>
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<td></td>
<td>Perform quality assurance</td>
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<td>Perform quality control</td>
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<td>Develop HR plan</td>
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<td>Develop project team</td>
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<td>Manage project team</td>
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<td></td>
<td>Plan communications</td>
<td>≥</td>
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<td>Distribute information</td>
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<td>Manage stakeholders expectation</td>
<td>≥</td>
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<tr>
<td></td>
<td>Report performance</td>
<td>≠ unknown</td>
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<tr>
<td></td>
<td>Plan risk responses</td>
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<tr>
<td></td>
<td>Plan stakeholder engagement</td>
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<td></td>
<td>Manage stakeholder engagement</td>
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<td></td>
<td>Monitor stakeholder engagement</td>
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<td>Project Integration Management</td>
<td>Develop project charter</td>
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<td>Develop project management plan</td>
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<td>Direct and manage project work</td>
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<td>Manage project knowledge</td>
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<td>Monitor and control project work</td>
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<td>Perform integrated change control</td>
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<td>Close project of phase</td>
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<td>Project Health, Safety, Security and Environment Management</td>
<td>Proactive view of health, safety and environmental policy compliance</td>
<td>≥</td>
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<tr>
<td></td>
<td>Develop management plan including health, safety and environment</td>
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<td>Identify the financial requirements for construction projects</td>
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<td>Contract requirements and risk allocation</td>
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<td></td>
<td>Tax planning</td>
<td>≥</td>
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</table>

Table 6 Project management analysis of project B (own work)
6.1.3 Project C

Project C is a newly built pavilion located at a business district. At first, circularity was not the aim. However, during the process, circularity became an ambition. In the end, the aim of the project was not to make a perfect circular building, but to learn from it. The client wants to share the things that went wrong to make sure the transition continues (Interviewee 2). More detailed information about the project is available in appendix F.3.

6.1.3.1 Stakeholders of project C

The first interviewee for project C (interviewee 2) was an intern, who did not give information about the project management process since she was not involved. She did provide a document and some information about the project. The second interviewee (interviewee 8) took on the role as the project manager of project C. He worked at an external company and was responsible for the project management on the client side. The third interviewee (interviewee 9) was the lead engineer of the project, working at the main contractor (at that time). The fourth interviewee (interviewee 12) was the project manager on the client side during the project. He worked closely with interviewee 8. The fifth interviewee (interviewee 13) was a supplier and subcontractor of secondary products and materials. The interviewee was involved in project A as well, but only project C is discussed during the interview.

For the project a ‘round the table’ model was used, which is visible in Figure 14. In the middle, external project manager working as a delegate of the client and the project manager of the client organization, were responsible for the project management. The rest worked in a round structure around the managers. The main-contractor was in the end responsible for the contracting of suppliers and subcontractors.

![Organizational structure project C (Interviewee 9)](image)

Different decisions for all of the work groups were discussed together with all the disciplines. In the end, this group was a team of enthusiastic people, with the same aim (Interviewee 9). In the first phases circularity was not the aim. During the process, somebody came up with the idea to apply circular principles. The client agreed on this. When the idea was first given, one of the feedback comments from the stakeholders was that circular investments are not recouped. After that, the entire team was removed from the project. The mindset that was needed for this project, the willingness to cooperate and the different way of thinking were missing in the old project group. For that reason, they were removed. After, a new team was hired (Interviewee 9). Project C was not only about what was profitable, but also about sustainability, circularity and being future-proof. In the end parties were found that were supportive of this way of thinking (Interviewee 8).
6.1.3.2 Circular Economy

All the interviewees except for interviewee 13, see project C as a circular building. The following principles are used based on the 10R-model to define the degree of circularity of the building (appendix E):

09 Reduce – the amount of raw materials is decreased by making new and unconventional choices. For example, the main bearing construction is made out of wood instead of concrete.
08 Rethink – for the elevator, a Product as a Service contract is used. Moreover, the building is constructed to be able to disassembly.
07 Reuse – for the construction second hand materials are used with the help of the secondary material supplier. For example, the tiles on the terrace, the wooden floor on the first level or windows used as walls in the cellar.
02 Recycle – the planters outside have been attached by recycled plastic pins, insulation material has been made of recycled jeans and old company clothing is used for plastering.

For the Dutch Green Building Council interviewee 8 is helping with a ‘losmaakbaarheid indicator’. This is a tool to measure the ‘losmaakbaarheid’ of a building. In the end score, project C is not rated very well. The reason for this is that the concrete tub that has been poured at the start of the project. This has a negative effect on the circularity of the building. Without the concrete tub, the building is for 80% demountable and reusable (Interviewee 8). For every decision during the process, a matrix was made to deliberate the different options. Weighing factors were set for criteria like esthetics, circularity, costs and sustainability. Hard measurable requirements for circularity were not set (Interviewee 9).

The dismount time of the construction is about 2,5 years. As Thomas Rau says, everything you buy with new materials has a kind of promised circularity. It only becomes circular at the end of the life cycle when steps can be taken. However, there does not exist a document that explains how the building should be demounted element by element. A material passport is made, where the client decided to only use elements that would be there for a long time such as the main load-bearing structure. A high extent of details is incorporated in the BIM model, to make it easier to dismount is. The interviewee likes to compare it to a LEGO manual, where you can see what it must look like. With knowledge on constructions, it should be possible to disassembly, based on the plans (Interviewee 12).

6.1.3.3 Type of project

It can be said that the project is an experiment. Project C was not only about what was profitable, but also about sustainability, circularity and being future-proof. Money was always considered during the entire project, but it was not the main criteria to make decisions (Interviewee 8). In the end, the project cost a lot of money for (among other parties) the contractor. For this project it was doable due to the great exposure, but the extra costs are not possible for a normal business case (Interviewee 9). This is explained by interviewee 12, at this moment circular buildings have a high experimental character with high risks. What does not help is to set a lot of requirements on the front side of the project. If the market is not that large, it is difficult to achieve the specific demand or design. You need to make a lot of space in the question specification to make sure market parties can be involved in the project (Interviewee 12).

6.1.3.4 Conflicts

During this project, some conflicts arose. Interviewee 13 explains the conflicts in more detail. The interviewee believes that all the people involved are very proud of the result, but it was a project with a great deal of friction. This was mostly because circularity became a topic during the process instead of at the start of the project. The main contractor was already contracted for the old plan. A contracting form is chosen between the client and the contractor, where they were jointly responsible for the circular interpretation. This was no turnkey agreement, it was a joint performance agreement to come to a circular project. The contractor did not have many circular ambitions, which frustrated the client. The main contractor is a very large company. They chose to work with the client and were willing to cooperate on the circularity ambitions. However, the contractor is no circular frontrunner, it is one of the most traditional construction companies in the Netherlands. They had a culture problem within the company, when it comes to the implementation of circular principles. The board agreed on the circularity but the interviewee noticed a lot of resistance during the execution of the project, not every person involved in the execution understood the circular principles (Interviewee 13).
An example is, in the basement old windows from a building were going to be used. The contractor’s employees refused to use the secondary products. During a meeting interviewee 13 said ‘if you don’t insert the windows in the walls, then I will do so’. The contractor replied: ‘Ok you do it then’. The interviewee became at that moment not only the supplier of secondary materials, but also a subcontractor where he had to implement his own products. He became a subcontractor under the coordination of the main contractor. This all increased the tension enormously (Interviewee 13).

This was the first project where the new type of flooring made of reused wood was manufactured for. As a supplier, it is very hard to give guarantees on something that new. The interviewee was willing to give guarantee but wanted to share risks, the client agreed on this. This did not fit the standard contract of the main contractor. The contractor did not care about the agreement between the interviewee and the client, they only wanted to use their own contract. The standard contract could not be changed. The interviewee wanted the client to tell the contractor what agreements had been made. This was done a little, but the client found this hard to do because they were dependent on the contractor. In the end, the supplier of the secondary products was obliged to give guarantees and bear all the risks. Everyone was already involved in the project so nobody could take a step back. This became a forced collaboration form. The contract that was used was not different to the usually used contracts, it was a traditional and linear subcontractor contract. All these conflicts show the phase of the transition to a circular economy we are currently in. Not the entire chain is ready. The interviewee concluded that the people working on the project are the determining factor of success (Interviewee 13).

6.1.3.5 Lessons learned
For interviewee 9, the following was an important lesson learned: the project team consisted of several parties in a round table model. This was new for everyone. The round table is a type of direction model, where all design decisions are made in collaboration with the client. The risks in this project were jointly put on the table (Interviewee 9). Besides, team composition and collaboration models are essential. Without the right people and organizations, a project becomes sub-optimal. Next, it is very important that everyone involved in the project understands the philosophy. That way, in the entire chain, all decisions and considerations are done according to the circular principles. Interviewee 12 learned here, another important learning, that the determination of the sustainable ambitions in the initiation phase of the project is the most important thing you need to do as a client. If no good meaning is given to this and it has not been thought through well, you can be faced with the fact that you do not think the design is sustainable enough and you need to throw the design away. This is very expensive (Interviewee 12).

Interviewee 13 has two large lessons learned. First, for suppliers, it is important to know beforehand what the contract form is that the main contractor has with the client. Misunderstandings arose because the interviewee did not know this. Because of this, the project cost him a lot of money. The most important lesson is that the interviewee will ask beforehand on the structure of the project team. So that he can prepare his own organization for this and educated guesses can be made for the opportunities and the risks of the project (Interviewee 13).

6.1.3.6 Project Management
According to interviewee 8, for project management it was very important in project C to involve the suppliers at the start of the project, it helped in becoming more circular. This made the process different compared to a traditional building process. Where architects normally design with materials they would like to use, that are produced specifically for the design. It becomes more difficult when you need to design with materials that need to become available. A logistic process needs to be set up, to get the materials on time on your project, because the materials become available at a certain time in the donor project. This makes the process a challenge. Most materials have been chosen based on the availability, which can also be called supply-based design (Interviewee 8).

6.1.3.7 Project Documents
1. Energy Circl – by interviewee 2 - The report is mainly about Energy and is therefore not relevant.
2. The added value of circular procurement – by client project C

During the start of the project the following principles are the starting points: sustainability, differential, connecting, functional, informal and transparent. After the change in project team, the new aim is to become a circular pavilion where they want to be the connecting factor between the client, the industry and the society. The client set circular goals:

a. Challenge the market to work on a as high as possible circular pavilion;
b. Test current chains and structures (such as circular financing and circular tendering);
c. Share knowledge and experience with external and internal parties;
d. Be a frontrunner in the transition towards the circular economy;
e. Speeding up the transition towards the circular economy;
f. Stimulate the connection between the client and society;
g. To be an inspiring example for others.

The term circularity is defined to make it more precise and concrete. They did this consciously very broad and ambitious, to make it a sort of ideal end stage. The following six definitions helped in the design, construction, use and programming of the building: all materials are endlessly recycled, the energy is produced by renewable or sustainable sources, human activities support and reinforce the ecosystem, diverse societies and health and happiness and raw materials are used more than to only create financial value.

![Diagram](Figure 15 Procurement strategy made by the client (Client source, known by author))

The main procurement was done in the following way. This is shown in the figure above (Figure 15). The client did not have any expertise or experience in complex circular design processes. To gain that expertise, the client contracted the architect and advisors directly. The main contractor is contracted after a negotiation, for the construction of the concrete tub. After changing the design to a circular design, the client decided to contract the same main contractor for the construction of the circular design. This was done with an UAV-GC contract. Together the architect, advisors and contractor, made an agreement called the Agreement Circular Construction.
Besides the circular principles and the framework for procurement, the following themes are described in this agreement: organization, responsibility per expertise, high level of authorization of decision making, integrality, total transparency (to the client and mutually), budget control and the efficient escalation model. Although an UAV-GC contract was chosen for the main contractor, for the decision of subcontractors and suppliers the project team worked together. The procurement of (among others) wood construction, facades, lifts, lighting, roof cover and solar cells was done jointly with the project team. With the help of the deliberation matrix (sustainability, aesthetics, circularity, life cycle costs and social sustainability) the parties have been selected.

The document describes some lessons learned. The first was trust and transparency. Transparency in goals and ambition is the base of trust. Open communication was done to make sure to the suppliers that client was determined to accomplish the circular ambitions. This was necessary to make space for unconventional thinking. Next, communication was very important. This way a learning and creative project and organization arose with enthusiasm. A learning point was that it cost a lot of time to define circularity at the start to implement this in the project. Because the client was looking for the definition of circularity, they held the project open for new ideas for as long as possible. For example, the program requirements were not written at the start. The starting point was that everything was possible, to stimulate advisors to investigate different options.

6.1.3.8 Summary project C

For project C, a round table organizational model was chosen where within the entire group decisions were discussed for all the disciplines. The group consisted of enthusiastic people with the same aim. It was not always like this. Circularity only became an aim after the entire project team was removed from project C and replaced. The project then became about not only being profitable, but also about the circular economy and being future proof. The interviewees believe project C is an innovative and ambitious experiment, however some conflicts arose during the project between the main contractor and the secondary material supplier. The main contractor used its traditional contracts, which were too conventional for secondary materials. Besides, the employees of the main contractor did not understand the circular principles and they were not willing to help on this theme. A lot of friction took place between the main contractor and the secondary material supplier. They concluded that the people working on a project are the determining factor of success. It is very important that everyone involved in the project understands the philosophy. That way, in the entire chain, all decisions and considerations are done according to the circular principles.

Besides, during project C, the risks in the project were jointly put on the table. The client took on many risks to make sure innovation and creativity was not restricted. The client, architect, advisors and main contractor made agreements called the Agreement Circular Construction. One of these parts is transparency, this was very important in the project. This was also one of the lessons learned, trust and transparency, as a client they trusted the knowledge and potential of the suppliers. This was necessary to give people the space to think unconventional. During the process, money was not the main criteria, the circular way of thinking was in this project at least as important.

For the PMBoK+ themes, some conclusions can be draw as well. The entire analysis is shown in appendix F.3. The summary of the analysis is shown in Table 7. First, the requirements from the client were written very briefly, they were more ambitions than requirements. This was done to stimulate creativeness and innovation. For the Project Time Management is more plausible that it happened in the traditional way, where all the steps from the framework were followed. The Project Cost Management the steps of the framework where followed, for that it is more plausible that the traditional project method is chosen. However, there is one large difference: the budget was known to everyone and very transparent. For the Project Quality Management, circularity (shown in the project document) was one of the five criteria to what solutions and designs were reviewed. For HR Management in this project, responsibilities were shared among the project team members. The (second) team was formed with very enthusiastic people.
In the end it is more likely, according to the interviewees, that the risks were for the client. People were removed from the project that did not understand the circular principles. Team composition and collaboration models are very important. Procurement is done earlier in the process. The tenders were evaluated based on the philosophy of circularity and innovation. The tender was focused on finding circular solutions. The tenders were done together with the project team. Moreover, the suppliers were not tendered on most economic tender. For the secondary materials, traditional and fixed contracts were used by the main contractor. Other contracts should have been used for this for circular building materials. A re-buy obligation was an aim by the client, but unfortunately this did not work.

For the Project Integration Management, knowledge of the project is more plausible to be shared in a transparent way. Lastly, for the Project Financial Management, some other steps were taken compared to the PMBoK+ framework. The client was willing to take risks, to make sure parties were working in the most innovative way. The risks taken were substantial because the project contained a lot of new techniques for circularity that were never applied on this scale before. However, in the contracts of the main-contractor all the risks were for the suppliers. For Project Communication Management, Project HSSE Management and Project Risk Management, it is more plausible that the steps from the PMBoK+ framework were followed. It was a very large project with experienced parties, so these themes are standard within their projects.
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<td>Control scope</td>
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<tr>
<td>Project Time Management</td>
<td>Define activities</td>
<td>≥</td>
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<td>Sequence activities</td>
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<td>Estimate activity resources</td>
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<td>Estimate activity durations</td>
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<td>Develop schedule</td>
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<td>Control schedule</td>
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<td>Determine budget</td>
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<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Project Risk Management</td>
<td>Plan risk management</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Identify risks</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Perform qualitative risk analysis</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Perform quantitative risk analysis</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Plan risk responses</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Monitor and control risks</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Procurement Management</td>
<td>Procurement planning</td>
<td>Yes</td>
<td>Yes, however procurement was done earlier in the process. After the design team switched, committed parties were chosen.</td>
</tr>
<tr>
<td></td>
<td>Solicitation planning</td>
<td>Yes</td>
<td>Yes, earlier in the process.</td>
</tr>
<tr>
<td></td>
<td>Solicitation</td>
<td>Yes</td>
<td>Yes, this was done with the entire project team.</td>
</tr>
<tr>
<td></td>
<td>Source selection</td>
<td>Yes</td>
<td>Yes, however, done with the circular budget of the client. This was done for different requirements.</td>
</tr>
<tr>
<td></td>
<td>Contract administration</td>
<td>Yes</td>
<td>Yes, but parties had other responsibilities than in a traditional project. Moreover, some large conflicts arose because the traditional contracts by the contractor did not fit the circular materials of the suppliers.</td>
</tr>
<tr>
<td></td>
<td>Contract closeout</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Stakeholder</td>
<td>Identify the stakeholders</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Management</td>
<td>Plan stakeholder engagement</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Manage stakeholder engagement</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Monitor stakeholder engagement</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Project Integration</td>
<td>Develop project charter</td>
<td>≥</td>
<td>No</td>
</tr>
<tr>
<td>Management</td>
<td>Develop project management plan</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Direct and manage project work</td>
<td>≥</td>
<td>Yes, done in a round table model.</td>
</tr>
<tr>
<td></td>
<td>Manage project knowledge</td>
<td>≥</td>
<td>Yes, project knowledge was shared in a very open and transparent way.</td>
</tr>
<tr>
<td></td>
<td>Monitor and control project work</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Perform integrated change control</td>
<td>≠</td>
<td>Unknown. However, this is more difficult for circular projects because more changes occur.</td>
</tr>
<tr>
<td></td>
<td>Close project of phase</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Health, Safety,</td>
<td>Proactive view of health, safety</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td>Security and Environmental</td>
<td>and environmental policy compliance</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td>Management</td>
<td>Develop management plan</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>including health, safety and environment</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Financial Management</td>
<td>Financial planning</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Identify the financial</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>requirements for construction projects</td>
<td>≥</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Contract requirements and risk allocation</td>
<td>≥</td>
<td>Yes, however, this was done with conflicts. Suppliers could not guarantee their delivery and take all the risks.</td>
</tr>
<tr>
<td></td>
<td>Tax planning</td>
<td>≥</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Table 7 Project management analysis of project C (own work)*
6.1.4  Project D

Project D is a building that has been constructed with the aim to be deconstructed in 5 years and to be rebuilt on a new location. The temporary building is newly build. While the activities of the old building took place in this new building, the old building is reconstructed. From the social responsibility the client has, the aim for the project was to prevent waste. The two selection criteria were added to the tender: prevent waste and maximize the residual value of the building. After the period of use, the building can be reused as a whole on another location. The entire analysis of the project is documented in appendix F.4.

6.1.4.1  Stakeholders of project D

For this project, two stakeholders were interviewed. The interviewee 3, who was the sustainability advisor on the client side during the project. The interviewee was not always involved in the project, but incidental. The second interviewee (interviewee 6) was the project developer of project D. The interviewee was part of a consortium with the main contractor (Figure 16). The company of the interviewee represented the development side, focusing on the design part and the contractor in the consortium focused on the output (Interviewee 3).

![Figure 16 Organizational structure project D (Interviewee 6)](image)

6.1.4.2  Circular Economy

Throughout the process, the involved parties looked for ways to reduce, reuse and the recycle the materials, on each scale of the building. For example the floor system was made out of channel plates, reused from buildings that were going to be demolished. In the end, the building might have had some waste, but it is designed to be able to dismount and rebuild the building maximally (Interviewee 3). The elements of the 10R-model describe the degree of circularity of project D:

08 Rethink – The building has been designed entirely to be able to dismount and relocate to a different location. Over 60% of the building can be reused after deconstruction.

07 Re-use – About 60% of the weight of the building originate from other concrete buildings by reusing floors and beams.

02 Recycle – Several materials that have been used were recycled.

According to interviewee 3, the project was a very quick project, with little time and little money. Circularity was not the aim at the beginning. The interviewee warned his colleagues that they should make sure the project would not make the headlines of papers. It would be very bad publicity to build the construction for 5 years and after that turn it to waste. This would be a waste of tax money and an environmental burden. Because the client wants to be a frontrunner when it comes to circularity, they should lead by example. The project team agreed on this. The client decided that he was not going to become the owner of the temporary construction. By doing that, they ensured that the other stakeholders would make a design where the most value could be harvested and the design with the most quality would be ensured. Concluding, the following factors played a large role in the decision to make a circular building: reputation, costs and ecology (Interviewee 3).

In the award criteria used in this project were categorized into three subjects: the life cycle of the products that were used out of donor buildings, the environmental burdens during the life time of the building and the future of the building after this life time of 5 years.
For example, during the tender this was calculated in the following way: if the building was already sold after the life time of five years and the contract included a signature of the buyer, 100% of the total points would be received. If a contract was set up but only a signature was missing, 80% of the points would be received and so on. The downside is, you can never be sure of what happens after the life time. After life time of 5 years, it is out of the responsibility of the client (Interviewee 3). Investigation is now ongoing to see what the different possibilities are for the new location of building D (Interviewee 6).

6.1.4.3 Type of project
The project is characterized by the ability to dismount. In total, 60% of the weight of the building can be dismounted. The interviewees have been asked by email whether a dismantle guide is available, that shows the steps that need to be taken to dismount the building. Interviewee 6 explains, that because the organization is going to disassembly the building themselves, no plan is made beforehand that could be used by third parties. At this moment, they are working on a detailed disassembly and reassembly plan. During the tender this is made as well but on a global level, to mostly test the logistics of the disassembly. Now that they have a better sight on the environment and surroundings, the definitive plans can be made (Interviewee 6).

6.1.4.4 Lessons learned
One large learning for interviewee 3 is that with public procurement you cannot compose the tender to attract a certain party. With private parties you have more possibilities. Some new innovative parties make great products, but the client cannot choose that party directly. Because that would be unfair for the competition. The company of interviewee 6 had benefits to make the quality of the building as high as possible, so that the residual value would be high at the end of the life cycle of 5 years. The client wanted a building of high quality with elegance. The ambitions of the two parties were the same while having different long-term goals (Interviewee 6).

6.1.4.5 Project Management
According to interviewee 3, the only large difference between a traditional and circular project is the type of contract. For this project a DBMR contract was chosen by the client, including the R of removal (or reuse). This means another procurement concept was chosen. But this did not influence the management. If you look at the strategy on how to tender, there is a difference. The definition of the requirements is the change. In this case also the measurement instruments. The instruments are used to make ambition clear to the market (Interviewee 3). Interviewee 6 believes that the success of projects is not related to the process design. The company sees many traditional projects that are very innovative. While other very innovatively managed projects produce projects that are not of high quality. For the interviewee it is about the people, with their intelligence and effort, that make a project a success (or not). So, the interviewee believes it depends more on the people than on the process (Interviewee 6).

6.1.4.6 Project Documents
No project documents were available for this project. This was due to the large confidentiality (Interviewee 6).

6.1.4.7 Summary project D
Project D can be disassembled after five years and for that reason it can be called a circular construction. However, this cannot be decided upon until the future. First it must be known what happens with the building before it is possible to label it circular. Circularity was used in the award criteria of project D. Often circularity does not make it to the award criteria, because quality and functionality are more important. Thus, if a client has ambitions, he or she should always implement it in the criteria. A downside of public procurement is that the client cannot write a tender to attract a certain party, because the client cannot choose directly. Everything needs to be done in an honest and transparent way. A global disassembly plan was made during the tender phase, to test the logistics of the disassembly. In project D, circularity was not an aim at the start of the project. The factors that played a role in the decision to make a circular building were: reputation, costs and ecology. Both interviewees do not think there is a difference in project management nor process, between a circular construction project and a traditional construction project. Finally, it can be concluded that it is more plausible that traditional project management is used in project D. The summary of the analysis is shown in Table 8. Except for Project Procurement Management, with the DBMR type of contract, a circular method for procurement is used. The award criteria for the tender were based on this as well.
<table>
<thead>
<tr>
<th>Theme</th>
<th>Traditional project management</th>
<th>Plausible?</th>
<th>Project D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Scope Management</strong></td>
<td>Collect requirements ≥</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Define scope ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Create WBS ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Verify scope ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control scope ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Project Time Management</strong></td>
<td>Define activities ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sequence activities ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Estimate activity resources ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Estimate activity durations ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop schedule ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control schedule ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Project Cost Management</strong></td>
<td>Estimate cost ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Determine budget ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control cost ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Project Quality Management</strong></td>
<td>Plan quality ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perform quality assurance ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perform quality control ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Project Human Resource Management</strong></td>
<td>Develop HR plan ≥</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Acquire project team ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop project team ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manage project team ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Project Communication Management</strong></td>
<td>Identify stakeholders ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plan communications ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distribute information ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manage stakeholders expectation ≥</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Report performance ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Project Risk Management</strong></td>
<td>Plan risk management ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Identify risks ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perform qualitative risk analysis ≥</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perform quantitative risk analysis ≥</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plan risk responses ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor and control risks ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Project Procurement Management</strong></td>
<td>Procurement planning ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solicitation planning ≥</td>
<td></td>
<td>Procurement is done in a different way than normally. A DBMR contract was used.</td>
</tr>
<tr>
<td></td>
<td>Solicitation ≥</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Source selection ≥</td>
<td></td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Contract administration ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contract closeout ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Project Stakeholder Management</strong></td>
<td>Identify the stakeholders ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plan stakeholder engagement ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manage stakeholder engagement ≥</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor stakeholder engagement ≥</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><strong>Project Integration Management</strong></td>
<td>Develop project charter ≥</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Develop project management plan ≥</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct and manage project work ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manage project knowledge ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor and control project work ≥</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perform integrated change control ≥</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Close project of phase ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Project Health, Safety, Security and Environmental Management</strong></td>
<td>Proactive view of health, safety and environmental policy compliance ≥</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Develop management plan including health, safety and environment ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Project Financial Management</strong></td>
<td>Financial planning ≥</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Identify the financial requirements for construction projects ≥</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contract requirements and risk allocation ≥</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tax planning ≥</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8 Project management analysis of project D (own work)
6.2 Cross-case analysis

According to Yin, one of the possibilities to do a cross-case analysis is to create tables that display the data from the individual cases (2003). This should be done according to a uniform framework, in this case the PMBoK+ method with the different activities. The overall patterns in the table will lead to conclusions. Furthermore, the analysis can go further by investigating if different groups of cases show similarities and can be considered of the same type of case. A challenge for this will be that the drawing of conclusions will strongly be based on argumentative interpretation. Therefore, strong, fair and plausible arguments should be formed that are supported by data (Yin, 2003). The table showing the individual cases according to the uniform framework is shown in appendix G. In this chapter first, extra project information is documented, where arguments about the cross-case analysis are based on. Afterwards, the cross-case analysis is done and the results are documented in paragraph 6.3.

6.2.1 Project information

To be able to substantiate the different choices made in the process, a table is made with relevant project information. The information is based on the 13 interviews, project information provided by the stakeholders and external sources such as internet. This information will help to clarify the decisions made (Table 9).

<table>
<thead>
<tr>
<th></th>
<th>Project A</th>
<th>Project B</th>
<th>Project C</th>
<th>Project D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of client</td>
<td>Private</td>
<td>Public</td>
<td>Private</td>
<td>Public</td>
</tr>
<tr>
<td>Roles client</td>
<td>Owner, financier, project leader, main contractor</td>
<td>Purchaser, operator, landowner, owner</td>
<td>Owner, landowner, financier</td>
<td>Landowner, financier</td>
</tr>
<tr>
<td>Team structure</td>
<td>Triangular</td>
<td>Hierarchical</td>
<td>Circular</td>
<td>Hierarchical</td>
</tr>
<tr>
<td>Type of project</td>
<td>Temporary experiment</td>
<td>Redevelopment</td>
<td>Experiment</td>
<td>Temporary building</td>
</tr>
<tr>
<td>Surface</td>
<td>250 m²</td>
<td>11200 m²</td>
<td>3350 m²</td>
<td>5400 m²</td>
</tr>
<tr>
<td>Change in project team during project</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Contract form</td>
<td>DBMR</td>
<td>UAV-GC</td>
<td>Main contractor: UAV-GC</td>
<td>DBMR</td>
</tr>
<tr>
<td>Circularity aim from the start?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Interviewees feel that the project is a circular project?</td>
<td>3/3 yes</td>
<td>1/3 yes</td>
<td>4/5 yes</td>
<td>2/2 yes</td>
</tr>
<tr>
<td>Procurement</td>
<td>Direct contact with people from network</td>
<td>Open procedure</td>
<td>Open, asking for circular solutions</td>
<td>European procurement</td>
</tr>
<tr>
<td>Manual for deconstruction?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes, now in the making</td>
</tr>
</tbody>
</table>

Table 9: Project characteristics (own work)

6.2.2 Cross-case comparison

Based on the analysis of the different projects, the most plausible results of the four projects have been documented in Table 10. From now on, these more plausible outcomes, will be assumed to be true for the cross-case analysis. The green cells indicate the activities of the PMBoK+ framework that were executed in the same way as the framework. These are assumed to be executed according to the traditional project management method. The red cells indicate the activities of the PMBoK+ framework that have not been done according to the steps in the framework. For the orange cells, no conclusion can be drawn. For these activities the interviewees gave contradictory answers. The most important cells are the yellow cells. For these, the interviewees explained that new or circular alterations have been made compared to the steps they traditionally would take. These yellow cells will be discussed further in this chapter, to investigate what happened that is different to a traditional approach. This is done in chapter 6.3.
<table>
<thead>
<tr>
<th>Theme</th>
<th>Traditional project management</th>
<th>Project A</th>
<th>Project B</th>
<th>Project C</th>
<th>Project D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Scope Management</td>
<td>Collect requirements</td>
<td>Yes, but no specific requirements, three short requirements.</td>
<td>Yes. Yes, more ambitions than requirements. Three short ambitions.</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Define scope</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Create WBS</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Verify scope</td>
<td>No, but due to project characteristics.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Control scope</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Time Management</td>
<td>Define activities</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Sequence activities</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Estimate activity resources</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Estimate activity durations</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Develop schedule</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Control schedule</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Cost Management</td>
<td>Estimate cost</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Determine budget</td>
<td>Yes, the budget was open for everyone and the entire project team was responsible for the budget.</td>
<td>Yes, in a transparent way for the team.</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control cost</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Quality Management</td>
<td>Plan quality</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Perform quality assurance</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Perform quality control</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Human Resource Management</td>
<td>Develop HR plan</td>
<td>No, but due to project characteristics.</td>
<td>Yes, if selected on knowledge and enthusiasm (of circularity).</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acquire project team</td>
<td>Yes, with committed and enthousiastic parties. Only parties asked out of own network.</td>
<td>Yes</td>
<td>Yes, however the entire project team changed during the project.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Develop project team</td>
<td>Yes, with committed and enthousiastic parties. Only parties asked out of own network.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Manage project team</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Communication Management</td>
<td>Identify stakeholders</td>
<td>Yes</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Plan communications</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Distribute information</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Manage stakeholders expectation</td>
<td>No, but due to project characteristics.</td>
<td>Yes, however the entire project team changed during the project.</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Report performance</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Project Risk Management</td>
<td>Plan risk management</td>
<td>Only costs were managed in the risk management.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Identify risks</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Perform qualitative risk analysis</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Perform quantitative risk analysis</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Plan risk responses</td>
<td>No, but due to project characteristics.</td>
<td>Unknown</td>
<td>Yes, it was done with the entire project team.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Monitor and control risks</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Procurement Management</td>
<td>Procurement planning</td>
<td>No, procurement is done by contacting their own network and looking for comittable parties that were willing to lend their products and materials.</td>
<td>Yes, however procurement was done earlier in the process.</td>
<td>DBMR contract</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solicitation planning</td>
<td>No, parties contacted earlier in the project. Before making the design they had to know what materials they could borrow.</td>
<td>Yes</td>
<td>Yes, earlier in the process.</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Solicitation</td>
<td>No, not done the traditional way.</td>
<td>Yes</td>
<td>Yes, it was done with the entire project team.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Source selection</td>
<td>No, this was done with the entire project team.</td>
<td>Yes</td>
<td>Yes, however, done with the circular budget of the client.</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>Contract administration</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Contract closeout</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Stakeholder Management</td>
<td>Identify the stakeholders</td>
<td>No, but due to project characteristics.</td>
<td>Yes</td>
<td>Yes, however, done with the circular budget of the client.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Plan stakeholder engagement</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Manage stakeholder engagement</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Monitor stakeholder engagement</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Integration Management</td>
<td>Develop project management plan</td>
<td>No, but due to project characteristics.</td>
<td>Yes</td>
<td>Unknown</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Direct and manage project work</td>
<td>No, project work and knowledge was not really managed, it was professionals working together with the same aim to achieve the same goal.</td>
<td>Yes, in a transparent way.</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manage project knowledge</td>
<td>Yes, project knowledge was shared in a very open and transparent way.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Monitor and control project work</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Perform integrated change control</td>
<td>No, but due to project characteristics.</td>
<td>Unknown. However, this is more difficult for circular projects because more changes occur.</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Close project of phase</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Health, Safety, Security and Environmental Management</td>
<td>Proactive view of health, safety and environmental policy compliance</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Develop management plan including health, safety and environment</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Financial Management</td>
<td>Financial planning</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Identify the financial requirements for construction projects</td>
<td>No, but due to project characteristics.</td>
<td>Yes</td>
<td>Unknown</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Contract requirements and risk allocation</td>
<td>Yes, all the risks were for the client.</td>
<td>Yes</td>
<td>Yes, the client took on a lot of risks. However, this was done with conflicts. Suppliers could not guarantee their delivery and take all the risks.</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 10 Cross-case comparison (own work)
6.2.3 Grouping of the projects

Based on the project characteristics of Table 9 and the cross-case comparison of Table 10, it becomes visible that the four cases can be grouped into two categories indicating whether a traditional approach is used or a circular approach. Project B and D show many similarities. First, it is concluded to be more likely that traditional project management is used in both projects. Almost all the activities within the 12 themes of PMBoK+ have been followed. This can be explained by the project characteristics. To start with, the clients of projects B and D are both large public organizations. For that reason, they needed to use public procurement and they are not allowed to select the project team directly. For public organizations societal value is the most important interest. This is different to private parties, where other values exist such as profit and marketing. Both projects have hierarchical organization structures with the client on top and below all the other parties involved. Projects B and D have a larger net floor area than project A and C. Another striking similarity was found, for project B and D no documents were provided by the interviewees to investigate. The only data used was the data obtained from the interviews.

There are two large differences between projects B and D. To start with, project D is more likely to be a circular project, since two out of two respondents describe the project as a circular project. For project B, one out of three respondents believe the project is a (partly) circular project. The second large difference is that in project D a new contract type was used, that made sure the project was removed after five years, a DBMR contract. For this tender, requirements were set that made sure the tenderers made use of the circular principles. For project D, circularity never was an aim during the process. An UAV-GC contract was used.

For projects B and D it can be concluded that the projects are both circular construction projects, where no circular process was used, but traditional project management instead.

Project A and C have some similarities. Firstly, as the cross-case comparison in Table 9 shows, both projects have done many modifications to the PMBoK+ framework, which the respondents call circular adjustments. Accordingly, there need to be investigated to draw conclusions on why they happened and if it is really a change to traditional project management. A large similarity is that both projects are experiments, according to the interviewees. Projects A and C are planned and carried out (during the process, since circularity was not an aim at the start) because the clients had the ambition to show the construction sector that it is possible to deliver circular constructions. The experiments have been performed with enthusiastic and committed parties, that shared the circular economy philosophy and were engaged to show the industry that circular constructions are the future.

There are some differences in experimental projects compared to traditional projects. Usually, the list of requirements is less strict compared to traditional projects. In the initiation form, conditions are created that are friendly and favorable for the implementation of circularity or sustainability. The goal of experimental projects is to create an environment where it is the aim to make the experiment a success. In project A and C, it is visible that the budget was less strict compared to other projects. Money was not the number one criterion. Suppliers and subcontractors were not selected with the most economically advantageous tender method. They were selected on their ability to identify and design circular solutions and their circular commitment. Due to the media attention of both projects, parties involved were willing to take more risks and to invest more in the project.

Both projects made use of a new type of organizational structure, which is not hierarchical. For project A, a triangular project team with 3 teams was chosen and the organizational structure of project C consisted of a circular project team with 7 organizations at the ring and in the center the two project management organizations. The client chose this type of structure to make sure transparent and innovative management could be done with open communication. Both projects selected the design team by looking for enthusiastic people that shared the circular vision. In both projects, the subcontractors and suppliers were selected with the entire project team. For projects A and C it can be said that the projects are circular construction projects where a circular process is applied.

Concluding, projects B and D are labeled circular construction projects with public entities as client. These two projects show similar characteristics. Project A and C are labeled experimental circular construction project. Based on these two characterizations, the comparison is made between theory and practice.
6.3 Comparison theory to practice

Based on the characteristics of the projects described in chapter 6.1, the grouping in 6.2 and the project outcomes visible in Table 10, the comparison is made between theory and practice. In the previous paragraphs, the aim was to find out what projects made use of a circular project approach, compared to traditional project management. The subdivision is made between projects B & D and projects A & C. In projects B and D, it is more likely that traditional project management is used. One circular activity took place, which was the use of a DBMR contract in project D. However, the use of a DBMR contract only does not imply a circular approach was used. The award criteria chosen for this project were: the life cycle of the products that were used out of donor buildings, environmental burdens during the life time of the building and the future of the building after the five years. Like interviewee 3 (working at the client company) said, a DBMR contract does not change the management, it is only a different procurement strategy. Adding two tender requirements does not mean the process changes.

The next step is to find out what alteration to traditional project management is used for projects A and C. For the comparison, the following project management themes from the PMBoK+ framework can be assumed to be done in the traditional way in the experimental projects: Project Time Management, Project Risk Management, Project Communication Management, Project Stakeholder Management and Project Health and Safety, Security and Environmental Management. These themes will not be discussed and will be labeled traditional project management. Because of that reason, these are deleted from the cross-case table. The table that follows (Table 11), only shows the activities where the interviewees indicated changes were made because the project was done in accordance with circular principles. For the experimental projects (A&C) the activities with the yellow cells are discussed in the chapter below. Two activities have not been further analyzed because the researcher believes no significant changes need to be made to project management when applying these. The first one is Project Quality Management. In project C, circularity was one of the 5 criteria set for the project. However, this does not change the management of Quality, it is just an extra criterion. Second, for project A, according to the interviewees project work and knowledge is not managed. This was unnecessary because of the size and characteristics of the project. However, for other projects, knowledge will always need to be managed.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Traditional project management</th>
<th>Project A</th>
<th>Project B</th>
<th>Project C</th>
<th>Project D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Scope Management</td>
<td>Collect requirements</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No, but no specific requirements, three short requirements.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Cost Management</td>
<td>Determine budget</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Unknown, in an open and transparent manner.</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Quality Management</td>
<td>Plan quality</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, based on the circularity of the project as one of the 5 criteria.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project HR Management</td>
<td>Acquire project team</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, with committed and enthusiastic parties. Only parties asked out of own network.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, selected on knowledge and enthusiasm (of circularity).</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Develop project team</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, with committed and enthusiastic parties. Only parties asked out of own network.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, however the entire project team changed during the project.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Procurement Management</td>
<td>Procurement planning</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, procurement is done by contacting their own network and looking for committed parties that were willing to lend their products and materials.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>DBMR contract</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Solicitation planning</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, parties contacted earlier in the project. Before making the design they had to know what materials they could borrow.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, earlier in the process.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Solicitation</td>
<td>No, not done the traditional way.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, this was done with the entire project team.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Source selection</td>
<td>No, this was done with the entire project team.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, however, done with the circular budget of the client. This was done for different requirements.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Contract administration</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, but parties had other responsibilities than in a traditional project. Moreover, some large conflicts arose because the traditional contracts by the contractor did not fit the circular materials of the suppliers.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Integration Management</td>
<td>Direct and manage project work</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, in a triangular organization structure.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, done in a round table model.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Financial Management</td>
<td>Manage project knowledge</td>
<td>No, project work and knowledge was not really managed, it was professionals working together with the same aim to achieve the same goal.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, project knowledge was shared in a very open and transparent way.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Monitor and control project work</td>
<td>No, project work and knowledge was not really managed, it was professionals working together with the same aim to achieve the same goal.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Perform integrated change control</td>
<td>No, but due to project characteristics.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Unknown, however, this is more difficult for circular projects because more changes occur.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Financial Management</td>
<td>Contract requirements and risk allocation</td>
<td>Yes, all the risks were for the client. Moreover, everyone was responsible for the budget.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes, the client took on a lot of risks. However, this was done with conflicts. Suppliers could not guarantee their delivery and take all the risks.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 11 Cross-case comparison of activities were according to the interviewee’s circular steps were taken (own work)
In the following subchapter, the different PMBoK+ themes are discussed which were adjusted because of the circular characteristics of the project. The standard PMBoK+ activities per theme are indicated in blue. The activities in the yellow boxes are the added circular activities, based on projects A and C.

6.3.1 Project Scope Management
For Project Scope Management, interviewees from project A as well as from project C, indicated that the collection of requirements was done in a different manner compared to traditional project management. In traditional project management as defined by the PMBoK+ framework, the client sets detailed requirements for the project. This is the process of documenting, determining and managing client requirements to meet project ambitions. It is the basis for defining the project scope (Project Management Institute, 2017). This is done, however differently than described in the PMBoK book. For projects A and C, both clients define three very short ambitions. They called it program of ambitions instead of program of requirements. The three ambitions were defined instead of detailed requirements, to allow involved parties to innovate during the project and to implement new techniques. By setting detailed requirements, many options and solutions are excluded (Interviewee 8). If the project definition is defined together with the project team, it could lead to innovative and intelligent ideas (Interviewee 4). Later, it is useful to define the project requirements with the project team, to use the team’s experiences and knowledge. It can be concluded that for experimental circular projects, brief high-level project ambitions should be defined instead of extensive requirements. Secondly, the project requirements should be defined within the project team (Figure 17).

6.3.2 Project Cost Management
In the two experimental projects, Project Cost Management is done according to the traditional steps defined by PMBoK+. However, in project A and project C, the budget was accessible, available and transparent for the project team. The interviewees of both projects described that this was done to increase shared responsibility. Instead of only the client, more parties were responsible for the budget. In project C, the purchasing departments of the client and the main contractor were bargaining together with the subcontractors. This was a completely transparent process (Interviewee 12). In project A this was the same, the budget was transparent and all project team members could investigate the budget (Interviewee 4). It can be concluded that for the experimental projects is chosen for a transparent budget to increase commitment and responsibility. By that increase, more creative solutions for the budget can be found with the project team (Figure 18).
6.3.3 Project Human Resource Management

In the process of Project Human Resource Management, some steps have been performed differently. The activities that were different to the traditional framework are ‘Acquire project team’ and ‘Develop project team’. For both project A and C, the project team was formed with enthusiastic and committed parties that had the same philosophy about the re-thinking process that is required to move towards a circular economy. Besides, the project teams were selected on the knowledge and experience in constructing according to the circular principles. To illustrate the importance of having a committed project team, project C started out with a traditional project team. During the process they found out that this project team did not have the same philosophy and ambitions as the client. Because of that, they were asked to leave and a new committed and ambitious project team was formed. It is very important that everyone involved in the project understands the philosophy. That way, in the entire chain, all decisions and considerations are done according to the circular principles (Interviewee 9).

In the preparation phase of project C, terms such as circularity, circular economy and circular building have been explained to the project team, work groups and internal stakeholders. Definitions by the Ellen MacArthur Foundation have been used to do this (Anonymized reference). Yet, this did not work out completely well in project C. As explained by interviewee 13, some conflicts occurred between the secondary material supplier and the main contractor. The main contractor is a very traditional company where on execution level people worked with the old mentality. The people on site did not understand the circular economy mindset and were not willing to help with this (Interviewee 13). Consequently, it can be concluded that everyone involved in the project should be selected based on circular economy commitment, vision and philosophy (Figure 19).

![Figure 19 Circular Project Human Resource Management (own work)](image)

6.3.4 Project Procurement Management

For this theme in project A and project C, changes have been made to traditional project management. In project A, procurement is done by contracting people from the direct network of the client and architects. They looked for committed and enthusiastic parties that were willing to lend their products and materials. Suppliers were contracted earlier in the process. After knowing what exact materials could be borrowed, the design was finished. The source selection was done with the entire project team (Interviewee 1).

Some similar steps were taken by the project team C. Normally, clients of large constructions have the obligation to perform public procurement, to create a level playing field for businesses across Europe (European Commission, s.d.). However, the client of project C did not have the obligation to procure publicly but they did use the company tender policy. Architects and advisors were involved very early and after the first designs, other parties were invited to the table. For a long time of the process there were no program requirements, this gave the potential to discover all the possible options and solutions. A starting point for this was that everything should be possible. The circularity of the project is shaped in the procurement process by choosing some starting points in advance, to be able to speak a common language. These starting points have been defined for four phases: preparation phase, specification phase, selection phase and contracting phase. In the specification phase, the client did not know what circular solutions or innovations the market had to offer. Therefore, they aimed at specifying at a high level by asking questions such as ‘What do we need?’ and ‘For how long do we need the functionality?’ In the end, the circular solutions are evaluated for the combination design, production phase, user phase and the phase after use (Anonymized reference).
By tendering on functionality, the client of project C made space for new business- and revenue models. The client defined five circular revenue models: circular input, product as a service system, lifetime extension, sharing platforms and value recovery. Besides, executing parties such as subcontractors and suppliers were involved as soon as possible. In the contracting phase, the market is challenged to come with new contract forms such as product service systems, performance contracts, pay-per-use contracts and agreements on high-quality reuse (Anonymized reference). The client of the project tried to use rebuy obligations to the suppliers of the products. Unfortunately, this did not work out because there is no business model for this (Interviewee 9).

The election on suppliers and subcontractors is done in close consultation with the project team. The procurement of, among others, timber construction, facades, elevators, lighting, roofing and solar panels is done collectively with the project team (Anonymized reference).

Moreover, in project C traditional contracts were used for secondary products. The secondary material supplier had to bear all the risks for the new products. This led to a great deal of friction between the two companies.

Hence, for this part can be concluded that the tender process needs to be done early in the project phase to involve suppliers earlier in the process. Besides, new contracting forms should be used to make sure the building is removed in the best possible way or that the materials are bought back at the end of the life cycle by the original suppliers. Lastly, also the suppliers and subcontractors should be fully committed to the circular way of thinking. They should be selected on this during the tender procedure, so the tender procedure should be designed for this (Figure 20).

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6.3.5 Project Integration Management

In project A and C, project work is directed and managed differently compared to traditional projects. Both projects were organized in non-hierarchical organization forms. For project A, a triangular structure was chosen and for project C a round table model was used. Both structures were based on team work, shared responsibility and creative process. For project C, project work was always shared in an open and transparent way. One of the aims was to share as much knowledge as possible and give market parties the opportunities to catch up on their knowledge deficit and apply the new knowledge to the own organization (Anonymized reference). Finally, special attention should be payed to change control. There is a large uncertainty about the supplies when you wish to use secondary materials or products. It is always unsure when materials will be available from donor buildings and what the exact state of the materials will be. Due to the high uncertainty, more changes can occur. Because of this, the role of the project manager transforms, change management is usually not in the scope of the project manager. However, for circular construction projects (in the transition phase we are currently in) change management becomes more and more important (Interviewee 13). Based on the experimental circular projects, it can be concluded that project work should be managed in open and cooperative organizational structures, project knowledge should be shared in an open way and special attention should be payed to change control of available products and materials (Figure 21).
Finally, for Project Financial Management, a large change was made in project A and C compared to traditional project management as explained in the PMBoK+ framework. For both projects, the clients took on more risks than traditionally. Interviewee 4 explains that for project A, the risks were not legally shared but if something went wrong in the project, the risks were for the client (Interviewee 4). In project C, the client wanted to be more responsible for risks than normally. The risk level was higher because the project contained many new things, such as new circularity techniques (Interviewee 8). It is complex to say to a contractor that you want something new and innovative and the contractor needs to bear the risk as well. That is the traditional way, however, with that, innovation and creativity are restricted. A contractor or installer will always choose the safe option, instead of new options that he has never done before while bearing all the risks. The most secure option, the option with the most profit, will always be chosen. In project C, the creativity and innovation were highly stimulated. For that reason, the round table model was a good option (Interviewee 9).

However, this is the element that went wrong in project C, between the secondary material supplier and the main contractor. Interviewee 13, agreed with the client that he was going to give guarantees for the secondary products, however the risks were going to be shared with the client. The main contractor did not agree on this and this did not fit the standard contract of the main contractor. For Project Financial Management, it is concluded that a client should accept to take on more risks compared to traditional contracts to ensure creative and innovative solutions from the contractors and suppliers (Figure 22).

Figure 21 Circular Project Integration Management (own work)

**6.3.6 Project Financial Management**

Finally, for Project Financial Management, a large change was made in project A and C compared to traditional project management as explained in the PMBoK+ framework. For both projects, the clients took on more risks than traditionally. Interviewee 4 explains that for project A, the risks were not legally shared but if something went wrong in the project, the risks were for the client (Interviewee 4). In project C, the client wanted to be more responsible for risks than normally. The risk level was higher because the project contained many new things, such as new circularity techniques (Interviewee 8). It is complex to say to a contractor that you want something new and innovative and the contractor needs to bear the risk as well. That is the traditional way, however, with that, innovation and creativity are restricted. A contractor or installer will always choose the safe option, instead of new options that he has never done before while bearing all the risks. The most secure option, the option with the most profit, will always be chosen. In project C, the creativity and innovation were highly stimulated. For that reason, the round table model was a good option (Interviewee 9).

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Figure 22 Circular Project Financial Management (own work)
6.3.7 Modification PMBoK+ framework

Based on the above sub-chapters, it can be concluded that for experimental projects, the following project management framework could be used (Figure 23):

![Diagram of modified PMBoK+ framework]

Figure 23 Modification PMBoK+ framework based on project A and C (own work)
6.3.8 Results

The first two results are focused on circular construction projects:

- In practice, a distinction can be made between circular public construction projects on the one hand (B and D) and experimental circular construction projects on the other hand (A and C). For the two (partly) circular construction projects with a public party as client, in projects B and D traditional project management is used;
- Circularity should be an aim at the start of the project. All decisions during the process should be made with the circular principles in mind.

By comparing traditional project management with the management of experimental circular construction projects in practice, the following differences were found:

- The client should not make a detailed and extensive list of requirements, the client should write short ambitions he has for the project;
- Based on the ambitions, the project team should together define the project requirements;
- In circular constructions, the budget should be accessible to everyone. By doing that, the project team gets more engaged to make sure the budget is safeguarded;
- Circular economy commitment, ambition and philosophy should be present in the entire project team including the suppliers and subcontractors;
- The procurement should take place in an early phase;
- The suppliers and subcontractors should be involved early in the project. The new technologies and techniques for circularity are developed in the lower part of the chain. To make use of this new knowledge, the supplier needs to be involved in an early phase to provide input;
- In circular constructions, it is useful to select the subcontractors and suppliers with the entire project team;
- Contractual measures should be taken to assure that the project does not end demolished after its life cycle;
- The project team should use a non-hierarchical and cooperative organization structure to enlarge the responsibilities of the team;
- Share project knowledge in a transparent way;
- The project team should pay attention to change control;
- It is important that the clients are prepared to take more risks than traditionally. To make sure the suppliers and subcontractors choose the best options they have for the circularity of the project, the client should take a share of the risks of these parties;
- Risks and responsibilities should be distributed within the project team, to make sure all the involved parties come with the most innovative and circular solutions.
6.4 Are changes necessary?

The results that describe the difference in project management between traditional construction projects and circular construction projects, do not automatically mean these changes need to be executed in future projects. The aim of this final chapter of the results is to determine if changes to the traditional project approach need to be made to deliver circular construction projects.

To start with, most of the case study interviewees do not consider traditional project management a suitable approach for managing circular construction projects. In total, 11 out of the 13 interviewees believe changes need to be made to traditional project management to deliver circular construction projects. The conventional way of thinking about project management needs to be forgotten when working on circular projects (Interviewee 1). To deliver circular constructions it is required to abandon the traditional model where responsibilities are separated among the involved parties (Interviewee 4). A different project approach is vital for circular construction projects, which consumes more energy by all the parties involved, from managers and architects to users (Interviewee 5). Flexibility is more important in circular construction projects compared to traditional construction projects. A new form of cooperation needs to be designed, in which flexibility plays a large role (Interviewee 9). The people involved and their roles are important elements that need to change (Interviewee 12). The role of the project manager changes as well. The project manager gains more of an advisor role when managing circular constructions. The project manager should make the client aware of the different options and discuss the pro’s and the cons of those options (Interviewee 11).

As explained before, the dissertation by Marc van den Berg explains that the new circular construction method requires a radical new approach (Berg, 2019). To make the transition to a circular construction economy, new technology, expertise and a new socioeconomic system is required where chain partners, manufacturers, governments and clients work together (Holland Circular Hotspot, 2018). Every PMBoK+ theme where circular changes need to be made according to the case studies will be compared to literature. This is done to define what differences in practice need to become changes in future projects.

According to the UKGBC, a broad objective is necessary to achieve circular economy aspirations (UKGBC, 2019). A broad scope is required for the transition towards a circular economy. This makes room for expertise and new technologies and this room is needed for the system in which the chain partners work together in a new way (Holland Circular Hotspot, 2018). For Project Cost Management, it resulted from this research that the budget should be transparent for the project team. Research by Pots described that the procurer and the project team work together after the procurement phase to realize the maximum value. To do so, circular strategies need to be applied within the budget that is available. For this process, transparency and equality is required between the procurer and the project team to make sure the cooperation between the two is successful and effective. The availability of the maximum and/or shared budget make sure there is possibility to share the risks (Pots, 2018). For Project HR Management, for the experimental projects it was concluded that team members need to be found with the circular economy ambition, vision and commitment. This is confirmed by Pots, the aim of the tender process is to elect partners that can help the client to finish the project. In circular construction projects, the partner is selected during the initiative phase and needs to be based on qualitative criteria such as their vision or ambition on the circular economy (Pots, 2018).

Thomas Rau agrees different contracts need to be made with different agreements between parties. This needs to be done with the aim to organize things to make sure no value decrease takes place. Power and responsibility are currently separated in the system. In a circular economy everyone needs to take responsibility for the permanent consequences of their actions. Therefore, new contracts and agreements are needed. New contracts, such as product as a service, change the system from ‘take, make and dispose’ to ‘make, use and return’ (Rau, 2016). Moreover, Rau advices to lay down requests at the suppliers and let them inventory the problem and come with ideas. They are the professionals of the chain (Rau, 2016).
Finally, the UKGBC published a report which explains that new business models need to evolve for the entire construction value chain to generate a new approach to develop circular economy principles to work successfully in the built environment. Early input and buy-in is necessary from all the players with financial gains shared across the value chain. This especially applies to manufacturers and contractors of materials and building components along with designers (UKGBC, 2019). New developments need to be made about new partnerships, business models, ownership relations and forms of contract to embed circularity (Holland Circular Hotspot, 2018).

For Project Integration Management in a circular economy, the parties involved need to put the cards on the table for transparency about what they do, why they do it and what the impact is. Transparency is a very important factor in the circular economy (Tilman, 2017). Sharing experiences and knowledge are crucial to find solutions in the long-term (Holland Circular Hotspot, 2018). The design, construction and harvesting of materials need to be interlinked closely, the key for this is communication and cooperation within the project team (Fischer, 2019). For change control nothing is said in literature. Therefore, this change is not perceived as necessary for future circular construction projects. It will not be taken into account in the last chapters.

Risk sharing, transparency, early procurement, equality, functional specifications and cooperation is required in the procurement process to stimulate the construction sector to embrace and apply the circular economy principles (Pots, 2018). To enable companies to share risks an effective collaboration structure is necessary. With collaboration, companies are enabled to identify risks and benefits from collective work (Pots, 2018).

All this gives enough proof to conclude that the differences (except for change control) discussed in chapter 6.3.8 are changes that need to be applied in the project approach to deliver circular construction projects.
7. Discussion

The discussion chapter is set up in two parts. First, the findings and recommendations are validated based on four semi-structured interviews. Second, the findings of the research are discussed.

7.1 Validation

The validation is based on four semi-structured interviews with experts in the field of the circular economy in the built environment. The interviewees were not involved in any of the case studies and are independent. The first interviewee is a former Ellen MacArthur Foundation employee and currently works at the Circle Economy. The second and third interviewee work at Arup and are very much involved in the transition towards a circular economy. The fourth interviewee is responsible for the circular economy at NEN. The validation protocol interview is shown in appendix H. By interviewing people from Arup as well as external, a wider perspective is used for the validation of the findings and practical recommendations. The findings and recommendations are discussed to test the generalizability of the statements. The aim is to analyze the transferability of the differences that were found from the case studies. The findings for Project Integration Management (as documented in the findings chapter 6.3.8) are not discussed in the validation interviews. Because of a change in the cross-case methodology, in the end these findings were included in the research. The recommendations of the research are introduced in chapter 7.1.2. The conclusions from the validation interviewees are discussed in the following two paragraphs.

7.1.1 Validation of findings

The first finding discussed that for circular construction projects with public parties as a client, in the researched cases, traditional project management is used. Interviewee 1 and interviewee 3, the two Dutch interviewees agree with this finding. Interviewee 1 explains that public clients are dealing with a lot of regulation and it is more difficult to make changes. Interviewee 4 explains that she has not yet seen or heard about a Dutch construction where the public client did not use traditional project management. Interviewee 2 (based in London) and interviewee 3 (based in Milan) disagreed with the fact that public parties as clients manage projects traditionally. It can be said that this finding is suitable for the two investigated cases, but not generally.

The second finding states that circularity should be an aim at the start of the project to make sure all the decisions are made with the circular principles in mind. All the interviewees agree with this as well. Research by Arup and the EMF identified that investors, policymakers and construction clients need to lead the circular economy in the built environment. They set the direction and ambition of projects, so having circular economy principles in the project from the beginning is important (Validation interviewee 2). Interviewee 4 explains that if you have circular ambitions for the project, this needs to be used from the start until the end of the project, in all the layers. Otherwise, ambitions dilute, or decisions are made on other arguments because it might be easier, cheaper or better known or more reliable etc. (Validation interviewee 4).

The next findings are only focused on experimental construction projects. The third finding states that circular economy commitment and ambition should be present within the project team, suppliers and subcontractors. All the interviewees agree with this finding. Interviewee 1 explains that this is the aim but it can be hard to get everyone involved. One of the ways to achieve this is to make sure the entire project team has basic knowledge by getting everyone to do a circularity training. That way you can make sure that everyone in the team understands the circular economy (Validation interviewee 1). Interviewee 2 agrees as well that everyone needs to have a shared goal and ambition, because that is where you identify the mutual benefit to have aligned incentives to reach that goal (Validation interviewee 2).

The fourth finding is about the definition of requirements by clients. It is concluded that in experimental circular constructions, it is more useful to define a brief set of high-level ambitions instead of an extensive list of requirements. All the interviewees agreed on this. Interviewee 1 explains that ideally you want to organize a co-creation session to define the requirements together with the project team (Validation interviewee 1). Interviewee 2 believes that the most creative projects have outcomes cited in the brief instead of prescriptive measures (Validation interviewee 2).
Interviewee 4 thinks that the best results can be obtained when the project requirements are elaborated with the entire involved team. However, this makes it hard to decide on what grounds to select parties. Team members need to have a great deal of trust in each other. This sometimes lacks in the sector. If you do not have extensive program requirements, clients do not know exactly what to ask from the market parties. This can result in complexities (Validation interviewee 4). Interviewee 3 agrees with the finding, the client and the design team should define the requirements together (Validation interviewee 4).

The fifth finding states that the suppliers should be involved early in the process because often new technologies and techniques for circularity are developed in the lower part of the chain. All the interviewees agree on this finding. Interviewee 1 believes this must be done to make sure no unexpected events or issues will arise during the project (Validation interviewee 1). Interviewee 4 heard this from several suppliers, they are often involved too late in projects. For that reason, they are not involved in the discussion on how to make the solution as circular as possible (Validation interviewee 4). Interviewee 2 agrees on the finding as well, however, currently not many suppliers have a circular business model (Validation interviewee 2).

The next finding states that it is useful to select the subcontractors and suppliers with the entire project team. The interviewees have some different opinions about this. Interviewee 2 explains that this depends on the country, suppliers are involved at different times (Validation interviewee 2). Interviewee 4 believes that information transmission in the chain is very important in a circular process. This is partly based on trust. The more careful you work with this, the better this is expected to go. Careful does not mean that everyone should be involved but that together you determine what parties need to be selected. As a client you cannot select all the parties by yourself (Validation interviewee 4).

The budget should be transparent and accessible by everyone. That way, the project team gets more engaged to make sure the budget is safeguarded. Interviewee 1 agrees that a transparent budget is useful for the project team (Validation interviewee 1). Interviewee 2 thinks this finding is an option, but not necessarily needs to be applied. The interviewee believes that the concept is not applicable to all construction projects. She thinks it is great to be open but there needs to be a culture in the industry where that is acceptable (Validation interviewee 2). Interviewee 4 believes an open and transparent budget could help. However, this might be a large step for clients. It is something that would help in the transparency, to look together how within the budget the best solutions can be chosen. The client needs to become transparent however, it often occurs that clients are not willing to show everything. This sustains the culture that price is the most important criteria. Price will always be important, because you have an ending budget, but you can discuss openly how the best solutions can be found within the financial budget (Validation interviewee 4).

The next finding states that measures should be taken in contracts to ensure that the construction should not end up demolished and wasted after the life cycle. All the interviewees agree on this. Contracts are becoming more and more important, according to interviewee 1. Risk distribution is crucial and this should be agreed upon in the contract (Validation interviewee 1). Interviewee 4 explains this has to do with the long lifetime of buildings. When making a temporary building, the lifetime is defined so plans can be made for after the building lifetime. But in most occasions, there will not be a plan about what will happen with the construction. In those cases, it is useful if information about the end of the life of the construction is documented (Validation interviewee 4).

Finally, the last finding states that it is important that clients are prepared to take more risks than traditionally, to make sure the suppliers and subcontractors choose the best option for the circularity of a project. The interviewees did not all agree with this finding. Interviewee 1, agrees, she thinks risks should be distributed equally in the contract but not necessarily more risks for the client (Validation interviewee 1). Interviewee 2 explains that with change typically always comes more risk for any change in a business model. She does not think the client should have to take on more (Validation interviewee 2). Interviewee 4 finds this finding a bit short sighted. It is too easy to state that more risks need to be transferred to the client. The project team must make agreements about the responsibilities that need to be shared, to agree on the risks. In the end, the client is responsible about many things and clients bear a lot of risks. You need to think about the risks that exist and where they can be transferred to (Validation interviewee 4).
Interviewee 3 agrees with the finding. She adds that the suppliers will have to bear more risks when, for example, making use of product as a service contracts (Validation interviewee 3).

### 7.1.2 Validation of recommendations

The recommendations of the project are presented and discussed. The interviewees all agree that it should be recommended to discuss and agree on what circularity means to everyone involved in the project. It is important that everyone speaks the same language (Validation interviewee 1). Interviewee 2 believes it is a good idea but you are not going to have all the stakeholders involved in the delivery room of the project from the beginning. Inevitably as things progress you bring people on. She believes it is good to have it from the beginning but it is also good to always have moments and check points in time where you bring people back together (Validation interviewee 2).

For clients it is recommended to think about the consequences of the choice of contracts on the circularity of the project. The interviewees agree on this as well. According to interviewee 1, contracts are very important, it is the way to record the collaboration (Validation interviewee 1). Interviewee 2 agrees with the recommendation as well, however clients always look at the choice of contract. Even more so in the circular economy where more product as a service procurement will be used (Validation interviewee 2). Interviewee 3 adds that it is important to have a legal piece of paper, a contract, to distribute the responsibilities transparently over all the actors (Validation interviewee 3). Besides, the same recommendation is done for the main contractors. It is recommended to look for an in between contract form, that shifts part of the responsibility from the secondary material suppliers to the main contractors. According to interviewee 1, the division of risks and the way the contracts are set up need to change (Validation interviewee 1). Interviewee 2 is not sure if she is qualified to answer this question. Nobody is going to reuse a steel beam if it has not been tested. It needs to be verified or warranty needs to be given (Validation interviewee 2). Interviewee 4 agrees with the recommendation, for this counts that the responsibilities need to be shared and cannot be for one party. Together you need to look for the best solutions. If you work with secondary mining materials, you need to work differently and a part of this is the agreements on risks and responsibilities. When it comes to materials, as secondary material suppliers, you need to show what a product can do (Validation interviewee 4). Interviewee 3, adds that certification is very important, especially secondary materials should be certified before using them, for safety reasons and for the durability of the properties (Validation interviewee 3).

The next two recommendations are focused on project managers. First, it is recommended that project managers should make sure the entire project team has the same circular mindset and when conflicts arise because of this, act. The interviewees do not agree with this recommendation. It is very important that the team has the correct ambitions, according to interviewee 1. If the team does not fit within the culture of the project it is very hard to collaborate and bring the project to a success (Validation interviewee 1). Interviewee 2 adds that the responsibility depends on the responsibility given to the project manager (Validation interviewee 2). According Interviewee 4 it is important that everyone is on the same page (same ambitions). This is the responsibility of the entire team. It must be the responsibility of the entire team to make sure everyone is involved. This must be a team effort (Validation interviewee 4). Interviewee 3 believes that the project manager and the client have shared responsibility (Validation interviewee 3). Secondly, it is recommended that the leadership must change, people should be made responsible for the problem. Interviewee 1 agrees, as a project manager you want people to take responsibility. We need a lot of new skills to go from a linear economy to a circular economy. Focus is going to be more on creativity, critical thinking and making connections. These new skills are very important for leaders to be able to lead circular projects (Validation interviewee 1). According to interviewee 2, this recommendation is applicable to a lot of projects, not only to circular ones. She does agree that you should spend more time on doing things instead of reporting (Validation interviewee 2). Interviewee 4 agrees with the recommendation, the project manager cannot tell everyone what to do, because at this moment project managers do not know the answer to everything, when it comes to circularity. If the project has very extensive and detailed program requirements, a project manager can tell everyone what to do. But that is not the case with circular buildings. So together, they need to figure it out and carry responsibility to together come to the best solution (Validation interviewee 4). Interviewee 3 believes that co-creation workshops could help to achieve this (Validation interviewee 3).
7.2 Research discussion

In the first part of this paragraph, the literature study on project management of circular projects is discussed. Marieke Venselaar concluded in her article that in the two investigated cases, the circular ambition was an extra ambition that was used in the same manner of thinking about project management, instead of making changes in project management. In this research, this was the situation for project D. Circularity was an ambition but the management of the project was not adjusted to this ambition. However, the other three investigated cases do not show the same conclusion.

The dissertation by Marc van den Berg explored how information can be used to reduce, recycle or reuse building materials. In the current research, information only played a small role, as part of the Project Communication Management. This research concluded that project knowledge should be shared in a transparent way when managing experimental circular projects. This needs to be done to learn from each other to accelerate the transition towards a circular economy. This is a more high-level result compared to the result of Van den Berg’s dissertation, where he looks into the closed-loop material streams that can be leveraged by the information potentials of later and previous design stages. Finally, research by Gerding assumed that the difficulties of the implementation of circularity in projects are expected to be more related to the process and to a lesser extent to the technicalities. In the current research, this is confirmed during conversations with interviewees. Nowadays the sector is capable of making very innovative and circular solutions. Materials can be used and reused in many ways, buildings can be made energy neutral and entire buildings can be disassembled and reassembled at another location. However, the largest challenge lies in the process between a circular ambition and a circular construction. Circular ambitions tend to fade away because of the current construction processes, collaboration forms, construction parties and building methods. This research contributes to this difficulty, by giving a clear overview of the changes that need to be made to traditional project management to deliver circular construction projects.

After this, the findings of the research are discussed. The outcome of the research is indicative because the sample size is very small. The conclusions and recommendations that are going to be made indicate the differences in current project management between public circular building projects and experimental circular building projects. However, more research is necessary to make generalizable conclusions for the construction sector. The outcomes of the themes of the PMBoK+ method are based on the answers of the interviewees. The different answers of the stakeholders are merged into answers that are more likely to be true. The more interviewees said the same thing, the more plausible this answer is assumed. However, there is a possibility that these answers are wrong. If different stakeholders would have been interviewed, other answers or interpretations could have arisen because the sample size is small. It is a qualitative research, so the interpretations are substantiated with arguments. However, the conclusions are not supported with numbers and often not with documents. The conclusions are based on the credibility of the interviewees, which are substantiated with arguments.

At the start of the process, personal communication helped the interviewee in shaping and forming the research. Besides the six exploratory interviews, Thomas van Schaick and Boukje van Reijn were asked several open questions. These informal interviews gave guidance in defining the aim of this research and it helped the researcher to find a relevant research question for the current construction sector. However, because the conversations were unstructured, the problem description is more incidental and less reproducible.

Besides, project A cannot be seen as a regular circular construction project. To start with, the building was set up for nine days and after that it is disassembled. This makes the project management trajectory more well-ordered, it is possible to have a clearer overview of the entire process. The time frame from the idea to the disassembly took less than a year. Next, the building did not have a controllable indoor climate. The construction was not insulated, nor it had heating or cooling. Last, because it was part of an event, no permits or stakeholder management needed to be done. Besides all this, the project is chosen because the circular way of thinking was used and for that reason it is a circular construction project where circular ambitions and principles have been applied. In the end, four circular construction projects were selected, substantiated with the 10R-model, however, only in one (or one and a half) case a circular process was applied. This is something that the reader should keep in mind when reading the conclusions.
The aim of the research was to observe the projects to see what changes must be made to circular project management. For that reason, a perceiving research design is chosen and the decisions made in the projects are discussed. In this regard, a minor downside of the research is that the researcher did not look at what choices are advantageous for the circularity of a project or what choices are disadvantageous for the circularity of a project. The research documented what steps have been taken and based on that concluded what changes would need to be made in the future.

When talking to the different people involved in the projects, the researcher found out that project managers have their own management style. Where one likes to control every step of the project the other prefers to let go of this and trust the stakeholders. This can have some consequences on the outcomes of the project. As much as possible this is decreased by the triangulation of the outcomes, however, if the project manager was very dominant, the own project management style could have been used in the entire project. The projects had some similarities, discussed in the cross-case chapter, however they also had some dissimilarities. Some of these are: location, the external circumstances at the time of construction and the number of different parties involved. These characteristics are not considered in this research.

Not many project documents were made available. Confidentiality was one of the reasons the researcher did not receive many documents. For the projects with public entities as clients (projects B and D), no document was received. The building of project D has a public function and therefore no information could be shared. For project B, confidentiality was not the main issue. Documents were not received because the interviewee did not have the document, the interviewee did not know who had the document or the interviewee did not want to ask the other parties for documents. For this reason, the triangulation is not done as thoroughly as could have been. Some conclusions are made based on the answers of the interviewee. This is less reliable than when using project documents to compare the answers of the interviewees.

As discussed in the scope chapter, process management is not taken into consideration in this research. This research only focused on project management in the general term. However, process management could play a role in managing circular construction projects. There could be a large difference in traditional process compared to circular process. This is not investigated.

Some interviewees answered the questions of the interview from their own perspective on the project. The answers given were applicable for the project team within the company, but not for the project team of the entire project. For that reason, it was often additionally asked if the answer given applied to the company team or to the project team. However, some interviewees only knew the answers for the own company project management, but not for the project management of the project team. This was the case for the secondary material supplier of case C. This is considered in the triangulation and analysis.

The findings of the research are additions that need to be made to the PMBoK+ framework to deliver circular construction projects. The changes are mostly well-known project management solutions. Many books and articles have been written about most of the solutions, such as early supplier involvement and shared responsibilities. Most of them are not new ‘circular’ solutions, which is remarkable. Circular construction projects demand a different approach, however it seems that the ‘new’ approach is an already known approach, that could be applied to traditional projects as well. Nevertheless, in this research is concluded that the combination of known project management strategies need to be added to well the established traditional management framework for circular construction projects.

Finally, this research briefly investigated whether the perceived differences in project management need to become changes in future circular construction projects. However, this could have been done more thoroughly. Follow-up investigation should be emphasized on finding out if the differences in practice mean these differences should be applied in the future.
8. Conclusion

This chapter answers the five research questions introduced in chapter two. Throughout the research, the sub-questions are answered and utilized to develop the conclusion of the main research question.

To start with the first sub-question: ‘How is circular economy used in the built environment?’. The built environment is globally the largest consumer of raw materials. This industry, which continues to grow, is putting pressure on the availability of natural resources. The circular economy could be an approach to reduce the environmental footprint of the sector. For construction projects, building products and city development six actions could guide the transition towards a circular economy: Regenerate, Share, Optimize, Loop, Virtualize and Exchange. By including these actions in the project management of the built environment, innovation and collaboration could be scaled up to complete the transition towards a circular economy. When applying these six actions, renewable materials are used whenever possible, all energy use is based on renewable sources, natural systems are sustained and augmented when possible and waste and negative impacts are designed out.

The second sub-question reads: ‘What is traditional project management?’. Project management is a discipline consisting of a set of tools, practices and techniques that are used to plan, estimate and control project activities. In this research, traditional project management is defined with the help of the Project Management Body of Knowledge framework (PMBoK), which is a set of techniques and tools that can be applied to an activity that seeks an end product, service or outcome. The PMBoK framework consists of 10 project management themes, which contain different activities that ought to be followed. The latter two themes are added based on an extension for construction projects. The following twelve themes are used in this research to define traditional project management (PMBoK+ framework):

- Project Scope Management
- Project Time Management
- Project Cost Management
- Project Quality Management
- Project Human Resource Management
- Project Communication Management
- Project Risk Management
- Project Procurement Management
- Project Stakeholder Management
- Project Integration Management
- Project Financial Management
- Project Health, Safety, Security and Environmental Management

The third sub-question that is answered is the following: ‘Is there a difference in project management between traditional construction projects and circular construction projects?’. The four analyzed projects are (partly) circular construction projects (based on the 10R-model). However, not all four cases made use of a circular process. A distribution is made between the four projects. In projects B and D, which are projects with public entities as owners, traditional project management is used. For these projects there is no difference in management between traditional project management and circular project management. This is different for projects A and C. These two projects can be characterized as experimental circular construction projects. For the experimental circular construction projects, a circular process was used. Alterations were made to the PMBoK+ framework, used to define traditional project management. These alterations were done in the following themes: Scope, Cost, Human Resource, Procurement, Integration and Financial management. For the other themes traditional project management was applied.

The fourth and final sub-question is: ‘Do these differences warrant a need for change in project management?’.

The third sub-question analyzed the differences in management in practice, between traditional construction projects and circular construction projects. Although, these differences do not automatically imply something needs to change in project management, during the case study interviews, 11 out of 13 interviewees concluded that the traditional project approach needs to change to deliver circular construction projects. This is also substantiated by literature. Experts in the field of circular constructions like Thomas Rau and Marc van den Berg and organizations such as UKGBC believe the traditional approach needs to change.
All the alterations of the PMBoK+ method are substantiated by literature, except for ‘pay attention to change control’ as part of the Project Integration theme. Because of that, all the determined differences in project management between the PMBoK+ framework and the project approach applied in cases A and C (sub-question 3) will be considered changes that must be made in practice, except for ‘pay attention to change control’.

Based on the answers on the sub-questions, the main research question is answered:

*What changes must be made to the management of projects, compared to traditional project management, to deliver circular construction projects?*

The main question is answered based on the analysis of the experimental circular construction projects (projects A and C). The additions that need to be made to traditional project management to deliver circular construction projects are listed below:

The objective to develop a circular construction should be an aim at the start of the project. This should be done explicitly to make sure ambitions do not dilute. For the scope, the client should define ambitions (instead of detailed requirements) and once the project team is selected, the requirements should be defined together with the entire project team. For Project Cost Management, the budget should be accessible by the project team in a transparent way. This needs to be done in a trustful environment. The project team should consist of people with parallel circular economy commitment, vision and philosophy, as part of the Human Resource Management. The procurement process should be different from the traditional process: plan the tender process early in the project and involve suppliers early in the project. Parties such as suppliers and subcontractors should be selected with the entire project team. Finally, new contract forms should be used to ensure that the building is not demolished after its life cycle. For Project Integration Management, non-hierarchical and cooperative organizational structures should be used where project knowledge is shared in a transparent way. Lastly, for Project Financial Management, responsibilities and risks should be transparently shared between the involved parties.

It is observed during this research that the difficulty of circularity in the construction sector is only partly related to the technicalities. The complication of the transition towards a circular built environment lies in the process of a circular construction project in terms of cooperation, finding the right parties, procurement and project approach. The outcomes of this thesis report provide actionable knowledge on what alterations need to be made to traditional project management to deliver circular construction projects.
9. Recommendations

The first part of the recommendations describes the recommendations made for practice. First, general recommendations are given for project teams that are involved in circular construction projects. After, recommendations are documented different types of organizations in a construction project. These are done for clients, main contractors and project managers. Subsequently, recommendations are done for further research.

9.1 Recommendations for practice

For the parties in the current building sector, some general recommendations can be made. The first recommendation is to discuss with the entire project team what circularity means to everyone. Based on this, define an interpretation that will be used with the entire team during the complete process. Many different definitions and interpretations exist. By using one clear translation for the project, no misunderstandings can arise because of this. Next to the definition, a strategy or roadmap can be chosen to make sure the entire team is on the same page during the process. This is important to make sure everyone involved speaks the same language. However, not all the stakeholders are going to be involved at the start of the project. It is good to, besides the definition at the start of the project, plan moments and checkpoints to bring people back together to evaluate and document the process concerning the circular economy.

It is recommended to make sure the integrated project team has the same mindset and knows the same principles of the circular economy. It is the entire team’s responsibility to verify if everyone has the same commitment, and if not, act. For example, during the conflicts between the main contractor and the secondary material suppliers in project C, someone from the project team should have stepped in, for example the project manager or the client. If the secondary material suppliers agreed on certain risk distribution with the client and the main contractor does not agree on this, in this case, someone should have interfered. It should be the responsibility of the entire team to make sure everyone is involved. This type of conflict has a very negative influence on the commitment, teamwork and creative process and should be avoided.

The involved project members should ask beforehand the ambition of the client in respect to the level of circularity and what the structure is of the project team. So that the organizations can prepare their own organization for this and educated guesses can be made for the opportunities and the risks of the project. It is very important to know the bigger picture and to know who is involved. The organizational structure is important for every party to know beforehand. If you are integrally part of the team, it is important to know who part of the team is and how the process works. The type of organizational structure is important in a circular project to make sure everybody has the same responsibility and decision making is done with all the involved parties.

9.1.1 Recommendations for clients and contractors

Clients and contractors must be aware of the type of contracts they choose. For example, interviewee 11 explains that the connection between an UAV-GC contract and circularity is very complicated. The client must think about the consequences of the choice of contract on the circularity of a project. A client must always deliberate this choice, but even more so in circular projects where for example more product as a service procurement is going to be used. The standard contracts for suppliers and subcontractors need to change. When making use of secondary materials, it is impossible for the supplier to give guarantees and bear all the risks of the secondary materials and products. An in-between form should be used for this, so a part of the risk must be shifted to another party. However, this cannot be done easily, you cannot just transfer responsibility. The products and materials need to be tested, verified and certified before they can be used. This is also one of the points where further research should be done, to find out what contracts are suitable to work with secondary material companies and what certification is necessary to safely use these materials.

9.1.2 Recommendations for project managers

A recommendation for the project manager is that the type of leadership must change. Instead of making a PowerPoint and presenting what every discipline needs to do, people should be made and commit to be responsible for the problem.
By solving the problems together, better teamwork with creative solutions is assured. New skills are needed to go from a linear economy to a traditional economy. The focus is going to be more on critical thinking, creativity and making connections. Project managers can play an important role in circular construction projects. By having a lot of knowledge about circularity and being aware of the long-term consequences of circularity on a project, they can bring people together to successfully deliver the projects.

As a project manager you want people to take responsibility. In a linear project, the requirements are detailed and extensive and as a result the project manager can tell everyone what to do. In circular projects, the project manager does not know the answer to everything. Together they need to figure out the steps that need to be taken and the team needs to jointly carry responsibility to come to the best solutions.

9.2 Recommendations for further research

The recommendations will cover aspects that could be included in future research to improve and build on the findings of this research. The first recommendation is about successful circular project management. This research only looked at the way the process was designed in terms of project management. An analysis is done to investigate what steps were taken by the involved parties, in relation to the circular construction. However, the investigation did not analyze what project management steps and decision helped the project to be successful and thus had positive effect on the circularity. Nor the other way around, what steps taken had a negative influence on the circularity of the project. It can therefore not be concluded what steps have been successful and which ones did not. So, more research is necessary to find out what successful circular project management is.

The second recommendation is related to organizational structures. It is unknown what the effect is of the organizational structure on the circularity of the project. Can decisions better be made in a hierarchical model or in a non-hierarchical model? This is discussed as well by validation interviewee 2. The organizational structure is important for every party to know beforehand because a circular business model, whether you are supplier, client, whoever, you need to have the right organizational structure to maintain the business model. Organizational structures have everything to do with it, to be able to supply circular products (Validation interview 2, personal communication, 2019). Future research should be done on circular organizational structures.

Possibilities in ownership should be analyzed, to investigate how the quality of the buildings and products can be as high as possible. For example, in project D, the ownership of the construction is transferred from the client to the consortium. For that reason, the consortium is responsible for the construction after 5 years. The quality was aimed as high as possible to make the displacement of the construction possible. Therefore, other types of shifting in ownership should be analyzed.

This research aimed at investigating the broad definition of project management, to find out if there is a difference in practice between traditional construction projects and circular construction projects. By looking at the wide definition of project management, a more general overview is created of this difference. It is recommended to do research into the specific themes of project managers. The researcher would recommend looking more into the themes that changed in experimental projects in this research. These are: Project Scope Management, Project Cost Management, Project Human Resource Management, Project Procurement Management, Project Integration Management and Project Financial Management. When looking at these themes in detail, interesting conclusions could arise that could build further on the conclusions of this research, by adding new knowledge. It seems that procurement has a lot of effect on the circularity of the project. To start with, more research should be done to investigate this topic in more detail.

Finally, the conclusions of this research are aimed at experimental circular constructions. It would be very interesting to find out if these conclusions could also be implemented in circular construction projects with public entities as clients. Further research should be done in the future, in the form of a pilot study. The PMBoK+ framework including the circularity activities of Figure 23 could be used in a pilot study, to find out if the extension of the framework is also suitable for non-experimental projects.


Pots, J. (2018). How procurement processes can realize a transition arena that is required in order to stimulate the transition to a circular economy. Enschede: University of Twente.


Interview references:

A.3. (2019, 10-05-2019) Exploratory Interview Carlijn van der Werff

C.1. (2019, 07-08-2019) Case study interview – interviewee 1
C.4. (2019, 30-08-2019) Case study interview – interviewee 4

G.1. (2019, 17-10-2019) Validation interview - interviewee 1

Anonymized reference -
These references are known by the author of the thesis. The references have been anonymized because of the anonymization of the cases. Therefore, no names are mentioned in the report.

Photo cover-
Project reference: Metropol Parasol Sevilla
Source: Handluggageonly.co.uk
Appendix A: Exploratory interviews

The exploratory interview goal is to gain insight in the current situation. The data collected with the exploratory interviews are used to define the research goal and research questions. A semi structured interview method is used. This method was used to promote the interviewees to talk into perspectives and in their own words. Interviewees have been selected based on the following requirements:

- High level of experience in construction projects
- Involvement in circular constructions
- Variation in functions in project organization

The interviews were performed face-to-face. After a short introduction of the research including background information, goals and main research question, the interview started. The interviews were recorded after asking the interviewee. Because the interviews were performed in a semi-structured way, there was not a strict interview guide with questions. A list of themes was set up that the interviewees needed to discuss. The themes were:

- Current trends of circularity in the built environment
- Circular building demand
- Supply of parties that are known with circularity
- The future of circular economy in the built environment
- Learning development of circular economy in built environment by stakeholders
- Construction clients
- Stakeholders

A summary of the interviews is in the chapters below. After the analysis of these interviews, a summary of all the interviews was written in chapter 3 of the report.

A summary of the exploratory interview details is shown below.

<table>
<thead>
<tr>
<th>Company</th>
<th>Name</th>
<th>Function</th>
<th>Circular function</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arup</td>
<td>Carol Lemmens</td>
<td>Global Management</td>
<td>Carol spearheads Arup's circular economy work</td>
<td>A.1</td>
</tr>
<tr>
<td>Arup</td>
<td>Edwin Thie</td>
<td>Structural Engineer</td>
<td>Arup Circular Team</td>
<td>A.2</td>
</tr>
<tr>
<td>Arup</td>
<td>Carlijn van der Werff</td>
<td>Building Physics</td>
<td>Arup Circular Team</td>
<td>A.3</td>
</tr>
<tr>
<td>Arup</td>
<td>Salome Galjaard</td>
<td>Design Integrator</td>
<td>Arup Circular Team</td>
<td>A.4</td>
</tr>
<tr>
<td>SuperUse</td>
<td>Elsebeth the Kiefte</td>
<td>Architect</td>
<td>Involved in circular projects like Bluecity</td>
<td>A.5</td>
</tr>
<tr>
<td>Arup</td>
<td>Thomas van den Nouland</td>
<td>Business Development</td>
<td></td>
<td>A.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coordinator</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 12 Interviewee exploratory interviews (own work)
The current situation

Measuring circularity
Because there is no universal method to measure circularity, clients are struggling to review and judge circularity in a qualitative way. Often BREEAM, LEED and C2C methods are used to audit circularity. These methods show some overlap with circular buildings; however, at this moment they are not the same (Lemmens, personal communication, 2019). For example, BREEAM is globally the leading sustainability assessment tool for construction projects. Additional steps should be taken to further incorporate the circular economy principles into assessment frameworks such as BREEAM (Kubbinga et al., 2018). There is a need for a tool that weighs out the cost-benefit trade-offs. Designers and constructors need to be able to see what effect certain decisions have on the circularity of the project. That way a balanced decision can be made on the design with the most effective circularity approach (Galjaard, personal communication, 2019). This is for example visible in a new project from the Ellen MacArthur Foundation. They are working on Circularity Indicators Project, which provides companies with a methodology to assess the project or company functions according to the context of the circular economy. This allows companies to evaluate their advance in the process from a linear to a circular economy (Ellen MacArthur Foundation, 2019).

Trends
At this moment, the construction industry is evolving and taking steps in the right direction. A growing trend is modularity and recycling; however, the circular economy is not being tackled in a systematic way at this moment. The circularity of components is mostly increasing. Suppliers of circular components are willing to take more risks on own products. They see the necessity in taking responsibility for what will happen to the product after the first life cycle (Lemmens, personal communication, 2019). Rijkswaterstaat and the Ministry of Infrastructure and Water Management performed a research on this. They state that the collaboration between markets and suppliers is essential. Procurement for circular economies is very new and currently there is a gap between what the market is capable of offering and current market availability. One of the proposed strategies for this is that suppliers and contractors should make regenerative use of natural resources to encourage lifetime optimization during the use phase to enable reuse, repair and remanufacturing (Rijkswaterstaat, 2017).

Barriers
One factor that forms a barrier for the transition into a circular economy is unfamiliarity. Due to the unfamiliarity, risks and high investment costs arise (van Thie, personal communication, 2019). The biggest barrier for the transition is the fear for the unknown (Van der Werf, personal communication, 2019). In research, this is analyzed as well, by investigating the reasons for the difficulty of implementing circular economy in supply chains. The outcomes of the research show that the diffusion of responsibility and distinctions in perceptions are two reasons of the complexity to implement circular economy in supply chains. The main reasons for these two developments are the lack of mutual interests between supply chain actors, the lack of incentives for the actors to make changes towards circularity, clashes of perceptions on all levels and high uncertainties and risks (Schraven, Bukvić, Di Maio, & Hertogh, 2019).

Another large barrier of the transition is similar: human behavior. The transition into a circular economy demands some large behavioral changes and changes are often perceived as scary. The organizational structure therefore has to change with the transition, which can cost time and money and brings uncertainty (Salome Galjaard, personal communication, 2019). This is confirmed in research by Ünal, Urbinati and Chiaroni, who investigated what managerial and organizational changes needed to be made for circular economy business models. The proposed framework exists of three pillars: customer value proposition, interface & value network and managerial commitment. The first pillar shows the positioning of the company against competitors by creating value with the circular economy. Value network explains that the nature of the relationships between the company and suppliers is mainly based on shared values and trust. Lastly, commitment is very important since managers face trade-offs between circularity of the business and profitability. These three pillars are a condition at employee level adoption of the circular economy philosophy (Ünal, Urbinati, & Chiaroni, 2018).
Construction supply chain

The current construction supply chain, consist among others of: initiators, financiers, designers, builders and users. At this moment, suppliers of components are willing to take more risks. However, other parties are needed to start the transition. Large parties, such as contractors, find it hard to collaborate in the transition (Lemmens, personal communication, 2019). A difficulty of the transition is that the organizations are very interdependent. This is also proved in the research by Schraven, Bukvić, Di Maio, & Hertogh, as discussed before. The entire chain needs to make changes, not only one organization. This can be achieved by formulating clear circular ambitions. If a client has high circular ambitions, the market parties are obliged to react to these ambitions (van Thie, personal communication, 2019). As described by the Circle Economy, market parties are willing to build according to circular principles, however, they need clients to demand circular ambitions (Circle Economy, 2018).

The demand for circularity is growing, but clients do not know what to ask for, how to ask for it and how to measure and compare it (van Thie, personal communication, 2019). There is a rising demand, although clients struggle with what they should ask for (Galjaard, personal communication, 2019). The UK Green Building Council noticed this complexity for clients as well. Therefore, a guidance is made for construction clients explaining how they can practically apply circular economy principles at the project brief stage of built assets. It provides evidence and support to assist clients to set clear strategies. Moreover, it ensures that planning, budget and risks are minimized and mitigated (UKGBC, 2019).

Government

The government should give a good example by creating governance, policies and regulation based on the circular principles (Lemmens, personal communication, 2019). The client’s ambitions can be adjusted by modifying policy (Van der Werf, personal communication, 2019). The government is a key player because of the following different reasons: it is an important construction client (i), defines policies and governance (ii), owner of large land and it is the only party that has citizen health and welfare as main objective (iii) (Galjaard, personal communication, 2019). Investigation showed strong evidence that the governments are core responsible parties. They are important parties because it can give incentives with power and resources and it can create cohesion among changes (Schraven, Bukvić, Di Maio, & Hertogh, 2019).
Appendix A1: Interview 1 - Carol Lemmens
Global Management Consulting Leader – Interview on 07-05-2019

‘The Growth Within’ a report written by the Ellen MacArthur Foundation and McKinsey showed for the first time what the impact and resources are of the construction industry. About 40-60% of worldwide waste and resources are produced by the construction industry. If you investigate what is really done at this moment to decrease this amount of waste, it is inconsequential.

If you analyze the entire construction supply chain: from initiators, financiers, designer, construction companies and users, the only circular principle applied is recycling (which is circularity of materials). Moreover, things as cradle-to-cradle, LEED and BREEAM were often mentioned, however, though it shows interfaces, it is no circular economy.

To measure circularity, we need to look at the core, the yields of circularity:

1. **Uncoupling of resources (material sources, energy sources).** Renewables is added by economic growth. What you see now, economic growth is accompanied by growth of cities which means an exponential increase in use of resources. You want to unlink the connection between those two growths. This results in a bend of the curve of economic growth and resource consumption.

2. **A good business case.** There should be a good reason to embrace new practices versus the old practices. A transition can only succeed if there is a good economic case, financial case study or business case.

3. **Limit negative externalities.** Increase values as social impact, impact of quality of life, health, quality of life in cities or fine dust.

The current industry shows that some changes are happening concerning modularity and recycling however, the transition to a circular economy has not (yet) been tackled on a systematic way. Seen from the point of view of Arup, there is much to be gained. Design principles, design choices that are submitted to clients, can be influenced which is now done in minimal way. A few years ago, Arup decided to make a design with all the circularity principles in one object where the elements of circularity were visible to everyone: the circular house (circular pavilion in London). The house was fully able to be deconstructed. However, the experiment did not work. All materials and products of the house were borrowed and assembled so that it could be disassembled without harming the materials and products. However, the organizations from whom the components were borrowed did not want their products back because they did not know what to do with it. Therefore, the circular house was not completely circular. An advantage of the project was that it gained a lot of attention which is positive for the awareness.

On component level, the construction industry has evolved. Almost every office chair is circular, and elevators and escalators are often rented under the principle use as a service. Mostly suppliers of components are becoming more and more circular. They are willing to take more risks on own products. They are taking responsibility about what will happen to the product after the first life cycle.

For large contracts such as BAM and Strukton, becoming circular is difficult. Especially contractors that take the role as main contractor have little ownership on processes and products, because they outsource everything. These organizations do not control the chain. For example, in the automotive industry circularity is ahead of the construction industry. Large companies such as BMW and Renault control the entire supply chain. When controlling the supply chain and having ownership over the quality, things as refurbishment can be applied.

Large contractors agree they want to do something, but not a lot of action is taken. What happens for example is that contractors ask suppliers for circular products. To do so, the supplier wants guaranteed delivery because the organization needs volume for the new investment. Or a divestment to the machinery they already bought, to compensate. To achieve this, the entire purchase- and contracting models should be changed. Contractors will think about circularity when they are asked but if not asked, they will not change. Clients and investors should therefore develop a new mindset to get the entire chain into circularity.
In the construction industry, we have started on the wrong side of the chain. Arup and some other organizations with the same type of motivations started a few years ago with influencing the designer. Little circular cases have been produced and the uncoupling of growth does not take place at this moment. It seems that clients are not thinking about the impact of the building on the environment and social capital is not considered. However, the financial cases should be combined with social cases and health cases. There are lot of idealists, but barely institutionalized parties are willing to change the business model.

Another way to accomplish this is by turning around the way of thought. Investors should formulate their question clearer and be much sharper in how a good investment would look like for them. Large banks are implementing ESG criteria to investments. ESG stands for environmental, societal and governance. Most of the times circularity is used in the criteria. A bank can calculate lower interest rates for a circular investment, if the investor is conscious about the higher resale value a circular building has compared to traditional building. A higher resale value means more revenue which means the investors can ask for less interest.

Other sectors, such as the automotive industries are making much larger steps. This can be explained by the supply chain. In the automotive industry the designer takes the lead and the supplier or constructor follows. At Apple for example, the designer is the lead in the supply chain, all other parties follow the designer. Because of the complexity of the build environment, the built environment is hard to make changes and therefore the step to circularity is the most difficult. However, there can also be a lot of profit gained.

Summarized, circularity in the built environment is taking its first steps. Individuals (mostly on component level) are starting to act, little crystallizations are taking place. The innovative stream is slowly coming. The consumers are dominant, based on the consumers requirements, the producers will produce some products or others.

In the future, governments will have to give good examples. Governance, policies and regulations should be developed in such a way that it makes circularity somehow mandatory. When not obeying to the regulations, negative consequences should take place (for example tax). Moreover, government should give the good example by implementing it themselves. Rijkswaterstaat is the largest landowner in the Netherlands, it therefore has the most resources and the largest investment budgets. They should become a role model to other parties. In the design world optimization is a hype that could show large advantages for the circular building environment. By optimizing design and showing circularity in for example parametric models, clients could get convinced by the large advantages.

In 2050 the aim is to become completely circular in the Netherlands. It is not sure if we have that much time left because of resource depletion. Scarce materials are coming to an end such as silver and other materials for, for example batteries. Solar panels that have been produced 20 years ago are at the end of their life cycle, however, they cannot be reused, and no one knows what to do with them. At this moment financiers are looking for a new language in investments. How can they create new circular business cases without prove of the business case. Some banks are willing to take a step however, without prove or reference projects, the business case will never be positive. They have the ESG criteria however, a large step should be made to change the business cases.

The most important factors that influence the ambitions of the construction clients are the following:

1. Consumer behavior (Collective)
2. New financial models (both for the investors s for those invested important)
3. Governance by authorities (policies can have a positive or negative influence)
4. Market (Demand for new organizational models)
Appendix A2: Interview 2 - Edwin Thie
Structural Engineer – Interview on 10-05-2019

Clients are at this moment not aware of the longtime consequences of their decisions, when looking at circularity. Not only clients perceive that problem, but also Arup is still looking for ways to have a better view of the consequences. Circularity is a new way of thinking and working so the organizations working in the built environment still must figure out how to work with that. Two years ago, Edwin worked on project A in Eindhoven. This building was fully demountable, and all the materials were given back to the original owners. Two years ago, they did not call the building circular, although it showed a lot of similarities. Arup does not have a lot of experience when it comes to circularity, however, they are trying to figure out how they can start working with it.

In the infrastructure sector, Rijkswaterstaat is the larger client. Rijkswaterstaat has some ambitious goals in the field of circularity. The three main points are: sustainable area development, climate/energy and circularity. These aims have given an enormous boost to the infrastructure market. Groups are formed of organizations that want to talk and learn from each other.

Furthermore, the demand to circularity is growing. Clients are in a struggle with what to ask for, how to ask for it and how to measure it. Governmental parties such as Rijkswaterstaat need to be objective and transparent at all times. When in a tender they ask for circularity, they need to know how to measure circularity to be able to compare the different proposals in a transparent way. Other organizations such as municipalities and developers sometimes ask for circularity but keep the definition of circularity open. They probably do this because they do not know precisely how to use it. This makes it much more difficult to compare the different proposals.

All large Dutch engineering companies are working with and learning about circularity.

The factors that form a barrier for the transition into a circular economy are unfamiliarity, due to the unfamiliarity risks and high investment costs. Some organizations wait until the wheel has been invented before going in with the hype. This means no development costs, but the parties need to accept they will not be one of the frontrunners. A difficulty of the transition is that the parties are all very interdependent. The entire chain needs to change to make steps. To achieve this, it helps if the client has circular ambitions. That way the market can react to those aspirational ambitions.

Circularity is a large hype at this moment, which is positive, we are going in the right direction. There is a chance we will find out that circularity in the built environment is too difficult or that it does not make the world more sustainable. This is something we still need to find out. However, positive signals have been given from higher up. Almost all countries signed the UN sustainability goals. The consciousness that something must change is growing. One of the factors that influences this is the changing policy and governance. It’s one of the changes that must be made to have effect on the build environment. Another big motivator to participate in the circular trend is reputation.
Appendix A3: Interview 3 - Carlijn van der Werff
Building Physics Engineer – Interview on 10-05-2019

As a building physicist, we advise on sustainability and the performance of a building. Circularity is a large trend at this moment. Circularity is a way to comprehend sustainability into numbers. Circularity however is a very broad term. A client can ask for different thinks when asking for circularity. Currently, some clients ask for a flexible building. However, this is more a question for the cost manager or the architect, rather than the engineer. In the field of physics, the trend is wood and bio-based materials.

When looking at clients, there is a large difference between the different municipality when it comes to circularity in the built environment. For example, Amsterdam and Utrecht are investigating and working with circularity. For example, the municipality of Amsterdam is writing a new policy with the help of Kate Raworth, writer of the book Doughnut Economics. The municipality of Amsterdam offers room for creativity, they do not insist on certain performance values or guidelines. The municipality of Utrecht is stricter when it comes to the guidelines. On the other hand, municipalities like The Hague are do not have circular ambitions. It therefore depends on the municipality how circular a building will be.

The largest barrier for the transition into a circular economy is the fear for the unknown. That is connected to the fact people’s decisions are always based on money and the fact people are short term oriented. Clients demand guarantees on investments. The new generation has a culture of instant gratification. Clients tend to look at the short term instead of thinking themselves as asset owners.

In the future and acceleration of sustainability is possible, equal to the acceleration of the computers from 1900 to 2000. Changing the regulations has had a large effect on the circularity over the years. Clients are being more and more critical and therefore providers, constructors and consumers tend to move in the right direction.

The entire supply chain has a share in the transition. You could say the demand of the consumer has to change to change the supply chain. However, the consumers are not informed, most of the might not know wat a circular building is. For example, people that work for 40 hours a week at a construction site, are informed. An argument will always be a lack of market demand but that is not a good reason. A start is by changing policy and changing client ambitions, so that the market knows what ambitions clients have. However, this is an issue due to the dependency of the entire chain.

Large issue is that the juniors are the most concerned people when it comes to circularity, but they are too junior to make large steps.
Appendix A4: Interview 4 - Salomé Galjaard
Design Integrator – Interview on 10-05-2019

The circular economy is a trend itself. A trend within the CE is working from the theory and talking, to making steps, active involvement and results. Everyone is conscious about the fact that we cannot talk about it any longer, action is needed. This brings complexity and uncertainty. With every step that is been made, is noted that lots of tools and methods are still unknown. A new trend is circular area development. For the municipality of Amsterdam, which can be seen as a frontrunner when it comes to circular buildings, circular area development is still very new. Material passports is a passed trend. Nowadays, it is clear material passports are necessary to start the transition into a circular economy. Another trend Salomé wants to start working on is to bring together demand and supply. This will eventually only concern data, nonetheless, a large material market place must set up. At this moment there are about 20 small material marketplaces, however they need to be scaled up into a large national market place. Moreover, there is a need for a tool that weighs out the cost-benefit tradeoffs. Designers and constructors need to be able to see what effects certain decisions have on the circularity of a project. In circular area development, organizations find it hard to combine choices as climate adaptation, energy transition, densification of the city and mobility, combined with circularity. There exist a lot of relationships between these components which can be combined. By consulting and combining ambitions, a lot of value can be created.

There is a rising demand to circularity. Clients are struggling with what they can ask for. Some clients have high circular ambitions, but what is that? For example, the municipality of Amsterdam tenders a lot of projects asking for adaptivity, which at the same time is an unclear term as well. It is an easy requirement to use, where problems are pushed away to the future. A measurable term that is used to measure circularity or sustainability is the MPG, environmental performance of a building. This is a score that measures the balance between the energy impact and material impact. The scores are like shadow costs. It does not cover the circular spectrum, but it is quantifiable, and everyone agrees on it.

For circularity in the build environment it is important to take steps on different scale levels. An option is to look at the seven layers by Brand: site, structure, skin, services, space plan, system or stuff. The goal should not be that the area should become 100% circular, that is too complex at this moment. Circularity is about value retention. System is an important layer; the other layers are on building level but system interacts with the context. System interacts with different flows of energy, mass, mobility and people. These flows are currents going in and out of the building. That is why we always should look behind the boundaries of a building.

The offer in specialists in the field operating in the circular build environment is not very large. Nevertheless, there is a lot of interest from a wide selection of parties in the sector. They are now at the point that they realize that circularity is something complex and not easily achievable. There are some parties that are waiting until other parties act. Even established parties are not all acting upon the movement. The organizations agree on the value retention, but the question remains, how we will accomplish it. One of the large barrier for the transition, is human behavior. Circular Economy asks for some large changes, and changes are often perceived as scary. Another reason is the fear of costing a lot of money. Thirdly, the organizational structure will have to change within the transition, which can cost time. The time part is normal, we cannot just push the bottom, together one step at a time we need to figure out how to do it.

In the future, some potential scenarios could occur. A risk is that the transition or trend of Circular Economy, extinguishes as a candle. This could for example happen if an economic crisis would hit the Netherlands, or Europe. However, there are hopes this will not happen. One of the good signs is that financial companies are participating in the transition. Companies such as investors, banks and pension funds are realizing that it is riskier to invest in a linear model compared to a circular model. They realize that owner’s linear models are far less involved in the entire life cycle and feel less responsibility to keep the quality high.

The government is a key player in the transition. All stakeholders look at what the government says and does. It is a key player because of the following reasons: it is an important construction client, defines policies and governance, owners of large soils and it is the only party that has citizen health and welfare as main aim. The
Dutch government is in a dilemma: they want to challenge the market, but they do not want to trap the market with ambitions that are too high. They will need to find a balance to boost the market.

When talking about standards and values of clients, there is more and more a deliberation between: economic, ecologic and social. At this moment there are no models or tools to deliberate these values. There is a trend moving towards health and wellbeing. Construction clients are willing to pay more for a healthy building. This trend helps the circular transition.
Appendix A5: Interview 5 - Elsebeth the Kiefte
Architect at SuperUse – Interview on 16-05-2019

The office of SuperUse is located at the old swimming pool called Tropicana in Rotterdam. In 2015 Tropicana was bought by iFund, a foundation that supports impact entrepreneurship for planet and people. Blucity was set up in Tropicana by a group or organizations, among others SuperUse. Blucity is a circular example city, which serves as a breeding ground for innovative companies. They aim at creating their own ecosystem by for example linking streams, such as waste streams. The streams can be physical streams but also energy streams. For example, if one company has some warmth left, another company can use it. This can change in the future, since it shifts from demand and supply. In Blucity the offices have their own climate system and the materials have been reused from other buildings. For example, the old Disco is 98% circular, almost every material has been reused. The design of the offices was based on the materials they could buy second hand. When applying reused materials, a life cycle analysis is made. The life cycle analysis of the circular building is compared to the life cycle analysis of a traditional building. In the case of the Disco in Blucity, the CO2 use was decreased with 68%.

A large change compared to traditional building projects is that the application is sketchy. The concept design and the licenses that need to be applied for remain sketchy. The design is detailed till a certain level, not too detailed because you do not know what material you will harvest. At the same time, you have an idea of the available materials. At SuperUse three methods of circular building are used, from most important to least:

1. Reused
2. Reusable / Detachable
3. Bio based

At the start, the aim is always to use reused materials, the building should be designed with reused materials. Secondly, these materials are attached in a way that they can be detached easily, that means the least possible sealants. The building elements should be able to take apart and build somewhere else. If these two parts are not possible, the aim is to use bio-based materials. That means wood instead of steel for example. Thus, the designs are made using at least one of the methods but favorably combined. That way the footprint is kept as small as possible.

The different methods are used in different phases. For reuse, the design is made until the preliminary design phase, because you still not know what material you will harvest for every component. You need to keep a gap in the design, to later fill in with the material you will use. When the materials are known and the contractor as well, they go on to the new stage, the dynamic final design. When using reusable method, you design until the technical design phase. This because the components need to be fully detachable, it needs to be designed in a detailed way. The contractor is involved in this part as well, since they need to see how the building is detached. And bio based is controlled in the final design phase. So, all methods are applied in different phases.

Oogstkaart, a platform (like a kind of market place) has been developed by SuperUse. At this moment it is a separate company. It is growing rapidly; more and more people are learning about circular buildings.

An important aspect about building circular is communication with the contractor. The architects at SuperUse always calculate with a certain margin, you never know exactly what kind of material will be harvested. In a project in the past, the communication with the contractor was not that good. The contractor sawed all the wooden panels precisely and therefore they did not fit the design which cost 200 euro extra per meter.

Construction clients are important client when it comes to the shift from traditional buildings to circular buildings. However, how can clients decide on circularity when they do not know what it is? Stakeholders that do
know what it is, should counsel clients on these types of decisions. Parties like architects are connoisseurs, clients are (usually) not. Copper8, an organization which advises clients on circular buildings, noticed that clients can be surprised too. As an advisor, you can counsel clients to make plans they never knew they wanted. It is important to listen to what the client wants, and to challenge that desire to the most circular as possible.

Regulations and laws are not ready for the quick transition. An example is municipal regulations such as fire regulations. SuperUse is talking a lot to the municipality and to firefighters. They know the principles of circular buildings and they like and support it. However, because there are no certificates for circular building materials, it is very hard to prove fire resistance. When introducing a material which is not a building material but will be used as one, is unknown. Fire safety is then very hard to measure. It is not impossible, but since it is all new it takes more time, it is not catalogue work.

Important parties that should take the lead are large construction companies such as BAM. Only because these large companies can make large impact. Large construction companies have a large network which will make the circularity trend spread more easily. People are simple followers, they follow mass and money. If there is a fast transition, nobody will be so stupid to not do anything.
Appendix A6: Interview 6 - Thomas van den Nouland
Business Development Coordinator – Interview on 24-05-2019

It is clearly visible that the public sector is working on circularity. Especially large municipalities have been working on it for a while. The demand is growing over the years, in the past 1,5/2 years this amount has grown. Sustainability had already played an important role during tenders. Municipalities of Amsterdam and Rotterdam are forerunners, they are more and more working with circularity. An example is the public tender from 2017, a market consultation in Amsterdam. At that time, the municipality was looking at what would be possible and how, what is the vision of the market and how can we translate this to practical examples. Clients as the municipality of Amsterdam and Rotterdam know what it is, however, they find it hard to translate circularity into projects, in a way the market can anticipate on it as well. They are trying to find a way to do this. Another example is the tender by the municipality of Hoogeveen, for a theater. They had high ambitions, it should become the most sustainable theater in the Netherlands. They asked the tendering parties for a reference project with two characteristics: CO2 neutral and circularity. They received quite a lot of reactions since a CO2 neutral and circular building does not exist in the Netherlands. In the end they dropped the criterion. It is a good example of a phenomenon that is happening: the ambitions are running ahead of that is happening.

Other parties are looking for flexibility and modularity. This is not something new in tenders, although it is the first time it is referred to as circular. Flexibility is a difficult term. To make a flexible building is complex because buildings are unique, they are made for a certain goal. At this moment there is a focus on demountable buildings, however there needs to be a shift to reusable materials.

One of the barriers for the transition into a circular economy is that it entails the entire chain. Clients ask for certain buildings to architects and engineers, but these questions cannot be only solved by these parties. Large things need to change in the chain during the process to achieve this. Clients tend to evaluate circularity with the help of BREEAM, to measure it on a quantitative way. However, it is often unknown in a project what the output of the building will be since it is influenced by CO2 emissions and energy use.

Most of the tenders include circularity in large or small part in the proposal. Thomas believes that if it is not used, it is because it was not possible for the project. Because the certain characteristics of projects, circularity cannot be used.

If you want the market to follow the trend, there should be a kind of incentive. The government plays an important role in this aspect. Another advantage of being one of the frontrunners is that in the future you it is easier to win more circular tenders.
Appendix B: Project Management Themes

Appendix B.1: Project Management Body of Knowledge (PMBoK)

PMBOK process management groups

The institute described the following five process groups: initiating, planning, executing, monitoring & controlling and closing. The initiating process describes the processes that define a new project by receiving agreement to start the phase or project. The planning process describes the processes needed to determine the scope of a project, to end the project and the activities needed to achieve the goals of the project. During the Executing phase the processes are described that are used to complete the work which is defined in the project management plan. In the next phase, Monitoring and controlling, the processes are described that need to be tracked and reviewed to regulate the progress and performance. While in the last phase, Closing the processes are described that are implemented to end the activities (Roudias, 2015).

The planning process group consists of the processes to define the scope of the client refines the objectives and define the activities necessary to obtain the objectives. The project management plan is developed in this process and project documents that will be used to carry out the project. First, the Project Management plan is developed. This is the process of documenting the actions that are needed to prepare, define, coordinate and integrate the plans. It becomes a primary source of information which will be used in the planning, execution, monitoring, controlling and closing phase. Next, the requirements are collected. The stakeholders need to set project objectives which are defined and documented. Later, the scope is defined. This is done by describing in detail the project and product, based on client requirements. After that, a Work Breakdown Structure is created to subdivide project deliverables and project work into smaller elements. The next activity is to define activities which need to be performed to produce the project deliverables. The relationships between these activities need to be found to sequence the tasks. When this is done, the activity resources need to be estimated. This is the process of defining the type and quantities of the resources (people, material, equipment or supplies) needed to perform all the tasks. After this, estimation can be made of the task durations. Based on the estimated work periods needed to complete the activities with the resources a schedule can be developed. With the schedule, the cost can be estimated. This is the process of developing an estimation of the money needed to complete the activities. The budget is determined by aggregating the approximation of the costs of the activities to determine the cost baseline (Project Management Institute, 2017).

Based on the client requirements, the quality standards are established for the project and product. The next process is to develop a Human Resource plan. This is the process of determining roles, responsibilities, relationships, required skills by creating an organizational structure (or staffing management plan). To determine the project stakeholder information needs, a communication approach is made. Next is the risk management. A process is performed where the project manager sets and performs the risk management during the project. Steps that are involved are: risk identification, qualitative risk analysis, quantitative risk analysis and the planning of risk response. The last step is to plan procurement. This is the process of identifying the project purchasing decisions, identifying potential sellers and specifying the approach (Project Management Institute, 2017).

This all is documented in the following project management categories: project integration management, project scope management, project schedule management, project cost management, project quality management, project resource management, project communications management, project risk management, project procurement management and project stakeholder management (Project Management Institute, 2016).

PMBOK+ themes

The first project management category is Project Integration Management. In this category the processes and activities that need to be done are identified, defined, unified and coordinated within the management groups. In other words, the project manager needs to keep an eye on all the aspects of the project and they need to check if everything is according to plan. Good project integration is impossible to achieve without good teamwork. The project objectives should be clear at all times and the interdependencies should be managed to
execute the project in a successful way (Hasan, 2017). The following activities need to be performed (Roseke, 2017):

- Develop Project Charter;
- Develop Project Management Plan;
- Direct and manage project work;
- Manage project knowledge;
- Monitor and control project work;
- Perform integrated change control;
- Close project or phase.

The second theme is Project Scope Management. This includes all the processes required to make sure the project includes all the activities to complete the project in a successful way. The project scope management starts early in the project life cycle and is constantly developing during the project. Early scope definition is critical, since cost can be influenced highly in the first phases of a project (Project Management Institute, 2016). The scope management processes include the following (Project Management Institute, 2017):

- Collect requirements;
- Define scope;
- Create WBS;
- Verify scope;
- Control scope.

The third theme is Project Time Management. In the construction sector, there is an added emphasis on scheduling since construction often depends on time restrictions in contracts. Project Time Management includes the processes that are necessary to manage the project on time. In the Planning Process Group, activities are defined, and duration and resources are estimated (Project Management Institute, 2016). The following activities, which are interrelated, need to be performed (Project Management Institute, 2017):

- Define activities;
- Sequence activities;
- Estimate activity resources;
- Estimate activity durations;
- Develop schedule;
- Control schedule.

The next theme is Project Cost Management. This is vital when it comes to project success and the organization’s profitability. The day-to-day costs should be managed which could be challenging due to the large amount of stakeholder (Project Management Institute, 2016). This includes the processes associated with budgeting, estimating and controlling the cost that are involved in a project so that it can be completed within client budget. The processes that need to be completed are (Project Management Institute, 2017):

- Estimate costs;
- Determine budget;
- Control costs.

Following, Project Quality Management seeks to meet the requirements and specifications of the client. It manages both the product and the process. This includes the activities and processes of the performing company which determines the quality policies, responsibilities and objectives. To make sure the projects satisfies the client requirements. During the Planning Process Group, construction documents are reviewed which outline quality standards that are required to make sure the project is successful. These documents could be contracts, specifications and construction documents (Project Management Institute, 2016). The following processes need to be executed (Project Management Institute, 2017):

- Plan quality;
- Perform quality assurance;
- Perform quality control.

Furthermore, Project Human Resource Management includes the processes to manage and organize the project team. The project team consists of the people with roles and responsibilities during the project. An organizational structure can be made of the project team. The number and roles of team members can change during the project. Involvement of team members and decision making can be very beneficial. By involving team members in early stages, team expertise can be used during the planning process to increase team commitment. The following processes need to be performed (Project Management Institute, 2017):

- Develop Human Resource plan;
- Acquire project team;
- Develop project team;
- Manage project team.

The seventh theme is Project Communication Management. The effectivity and efficiency of a construction process depends on the communications, mostly on its quality (Project Management Institute, 2016). Project Communications Management involves the processes to ensure appropriate and timely generation, distribution and disposition of information. Project managers spent a lot of time in communicating to team members and stakeholders. Effective communication can close the gap between different stakeholders, with diverse backgrounds, values and goals. The following processes need to be done (Project Management Institute, 2017):

- Identify stakeholders;
- Plan communications;
- Distribute information;
- Manage stakeholder expectations;

In addition, Project Risk Management deals with the probability of positive and negative events to happen (Project Management Institute, 2016). This includes the processes of risk management planning, analysis, response planning and control during a project. The aim is to increase the probability and impact of favorable events and to decrease the impact and probability of unfavorable events. The following processes need to be performed (Project Management Institute, 2017):

- Plan risk management;
- Identify risks;
- Perform qualitative risk analysis;
- Perform quantitative risk analysis;
- Plan risk responses;
- Monitor and control risks.

Furthermore, Project Procurement Management is an important theme. Projects and especially construction projects are based on procurement of contractual arrangements between parties. This could be for example the procurement of capital, materials and equipment. Project Procurement Management focuses on the scheduling and execution of contract agreements for scope during the project life cycle. The following activities should be performed (Project Management Institute, 2016):

- Procurement planning;
- Solicitation planning;
- Solicitation;
- Source selection;
- Contract administration;
- Contract closeout.

The last PMBoK theme is Project Stakeholder Management. In construction projects, many stakeholders are involved. In the Initiating Process Group, the involved stakeholders are categorized. In the Planning Process Group, the relationships among the stakeholders are developed, based on contractual formal documents. In the
process, responsibilities are analyzed, and communications are used in the project communication plan (Project Management Institute, 2016). The following activities are performed (Roseke, 2018):

- Identify the stakeholders;
- Plan stakeholder engagement;
- Manage stakeholder engagement;
- Monitor stakeholder engagement.

In addition, Project Health, Safety, Security and Environmental Management (HSSE) is added to the ten PMBoK themes. For construction job sites, site security and controlled access are very important. Health and safety of employees is investigated when the personnel are directly affected by the construction project risk and safety. The following activities are performed (Project Management Institute, 2016):

- Proactive view of health, safety and environmental policy compliance;
- Develop management plan including health, safety and environment.

Further, Project Financial Management is added as well. According to the project Management Institute, project managers should have a basic knowledge on project accounting and financial systems. A project manager should be able to summarize project financial transactions, analyze and report the results and provide financial cash forecasts. The following activities take place (Project Management Institute, 2016):

- Financial planning;
- Identify the financial requirements for construction projects;
- Contract requirements, risk allocation;
- Tax planning.

Appendix B.2: Projectmatig werken

An organization performs several activities which can be divided in three subgroups: improvisation, routine work and project work. Projectmatig werken is a form of work, which lies between improvisation and routine work. Improvisation is mostly used when new work comes up. It is used when an unplanned situation occurs, and a fast reaction is necessary. In those cases, ad hoc reaction will be made which means that it was not according to a plan. The second task is routine work. These tasks are performed repeatedly and are predictable. The tasks a performed according to a plan, it is not necessary to think of what needs to happen, this was already thought of. For these tasks work procedures can be made, so that the tasks are performed efficiently. In this case, only project work will be analysed. Project work is positioned between routine and improvisation. These tasks are unique and temporary and are somewhat predictable. To enlarge the predictability, the activities are approached in a systematic way. Beforehand, time is taken to think of the aims and the best approach to achieve this. Large projects are often divided into sub-phases to make an approach per phase (Grit, 2015).

For each project-based activity, a separate project organization is designed. This means new teams are set up with people that usually do not work together. This makes large projects difficult to manage. To make teams operate more effective and controllable, the project is subdivided into different phases. This reduces total project risk. A traditional project is divided into the following phases (Grit, 2015):

1. Initiative. In this phase the idea is translated into a project proposal.
2. Definition. In this phase the end result and the way to achieve this is defined. The aim of this phase is to formulate the action plan.
3. Design. This phase the design of the project is made.
4. Preparation. The design is developed into a detailed plan including drawings etc.
5. Realisation. In the end of this phase, the aimed project result by the client is delivered.
6. Maintenance. The project result is used in this phase.
Figure 24 The management aspects of Projectmatig werken (Grit, 2015)

Projectmatig werken themes

The first management aspect is Time. To make sure the project is finished within time, in the first phase of the project it is required to make a planning. The following activities are performed during the drafting of the planning (Grit, 2015):

- Make list of activities;
- Define dependencies of activities;
- Define resources needed per activity;
- Estimate project end-date.

A part of this is progress monitoring. Beforehand agreements should be made to determine the way the project team report their time spend on the project and the means that were needed. For every activity the progress can be monitored live (Grit, 2015).

The second aspect is Information. To exchange information, constant consultation between the stakeholders should take place. The project meetings, usually every week, are important for the exchange of information. During these meetings the progress can be discussed, everyone is kept up to date and action points are drafted. Besides these planned meetings, information exchange is constant because project members communicate with each other through email, telephone, skype etc. Project team members need to be informed correctly. Changes in the specifications of the project need to be communicated to the people involved as soon as possible (Grit, 2015).

In addition, the third aspect is Money. Before starting the project, the budget is determined. The client makes the budget available. The budget shall be spent on resources, human as well as material. During the process, the amount spend in relation to the budget will change and this needs to be managed (Grit, 2015). The following steps need to be performed (Kaldewaij, 2006):

- Determine costs and benefits project;
- Determine costs and benefit per activity;
- Define norms, margins and budget;
- Determine periodicity of costs;
- Get budget approved.

The fourth aspect is Quality. For large projects it is difficult to make specifications for the end product, which makes it difficult to define the quality. Quality is highly related to costs. High quality is more expensive than low quality. Quality can be measured by determining the deviation of the product on client specifications. When these margins are not exceeded, the quality of the product is sufficient (Grit, 2015).

Finally, the last aspect is Risk. There are some large project risks that could take place. These are related to scope, planning, market, material, facilities and tools, people, organization and external influences. For the risk analysis, he following steps need to be performed (Grit, 2015):

- Assessment of risks;
- Analyze the risks;
- Formulate the measures.

**Appendix B.3: PRINCE 2**

**PRINCE2 principles**

The first integrated element is the principles. These are the core concepts of PRINCE2. These principles are strict, the project should include the seven principles at all times, if one is missing the project cannot be considered a PRINCE2 project (Turley, 2009). Each project should consist of the seven best practices (Hinde, 2017):

1. Continued Business Justification – there must be a documented justification to start the project.
2. Learn from Experience – always consider the good practice and mistakes from other projects. This should be done during the entire length of the project.
3. Define Roles and Responsibilities – each person needs to take on a role where they understand what is expected.
4. Manage by Stages – always manager projects into several time periods, stages. A project is planned, monitored and controlled based on different stages (Turley, 2010).
5. Manage by Exception: The elements Time, Cost, Scope, Quality, Benefits and Risk should only be managed by the above management layer is there is an issue which is outside their tolerance (Turley, 2010).
6. Focus on Products – during the entire process of the project, it needs to be clearly defined what the project is making.
7. Tailor to Suit the Project Environment – the project should be designed to suit the clients desire, which means the project’s size, complexity, capability and environment (Turley, 2010).

**PRINCE2 processes**

The second integrated element is the seven processes. These processes show a set of activities providing information on how to manage the different parts of the projects. The processes show management work from before project start to project end. Every process covers a specific time in the project. Per process is shown who is responsible and what management documents could be useful (Hinde, 2017):

1. Starting of a project;
2. Directing a project;
3. Initiating a project;
4. Controlling a stage;
5. Managing product delivery;
6. Managing a stage boundary;
7. Closing a project.

PRINCE2 defined the six aspects of project performance that need to be managed. The performance of a project can be measured by (Hinde, 2017):
- Calculating how much money is spent, project costs;
- Project’s timescales;
- Project’s quality;
- Project’s scope;
- Level of project risk;
- Project’s benefits, how much value a project has delivered to the organization.

These six variables are also perceived as performance targets.

The framework also defines project roles with responsibilities to implement the principles, process and themes effectively. The most important parties involved are the project board and the project managers. The project board is responsible for the high-level management of the project and aims at ensuring that the project continuous to deliver the business value for the organization. The project board consist of three main groups or persons, the executive, the senior user and the senior supplier. The executive represents the senior management of the organization, the senior users represents the target audience of the project and the senior supplier represents the internal or external team to deliver the required outputs. The project manager on the other hand is responsible for the project delivery (Cooke, 2016).

PRINCE2 is made up from four main parts, also called integrated elements. These are principles, themes, processes and the project environment (tailoring) (Turley, 2010). These elements will be discussed further in the following chapters.

**PRINCE2 tailoring to project environment**

This part answers the question ‘How do I best apply PRINCE2 to my project or my environment’? Tailoring is about the best way to apply PRINCE2 to a project. When tailoring, there are some things that can be changed: principles, adapting the themes, terms and language, adapting the management produces, adapting the roles, adapting the processes and the level of experience to do tailoring (Turley, 2010).

**PRINCE2 themes**

Seven themes are used throughout the initiation of the project to make sure the project is managed in a correct way. Themes are items that should be continually addressed during the project, monitored and maintained during the project’s life cycle (Turley, 2010). The themes will be discussed shortly below (Hinde, 2017):

The first theme is Business Case. This theme describes how the project manager can ensure that the project is achievable, desirable and viable. Four steps are performed to create the business case (Hinde, 2017):

- Develop the business case;
- Verify the business case;
- Maintain the business case;
- Confirm the benefits.

The second theme is Organization. This theme sets out the project team structure including responsibilities. The team is appointed during the ‘Starting up a project’ process. During the ‘Initiating a Project’ process, the Project Manager will perform a stakeholder analysis. The results of this analysis will be used in the Communication Strategy. The Project Management method is used in four management levels (Turley, 2009):

- Corporate or Programme Management – make the project mandate;
- Direction – this is the level where the Project Board works;
- Management – this is the level where the project manager works. This level contains most of the processes and activities;
- Delivery – this is the level where the project products are created. This includes management products such as project plan and project brief.

Following, the third theme is Quality. This theme shows how a project should be managed to create the correct products. This involves the following activities (Turley, 2009):
- Quality planning;
- Quality control;
- Customer’s quality expectations;
- Acceptance criteria;
- Adding quality information to the product descriptions;
- Quality management strategy document;
- Quality register;
- Quality review.

The forth theme is Plans. This theme shows how to plan the work of the project. There exist three types of plans: project plan, stage plan and team plan. The project plan is a high-level plan and it is used to determine project’s time, scope, cost and quality targets. The stage plan is a required plan for each stage of the project. It is more detailed than a project plan, it is used daily by the project manager. A team plan is drafted to plan the execution of a work package (Turley, 2010). For every plan, seven activities need to be done (Turley, 2010).

- Design the plan;
- Define and analyse the products;
- Identify activities and dependencies;
- Prepare estimates;
- Prepare the schedule;
- Document the plan;
- Analyse the risks.

The next theme is Risk. This theme improves the likelihood of project success by identifying and controlling threats and opportunities of the project. For risk management, the following steps need to be performed (Turley, 2010).

- Identification of risks;
- Assess the risk by estimating and evaluating;
- Plan the responses to risk (threats and opportunities);
- Implement the responses;
- Communicate, to make sure that the information related to threats and opportunities is communicate to the necessary stakeholders of the project.

The next theme is Change. This includes to aspects: track and control the project’s produces and control changes in the project. This is described in the Configuration Management Strategy. To control issues during the project, six management products are used. These are the following (Turley, 2010):

- Configuration management strategy – report with the strategy of how changes and issues will be tackled during the project;
- Configuration items records;
- Product status account;
- Daily log;
- Issue register;
- Issue report.

The last theme is Progress. This theme shows how the progress is controlled and eventually kept on track. In the PRINCE2 method, process is controlled with the help of four main ways (Turley, 2010):

- Delegating authority from one level to another;
- Divide the project into management stages and authorize each phase separately;
- Progress reports based on time and events;
- Raise exceptions, use exceptions to alert the layer above.
Appendix C Interview protocol

Appendix C.1: Interview protocol

Interview protocol vragen

Een onderzoek naar het verschil in project management tussen een traditioneel bouw project en een circulair bouw project

Datum
Naam respondent
Organisatie
Naam interviewer Ana Versteeg Conlledo
Email interviewer Ana.versteeg@arup.com
Interview nummer
Project

Introductie

Introductie van mijzelf

- Tweede jaar master Construction Management and Engineering aan de TU Delft, faculteit Civiele Techniek en Geowetenschappen
- Master thesis onderzoek uitgevoerd bij Arup in Amsterdam
- Interesse in Circulaire Economie, project management en duurzaamheid. Nieuwsgierig en geïnteresseerd in wat de relatie is tussen deze drie en hoe ze het beste gecombineerd kunnen worden.

Onderzoeksdoel

Het doel van het onderzoek is om erachter te komen of er een verschil is in project management tussen traditionele bouwprojecten en circulaire bouwprojecten. Na de analyse, zullen aanbevelingen worden gedaan om toekomstige klanten en stakeholders te helpen met het afronden van succesvolle circulaire bouwprojecten.

Doel van het interview

Het interview zal worden gebruikt om inzicht te krijgen in hoe partijen circulaire bouwprojecten managen op dit moment. Het doel is om een goed beeld te krijgen van hoe het er in de praktijk aan toe gaat.

Structuur van het interview

Het interview bestaat uit 4 delen. Het eerste deel zal zich richten op de circulaire economie. Het tweede deel zal bestaan uit project specifieke vragen. In deel drie zal het theoretische kader besproken worden. De vragen zullen gericht zijn op de verschillende project management thema’s uit het kader. Tot slot, zal uw mening gevraagd worden naar de toekomst van project management van circulaire bouw projecten.

Vertrouwelijkheid

Voordat ik begin met het interview zou ik voor de vertrouwelijkheid het volgende willen weten over de informatie die u gaat geven.

Hoe zou u willen worden geciteerd:
Ik zal de samenvatting van het interview binnen twee weken sturen. Als ik niks hoor binnen twee weken, kan de instemming worden aangenomen en zal het document worden gepubliceerd. Gaat u hiermee akkoord?

- Ja
- Nee

Mag ik het interview opnemen? Aan de hand van de opname zal het interview worden samengevat.

- Ja
- Nee

Zijn er documenten die ik in zou mogen zien met betrekking tot het project? Denk hierbij aan:

- Request for tender documents
- Project Planning
- Meeting notes
- Invitation to register
- Cost estimate
- Risk register
- Organizational structure

Voordat we beginnen met de vragen, wil ik duidelijk maken dat er geen goede of foute antwoorden zijn. Dit gaat over uw perspectief en adviezen.

Mocht u een van de vragen als onaangenaam beschouwen en liever niet te beantwoorden, bent u vrij om dit te doen. Als een vraag onduidelijk is, dan hoor ik dat ook graag. Heeft u vragen tot nu toe?

### Interview vragen

#### Interview deel 1: Algemene vragen

1. Denkt u dat er verschil is in project management tussen een traditioneel- en circulair bouwproject?
2. Zo ja, kunt u aangeven wat de verschillen zijn?
3. Wat verstaat u onder circulaire economie?
4. Hoe werkt u, of uw bedrijf, met circulaire economie in de gebouwde omgeving? Welke activiteiten worden verricht met betrekking tot circulariteit?

#### Interview deel 2: Project gerelateerde vragen

1. Wat is uw rol/unctie binnen het project?
2. Hoe lang vervult u deze functie binnen het bedrijf?
3. Denkt u dat het uitgevoerde project een circulair project te noemen is?
4. Waarom is gekozen voor circulariteit in dit project?
5. Was de circulariteit gemeten of geëvalueerd?
6. Is er gebruik gemaakt van een circulaire strategie? Denk aan bijv ReSOLVE (Regenerate, Share, Optimise, Loop, Virtualise, Exchange)
7. Wat zijn de belangrijkste leerpunten van het project met betrekking tot circulariteit?
8. Was dit het eerste circulaire project waar u bij betrokken was?

9. Welke partij was verantwoordelijk voor de project management?
10. Waren er vooraf circulaire eisen aan het project gesteld en zo ja, wat waren deze eisen?
11. Bent u bekend met de ‘Project Management Body of Knowledge’ methode?
Interview deel 3: Project Management Thema’s

Specifieke vragen

1. Project scope management
   a. Hoe hebben jullie de projecteisen geanalyseerd?
   b. Hebben jullie specifiek de scope gedefinieerd? Gebaseerd op de eisen van de klant?
   c. Hebben jullie een Work Breakdown Structure opgesteld?
   d. Is de scope door het project door geverifieerd en gecontroleerd?

2. Project time management
   a. Zijn alle activiteiten vooraf gedefinieerd? Inclusief sequentie tussen activiteiten?
   b. Zijn de resources en tijdsduur van de activiteiten bepaald?
   c. Is een planning gemaakt?
   d. Is de planning tussentijds gecontroleerd?

3. Project cost management
   a. Is er aan het begin van het project een schatting gemaakt van projectkosten?
   b. Is het budget aan de hand daarvan bepaald?
   c. Zijn de kosten tussentijds gecontroleerd?

4. Project quality management
   a. Is de beoogde kwaliteit van tevoren vastgesteld?
   b. Zijn er activiteiten uitgevoerd om ervoor te zorgen dat het beoogde kwaliteit level werd behaald?
   c. Zijn er activiteiten uitgevoerd om de kwaliteit te controleren?

5. Project human resource management
   a. Is er een HR plan opgesteld?
   b. Is een projectteam gewerfd en opgesteld?
   c. Is het project team gemanaged?

6. Project communication management
   a. Zijn stakeholders van tevoren geïdentificeerd?
   b. Is er een communicatieplan opgesteld?
   c. Is informatie op bepaalde vooraf afgesproken redenen gedistribueerd?
   d. Is de performance (prestatie) gerapporteerd?

7. Project risk management
   a. Is risicomanagement gepland?
   b. Zijn de risico’s voorafgaand aan het project geïdentificeerd?
   c. Zijn risicoanalyses uitgevoerd? Kwalitatief zowel als kwantitatief?
   d. Zijn risico responses gepland?
   e. Zijn de risico’s gemonitord en gecontroleerd?

8. Project procurement management
   a. Zijn de aanbestedingen gepland?
   b. Zijn de invitaties / verzoeken gepland en uitgevoerd?
   c. Zijn de leveranciers gegund?
   d. Zijn contracten opgesteld en in laten gaan en afgesloten?

9. Project stakeholder management
   a. Zijn de stakeholders geïdentificeerd?
   b. Is er een stakeholder betrekking plan gemaakt?
c. Is stakeholder engagement gepland en gemonitord?

10. Project integration management
   a. Is een project charter gemaakt?
   b. Is een project management plan opgesteld?
   c. Is projectwerk gemanaged?
   d. Is wijzigings controle (change control) uitgevoerd?
   e. Zijn de fasen tussendoor afgesloten?

11. Project health, safety, security and environmental management
   a. Is beleid opgesteld met betrekking tot HSSE?
   b. Is een management plan opgesteld met betrekking tot HSSE?

12. Project financial management
   a. Is een financiële planning opgesteld?
   b. Zijn de financiële vereisten opgesteld voor het bouwproject?
   c. Zijn de risico’s verdeeld in het contract?
   d. Zijn belastingen gepland?

Interview deel 4: Toekomst van Project Management in circulaire bouwprojecten

1. In dit project, welk project management thema had meer gebruikt kunnen worden (of op een andere manier) om circulaire economie beter te gebruiken?
2. Hoe moet projectmanagement worden toegepast op geheel circulaire projecten naar uw mening?
3. Welke 5 activiteiten zouden moeten worden uitgevoerd om de implementatie van circulariteit in een project te verzekeren?
4. Is er nog iets anders dat je wilt toevoegen of bespreken?
5. Als we terugkijken naar de eerste vraag, denkt u dat er verschil is in project management tussen een circulair en een traditioneel bouw project?

Hartelijk dank voor de deelname. Over twee weken zal ik de samenvatting van het interview sturen. Bent u het ergens niet mee eens, laat het mij dan binnen twee weken weten.
Appendix D: Case study interviews

Appendix D.1: Interview project A - interviewee 1
Function general: program director
Function: project leader
07-08-2019

The client is an organizer of events, awards and labs with other businesses. It is a promoter, connector and a driver for innovation. The interviewee is the program director and took on the role as project leader for project A.

Part 1: General project questions

The circular economy is a different term for different disciplines. Circular economy in the build environment is very different to the circular economy of products. A lot of parties in the building sector are limited to the recycling of building materials. However, according to the interviewee, it goes further than that. It is important to ensure that objects and materials do not lose quality and value when they are reused. For example, plastic was used for the façade of the project, where tiles were made out of old plastic bottle caps which were collected by the citizens of the town. Normally plastic is tossed on a mountain and where possible divided into different plastics. Best-case scenario it is made into a product that is OK to reuse but it is impossible to recycle again. For the client the question is: how are we able to develop materials, that during the material life cycle can have different functions, that can be used in different combinations? The answer to that question is different for different products. To illustrate, the answer is not the same for a phone than for a building.

The second point about circular economy is that it is often seen very small scaled, in a chain. However, the biggest steps are made when looking at circularity within different chains, so that it outreaches sectors. It is noticed that various stakeholders and partners in the construction chain keep their traditional work-ethic. Although circularity should be about forgetting the traditional way of working and built a new one. This new chain should be about clever use of materials, smart use of the available resources, you must think of a way to combine these to ensure that these materials are always available for reuse. To ensure this, new models should be developed, instead of the conventional methods. For the project, all materials have been borrowed, yet rental materials could have been used as well. However, borrowed is purer, it forces to think in the least harmful way for materials as possible. The challenge during the project was to look for the way to use the materials without damaging them.

It is noticed that in the construction sector, but also in other sectors, we all agree we should do something with the terms sustainability, circularity and bio-based. However, it is not yet a matter of course. It is something we perceive as an ‘extra’. That is something that must change. Most of the projects of the client are short and small, but it gives the chance to do some experiments. These experiments are differently organized compared to normal construction projects. Building permits are different than temporary permits, we are not supposed to live in our projects. With these experiments, the client aims at inspiring the construction industry. It seems that project A did inspire. Mostly the paradigm change. The client saw that the project got around the world, from Canada to China, the project was in different papers. In a lot of Dutch tenders, the project is given as a reference project.

At the start of the project, during the first few internal meetings, circularity was not an objective. The designers indicated during the feedback of the briefing that they would feel comfortable to work along the circular principle. The designers explained that it was never done on this scale and that it therefore would become an experiment. Which is exactly what the client wanted. The client had a few central aims. First, the project had to become an iconic and eye-catching building. Next, another aim was to increase co-creativeness with the audience. The client wanted the neighbors to be able to work on the project as well. This was done by letting the public collect plastic to create the tiles of the façade.

The commission was extremely rapid. The assignment was given in November 2016. The interviewee contacted the architects then and they were in touch again in March 2017. In the last week of March the first feedback was
given on the briefing. In April 2017 the first sketch was received by the client. A few weeks later, it was known how the cross formed structure was going to be made. At that point different supply parties were contacted, asking if they would like to join the project. Several suppliers were found that felt very interested in the circular project and offered their help. For example, a concrete pile supplier was immediately very interested, although there was a pile scarcity, about lending out his concrete piles. For other elements, talking to different organizations went very slow. A meeting was organized with the entire network (of suppliers of construction products or materials) of the client, where they were asked if they would feel interested in cooperating in the project. After, the foundation started talking to the Urban mining company. They helped in providing the borrowed materials and building products. By borrowing everything, it became a material storage in the form of a building. About 99 percent of the materials have been given back to the actual owners for reuse. The experiment worked, because all the materials were given back and afterwards reused.

Not a known strategy was used, however a new strategy was implemented. The client assumed the building is a temporary storage of materials. These materials are in a transit to another destination. Before they go on to the next destination, they are part of the building. The principle here is that a material can be used in different ways during its life time. The client wanted to illustrate the fact that a building can be seen as a temporary storage of materials. This is very alike the principles of the urban mining company.

The project has three learnings for the client. First, because the materials are borrowed, the materials should be given back undamaged, or with higher value than before, to the original owner. This is a very hard objective to accomplish. This was the biggest challenge for the interior. The original idea was to borrow broken chairs from citizens, repair them, use the, and give the mended chairs back. Nevertheless, this would take too much time. In the end old church benches were borrowed from a church in Amsterdam. The learning here is, if you want to comply to your own principles 100%, you have to think of different strategies. One strategy is not enough for all the different aspects.

The second learning is that they realized that this way of completing projects is a style that fits the organization, however, the client realized that it was not the classic owner-contractor situation. The contract was signed with different parties to achieve a certain idea. In terms of approach you need all hands-on deck always to think about how to get things done. As a client they had the same structural risks as the architects. And company x was not only responsible for the construction calculation but also needed to be flexible because of the dependence of the suppliers the business developers could find. So, the roles were not the same as a traditional construction project. This was very interesting, it leads to more teamwork between the different involved parties. You cannot just pass on responsibilities to other parties. The parties are not the owner of the solution, but the owner of the problem. This mentality fits the client’s mentality very well. Within this mentality, teamwork is very important. As a team worker, you need to rely on each other’s vision and expertise. A disadvantage is, it takes more time than a traditional way of work. It also requires a different mindset. The internal project manager, who was working as a technical project leader from an external company, was used to keeping tight schedules and deadlines, which did not work in this project. There was one tight deadline and that was the opening of the building. Because the project manager had never done such a project, it was very hard to make estimations on how the process should evolve. The conventional construction planning he had in mind, did not work during this project. It was therefore concluded that such a project requires a new approach. The interviewee is fully convinced these types of projects need another approach than classic construction projects.

The biggest learning is that in the end, the project would have cost the same as a normal project, because the highest costs here were the man-hours. The man-hours of all the calculations, from the team and from the construction crew. The construction crew were not employees from a contractor but furniture manufacturers and exhibition builders. They had the same mindset as the rest, a sense for constructions, knowledge on site safety and a feel for art. This was very useful when for example arranging the tiles on the façade. It looked beautiful without telling the people how to do it. The learning was that it does not become cheaper when borrowing the materials because materials do not carry the highest costs. It’s the number of man-hours that makes the change.
Part 2: Project management of the project

Project Scope Management:

Three parameters were set before starting the project and are of importance: the building should be developed co-creatively (because the materials were borrowed), no drilling, screwing, cutting, sawing or gluing was allowed and the budget was fixed. This means that everyone was responsible for this budget. If a new development showed that the costs would be over budget, something else needed to be changed. The architects were made responsible for the budget as well. They could spend the budget as they wanted, as long as the building would there on the 19th of October within budget. This meant the budget was handled in a very different way then normally, more creatively. This all made the scope different to a normal project scope.

Project Time Management:

A fixed deadline was set, the 19th of October. Because of another event, the building could only be constructed in three weeks. This was a large puzzle to accomplish. The planning was made by the external project manager. This was a challenge as well because the elements could only be built up in a certain order. In the end it was constructed in 12 days. A contractor was hired to direct the construction. The architects took on the role as construction supervisors. There was always someone on site from the design team, because they knew beforehand not all problems would have been solved before starting construction. They knew some things needed to be solved on site. At some moments company x employees were also on site to solve structural issues. It was a very intensive construction trajectory, in short amount of time building an entire construction.

Project Cost Management:

The fixed budget was set beforehand. This was the total budget of the entire project, from the coffee and tea of the volunteers for event where the old plastic bottle caps could be delivered, to the cost of the truck that needed to bring back the materials to the original owners at the end of the project. The budget was split up in different parts. The ratio of these sections within the budget was the only part they could ‘play with’. For the budget a real-life estimate was made where all the parties had access to. A type of real life excel sheet was made and the parties communicated with each other before changing it. The lines of communication were short, no meetings, but calling or texting each other instead. If necessary, meetings were arranged.

The project structure was like this: the interviewee was the final responsible of the client side. He did not do the project management, for that reason an external person was hired to do this. An important aspect of the group work, was that they needed to use each other’s resources. The network of the entire project team was used to find the different suppliers. The final design was decided upon in July and the construction was finished in October. In three months everything needed to be sourced.

Project Quality Management:

There was no quality management used during the project. It was an experiment and the building had a lifetime of 9 days. Two weeks after the demolition of the building, the materials were used in other projects.

Project HR management:

There was a clear organizational structure, the triangle consisted of the client, the architects and structural engineers. Most of the contact was between the project leader and the designers, that had a very executing role and responsibility for all the processes. These two parties together communicated with the constructor. The project manager was responsible for the general outline of the project and the planning and was therefore continuously talking to the building team. A little extra attention needed to be given to the more social interaction between the different parties. For example, remembering the team members birthdays and having a drink occasionally.
Project Communication Management

Most critics at the end of the project of the project team internally were about the communication. Because the project was complex, transparent communication is vital. It is useful to have a type of strategy on how to accomplish this. For this project, there was not a useful tool for this. The office of the client was located next to the building site. So direct communication was very easy, you could just walk to the site if something was going on. However, we had a problem if someone came in an hour late and missed the conversations. Communication was done with very short lines and mostly 1 on 1 and this worked very well. However, we needed a tool to make sure that communication was registered somewhere, to keep an history. That way everyone is up to date on the decision points and meetings. The method used was not wrong, however, it costed a lot of time. People that do not receive information on time can yield frustration. An appropriate tool for this is Slack, which the client started working with after this project.

Project Risk Management

This part was done in a limited way. Expenses were monitored continuously, including expected expenses, what could go wrong and parts with financial risks. This was mostly monitored in the last few months. During the project this was not used that much, the budget was more a prognosis. Life risk management was done for the budget. A spreadsheet was made with three columns: budget, revised budget and realized budget. The realized budget is that it is assigned, and an invoice can be expected and revised means the parties spoke about the proposal, but it is not yet signed. The combination of the three columns determines the status.

Project Procurement Management

Procurement of the suppliers and project team members is not done on the conventional way. They asked parties that were enthusiastic about this idea to collaborate. The enthusiastic parties were asked to collaborate, a contract was signed, and everyone started working.

Project Stakeholder Management

Other stakeholders, beside the project team, did not play a large role during the project. Because of the following reason: the building was constructed as a part of the event where the building was used for. Therefore, all the contact with parties was with the client and permits were given like this as well. Because the project was so experimental, the municipality agreed on all the permits.

Project HSSE Management

This part of the project is done the conventional way.

Project Financial Management

Not a traditional nor a circular business model was used. The client is a programming cultural institution. Per program, a budget is given which needs to be spent on infrastructure and the program. The interviewee combined this entire budget and presented it as the budget for everything. And if a party needed more money, that was all right but together the project team needed to think of a way to obtain this extra money. Everyone was responsible for the budget, that is was made it a new business model.

Part 3: The future of Project Management in circular projects

The problem at this moment is managing a circular construction project is like reading tea leaves. Only experiments are done, since no large-scale projects have been delivered until now. Communication is a very important aspect for these types of projects, as a project manager you need to make sure that every project member is always up to date.
Next, the conventional way of thinking about project management needs to be forgotten when working on circular projects. The new method is a lot more organic and does not follow a certain path. What is noticed, is that it does not work to have a fully conventional work plan, specifications and budget beforehand. The question should be how to combine the specifications of the project to the ambition. For project A, a white book is made with the client’s ambition, aims and principles and based on this white book parties were asked to join the process. The white book is pitched for different parties.

Traditionally, the client procures and together with the procured parties make rules of the game. For circular projects, that does not work that way. Different parties with the same dream should work together by saying, I do not know exactly what I ask for, but this is the budget and this problem needs to be solved. Also, leadership should change, a manager should not make a PowerPoint explaining what should be done and when. You need to make people responsible for the problem.

If circular projects need to be upscaled, the interviewee would recommend looking at the streams of materials that are available. Those streams should be used at the start of the project. Later, this should be standardized. By standardizing, things can be managed more easily.
Appendix D.2: Interview project C - interviewee 2

Function: intern
23 August 2019

We are working together with Arup in London. Together with the Ellen MacArthur Foundation they are doing a research on the impact of circular constructions. This project is a test case, so the client sent a lot of information, so they can research it. Part 1 of the report has already been published. It’s called Principle to particles. There is little information available on how to do circular projects. A large advantage for the project was that during the construction the design changed. Therefore, a good comparison could be made between the old (traditional) design and the new circular design. Interviewee did an internship and has now been working at the company for a few months. She did a research on the energy techniques in the project and how these were interrelated.

What happened is that a lot of people that worked on the project during construction left the company after completion. Few people understood very well the entire building, or people that understood it so well they could not explain is easily. The knowledge was therefore lost. The report explains the techniques and looks at the innovations that are now available, how are we going to test them and how can the living lab be exploited. The project is set up as a test case.

The interviewee believes in circular construction, but it’s very complex. Mostly if you look at organizational. There are a lot of parties involved, and for that reason the ownership got lost. That is what went wrong in building management. A lot of people involved during construction, when it was completed, and the doors were opened, all the involved people were gone. Or they started a new project or started working somewhere else. This happens everywhere and makes sense. The project was finished but there were things not finished entirely. That had to be fixed after completion but that is difficult because the people that made up everything carried the entire project. And those people were not available, there was not one boss of the project. It is very useful to have one person that shows ownership and says this is how we are going to do it. After, new coalitions started that helped the exploitation of the building. They often sit together to make sure that the circular set of mind stays within the building.

The aim of the project was never to make a perfect circular building, but to learn from it, they want to share the things that went wrong to make sure circular construction goes further. A lot goes wrong in construction projects, so also in circular construction projects. Often a reason is communication. Because so many different parties are involved it can be hard to contact some parties, you don’t get replies and therefore the process gets stuck.

The building first had a different design before the circular design came through. The building was going to have the same style and form, however, the materials in the two designs are very different. In the first design, a lot of concrete and marble was going to be used where in the new design more wood is used, everything is recycled. The building is not 100% demountable. The aim was to do as less tight connections as possible, so the construction was as demountable as possible. The problem is, the craftsman that do the construction might not be that into circular constructions as everyone else is. So, if they need to fix something, you can never know for sure they will not use fixed connections. The largest parts have been screwed together.

Interviewee is sure there is difference in project management between traditional and circular construction projects. But how is difficult to say. The interviewee does not know if the collaboration form changed after the second design change. In this project there were some visionaries, they thought creatively about everything and the manager performed this. The project manager thought of ways to carry out the plans. After the second design a lot more companies joined to project. All these companies had creative circular niches which made it way complexed, more companies involved. This makes it hard if you need something, to who to go to.

They are still working on the commissioning of the project.
Appendix D.3: Interview project D - interviewee 3
Function general: sustainability & circularity advisor
Function project: sustainability advisor
26-08-2019

Part 1: General project questions

The interviewee was the sustainability advisor on the client side during project D. According to interviewee 3, there is no large difference in project management between this project and other project he did. The only large difference was the type of contract. For this project a DBMR contract was chosen by the client, including the R of removal (or reuse). This meant another procurement concept was chosen. But this did not influence the management.

The client is more and more working on the circular economy. Within the company there are some frontrunners. However, the question is how to get the rest of the organization to follow. The employees are doing their project work in the way they are used to and there is little time and money to start thinking about new concepts. Even if the employees would be willing to do so. In a slow pace, steps are taken. There is a core circularity team which includes team members of different departments. Advisors for example, are trying to develop knowledge to translate the circular economy into certain demands to be able to implement it in real projects.

The client is responsible for the award criteria for projects. What happens, is that sustainability and circularity often do not make it to the award criteria. Because quality and functionality are often perceived as more important. For that reason, interviewee 3 finds that sustainability and circularity aspects should be implemented in the project requirements. That is the only way to make sure something will happen with it. That way possible stakeholders need to think about it in a strategic way, by thinking about opportunities to guide on. To accomplish this, the client is working on a new instrument. The instrument will not give a specific answer, but it will help consider and deliberate the different options. For this specific project, the entire building will be removed. But for other projects, there could be options such as renovation, bio based, remove or remove partly for different objects of the building. The instrument lets you consider the options for all the different layers of the building. Project D was the first project of the client to introduce the circular economy.

The role of the interviewee during the project was sustainability advisor. The sustainability advisory team consisted of a few team members where all the team members were involved in different projects at the same time. All the project team members had their own priorities. The interviewee was not always involved in the project, but incidental.

The project was a very quick project, with little time and little money. Therefore, circularity was not the idea at the beginning. The interviewee warned his colleagues that they should make sure the project would not make the headlines of papers. It would be very bad publicity to build the construction for 5 years and after that turn it to waste. This would be a waste of tax money and an environmental burden. Because the client wants to be a frontrunner when it comes to circularity, they should lead by example. The project team agreed on this. However, they did not know how to achieve this. Therefore, a discussion night was organized with professors of the TU Delft. Interesting ideas came up during the night. On the way back of the event, the eventually carried out plan was discussed by the interviewee, the project manager and the architect. The interviewee should not become the client of the temporary construction. By doing that, they ensured that the other stakeholders would make a design where the most value could be harvested, and therefore the design with the most quality would be ensured. The project team became even more enthusiastic about the plan when they found out it circularity could also save costs. Concluding, the following factors played a large role in the decision to make a circular building: reputation, costs and ecology.

In the award criteria used in this project were categorized into three subjects: the life cycle of the products that were used out of donor buildings, the environmental burdens during the life time of the building and the future of the building after this life time of 5 years. For example, the future of the building was calculated in the following way. If the building was already sold after the life time and the contract included a signature of the buyer, 100% of the total points would be received. If a contract was set up but only a signature was missing, 80% of the points would be received and so on. The downside is, you can never be sure of what happens after the life time. After life time of 5 years, it is out of the responsibility of the client.
In the end, the building might have some waste, but it is designed to be able to dismount and rebuilt the building maximally. A new type of measuring device was developed to evaluate the circularity. The MPG method was used in a circular way.

**Part 2: Project management of the project**

Project Scope Management:

The scope is always defined at the start of the project, as in this project. System-oriented contract management is used to control the scope.

Project Time Management:

The sequence of the activities and the estimated resources of the activities have been partly done by the client and partly by another party. The client estimated the project lead time of the execution. But this had to be fine-tuned with the involved parties. The moment you are going to tender, you need to have agreement on the planning, if it fits or not. If three parties disagree on the planning during the tender, you know something needs to change.

Project Cost Management:

At the start of the project, the client estimated the costs. Based on that, the budget is determined. The interviewees organization has internal cost advisors. They helped them with the costs, based on their experience.

Project Quality Management:

The expected quality has been determined beforehand. Activities have been performed to ensure the quality is as high as expected at the start of the project. The client has made a relatics model where the minimal requirements were described. The client defines everything in performance criteria. This is dependent on the type of contract. The client did not remain owner in this project and a DBMR (without operate) contract was used. Based on these facts, the requirements are defined. This all ends in an output specification. This is one way to assure quality. On the other side quality was assured in the EMVI, or award criteria, where the client tries to stimulate parties to go a bit further on certain aspects.

Because of the rush of the project, the architect elaborated the floor plans at the beginning, so it was more an Engineer and Built contract. Because the basis of architecture was already laid down. During the tendering, activities have been done to control the quality. This was mostly for the risks and the award criteria. Responsibility was moved to the market parties.

Project HR Management:

The project team is acquired and developed. From the start, the project team have been managed by team leaders that have been involved during the execution phase as well.

Project Communication Management:

Stakeholders is a very broad term. Information is always distributed in a certain way. A project initiation document is always made where planning, costs and distribution of information are described. Every GOTIK element (money, organization, time, information and quality) is discussed. That needs to be actualized during the project. The core project team mostly held meetings. The project manager is part of a project management team where each of the managers, manage other groups. These project managers coordinate the different advisors, from structural to architects. In this case, the interviewee has barely been to a meeting. Mostly one-on-one contact was used.

Project Risk Management:

In the system-oriented contract management, risks are managed. There is a difference in process risks and substantive risks. Without doubt, risks have been managed for this project.
Project Procurement Management:

Procurement is planned beforehand. Before deciding on the procurement, solicitations have been planned and executed.

Project Stakeholder Management:

The location was very crowded and there was a lot happening on the terrain. So, all the stakeholders have been inventoried and stakeholder planning was made. Furthermore, one of the award criteria was the prevention of nuisance. So therefore, it was important to analyze the environment and surroundings. This has been monitored during the execution of the project.

Project Integration Management:

Standard in the organization is to make a process card. Here the steps are described of the process. The project management plan is described in the project initiation document. Changes, and for example how are changes made in the project defined in the contract, are done via a fixed system used in every project. Phases are closed off during the project with the help of documents.

Project HSSE Management:

This has a different name in the client’s organization, but all the elements are used. The organization does a risk analysis based on safety. Health is a continuous theme and is implemented in the company, translated in all the building physics aspects. For environmental the organization has their own sustainability criteria. This all is for the client organization, not for the consortium. No management plan regarding these elements has been created, although all elements are implemented in some way in other documents.

Project Financial Management:

The finances of the project have been calculated in a traditional way. Which showed that circularity can save money.

Part 3: The future of Project Management in circular projects

The costs could have been calculated in a different way. In the section architecture and technique, it is an aim to achieve more knowledge on the circular economy in the built environment. Often a problem is that consultants believe there is no budget for circular buildings, when a project is approached on the traditional way. And, at this moment, what can be gained (the advantage) at the end of the project life cycle is often not used in the calculation at the start. So, the revenue (for another organization for example) is not used in the project. And this does not mean we should all start building demountable. If a client knows the project will be there for 300 years, a demountable construction is not necessary.

Although everyone understands that if you are frugal with your belongings and you repair broken products, that should be economically advantageous. But the investment at the front side does not work at this moment. The mindset of the people need to change to see this. There is also a difference in the various sectors, for offices this is more and more known, but for the specialties, such as this project, the circular advantages are less known.

To achieve this, ambition documents need to be drafted to explain the various strategies of circularity. That way a conversation can be entered with the client. Demountable is a type of circularity where bio based is another form. But in this project, it is not visible that it is completely demountable and re-mountable.

A mix of materials from donor buildings and new products could lead to spectacular architecture. But it can also become a mess. You need to apply it in a stylish way, and not everyone can do that. Architects need to let go of some things, for example different doors on each floor. Architects need to make a plan for this and present it to the client, not every client will be against it. But the way we procure does not stimulate this way of working. We are not triggering imagination with our way of working. This could be changed by ambition documents or by changing the requirements. The requirements should be emphasizing that the client is okay with everything not being brand new. Besides, it should obey to the technical requirements. However, this can be difficult as well since there do not exist certification of used materials. But for some products or materials, this is doable. An example is security cameras, an idea was to use old cameras from buildings that were demolished for new
buildings. But only sets of cameras with entire systems are certified, and therefore you cannot use and certify old ones. So, no one is interested in the old cameras.

Overall, the management of the process does not give changes. But if you look at the strategy on how to tender, then there is a difference. The definition of the requirements is the change. In this case also the measurement instruments. The instruments are used to make ambition clear to the market. The client needs to enforce it so that is way you need it.

The problem with public procurement, is that you cannot write the tender to attract a certain party. With private parties you have more possibilities. Some new innovative parties make great products, but they cannot choose that party directly. Because that would be unfair for the competition.

In this project the way the procurement was performed was different. In this project there was also a minimum requirement that all the materials and products that were used, they had to be of environmental class 1, 2 or 3. So you could not put down bad quality materials, and later harvest these bad quality materials. Because if they would not have done that you could have asked yourself, how circular is this? We mount and demount is, what is the life cycle is over at the second location, then you have waste.

Another learning point is, that you should not only think of the 5 years you have used it, but you need to make sure it produces no waste. Ownership could go to 3 owners, you have no sight on it anymore.
Part 1: General project questions

According to interviewee 4, there is a difference in project management between a traditional construction project and a circular construction project. Mostly now, in the starting phase of circularity in the built environment, more circular thinking is necessary. Circular thinking includes more than just constructing circular buildings, such as the calculation of circularity. To use circular thinking, you need to do the thinking in a completely different way. In a traditional project management model, the clarity of a project arises when separating responsibilities. As an architect, for example, you receive a task with a statement of requirements. This can be a package of hundreds of pages explaining what the architect should do. The moment the architect receives the package, is often the end of the responsibility of the project developer or project manager. After a few phases, they receive a design in return. The responsibility, honorarium and expertise of the architect stops at the submission. At that moment the responsibility is shifted to the contractor for example. At the end of the ride, which is more complex that the explained example, including a lot of different steps, the supplier delivers the products and materials and the contractor starts to build it. The contractor and suppliers often have no contact with the other disciplines. The tasks and responsibilities are separated for all the involved parties, for example the architect delivers the assigned jobs (the drawings and designs) and starts at another project.

With circular constructions, this is not possible. You must abandon the model where responsibilities are separated. This means that also juridical responsibilities should not be split up. With the traditional model, the responsibility of the architect stops in juridical terms when submitting the design. We need to work towards a parallel model (instead of serial), where responsibilities are shared among all players. This means for example an architect needs to discuss the design in an early stage with the suppliers. Because of the circular design, other expertise is mandatory for the different products and materials. The responsibility of the design is therefore partly transferred to the propositions of the supplier and its expertise.

The company where interviewee 4 is founder of, has the motto ‘Invent-Design-Built’. The company invents new things, such as plastic slates. These slates are made of recycled plastic and can be used for the façade of buildings. They will be sold, so it is a product of the company (in collaboration with another company). Furthermore, the company’s employees are designers. Lastly, they initiate projects by themselves, where they can construct the buildings as well. Project A is an example. Together with other organizations, they constructed building A. They worked on the scaffolding and thought about screws, bolts and nuts. Another example is that they just finished three residential buildings, where the organization also functioned as the contractor. The company finds it interesting and important to implement the circular way of thinking on all the layers of the process.

Circularity was never a central aim in project A. But it was the suitable answer to the question. The query of the client was to make the leading pavilion for only 9 days. In total 600 people had to fit in the building and it should become the sustainable statement of the coming generation of designers. It should be the precursor on the field of sustainability. But the architects concluded this was an absurd question, to construct a building for 9 days which should become a sustainable statement. For 9 days the most sustainable option would have been a circus tent, not to construct a building. The only answer to the absurd question, was (an absurd answer) to borrow everything. If you borrow every material or product, and you give everything unaffected and unbroken back to the owner, then you make a loop in the material life cycle which is unnoticed. For example, you borrow wood from a wood producer and after 9 days you return the wood in the shelf of the producer. This is extremely sustainable.

When you start thinking about this way of work, more possibilities arise. If this type of building is possible for 9 days, maybe it would also be possible for 9 months, or even 9 years. Then the new economic model arises, which is naturally very circular. The materials are after building life cycle equally good as before, and thus worth the same or even more.

The main strategy for this project was borrowing, they did not need another strategy such as ReSOLVE. Also, if it is a virgin material, after 9 days it will still be a virgin material. By using it, you do not change anything about the properties of the material. However, during project A, the architect had to really think through what to borrow.
A possibility is to only borrow new materials, but another possibility is to borrow materials that already had a life before. This is done with the help of the garbage of the citizens of the city the project was located at. With the garbage, new building materials, which in this case were slates in different colors, were made. These were returned to the citizens at the end of the 9 days, in more value. The value of the garbage increased to a slate. Moreover, the façade on the ground floor was borrowed, it was an old façade of an office and they were planning on moving the façade to another location. The façade was used in its entirety in this project, when it was on its way to the new location. The windows were going to be dismantled, so the truck only had to drive past the project site on its way to the new location. The materials used in the project had therefore no impact on the environment (besides the trucks moving them to different locations).

The most important learning was that it is possible to make a 100% circular project with materials that were returned undamaged and dismantled, back to the owner. This has now been proved. The next question is, how to scale this type of experiment up. Questions that need answers are for example, what if we insulate the building, or what if we place the building for 9 years. Therefore, we need to start thinking differently.

The project was a success because the commitment was carried by all the different layers involved in the project. In this project all the parties were responsible and committed from the start to the end of the project. The process only took 8 months and was therefore clear and comprehensible.

Part 2: Project management of the project

Project Scope Management:

The project did not have requirements. The assignment was: make a spectacular building. People needed to be able to sit inside of the building. This is positive, because it gives you the possibility to make plans together. If you have the courage to define the project definition together, it could lead to innovative and intelligent ideas. Normally, the input of the project is done by the client by him or herself. While you could have a lot of fun to be part of a team with different disciplines to define the input of the project. Because in this project it was a team effort, a work breakdown structure was not created.

Project Time Management:

There were two activities defined, which were design and construction. This was possible because everyone was committed, and every person involved shared the same idealism of perseverance and conscious naive optimism. There was not a detailed planning, only a very strict deadline. The deadline could not shift to one day later. Funny is the difference in project planning, in traditional project every project is eventually over time. However, in this project, where there was not a detailed planning, the project was not one day over time.

Project Cost Management:

The budget is defined at the start of the project and this was clear to everyone, always. In the end, the costs were a bit over budget. Because it was a very new project it was hard to quantify at the start. So, interviewee 4 is proud that the cost overruns are small. A budget was made by the client. The costs have been controlled continuously, it was a dynamic budget. The budget was very transparent, all project team members could investigate the budget.

Project Quality Management:

Quality was defined in terms of safety and regulation. The aim was to make a pavilion that satisfied the construction regulations. This set the bar very high. During the same types of events or festivals, rules are made related to construction safety. These are relatively light. There are little control mechanisms. The architects decided that they wanted to submit a formal construction application. This was done to show and prove that the circular way of thinking could work, and not just for an event of 9 days. To show it had more potential. Therefore, the relevance was proved, not only for 9 days. The municipality admitted they never received an application of this level. By doing this, the quality level was reviewed. The construction has been checked and verified at a laboratory of a university. Therefore, the safety was controlled before starting the construction. This has therefore been substantiated theoretically.
Project Human Resource Management:

No Human Resource plan was made. The main project team consisted of the three architects from the same organization, the program manager of the client competition, the financial manager of the client and the director of the client company (with 5 or 6 employees). The project team was not managed by one person, the project team together made the decisions. Besides the project team other persons were involved such as the contractor, volunteers and designers.

Project Communication Management:

There was no beforehand chosen software used to share information with other parties. There were not that documents. The documents were emailed to the different parties.

Project Risk Management:

The risks of the project were very high. And the ambitions were also very high. The art is to take a lot of risks, because then the chance it goes well is the largest. If you try to control risk and plan risk responses, then usually the risk response will be used because in the heat of the moment, the stress is the highest. If you use these risk responses, the project will be of lower quality. If you agree beforehand that there is only a plan A, you will still feel the same stress but together you know there are no better options. And that is usually successful. So, there is made a conscious decision that no risk responses were planned because that is at the expend of the project.

To make a list with everything that could go wrong is almost impossible in such an innovative project. That is very difficult to oversee. So, you need to do risk management in another way. The project team works based on trust and responsibility. You need to invest in this because it is really a risk tactic. By sharing responsibilities and tactics, the team members help each other instead of sticking to your own tasks. So that has effect on the risk management: no detailed risk management is needed but when a risk comes up you deal with it together.

Project Procurement Management:

The project team members called suppliers to ask for participation. Suppliers became more and more enthusiastic. Some did not understand entirely what the project would consist of, but they were conscious of the fact we need to start to think differently about materials and they wanted to be a part of that. All the materials were borrowed for free. So, no procurement management was used. In the end the contracts were closed off.

Project Stakeholder Management:

The stakeholder engagement plan not made by the project team. But the citizens of the city were engaged actively in the project. The project was part of a larger event, so the rest of the stakeholder management was done by the client. The organization manages the stakeholders in a very good way, aside from the project. People living in the vicinity received VIP treatments during the period of the larger event.

Suppliers, producers, contractors and users were all managed during the process. The way the communication was done during the process is not decided on beforehand. There were a lot of meeting and 24-hour WhatsApp contact. But that has not been formalized. There was not fixed meeting moment. Because of the nature of the project, there was not a fixed structure for communication. As the deadline came closer, the communication became more compact.

But a structure was laid down with different phases, with preliminary design and final design, for supplier’s product specifications, supply management. This came together and was monitored well.

Project Integration Management:

No project charter was made for the project. The project management plan was not made either. All the phases have been closed off in between, with the help of meetings and official documents.

Project HSSE Management:

Beforehand, a definition and inventory have been made about the rules that need to be obeyed for the project. An example is that these types of constructions need to be able to handle wind force 7. If the wind force is higher, the constructions need to be evacuated. The current project had the following rules: the construction
should be able to handle wind speed 11 and be safe, and at wind speed 9 the construction is evacuated (for double safety). So, the boundaries were pushed to ensure high quality and high safety. This is also done for fire safety, among others. There is not separate document made for these subjects, but the definitions have been described in collaboration with the engineers involved. This also has not been formalized.

Project Financial Management:

A financial planning was not necessary for a project with such a short planning. The risks were not legally shared by all the parties. If something went wrong, the risks were responsibility of the client. If for example the deadline was not met, the architect would have not received its honorarium. But the client did not have the construction for the event, which is a very large risk. The taxes have not been planned, this was not necessary. Thus, in the end, a circular business model was used.

Part 3: The future of Project Management in circular projects

The interviewee was very happy with the process, assuming that it is the first step to a circular economy. A thing that the interviewee would have done in the future is to highlight the relevance in the bigger picture. A method should be invented in project organization, but also in design organization and new financial models, another type of economy. Labor is taxed higher for example than materials. While labor is a very circular way of working, one sandwich in and one can work tomorrow again. This is very CO2 friendly. If you take this into account in a new economic model, then the entire system changes and thus the entire building environment. In a future project, the interviewee would try to generalize the results. More than they have done now with project A.

The most important step that parties need to take is to be open to a shared responsibility model. And from that model, take active steps. This asks for a certain mentality. If you start working with that work ethic and find partners, then everything will shift once starting a project. The interviewee notices this with suppliers of products, some suppliers only have the options buy or do not buy, but others are happy to be able to join the movement. With that supplier you want to work together to think of a construction to make the design different, stronger, better and maybe prettier. The new idea is that with circular thinking you can tackle societal problems that the traditional type of thinking cannot solve.

Circular thinking could be an answer to a lot of problems in the city. If on the moment that the materials of a building could produce money if you put them together in a smart way. That means you do not have to recoup the investment, but instead you build up the investment. And the fact that somebody lives in the building, is only useful. You get a totally different model. The interviewee really believes that if the societal problems from today, are tackled with the help of the circular mindset, that there is a lot to win. And for governmental parties this is very difficult because the system of logics need to change entirely. But if we stay optimistic, this will be alright in some time.
Appendix D.5: Interview project B - interviewee 5
Function general: architect, co-founder and owner architecture firm
Function project: leading architect
04-09-2019

Part 1: General project questions

Interviewee 5 believes there is a difference in project management between traditional construction projects and circular construction projects. Not only in management, also in project approach. Project B is a reuse project of an existing building. The building was an industrial monument, owned by the municipality. After the construction, the building got a different function. The process of a circular construction takes more energy by all the parties concerned, the project managers as well as the designers and the users. To design circularity takes extra time but because it was an old building with an industrial function, made it even more timely to design. An example for this is that a lot more investigations had to be done. Investigations on the constructions, contaminations and pollutions, the hanging façade and more. It therefore cost a lot more time. In this project there was a lot of commitment, so the extra time was not a burden.

During the project, there always has been a lot of commitment among all the parties. The commitment made it possible that more time and more investigation was not a problem, there was no battle about it. What happens with other projects is that sustainability or circularity have lower priorities than other ambitions. Often sustainability and circularity are then lowered. With project B, this did not happen. Like every project there have been some hiccups or communication issues, but never about the importance and relevance of the project. Everyone always agreed on that the vision should be implemented.

Circular construction is a buzzword according to interviewee 5. In more and more projects circularity is a requirement. The interpretation of the definition varies a lot. The architect firm has done several transformation projects, where the reuse of an existing building considered as a circular aspect to the project. Another thing that is more and more common, is the reuse of materials. Often materials deform after the first use, and after that need to be modified for further use. You could ask yourself how circular that is. For example, for one project bottles have been collected from citizens, which are later processed into plastic panels. This is nice, and it is a way to engage stakeholders but if we look from the sustainability point of view, you could ask yourself what is achieved with it. It is not a bad idea, but there are a lot of different ways to work with materials. Glass windows for example, is often made of old recycled glass.

Interviewee 5 believes that project B is a partly circular project. The project contains a glass hall, which was situated in an old building and was dismounted and mounted in building B. This was very circular, and people were enthusiastic about it because of the history. Next, as much as possible is preserved from the old building. The façade and the floor (as much as possible), the roof, the steel structures, the old crane lanes, the two largest cranes and a little crane and the old train tracks have been preserved. The structure, has been treated and painted a lot of times in the past years. The structure had multiple layers of paint. From early on was decided that this should be preserved. No circular strategy has been used in the design of project B.

The building consisted of two large halls, where one needed to be transformed for different functions. Together with the engines a construction with 5 climate zones was invented. The hall itself is not climatized, were different rooms have their own climate zone. The temperature range can be large. In other zones local sanctions have been taken to make sure the comfort is high. That is the concept that was designed to make the hall livable. The circularity has not been measured. The architects investigated the building to see what could be preserved. An idea was to retain all the glass, but on three sides the glass needed replacement because it was old and broken. Because of the different time zones of the building, it can be too hot or too cold. This is something that is part of the building. In addition, a calculation has been made what the consumption would have been of the building with or without solar panels and thermal storage. Last week the first calculation of the monitoring was sent to interviewee 5 until from the start until august. It seems the actual consumption is aligned with the calculations of the consumption.

There were several project managers involved in the project. In the design team, the leading architects were responsible for this. The municipality hired an external project leader (project manager x) and the project leader organization hired another organization that were responsible for the project management (project manager y) between designers and users.
Part 2: Project management of the project

Project Scope Management:

The project requirements set by the client have been analyzed. Based on that, the scope is defined. The work breakdown structure is created. The scope has consistently been verified and controlled. Excel lists are made including all the scopes. The project scope is approachable on different ways. As a designer you receive program requirements and you need to analyze what the client wants and what you want to propose as a designer. Later the architect presents a vision, which is reviewed by the client to check whether that is what they asked for. On the level of vision and design, scope is already assessed. Later in the project you will find scope lists with the responsibilities per party. At the start the responsibility lays with the designers and the technical advisors. A step further you have a scope on what every party does.

Project Time Management:

All the activities have been planned in phases and based on that a detailed planning was made. Along the way, new definitions need to be implemented in the planning. In the end it always takes longer than was planned during the time management. This part has been done in a very structured way. Per activity the time and resources have been planned. The planning was continuously controlled, also during the two-weekly meeting. Planning and scope were among others, the subjects that were discussed every time during the two-weekly meeting. The meetings were held with the designers, the client and the users. A meeting day consisted of two parts: in the morning a technical design team meeting and in the afternoon design meeting. The architect was involved in the technical team meeting and the design team meeting. The organization that was responsible for the process (project manager y) was also present during both meetings.

Project Cost Management:

At the start of the project, an estimate has been made of the project costs. The costs for every phase have been calculated and this has been done in several steps. First a calculation has been made, during the phases, checks were done to see if the costs were within budget or cut backs needed to be done. So, costs have been steered on a lot. The budget has been decided on at the start of the project. The budget was given, and the costs were continuously checked to be sure these were within budget. In the end there was a little cost overrun, but these overruns occurred mostly because of the new desires of the client during the process. Two examples are the thermal energy storage and the solar panels on the roof. The client did not ask for this and it was not implemented in the budget. But the decision for these two systems was made when options to become more sustainable were discussed. But when such a decision is made, budget needs to be enlarged for these two systems.

Project Quality Management:

As an architect you have a vision for the project. In the end you want to live up to that vision. Quality was therefore planned by the architect. In another way, quality was improved during the process. Mostly about sustainability, with input of the engineers. At the start, the client did not have high sustainable ambitions. Mostly because the client has in mind that within the hall a new building would be placed that would be equal to a completely new building. Because the designers came up with a totally different vision, it has been chosen to increase the sustainability ambition. That has been implemented in the entire project. Later, from different directions, the ambition was increased even more. Solar panels were added to the plan (which were not in the design at the start) and the contractor pulled it to the next level by requesting a certificate for the building. Eventually BREEAM very good was obtained, which is high for such a project. Thus, with these examples is illustrated that the quality has been increased during the process.

Project HR Management:

The project manager has developed an organogram with responsibilities per organization (project manager x). The organogram focused on responsibilities of companies, not on individual people (on what characteristics they should have). It was the responsibility of the company to divide the tasks within the organization. In accordance with the organogram, the project team has been developed. The second project management organization (project manager y) lead the project team. At the start there was no project manager involved, but since there were so
many involved parties with all different interests, it was necessary to manage the project team. These persons managed the project team as spiders in a large web.

Project Communication Management:

Stakeholders have been identified beforehand. The building was going to have several different users. One of them was brought along during the entire development of the plan. The plan started with 5 users (or tenants). Three of which have been taken along during the process. The last party, has been contracted only 14 days before the architect selection. A communication plan has been made during the process. At the start communication was planned with the communication section of the municipality. Early on, points have been chosen where communication needed to be about to the external environment. Another important point of communication was to the city council. The money was not there yet. A decision had been made about what the team was going to do including a budget, so the municipality gave a price it may costs. Therefore, an entire communication trajectory was made focused on the politics. Moreover, the building is a municipal monument. Therefore, communication with the landmark’s committee was discussed in detail as well. So, concluding, there were several communication trajectories: to the inhabitants of the city, to the politics, to the industry etc.

Two systems have been used to distribute information. In the project phase a certain platform was used. All the documents were uploaded here. In the second part of the project, the contractor always worked with a certain system so that was used after. Interviewee 5 is certain the performance has been reported, but she does not know anything about that.

Project Risk Management:

Project risks have been management continuously, also during the two-weekly meeting. Risks were identified during the progress of the design, about the investigations and the budget, among others. Risks have been identified as much as possible at the start of the project, but this was refined along the process. Risk analysis have been performed, quantitatively as well as qualitatively. The risk analysis is done during the design phase and the contractor steered on this as well. Risk responses have been planned during the process. Risks are monitored and controlled during the meetings and project manager (y) was leading in this.

Project Procurement Management:

Procurement have been performed in a traditional manner. The contract form was not traditional, a UAV-GC contract form has been chosen. Besides that, a basic traditional tender procedure has been used. In the first rounds, interested parties could inscribe in the tender. Suppliers of products and materials have been contracted by the contractor. In the tender documents requirements about products have been described. During the process the products were checked on whether they matched with the question of the client.

Project Stakeholder Management:

A stakeholder plan has not been made that literally, but on another level, stakeholders were managed as well. This was very special, the users/tenants were part of the process from day 1. They attended the design meetings, they organized user meetings and they organized plan team meetings, to think about the politics of the project. So different consultations were done on different levels. Presentations were given to the political department of the municipality. It was not only about talking to the investors but also the inclusion of the industry. Therefore, several communication events took place.

Interviewee 5 is not sure if a stakeholder engagement plan was made, it was not made by the designer. But it was a subject that has been checked continuously.

An example, is the interviewee did 91 presentations in the design phase. She had to present to the users, the politics, etc. The interviewee went 11 times to the environment commission. So, stakeholders have been managed actively. The success of the project was for a part to thank on the stakeholder involvement. It has become everyone’s building and the architects are very proud of that.

Project Integration Management:

A project charter has not been made. The steps that have been performed are very traditional. They had draft design phase, definitive design phase, tender documents, permits applications, the different steps were known by everyone. With the textiles, the team noticed that they were working in a traditional building process. The
The architect presented a vision: an open building with enormous textile curtains. This was an integral concept; the textiles are part of the design. The contractor put the textiles on hold. While the developer of the textiles kept on saying that the group needed to hurry because the development of these textiles cost a lot of time.

The development would cost over 2.5 years. At one moment there was a money shortage, were people said let’s eliminate the curtains from the design. That was impossible, it was an integral part of the design. In the end the client and the users made clear they wanted the curtains. The process went very well but the moment something unknown came up, with unknown steps, that has been the most difficult part of the project. The process of the curtains was very new, even new threads were developed for this project. Therefore, it was noticed that there was a large difference between traditional activities and more innovative activities. These were worlds apart. It can be said that the construction sector is very traditional, and it is not ready for innovations. There are experts that can handle innovation and know what to do with it, but to harmonize the two different type of parties, a lot of time is needed.

The professional project management company, made the standard project management plan which has been monitored continuously. Change control has been done, but not in a systematic way as a management tool. Because of the continuity of the process, and because of all the agreements made it has been done, but not as a separate assignment. The project phases have been closed off during the process. This had partly to do with the agreements that had to be made to the users of the project. Tenant contract needed to be made. Steps in between were also necessary to receive money from the politics. Therefore, phase documents have been made.

**Project HHSE Management**

Policy and rules regarding this was made by the engineers of the project.

**Project financial management:**

Agreements were made on the timing that all the parties could invoice the project work. Risks among the parties have been divided in the building contract. Taxes have probably been planned. Traditional business model has been used. A circular building but the entire process was traditional.

**Part 3: The future of Project Management in circular projects**

Three things need to change. First, construction clients need to have more circular ambitions. And if the situation gets difficult or hard, they should not deviate from these ambitions. Secondly, as designers and advisors, it is learned that during the trajectory, ambitions can be increased. Certainly, when you are dealing with experts, that understand how it works. Not only the client, but also other parties can increase the ambition during the process. Parties can inspire each other. Thirdly, always look critically at what you are doing and why you are doing that. Do not make choices just for the show but look at what really contributes. If you look at the current sector, we can all handle a lot. It is about knowledge, inspiration and motivation. If we have that, the chain can manage a lot.
Appendix D.6: Interview project D - interviewee 6
Function general: Director project development
Function project: Project developer
05-09-2019

Part 1: General project questions

Interviewee 6 believes that the success of projects is not related to the process design. The company sees a lot of traditional projects that are very innovative. While other very innovatively managed projects produce projects that are not of high quality. For the interviewee it is about the people, with their intelligence and effort, that make a project a success (or not). The interviewee can imagine that if you use a project management style where there is one director that decides on everything, you can also produce a circular project. But it depends on that person. So, the interviewee believes it depends more on the people than on the process.

The company sees circular construction in the context of sustainability and the making of buildings that during their life cycle can adjust to new situations. By doing that, you can make sure that projects and buildings can preserve their value (or have a more predictable value). It increases the chance that in the future the building can be adapted, such as a new functionality, to dismount, to relocate it, compared to traditional projects. The company calls it circularity on intrinsic level. Later, the cycle of circularity can be 5 years or 1000 years, that is unpredictable. We cannot influence that. But what we can influence is to develop a building that is made as good as possible for future generations with as much value as possible. That is possible with the help of traditional business models, circular business models, as a service business models etc.

The company works in the entire range of the building process, the development, architecture, realization and maintenance. They do not do this on their own, often they work in consortia with other developers, advisors etc. Together with the architecture firm they are allied to, they can work on the entire trajectory of a building. The basis of the company is that they approach every assignment based on the design. They believe you first must design something before building it, which often does not happen. Because they have knowledge of the entire chain, it is easier to set priorities. Nowadays, barely value gets added to projects. The design starts off very beautiful but is deteriorates over time. The company has much more hold on costs and spatial planning regulations from the start of the project, because they have a lot more knowledge in-house. Therefore, the quality is more consistent, processes are more efficient, and the costs are lower.

Project D will become a circular project after it has been used for several years, with or without a change in location. That will show whether it is a circular project or not. Moreover, even then it is hard to demonstrate because circularity is something different then recycling. For real circular projects you want buildings that exist for a lot of years with different functions, such as a canal house. The structure of the buildings is maintained, but because of the adaptive ability different functions are possible. The company sees this as the basics for circularity. With that said, project D could be a very circular project, but it depends on the future.

The tender of project D described that a new location needed to be found for the building after 5 years. However, a lot can change in 5 years. The best solution needs to be found. During the process possibilities could arise that are a lot more efficient or sustainable. Which can yield more than the solution of five years ago. Investigation is now ongoing to see what the different possibilities are for the new location of building D.

In the last few years, the company has worked on several projects that are built as kit-of-parts. The question of the client was to make a temporary building, which has the less waste as possible. Other parties made a temporary building for the temporary use, but this company made a permanent building for the temporary use. The permanent building can be dismounted and relocated for other temporary uses. In the transition to a circular economy it is visible that the value of a building is higher when the components of the building stay together, instead of being separated into different components. The ability to dismount is to make it easier to relocate the building. The word circularity was not used in the tender, the company introduced that.

The 10R model was used, the company tried to be as high as possible in the ladder with R’s, mostly refuse and reduce. They believe as little as possible materials should be used in the most efficient way. This is measured with the brutto/netto ratio. The company tries to be at least above the 90 in the ratio. Which means you use little virgin materials and when using materials, make sure to use it in a smart way. That is incorporated in reuse and refuse.
Refuse is for example possible when a company is deciding whether they would like to grow in the future. By making it possible in the design to grow in the future without doing major changes, refuse can be used.

The most important learning of the project is that somebody needs to have interest and find it relevant to use apply circularity principles. Therefore, it can generate something. The reason (money, publicity etc.) does not matter. Somebody needs to put a lot of effort in it, otherwise the output is not positive. In project D, the company of interviewee 6 has interest in reusing the building on another location. The company also had own benefits in making the building’s quality as high as possible, so that the residual value would be high at the end of the life cycle of 5 years. And the client wanted a building of high quality with panache. Therefore, the ambitions of the two parties were the same while having different long-term goals. However, maybe this is a more general believe and not a circular believe.

**Part 2: Project management of the project**

*Project Scope Management:*

The project requirements have been analyzed, with the help of a requirement analysis. After that the scope has been defined with the help of a new verification and validation tool which is developed at the start of project D. The tool is later used for other projects. The work breakdown structure is made, as is always made, to divide the building in easily manageable pieces which can be made or designed by one party. The tool made sure the scope is verified and controlled during the process. The tool first analyzed all the requirements, at every design step and the tool checked if the design complied with the requirements. It also checked how the design complied with the requirements, and if they did not meet the requirements, why not. It was checked with the client and sometimes it was better not to meet the requirements. A record of this has been made per phase (vo, do, etc). That was the verification trajectory. The validation trajectory consisted of activities to see if the team was working well on the more abstract scope of the project. Seven critical success factors have been defined with the client, such as budget and planning. Some very pragmatic subjects as well. But also, if the project still fits the quality ambition of the client, which is very abstract. But for every step taken, these factors have been checked. That means, continuously checking on a higher abstraction level, are we meeting the targets? The details (how many toilets for example) are discussed in the verifications. That is more pragmatic. One of the validation criteria was nuisance in the surroundings. This was very important for the project.

This tool is developed in a web-based system for this project. Before the tool existed, it was done as well, but in an excel sheet which is sensitive for disruptions. In collaboration trajectories with different consultants that need to verify the different steps, excel sheets were very sensitive to malfunctions. Some projects are still done in excel because a web-based system is not necessary. But it costs a lot of time and money, so with every project a trade-off is made to see if it is necessary or not. But for governmental projects it is mandatory. This has nothing to do with circular, it is about safeguarding the things you promised to the client are as expected. It has to do with the consistency and quality in the delivering commitment.

*Project Time Management:*

The activities have been defined and a detailed planning is made with all the activities. Hereby the sequences have been defined with the help of the critical path method. This includes the resources and the lengths of the activities. The planning is monitored continuously and adjusted when needed. They always say, ‘a planning is made to deviate from’. Weekly meetings took place to discuss this. Meetings took place on different levels and different planning’s are monitored. The planning at the construction site is very detailed, where the planning in the project team is on a higher abstraction degree. Here the basic line is surveilled.

*Project Cost Management:*

A very detailed budget is made at the start of the project. The costs have been controlled continuously, such as the planning. In the project they worked with budgets separated into different sections. Based on the design, the budgets are divided into the different parts. Further, an expenditure overview is made to check what is budgeted per part, what is commissioned and what is estimated/forecasted. With the overview the project team knows what costs can still be expected. An idea is to couple this to the resources, but that has not been put into practice yet.
Project Quality Management:

The quality ambitions have been translated into the verification and validation system. The system has been monitored, especially during design phase, every decision taken has been checked in the verification and validation system. The decisions on quality were always conscious decisions, sometimes the quality was deliberately increased because it had advantages from the consortium and the client. Other times, the quality was lowered. But this was always intentionally.

Project Human Resource Management:

In the project quality plan, the roles of the different parties are defined including consultation structures. That is, what role meets with whom, the frequency, etc. For this project the project quality plan discussed the different roles of all the individuals, what the tasks are and when they need to meet with each other. Interviewee 6 and a companion from the consortium were responsible for the different companies with the different tasks. The interviewee talked with the leaders of all the parties to manage the process. It was no micro management. They did the coordination of the different advisors.

Project Communication Management:

Projects have been identified beforehand, which is a part of the management plan. A communication plan was developed, which was mainly of importance for the client, to make sure the communication was according to plan. A BLVC (bereikbaarheid, leefbaarheid, veiligheid, communicatie) plan was made, which stands for accessibility, viability, safety and communication. That plan describes how the construction site is organized, the way to communicate to externals, etc. For critical activities it was very detailed. This is different per project phase. In the preparation phase communication activities took place as well: presentations were given to the neighborhoods. If the people living nearby notice you are keeping your promise, the complaints will decrease. The documents within the project team were distributed in a system, that is always used. The prestation has not been analyzed. The project is still in the maintenance phase, so it is still running. No evaluation has been done of the performance, since it always works.

Project Risk Management:

Risks have been identified at the start of the project. Risk analysis have been performed, qualitatively as well as quantitatively. For the risks, risk responses have been planned. These risks have been monitored and controlled. This was a part of the verification and validation system. The interviewee was responsible for this.

Project Procurement Management:

Some parts of the procurement followed the traditional path, others did not. Some parts were more critical than others. Some parts of the building can be tendered on the lowest price, while others are very critical that a co-engineering trajectory is more suitable to develop the idea. The steel structure is an example, together with the tendering parties was investigated if the design of the architect could be made and optimized. That party needs to be involved in every change. So beforehand, a global price is agreed on for the task. This also consist of continuous monitoring of the budget. Sometimes a task is more expensive in the end and another one is cheaper. Moreover, the tenders were not open to everyone.

The interviewee was in a consortium, together with a contractor. Jointly they contracted other parties, such as subcontractors. For some activities the contractor knew a subcontractor and they worked together in the past, they were contracted then. The company of the interviewee represented the development side, focusing from the design side, and the contractor in the consortium focused on the output.

Contracts have been made and closed out at the end.

Project Stakeholder Management:

The stakeholder engagement plan was made but had a different name. In the stakeholder analysis the company of the interviewee looked at the interests of the different parties and they thought of ways to comply to those interests. This is part of the critical success factors, to see who is important in what process. This is all defined in the stakeholder plan. This has been monitored frequently.
Project Integration Management:

The project charter was part of the verification and validation system. Together is defined how the project can be made to a success. The project management plan is made in the project quality plan. The document defined how the project will be managed, with a steering group, meeting cycles, that is all defined in there. Change control is part of the verification and validation system. For governmental organizations a request for amendment needs to be made when a change occurs. Also, this was used in the quality plan. A chapter in the quality plan defines the way to handle changes. A flow-chart was made on how to deal with changes and how to administer it. Phases have been closed off at the end, in an official way with official documents.

Project HSSE management

This is discussed in the accessibility, viability, safety and communication plan. Also, the V&G plan, the health and safety plan is set up to discuss this theme in detail.

Project Financial Management:

A financial planning has been set up. This includes of an overview of the investment you can do and the different cashflows along the process. You always need to make sure you do not exceed the budget. Risks have not been divided in the contract in the sense of penalties or financial incentives. The company of the interviewee tries to use as little financial incentives as possible, but instead make good agreements so everyone knows their responsibility. VAT and BTW have been used during the calculations.

It is a hard question to answer, weather a circular or linear business model was used. If the cycle of a circular building is long, you come to a linear line. The business model is based on a revolving building, a building that receives a new value on a new location, the costs can be reduced by making it easier to relocate the building, in that case this building is based on a circular business model. It is for sure not a traditional business model. However, this can only be concluded for sure in 20 or 30 years.

Part 3: The future of Project Management in circular projects

The financial model is often decisive. The planning of the costs and revenues are important, but first costs need to be made in order to make revenues. In the end before getting to a circular economy, the investors have the card to play. They can decide to invest in a circular building, maybe it is more expensive, but they make a higher return. Because I have less costs at the renovation. Circularity is not a technical challenge. The challenge is the politics and the investment that makes it hard. It depends on the horizon of the investor, if he wants to make revenue in 5 years, circularity is not an option.

If you look at materials, we work very traditionally. The sector works a lot with concrete, which is not the best material to use if you look at CO2, weight and flexibility. It does have some good properties. You would like to move away from concrete or make more smart constructions with concrete that is deamountable. This kind of fundamental changes in the construction sector are necessary. Besides, the construction sector needs to be more design driven. What now happens, in a traditional way, that a design is given to a contractor and the contractor does not really look at the design. That has to do with the construction sector, everyone is used to work on things the way they did for the last 100 years. That is not possible anymore, you need to be open to new things. That focus is something that is wrong in the construction sector now.

You now have new structures such as ‘bouw team’. Where there is not someone with expertise in charge. The client is mostly in charge but he or she is no expert. What happens is you have a group of people at the table with conflicting interests. Where one that needs to make decisions is not the expert, which can lead to bad results. The most successful projects are about a very clear idea and it includes people that have it very clear where they want to go. They need to inspire the rest. This insinuates a type of hierarchy. Someone that takes the lead and says: ‘we need to do it like this’. Everyone that likes to join is welcome, but if you do not want to join then you do something else. However, this is general for successful projects.
Interviewee 7 believes there is a difference in project management between a traditional construction project and a circular construction project. Mostly for the program requirements, because as a client you want to make sure that in all the design phases circularity is taken into consideration (for example the use of materials). Where normally functional and technical requirements are defined in the program requirements. However, for circularity, other requirements need to be set up, besides the functional and technical requirements. Moreover, the financial model is very different in a circular construction project. Normally a budget is defined during the initiation phase, often based on the square meters and reference projects. At this moment we have been working with the definition of circularity for about 5 years. We do not have a database, even though initiatives exist to create a database. But there is no benchmark. And with circularity, people might not want to buy everything new but prefer to lease everything or giving suppliers a take-back obligation. Which asks for other financial models. In the interviewee’s experience, the business models are the core of project management of construction projects. Everything is about the money in the end. So, all the aspects of circularity need to be ensured financially. This means that suppliers need to become designers, which need to be at the table at the start of the project.

The interviewee left the company, he was working at during the project, a year ago. The company did a lot with circularity from the policy point of view. Moreover, the company did a lot of strategic advisory when it came to circularity. However, there was more demand for specific applications of circularity in the projects. So, the challenges were tackled from the advisory side, which had a different focus. While some clients just want to know what materials to use instead of strategic advice. There is more demand for practical and specific advice.

The interviewee has been a project manager for over 7 years. He does not like to talk in statements. In the end it is not about the term sustainability or circularity, but about solution being a high-quality project specific solution. He would therefore prefer to refer to the project as a very strong optimized redevelopment project which contains sustainable additions, instead of a circular project. Other projects are more circular such as People’s Pavilion, where the aim at the start was to dismount it after some time. That building should therefore be removable. During project B, this was never an ambition. The question is if the redevelopment of a neglected warehouse that has been empty for many years, can become circular or not.

The project had some important learnings. If you start with the traditional approached program requirements, which has been applied in a complex user-based organization, it is very difficult to give the people a sustainable building and it is difficult for them to realize that. During this project this was noticed on several fronts. Namely in the tender phase, the engineers assisted the architects. Besides, a separate tender would take place for the engineers. So, the architects started at 0, by examining all the documents, the program requirements and the budget. The budget has been compared to other budgets of other projects and an analysis is done to see whether the budget made sense in combination with the program requirements of the client. With that, they looked at how to make the design as optimal as possible. The project has 4 user-based tenants. Sometimes these tenants had conflicting interests. The client needs to represent the clients and their interests and set a program of requirements. This might be very difficult. When the designer said that the program of requirements needed to be set to discussion because some things might change, this led to a sensitive discussion. Where in the end everyone was very positive, but it took some time. This started when the architects, amongst others interviewee 5, decided to change the original idea of the use of the hall. Instead of the empty hall with a building inside, they decided to use the entire hall in the width. Because different spaces were used, the environments and temperatures are different per room or space. Another large challenge was to increase the sustainability of the entire project.

The company which the interviewee worked at was working at that time with about 15 people on the project. The role of the interviewee during the project was as project manager of the technical issues. That was not a role that was demanded by the client, they asked for total engineering which means that all engineering services are with one company. And within the company somebody needs to coordinate that, which was the role of the interviewee. The client hired a company to execute the project management part of the project.
**Part 2: Project management of the project**

**Project Scope Management:**

During the tender phase the project, the requirements have been analyzed. The requirements were analyzed, to see if nothing odd was asked, what the opportunities were and whether they were able to do the job. The client provided the engineers with a grid list, with the standard job descriptions. So, the scope was defined by the client. The interviewee could ask some questions in the procurement phase. The work breakdown structure has been set up for the four main disciplines: construction, mechanical, electro technique and building physics (including fire and acoustics). Together with the lead engineers of the disciplines, the different work descriptions have been defined. With this the disciplines were able to define their tasks and to make an educated guess on the fees. The scope has been verified throughout the project by the interviewee, this was one of his main tasks. This was monitored, by knowing the tender documents and remembering the exact tasks consistently.

The scope of the client was not focused on redevelopment. According to their base scope, the building did not have to be inventoried at the beginning. Because the specification the client made was to make a new building inside the old building. However, for the construction, a lot of research needed to be done of the existing construction. When these changes occur, the changes need to be defined correctly and good agreements need to be made about who is responsible for the changes. Every change, outside of the beforehand set scope, was possible when agreeing on the number of hours and a fee.

**Project Time Management:**

A planning can never be made with all the activities beforehand, only after the project you can tell what exact activities took place. But the main activities have been defined beforehand. These were described in the tasks list provided by the client at the beginning of the project. Based on these tasks, a planning is made. For these activities, the sequence, resources and durations have been defined. During the process, the scope changed based on the discipline. In the end the responsibilities and tasks shuffled around a bit, in respect to each other. The interviewee kept track of this by communicating well with the different parties and on every Monday a regularly meeting took place with the engineers. To be sure the tasks and responsibilities were clear to everyone.

The interviewee never delivered a project with losses, always delivered successful projects. But he never used lean, project management methods that track every step. Real projects are mostly management on the relationship between people. And by understanding the project together. The planning was made but was not very detailed. Because the engineering team sat together on fixed moments and they could always walk up to one another in the office. Instead of writing emails while being in the same building. According to the interviewee, very extensive planning’s are a waste of time, as it will always change. A global planning with milestones is more useful. The time you can spend in making an extensive planning can be better used for managing the people and the product.

**Project Cost Management:**

A calculation of the costs has been made at the start of the project, namely for the mechanical and technical installations. Traditionally, these are the responsibility of the advisor, but the architectural costs including construction costs are done by third parties, by a building cost advisor. The total budget is defined by the client. This gave some confusion, since the client only presented the total budget. There was no specification at first of what that budget consisted of. As an example, it was not clear if the taxes were included or not. So, this needed more clarification. Cost surveillance is something that still goes wrong very often. This is a large risk in the future when circular procurement take place. Because then you will need even more interaction with each other and with market parties.

**Project Quality Management:**

The quality is defined in the program requirements set up by the client. However, they found a way to define the quality gradually during the project together. The quality has been increased when it comes to sustainability. But for example, the climate (with reference to the requirements) has been decreased, which was acceptable for the environment. The quality was controlled internally within the interviewee’s company, where the company has a reviewing system. Colleagues that are not involved in the project are asked to do an independent test within
each discipline. Monodisciplinary reviews are done as well as multidisciplinary review, where a broad committee with experienced people audited the integral themes.

Project Human Research Management:

An organogram is made by the interviewee, which served as a base for the recourse plan. This plan explains who is involved in the project, what grade they have (how experienced they are) and what the costs are per hour. The responsibilities are defined in the appraisal. In this document is explained what can be expected from someone in a certain grade. So, the responsibilities are not further explained in the organogram. The project team of the company has been set up with the help of all the discipline leaders. This team of engineers is managed by the interviewee.

Project Communication Management:

The stakeholders have been identified at the start of the project. This has been done in the procurement procedure because it is useful to know who you will work with. Moreover, the client handed over a document with the different stakeholders involved, including extra information on the tenants and the building. Within the company, a communication plan has been made in the form of an inception review. This is a kick-off for the design team, where a presentation is given to the entire project to everyone involved in the project. A lot of information is presented in this meeting: the stakeholders, the budgets, the planning, the number of hours per person on the project and the communication plan internally. The communication plan was not very detailed: every Monday they would sit together and walk up to each other instead of writing emails while being in the same building. Also, the way of communication to external parties is discussed here. The lead engineers are responsible for the communication to the architects. So, these communication lines are clearly discussed. The client also prescribed the communication plan, mostly for the design team. There were different types of meetings: design team meetings, steering committee meetings and user meetings. The interviewee knew beforehand in what meetings he was expected. The way documents were shared was discussed and agreed upon beforehand. However, this went wrong a few times. The project manager of the client would have to receive all the documents, and her or she would distribute it to the rest (via mail or file share system). Later a type of SharePoint environment is used to share the documents. The performance of this was not reported at the end of the project, however, if something went wrong, this was communicated with each other directly.

Project Risk Management:

Risk management has been done during this project. Within the interviewee’s company, extensive risk management has been performed including a risk register. Which contained process risks as well as substantive risks. Mostly this was presented in the design report. Where risks were presented as recommendations and issues. This is useful when a problem arises, since the risk has been noticed before, the company is not immediately the problem owner. It is very useful, however during the chaos and commotion of the design process, often there is not enough time to make extensive lists of risks. But it is useful to write risks down along the way when thinking of one. The client itself, did not really plan risk management. Which is strange with such a large redevelopment project with political sensitivity. It has been discussed within the client meetings, but a good risk management plan has not been made. Therefore, risk analysis was not done. The engineers formulated risks from the own scope perspective. The risk responses were therefore mainly for the construction, which had been done extensively for this project. So, from the client side, barely anything was done but from the engineer’s side, more risk management was done. Some risks have been monitored and controlled, if that was necessary. This has been defined in dossiers, the largest risks were the construction and acoustic quality. Therefore, extended analysis has been done for these risks to ensure quality and safety. The results were presented in the dossier.

Project Procurement Management:

The design team is selected by the client. The suppliers have been selected by the contractor. During the VO+ phase, the design team could give preferences for certain suppliers. The interviewee was involved in the procurement phase, because he was in the committee to control the tender documents for the contractors. They advised the client on what contractor to award.

Project Stakeholder Management:
The stakeholders have been identified at the start of the project. No stakeholder engagement plan has been made in a formal way. However, when sitting around a table with different parties, informally this has been done. When you spend more time together, you know to whom to go with every question, problem or issue. This is tracked by the project manager interviewee, but it cannot be called a plan. It is more hands-on work, but it had the same aim. This was monitored continuously by the interviewee.

Project Integration Management:

No project charter has been developed for the project. A project management plan is developed. The project work has been managed by several parties. The general process has been managed by the project managers, contracted by the client, and the engineering work has been managed by the interviewee. Change control has been performed by keeping track of a change register. Which consisted of an excel file containing questions that were not in the basic scope which is introduced one on one. These changes were made by the client. The contracts have been closed off in a formal way. For contracts you receive a confirmation when the phase has been closed off. Therefore, companies knew when to send out the last invoice.

Project HSSE Management:

The policy used for the HSSE is a company policy for the company of the interviewee. This was very important in this project. This is a very strict policy, which was used in the end by the entire project team. In this company several safety briefings are given to the employees and a lot of effort is put into the HSSE of the building sites and the employees. Therefore, based on the policy, a management plan has been drafted for the HSSE. This was a component of the project management plan. Two important parts of the HSSE component of the project management plan were that everyone should obligatory follow the site-specific safety briefing and secondly, if there was a risk, the site could not be entered.

Project Financial Management:

Every month a project financial report is made. This consisted of the surveillance of the financial planning, possible profit, the status of the buffer, etc. The financial risks have not been divided in the contract. It sounds more as something that needs to be divided between the client and the executing parties. The taxes have been planned. The client also asked for a social return on investment, because of the value in society of the project. This is a return on investment criteria by the client that has never been verified at the end of the project.

Part 3: The future of Project Management in circular projects

Mostly in the procurement, changes could have been made in project B to implement more circular economy principles. For example, the armature could not have been purchased. And the lights could have been leased with a repurchase obligation. The client could have set other requirements for these elements of the project. Moreover, the building could have been designed more demountable. If the scope would have been different and the planning as well, more things could have been changed. The building itself has little welded joints, however, the floor is a steel sheet concrete floor. This is very fixed and cannot be dismounted. For the floor another choice could have been made.

The interviewee has confidence in the construction sector. Especially the planners have a lot of knowledge and work creatively. It is the mindset or culture that needs to change to move to a circular construction industry. It is not about the incompetence of the sector, because the sector is very competent. People working at the construction site are very capable. So, giving them an extra precondition, will not change that. But somebody needs to change what that precondition is. Thus, the client needs to set this precondition at the start of the project. The construction sector is not very innovative, but for circular projects there is no necessity to be super innovative. It is about the conscious use of materials and to think about the connection of things. Concluding, it is an extra design condition that should not be very difficult to accomplish. A large incentive for clients is the business model. A circular business model should be defined to encourage clients to move towards circularity. However, on more than one front should be focused. A lot of clients refer often to the payback period of sustainable measures. Instead of focusing on the earnings, clients should want to implement sustainability and circularity because they want to. That motivation needs to be there as well.
Appendix D.8: Interview project C interviewee 8

Function general: Project manager
Function project: Project manager
11-09-2019

Part 1: General project questions

Project management is the leading of a project or processes. The process of a circular construction project is different to a process of a traditional project. It is approached in a different way. You make different choices and trade-offs based on other grounds. Of course, it depends on what you call circular. In the last period this has taken a large jump, and everything seems to be circular. Which makes it different as well. For project management it was very important in project C to involve the suppliers at the start of the project, it helped in becoming more circular. This made the process different than a traditional building process. By doing that you work with other parties than you are used to, and you design in a different way. Where you normally design with materials you would like to use, that are produced specifically for the design, it becomes more difficult when you need to design with materials that need to become available. Where a logistic process need to be set up, to get the materials on time on your project. Because the materials become available at a certain time in the donor project. This makes the process a challenge. This might get easier with time, because more and more materials are available but when working on this project this was not the case. Most materials have been chosen based on the availability. Later a cooperation started with a company that trades in second hand materials and products. Together with this company, the interviewee went to donor buildings were materials were inventoried. Moreover, the interviewee made a list of materials which they needed, and the company started looking for these materials. Factors that influence this are quality, money, esthetics and logistic possibilities. The latter, because you need to be sure the materials are available in time. With new products, the last factor is not of importance. So, in this case process management is for sure different.

The circular economy has the aim to minimize the use of primary resources. This follows the aim to make products that can be used limitless, with no end date. In the construction sector this means being demountable without value losses. This is the challenge we need to work on in the next period. The company of the interviewee performs amongst others, project management. The company tries to introduce the project management method used in project C, in other projects. Project C was a very innovative and ambitious project. During the project new roads were explored that were not explored before. Other projects find circularity very important, but they are not willing to make the innovation step that is needed. The company tries to use innovative project management methods as much as possible. Circularity at this project has been about not making what you do not need.

The interviewee thinks project C is a circular building. For the Dutch Green Building Council the company is helping with a ‘losmaakbaarheid indicator’. This is a tool to measure the ‘losmaakbaarheid’ of a building. In the end score, project C is not rated very well. The reason for this is that the concrete tub that has been poured at the start of the project. In mass and financial share, this concrete tub plays a large role. This has a negative effect on the circularity of the building. The rest of the building has been constructed in a very circular way. Without the concrete tub, the building is 80% demountable and reusable. It can be reconstructed in different parts, or the same way the building is constructed now.

If you look at the progression of the use of raw materials and the pressure the construction sector lays on the earth, we urgently need to change something. In the design process, in 2014, circularity and sustainability were not a spearhead of the design. Within the team, the mindset changed during that process. They realized that they could not construct in the business center of the Netherlands a building that is not progressive on the field of sustainability, health and circularity. By that time, the plans changed, and circularity was a main theme. Not all parties were directly committed to this new idea. Conversations took place with different parties to discuss this. During the process different parties were replaced because the collaboration did not work as aimed. These parties thought in a very traditional way, they were working with internal rates of return or payback models. Project C was not only about what was profitable, but also about sustainability, circularity, or interesting for the future. In the end parties were found that were supportive of this way of thinking. They helped to make the project trade-offs. Money was always considered during the entire project, but it was not the main criteria to make decisions.
The butterfly model of the Ellen MacArthur foundation was often used in the project as a sort of guideline. Therefore, the first consideration was, should we make it, is it necessary? For example, the floors and walls do not have finishing, since this was not necessary. For every decision, the options have been delivered by asking, is it necessary? And if it is necessary, do we need new products, or can we use used products. So, every time a step downwards is taken in the 10R ladder. And if we need to make the product, the product needs to be sustainable and demountable and reusable. The Ellen MacArthur Foundation and the 10R model helped in every decision.

With this project, selection procedures have been designed to select suppliers and subcontractors. These were not contracted by the client but by the main contractor. All the parties together, tendered the suppliers and subcontractors. Here, circularity played a very large role. That was a very important decision to be sure you only select parties that support the vision and the philosophy of the circular economy. And that they use this vision on the construction site. The contractor was chosen and together with the main contractor subcontractors were selected based on the circular economy. Also, parties applied for this job because they heard of it. By choosing the parties on their vision and philosophy worked very well in this case.

Circularity was not part of the first phase of the project. At that moment, no requirements were set for the circularity of the building. During the process, no requirements were defined, because there is no methodology to set requirements of circularity. For every decision, a matrix was made to deliberate the different options. Weightings factors were set for criteria like esthetics, circularity, costs, sustainability and more. But hard measurable requirements for circularity were not set.

Part 2: Project management of the project

Project Scope Management:

The project requirements by the client, which describe what the client wants, have been analyzed. Based on these requirements, the scope has been defined. A type of work breakdown structure has been set up. An organization structure has been created, with the center being the project management organization. This consisted of the interviewee with the project managers of the client. Around the center, workgroups were created. There were workgroups for the façade, for the load-bearing construction, for the exploitation phase, for the financial aspects, for the sustainability, for health etc. So, around the project management, different groups worked together on different themes. For every workgroup, work plans were defined explaining what every groups task was. The project managers made sure the overlap between the groups was managed and controlled. The scope has been verified with the help of a BREEAM certificate. This consists of, among others, the element commissioning. Where continuously per phase needs to be tested if you still comply to the guiding principle that was set in the previous phase. From the program requirements specific demands are formulated. In the preliminary design it is tested if the demands of the program requirements are met, and if not with clear arguments substantiated why not. So, that testing took place continuously.

Project Time Management:

The main contractor drafted a very detailed planning for the entire project. The sequence, resources and durations have been defined per activity. The planning is controlled very often, since it is a document that can change day by day. At the start of the project you make an estimation on how long things will take and when activities will take place etc. However, things change continuously. This is partly due to the fact that you use materials/products that already exist. With this, you need to be more creative to solve problems in a different way. So, the planning is a document that is changing continuously.

Project Cost Management:

The project costs have been defined and a budget is set for the project. The budget and costs have been monitored often. When the subcontractors were tendered with the main contractor, one of the criteria was to compare what has been calculated for the different parts and if it fits with the different parties. If it does not fit, two options are possible. First is to change the budget and second is to optimize the assignment of the subcontractor. This could mean to ask less from the subcontractor. This happens continuously.

Project Quality Management:

The aimed performance has been documented. The program requirements of the client were more a type of program of ambitions. The wish has been expressed to innovate during the project and to implement new techniques. This makes it difficult to predict what the exact requirement is.
By setting detailed requirements, a lot of options and solutions are excluded. The project team checked what achievements are obtained with innovations. So, the program requirements where not very extensive or detailed. It was more a program of ambitions about how the building should perform and function. BREEAM and WELL certificated were part of this. Of course, there was a program available of what should be made. But not as strict as is done for traditional projects. Commissioning has been done to make sure the aimed quality level was achieved. This tests the achievements immediately and checks whether the aimed quality is obtained. Moreover, phase documents have been made that describe the progress, what the performance is, how time, cost, quality and organization is going and what has been achieved up to that moment. This document compares this to the original program. This is done to obtain approval by the project board to move to the next phase. Together with the client and the user this has been done continuously.

Project HR Management:

No specific HR plan is made for the design team. During the process the roles are defined, and the responsibilities were divided. In this document, the people that can approve certain documents have been defined as well. This is done per person. The project team is created and managed by the interviewee, together with the project management team of the client. They worked very closely together during the entire process. The interviewee took on the role as delegate client.

Project Communication Management:

The stakeholders have been defined. Stakeholder meetings took place at the start of the project, even before circularity was part of the plan. Meetings were also organized with the municipality, local residents and companies of the area. A communication plan was set up for this. The main contractor used a central system for document sharing. Via this system, documents were shared. That was done for the project content documents, the communication with the environment was done via newsletters. Moreover, the client has its own channels to communicate to the employed of the company. For the project dossier Docstream has been used. The interviewee took part in the meetings with the municipality. The performance of the communication between the different parties has been evaluated. This evaluation is done at the end of the project. Changes to the communication have been made during the process when they noticed some things were not functioning as expected. The optimal way of communication was searched and to achieve that changes took place.

Project Risk Management:

Integrally in the process, risk management was done. The interviewee is unsure if risks were planned in the risk management. In the phase documents, a summary is given of the VO. Here is documented what further risks arise in the further development of the project. That risks need to be anticipated on and when possible with risks responses. So, risks have been identified, but no separate document was drafted for this, it was part of the integral phase documents. In these phase documents, other stakeholders could introduce risks. The risks have been analyzed quantitatively as well as qualitatively. Risk responses have been planned and the risks have been controlled during the process. Not very explicitly but as a project manager you are continuously checking the risks and managing these to control and to minimize the impact. These are also discussed during construction meetings with the project board. All relevant parties are herein involved, minutes are made of the meeting and these are distributed. Thereby it is always clear what risks occur and what the status is of the management.

Project Procurement Management:

The client has a procurement department which was involved during the procurement process. The procurement is done earlier in the process than normally is done. And the tenders have been based on the philosophy of the client of circularity, innovatively and sustainability. Nine out of the ten suppliers were subcontractors of the main contractor. These were selected together with all the parties. That is done that way with almost all the materials. The suppliers were asked to present a pitch, so that the project team could ask questions about circularity, reuse of products. Agreements have been made with the parties about the re-buy obligation of the products. A lot of parties were interested in this, but it appears to be hard to agree on this in a contract. Therefore, this did not work. The suppliers cannot assess the risk of this in the future. There is a lot of uncertainty about the future worth of the products and their usability.

When the work was done, the contracts were closed off in a formal way. The main contractor was contracted with a UAV-GC contract. They were not only responsible for the realization, but also for the design and the design solution. This consisted of making the details in how it should be made.
They had therefore more responsibility than in a normal building contract. So, they became a partly designer as well. With that, the architect becomes more an esthetic controller, that verifies the elaboration and plans of the main contractor. The architect designs the VO and DO, and the contractor developed this further until the details.

Project Stakeholder Plan:

At the start of the project, a stakeholder engagement plan is developed. This is monitored during the process, it is constantly managed. For a project such as project C, the environment keeps growing. Where at the start the design team is small, but when construction starts the involvement of the parties (such as the client) changes. More people become involved and have opinions, so stakeholder management grows a lot compared to at the beginning. It becomes more complex.

Project Integration Management:

The project charter idea is incorporated in the work groups, in the action plans of these groups. Next, in the planning mutual relationships are defined with milestones and interdependencies. A project management plan has been made which defines how the project team communicates, what the contractual interdependencies are, where responsibilities lay etc. In the minutes of the design team a decision list was used. This was a list of the decisions made during the meeting. These decisions can show differences with the program requirements. So, this is a list with changes. A change control system would have been positive for this project. In hindsight, this was not used enough. It is noticed that if you come further in the project, there are more stakeholders and more opinions. More changes occur due to growing insights. It is hard to keep on managing this and keeping it central, to make integrated documents that are comprehensive. This is one of the largest challenges in construction projects. When using the before used products, it is even more difficult to know the specifications of the products. Therefore, sometimes you find out on the construction site that things are different than expected. Then you need tasks, to solve the discrepancy with the original plans. Changes take place daily, which always happens on the construction site, it is difficult to document these changes correctly. This is a real challenge. The same is with renovation, you never know what you will find which makes it more difficult to do change control. Project phases have been closed with the phase documents. These need to be approved before a phase can be closed.

Project HSSE Management:

The client has policy concerning this. When a phase document (or the DO) was finished, it was first send to the HSSE department to check whether the starting points of the company were implemented. These starting points were about escape plans, fire safety, the permits and the legal frameworks etc. This has been incorporated in the management plan as well.

Project Financial Management:

Financial planning has been done in the budget monitoring model. This was namely a comparison between what originally was reserved in the budget, what commitments were contracted and the commitments that were expected. An analysis was made of what this meant for the end result. This has been continuously monitored in detail, until the subcontractors level. This was presented periodically to the project board. The main contractor included the main financial risks in his contract. The client wanted that part out of the contract, because the bank wanted to be responsible for the risk. That is something you do not see very often. That risk item was substantial because the project contained a lot of new things. Techniques, circularity that were never applied on this scale before. The risk response in this case was to set apart some extra buffer. The client did not expect that risks to be that large, so they said give us the jar with money, so we can save the buffer. Taxes have been planned. The interviewee thinks a circular business model was used. When looking at the progress of the process and the product, certainly for that period where circularity was not that large, it was very innovative where new paths have been discovered. And people can use these paths now. The leasing of the products was analyzed as well. In this case, only the lift is leased. Therefore, several business models were investigated.

Part 3: The future of Project Management in circular projects

In retrospect, more quality control during the construction could have been used. Moreover, it would have been positive, if the company that made the building would have been responsible for the execution and maintenance of the project. This was not the case.
After commissioning, the maintenance responsibility was shifted to another party, that worked more often together with the client. This was a large challenge, because the construction was very different to other buildings, it has many specific properties. The new operator needed a lot of time to understand everything, while the system was not operating correctly. This cost a lot of time and energy. In the future, the frames need to be guarded constantly to operate the building optimally. As a project manager it is very important to understand the desire and the requirements of the client. This is done by inventorying it in detail. Moreover, as a project manager you should be critical about this. The client in project C was to have a constant indoor temperature of 21 degrees. However, the impact on the installation of this is enormous. If you let the temperature be between 19 and 22 degrees, that can have huge consequences, the power of the installation can be decreased by 50%. To search those boundaries between comfort and sustainability, is a task of the project manager. He or she should be critical to the client and the performing parties about what is made. The project managers expertise and experience should help in this. Looking for those boundaries is very important for circular constructions. It is about what you not make. Start with the building, do we need the building? The client of project C was very open to this, open for circularity and open to innovation. In the end it is all about the client, since they make the decisions. A project manager can hold a mirror and be critical, but decisions are made by the client. So, it starts there. Awareness is very important. We need to tell the client what impact certain requirements have, since they do not know this. Clients want what they know or what they have experiences before. Clients are not aware of the effects of their decisions on the project. Moreover, they are unaware of the risks of their decisions. This is therefore an important role of the process manager.
Appendix D.9: Interview project C interviewee 9
Function general (now): Advisor building installations
Function project: lead engineer (of technical installations)
20-09-2019

Part 1: General project questions

At the time of the project, the interviewee worked for the main-contractor. The company he works at now was not involved in the project at the time. After the commissioning, there were a few problems with some technical aspects, were the interviewee gave advice. The interviewee thinks there are large differences in project management between a circular construction project and a traditional construction project. A form of cooperation is chosen and that is a separate choice to what type of building it is (a sustainable, circular or temporary building). That is not yet connected, they are two different decisions. However, this could be useful. If you want to deliver a circular project, then integrality should be included in the requirements and design. That should be done on the front side, for it to work. This means an integral contract form is necessary. At this moment we still need a lot of input of the performing parties to figure out what the possibilities are. A total integral construction combination or design, where circularity can be used in its highest form. Moreover, it is important to keep the flexibility in a project.

According to the interviewee, circularity is about that everything that you make should be sustainable (available for a long time). This can be done in different facets, materials, energy and bio-based materials. In the end it is about all those facets. Everything you build cannot be exhaustive for the planet. For the current employer of the interviewee, circularity is something that needs to be thought about. From the department of sustainability, circularity is motivated. But no large steps are taken. The interviewee thinks that circularity should be a design philosophy that is used by everyone. Besides the specific systematic or models that are used within projects, the way of thinking or philosophy should be used. If a client has a question, everyone should be able to advise him or her instead of saying I can link you to that department. That should be embedded more broadly. At this moment, not that many changes are happening. The transition into a circular economy is standing still. The interviewee is a pioneer on the circular construction, but it is hard to get people enthusiastic about this.

Most of the clients the interviewee works with now, understand the importance of the subject. However, other clients do not know this. It is therefore the engineers job to advice and guide them. As there is not regulation developed by the government about this, clients do not feel the necessity to introduce the principles into projects. After 20 years it is possible to regulate energy use, but this took a long time. And now you see that because of the rules, less energy is consumed. With circularity this is different since there is no universal way of measuring circularity. The government has let it go, the objectives were set in 2030 for 50% circular and in 2050 for 100% circular. No rules are set for that. The market is starting to make moves. When something useful arrives from the market into practice, this can become the base for the legislation in the future. That means the government has a following role, where they normally should have a frontrunners goal. The objective is to be a frontrunner but in practice they are not.

The interviewee thinks project C is a circular construction. Circularity has been a choice of the client. In the first phases circularity was not the aim. The aim was to make more meeting rooms. During the process, somebody came up with the idea to make it circular. The client agreed with this. When the idea was first given one of the feedbacks was that circular investments are not recouped. After that, the team was removed from the project. The mindset that was needed for this project, was the willingness and the different way of thinking. The old team did not have this and therefore they were removed. After, a new team was hired. Hereby the interviewee’s old employee was contracted as the main-contractor. This company was very motivated in working in such a new project. During the design, the team switched another few times. The people that were removed from the project did not have or understand the re-thinking process that the circular economy demands. However, for circular projects you need to exit the beaten tracks to be able to accomplish something different. This took some time before the entire project team understood this. The change of people made the process more complex. In the first phases you make program requirements and other documents, if you change people in the design team, a handover is necessary. This is always a bit chaotic. If at the start the right people were involved in the project, a better result could have been achieved. Because some decisions were made at the start that could not be changed during the process.
The client of the project is working at this moment to evaluate the building on circularity. This is focused on the material index. Which is only one aspect of the building. Measurability of circularity in the future is useful since it gives support. The 10R model of Cramer has been used. For all the decisions, design versions were elaborated which were verified based on the 10R-model and the ladder of Lansing. The project team consisted of several parties in a round table model. This was new for everyone. The client was looking for a new form of contracting. They wanted a new form of contracting because they were not completely satisfied with how traditional types of contracting went. The round table model was therefore chosen. It is a type of direction model, where all design decisions are made in collaboration with the client. The risks lay therefore as well with the client. It is complex to say to a contractor that you want something new and that he bears the risk as well. That is the traditional way. But with that, innovation and creativity are restricted. As a contractor or installer will always choose the safe option, instead of new options that he has never done before while bearing all the risks. The most secure option, also in terms of the option with the most profit, will always be chosen. In project C, the creativity and innovation were highly preferred. Therefore, the round table model was a good option. In the end, the project cost a lot of money for the contractor, so this should be controlled better in the future. For this project it was OK due to the great exposure, but the extra costs are not possible for a normal business case. This is an important lesson learned from the project. The risks in this project were jointly put on the table. The interviewee was lead for the installations, but in the round table model all subjects (construction, design, architecture, garden, etc.) were discussed together. Different decisions for all disciplines were discussed together with all the disciplines. The parties involved here were the main contractor, the client, advisor sustainability, advisor phase change material (PCM), the architect and the gardener. In the end, this group was a team of enthusiastic people, with the same aim. An external party on the client side was hired to manage this team. Interviewee 8 managed this group.

The most important lesson is that the team composition and collaboration model were very important. Without the right people and organizations, a project becomes sub-optimally. This I therefore important to secure, the right collaboration model and the right people. Next, it is very important that everyone involved in the project understands the philosophy. That way, in the entire chain, all decisions and considerations are done according to the circular principles. If a traditional group is involved, something becomes less optimal. Some subjects can be performed neatly in the traditional way, but the risk is to lack on other aspects. Thirdly, it is important to be aware of the fact that the circular economy is not something entirely new. There are some aspects that are already done. Minimalistic is one of those aspects, circular buildings are minimalistic when products are left out. In project C, the cellar has some reused façades, but the rest is new. At the project, you do not see it is circular, that needs to be explained. The tenders are going to change as well. In the future we will ask for example the carpet dealers to put as little carpet as possible inside the building. Normally it is the other way around, the more the better. So, to find creativity for these types of solutions lie in the bottom of the chain. Suppliers should help with these types of solutions. The people of the workplace have the good ideas. In the traditional side, it is still about what costs more money to make certain decisions.

Another lesson is that the tax on labor needs to change, which is difficult because it is part of the economic model. When you want to repair or reuse something, this takes more labor hours. It is therefore cheaper to buy a new lamp from China than to repair an old lamp for 2 hours. There is also the risk that the repaired lamp needs to be fixed the year after again. Besides that, it is more expensive, there are not that many people with these expertise and skills. The interviewee does not see directly a solution for this. For project C, new materials are chosen, however, they are all weighted. You know if the construction gets a new destination in 30 years, that is possible. Effort needs to be put into the construction, but it is doable.

**Part 2: Project management of the project**

**Project Scope Management:**

The project requirements have not been analyzed. Mainly because of the fact that the client did not know exactly what they wanted. In the basement, meeting rooms were required but in the two floors above it was unsure for a long time what destination it should have. There were three demands from the client side. First, the construction should be circular. Second, the construction should be preferably energy neutral and thirdly, the construction should become a living lab. These were the three requirements, there was not a document with several pages on what the design of the construction needed to meet. This was very complex; the first project team did not know what to make. Phase documents have after been drafted to define the scope. That document describes what starting points have been defined and what design decisions need to be made to continue the process. The project management company (interviewee 8 works at) controlled and verified the scope.
Project Time Management:

The activities have not been planned before the project. Several planning’s have been made. The planning is verified during the process. It was done, but not always in the best ways.

Project Cost Management:

The interviewee does not know how cost management is done. Based on the phase document of DO, the costs were calculated. This price, of the first DO document, was too high. After, cost-cutting measures took place. The aim was to cut some design decisions, to get to a budget where the management team would be in acceptance with. Therefore, the interviewee believes there was a budget.

Project Quality Management:

The aimed quality is established, which is described in the principles of the project. In technical teams this was that the building should attain certain temperatures, aims for CO2, aims for the energy consumption and more. These have been documented. Later in the process, the client made the decision to certify the building with a BREEAM label. These above-mentioned quality themes, are also part of the BREEAM certificate. Commissioning is one and during the project other activities take place. Since the decision was made later, the requirements of the client were not compliant to BREEAM. This took a bit longer, since documents and practice need to be checked, in the end only a week ago the control technology passed the commissioning of the certificate.

The quality is checked with the quality system of the main contractor. This is highly embedded, and everything is controlled with this system. Intermediary as well as in the end.

Project HR Management:

An HR plan is not made. In the end the team is formed. This was formed because there were very enthusiastic people that wanted to be a part of the round table. Everyone knew the tasks of the other people around the table, but the responsibility was shared. This was something new. In the end the risks and responsibilities laid with the client. Therefore, traditional models did not apply. The project management company did the project management of the group around the table. Per discipline, own project managers were assigned.

Project Communication Management:

The interviewee is not sure how the stakeholders were identified. At the start of the project, the interviewee is unsure on how this went. But during the construction, this was definitely used. The main contractor made a communication plan for the surroundings. A lot of guided tours were organized and the communication on the client side is always very well managed, they have a separate department for this. The interviewee was less involved in this part; however, he did do the guided tours. The main contractor has a communication strategy that is used for projects. Docstream is used for the file sharing during the project. If the performance of the communication is tested, is unclear for the interviewee.

Project Risk Management:

Risk management has been done for this project. The risks have been identified before the execution of the project, from the contractor side. A risk inventory document including risk mitigations is set up. This is done in the traditional way. Risk analysis have been done, but not very extensive. The interviewee is unsure whether this has been done qualitatively as well as quantitatively. A lot of mitigation measures have been planned, for the construction there were a lot of risks since the project was built in an accessible area. The inventoried risks have been monitored.

Project Procurement Management:

This part is not done in the traditional way. The main contractor is probably chosen for its network and because the company was interested in getting involved in circular projects. They were willing to take business risks. Therefore, the companies came together. The budget was set in the DO phase. The budget was monitored together with the other parties. Which is not how it is done traditionally. The subcontractors are selected in different ways, some were tendered the traditional way, and some were not. Some tagged along during the design phase and were proposed directly to the client. They were not tendered based on most economic tender. For products, more traditional methods were used. An example is the elevator, a company lend this product as ‘Product as a service’.
The aim was to do this for the lighting as well, but due to some technical differences in this building, this was not possible. That innovation was a more important aspect than the way of tendering. Contracts have been made and closed off at the end of the project. Most of them, the lift for example is an aspect that remains in the contract.

**Project Stakeholder Management:**

The interviewee is unsure about this part.

**Project Integration Management:**

The interviewee is unsure about the project charter, but he expects this was not made. It is expected that if it was made, more evaluating points would have been made regarding this. The interviewee is unsure whether a project management plan was made. Change control was not used. In a UAV-GC contract this is mandatory. In this case that was not done. When a change took place, decisions were made together within the project team. The large changes were also communicated with the client, so that they could accept them. Project phases have been closed off, the phase documented were used to do this. However, this process was a bit messy. But everyone knew about these documents and they were controlled as well.

**Project HSSE Management:**

This is a standard aspect within the main contractor. The interviewee is unsure how this part went project specifically. Safety is always the priority, this is visible in every activity of the project. This is always done like this by the main contractor.

**Project Financial Management:**

The interviewee does not know if a financial planning is made. The financial risks were partly for the client, and partly divided over the different parties. But for the innovative parts of the project, the financial risks were for the client. Taxes have been planned within the project. A combination between a circular and a traditional business model was used for project C. An adapted traditional model was used.

**Part 3: The future of Project Management in circular projects**

The largest recommendation by the interviewee is that on the front-end of a project circularity needs to be embedded. These are project specific requirements, the form of organization, how to connect parties, what type of contracts need to be concluded. This is only possible when working with the correct people. This is part of the Human Resource Management. In this project, the team switched several times of team members. That can be managed more during the HR Management on the front-end of the project. A requirement could be to find commitment for the circular project on the front-end of the project. Things could have gone better within project C, if this was done. A new method for circular project management could be very useful, it could give some grip while managing the project. A recommendation is that managers need to go off the beaten track.
Appendix D.10: Interview project A interviewee 10

Function general: Owner event management company
Function project: Project manager production line
23-09-2019

Part 1: General project questions

The project management of the project was done by the interviewee together with another person from the client side. The architects searched the suppliers, they made sure the products and materials were available before being used. This is easier to accomplish as designers than as large organizations. The focus of the interviewee changed from the budget level to the more practical level during the process. This arose in an organic matter. During that change nothing was documented, because this made no sense. The entire project changed from day to day. So, that seemed to be a waste of time. After, instead of planning and documenting everything, the process was followed, and the project manager made sure the project was constructed. Another question is if this new method was structural and reliable.

The interviewee is sure there is a difference in project management between a traditional construction project and a circular construction project. The interviewee is event producer who by his background as industrial designer has technical knowledge and therefore can imagine things better and manage projects better. He is not specialized in the traditional construction process. But he knows it through other people. Circularity is currently making steps, but a lot is still unknown. Mostly in materials, how to adapt it and in what way it can optimally be processed. For this, parties are continuously reinventing the wheel. This means you will get an organic process. Mostly in the first phases of the development of materials. This changes continuously. That is the challenge of building experimental (circularity is experimental according to the interviewee) constructions. It depends on the type of circular constructions to decide on what changes to the traditional process need to be made.

Circular constructions are about leaving the smallest possible footprint on earth. Which means to reuse materials as much as possible and to use materials without harming the nature and environment. The circular economy can play along by matching the materials that exit one building and are inserted in the other building. And literal money is pumped around, which makes it a circular economy. In the event world this is difficult. The moment you decide to organize an event: it is sure you will leave a footprint. Transport is needed, it is all temporary and not for a long term, so you cannot recoup this over the years. In these terms, project A is not circular. A lot of transportation was needed to bring and pick up the materials and all the people that came to visit the construction did not all come by bike.

The interviewee believes the project is a circular building. The project stood for 9 days, although with the setting up and dismantling this was some longer. However, a lot of transport was used to move the materials. Yes, the construction is circular because the materials were borrowed or recycled. Nonetheless, the transportation was done in the traditional way. Thus, the project was circular on the field of materials and construction principle. But in total, it was not. In the end of the project, there was no time to evaluate or measure the circularity.

The architects started with the aim to make the project a circular project. They had some experience in making sustainable and circular expositions. From the relation between the architect and the client, the idea for circularity grew. This company sees the circular principles as the basis for all the projects they do. They really believe in these principles. From the 10R model by Cramer, mostly the repurpose and recycle steps were used. Most of the materials were borrowed. Where some materials, such as the concrete piles, were manufactured for the project but later given back to the owner. Other materials came to the site in the original state, after being used in another project (such as the windows). The tiles were recycled from old plastic. The steel that was left was brought to a metal farmer where new steel was made. The tie wraps were sent to a plastic processor. So, some products were bought or lend that in the end were reused or recycled. The tiles are still stored, since they are not fire resistant, they cannot be reused in a façade of a building. The client has too much emotional value to send the tiles to the plastic processor and melt the tiles into little plastic parts.

The most important learning from the project when it comes to process is: start on time. This was a very fast project. In February the process started, and the interviewee joined in May, but in May the project was still a plan. There was little established. In September the construction started, but this was as well the time the construction report was finished. Therefore, starting on time is very important, because time is the largest enemy for such experimental processes.
You need to learn by doing, but for that reason it takes more time than a traditional project. Doing experiments beforehand can also help, if you test beforehand what you are going to do, it will take less time in the construction.

**Part 2: Project management of the project**

**Project Scope Management:**

The interviewee worked from the client side. The project requirements were simple: a pavilion needed to be constructed. This construction should give a WOW effect which would be an example for many, so that a lot would be talked about it. This was the assignment for the designers. It is unclear what further requirements came directly from the client and what was conceptualized by the designers. The client often works like this, to ask for simple and not detailed requirements so creativity can be used. The companies that are willing to take these challenges are the companies that make sure innovative projects are completed. However, it is hard to find these companies. The risk of the project lays mostly with the client, the project manager should update the client on how it goes, if the planning goes according to plan and what the costs are. But one thing is for sure, when you construct an experimental building the costs will be higher. Minimally they increase by 25%.

Defining the scope was done by the designers. They were responsible for that process and the project manager was involved after this was defined. A work breakdown structure was not made in detail. The interviewee made an overview of the materials that were necessary for each part of the project. Five parts were defined: basic construction, the lower part of the façade, the roof, the tiles and the interior. This distribution came to existence during the process but was never defined. This came to work during the organic process. The scope is not defined and verified during the process.

**Project Time Management:**

The activities have not all been defined, the project manager looked at the time that was needed for the construction. An end date was set for this. From that end date you calculate what is due on what date. In the end, the materials needed followed the design. There was no leading theme for this, it was common sense. Based on the materials from the design, they looked at where to get what materials. An excel document was made to keep track of the materials that were available and the materials that they still needed. In the end, more materials were needed than on the list because during the project other materials were needed. The list was used as much as possible but sometimes it was forgotten. At a certain point in the project, you know the list by heart and you do not need the list. The list of activities did not contain resources and durations.

A general and a construction planning was made. The general planning was not really followed at the end. The planning was controlled. They found out some activities were going to take longer so the project manager tried to anticipate on this. But in the end, the planning was not an important document. The keeping track of the planning is the task of the project manager but in the end, it does not have the largest priority, because the largest priority is to make sure the construction is completed.

**Project Cost Management:**

An estimation is made at the start of the project for the project costs. Based on this, a budget is set up. The costs have been continuously controlled. This started with once in two weeks, then every week and in the end on daily basis. Even per hour in the last few days. The budget was 200.000 for the project, assuming the materials used were either borrowed or a gift. So, at the start it was already assumed that those costs would not be made. Which is optimistic. For some materials (such as the concrete piles) transportation costs needed to be paid. Tie wraps needed to be bought as well. Later some money is received for the recycling, but never as much as the purchase price. The material costs are reimbursed but the production costs are not. These same accounts for the steel connection products, used to connect the wooden beams. In the end you reimburse the amount of kg’s, but not the production costs. The clamping straps were sold to another company, that recycled them.

**Project Quality Management:**

The aimed quality is defined in two requirements: it needed to be a real building and a comfortable building. In the end the inside climate was cold, since the building was not insulated. On construction level, the building was checked to make sure it was in order. And on esthetic level this was checked by the designers. Activities were performed for the tiles to make sure the aimed quality was obtained.
The first batches were not very esthetic. The rest is communicated, such as the construction, and no extra activities were performed. The quality of the materials is controlled by the suppliers.

Project HR Management:

A kind of HR plan was determined, the three architect firms were the designers, the interviewee was the project manager and the client was his supervisor (interviewee 1). Above interviewee 1 was the board of the client. This was the project team. In the end a constructor was added to the project team. The most unconventional group in the team were the builders. The builders were old-school handcraft workers. They were very open to help in everything, since they were carpenters. The interviewee is sure that if a conventional construction company was hired, the project would not have been completed. Because they cannot switch and connect as fast. On the construction site, problems arose. With a conventional contractor, a conventional solution would be used. With these builders, they are very inventive and come with innovative solutions and propositions. The builders of the project were no contractors, because they did not want this role. The client took therefore the role as the contractor. So, the client had three roles, principle, project manager and contractor. According to the interviewee, the builders were involved too late. Some of the mistakes on site could have been avoided. The construction rank of the constructor is revised by the builders.

The HR plan was made on individual level, per person the role was defined. Everyone had its own role within the project team. Together they pioneered the project, which resulted in a solid and explosive relationship. At some point interests arise, which could lead to conflicts if it is unclear who the boss is. The architects felt like mom and dad of the project. Because of that, they accepted less changes from other people. In a traditional building process, each party has its own responsibility that are aligned perfectly behind or in front of each other. After the architect makes the design, he or she monitors if everything is going to plan but the architects are only used for the esthetics. But for these type of experiments, this is different. The designers are needed because they had the idea and they were in contact with all the suppliers. They kept a lot of responsibility along the project which makes it hard. But it is good to work together with an involved designer.

The management of the team was done by one other manager from the client side and the interviewee. The interviewee took on the role as process guarder and the other person was responsible for the project in terms of content. A reason for this was that there was no time to get the interviewee up to speed when he started.

Project Communication Management:

The stakeholders have been partly identified at the start of the project. During the process, more and more stakeholders participated in the project. Urban mining collectors for example, became the largest supplier during the process. Next to be a large supplier they also became important for the external communication of the project. The fact that the materials were borrowed made the communication with supplier hard, you can never be sure when materials come out of the donor building and are available for your project. This is a risk for the planning. By borrowing you are less flexible in demanding than by buying products. This gave new challenges. No communication plan was set. At first, documents were shared through email. After, a google drive was made. Communication within the team was done via WhatsApp.

At one moment the client was removed from the WhatsApp group because he wanted some last-minute new changes. He likes to do lastminute modifications and to challenge people till the last moment, which is fine but at some moments this communication was not appreciated. Preferably then via the email. There existed several WhatsApp groups, one for project management and one for the construction.

The meetings were planned at the moment the team members were in each other’s towns or cities. And a lot was communicated via the phone. It was impossible to travel for every question. No fixed meeting moments were held. The interviewee processed the way communication was going, but not project wide. No document or plan was made for this.

Project Risk Management:

Too little risk management was done. During the plan, the costs have been analyzed, whether it was a factual plan. But no complete risk management of the process of the project is made. There was no plan B for the risks. For finance risks no plan was made because there was a budget of 200.000 and that was it. In the end this led to a cost overrun of 50.000. The client was responsible for this. Risks were perceived as things that could not be changed but needed to be fixed.
The risks arose during the process which could not have been visible at the start. Because what they did was not done before. Therefore, it was very hard to define the risks. Except that you make sure the building does not collapse. The constructor was responsible for this.

Project Procurement Management:

The procurement of the project did not go in a traditional way. It was about knowing each other and having the contacts. When in the network the parties could not be found, google was used. The suppliers were found like this as well. The contracts have been signed and closed off. In the end all parties worked with contracts and quotations, that is how the client works, to justify the finance. Without a quotation, nothing was paid. Therefore, time is (again) very important for these types of projects. Somethings needed to be paid before ordering, this led to some issues.

Project Stakeholder Management

The stakeholders have been identified partly. No stakeholder engagement plan was made, nor monitored.

Project Integration Management:

No project charter was made. A project management plan was not made because it was useless. Everything was done for the first time. For that reason, everything you think of changes within one day. Or it is out of date or not functional. It is a waste of time. The interviewee feels the most important thing about project management is, is that the project makes progress, within the agreed frame. But he feels it is not important to plan every step. That costs a lot more time than it gains profit. In traditional processes, this is important because you know where you stand. But in this case, you do not know what is happening, so 85 percent of the project management plan would be incorrect. Change management was done by calling each other and communicating. The project had many iterations, the design was changed about 15/20 times because the suppliers and the products changed all the time. The large changes were communicated through email. Project phases have been closed off with the phase documents. The phase documents were made because they needed to be made but they were not very important in the process. These phases overlapped. Therefore, the phases were not closed of formally.

Project HSSE Management:

The safety in the project was very important. To achieve this, for example, the crane operator was involved early and sat around the table with the builders. The workers on the floor were included in the construction phase to ensure the safety. A lot of helmets were involved on the site for people that wanted to watch. So, a lot of attention was paid to safety. This is done in the traditional way.

Project Financial Management:

An attempt was done to make a financial planning. From the budget followed a document that described what parties were involved in what part of the process. The payment differed per supplier. The financial part laid with the client. The financial risks were all for the client. This was described in the contract. Taxes have been planned and payed.

Part 3: The future of Project Management in circular projects

For circular projects (but also for traditional projects) time, finance and flexibility are very important. Creativity as well. Flexibility and creativity are very important to let projects succeed, because it is circular and innovative. Time and finance are necessary to give people the chance to adapt to the new way of constructing. The traditional construction sector knows a way to do so and it is difficult to change this. Mainly because these large construction companies are ponderous companies. You see that the innovative projects are done by smaller companies. The flexibility which means these companies must switch quickly and think quickly are one of the key factors to make such a project a success. In the future, the large companies are going to take over things from the smaller companies. Where the circular project management becomes the new traditional project management and the smaller companies start working on something new.

The project manager should look at what parties to join and bring together. Parties that have the knowledge as well as the commitment must be linked for circular projects in the future. In these types of project, such as project A, commitment is very important. This is one of the key factors for innovation and therefore also for circularity in the building process.
Appendix D.11: Interview project B interviewee 11

Function general: Project manager
Function project: Project manager construction
30-09-2019

Part 1: General project questions

In project B collaboration took place between interviewee 11 and another project management company. The interviewee was responsible for the construction and users and the other company was responsible for the administrative and political side of the project. The other company made sure the politics were correctly and timely informed. They worked together yet, formally, the other party was the commissioning party of the interviewee. That was the hierarchy on paper but in cooperation the parties worked besides each other.

The process of a project is completely different of a circular project compared to a traditional project. However, the job of a project management is not different because you still need to organize the process. The first discussion is, what is circularity? There is difference between renovation and a newly built building. The way circularity is applied, is different in all types of projects. For new constructions, the process could be like a traditional process, but more construction team collaborations are implemented, and suppliers are involved earlier in the process (instead of only the contractor). The process is comparable to a traditional process. In transformation projects, a lot of materials and products are reused. An analysis is first made to see what is there and with the help of the Oogstkaart principle the building is reconstructed. The Oogstkaart first looks at the building itself and after, other demolition materials of the rest of the country are used. This is reversed engineering, you know what is released from other buildings and you know what demands and necessities you have, and with that a puzzle is made.Circularity is very interesting, but nothing new. An inner wall is always produced to get two destinations. The question is more about to make the inner wall instead of standard 2.30 meters (which fits in 70% of all the buildings), making it 2.10 meters so it fits in 100% of all the buildings. There are a lot of degradations of circularity. It costs more time to do this type of reverse engineering. But other themes stay the same, like budgeting.

The program requirements become more complex with a circular building. You can write down what the requirements are but, in the end, it is often contradictory with the available materials and products. A clear division in priority must be made between hard requirements and soft requirements. Moreover, it cost more time because it becomes a creative process. A project manager cannot say from a distance ‘organize the project together’. The market is discovering the circular economy. All parties are still learning about this. Project managers need to advice clients on this. Next, the translation must be made from the specialists and advisors between their themes/proposals and the sustainability and circularity.

The theoretical approach of the circular economy is that everything you hold, should be deployed again. The question is, where to stop. Should we handle the cradle to cradle thought that everything should be demounted to raw materials? Or is it acceptable that the material remains reusable without being a raw material? There are many definitions. For the interviewee, circularity is that there has been thought about the application in the future where the large waste stack is the last possibility. The products and materials should be mounted in such a way that the impacts of the waste stack are nihil. In the basis, this means the cradle to cradle way of thinking. Almost all projects the interviewee works at (started this year) circularity plays a role. Not one 100% circular project, but all partly circular projects. All clients are asking the circular question, at this moment.

The interviewee does not think project B is a circular project. The project has a hull and an interior. The hull, which is the shell of the building and the basic renovation, is circular because it is a renovation project. A lot of the existing construction and material is used. Yet, everything that has been added or replaced to the construction was new, without any circular principle. These were mostly large installations and façade materials (mainly glass). There was not a circular ambition. The building has a very resistant indoor climate concept, which can be called circular. The indoor climate is not user or area specific, but it is made on building level. The materials that have been applied are new and are not designed with the thought to demount and reuse it later. The same for the glass or concrete, this is all new. No new techniques have been used to look at what concrete to use. The glass hall in the building is reused 1 on 1, so this is circular. However, the foundation beneath the glass hall is new. This is not bad, just to illustrate that the building is not completely circular.
Some materials used had potential for reuse, but due to the height of the building, reuse was not possible. The height of the building was a lot higher than normal buildings. Circularity was not a theme, so no lessons were learned from this project.

**Part 2: Project management of the project**

**Project Scope Management:**

The project requirements have been analyzed. Based on these requirements, a scope is defined. A work breakdown structure is made by the project manager. On high level, a planning is made. This planning has phases and per phase is known what the product(s) should be. The advisors were taken along in this process. The requests of the other parties are often based on the work breakdown structure. A cross list was made by the client where all the activities and products were documented. However, not every activity was evenly applicable for an innovative project. To this extent, the list with crosses was changed based on the activities that the client found important. The project scope has been evaluated to check whether the project was still going according to plan. This is done with several parties together, with the tenants, the client and the administrator of the building. But not with the advisors. The project managers challenged the client with the question ‘are you still doing what you wanted to do’?

**Project Time Management:**

All the important activities have been defined at the start of the project, including durations. Some small things, of which you know they will happen but have less consequences, can happen and do not need to be defined in detail. This is impossible to define everything. The strategy and end goal need to be taken into consideration, but in the end, things happen on which you need to tackle. The sequence between these activities is defined by the interviewee, on the back side. The resources and durations of the activities have been defined as well. The planning is made and controlled. That is the job of the project manager. That is something you do the entire day, it is a continuous process. The planning was part of the two-weekly meeting. The design meetings had themes. During some meetings the philosophy of what you were doing was discussed while in other meetings the planning and decisions were made. This is something organic and dynamic. The themes for the meetings were decided upon together with the design team.

**Project Cost Management:**

For the project cost management, everything was done in the traditional way. Cost estimates were made, and a budget was drafted, which was controlled over time. This is something that is done in every project. Unless in an innovation, but even then, you can never work with unlimited funds. So, this is always done.

**Project Quality Management:**

The quality is described in the program requirements, herein spatial quality is delineated and technical requirements (architectural as well as installation requirements). Strictly taken, the aimed quality is fixed. All day long activities are undertaken to ensure the aimed quality. The program requirement is known at the start, so everything is done to ensure everything that has been defined in there. Some examples are a mock up that has been made (test or sample), modelling for acoustics and simulations. Activities have been performed to test the quality. The contract form was UAV-GC. Not all contractors are known with this type of contracting. So, the client did extra quality control and inspections for this. In the end, the total dossier was tested.

**Project Human Resource Management:**

An HR plan is made, in the form of a project plan. This has been checked several times during the process to see if every project team member is in its place. But it was not a detailed HR plan. The design team tendered as a team but were individually active as well. Some advisors were hired by the client, some were not. Therefore, a lot of people were involved. Based on this a project team was set up which was managed by the interviewee. The client took on the job and next to that, administers the project when finished. The administrator then becomes the lessor. The client selected the design team, which was formed by the architect, the constructor and another architect. The project management company added the cost manager to this design team. In this contract form, the team was tenderer as a group, not individually. The company of the interviewee, managed the design team and managed the group of three users. This was the design process. Later, the contractor was selected. In the execution, the project management company was also involved. Here the design team worked as advisors. During the construction, there were two parts responsible for the completion, the contractor for the
hull (casco) and another company for the interior. The project management company was responsible for the management of the both parts. According to the form of contracting, the contractor makes the realization design and the final design. This makes it complex. If you think traditionally you have the following timeline:

Normally an architect makes the design until the technical design, but in this case with this type of contracting, until the definitive design. So, the contractor worked out the rest of the design. Because the design was made 2 years before use, the users, which where three separate parties, needed to give input for the design very early in the process. This was hard to manage. In the process, key moments took place where decisions needed to be made before going to the next step.

Project Communication Management:

The stakeholders of the project have been identified beforehand. Communication plans have been made, for the project team and for external parties. Because the project is so large, between the client and the project manager specialists from the client side were involved regarding procurement, communication and legal. They helped the project team on these specific topics. Based on the subject, certain people joined the meetings. Information is distributed on a certain way. The performance of communication is not reported or evaluated. These two subjects have been discussed during the meetings: information provision and information necessity.

Project Risk Management:

The risks have been identified at the start of the project. Risk analysis have been performed, qualitatively as well as quantitatively. A risk is everything that can happen unforeseen, by external influences. It is useful to see what the consequential damages are of risks, but no reserve budget needs to be made to account for this. Several parties contributed to the list of risks that could happen. Risk sessions have been organized during the milestones, where potential risks are identified. Sometimes during these sessions risks were analyzed thoroughly and sometimes new risks were identified. Risk responses have been planned. The risks have been monitored. Therefore, project plan, the planning and the resources are always developing. The breakdown structure is never finished.

Project Procurement Management:

The European-level tender procedure is used to select the parties. This is done based on the UAV-GC. The designing advisors and contractor are tendered by the client. The subcontractor and suppliers are tendered by the contractor. Contracts are set up and closed off after the project finished.

Project Stakeholder Management:

The stakeholders have been identified. For this, a stakeholder engagement plan was made. This was part of the communication plan. The plan is monitored but the effect of the plan was not monitored. You always check how it is going, but not intensively. You know when the project is in the newspapers, you are too late.

Project Integration Management:

A project charter is made, but such as the risks, you define the most important parts and then you start. Because if you try to define all the interactions then you never finish. You need to accept what the impact is of things. So, only high priority things are defined. You can presume that because you work with professionals, that in time issues or other things come forwards. A project management plan has been set up. Change control is done by the phase documents that are produced, where is verified if you still work according to the starting points. If there is a deviation, agreement needs to be done on the deviation. A change log is made of large design choices that have been made. Phases have been closed off in between with the help of the phase documents.

Project HSSE Management:

A V&G plan is made, which is a safety and health plan. This is regulated in the legislation, it should always be made project specifically. Everyone involved in the project was known with this project. Normally you analyze the laws, safety etc. Per location you check this before starting the project. Some parts are secured in the process (safety, noise, unwanted animals etc.) so not extra plan is written for these plans. Some things are done, but no extra plan is written for it.
Project Financial Management:

A financial planning is made. The financial risks are always divided in the contract. This is divided in terms of liability. And the contractor has some discount amount and penalties, where financial coverage is inserted in. Taxed have been planned and payed.

Part 3: The future of Project Management in circular projects

The interviewee feels that project managers in circular projects become even more advisors. The project manager needs to make the client aware of the different choices he has with its pro’s and con’s. This should always be multidisciplinary and context dependent. Also, the project manager should interfere on substantial themes of the project. With substantial knowledge, parties need to be engaged around the table about what circularity is. They need to be challenged to do circular things.

Quality and money of circular projects are complex, but soluble. The other discussed themes need to always be done because only the content of the theme change, not the activities. It is mostly the change in context which makes it more complex and therefore takes more time. The question is if you need to mastermind all the new steps. There is a new perception of circularity between a project manager and a specialist. They have different stakes as well. An architect finds that he or she needs to mastermind every step, while the interviewee thinks you should mastermind less. Because the market does more, or some things are available. You need to think of a way to set your signature as an architect, but respect as well that something has a second life or will get a second life. The question is if you should do that innovation as an architect or installation advisor. A lot of innovations exist of which advisors have no knowledge of, because the market is too large. You need a lot of specialist and material knowledge for the assembly. Sometimes you need to let someone else do this. When adding quality by demanding for circularity, it has some consequences for the rest of the project.

The designing parties need to let go and need to trust, and the manufacturing parties need to want to innovate and be open to development. This is for a large part based on changes in personal relations, to make sure everyone’s work is done correctly. Project managers manage the relation between money, time and quality which is continuously under pressure. It is impossible to score equally on the three themes. This also accounts for circularity, it is a part of the quality of a project. If this is an important factor, you need to do concessions somewhere. However, the current market is not ready for this at this moment. They are learning, interior designers are making the first large steps, because the circularity way of thinking is the easiest there.

The largest difference in process, is that the suppliers are engaged sooner in the process in the project. For a large or small project, you always make an analysis of the task. The process is designed based on this analysis. So, it depends on the vision of the client at first, because every step taken in the project is a result of this. You only ask different questions and connect different conclusions to this. But the connection between a UAV-GC contract and circularity is very complicated.

With circularity you see that a lot is talked about, but it starts when people start acting. It is about the entire chain. The interviewee believes circularity is more expensive at this moment compared to a standard building. Because you are going to make things instead of producing things. Therefore, people are more expensive, you deviate from a mainstream process, while all suppliers have the mainstream process structured very lean, but they need to variate their very lean process. This gives difficulties. Making things cost more time, more transport, workplace etc. But it is going quickly now, in two years this conversation is very different.
Appendix D.12: Interview project C interviewee 12

Function general (now): Project manager/consultant of circular constructions
Function project: Project manager (client side)
02-10-2019

Part 1: General project questions

The interviewee thinks there is a difference in project management between a traditional construction project and a circular construction project. The company the employee works at now is not the same company as during project C. The current company works more with traditional project management and he can therefore reflect better on the decisions made in project C. An important difference is that the correct team needs to be found that can work well together. During the project, they also looked at the process and the difference that needed to be made compared to traditional project management. They also looked at what roles should change. The possibility for example for the architect to not design the entire building till detail but designing with room for suppliers to come with their own ideas.

The establishment of a circular design is different compared to a traditional design. There are large differences that ask for other facets from the project manager. The old design was made for 70% when they decided to change everything. The TU Delft helped in several pressure cooker sessions for the new design. A part that advises on installation techniques joined these sessions. A new team evolved that together were thinking of ways to interpret this new philosophy. It was noticed that the people attending this session did not have the correct input. Because there needs to be a complete different philosophy for the design. The question is how far you give this person the space and time to learn about the new philosophy and when do you replace this person or party. There must be space for people to get used to the idea of circularity. But you should never lose out of sight that a planning needs to be reached. You need to source competence focused. Traditionally you tender how things are going to look like in relation to the price. In circularity, these two parts are more difficult since there are no direct solutions for this. This requires more thinking.

The circular economy knows a lot of definitions. Looking at the constructions it is definable in principles as design for disassembly and about not making things you do not need. In the end it is about working towards an ecosystem where traditionally the ‘take-make-waste’ system needs to change into an infinite cycle. Where everything needs to stay in the loop and minimize material loops. The system way of thinking is very important and maybe the most difficult part. To make a construction that can be disassembled is something we can achieve with our brainpower. But how this fits within the system is complex, it is very difficult to influence this now. Large changes need to take place that cannot happen in matter of days. Therefore, this feels very experimental.

One document is available about how they shaped a market study to come in contact with the subcontractors of the contractors that gave meaning to the circularity. This has been an important part of the approach. At this moment, in the new company, he observes that the demand to circularity is growing. Clients have interests and in the demand specification it is mentioned easily, but the further the demand specification goes towards the further elaboration, the circularity continues to weaken. A reason for this could be that because the market solutions are not yet available, it is hard to keep to the starting point with no specific interpretation possible. There are some customary methods like cradle-to-cradle, where you can look at. What is observed as well by the interviewee, is that the first design of the architect is very binding for the design. Maybe we should start with a program of materials? That changes the approach of the process. The interviewee thinks something needs to change in this area.

The interviewee believes project C is a circular construction building. When the decision was made to make a circular construction, they decided to be careful in communication to say things such as ‘100% circular’. He always says that it is an experiment of something they thought they could do circularly. During the tours in the building, the interviewee tries to tell the things that did not work as well. An example is the DC voltage system in the building. The idea was that the entire building would work on this DC voltage. It turned out that the current techniques do not let you leave out the AC voltage system. The kitchen supplies in building C work on AC voltage. This means there are two systems, which is not that circular, because two systems are made (where only one could be enough). The deliberate choice is made to use DC voltage because they believe this can help in the future to prevent losses. That was a more important principle than the two systems.
The principle design for disassembly worked well in this project. However, the dismount time is about 2.5 years at the end of the life cycle. As Thomas Rau says, everything you buy with new materials has a kind of promised circularity. It only becomes circular at the end of the life cycle when steps can be taken. According to the interviewee, our financial system is not ready for this. To be ready, the process needs to change and the system needs to change. Project C is constructed for 50 years on the same location. After, it is possible to disassemble, with a long disassembly time. In this project there was the intention to incorporate a take-back commitment, but it did not work. The suppliers would like to do it; however, they could not find a bank that financed this. There is a search for circular business models. There does not exist a document that explains how the building should be dismounted element by element. A material passport is made, where they decided to only use elements that would be there for a long time such as the main load-bearing structure. But a high extent of details is incorporated in the model, to see how you should dismount is. The interviewee likes to compare it to a LEGO manual, where you can see what it must look like. With knowledge it should be possible to disassemble, based on the plans.

The 10-R model is used in this project. This is used as an assessment framework. The five axes that have been used as criteria for solutions are described. With this, all the design solutions were evaluated with a grade. This was done per decentralized team. For example, there was a design team for the main load-bearing structure. Options were weighted against each other and after that a preference option followed. This option is presented to the central design team. This is iterated until a further detail level. In the end not every bold is evaluated, but this is the strategy that has been applied. The 10-R model is used to grade the circularity of every option.

The circularity has been evaluated with the participating parties. This is a part of the purchase strategy, to reflect at the end how the process went, regarding the quality etc. Afterwards, studies are published to evaluate the circularity. The good thing was, they had an old design of the pavilion. This was a good benchmark to calculate the decrease in material that was used. A true value analysis is published by KPMG. The interviewee proposed an MCI index evaluation, but nothing has been done since.

The most important learning is that we need to let go of the focus on how the building is going to be. We need to be open to supply based design. That creates space to start using used materials. In project C this did not happen that much, the window frames in the basement, wooden floor on the ground floor are reused materials are examples. Therefore, a lot is new but made with the principle design for disassembly. But this is a promise to the future. Supply based design is important if you want to work towards current circularity and not future circularity. This way it can be reasoned what we can do with existing materials. Secondly, the composition of the team and the embracing of the circular principles are important too, to make sure there is commitment from all the parts of the project. Another significant part is the willingness to take risks. In this case, the client was very willing to take risks.

The building would have been different if it would have been a building with inhabitants. Now it is a building with a meeting function. It is not a place where clients are received on the daily. Therefore, for example, inside climate is less important. In the chain, there are always subcontractors that are avoiding risks. So, if a client is willing to take some risks, more space for innovation is created.

No circular requirements were set, because at first, they started with the wrong design. They learned here, another important learning, that the determination of the sustainable ambitions in the initiation phase of the project is the most important thing you need to do as a client. If no good meaning is given to this and it has not been thought out well, you can be faced with the fact that you do not think the design is sustainable enough and you need to throw the design away. This is not cheap at all. It means you used a lot of resources for nothing. During the process with the first design, the sustainability was increasing. Some brainstorm sessions were organized but the client side found out that the advisors (during the first design) were not working at circularity. They were not coming out of the comfort zone; no unique solutions were thought of. An argument took place between the interviewee and an advisor installation technique. The latter thought a grey water circuit would never be profitable because drinking water in the Netherlands is very cheap. They concluded that the current team was not working on the interpretation of the ambition of the client. A senior colleague decided to stop the project. An email was sent to all the involved telling them the project was stopped. After that, circularity became the aim, after an intern of the architecture firm came up with this idea.

After, the new set up was made with the central design team. They tried to go on with the entire team. Together with the TU some pressure cooker sessions were organized. The architect was asked to sketch an image expectation of the construction, without designing it to the last bold.
Very soon, a market study was done together with the purchasing department of the contractor and with the architect. The client handed out a document of 2/3 pages where they defined what circular economy means to them. Together with the image expectation. A request for proposal was set for this with the standard purchasing technology. First was looked at the parties that were interested and after a shortlist was made of 10 parties that were engaged in the conversation. They were asked about how they see the client ambition. This is an important example how it was shaped. Which led to a success. Besides, they were lucky it was not such an overstrained market as it is now. The construction market stood still and because of that parties were interested in doing experimental projects. The five starting points that were defined for the project and what they understood for the circular economy were discussed literally in the purchasing document made by the client.

Part 2: Project management of the project

Project Scope Management:

The project requirements have not been defined in detail by the client. They started with program requirements, but these are so short you can all document them in one page. The client had a shortage of meeting rooms. Therefore, somebody came with the idea to make a small pavilion. Besides the meeting rooms and restaurant, not an extensive program requirement was made. This was very open. Based on this, the scope was defined. No work breakdown structure was made, and the scope was not controlled and verified during the process. The project was not completed with many documents. When the new design was chosen, design documents were defined with what the requirements were for the technical installations etc. But if you look at the initiation phase, this was kept very open. This was done consciously to create space. The destination of a part of the building was unknown for a long time. So, for that reason, the project started with assumptions and the development and interpretation came later.

Project Time Management:

The defining of the activities was approached on high level. With the old design there was such a planning but when decided to change the entire design, the design and execution were very close to each other. They had a type of rat race where the design needed to be made to make sure the execution did not have to stop. This was best effort where the aim was to be finished in September 2017. There was concluded that the construction would take half a year extra and therefore the budget became higher. But this arose organically. This is completely different then how it is done now. A planning was made, and this was controlled, mostly on the execution part to see where the project was.

Project Cost Management:

An estimation is made of the project costs. Based on this a budget was set. The costs have been controlled continuously. They were in a unique contract form with the contractor. In this ‘round the table model’ they decided together on a budget. This budget was spent together with the contractors. The purchasing departments of the client and of the contractor were bargaining with the subcontractors. This was a completely transparent process where everyone could look at. The budget was prognosed to see if it was still on target. This was monitored continuously. This was done by the project management department on the client side.

Project Quality Management:

No specific quality aim was described for project C. But in the process, more quality requirements arose. During the process, a building physics advisor consulted on the different norms applicable about the crosstalk of the different spaces. On that manner, quality was defined. A better climate concept was developed. Nevertheless, these quality ambitions were never recorded in a document. In an organic way, with the subcontractors they looked at how a circular climate installation could be developed. Because there were not that many requirements, for every decision the most circular and efficient solution was chosen. But they were not documented beforehand. Activities have been planned to achieve this quality. The project received a BREEAM outstanding certificate. This means noise tests took place, Q14 tests and commissioning on technical installations. The latter was a large problem for the project. The quality requirements arose after the concepts for installations were made.

Project HR Management:

Not with this name, but the project team did a lot of thinking on the organizational structure and the people with their competences that participated.
This has been modified during the process by adding or removing people from the project, when they saw it was not functioning correctly. This was not documented very consciously, but it was managed actively. Within the collaboration with the contractor, this was done in detail. For other collaborations, for example for the tender for the restaurant, these roles were less defined. A project team was made with the collaborating parties. The interviewee managed the project team.

Project Communication Management:

Stakeholders have been defined beforehand. A communication plan was made for internal as well as external parties. Communication was mostly managed by the client because the project was a determining factor for the client’s image. Externally, this was done so that a consistent story line was communicated. There was a lot of attention for this. A plan was made on how the client would incorporate its employees in the project. They used time lapses, newsletters and counted back on the opening of the building. Information was shared internally with the system of the constructor, Docstream. The information management was well recorded in this system. The exposure of the external communication was measured. It was calculated what increase in brand value was made by communication.

Project Risk Management:

The risks were managed continuously. This was also because the constructor company was a large company where this is done very professionally. The project consisted of the building, the garden on top and the new garden on top of the parking. This all is approached integrally. The risks are defined before the project started. Risk analysis has been performed, qualitatively as well as quantitively. As risk assessment method was used for the internal processes. Risk responses were drafted. The risks were controlled and monitored during the process.

Project Procurement Management:

The procurement was done in a circular manner. A purchasing process was done but with a very vague scope. This was done with some reference images and global thoughts on what it should be. At first, they let them price this on main lines until the client’s budget. Together with the parties, the detailed engineering was taken up. Here, the focus was more on circularity then on price. The suppliers were contracted in the same way. The party that was chosen differently was the contractor company. They were not selected based on a tender, but they were working on another project in the same location (square) and a lot of execution advantages were possible here. This has been a private tender. The same for some designer in the team, the architect was asked directly because they were responsible for the design of another building of the client. And the architect hired the engineers. So that were direct procurements. The client together with the contractor, did the procurement for the subcontractors. Contracts have been made, and afterwards closed off.

Project Stakeholder Management:

The stakeholders have been identified. A stakeholder engagement plan was not made. A stakeholder analysis has been done and plans have been made to see how to approach them. But not documented in detail. This was done with the communication plan. This was monitored and evaluated. This was part of the communication planning, where they controlled if all the stakeholders were approached correctly.

Project Integration Management:

The dependencies were not documented, in a project charter. A project management plan was made, on high abstraction level. Change control was done, but not according to an official procedure. Because they chose a flexible design, there were less large changes in the project. They were more changes that improved the circular character of the building. Therefore, no official procedure was used. The process was reported, and the choices and changes were discussed in these reports. These were made by the design team and the project board reviewed the update of the process. Large changes were communicated formally. The central team had a weekly meeting. The project board had two-weekly meetings. The working groups around the central team had their own frequencies of meetings. Project phases were closed off in the phase documents. This was also done to inform the project board what quality they were going to receive.
Project HSSE Management:

The contractor set up a V&G plan, which is a health and safety plan. This is standard done for every project. This was informally supervised to see if the project complied with the plan. So, the client addressed the contractor when the V&G plan was not lived up by. The management plan for this was made but was more in the scope of the contractor. The client was not actively involved.

Project Financial Management:

A financial planning was made. The financial risks were divided in the contract form. The risks were all for the client, only there were agreements about warranties by the contractor, so some risks were excluded by the contractor. The DC voltage installation was the only risk exclusion in the contract. The risks for this was for the client. They also did not have warranty on the circular applied materials. For taxes, the project is a unique situation since the tax liability is different for the client. But it has been considered, the tax department of the client was concerned.

Part 3: The future of Project Management in circular projects

Nowadays, in the program requirements circularity is used but it weakens during the process. Circular buildings have a high experimental character with risks, which needs a more open and different approach than the 12 themes we discussed. You need to let go of the idea of what you are going to get and let go of the strict themes and if you do that you can make a good circular building. What does not help is the setting of a lot of requirements on the front side of the project. If the market is not that large, it is difficult to achieve the specific demand or design. You need to make a lot of space in the question specification.

The project manager should make sure that the ambition of the client is clear, and the project manager should advice the client on how to achieve its aims. The client needs to let go of what he knows beforehand to come to a circular character. That guidance and the expectation management is a very important part of the role of the project manager. However, the current construction sector is not ready for this. The independence between the different links in the chain make it hard to make changes. The client was the purchaser, user and financier. This rarely happens. This makes it easier because he can make decisions in those three interests. Or to accept more risk. We are still in the do phase to come to solutions and insights.

An urban mining company was one of the subcontractors. Some things happened between him and the contractor. That might be interesting to see it from a supplier perspective. In the contract form a lot of things were open for a long time. For a lot of time the scope was not made specifically. The urban mining has its own business case where circularity cannot be more expensive than traditionally. I have the feeling this did not happen on a chique manner.
Appendix D.13: Interview project C interviewee 13
Function general (now): Owner and director urban mining company
Function project: Supplier and subcontractor – urban mining
10-10-2019

Part 1: General project questions

The interviewee was involved in project C as well as in project A. In this interview, we will only talk about his experience in project C. Interviewee 13 feels there is a difference between circular and traditional project management. At this moment we are in a transition towards the circular economy. In the transition phase, project management is different. In the end, a new model will arise at the end of the transition. During the transition phase, other things are asked of a project manager. In the end as well, the circular economy is about different values, other collaboration forms, other ways of ownership, so several dimensions are added. The process might not change that much, but other dimensions are added. In the transition phase, we are doing change management. Which normally does not belong to the scope of the project or process manager. Interviewee 13 notices this in practice, there exist very good project managers but they are used to operate in a very efficient, effective and purposeful manner. Nonetheless, they operate from the situation where parties are doing something they already can do. Of course, there will always be tensions on price, time and quality, but now you see that if we add the circular dimensions, people need to change. As a project manager, you are responsible for that change. That is not what the project manager have been educated for and what they are rewarded for.

Circular economy for the interviewee means a new economic model. It is an inclusive model, which is about keeping material streams in the loop, but it is also about energy neutrality, water and health. It is very broad. The interviewee works on materialization and the inclusive economy, involving people with a certain distance to the labor market, by making sure everyone participates. His vision about the circular economy, being a new economic model is in contrast with the people saying that the circular economy is a new package or a stream of sustainability.

The interviewee founded the company to give interpretation to his own circular ambitions. He has the ambition to achieve the circular economy in the built environment. He noticed that to accomplish his own circular ambition, an advisory role is not enough. He wants to be in charge and the owner, while bearing risks to show it is possible. His company is about moving towards a circular economy. That is different to a company that is a concern and that needs to implement circularity. The company consist of two work societies. The first one works on the delivery of building materials that are made of or consist of materials that have been released with urban mining techniques. On the one side this is about sales and marketing and on the other side about innovation management and financing. He is an investor in technologies and system changes to come to the assortment of building materials. Therefore, he needs to have disposition over materials and raw materials, because otherwise the innovative techniques have no function. So, the other work society takes risks bearing demolition jobs. This is traditional demolition, or transformation demolition or total demolition. So, the other side of the company is main contractor of demolition projects. Both these activities lead to the core of the company: the supply of building materials.

The interviewee does not see project C as a circular building. He does not see the circular economy as a type of finish flag we need to work towards. Project C is a good step that is done by the client that wanted to show what was possible at that moment. It is an inspiring example, a lot of principles of the circular economy have been used. On his own field of study reuse, building systems, material choices and Product as a Service are used. It is mostly focused on the user and visitors of the building. The largest impact is maybe the story that is being told with this building. If a circular strategy was used, the interviewee did not notice this. The interviewee had a special role in terms of structure. Talking about project management, this is a very special project. He did not recognize any strategy being used. This could be because circularity only became a topic after the start of the construction. They did not have a circular agenda from the start. It is more pushed in along the way.

The interviewee believes that all the people involved are very proud of the result, but it was a project with a lot of friction. This was mostly because circularity became a topic during the process. The client decided along the way, let’s do something with the circular economy, which is very good. But the main contractor was already contracted for the old plan. On a certain moment a contracting form is chosen where they were jointly responsible for the circular interpretation.
This was no turnkey agreement but it was a joint performance agreement to come to a circular interpretation. This lead to the fact that the contractor did not have a lot of circular ambitions, which frustrated the client. The client did not see another possibility then to explore and investigate the interpretation and to start contracting by itself. But next they ask the contracted parties to work with the main contractor directly. What happened is that the main contractor disagreed with some of the decisions made by the client. It was a weird co-creation form. This was also about culture. The main contractor is a very large company. They chose to work with the client and were willing to cooperate on the circularity ambitions. However, the contractor is no circular frontrunner, it is one of the most traditional construction companies the interviewee knows of. They also have a culture problem when it comes to the implementation of circular principles. The board can agree on the circularity but the interviewee noticed a lot of resistance on the execution of the project. Not everyone had this attitude at the contractor’s firm, but the employees involved in the execution did.

An example is, in the basement old windows from an old building of Philips were going to be used. The contractor refused to use the materials of urban mining. During a meeting the interviewee said if you don’t implement the windows in the walls, then I will do so. Then the contractor said, ok you can do it. The interviewee became at that moment not only the supplier of reused materials, but also a subcontractor where he had to implement his own facades. He became a subcontractor under the coordination of the main contractor. He then got direct assignments by the client but the payment was done by the contractor. He therefore also had to sign a contract with the contractor. The agreement with the client was on one paper but the agreement with the contractor consisted of 67 pages. Crazy things happened then. Seven aerial work platforms were not used in the basement and the contractor needed one for one hour but he could not use one of the seven because he is a contractor. Moreover, the hoist hatch, where products were hoisted from to the basement was closed off a day before the interviewee arrived with the materials. The interviewee’s truck with materials always had to wait three hours before driving, because others could always precede. This all increases the tension enormously.

When the windows were installed six people of the contractor firm were looking at it and saying what are we doing with this old shit. This is also something about the transition we are now at. The interviewee is still very proud of the result. All parties have done the best in their capabilities. The interviewee is a small company and therefore must convince less people of his story because people with the same circular ambitions work at his company. With a large contractor that is different, however, this is an observation. For such a large company to collaborate in the transition, that may take many years. If you do project management, this is your problem. The problem is not ‘how can we make a logistic planning?’. But instead it is, if the culture is not there to do the work together then the planning makes no sense. The people working on the project are the determining factor.

Another thing that went wrong is when the interviewee was delivering the floors to the project and they found out that the BIM model was not correct. They found out they missed 150 m2 flooring. That is a problem with a normal production, but with a circular production the problem is larger. A weekend they had to work for 24/7 to make sure 150 m2 could be produced from the same batches, to make sure there were no color differences. In the end the company of the interviewee was supplier and subcontractor. The interviewee opposed to the contracts the main contractor normally uses for this. This was the first project where this floor was made for. It is very hard to give guarantees on something so new. The interviewee was willing to give guarantee but wanted to share risks, the client agreed on this. This did not fit the standard contract of the contractor. The contractor did not care about the agreement between the interviewee and the client, they only wanted to use their own contract. To this standard contract no changes could be made. The interviewee wanted the client to tell the contractor what agreements had been made. This was done for a bit but they found this hard to do, because they were dependent on the contractor. Everyone was working in the project so nobody could take a step back. This became a forced collaboration form. The used contract was not different to usual, it was a traditional and linear subcontractor contract.

The interviewee has two large lessons learned. First, it is important to know beforehand, what the contract form is that the main contractor has with the client. Misunderstandings arose because the interviewee did not know this. No one told him but he did not ask. From now on he will ask about the contract, because of that, the project cost him a lot of money. The fuzz was not in the price so all that was lost money.

Second, the project management company (of interviewee 8) had a managerial role. The interviewee was told at the start that this party was the only party that had the authority to make decisions and decide on commitments for the and in the name of the client. The interviewee did not check this. In the end, the contractor also had responsibility and a position which could not be overruled.
In the end there were three commissioning parties. The most important lesson is that the interviewee will ask beforehand on the structure of the project team. So that he can prepare his own organization for this and educated guesses can be made for the opportunities and the risks of the project for the interviewee. The interviewee does not recognize the round table model. The project in the end was finished because it was the necessity, not because they had the same ambition.

In the design phase the detachment of a building was an item. Everything that has been made was documented. The architect made a material passport. Next the project was designed in BIM and a madaster account was coupled to the project. In the closing of the project, three types of information were asked for, for the material passport. This must be documented. Based on this, the intention is that an external party can dismount the building.

Part 2: Project management of the project

Project Scope Management:
The scope was analyzed for the parts that were relevant for the company of the interviewee. This was about the circular character but also about fire safety and acoustics. Based on this, a scope was defined. A work breakdown structure was not made. The scope is verified during the process.

Project Time Management:
Activities have been defined beforehand. Including the sequence, resources and durations. Based on this a planning was made, that was not achieved, but it was made. The planning is controlled.

Project Cost Management:
An estimation has been made on the project costs. Based on this a budget was made. The costs have been controlled in-between.

Project Quality Management:
The aimed quality was defined. Activities were performed to make sure the quality was achieved. The quality was controlled, externally as well. Quality was defined in the requirements that were documented in the scope by the client, fire safety, acoustics, esthetics and circularity.

Project HR Management:
An HR plan was not made. A project team is defined and managed. There were two project teams, the project team of the interviewee (within the company) and the leader of this was part of the project management team of the client. This leader was an external party, an external project manager. The interviewee only went things went wrong. The escalating was on management level. Which happened several times.

Project Communication Management:
The stakeholders were not defined beforehand. No communication plan was made within the company and documents were not distributed within a certain way, in the company. The prestation of communication was not reported.

Project Risk Management:
Risk management within the interviewees company is done, but not very explicitly in a separate document. Risks have been identified for the entire project, but for the interviewee’s task they were not. He is not sure about the risk analysis and risk responses.

Project Procurement Management:
The part of the interviewee was procured with offers and bargaining. This was done traditionally. He believes this is done this way for the rest of the suppliers and subcontractors. He believes the client had a circular budget. So, above on the traditional part they said the circular character may cost a certain amount. On that way the tendering is done in a more circular way. Contracts have been made and closed off.
Project Stakeholder Management:

This part was not done by the interviewee, on the urban mining side.

Project Integration Management:

No project charter was made. Neither was a project management plan. Change control was not done. This all within the company of the interviewee. The interviewee does not know these steps, as well as for communication and risks. His company did not make this. He does not know whether this has been made for the project by other stakeholders, but maybe it is. Phases have been closed off during the project. The deliveries consist of more phases. This is done in a formal way because inspections are needed. For this several documents have been made.

Project HSSE Management:

Policy has been made for project HSSE management. Based on this a management plan is made. This was made for the company of the interviewee and for the suppliers of the company. That is connected to the larger plan of project C.

Project Financial Management:

A financial planning is made. Financial requirements have not been set up for the project. The financial risks were all for the interviewee, but they were mentioned in the contract. Finally, taxes have been planned, per project the company has a fluid asset budget where fiscal aspects are incorporated in.

Part 3: The future of Project Management in circular projects

In the transition phase skills are expected from project managers. He wonders if all these skills should be comprised by one person. He thinks that project management of the larger projects needs to be done in teams. In the future, mainly on the theme risks, besides managing time, quality and money, the relation will become different compared to the linear economy. In a circular economy model a large part of the materials that are used in a project will not change in ownership. It is not the client that hires the project manager that becomes the owner of everything, but others keep the ownership. This means that they have a say in how the process evolves. Because it’s their materials, so they want to make sure the materials are used properly. On this theme, this will have a large influence because a new stakeholder is added.

Project managers now are used to steer on different qualities, energy performance or the BREEAM certification etc. So, the project manager will be addressed more on his or her capabilities to secure the integrality of the development. Instead of working with checklists.
Appendix E: 10R-model

With the help of the 10R-model, the degree of circularity is analyzed. The figure below (figure 25) shows the 10R model. In this model, method 10 (Refuse) complies best with the circular economy where method 1 (Recover), complies with the linear economy.

The 10R-model consist of the following R’s (Cramer, 2017):

10. Refuse – Prevent the use of raw materials
09. Reduce – Decrease the use of raw materials
08. Rethink – Redesign the products in the view of circularity
07. Re-use – Use products again, second hand
06. Repair – Maintain and repair the products
05. Refurbish – Revive the product
04. Remanufacture – Make a new product from a second hand product
03. Re-purpose – Re-use the product with a different function
02. Recycle – Salvage materials streams with the highest possible value
01. Recover (Energy) – Incinerate waste with energy recovery

Figure 25 The 10R model (own work)
Appendix F: analysis per case

In this appendix, per case the entire individual case analysis is shown.
## Appendix F.1: Analysis project A

<table>
<thead>
<tr>
<th>Name</th>
<th>Theme</th>
<th>Traditional project management</th>
<th>Project A</th>
<th>Questionable?</th>
<th>Project A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collect requirements</td>
<td>Project Scope Management</td>
<td>Yes, checked off of three items; design creatively, no sawing and building and keep to the fixed budget.</td>
<td>Yes, but the project did not have specific requirements. Yes, three items were formulated by the client.</td>
<td>Yes, correct</td>
<td>Yes, three new RFP requirements, three new contract requirements.</td>
</tr>
<tr>
<td>Define scope</td>
<td>Project Scope Management</td>
<td>No, there was no scope defined.</td>
<td>No, there was no scope, the only scope was spectacular sustainable building for 8 days. Yes, the scope was made out of the 5 parts of the building.</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Create WBS</td>
<td>Project Scope Management</td>
<td>No</td>
<td>No, there was no scope, the only scope was spectacular sustainable building for 8 days. Yes, the scope was made out of the 5 parts of the building.</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Verify scope</td>
<td>Project Scope Management</td>
<td>No</td>
<td>No, there was no scope, the only scope was spectacular sustainable building for 8 days. Yes, the scope was made out of the 5 parts of the building.</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Control scope</td>
<td>Project Scope Management</td>
<td>No</td>
<td>No, there was no scope, the only scope was spectacular sustainable building for 8 days. Yes, the scope was made out of the 5 parts of the building.</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Define activities</td>
<td>Project Time Management</td>
<td>No, only fixed deadline.</td>
<td>No, only two activities were planned, design and construction. No, only construction.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Sequence activities</td>
<td>Project Time Management</td>
<td>No</td>
<td>No, only two activities were planned, design and construction. No, only construction.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Estimate activity resources</td>
<td>Project Time Management</td>
<td>No</td>
<td>Yes, a planning made by PM with very fixed deadline. Yes, not a detailed planning only a clear deadline. Yes, a general and construction planning with fixed deadline.</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Estimate activity durations</td>
<td>Project Time Management</td>
<td>No</td>
<td>Yes, a planning made by PM with very fixed deadline. Yes, not a detailed planning only a clear deadline. Yes, a general and construction planning with fixed deadline.</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Develop schedule</td>
<td>Project Time Management</td>
<td>No</td>
<td>Yes, a planning made by PM with very fixed deadline. Yes, not a detailed planning only a clear deadline. Yes, a general and construction planning with fixed deadline.</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Control schedule</td>
<td>Project Time Management</td>
<td>No</td>
<td>Yes, a planning made by PM with very fixed deadline. Yes, not a detailed planning only a clear deadline. Yes, a general and construction planning with fixed deadline.</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Information</td>
<td>Project Time Management</td>
<td>No, was an experiment, quality was not planned.</td>
<td>Yes, in terms of safety and regulations, yes, in terms of construction and aesthetics.</td>
<td>≠</td>
<td>Yes</td>
</tr>
<tr>
<td>Plan-quality</td>
<td>Project Quality Management</td>
<td>No</td>
<td>Yes, regulations were assumed to applying for permits. Safety assured by aiming at high safety requirements.</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Perform-quality assurance</td>
<td>Project Quality Management</td>
<td>No</td>
<td>Yes, regulations were assumed to applying for permits. Safety assured by aiming at high safety requirements.</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Perform-quality control</td>
<td>Project Quality Management</td>
<td>No</td>
<td>Yes, the quality of safety and structures were looked at the university. No, only materials.</td>
<td>≠</td>
<td>Unknown</td>
</tr>
<tr>
<td>Develop project plan</td>
<td>Project Human Resource Management</td>
<td>No, state were defined on individual level, but not a real exit plan.</td>
<td>Yes, all stakeholders were interested in the quality of the project. No. No. Yes, all stakeholders were interested in the quality of the project.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Acquire project team</td>
<td>Project Human Resource Management</td>
<td>Yes</td>
<td>Yes, all stakeholders were interested in the quality of the project. No. Yes, all stakeholders were interested in the quality of the project.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Develop project team</td>
<td>Project Human Resource Management</td>
<td>Yes, with a very clear organisational structure with a triangle of parties in the middle.</td>
<td>Yes, all stakeholders were interested in the quality of the project. No. Yes, all stakeholders were interested in the quality of the project.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Manage project team</td>
<td>Project Human Resource Management</td>
<td>Yes, the project team was the most important in the middle.</td>
<td>Yes, the project team was the most important in the middle.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Identity stakeholders</td>
<td>Project Governance Management</td>
<td>No</td>
<td>No, not identified, but managed during the process. No, only a few and managed during process.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Plan communications</td>
<td>Project Governance Management</td>
<td>No</td>
<td>No, only a few and managed during process.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Develop specification information</td>
<td>Project Governance Management</td>
<td>No</td>
<td>No, only a few and managed during process.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Manage stakeholders expectations</td>
<td>Project Governance Management</td>
<td>No, parties and stakeholders were managed on the client side, for all projects during the events.</td>
<td>No, parties and stakeholders were managed on the client side, for all projects during the events.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Plan risk management</td>
<td>Project Risk Management</td>
<td>No</td>
<td>No, only financially budget was monitored including financial risks. Only focused on budget. This is part of the project cost management. No, because the risks were tackled by everyone together. No, only for the costs.</td>
<td>≠</td>
<td>No, only costs were managed in the risk management.</td>
</tr>
<tr>
<td>Identify risks</td>
<td>Project Risk Management</td>
<td>No</td>
<td>No, only financially budget was monitored including financial risks. Only focused on budget. This is part of the project cost management. No, because the risks were tackled by everyone together. No, only for the costs.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Perform qualitative risk analysis</td>
<td>Project Risk Management</td>
<td>No</td>
<td>No, only financially budget was monitored including financial risks. Only focused on budget. This is part of the project cost management. No, because the risks were tackled by everyone together. No, only for the costs.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Perform quantitative risk analysis</td>
<td>Project Risk Management</td>
<td>No</td>
<td>No, only financially budget was monitored including financial risks. Only focused on budget. This is part of the project cost management. No, because the risks were tackled by everyone together. No, only for the costs.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Plan risk responses</td>
<td>Project Risk Management</td>
<td>No</td>
<td>No, only financially budget was monitored including financial risks. Only focused on budget. This is part of the project cost management. No, because the risks were tackled by everyone together. No, only for the costs.</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Monitor and control risks</td>
<td>Project Risk Management</td>
<td>No, only the monitoring of the budget (which is part of the project cost management).</td>
<td>No, only the monitoring of the budget (which is part of the project cost management).</td>
<td>≠</td>
<td>No, but due to project characteristics.</td>
</tr>
<tr>
<td>Procurement planning</td>
<td>Project Procurement Management</td>
<td>No, parties were asked directly.</td>
<td>No, parties were asked directly. No, parties were asked directly.</td>
<td>≠</td>
<td>No, procurement is done by contacting first network and looking for committed parties that were willing to lend their products and materials. No, parties contacted earlier in the project. Before raising the design they had to know what materials they could borrow. No, they had to know what materials they could borrow.</td>
</tr>
</tbody>
</table>
Stakeholders of project A

The most unconventional group in the team were the builders. The builders were old-school handcraft workers. Interviewee 10 is sure that if a conventional construction company was hired, the project would not have been completed. Because they cannot switch and connect as fast. On the construction site, some problems arose during the process. With a conventional contractor, a conventional solution would be used. With these builders, they are very inventive and came with innovative solutions and propositions. The builders of the project were no contractors, because they did not wish this role. The client took on the role as the contractor. So, the client had three roles; principle, project manager and contractor. According to the interviewee, the builders were involved too late. Some of the mistakes on site could have been avoided (Interviewee 10, personal communication, 2019).

The architects felt like parents of the project. Because of their dominant position, they accepted less changes from other people. In a traditional building process, each party has its own responsibility that are aligned perfectly behind or in front of each other. After the architect makes the design, he or she monitors if everything is going to plan but the architects are used for the aesthetics. For these type of experiments, this is different. The designers are needed because they had the idea and they were in contact with all the suppliers (Interviewee 10, personal communication, 2019).

In a traditional project management model, the clarity of a project arises when separating responsibilities. As an architect, for example, you receive a task with a statement of requirements. This can be a package of hundreds of pages explaining what the architect should do. The moment the architect receives the package, is often the end of the responsibility of the project developer or project manager. After a few phases, the client receives a design in return. The responsibility, honorarium and expertise of the architect stops at the submission. At that moment the responsibility is shifted to the contractor for example. At the end of the ride, the supplier delivers the products and materials and the contractor starts to build it. The contractor and suppliers often have no contact with the other disciplines (Interviewee 4). With circular constructions, this is not possible. You must abandon the model where responsibilities are separated. This means that also juridical responsibilities should not be split up. With the traditional model, the responsibility of the architect stops in juridical terms when submitting the design. We need to work towards a parallel model where responsibilities are shared among all players. This means for example an architect needs to discuss the design at an early stage with the suppliers. Because of the circular design, other expertise is mandatory for the different products and materials. The responsibility of the design is then partly transferred to the propositions of the supplier and its expertise (Interviewee 4).

Type of project

The only answer to the absurd question, was to borrow everything. If you borrow every material or product, and you give everything unaffected and unbroken back to the owner, then you make a loop in the material life cycle which is unnoticed. This is very sustainable (Interviewee 4, personal communication, 2019). The principle used, is that a material can be used in several ways during its life time. So, the strategy used here, was to illustrate the fact that a building must be seen as a temporary storage of materials (Interviewee 1, personal communication, 2019).

Interviewee 1 explains that most of the projects of the client are short-term and small, but it gives the chance to do experiments. These experiments are differently organized compared to normal construction projects. Building permits are different than temporary permits, nobody is supposed to live in the projects. With these experiments, the client aims at inspiring the construction industry. At the start, when circularity became the new aim, the designers explained that it was never done on this scale and that it would become an experiment. Which is exactly what the client wanted.

Lessons learned

First, because the materials were borrowed, the materials should be returned undamaged, or with higher value than before, to the original owner. This is a very hard objective to accomplish. The biggest learning is that in the end, the project would have cost the same as a normal project, because the highest costs here were the man-
hours. The man-hours of all the calculations, from the team and from the construction crew. The learning was that it does not become cheaper when borrowing the materials because materials do not carry the highest costs. It’s the number of man-hours that makes the change (Interviewee 1, personal communication, 2019).

The focus of the project manager, interviewee 10, shifted during the process, from the budget level to a more practical level. This arose in an organic matter. During that change nothing was documented, because this made no sense. The entire project changed from day to day. So, that seemed to be a waste of time. After, instead of planning and documenting everything, the process was followed, and the project manager made sure the project was constructed. Another question is if this new method was structural and reliable (Interviewee 10, personal communication, 2019).

RISK MANAGING

Interviewee 4 has a different vision on project risk management. The risks of the project were very high. And the ambitions were also very high. The art is to take many risks, because then the chance it goes well is the largest. If you try to control risk and plan risk responses, then usually the risk response will be used because in the heat of the moment, the stress is the highest. If you use these risk responses, the project will be of lower quality. If you agree beforehand that there is only a plan A, you will still feel the same stress but together you know there are no better options. And that is usually successful. So, according to interviewee 4, a conscious decision that no risk responses were planned was made. However, the other interviewees do not share this vision. It is less plausible that the project team did risk management they way they did, because the wanted to do it like this.

PMBoK+ IN PROJECT A

The PMBoK+ method, as described in the methodology chapter, is used as a framework to compare the steps made in the project, to traditional project management. The different steps for each theme are discussed briefly in this chapter. The results are shown in Table 4.

For Project Scope Management, the requirements have been described in the traditional way, however they were very short. The client does this often, they ask for something simple with no detailed requirements so that innovation and creative solutions can be used (Interviewee 10). Interviewee 4 found this positive, because it gives the possibility to make plans together. Normally, the input of the project is defined by the client. If you define the project definition together, it could lead to innovative and intelligent ideas (Interviewee 4).

For the Project Time Management, compared to the PMBoK+ framework, only a schedule was made. This very short and brief schedule was provided by interviewee 4, where the last three weeks of the project (the construction phase) was planned. In the end, the planning was not an important document. The keeping track of the planning was the task of the project manager but in the end, it did not have the largest priority, because the largest priority was to make sure the construction is completed (Interviewee 10).

For the Project Cost Management, the three interviewees confirmed that the costs were estimated, the budget was determined and the costs were continuously controlled. Because of that, it is assumed as more plausible that this happened. For the budget a real-life estimate was made where all parties had access to (Interviewee 1). This means that everyone was responsible for this budget. If a new development showed that the costs would be over budget, something else needed to be adjusted. This meant the budget was handled in a very different way than normally, more creatively (Interviewee 1).

For the Project Quality Management, no conclusions can be made. The three interviewees have different interpretations on what quality is.

For Project Human Resource Management, no human resource plan was made. Yet, there was a clear organizational structure. The project manager was responsible for the general outline of the project and the planning and was continuously talking to the building team (Interviewee 1). Interviewee 4 believes the team was not managed, although interviewee 1 and 10 believe the project was managed. Therefore, no conclusion can be made that are more plausible.
For the Project Communication Management, it can be assumed as more plausible that not one step of the traditional framework was used, since all interviewees said no Project Communication Management was used. For this project communication was done with very short lines and mostly 1 on 1 and this worked very well (Interviewee 1).

According to the three interviewees, no Project Risk Management was performed. It can be said that it is more plausible that this did not happen. However, some risks were defined briefly in the Health- and Safety plan, provided by interviewee 10. Interviewee found the project a risky project, because the materials were borrowed, you can never be sure when materials come out of the donor building and are available for your project. This is a risk for the planning. This gave new challenges. Risks arose during the process which could not have been predicted at the start. Because the type of project was not done before. For that reason, it was very hard to define the risks (Interviewee 10). By sharing responsibilities, the team members help each other instead of sticking to own tasks. No detailed risk management is needed but when a risk comes up you deal with it together (Interviewee 4).

The interviewees feel that the Project Procurement Management did not follow the traditional method. According to interviewee 10, it was about knowing each other and having a network (Interviewee 10). The network of the entire project team was used to find the different suppliers. Procurement of the suppliers and project team members is not done in the conventional way. They asked parties that were enthusiastic about this idea to collaborate working (Interviewee 1).

All the interviewees agree that the Project Stakeholder Management was not done in this project. No stakeholder management plan nor a stakeholder engagement plan was made, because the building was constructed as a part of the event where the building was used for, permit planning and stakeholder management was not required (Interviewee 1).

The only activity of the Project Integration Management theme that is more plausible to be done, is the closing of project phases. According to interviewee 10, a project management plan was not made because it was useless. Everything was done for the first time. For that reason, everything you think of changes within one day, so it would be a waste of time (Interviewee 10). It can be confirmed that the Project Health, Safety, Security and Environmental Management was done the traditional way.

For the Project Financial Management, it is hard to make conclusions, since the interviewees concluded different things. If a party needed more money together the project team needed to think of a way to obtain this extra money. Everyone was responsible for the budget, that is what made it a new business model (Interviewee 1). The risks were not legally shared among all the parties. If something went wrong, the risks were the responsibility of the client (Interviewee 4).
<table>
<thead>
<tr>
<th>Theme</th>
<th>Traditional project management</th>
<th>Project B</th>
<th>Documentation?</th>
<th>Plausible?</th>
<th>Project B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Scope Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collect requirements</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Define scope</td>
<td>No.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Create WBS</td>
<td>Yes.</td>
<td>Yes.</td>
<td>No.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Verify scope</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Control scope</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td><strong>Project Time Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Define activities</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Sequence activities</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Estimate activity resources</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Estimate activity durations</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Develop schedule</td>
<td>No.</td>
<td>Yes.</td>
<td>No.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Control schedule</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
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<tr>
<td><strong>Project Cost Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimate cost</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Control cost</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td><strong>Project Quality Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plan quality</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Perform quality assurance</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Perform quality control</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Develop H&amp;I plan</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Acquire project team</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Develop project team</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Manage project team</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td><strong>Project Human Resource Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify stakeholders</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Plan communications</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Distribute information</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Manage stakeholders expectation</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td><strong>Project Risk Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plan risk management</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Identify risk</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Perform qualitative risk analysis</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Perform quantitative risk analysis</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Plan risk responses</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Monitor and control risks</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td><strong>Project Procurement Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procurement planning</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
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<tr>
<td>Solicitation planning</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
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<tr>
<td>Source selection</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Contract administration</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td><strong>Project Stakeholder Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify the stakeholders</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Plan stakeholder engagement</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Manage stakeholder engagement</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Monitor stakeholder engagement</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td><strong>Project Integration Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop project charter</td>
<td>No.</td>
<td>No.</td>
<td>No.</td>
<td>Yes.</td>
<td>No.</td>
</tr>
<tr>
<td>Develop project management plan</td>
<td>Yes, updated continuously by PM</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Direct and manage project work</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Manage project knowledge</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Monitor and control project work</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td><strong>Project Health, Safety, Security and Environmental Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plan activity</td>
<td>Yes, in the traditional way.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Develop management plan</td>
<td>Yes, in the traditional way.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td><strong>Project Financial Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plan financial</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Identify the financial requirements for construction projects</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Estimate the procurement for construction projects</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td>Estimate the contract requirements and risk allocation</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
</tbody>
</table>

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Lessons learned

According to interviewee 5, the development would cost over 2.5 years. At one moment there was a money shortage, were people said let’s eliminate the curtains from the design. That was impossible, it was an integral part of the design, according to interviewee 5. In the end, the client and the users made clear they wanted the curtains. The process went very well but the moment something unknown came up, with unknown steps, that has been the most difficult part of the project. The process of the curtains was very new, even new threads were developed for this project. Therefore, it was noticed that there was a large difference between traditional activities and more innovative activities. These were worlds apart. It can be said that the construction sector is very traditional and it is not ready for innovations. There are experts that can handle innovation and know what to do with it, but to harmonize the two different type of parties, a lot of time is needed. This was the biggest learning for interviewee 5 (Interviewee 5, personal communication, 2019).

Project Management

The process of a circular construction takes more energy by all the parties concerned, according to interviewee 5, the project managers as well as the designers and the users. To design circularity takes extra time but because it was an old building with an industrial function, this made it even more timely to design. An example for this is that a lot more investigations had to be done. Investigations on the constructions, contaminations and pollutions, the hanging façade and more. It cost a lot more time. In this project there was a lot of commitment, so the extra time was not a burden. During the project, there always has been a great deal of commitment among all the parties. The commitment made it possible that more time and more investigation was not a problem. What happens with other projects is that sustainability or circularity have lower priorities than other ambitions. Often sustainability and circularity are then lowered. With project B, this did not happen. Like every project there have been some hiccups or communication issues, but never about the importance and relevance of the project. Everyone always agreed on that the vision should be implemented (Interviewee 5, personal communication, 2019).

Interviewee 7 believes there is a difference in project management between a traditional construction project and a circular construction project. Mostly for the program requirements, because as a client you want to make sure that in all the design phases circularity is taken into consideration (for example the use of materials). Where normally functional and technical requirements are defined in the program requirements, for circularity, other requirements need to be set up, besides the functional and technical requirements. Moreover, the financial model is very different in a circular construction project. Normally a budget is defined during the initiation phase, often based on the square meters and reference projects. At this moment we have been working with the definition of circularity for about 5 years. But there is not a benchmark. And with circularity, people might not want to buy everything new but prefer to lease everything or giving suppliers a take-back obligation. Which asks for other financial models. In the interviewee’s experience, the business models are the core of project management of construction projects. Everything is about the money in the end. So, all the aspects of circularity need to be ensured financially. This means that suppliers need to become designers, which need to be at the table at the start of the project (Interviewee 7).

PMBOKE+ in project B

By analyzing the project management steps used in project B, it can be concluded that it is more plausible that traditional project management, as described in the steps of the PMBoK+ framework, is used. For that reason, not all the project management steps will be discussed in detail. Only the exceptions to the traditional project management will be discussed. The entire table with the (short) replies to the activities from the three interviewees are shown in Table 5. The entire analysis is shown in appendix F.2. The first exception is the reporting of the performance of the Project Communication Management. Interviewee 5 explains that this was reported but she does not know how, while interviewees 7 and 11 said it did not happen. Accordingly, nothing can be concluded about this activity. The same accounts for the monitoring of stakeholder engagement. The project charter was not developed, this was confirmed by the three stakeholders. It can be concluded that it is more plausible that this did not happen. This is different than to the traditional project management. This was their method and is not relevant for this research. For the rest of activities, it is more plausible that the different steps of the themes of the PMBoK+ have been used.
### Appendix F.3: Analysis project C

<table>
<thead>
<tr>
<th>Theme</th>
<th>Traditional project management</th>
<th>Project C</th>
<th>Expected Y</th>
<th>Planned Y</th>
<th>Project C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Scope Management</td>
<td>Collect requirements</td>
<td>Yes, more activities included in ongoing process</td>
<td>Yes, not complete requirements included in the client process</td>
<td>Yes, not complete requirements, only on project level</td>
<td>Yes, no main changes from</td>
</tr>
<tr>
<td>Define scope</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Update VRS</td>
<td>Yes, a type of VRS</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Verify VRS</td>
<td>Yes, a part of BREEAM</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Control scope</td>
<td>Yes, a part of BREEAM</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Project Risk Management</td>
<td>Identify risks</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Plan activities</td>
<td>Yes, with different requirements</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Reduce activity resource requirement</td>
<td>Yes, high level</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Reduce activity duration</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Develop schedule</td>
<td>Yes, by the main contractor</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Control schedule</td>
<td>Yes, not centrally, it can change</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Project Cost Management</td>
<td>Delineate budget</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Control costs</td>
<td>Yes, not centrally</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Project Quality Management</td>
<td>Fine quality</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Perform quality assurance activities</td>
<td>Yes, in the process, reviewed by BREEAM</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Assess system effectiveness</td>
<td>Yes, based on requirements for the client, the safety, accounting, audit, and quality</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Project Risk/Recovery Management</td>
<td>Create EWP</td>
<td>Yes, during the process, with the same one but not called that way</td>
<td>Yes, not documented</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Update project team</td>
<td>Yes, although it changed during the project</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Develop project team</td>
<td>Yes, although it changed during the project,</td>
<td>Yes, changed during the process, with the same one but not called that way</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Manage project team</td>
<td>Yes, by the interviewee and by the head of the team</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Project Communication Management</td>
<td>Identify stakeholders</td>
<td>Yes, at the start of the project</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Plan communications</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Distribute information</td>
<td>Yes, documents for project control, classes, e-mails, and other documents for material provider</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Manage relationship</td>
<td>Yes, by sending messages of the project, and meeting at the start of the project</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Manage project coordination</td>
<td>Yes, by the technical director</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Plan communication</td>
<td>Yes, by the interviewee</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Plan network</td>
<td>Yes, very collaboratively</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Project Procurement Management</td>
<td>Plan contract planning</td>
<td>Yes, but written in the process</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Source selection</td>
<td>Yes, but not all that different</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Source evaluation</td>
<td>Yes, with the entire project team</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Source selection</td>
<td>Yes, with the entire project team</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Contract administration</td>
<td>Yes, with the entire project team</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Contact the client</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
<td></td>
</tr>
<tr>
<td>Project Stakeholder Management</td>
<td>Identify the stakeholders</td>
<td>Yes, at the start of the project</td>
<td>Yes, not that different and not called that way</td>
<td>Yes, not within the company</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Plan stakeholder engagement</td>
<td>Yes, although it changed due to the growing awareness of the project</td>
<td>Yes, not that different and not called that way</td>
<td>Yes, not within the company</td>
<td>Y ≠</td>
<td></td>
</tr>
<tr>
<td>Manage stakeholder engagement</td>
<td>Yes, although it changed due to the growing awareness of the project</td>
<td>Yes, not that different and not called that way</td>
<td>Yes, not within the company</td>
<td>Y ≠</td>
<td></td>
</tr>
<tr>
<td>Monitor stakeholder satisfaction</td>
<td>Yes, but not that different and not called that way</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
<td></td>
</tr>
<tr>
<td>Project Integrative Management</td>
<td>Develop project creative development management plan</td>
<td>Yes, a combination of different</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Define and manage change</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manage project knowledge</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manage and control project work</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plan (subjective) change</td>
<td>Yes, there is need for all kinds of changes</td>
<td>Yes, any change process that could be communicated, No, not that different and not called that way</td>
<td>Yes, not within the company</td>
<td>Y ≠</td>
<td></td>
</tr>
<tr>
<td>Plan project cost</td>
<td>No, with a high degree of uncertainty</td>
<td>No</td>
<td>Yes</td>
<td>Y ≠</td>
<td></td>
</tr>
<tr>
<td>Project Health, Safety, Security, and Environmental Management</td>
<td>Plan and manage safety and environmental policy and procedures</td>
<td>Yes, as it is a part of the project</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Develop management plan for health and safety and environment</td>
<td>Yes, the company managed the safety of the project, and it was a part of the management plan</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
<td></td>
</tr>
<tr>
<td>Project Financial Management</td>
<td>Financial planning</td>
<td>Yes, a change management model</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
</tr>
<tr>
<td>Identify the financial management plan</td>
<td>Yes, not different</td>
<td>Yes</td>
<td>Yes</td>
<td>Y ≠</td>
<td></td>
</tr>
</tbody>
</table>

- **Y ≠** indicates a significant change or difference from the traditional practices.
- **Y ≥** indicates lesser changes or differences.
- **Y ≠** indicates minor or no changes from the traditional practices.
Stakeholders of project C

During the design, the team switched another few times. The people that were removed from the project did not have or understand the re-thinking process that the circular economy demands. However, for circular projects you need to exit the beaten tracks to be able to accomplish something different. This took some time before the entire project team understood this. The change of people made the process more complex. In the first phases you make program requirements and other documents, if you change people in the design team, a handover is necessary. If at the start the right people were involved in the project, a better result could have been achieved. Because some decisions were made at the start that could not be changed during the process (Interviewee 9, personal communication, 2019).

Circular Economy

The butterfly model of the Ellen MacArthur foundation was often used in the project as a sort of guideline. For that reason, the first consideration was, should we make it, is it necessary? For example, the floors and walls do not have finishing, since this was not necessary. So, every time a step downwards is taken in the 10-R ladder. And if they needed to make the product, the product needed to be sustainable, demountable and reusable. The Ellen MacArthur Foundation and the 10-R model helped in every decision (Interviewee 8, personal communication, 2019). Interviewee 12 confirms this by explaining that the 10R model is used as an assessment framework. With this, all the design solutions were evaluated with a grade (Interviewee 9, personal communication, 2019).

Interviewee 12 believes project C is a circular construction building. He describes the project as an experiment of something they thought they could do circularly. Some things did not work in the experiment. An example is the DC voltage system in the building. The idea was that the entire building would work on this DC voltage. It turned out that the current techniques do not let you leave out the AC voltage system. The kitchen supplies in building C work on AC voltage. This means there are two systems, which is not that circular, because two systems are made (where only one could be enough). The deliberate choice is made to use DC voltage because they believe this can help in the future to prevent losses. That was a more important principle than the two systems (Interviewee 12, personal communication, 2019).

Interviewee 13 explains that in the design phase the detachment of a building was an item. Everything that has been made was documented. The architect made a material passport. Next the project was designed in BIM and a madaster account was coupled to the project. Based on this, the intention is that an external party should be able to dismount the building (Interviewee 13, personal communication, 2019).

Type of project

The project is a large newly built project. A large advantage for the project was that during the construction the design changed. A good comparison could be made between the old (traditional) design and the new circular design (Interviewee 2, personal communication, 2019). According to interviewee 8, project C was a very innovative and ambitious project. During the project new roads were explored that were not explored before. Other projects find circularity very important, but they are not willing to make the innovation step that is needed. The company tries to use innovative project management methods as much as possible. Circularity at this project has been about not making what you do not need (Interviewee 8, personal communication, 2019).

Conflicts

He then got direct assignments by the client, but the payment was done by the contractor. He also had to sign a contract with the contractor. The agreement with the client was defined on one paper but the agreement with the contractor consisted of many pages. Odd things happened from then on. For example, seven aerial work platforms were not being used in the basement and the contractor needed one for one hour, but he could not use one of the seven because ‘he is a contractor and needed to have his own’. Moreover, the hoist hatch, where products were hoisted from to the basement was closed off a day before the interviewee arrived with the materials. The interviewee’s truck with materials always had to wait three hours before driving, because others could always precede (Interviewee 13, personal communication, 2019).

Another thing that went wrong is when the interviewee was delivering the floors to the project and they found out that the BIM model was not correct. They found out they missed 150 m2 flooring. That is a problem with a
normal production, but with a circular production the problem is larger. The following weekend they had to
work for 24 hours to make sure 150m² could be produced from the same batches, to make sure there were no
color differences. In the end the company of the interviewee was supplier and sub-contractor. The interviewee
opposed to the contracts the main contractor normally uses for this.

This says something about the transition we are now at, not the entire chain is ready. Interviewee 13 is still very
proud of the result. All parties have done the best in their capabilities. The interviewee is a small company and
for that reason has to convince less people of the circular economy because people with the same circular
ambitions work at his company. With a large contractor that is different. For such a large company to collaborate
in the transition, that may take many years. If you do project management, this is your problem. The problem is
not ‘how can we make a logistic planning?’. But instead it is, if the culture is not there to do the work together,
how to solve this?

Lesson learned

Another lesson is that the tax on labor needs to change, which is difficult because it is part of the economic
model. When you want to repair or reuse something, this takes more labor hours. It is therefore cheaper to buy
a new lamp from China than to repair an old lamp for 2 hours. There is also the risk that the repaired lamp needs
to be fixed the year after again (Interviewee 9, personal communication, 2019).

The most important learning for interviewee 12 is that we need to let go of the focus on how the building is
going to be. We need to be open to supply based design. In project C this did not happen that much, the window
frames in the basement and wooden floors on the ground floor are examples of reused materials. A lot is new
but it is made with the principle ‘design for disassembly’. But this is a promise to the future, it gives no certainty.
Supply based design is important if you want to work towards current circularity and not future circularity.
Secondly, the composition of the team and the embracing of the circular principles are important too, to make
sure there is commitment from all the parts of the project. Another significant part is the willingness to take
risks. In this case, the client was very willing to take risks. In the chain, there are always sub-contractors that are
avoiding risks. So, if a client is willing to take some risks, more space for innovation is created (Interviewee 12,
personal communication, 2019).

Project Management

Interviewee 13 has a slightly different idea. At this moment we are in a transition towards the circular economy.
In the transition phase, project management is different. In the end, a new model will arise at the end of the
transition. During the transition phase, other things are asked of a project manager. In the end as well, the
circular economy is about different values, other collaboration forms, other ways of ownership, so several
dimensions are added. The process might not change that much, but other dimensions are added. In the
transition phase, we are doing change management. Which normally does not belong to the scope of the project
or process manager. Interviewee 13 notices this in practice, very good project managers exist yet, they are used
to operate in a very efficient, effective and purposeful manner.

Nonetheless, they operate from the situation where parties are doing something they already can do. Of course,
there will always be tensions on price, time and quality, but now you see that if we add the circular dimensions,
people need to change. As a project manager, you are responsible for that change. That is not what the project
manager have been educated for or what they are rewarded for (Interviewee 13, personal communication, 2019).

For the procurement of the project, a new type of tendering method is used. The procurement department of
the client was invited to the table after the first designs were drawn. Hereafter, the main-contractor is
contracted directly because they were doing another large construction job in the neighborhood. At that time,
circular tendering was unknown to the parties. There was no standard strategy for circular tendering. Therefore,
the client thought of a strategy within the standard procurement method. The procurement department set up
a procurement framework with the different steps that needed to be taken (Anonymized reference).
Project Documents

Energy Circ – by interviewee 2

However, it describes one issue that arose after the construction. What happened is that many people that worked on the project during construction left the company after completion. Few people understood the entire building well. Because of that, knowledge was lost. The report explains the techniques and looks at the innovations that are now available, how they are going to test them and how the living lab can be exploited. The project is set up as a test case (Interviewee 2, personal communication, 2019). The report describes that the main contractor was in charge during the construction, but after another company was assigned for the maintenance. Due to the delays in delivery, this did not go smoothly.

The added value of circular procurement – by client project C

The 10-R model is explained in the report. The project made use of the following five levels: Reduce, Redesign, Re-use, Recycle and Reconnect. Reconnect is a new one that has been added. These are described below:

- **Reduce**: Where possible material has been left out. In the main construction about 3500 ton of concrete is saved by making the main bearing construction in sustainable inland larch wood. The main bearing construction can be reused and saved an amount of 594 ton carbon dioxide emission.
- **Redesign**: The components have been designed for efficient maintenance, reparation, disassembly, revision, renovation, adaption, transformation and high-end recycling. The design principle was: design for disassembly.
- **Re-use**: During the construction second hand materials are used and there has been thought about the future reuse of the new materials that have been used. For this, urban mining is used. The wooden floors are made of waste wood, old fire hose reels are used and several wooden windows are reused from an old Philips building.
- **Recycle**: In the client organization, several waste streams are used to make recycled products in project C. For example, 16,000 old jeans of colleagues are used for isolation.
- **Reconnect**: Together with the suppliers, this new level was invented. This level is about the catering and exploitation.

The client defined five circular business models that were used to grade the tenders. These are: circular input, Product as a Service, life extension, sharing platforms and value retrieval. The design options were measured by making a consideration between sustainability, aesthetics, circularity, life cycle costs and social sustainability. During the procurement, they looked at the entire chain, from pre-use until after-use. Lastly, a material passport is made. This is done within the BIM method. In the contracting phase they challenged the market to come with new contract forms such as Product as a Service, prestation contracts, pay-per-use contracts and agreements about high end reuse. They looked at different types of ownership relations, guaranties (take back obligation or life cycle prolongment), involvement during exploitation, residual values and financing methods. To evaluate the reuse of the tenders, the client looked at the limitation of material use, the strive to maximize the value in the phase after use, provision of insight of the CO2 equivalent footprint in the production and process and the deployment of raw materials for the creation of more financial value. In can hereby be concluded that the client used a different type of procurement, compared to traditional project management.

PMBoK+ in project C

The project requirements by the client, which describe what the client wanted, have been analyzed. There were three demands from the client side, where not a document of several pages had been made on the requirements of the construction. The client expressed his wish to innovate during the project and to implement new techniques (Interviewee 12). By setting detailed requirements, many options and solutions are excluded. So, the program requirements were not very extensive or detailed. It was more a program of ambitions about how the building should perform and function (Interviewee 8).

For Project Cost Management, the project costs have been defined and a budget is set for the project (Interviewee 8). The costs have been controlled continuously. They were in a unique contract form with the contractor. In this ‘round the table model’ they decided together on a budget. This budget was spent together with the contractor. This was a completely transparent process where everyone could look at the budget (Interviewee 12).
The next theme is Project Quality Management. According to interviewee 8, commissioning has been done to make sure the aimed quality level was achieved (Interviewee 8). The aimed quality was defined in the requirements that were documented in the scope by the client: fire safety, acoustics, esthetics and circularity (Interviewee 13).

Not a specific HR plan is made for the design team. During the process the roles were defined and the responsibilities were divided. The team was formed with very enthusiastic people, where everyone knew the tasks of the other team members. In the end the risks and responsibilities laid with the client. For that reason, traditional models did not apply (Interviewee 9). The project team was modified during the process by adding or removing people from the project, when they saw it was not functioning correctly (Interviewee 12).

The client involved the procurement department of the company during Project Procurement Management. The procurement is done earlier in the process than normally is done. The tenders have been based on the philosophy of the client on circularity, innovation and sustainability. The suppliers were selected together with all the parties. These were not contracted by the client but by the main contractor. The suppliers were asked to present a pitch, so that the project team could ask questions about circularity and the reusability of products (Interviewee 8.). They were not tendered based on most economic tender (Interviewee 9). Agreements have been tried to be made with the parties about the re-buy obligation of the products. Many parties were interested in this, but it appears to be hard to agree on this in a contract (Interviewee 8).

For the theme Project Integration Management, a project charter was not made, however, the project charter idea is incorporated in the work groups. A project management plan has been made which defines how the project team communicates, what the contractual interdependencies are, where responsibilities lay etc. A change control system would have been positive for this project. In hindsight, this was not used enough. Changes take place daily and it is difficult to document these changes correctly. This is a real challenge. The process was reported and the choices and changes were discussed in these reports (Interviewee 12). Project knowledge was shared in a transparent way (Interviewee 8).

Financial planning has been done in the budget monitoring model. The client wanted to be responsible for the project risks, which is something you do not see very often. That risk item was substantial because the project contained a lot of new things, such as circularity techniques and -principles that were never applied on this scale before. Nevertheless, this led to conflicts as explained by interviewee 13. Several new business models were investigated. The potential to lease the products was analyzed. In building C, only the elevator is being leased (Interviewee 12).

The PMBoK+ themes Project HSSE Management, Project Stakeholder Management, Project Time Management, Project Communication Management and Project Risk Management were done traditionally. These themes will therefore not be discussed in detail.
<table>
<thead>
<tr>
<th>Theme</th>
<th>Traditional project management</th>
<th>Project D</th>
<th>Document?</th>
<th>Flexible?</th>
<th>Project D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Scope Management</td>
<td>Collect requirements: Yes, the requirements have been defined by the client, which is the organization: interviewee 3 works at.</td>
<td>Yes, with requirements analysis tool.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Defining scope</td>
<td>Yes, scope is always defined at the Plan.</td>
<td>Yes, with the verification and validation tool.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Create WBS</td>
<td>Yes, made with the help of the system-oriented contract management.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Verify scope</td>
<td>Yes, the requirements have been defined by the client, which is the organization: interviewee 3 works at.</td>
<td>Yes, with the verification and validation tool.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Control scope</td>
<td>Yes, with the verification and validation tool.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Time Management</td>
<td>Define activities: Yes.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sequence activities</td>
<td>Yes, with the critical path method.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Estimate activity duration</td>
<td>Yes, with the critical path method.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Develop schedule</td>
<td>Yes, together with the other stakeholder.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Control schedule</td>
<td>Yes, continuously and discussed during weekly meetings.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Cost Management</td>
<td>Estimate cost: Yes.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Determine budget</td>
<td>Yes, budget separated into different sections.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Cost control</td>
<td>Yes, with the help of an expenditure overview.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Quality Management</td>
<td>Plan quality: Yes.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Perform quality assurance</td>
<td>Yes, with the use of system-oriented contract management.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Perform quality control</td>
<td>Yes, quality translated into the verification and validation system. Therefore, monitored.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Human Resource Management</td>
<td>Develop HR plan: Yes, including the different roles and meeting sequence. Within the project quality plan.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Acquire project team</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Develop project team</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Manage project team</td>
<td>Yes, by the interviewee and another person. On project team level.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Communication Management</td>
<td>Identify stakeholders: Yes.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Plan communications</td>
<td>Yes, discussed in the management plan.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Distribute information</td>
<td>Yes, in the initiation document.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Manage stakeholders’ expectation</td>
<td>Yes, under a different name.</td>
<td>Yes</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Report performance</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Risk Management</td>
<td>Plan risk management: Yes.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Identify risks</td>
<td>Yes, continuously.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Perform qualitative risk analysis</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Perform quantitative risk analysis</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Risk response</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Monitor and control risks</td>
<td>Yes, as a part of the verification and validation system.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Procurement Management</td>
<td>Procurement planning: Yes.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Solicitation planning</td>
<td>Yes, no, not always.</td>
<td>Yes</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Solicitation</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Source selection</td>
<td>Yes, no, not always.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Contract administration</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Contract closeout</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Stakeholder Management</td>
<td>Identify the stakeholders: Yes.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Plan stakeholder engagement</td>
<td>Yes, under a different name.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Manage stakeholder engagement</td>
<td>Yes, under a different name.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Monitor stakeholder engagement</td>
<td>Yes, under a different name.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Integration Management</td>
<td>Develop project charter: Yes, in a process card: Yes, as a part of the verification and validation system.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Develop project management plan</td>
<td>Yes, part of the project quality plan.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Direct and manage project work</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Manage project knowledge</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Minimize and control project work</td>
<td>Yes, managed by the construction interviewee, it is a part of.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Perform integrated change control</td>
<td>Yes, in an official project.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Close project of phase</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Health, Safety, Security, and Environmental Management</td>
<td>Practive view of health, safety and environmental policy compliance: Yes, with a different name.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Develop management plan</td>
<td>Yes, part of the BL&amp;G and V&amp;G plan.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Project Financial Management</td>
<td>Financial planning: Yes.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Plausible? Yes,
 Hardware: Yes,
 Software: Yes,
 System: Yes,
 Process: Yes,
 Test: Yes,
 Validation: Yes,
The company of interviewee 6, sees a circular construction in the context of sustainability and the making of buildings that during their life cycle can adjust to new situations. By doing that, you can make sure that projects and buildings can preserve their value. It increases the chance that in the future the building can be adapted, dismounted or relocated, compared to traditional projects. The company calls it circularity on intrinsic level. Later, the cycle of circularity can be 5 years or 1000 years, that is unpredictable, we cannot influence that. But what we can influence is to develop a building that is made as good as possible for future generations with as much value as possible. That is possible with the help of traditional business models, circular business models, as a service business models etc. (Interviewee 3). Project D will become a circular project after it has been used for several years, with or without a change in location, according to interviewee 6. That will show whether it is a circular project or not. Project D could be a very circular project, but it depends on the future use (Interviewee 6).

Moreover, often a problem is that consultants believe there is no budget for circular buildings, when a project is approached on the traditional way. At this moment, what can be gained (the advantage) at the end of the project life cycle is often not used in the calculation at the start. So, the revenue (for another organization for example) is not used in the project. For that reason, a new circular business model is necessary to make circular projects financially attractive (Interviewee 3).

**PMBoK+ in project D**

As visible in Table 6, it is more plausible that a traditional project management method is used for almost all the themes in project D. The entire analysis is presented in appendix F.4. There is one part where interviewee 6 discussed a small difference in project management. He believes some parts of the procurement followed the traditional path, while others did not. Some parts of the building can be tendered on the lowest price, while others are very critical that a co-engineering trajectory is more suitable to develop the idea. Moreover, the tenders were not open to everyone. The interviewee was in a consortium, together with a contractor. Jointly they contracted other parties, such as subcontractors (Interviewee 6). This is also concluded by interviewee 3, by choosing the DBMR contract, another procurement process was used. However, he thinks this did not influence the management (Interviewee 3). It can be concluded that it is more plausible that for project D traditional project management was used, except for the Project Procurement Management.
## Appendix G: Cross-case analysis

The first table shows the entire table with all the respondents. The second table shows the summary per project.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Traditional project management</th>
<th>Project A</th>
<th>Project B</th>
<th>Project C</th>
<th>Project D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Scope Management</strong></td>
<td>Collect requirements</td>
<td>Yes, but no specific requirements, three short requirements.</td>
<td>Yes, more ambitions then requirements.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td></td>
<td>Define scope</td>
<td>Unknown</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td></td>
<td>Create WBS</td>
<td>Yes.</td>
<td>Unknown</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td></td>
<td>Verify scope</td>
<td>No, but due to project characteristics.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td></td>
<td>Control scope</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td><strong>Project Time Management</strong></td>
<td>Define activities</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td></td>
<td>Sequence activities</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Yes.</td>
</tr>
<tr>
<td></td>
<td>Estimate activity resources</td>
<td>Yes, but due to project characteristics.</td>
<td>Yes.</td>
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<td>Control schedule</td>
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<td>Control cost</td>
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<td>Acquire project team</td>
<td>Yes, with committed and enthusiastic parties. Only parties asked out of own network.</td>
<td>Yes.</td>
<td>Yes, selected on knowledge and enthusiasm (for circulars). Best suppliers are selected earlier on in the project.</td>
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<td>Yes, with committed and enthusiastic parties. Only parties asked out of own network.</td>
<td>Yes.</td>
<td>Yes, however the entire project team changed during the project.</td>
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<td>No, procurement is done by contacting their own network and looking for committed parties that were willing to lend their products and materials.</td>
<td>Yes.</td>
<td>Yes, however procurement was done earlier in the project. After the design team switched, committed parties were chosen.</td>
<td>Procurement is done in a different way than normally. A DBNBI contract was used.</td>
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<td>Solicitation planning</td>
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<td>Yes, this was done with the entire project team.</td>
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<td>Yes, project knowledge was shared in a very open transparent way.</td>
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<td>Contract requirements and risk allocation</td>
<td>Yes, all the risks were for the client. Moreover, everyone was responsible for the budget.</td>
<td>Yes.</td>
<td>Yes, however, this was done with conflicts. Suppliers could not guarrantee their delivery and take all the risks.</td>
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<td>Tax planning</td>
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*Note: The data is based on case analysis and may not represent all respondents.*
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<th>Project B</th>
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<td>Collect requirements</td>
<td>Yes, but no specific requirements, three short requirements.</td>
<td>Yes</td>
<td>Yes, more ambitions then requirements. Three short ambitions.</td>
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<td>Determine budget</td>
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<td>Project Human Resource Management</td>
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<td>Yes</td>
<td>Yes, selected on knowledge and enthusiasm (of circularity). Next, suppliers are selected earlier on in the project.</td>
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<td>Monitor and control risks</td>
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<td>Project Procurement Management</td>
<td>Procurement planning</td>
<td>No, procurement is done by contacting their own network and looking for committed parties that were willing to lend their products and materials.</td>
<td>Yes</td>
<td>Yes, however procurement was done earlier in the process. After the design team switched, committed parties were chosen.</td>
<td>Procurement is done in a different way than normally. A DBMR contract was used.</td>
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<td>No, parties contacted earlier in the project. Before making the design, they had to know what materials they could borrow.</td>
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<td>Source selection</td>
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<td>Yes, however, done with the circular budget of the client. This was done for different requirements.</td>
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<td>Contract requirements and risk allocation</td>
<td>Yes, all the risks were for the client. Moreover, everyone was responsible for the budget.</td>
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<td>Yes, however, this was done with conflicts. Suppliers could not guarantee their delivery and take all the risks.</td>
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Appendix H: Validation Protocol

Validatie protocol vragen

Een onderzoek naar het verschil in project management tussen een traditioneel bouw project en een circulair bouw project

| Datum
| Naam respondent
| Organisatie
| Validatie nummer

**Introductie**

**Introductie van mijzelf**

- Tweede jaar master Construction Management and Engineering aan de TU Delft, faculteit Civiele Techniek en Geowetenschappen
- Master thesis onderzoek uitgevoerd bij Arup in Amsterdam
- Interesse in Circulaire Economie, project management en duurzaamheid. Nieuwsgierig en geïnteresseerd in wat de relatie is tussen deze drie en hoe ze het beste gecombineerd kunnen worden.

**Onderzoeksdoel**

Het doel van het onderzoek is om erachter te komen of er een verschil is in project management tussen traditionele bouwprojecten en circulaire bouwprojecten. Na de analyse, zullen aanbevelingen worden gedaan om toekomstige klanten en stakeholders te helpen met het afronden van succesvolle circulaire bouwprojecten.

**Doel van het interview**

Het interview zal worden gebruikt om de conclusies en aanbevelingen van het onderzoek te valideren. De generaliseerbaarheid van mijn conclusies en aanbevelingen zal hierdoor gecontroleerd worden.

**Structuur van het interview**

Het validatie interview zal bestaan uit drie onderdelen. Het eerste onderdeel focust op algemene vragen. Het tweede onderdeel zal zich richten op de conclusies van het onderzoek. Het derde deel zal zich richten op de generaliseerbaarheid van de aanbevelingen.

**Vertrouwelijkheid**

Voordat ik begin met het interview zou ik voor de vertrouwelijkheid het volgende willen weten over de informatie die u gaat geven.

Hoe zou u willen worden geciteerd:

- Met naam, functie en instelling
- Zonder naam of instelling
- Anders...

Ik zal de samenvatting van het interview binnen twee weken sturen. Als ik niks hoor binnen twee weken, kan de instemming worden aangenomen en zal het document worden gepubliceerd. Gaat u hiermee akkoord?

- Ja
- Nee
Mag ik het interview opnemen? Aan de hand van de opname zal het interview worden samengevat.

- Ja
- Nee

Mocht u een van de vragen als onaangenaam beschouwen en liever niet te beantwoorden, bent u vrij om dit te doen. Als een vraag onduidelijk is, dan hoor ik dat ook graag. Heeft u vragen tot nu toe?

**Interview vragen**

**Interview deel 1: Algemene vragen**

5. Wat verstaat u onder circulaire economie?
6. Hoe werkt u, of uw bedrijf, met circulaire economie? Welke activiteiten worden verricht met betrekking tot circulariteit?
7. Hoeveel jaar ervaring heeft u binnen het onderwerp de circulaire economie?
8. Hoe kijkt u aan tegen de circulaire economie in de gebouwde omgeving? Wat is uw visie?

**Interview deel 2: Validatie conclusies**

Ik zou graag de conclusies een voor een willen afgaan. Per conclusie zou ik graag willen weten of de conclusie dragend/uitlegbaar is door jullie. Vinden jullie de conclusie logisch? Herkennen jullie je daarin? Ten tweede zou ik graag willen weten wat de uitleg is die jullie erbij zien, als je dit hoort? Ten derde zou ik graag willen weten wat we ervan leren in het vervolg?

**Conclusie 1:**

In practice, there is a distinction between public construction projects on the one hand and experimental construction projects on the other hand. For (partly) circular construction projects with a public party as client, it can be concluded that in practice there is not a difference in project management between a circular construction project and a traditional construction project.

1.1 Herkent u zich hierin? Bent u het hiermee eens?
1.2 Wat is hier de reden voor, volgens u?

**Conclusie 2:**

Commitment, ambition and circular economy philosophy should be present in the entire project team (assured in the Project HR Management theme) and for the suppliers and subcontractors (assured in Project Procurement Management theme).

2.1 Herkent u zich hierin? Bent u het hiermee eens?
2.2 Wat is hier de reden voor, volgens u?

**Conclusie 3:**

Circularity should be an aim at the start of the project. All decisions during the process should be made with the circular principles in mind.

3.1 Herkent u zich hierin? Bent u het hiermee eens?
3.2 Wat is hier de reden voor, volgens u?

**Conclusie 4:**

The client should not make a detailed and extensive list of requirements, the client should write short ambitions he has for the project. By together with the project team defining the requirements, based on these ambitions, the most clever and creative projects can be delivered.

a. Herkent u zich hierin? Bent u het hiermee eens?
b. Wat is hier de reden voor, volgens u?
Conclusie 5:
The suppliers should be involved early in the project. The new technologies and techniques for circularity are developed in the lower part of the chain. To make use of this new knowledge, the supplier needs to be in contact with the architect in the design phase to provide input.

5.1 Herkent u zich hierin? Bent u het hiermee eens?
5.2 Wat is hier de reden voor, volgens u?

Conclusie 6:
In circular constructions, it is useful to select the subcontractors and suppliers with the entire project team. It is important to procure them early on in the process.

6.1 Herkent u zich hierin? Bent u het hiermee eens?
6.2 Wat is hier de reden voor, volgens u?

Conclusie 7:
In circular constructions, the budget should be accessible to everyone. By doing that, the project team gets more engaged to make sure the budget is safeguarded.

7.1 Herkent u zich hierin? Bent u het hiermee eens?
7.2 Wat is hier de reden voor, volgens u?

Conclusie 8:
Measures should be taken to assure that the project does not end demolished after the life cycle. A few of the options are a contract including removal, contracts including the turnover of ownership and the obligation to re-buy the materials at the end of the construction life-cycle.

8.1 Herkent u zich hierin? Bent u het hiermee eens?
8.2 Wat is hier de reden voor, volgens u?

Conclusie 9:
It is important that the clients take more risks than traditionally. To make sure the suppliers and subcontractors choose the best options he or she has for the circularity of the project, the client should take a share of the risks of these parties.

9.1 Herkent u zich hierin? Bent u het hiermee eens?
9.2 Wat is hier de reden voor, volgens u?

Zou u nog een conclusie willen toevoegen?

Interview deel 3: Validatie conclusies
Ik zou graag de aanbevelingen een voor een willen afgaan. Hiervoor zal ik hetzelfde vragen als bij de conclusies. Per aanbeveling zou ik graag willen weten of de aanbeveling dragend/uitlegbaar is door jullie.

Aanbeveling 1:
Discuss what circularity means to everyone with the entire project team. Based on this, define an interpretation that will be used with the entire team during the complete process. By using one clear translation for the project, no misunderstandings can arise because of this.

1.1 Herkent u zich hierin? Bent u het hiermee eens?
1.2 Hoe zou dit vormgegeven kunnen worden?
Aanbeveling 2:

Labor costs are very high due to tax on labor, compared to materials costs. This is something that should be weighted with every decision and taken into account when designing and constructing a circular building.

2.1 Herkent u zich hierin? Bent u het hiermee eens?
2.2 Hoe zou dit vormgegeven kunnen worden?

Aanbeveling 3:

When making a circular construction, the project team should always think about preserving the value of the building, or to have a more predictable value. By being adjustable, they can preserve value over many years by being more flexible for future needs. This is important to keep in mind.

3.1 Herkent u zich hierin? Bent u het hiermee eens?
3.2 Hoe zou dit vormgegeven kunnen worden?

Aanbeveling 4:

There is a large uncertainty about the supplies when using urban mining materials or products. It is always unsure when materials will be available from donor buildings and what the exact state of the materials will be. It is recommended to pay extra attention to change control and agree on systems to manage and communicate the changes.

4.1 Herkent u zich hierin? Bent u het hiermee eens?
4.2 Hoe zou dit vormgegeven kunnen worden?

Aanbeveling 5:

This one is focused on clients. The most important thing you can do is to determine the circular ambition in the initiation phase of a project. It requires the stakeholders to think about it in a strategic way, by thinking about opportunities to guide the design on.

5.1 Herkent u zich hierin? Bent u het hiermee eens?
5.2 Hoe zou dit vormgegeven kunnen worden?

Aanbeveling 6:

This one is focused on clients. The client must think about the consequences of the choice of contract on the circularity of a project.

6.1 Herkent u zich hierin? Bent u het hiermee eens?
6.2 Hoe zou dit vormgegeven kunnen worden?

Aanbeveling 7:

This one is focused on project managers. It is recommended for the project managers to make sure the project team has the same mindset and the same principles of the circular economy are used. The project managers should verify if everyone has the same commitment, and if not, act.

7.1 Herkent u zich hierin? Bent u het hiermee eens?
7.2 Hoe zou dit vormgegeven kunnen worden?
Aanbeveling 8:

This one is focused on project managers. The type of leadership must change. Instead of making a PowerPoint and presenting what every discipline needs to do, people should be made responsible for the problem. By solving the problems together, better teamwork with creative solutions is assured.

8.1 Herkent u zich hierin? Bent u het hiermee eens?
8.2 Hoe zou dit vormgegeven kunnen worden?

Aanbeveling 9:

This one is focused on architects. Architects should trust knowledge of the bottom of the chain, from suppliers and subcontractors. The responsibility of the design is therefore partly transferred to the propositions of the supplier and its expertise.

9.1 Herkent u zich hierin? Bent u het hiermee eens?
9.2 Hoe zou dit vormgegeven kunnen worden?

Aanbeveling 10:

This one is focused on main contractors. The standard contracts for suppliers and subcontractors need to change. When making use of urban mining materials, it is impossible for the supplier to give guarantees and bear all the risks of the never used before products. An in-between form should be used for this, so a part of the risk must be shifted to another party.

10.1 Herkent u zich hierin? Bent u het hiermee eens?
10.2 Hoe zou dit vormgegeven kunnen worden?

Aanbeveling 11:

This one is focused on urban mining suppliers. The urban mining supplier should know beforehand what the contract form is that the main contractor has with the client. To know exactly what type of contract the supplier will receive before accepting a job.

11.1 Herkent u zich hierin? Bent u het hiermee eens?
11.2 Hoe zou dit vormgegeven kunnen worden?

Aanbeveling 12:

This one is focused on urban mining suppliers. The suppliers should ask beforehand what the structure is of the project team. So that the supplier can prepare his own organization for this and educated guesses can be made for the opportunities and the risks of the project.

12.1 Herkent u zich hierin? Bent u het hiermee eens?
12.2 Hoe zou dit vormgegeven kunnen worden?
Appendix I: Validation interviews

Appendix I.1: Validation interview 1
Current function: Program and business development of design and brands program – Circle Economy
Former function: Ellen MacArthur Foundation

The interviewee defines the circular economy as a new economic model. It is different to the model where raw materials are used for a short time and afterwards it is thrown away. It is a model where materials stay in the loop, the materials are often pure without toxics. In the design phase, products are designed so that they are durable and monotonous. The new model thinks in systems. The Circle Economy is a corporation that is partly a think tank where they look at the current situation of the circular economy and how they can make sure that a larger part of the world becomes circular, to reduce the circularity gap. The other part is that the corporation is an advisor where workshops are organized and advisory is given to take companies along in the transition. The interviewee has 3/4 years of experience working in the circular economy business. She believes it is necessary to make the transition in the construction sector, although it is one of the most complex material streams. This because the life cycle of a building is a lot longer than for example the life cycle of a phone. Therefore, the transition is slower. But it is not less important, there is a lot to gain from these material streams.

Conclusions:

Conclusion 1:
Yes agree. Public clients are dealing with a lot of regulation. Therefore, it is more difficult to make changes.

Conclusion 2:
Yes agree. Ideally yes, but it is very difficult to get everyone involved. This is one of the challenges the Circle Economy is facing. If it is possible yes, and otherwise a certain gradation should be found to make sure the project team has the basic knowledge but not in detail. The Circle is working on a program or academy where you have different levels. So that people that work on a project can watch a few videos to know the principles. To make sure everyone understands this. Because often traditional people in a project do not understand the steps which makes cooperation very difficult.

Conclusion 3:
Yes agree. The interviewee thinks a circular project cannot be done without starting circularly. You need to start circularly to avoid using traditional principles because circularity cannot be accomplished otherwise.

Conclusion 4:
Yes agree. This is about a design process. Collaboration is important because the client often is not an expert in the construction, he only has ambitions. It is better to have less requirements but legally with contracts and everything it is important to tie everything down in contracts. A cocreation session would be perfect to make the requirements together and later decide ‘is this really what we want’? The interviewee is curious whether this is doable.

Conclusion 5:
Yes agree 100%. The entire value chain should be in the process, suppliers, client and everyone that is involved. Also, to be sure that no unexpected things will arise.

Conclusion 6:
The interviewee does not have an opinion about this. She knows it is good to make decisions with several people.
Conclusion 7:
Ideally a transparent budget is good. For the project team, not for external parties. This can be a good tool to use.

Conclusion 8:
Yes agree. Contracts become more and more important. Another part of this is the material passport. Because you need to know what goes inside of a building. Risk distribution is very important, and this should be done in a contract as well.

Conclusion 9:
Yes agree. Risks should be distributed equally. It is best to agree this in the contract.

Recommendations:

Recommendation 1:
Yes agree. This is in line with what we discussed before. Everyone should at least have basic knowledge and everyone must speak in the same language.

Recommendation 2:
Yes agree. ABN amro is now working on something called ExTax. This is an initiative within the sustainable finance lab of ABN. They believe the tax of labor should be on materials and the other way around. They are going to lobby at municipalities. The interviewee thinks there should be a better balance between taxes on labor and on materials.

Recommendation 3:
Yes agree. Modularity is very important. There is a balance between sustainability and modularity, because modularity is often perceived as temporary. So, it is important to have a sustainable part and a flexible part. But modularity is definitely going to help.

Recommendation 4:
It is very important to look at the material passports. And to look at available technology and how this can be used to know exactly when a material arrived at a building and what happened along the way. With that an estimation can be made on how it will come back. Often this first step of making materials and safeguard the data is not done. This is going to become very important because it is hard to find out how materials are going to get out of a building.

You never know exactly what materials you will get. What you should do is to make contractual agreements on this and work together with trustworthy partners. In circular project it is about having a good relationship with the partners and to trust the delivery is going to be alright. The contract is very important. Agreement that could be made for example is if a material is delivered on site and they find out it is not as expected the client can send the material back within 24 hours.

Recommendation 5:
Yes agree. But isn’t this something that always happens? The interviewee thinks that more and more regulation will come from the politics, so clients will be obliged to do it. It is best to define it at the start, so most people can work with it and the problem is tackled in an effective way. But we are in a transition and it is not yet obvious to build everything circular yet. So, for now it is good if a client says during the process let’s do circular.
Recommendation 6:

Yes agree. Contracts is very important, it is the way to record the collaboration.

Recommendation 7:

It is very important the team has the correct ambitions. It is a general rule, if the team does not fit within the culture of the project it is very hard to collaborate and bring the project to a success. The same is for circular projects.

Recommendation 8:

You want people to take responsibility. We need a lot of new skills from a traditional economy to a circular economy. Focus is going to be more on creativity, critical thinking, making connections. This has to do with the transfer from a flat system to a real system. These new skills are very important for leaders to be able to lead circular projects.

Recommendation 9:

Responsibility might not be the good word because responsibilities go together with risks and other consequences. Here you want to make a cocreation setting where the knowledge is received from the correct people where no assumptions are made for suppliers without knowing for sure. You want to make sure a lot of people are brought together, but you want a person to lead this. But everyone will keep his or her own job, a supplier will stay a supplier and will not become 25% architect.

Recommendation 10:

Yes agree. The division in risks and the way contract are set up need to change. This is not only about the circular economy. The current economy and construction sector is not working as it is supposed to at this moment. So therefore, it is important to think of good collaboration when building circular constructions. It is difficult because we need new systems for this with different skillsets. Where different tools are necessary for risk management. This needs to change if you are going to collaborate more, which happens in a circular economy.

Recommendation 11:

Yes agree. Transparency is super important. At the start of the project you need to make sure that all the actors in the system are in one overview. These stakeholders need to know what other parties are in that overview and what agreements have been made. Only when working that transparently, no unexpected things can happen in the process.

Recommendation 12:

The interviewee wonders if the organizational structure is relevant for the urban mining suppliers? It should be clear who is in the team and transparency should be about this. It is also about what a company shares and what they don’t share. There is always a part that they won’t tell. It is important to know who communicates and who does not. But the question arises who is responsible from what part to communicate to the group who is in the project involved.
Appendix I.2: Validation interview 2
Current function: Senior consultant Advanced Digital Engineering, Arup

The interviewee sees the circular economy in a very simple way, it is an approach that decouples economic and business growth from resource consumption and the negative impact of resource consumption. In terms of environmental, social, economic and financial impact as well, it’s not just the resources. The interviewee works on several different sorts of projects. She helps advise clients to help them understand how they can incorporate the circular economy within that business. The clients can include from material suppliers and developers until cities and governments. So, it’s a big spectrum of different scales of clients. The interviewee has about 3 or 4 years of experience in the circular economy. Arup became affiliated in 2014 with the Ellen MacArthur Foundation and became a member of CE100. Arup became the built environment knowledge partner and the interviewee got very much involved in the scoping and delivery of the research projects.

The vision of the interviewee for the circular economy in the built environment is the following: It’s very multifaceted and it’s very different to products and consumables. And for the interviewee there’s five underlying things we need to think about. One is around flexibility so how you can use space more smartly (not intensively because you don’t want to sweat out the asset). The second one is adaptability, so trying to keep buildings and infrastructure design in a way that it can slightly change to meet market needs. It’s about the residual value of materials, really valuing the value of materials. So making sure there are materials possible designed for deconstruction so that materials are kept within the economy. And then there is product as a service. This is seeing how we can share the risk of material ownership with the supply chain. In general, flexible spaces but coming around urban planning and making sure that the right sort of policy density and diversity of pieces are put together to maximize the options in all of this is kind of underpinned by enablers around finance, digital and policy.

Conclusions:

Conclusion 1:
Disagree. That means you’re doing nothing different and actually to keep the circular economy, everyone has to do something different because it really is a true systemic shift in how we all behave. So, no the interviewee does not agree. In terms of delivery and project management in that sense there are so many different conversations and partnerships that you have to have from the beginning or different stages of the delivery process.

Conclusion 2:
The interviewee agrees 100 percent that everyone needs to have a shared goal and ambition. Because that’s where you actually identify any mutual benefit. You have aligned incentives to reach the goal that you want to use.

Conclusion 3:
In principle yes. In a research they identified investors, policymakers and construction clients as those who need to lead the circular economy in the built environment. They set the direction and ambition of projects, so having circular economy from the beginnings is important. But at this moment in time we’re in a transition process where external environment in which the built environment operates then doesn’t really allow to always benefit in the circular way. So, in this transition process you will need to do a kind of cost value benefit exercise to ensure that you’re not going to not make profit. So, in this transition process, to an extent yes as long as you are going to be commercially viable and obviously in a circular economy the kind of levers to drive this policy will be there for you to be to be able to do that.

Conclusion 4:
Yes agree. The interviewee thinks that the most creative projects have outcomes cited in the brief and not prescriptive measures. So yes, she definitely agrees with that.
Conclusion 5:
Yes, the interviewee does agree to an extent. Because when it comes to using product as a service, you’re going to be entering a contract. So, yes you definitely have to be engaging people. As said before there needs to be new partnership that you have to create, whether it’s with different types of investors to invest in a certain part of your project it could be like they pay for the additional design for deconstruction cost or you have one invested developing the shelling coal while you have the second one investing in the actual internal fit out. So she definitely agrees about involving people especially suppliers in the front end.

However, we are still trying to work through the whole competition and at the moment not many suppliers have a circular business model. Therefore, we need to keep the fairness and then the amount of working in the built environment. We need to make sure that everyone is involved somehow and this touches on the whole social impact. Something is not circular if it isn’t trying impact the society as well. But for the interviewee the circular economy is very much a holistic approach that it must be profitable and you must have beneficial environmental impact, social and economic impact. If it’s not touching a lot of these planes, then you’re not being circular.

Conclusion 6:
The interviewee knows that in different countries it is set up in different ways, so you involve the contractor at different times. They don’t want to get rid of the architect or engineer. But, they all need to do it together. She guesses, if you’re working together from the beginning then you can have the conversations about constructability and design for deconstruction up front. So, the architect and engineer are not doing part of the work and then the contractor must redo the work all over again. You have to meet the fair set of requirements. If the architect and engineer haven’t been able to think about them. So, the interviewee would say yes.

Conclusion 7:
The interviewee thinks that the concept isn’t applicable to all construction projects. But currently the construction industry is quite fragmented and everyone thinks that the other person is making more money than them. So she thinks it’s great to be open but there needs to be a culture in the kind of industry that that’s okay. So you have to be careful. There are also kind of examples where it could be possible to deliver a circular economy project without sharing the budget. There is a management system called contract management, where instead of having a contractor which holds the multiple relationships with all the suppliers. It’s the client who brings everyone together at the beginning and gets them to work together. You can have a pain gain share model. In which you incentivize people to work which is almost what you’re saying. So she thinks it can be but it does not have to be.

Conclusion 8:
This is something they have been talking a lot about recently. A new research is going to be published but due to confidentiality we cannot discuss this before it is published. There’s technical life and then the economic life. And she thinks people get confused sometimes and merge them together. The technical life is like how long it can actually last to provide the performance that was designed to do. And then there’s the economic life which in international finance standards they have set depreciation rates that you need to apply as a business to your asset. Now people get them confused because you’re not reporting on the life of building materials. The question is, if you build something, is it forever? The answer is no, as long as it is deconstructible and there’s a market for those materials. Then creating these things is not about them because you will always need new things. Especially as we’re doing the whole transition from the old building stock which isn’t designed for adaptability or flexibility and then moving forward or having to retrofit or even just building buildings.

Conclusion 9:
With change typically always comes more risk, for any change in a business model. She does not think the client should have to take on more because ultimately because everyone is changing so they will be taking on more
risk. In a circular economy that risk really wouldn’t exist in a way. The models are set up so it’s not so. We kind of have to be careful when we talk about current risk and future risk.

A good example of this is what the company says to some clients is that you continue with your linear business model but, try to explore this business model and also put it in place so in a way you have two business models running in parallel. Because we are moving to a circular economy and you need to be ready for that. Otherwise your business will go bust. In terms of business continuity you need to be thinking about that.

**Recommendations:**

**Recommendation 1:**
Yes. The interviewee thinks that’s a good idea, it is important. It is a good idea but you’re not going to have all the stakeholders to be involved in the delivery room of the project at the beginning. Inevitably as things progresses you bring people on. She thinks everyone always go a little bit off topic. Being honest she thinks it’s good to have it from the beginning but it’s good to always have moments and check points in time where you bring people back together. The circular economy has a quite specific meaning. When working on developments with contractors, small or large ones, you don’t want them to feel stupid.

**Recommendation 2:**
She does not think anyone will think about this. Unless you have metric around for the material intensity of the building and the need to put your tax on the balance sheet and all of that it is difficult for people to think about it. If it is not a requirement. The good thing about tax on labor is that it is based on income. If you earn more money you pay more tax. There is a lot more that needs to be thought about. She agrees there needs to be a greater tax on resources but it needs to be the right tax and structure in a good way where everybody still benefits from this.

**Recommendation 3:**
She does agree about always doing scenario planning. From the beginning to know potential uses and future uses of the building. To design for these uses. But you also need to have new investment partnerships, that allow that to happen in an economic viable way. For a developer, if you are going to put in loads of things from the beginning, because it can be used as a retail, office and converted into residential, it can become very expensive. If people do not value that ability to be market flexible, they are not going to pay extra for that. All the money you spent upfront is not going to be worth it. You are not going to recoup that money when you sell the building on. It really is about investment partnerships according to interviewee, money makes the world go around in a way. It needs to work financially, and this is really lacking in the circular building environment. We are all focused on design so much, which is great, but there needs to be sound business models that work for everyone.

**Recommendation 4:**
Do you mean keeping BIM models up to date with new maintenance information? Or digital twins? We discussed this that you so not really know when a building is going to be deconstructed. So, it is difficult to look at supplies. She agrees that there needs to be an up to date record and a centralized record as well. So, if you need a thousand bricks that come from 5 different developments, the centralized exchange allows you to go to one place if you need these materials. Short answer is yes. There can be a deconstruction estimate but you probably would need contingencies that allows those materials to be conserved before being used again.

**Recommendation 5:**
Yes. She agrees, that is applicable to projects.
Recommendation 6:

Yes, definitely. But they have to do that anyway. They always have to look at the choice of contract. But even more so in the circular economy where you are going to have more product as a service procurement. And the way in which this is managed and who manages them, like are you going to have a facilities management that has a tight role that manages all the contracts? So, it is very important, but in a way not different than to what they do now.

Recommendation 7:

This responsibility depends on the responsibility given to the project manager. The client might want all the decisions to be runned passed them. So, this depends on the responsibility.

Recommendation 8:

This one is applicable to lots of projects, not only circular ones. She does agree that you should spend more time on doing things instead of reporting, but you do need to have a paper trail. We might not think that is important but in the middle of a court case and you are being sued it is very much needed. Also, it is great to have a kind of design meetings, regular intervals, where you share knowledge. Not everyone will be working on things the same time, people will be working on details to an extent and coming together to discuss coordination, so she agrees to an extent.

Recommendation 9:

Yes, this one is partly true. It is hard because there is no abundance of secondary materials, ultimately architects really need to change the way in which they design, by thinking about available materials rather than new materials. But, she does think they need to engage people on a practical level a bit sooner.

Recommendation 10:

The interviewee is not sure if she is qualified to answer this question. You are not going to reuse a steel beam if it has not been tested. It needs to be verified or warranty needs to be given. And what better way to do this then at the original manufacturer. You could say that if you use more secondary materials you have to pay less tax. That way that additional money can be used to test materials? Suppliers are more liable and happier with testing their own products because they know them. Whereas if you give someone something similar to what they do but is not the exact product, then it’s quite difficult.

Recommendation 11:

This is touching upon competition laws. She does not think she is qualified to say but the circular economy is not this haven. The people still need to compete and in terms of confidentiality you might not want to know the contractual agreements between the client and the main contractor. Not sure she agrees with this one.

Recommendation 12:

This is what 100% needs to be done in the real world in all projects. Because we say that and you are just a one man show supplying doors to someone, how much can you do really? It is really important to know the bigger picture and everyone else involved and if you need to speak to someone about something you know. But in practice it can be difficult because the construction industry is made out of so many SMEs (small and medium sized enterprises) that you do not have the capacity to do that. The organizational structure is important for every party to know beforehand because a circular business model, whether you are supplier, client, whoever, you need to have the right organizational structure to maintain the business model. So organizational structure has everything to do with it, to be able to supply circular products, that you said you would.
Appendix I.3: Validation interview 3

Current function: Graduate engineer in the material consulting team, Arup

The circular economy according to the interviewee is the capacity to find a regenerative and restorative system based on three main principles: regenerate natural resources, design out waste and keep products at use in the long term. Some actions that characterize the circular economy are defined by the so-called R’s: Reuse, Reduce, Refurbish and Recycle. The interviewee’s role in the circular economy in the built environment is to suggest material selections based on sustainable criteria. Such as the recyclability, the locality and regionality of material so that there are no emissions during transports or materials characterized by environmental certifications such as the environment and product declaration. Another aspect of her involvement in the application of circular economy in the built environment is the life cycle assessment through which they define all the impact that the materials and the built environment have in a project. The interviewee has two years of experience.

The interviewee’s ideal vision of the circular economy in the built environment in the future is that all materials will be tracked by material passports. Maybe connect it to BIM or block chain so that we can always see where the material is located, to see buildings as material banks. Moreover, she sees a closed supply chain for the applications of reused materials in the same built environment but also a loop so that the waste from the built environment can be applied to other sectors.

Conclusions

Conclusion 1:
The interviewee neither disagrees nor agrees, in some cases the public institutions apply minimal environmental criteria to the public procurement. In Italy this is used in practice. The public values are decided upon with circular ambitions to make decisions.

Conclusion 2:
The interviewee agrees about this. Also, because product as a service business models can be fostered only through the inclusion of suppliers within the circular project.

Conclusion 3:
Yes agree. In the design phase you need to think about the circular economy so that it can be applied until the end of life of the building. It can be a principle integrated at the beginning.

Conclusion 4:
The interviewee thinks that both the client and the design team should define together the requirements that the design will have. Because on the one hand the design team will have a circular economy in mind but on the other hand the client has a better knowledge about the environment. Together through collaboration or partnerships the outcome can be better. The client should set ambitions, they can be achievable ambitions.

Conclusion 5:
Yes agree. This happened in practice, a few weeks ago the San Francisco team were looking for a supplier to be involved since the design phase to develop a product as a service model.

Conclusion 6:
The interviewee agrees. Because since the design phase you can start specifying materials that are more circular, and often the contractor made all the decisions and the other parties were not responsible.

Conclusion 7:
The budget might have to be divided per objective and not per time frame. Maybe a task is completed with a less amount of time while on the other hand another task that seems obvious requires more effort. Also, because maybe in circular construction you still do not know how much time you will need to do something. Budget can be linked to time.
Conclusion 8:
Yes, she agrees. Because through a contract you at least have a piece of legal paper which distributes the responsibility all over the actors.

Conclusion 9:
The interviewee agree with this, although it should be argued that suppliers have now the risk that they will have to take needs to be greater in the future than that they are taking now. Because now they sell a window and after they have no more responsibility. Now for example if you sell it as a service you will keep the responsibility over time and also the money that they will make will be splitted over time rather than all at the beginning and after no more.

Recommendations

Recommendation 1:
She agrees, if the design team knows some basic principles of the circular economy. Otherwise the basics should be told to everybody. And after that, it would be nice to also define the circular economy per discipline of the project to better understand what it means for the discipline so that they can better integrate the CE in their everyday work. A course, a Moodle course or the circular learning Hub (recently launched by the EMF with useful resources) could help in this.

Recommendation 2:
The interviewee agrees; however, this will not happen anytime soon.

Recommendation 3:
The interviewee agrees. This should be prioritized, rather than demolition and constructing a new building. Or at least reuse some materials and components coming from the old building. If you are constructing a new building, flexibility and adaptability for new functions should be taken into account.

Recommendation 4:
The interviewee agrees. Because material composition and toxicity coming from old buildings is important for the wide option of materials.

Recommendation 5:
The interviewee agrees.

Recommendation 6:
The interviewee agrees, as said before, since the design phase you should pay attention to the end of life and plan what the building will be in the future. This should be documented in contracts.

Recommendation 7:
The interviewee agrees. The project team and the client have shared responsibility.

Recommendation 8:
The interviewee agrees. Workshops are also optional together with stakeholders and the suppliers. Like a co-creation workshop.

Recommendation 9:
The design should be made by architects with the help of suppliers. They should work together. Architects have more responsibility but the suppliers have the responsibility for the durability of the products and for the tracking of the materials.

Recommendation 10:
Although the uncertainty coming from urban mining, you must at least certify the material composition and the materials that you are going to use. This should be done for safety reasons and the durability properties.
Recommendation 11:
The interviewee agrees. Everyone should be transparent about the type of contract they are using. This way the client is aware of where the materials are coming from.

Recommendation 12:
The client thinks the organizational structure is important. She suggests using a circular structure. Because in that way everybody has the same responsibility and decision making is shared among all the participants. It is not only the client that makes decisions but all of them have responsibilities of the decisions they are taking. So, shared responsibility is very important.
Appendix I.4: Validation interview 4

Current function: NEN

The circular economy is not yet a fully defined definition. For the interviewee and NEN it is about keeping materials as long as possible in the loop. NEN is working on making agreements, standards are factually agreements, however agreements can also be made in other ways. For the topic circular economy, NEN is trying to make these agreements. There are a lot of things that need to change, how we cooperate with each other and the agreements for the linear economy need to change into agreements for the circular economy. They think about all the different sectors. An example is, they investigate from the measurability of the effects or de quality of secondary materials until the use of secondary materials in a product. The interviewee has about 4 years of experience in the topic circular economy. However, she has always worked with sustainability, so the theory was always present in her work.

The interviewee believes we can technically do a lot of things, so it is less of a technical challenge, more a challenge in the chain. We need a lot more information about what materials to use and what happens to the materials in their life cycle. This has to be done with the several parties in the chain. Besides, the life time of a building makes it more complex. It is more complex to predict what will happen with the materials of a building with a life time of 50-100 years, compared to a coffee machine with a lifetime of 5 years. The effects of the things you think of in a circular building process, can only be tested very late. Technically there are a lot of possibilities, but the complexity is about the fragmentation of the process.

Conclusions:

Conclusion 1:

From what the interviewee has seen, this statement is correct. The interviewee looks at building projects from a distance. But she has not noticed or read that large changes are occurring.

Conclusion 2:

The interviewee agrees with this conclusion.

Conclusion 3:

If you are serious in the usage of circular principles and ambitions in the project, this needs to be used from the start until the end of the project, in all the layers. Otherwise, ambitions dilute, or decisions are made on other arguments because it might be easier, cheaper or better known etc. So, the interviewee believes this is true.

Conclusion 4:

This is something that is said more often, you need to specify functionally instead of too detailed. The interviewee thinks that in this phase the best results can be obtained when with the entire involved team the elaboration is done of the program requirements. However, this makes it hard on what grounds to select parties. What are they selected on? You need to have a lot of trust in each other. This sometimes lacks in the sector. Traditionally parties select advisors based on a global program requirement or a first ambition document. This is doable for advisors because you know what you can ask of them for activities per phase of the process. However, with the method explained in the conclusion, this is unknown. Clients do not know exactly what to ask the market parties. There are some parties that dare to do this but many dares not. So, what you ask for you need to keep in main lines, based on ambition for example. A party cannot make an offer for the entire process so you need to divide it into phases.

Conclusion 5:

The interviewee agrees on this. This is one of the things that they found in their work for the platform CB’23. A lot of suppliers were joining the platform and said that they are involved too late in the process. By being asked too late, you are not involved in the discussion on how to make the solution as circular as possible. So, they need to be involved earlier in the process.
Conclusion 6:

The information transmission in the chain becomes very important in a circular process. This is partly based on trust. The more careful you work with this, the better this is expected to go. Careful does not mean that everyone should be involved but that together you determine what parties need to be selected. As a client you cannot select all the parties on your own nor as a main-contractor select a subcontractor.

Conclusion 7:

According to the interviewee, this could help. However, this might be a large step for clients. This is something that would help in the transparency, to look together how within the budget the best solutions can be chosen. This also has to do with trust. Not only other parties in the chain need to be more transparent and open, also the client. It occurs a lot that clients are not willing to show everything because they might want the project to be cheaper than budgeted. But this sustains the culture that price is the most important criteria. Price will always be important, because you have an ending budget, but you can discuss openly how the best solutions can be found within the financial budget. This is a necessary step.

Conclusion 8:

The interviewee has too little experience to be firm about this. But her feeling is yes, because it has to do with the long lifetime of buildings. Unless you make a temporary building, the lifetime is defined so you can think of what to do after. But in the most occasions there will not be a plan about what will happen with the construction. Then it is useful if something has been documented about this.

Conclusion 9:

The interviewee is unsure. You need to make agreements about the responsibilities that needs to be shared, to agree on the risks. In the end the client is responsible about a lot of things and clients bear a lot of risks. If you want to put more risks with the client, then she wonders if the clients will be tempted to enter an experimental trajectory. You need to think about the risks that exist and where they can be transferred to. It might be too blindly to say, more risks should be transferred to the client.

Recommendations:

Recommendation 1:

It is very important to discuss on the front end what circularity means to everyone and what it means for the project. More clarity will arise but for now it is very important to discuss what we define with circularity and what it means for the ambition. In one project it can have a different definition than in another project. This needs to be clear at the start.

Recommendation 2:

It is okay to be aware of this. It is cheaper to buy a building of virgin materials then to use a secondary product. This because of among others, the labor costs and because processes are not mainstream. The consideration needs to be made but if you calculate everything this way, the labor costs will weigh more, and the question is what this means for the decision. This is difficult, the insight is relevant but on the other side, this can lead to the wrong decision. The processes are now set that you buy all the materials from China with the exact specifications and dimensions you want. The process should not be based on this but instead on ‘let’s see what materials we can find in the surroundings’. This costs more time. It is good to have insights in this but on the other hand it can mean somebody chooses a circus tent instead of a nice pavilion. That can lead to not achieving the goal.

Recommendation 3:

A building should not be constructed for one type of use. The flexibility can have a large added value. A disadvantage is that you then primarily use more material, but the interviewee thinks that the lifetime of the building can be increased a lot. More material is used in for example over-dimensioning or ceilings are made
higher than necessary to make a future other destination possible. For these type of things primarily more material is necessary. So, for flexibility this might be necessary. That means you have to see what it yields in terms of increase of lifetime or flexible use. It is difficult to compare this with numbers. This is one of the methods to use more circularity in the construction process.

Recommendation 4:

For example, keeping track of the history in a material passport? This is definitely required. The NEN is working on a project about the reuse of constructive elements. One of the problems is that you have no idea about the prestation of for example a beam. At this moment every product needs to be tested. This is not a method that stimulates reuse. If you have a history about what has been constructed, how it is maintained or modified over the years and what forces it was subject to etc. This is basic information which helps you define the quality of the product. You might still need to think about the way to test it, but it helps the efficiency of the process. So, yes, it is necessary.

Recommendation 5:

Yes, this needs to be an ambition from the start, if the client wants a circular construction.

Recommendation 6:

Yes, it is not possible to do a circular project with every contract. It is clear that very traditional contracts with tendering on specifications where nothing is settled for the period afterwards, that does not fit. But contracts such as design, build and maintain, could be suitable if you make agreements on this. It depends on how meaning is given to this by the client. Constructing according to circular principles is possible with (at least a few of the) existing contracting forms.

Recommendation 7:

The interviewee agrees with this. Nevertheless, traditionally project managers are responsible for the GOTIK principles, they need to safeguard the quality, planning and budget. In a circular process, mainly for time and costs, this is more difficult. Maybe more emphasis needs to lay on the quality and the organization, then on time and costs. As a project manager of a circular project, it is for sure important that everyone is on the same page (ambitions). If there is a conflict between two parties, the project manager can act together with the client (depends on how intensively the client is involved). But it is also responsibility of the entire team. You don’t want two people pointing fingers at the team saying what is not circular. That can lead to irritations in the process. It must be the responsibility of the entire team to make sure everyone is involved. This must be a team effort instead of one person as a sort of police officer saturating the circular ambitions. It is possible that the project manager or client need to step in.

Recommendation 8:

This endorses what the interviewee just answered. Also, because often you did not think of the solutions beforehand, if it is about a circular process. The project cannot tell everyone what to do, because at this moment project manager do not know the answer to everything, when it comes to circularity. If the project has very extensive and detailed program requirements, a project manager can tell everyone what to do. But that is not the case with circular buildings. So together, they need to figure it out and carry responsibility to together come to the best solution. The interviewee agrees with the recommendation.

Recommendation 9:

The interviewee thinks that more is going to be designed like this. When more secondary products are used, you will need to design with what is already there. Sometimes architects design beautiful buildings where the use seems to be of secondary importance. This is even more with circularity. If you design a building that is aimed at this client but must be adaptive in the future, you need to look at the design in another way. So, some architects need a new mindset. Some already have this but some others do not. This also accounts for other companies in the chain.
Recommendation 10:

Also, for this counts that the responsibilities need to be shared and cannot be for one party. Together you need to look for the best solutions. If you work with urban mining materials, you need to work differently, and a part of this is the agreements on risks and responsibilities.

Recommendation 11:

You will need to make good agreements on this. But also, as urban mining suppliers, you need to show what a product can do. Because a main contractor needs to know what he buys. With that, this might lower the risks. However, the interviewee does not know how. Maybe something that shows the level of applicability.

Recommendation 12:

The interviewee thinks you cannot be against this recommendation. It is always good to be conscious of the organization you work at. On the other hand, you can imagine that there are several possibilities for a supplier to take part in a project. A supplier can be used as a material farmer but on the other end you can be involved at the start of the project. This defines what position in the team the supplier has. As discussed, suppliers need to be involved earlier so that means this also accounts for urban mining suppliers. If you are integrally part of the team, it is important to know what the team is and how a process works. Organizational structures influence the process of a circular construction. Traditionally, a client lets an architect write the requirements. That is send to a main contractor (or several) and they calculate the price and ask prices to suppliers. This type of organization is not going to work in the future. On the front side a collaboration should be started with all the layers that are needed in the project.