Witteveen + Bos

UNIVERSITY OF TWENTE.

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BACHELOR THESIS

CORE DECISIONS FOR ANCHORING CIRCULARITY AMBITIONS INTO WORKABLE MEASURES OR PRACTICES FOR THE CONSTRUCTION SECTOR AT WITTEVEEN+BOS

Document

Topic	Core decisions for anchoring circularity ambitions into workable measures or practices for the construction sector at Witteveen+Bos.
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Preface

Dear reader,

This thesis concludes my Bachelor of Industrial Engineering and Management at the University of Twente. I was very fortunate to work on a project that includes solving a problem that helps to create a more sustainable world. During the past months, I have executed my Bachelor thesis at Witteveen+Bos. The goal of this research was to create a framework to help guide the process of translating circularity ambitions into workable measures and practices that can be written down in the contract. I learned a lot from the construction sector including the tendering and contracting procedures. Next to this, I worked in a very nice environment in which everyone was willing to help or call in case I had any questions.

First, I want to thank Jesper Pots, my supervisor from Witteveen+Bos, especially for all the help, guidance, insights, and weekly meetings. He always took the time to advise or help me. Next to this, I would like to thank all my colleagues at Witteveen+Bos for giving me a very welcoming feeling, making me feel valued and trusted, and above all making it possible to ask questions whenever it was necessary to anyone. I appreciate the helpful and open atmosphere at Witteveen+Bos. Next to this, they also gave me the opportunity to come to the office when this was possible despite the pandemic.

Furthermore, I want to thank Guido van Capelleveen as my first supervisor for all relaxed meetings with valuable feedback and for thinking along and answering all my questions. Next to this, he also really helped me with the scoping. Furthermore, I would also like to thank Devrim Yazan for being my second supervisor.

Lastly, I want to thank my friends and especially, Jasmijn Mennink, Susanne Heesterman, and Stef Huttinga for helping me with the poster and giving feedback on the structure of my thesis.

Nienke Rusch, 9-7-2021

Abstract

The national goals of the Netherlands have been set at being 100% circular in 2050 as there is a large need in the construction sector to move to a more circular construction environment. This thesis gives an insight in the process of translating circularity ambitions into workable measures and practices in the construction sector. The research was conducted at Witteveen+Bos. A lot of research has been done concerning the barriers and enablers of circularity in the construction sector, however, there is no research that tries to visualize these and that includes and identifies the key decisions that need to be made.

The main research question of this thesis is: *What are the core decisions with respect to the anchoring process of circularity ambitions of the Dutch government in the form of workable measures or practices in the definition, planning, and design phase in the construction sector?*

A multiple case study is conducted to answer this research question. The data for this multiple case study is retrieved by conducting interviews.

The results of this research can be used in projects to help guide you through the process of translating a vague circularity ambition into a concrete and workable practice or measure. Witteveen+Bos pointed out that a visual overview of the concrete steps and decisions creates more insight and brings support. Therefore, a flowchart and poster have been created from these core decisions. The results include the core decisions, which are:

- Determine what the concrete circularity ambitions and associated goals are, whether they are realistic, and how to make the goal measurable using KPIs
- Communicate and make sure that everyone is on the same page
- Analyze and research what the opportunities and chances are and where the biggest impact can be made.
- Make sure there is a reflection on the current idea and initial goals. Furthermore, the barriers that are met should be reviewed.
- If it is known what you want to tender, then this should be included as a minimum demand

Thus, the core decisions are identified and these are visualized in a flowchart. This visualization helps project managers to structure the process of translating a circularity ambition to a workable measure or practice and therefore this research contributes to the current body of knowledge.

Contents

Glossary

Abbreviation	Meaning
BIM	Building Information Modelling
CE	Circular Economy
LCA	Life Cycle Analysis
MEAT	Most Economically Advantageous Tender (*EMVI in Dutch*)
PMC	Product-Market Combinations
RWS	Rijkswaterstaat. *A part of the Dutch Ministry of Infrastructure and Water Management and responsible for the design, construction, management, and maintenance of the main infrastructure facilities in the Netherlands.*
SLR	Systematic Literature Review
SMART	Specific Measurable Achievable Realistic Time-based
TCO	Total Cost of Ownership
TCU	Total Cost of Usership
WLC	Whole Life Costing
W+B	Witteveen+Bos

List of Figures

List of Tables

Reading guide

Chapter 1: Introduction

In this chapter, the general problem and the company are both introduced. This gives the reader a good idea of the problem that is being faced.

Chapter 2: Problem identification

This chapter focuses on the core problem at the company and shows a visualization of the problem with all possible relationships and core problems. Furthermore, this chapter shows the relevance and scope of the research and lastly, the main and sub-questions are being formulated.

Chapter 3: Methodology

The methodology shows how the research is being conducted, and which steps are taken to be able to answer the main research question. The first step of doing exploratory interviews is already executed in this phase as it serves as an input for the literature research that is done in the following chapter.

Chapter 4: Literature

In the literature research, the important context is provided to the reader to be able to understand all important elements of the problem. These are based on the exploratory interviews and may therefore be perceived as disconnected elements. Yet it gives a full understanding of all elements that are necessary for a further understanding of the research.

Chapter 5: Results

This chapter shows the results of the multiple case study approach, interviews, and expert panels. The conceptual sub-questions are only being mentioned in chapter 4 and they are later combined in the discussion with the results from the interviews. Also, the exploratory interviews are not discussed in this chapter as the goal is to let them serve as an input for the researcher to gain information and as input for the literature. Therefore, only the results of the interviews and expert panels, and flowcharts are shown.

Chapter 6: Conclusion, discussion, and recommendations

The last chapter concludes the results of the research and answers the main research question. Thereafter, the results are discussed and recommendations are being given. Next to this, the scientific relevance and recommendations for future research are also given. In this chapter, the results from the interviews and expert panels are combined with the literature to give a full conclusion on all findings.

1 Introduction

This bachelor thesis addresses the key decisions and aspects that are made to translate circularity ambitions into workable measures and practices. This chapter gives the context of the research that is conducted for the University of Twente, including problem introduction, information on the company, and research motivation.

1.1 Problem introduction

The construction sector is one of the world's largest consumers of raw materials. They account for 36% of the global energy use and 39% of the energy-related carbon dioxide (World Green Building Council, 2017). Every year the Dutch construction sector consumes 250 million tons or 50% of raw materials in the Netherlands, as the raw materials that are being used are finite, something has to change (ABN-AMBRO, 2017).

It is apparent that the construction sector puts a lot of pressure on the natural environment and its resources, and therefore a change in the construction sector is crucial (Roders, Straub, & Visscher, 2013). A possible solution is applying the circular economy (CE). A circular economy is based on three principles: regenerate natural systems, keep products and materials in use, and design out waste and pollution. This change requires a shift in the way of thinking and in the way of planning and executing the construction process. The traditional life cycle approach follows the 'take-make-dispose' plan, while circular projects are structured according to the 'reduce-reuse-recycle' plan. The government has set circularity goals to be 50% circular by 2030 and 100% circular by 2050. The ministry sees this as an economy without waste in which everything revolves around reusable raw materials.

Awareness of opportunities to implement a circular economy is growing. Even though some existing frameworks or tools offer principles and philosophies, they do not explicitly demonstrate how stakeholders in the construction sector can change the ways in which they design, develop, finance, procure, construct, operate, maintain and repurpose services and assets to enable this transition. Therefore, there continues to be a need to translate these principles into workable practices and measures in the construction sector.

The objective of this research is to investigate which decision needs to be made to be able to anchor the circularity ambitions into workable measures and practices in the definition, planning, and design phase. Different cases are described that include circularity ambitions or realizations using interviews. Furthermore, the goal of this research is to support contract managers to control and implement the circularity ambitions into the workable practices using concrete steps.

Currently, every project manager has to fulfill the circularity ambitions by themselves and in their way. This leads to no circularity implementations or implementations based on the own interpretation and knowledge of a project manager. Witteveen+Bos wants to know how to structurally make their projects more circular.

1.2 About Witteveen+Bos

This thesis was conducted at Witteveen+Bos. Witteveen+Bos is an engineering and consultancy firm; they advise and help clients all over the world with resolving today's complex challenges. They operate in different fields in which they operate including infrastructure, water, the environment, and construction.

Witteveen+Bos has a network of 23 offices in 10 countries with over 1300 engineers and consultants. Together they work to improve the environment for everyone and in doing so they have the sustainable development goals of the United Nations serving as an inspirational guideline. Witteveen+Bos' activities cover the entire project chain, from the policymaking and design to the contracting and realization of a construction project. Because of this, they create long-term relationships with their clients in which the expectations and needs of the client are met as effectively as possible while also delivering maximum added value.

This thesis focuses on circular procurement, which is of high importance to Witteveen+Bos. The Rijksoverheid (2019) has set the goal that The Netherlands has to use 50% less primary raw materials by 2030. By 2050, the Netherlands should have a fully circular economy. (Rijksoverheid, 2020) Witteveen+Bos aims to make every design sustainable in environmental, social, and economic terms. They have created seven sustainable principles inspired by the Sustainable Development Goals from the United Nations.

The seven principles used by Witteveen+Bos are nature-based design, flexible design, circular design, multi-functional design, participatory design, trias, and socially responsible design. These principles are implemented in different projects and chosen based on the opportunities that are there.

1.3 PMC relational contracting

We conduct this in the Relational Contracting PMC division part of the Infrastructure and Mobility Business Line. This PMC division consists of four different groups and the group in which the thesis is conducted is called Relational contracting (Witteveen+Bos, Organisational Structure, 2021). The main tasks of the relational contracting PMC are monitoring and controlling the construction costs on complex projects. This ideally begins in the earliest planning phase so that maximum value can be derived from the available budget. They work with extremely accurate cost databases which are the product of many years of experience in monitoring international construction costs (Witteveen+Bos, Construction Management, 2021).

2 Problem identification

In this chapter, the core problem of this research is identified. Both the current and desired state are determined. Furthermore, the scope of the research is described and the main research question and sub-questions help to answer the main research question.

2.1 Problem cluster

To identify the core problem a problem cluster is used. The core problem can (partly) solve the presented problem. According to Heerkens and Van Winden (2017), a core problem is a problem that has no direct cause itself (Heerkens & van Winden, 2017). The core problem is being analyzed to determine the current and desired state. Finally, a research question is derived from the core problem to clarify the goal of the research. The action problem is defined as the discrepancy between the norm (the level at which the situation should be) and the reality (the level at which the situation currently is). Figure 1 shows the problem cluster. This problem cluster is based on exploratory interviews or conversations with the employees of Witteveen+Bos. In the figure, there are red, green, and white boxes. Red boxes are core problems that have not been selected in this research, and the green box is the core problem that has been selected in this research. The white boxes are not core problems as these do not comply with the definition of a core problem.

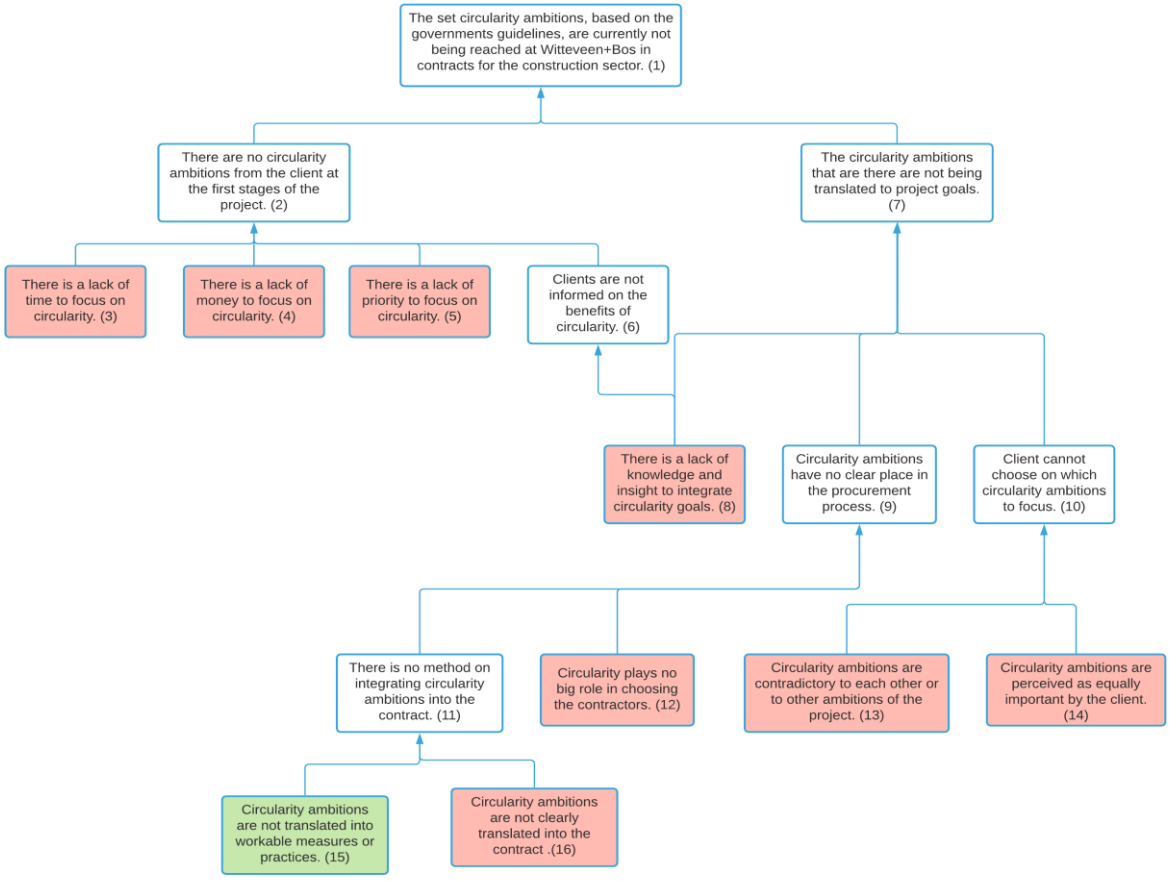

Figure 1: Problem cluster. Source: Self-made

2.1.1 Elucidation problem cluster

The circularity ambitions are currently not met. This has two causes, the first one being that there are no circularity ambitions from the client at the first stages of the project (2). The main reasons for this are that there is a lack of time (3), money (4), and priority to focus on circularity (5). Another cause of this problem (2) is that clients are not informed enough on the benefits of circularity (6) this is often caused by a lack of knowledge and insight to integrate circularity goals (8). It is an important part of becoming more circular to be able to show and convince the client of what (positive) impact each circular action will have. The second cause of not meeting the circularity ambitions is that the circularity ambitions that are there are not being translated into project goals (7). This is being caused by three different reasons namely, there is a lack of knowledge and insight to integrate circularity goals (8), circularity ambitions have no clear place in the procurement process (9) and a client cannot choose on which circularity ambition to focus (10).

For (8) the decision has been made to not further exploit this and therefore this is not the chosen core problem. However, it is interesting to research this and to bridge the existing knowledge gap between the sustainability department and the contracting department.

When a client cannot choose on which circularity ambition to focus (10) this can either be caused by circularity ambitions that are contradictory to each other or to other ambitions of the project (13) or by circularity ambitions that are perceived as equally important by the client (14).

For the third cause, circularity ambitions have no clear place in the procurement process (9), which is caused by two different elements. The first one is that circularity does not play a big role in choosing the contractors (12). Secondly, because there is no clear method on integrating circularity ambitions into the contract (11). The latter problem is caused by two different things.

- Circularity ambitions are not translated into concrete workable measures or practices (15)
- Circularity ambitions are not clearly translated into the contract (16)

Another bachelor thesis focused on core problem (16) and therefore the focus of this research is on core problem (15). This core problem was chosen because it is the core problem that Witteveen+Bos can influence the most. A method that can be adopted in the project plans' contracting phase should be set up to integrate workable measures and practices that help to realize the circularity ambition. Thus the chosen core problem is:

Circularity ambitions are not translated into concrete and workable measures or practices.

2.2 Action problem

The action problem is derived from the core problem. The action problem describes the current state (reality) and the desired state (norm) of a certain problem. Therefore, the action problem is described as follows:

The circularity ambitions set by the Dutch government are currently not always realized in the contracts for the construction sector in which Witteveen+Bos takes part.

2.2.1 Reality

The reality describes the current situation. The reality of this action problem is that the circularity ambitions are not being translated into workable measures and practices based on the circularity ambitions set upfront. Currently, there is no standard approach or way in which the ambitions are translated into workable measures and practices in the construction sector. Even though the awareness of sustainability and circular economy is rising in this sector.

2.2.2 Norm

The norm describes the desired situation. The norm for this action problem is a clear working method on how to implement and realize circularity ambitions. A framework helps contract managers as it gives them a tool that can be used. The desired situation is that 100% of the realistic ambitions at the start are being achieved.

2.3 Relevance

The government shaped a transition agenda in which it states that they want to become 100% circular by 2050 in the construction sector and that the Netherlands has to use 50% less primary raw materials by 2030. This important goal influences the way that Witteveen+Bos will need to operate. To be able to meet these requirements changes need to be made to realize the circularity ambitions set by the government. This thesis helps with creating a method to implement the circularity ambitions in the contract in the form of workable measures and practices.

2.4 Research scope

Circularity can be applied to different areas like materials, water, and energy use. This research focuses on circularity in projects in terms of material use and not water or energy. It is narrowed down to the construction sector in the Netherlands. The circularity ambitions are derived from the transition agenda, which was created by the Dutch Ministry of Infrastructure and Water Management.

Within this research, the starting point is stated as follows: '*Having a (vague) start ambition'*. In Figure 2 the different phases can be seen and this starting point is in line with the end of the initiative phase in which the ideation has been finished and there are ideas and ambitions. The endpoint of this research is defined as the moment when the exact measures are narrowed down on how to reach the set requirements and ambitions. Then the next step, which is excluded from this research, is writing these down in the contract. Figure 2 frames the phases that are focused on in this research this figure is based on conversations with employees at Witteveen+Bos. These phases are the definition and planning phase and the design phase. In this way, the preparation phase can be started and the measures should be written down into the contract.

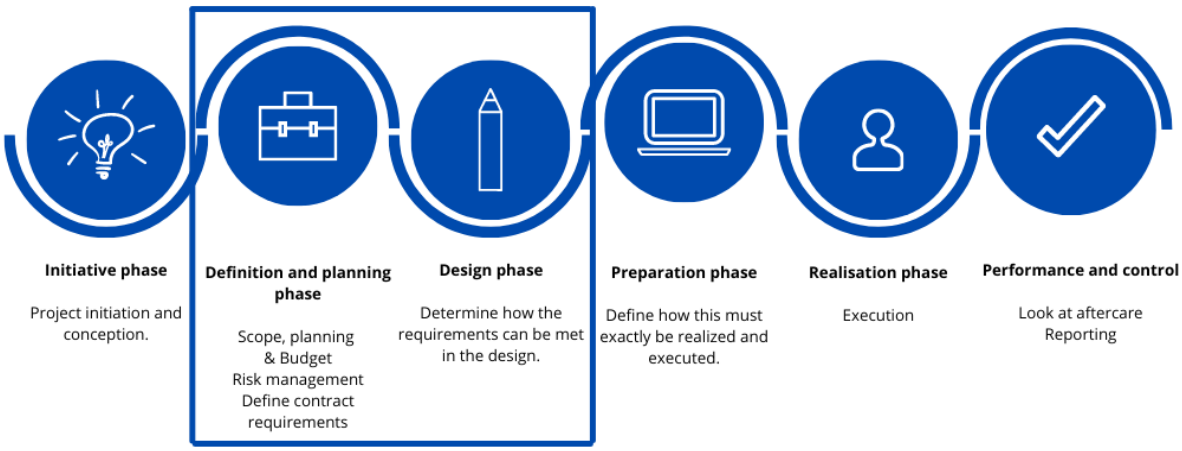

Figure 2: Phases of construction project and focus of this research. Source: Self-made

2.5 Research question and goal

To solve the previously introduced action problem a research question is needed. This entire thesis aims to get the answer to this question and to solve the action problem. The solution is to identify the core decisions that are made to anchor circularity ambitions into workable practices and objectives. This helps to give structure to the process of CE within the construction sector. The main research question is formulated as follows:

What are the core decisions with respect to the anchoring process of circularity ambitions of the Dutch government in the form of workable measures or practices in the definition, planning, and design phase in the construction sector?

The goal of this research is to support contract managers in anchoring circularity ambitions into workable practices and measures using concrete steps. Currently, every project manager has to fulfill the circularity ambitions by themselves and in their way. This leads to a lack of circularity implementations or implementations based on the own interpretation and knowledge of a project manager. The answer to this research question helps to give an insight to Witteveen+Bos on how to structurally make their projects more circular.

2.6 Sub-questions

Different sub-questions form the fundament of the approach. The research design describes all activities that are involved in each knowledge question. The answer to every knowledge question serves to eventually answer the main research question. The first two sub-question have a more theoretical ground and are therefore only discussed in the literature research and theoretical framework. These questions are not further discussed in the results or discussion.

1. **Sub-question**: *What is the definition of a circular economy of materials in the construction sector?*	
Research method Literature research (Exploratory)	**Data gathering method** Qualitative
Motivation: The goal of this question is to provide the context and a conceptual definition of circularity for the research. It is important to define the circular economy of materials in the construction sector from the perspective of literature. In this way, the concept of the circular economy becomes clear, and the contributing elements are mentioned. The different definitions of CE of materials are gathered from literature and bundled into one definition that is used in this research. **Answered in**: This question is answered in the literature review in chapter 4.	

2. **Sub-question**: *What are the key barriers and enablers of implementing circular economy practices in the construction sector?*	
Research method Literature research (Exploratory)	**Data gathering method** Qualitative
Motivation: From the literature, the key barriers and enablers are identified to give an insight into what the current bottleneck and options are to implement circularity. This is a key part of this research as these can give a clear direction on where more change is needed and what should be enabled. It gives direction to formulate the interview questions. Next to this, it also shows what the current knowledge and solutions are for circular construction. **Answered in**: This question is answered in the literature review in chapter 4.	

3. **Sub-question**: *Which decisions does Witteveen+Bos currently make regarding circularity in their contracts?* 4. **Sub-question:** *What are the key barriers and enablers of the anchoring process circularity ambitions from Witteveen+Bos' perspective and how do they relate to the key barriers and enablers identified from literature?*	
Research method Multiple Case study, interviews, and answers to sub-question 2 (Exploratory and descriptive)	**Data gathering method** Qualitative
Motivation: From interviews, the decisions that correspond to the implementation of circular construction are explored. In this way, the current barriers and enablers of circular construction are found. A multiple case study is used to give a framework to the research and interviews are used to gather the data. The results from the multiple case study are compared to the results found in the literature in Sub-question 2. This is done to get a full overview of the key barriers and enablers from both practice and literature. **Answered in**: This question is answered from the interviews and thus discussed in the results and conclusion.	

2.7 Scientific relevance

The findings of this research contribute to the scientific body of knowledge regarding identifying important decisions and barriers that are faced when translating a circularity ambition into a workable measure or practice. In the last few years, a lot of research has been done on circular economy, especially regarding barriers and enablers. Multiple key elements and decisions that are faced in the transition towards a circular construction sector are already known.

However, there is no research conducted on how to translate circularity ambitions to workable practices and measures, knowing the barriers and enablers. Especially regarding the logical steps and decisions that are encountered. This research creates the first visualization of this process and therefore, it helps to give a practical tool on how to implement circularity in contracts in the construction sector in the Netherlands.

2.8 Deliverables

The goal of this research is to investigate which decisions need to be made to be able to anchor the circularity ambitions into workable measures and practices in the contract. In this way, contract managers are helped to control and implement circularity ambitions into workable practices using concrete steps. Next to this, the research should also contribute to the current body of knowledge by exploring what the reasons are that the implantation and realization of circularity ambitions into concrete workable measures and practices are so hard. Furthermore, this research helps to design a framework that helps to make the decision-making process easier.

2.8.1 Flowchart

The first deliverable is a flowchart that includes all key decisions that need to be made to come from circularity ambitions to workable measures and practices that should be included in the contract. This helps to guide the process of starting with circularity ambitions to translating them into workable measures and practices. Bizagi is used to create this flowchart. All symbols that are used are shown in Figure 3. The level of detail of the flowchart is on meso-level meaning that it does not dive into every detail but shows the general flow of events and at the entire asset (Jilke, Leth Olsen, Resh, & Siddiki, n.d.).

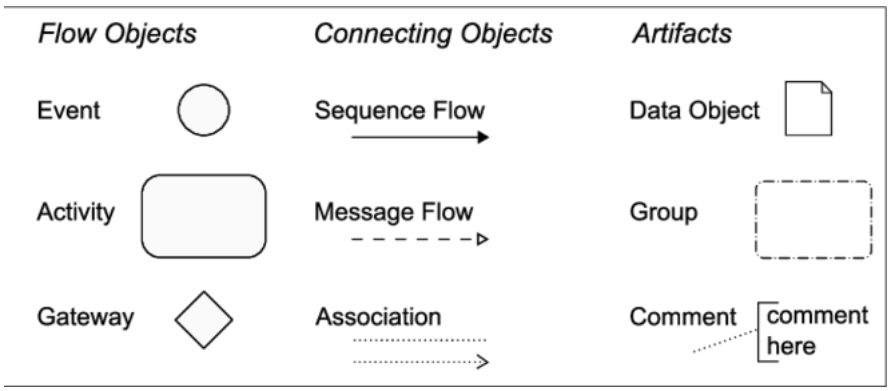

Figure 3: Bizagi symbols

2.8.2 Poster

For Witteveen+Bos a poster is created in which the key decisions are represented in a clear overview. Decisions identical to the ones in the flowchart are presented in the poster. The poster then guides you to concrete steps that help the contract manager to implement the circularity ambition. This is a more user-friendly version of the flowchart.

3 Methodology

This chapter presents the methodological approach and systematic process taken in this research. Different knowledge questions form the fundament of the approach. The research design describes all activities that are involved in each knowledge question. The answer to every knowledge question serves to eventually answer the main research question:

What are the core decisions with respect to the anchoring process of circularity ambitions of the Dutch government in the form of workable measures or practices in the definition, planning, and design phase in the construction sector?

3.1 Research approach

The research approach is discussed in this section. The start of this research consists of exploratory interviews in which the context and problem are researched to give the researcher an insight. These exploratory interviews serve as a basis and from this the literature research is done and important topics are highlighted. After this literature research is done to give more context to the research. Hereafter, a multiple case study starts in which 7 interviews are conducted to answer sub-questions 3 and 4. The data retrieved from the interviews is analyzed using grounded theory and combined with the literature. These insights are then visualized in a flowchart, which is validated by 3 expert panels.

Each of the different phases is explained in the upcoming sub-sections.

3.2 Exploratory interview

Exploratory interviews were conducted to gain more insight into the current problems and opportunities that are faced regarding the circular economy in construction. These help to gain a better understanding of the problems and their complexity. These interviews are informal and are not recorded. The 15 interviewed individuals and their functions are mentioned in Table 1.

Table 1: People and functions of exploratory interview

Name	Function
Individual A	CEO Contracting company
Individual B	Project Manager
Individual C	Contract advisor and risk manager
Individual D	Head of contracting group
Individual E	Contracting manager
Individual F	Risk-based contractor
Individual G	Project Engineer
Individual H	Project Engineer and Circularity Advisor
Individual I	Project Manager
Individual J	Project Engineer
Individual K	Contract Advisor
Individual L	Project Manager (external project)
Individual M	Circularity Advisor
Individual N	Energy and Circularity Advisor
Individual O	Circularity Advisor

These exploratory interviews give an insight into the current problem from different perspectives. Based on this insight the literature review is conducted and important elements that were mentioned more often are elaborated upon. Thus the exploratory interviews serve as an input to the literature review. Therefore, the literature review consists of multiple important yet loose elements that are connected later in the research in the flowchart.

These exploratory interviews are not further discussed in the results but the data retrieved is used for better understanding for the reviewer and as input for the literature review.

3.3 Multiple case study research

The analysis used for this thesis is based on multiple case study research. This multiple case study helps to delve into the problem and complex issues that arise concerning these types of problems. It is a good method when you want to gain concrete, contextual, in-depth knowledge about a specific real-world subject. It gives room to scrutinize the key characteristics, meanings, and implications of the case. Multiple case study research is also a good method when there is no time for large-scale research (Gustafsson, 2017). The information and data for this research are gathered by analyzing cases. The analytic conclusion that arises from more than one case study is more powerful than those coming from a single case study (Yin, 2003). Having only one case in a case study may lead to doubt about the uniqueness or artifactual conditions around the case, which can lead to skepticism. This skepticism can be reduced by using two cases as a minimum (Yin, 2003). This multiple case study analyzes four different cases by interviewing seven individuals.

While case studies focus more on details than general theories, a connection should be made with the theory in the field. Then the case study is not an isolated description, but it is integrated into existing knowledge about the topic. A literature review is conducted to ensure that the analyses of the cases have a solid academic grounding (McCombes, 2019).

A case study selection procedure takes place in which selection criteria are used to help select cases. Based on the selection criteria, different individuals from Witteveen+Bos advised on the most suitable project that could be used as case studies. All cases were provided and (partially) executed by Witteveen+Bos. In Section 4.3.1 the case study selection process is being described including the selection criteria.

3.3.1 Case study selection

The selection procedure for the 4 final cases is guided by setting up requirements and based on those requirements the cases are selected. This research aims to show the key decisions that you come across when translating a circularity ambition into a concrete and workable measure or practice. This should help to answer the question: '*Okay we have a circularity ambition and what now?*'

So firstly, it is important that the project has passed or is currently in the phase of making decisions. Only recent projects, meaning that they are in the realization phase or just finished, were chosen because the time span for the project is rather long. Therefore, important decisions in the preparation might be forgotten as a large amount of time has passed and the decision-making process passed a long time ago.

The second criterium is that there needs to be a circularity ambition and/or realization in the project. An important third criterion is that the project should be executed in the Netherlands. The scope of this research is in the Netherlands and it is important to keep this as laws, permits, culture and the way of working may differ in other countries.

3.1.1.1 Discussion

From these criteria, four cases have been selected. Table 2 provides more detail on these cases. Only the cases that have been selected are shown here. Something relevant to note is the fact that all selected interviewees are Early Adaptors.

Furthermore, it is important that there is access to the right interviewee and that this person has time to be interviewed. The criteria for the interviewee are that they were involved in the project and in the decisions regarding circularity. Therefore, the RWZI Terwolde has only one official interviewee as there was only one individual involved in the decision-making regarding circularity. However, Individual M was interviewed as an extra individual to give more insight into the implementation of circularity and possible barriers.

Table 2: Case study selection and interviewees

Ritsumasyl Bridge		
Individual H	Circularity advisor	May 10th
Individual P	Technical Manager	May 31st
Cruquiusbridge		
Individual Q	Circularity advisor	May 20th
Individual R	Project Manager	May 31st
NRU (Noordelijke Randweg Utrecht)		
Individual S	Technical Manager	May 26th
Individual T	Sustainability advisor	May 19th
RWZI Terwolde		
Individual U	Circularity advisor	May 12th

3.3.2 Cases

In the end, four cases have been selected. Every case is briefly described by discussing the general characteristics of the project.

Case 1: Ritsumasyl bridge

The province of Fryslân is building a bicycle bridge made of bio-based composite materials to complete a new ring road around the city of Leeuwarden. Bio-based composites are relatively new in the infrastructure sector. A study was performed in collaboration with several educational institutions to determine the optimal composition of the material. This resulted in a mixture that consists of 80% natural materials from renewable resources, with a service life of 50 years. This is the first bridge that is made out of bio-based composite at this scale, the bridge is 66 meters long. All partners involved gained new insights into bio-composites thanks to the material study. The collaboration form of this project was an early contractor involvement, which stimulates to ask questions to each other, to share ideas, and to research (Witteveen+Bos, Bio-based bicycle bridge, 2021).

Case 2: Cruquiusbridge

The Cruquiusbridge is a bridge in the Netherlands in the province of North Holland. A circular bridge in this project means minimalizing the use of primary resources and the environmental impact of the used materials and if it is futureproof and adaptable. At the end of its technical lifecycle, all elements and materials are reusable at a high value and there is no waste (Gaydadjiev & Lodder, 2019). It uses standardization in a modular building called IFD-building.

Case 3: NRU (Noordelijke Randweg Utrecht)

The 'Noordelijke Randweg Utrecht (NRU)' is the northern part of the 'Ring Utrecht'. There used to be a lot of traffic and therefore the road is being renewed, improving the reachability and liveability of the neighborhood. The circular aim in this project was vague at the start, stating that they wanted to be as circular as possible.

Case 4: RWZI Terwolde

A futureproof sewage treatment plant that is built with a focus on circularity and sustainability. That is the goal both during the renovation as during the use. In this project, the plant will be renovated in a circular way. Next to this, technical components of the installation will be used to conform to the modular Verdygo ® concept. This makes it easier to adjust the plant to the desired capacity and it makes installations interchangeable. During the construction phase, the focus will be on building modular and using second-hand materials (Vallei Veluwe, n.d.).

3.4 Interviews

Interviews are used to collect the data to get an insight into the approach of circularity ambitions within four different cases. Per case, two people from two different departments are chosen. The goal is to get one individual from the sustainability department and one from the contracting department. When this is not possible it is important that the person was involved in the decision-making process regarding circularity. In total seven interviews were conducted. The semi-structured

interviews are used to explore the interviewee's view on circularity, the key decisions that need to be made to translate circularity ambitions, and the barriers that are being faced.

The interviews are semi-structured interviews, which means that there is some predetermined order. However, they ensure flexibility in the issues addressed by the interviewee (Clifford, Cope, Gillespie, & French, 2016). The interviews from the multiple case study are recorded using the Teams recording tool if permission is obtained from the interviewee. This allows the interviewer to focus on the interview fully. Then the interview is summarized with all key elements per interview that contribute to the research. Research describes that the quality of the information obtained during the interview is largely dependent on the interviewer (Barriball & While, 1994), and therefore neutrality and no bias are important.

The semi-structured interview follows a guide called the interview protocol. This consists of four parts, which are outlined below based on Wilson (Wilson, 2014).

1. Introduction of the interview. The participant is briefed correctly. The interviewer will be introduced, the goal of the research, the goal of the interview, and the confidentiality. This will take approximately 5-10 minutes.
2. A list of questions and topics that will be covered during the interview. This part will take around 40 minutes.
3. General questions and open dialogue with the participant to discuss interesting topics that were not part of the protocol. This part will take 10 minutes.
4. Summary and closing comments and room for further questions. This part will take 3-5 minutes.

The interviews are all transcribed, not by writing every detail down but a first summarized filter is used to transcribe the necessary more important, and relevant information. The transcripts are then coded, using the computer program Atlas.ti, which is done based on a scheme of codes. The scheme is initially based upon the categories or themes found in the literature and operationalized. These categories were selected before the interviews were executed to help guide the interview and categorize the answers given into decisions. These categories are in line with the structure of the flowchart. The transcripts are then coded according to Grounded theory, which is explained in Section 3.5.

3.5 Grounded theory

Grounded theory is used as a data interpretation method. It is a general research method, which guides the research on matters of data collection and data analysis. While the grounded theory is mainly used for qualitative research, it is a general method of analysis that accepts qualitative, quantitative, and hybrid data collection from surveys, experiments, and case studies (Mills, Bonner, & Francis, 2006).

To study the data from an exploratory case study grounded theory was used as an overarching methodology. In this way, there can be data acquisition and analysis of activities within and outside the case study. The data that is retrieved from the interviews are being analyzed by transcribing the interviews. The coding process consisted of three parts. First, the transcripts and notes were coded exhaustively. All relevant pieces are labeled. Secondly, axial coding was used to find connections in the codes and to order them into categories. Thirdly, selective coding is used to connect all categories around one core category. The core category ultimately and connections represent the central thesis of your research (Delvetool, n.d.) (Benders, 2020).

Finally, the patterns in data are used to compose a general process model that provides an overview of decision space for anchoring circularity ambitions into measurable project outcomes.

3.6 Expert panel

Validity is the extent to which is measured what was intended to measure and reliability about the stability of the research result (Heerkens & van Winden, 2017). Since there is a lot of qualitative data gathering, like interviews and case studies, the validity and reliability are threatened. To verify and validate the final tool and flowchart that is created expert panels are being used. The expert panel gives feedback. These panels consist of people that have knowledge about circularity. The aim was not to use interviewed individuals for this expert panel. The panel also includes a secretary who takes minutes.

4 Literature

In this chapter, a theoretical insight is provided in which circularity in construction is defined first. This leads to a better understanding of the concept and the challenges that circular economy in construction poses. Some factors influence the implementation of circular innovations either in a positive or negative way, these are further explored in Section 4.5. Furthermore, multiple important concepts are explained that are of importance to the theoretical framework of a circular economy. Most of the elements that appear in this literature review are based on the exploratory interviews, which are conducted. These gave an insight into important topics and concepts, which are all being discussed in this chapter. These do not include all aspects that arise in a circular economy in the construction sector, however, all relevant loose pieces of information regarding this research are included.

4.1 Circular economy in construction

This section focuses on creating a clear definition of the concept of Circular Economy (CE) in the construction sector, as this is used throughout this research. From the Systematic Literature Review (SLR), the definition of Circular Economy (CE) is derived. The SLR is included in Appendix A. The following definition arose:

Circular economy (CE) is based on reducing, alternatively reusing, recycling, and recovering materials. In this way, it tries to maintain the value of materials and restore or regenerate this value. This is done using a closed-loop system by which the value cannot get lost or only has minimum waste. Next to this, CE aims to use renewable sources more to make sure that all materials still have value in their entire life cycle.

From further research, six principles should be taken into account in order to accomplish circularity in the construction sector (Verbrugge, 2016).

1. Renewable materials should be used as much as possible. To realize this, products should be of higher quality to last longer. In this way, the life of a product is extended. A possible solution could be ‘use instead of possession’: when the producer owns a product and earns money from letting others use it, it will stimulate making products that last longer.
2. Material passport should be included. To be able to use the raw materials again to make new products at the end of the life of a product. To do so it is necessary to know of which raw materials a product consists and bundled in a material passport. It is not yet obligatory but there are grants from the government which stimulate the purchase of it.
3. Raw materials should have a high value to be reused and the lifetime should be stretched when possible. A possible solution is the protection of certain types of raw materials by, i.e., using taxes for raw materials.
4. The modularity of products is necessary, which means designing products in such a way that they can be easily disassembled, moved, and replaced.
5. A collective platform on which products, raw materials can be exchanged between actors.
6. Buildings are a dynamic commodity warehouse in which the used materials are known and can be used and exchanged efficiently.

In a linear economy, the take-make-waste pattern is at the center. In this type of economy, companies take raw materials, produce a product, sell them to consumers, who use the products, and then throw them away. This causes a lot of waste and it causes high and volatile prices of resource extraction (MacArthur, 2013). In Figure 4 the circular economy is shown graphically with a biological and technical loop.

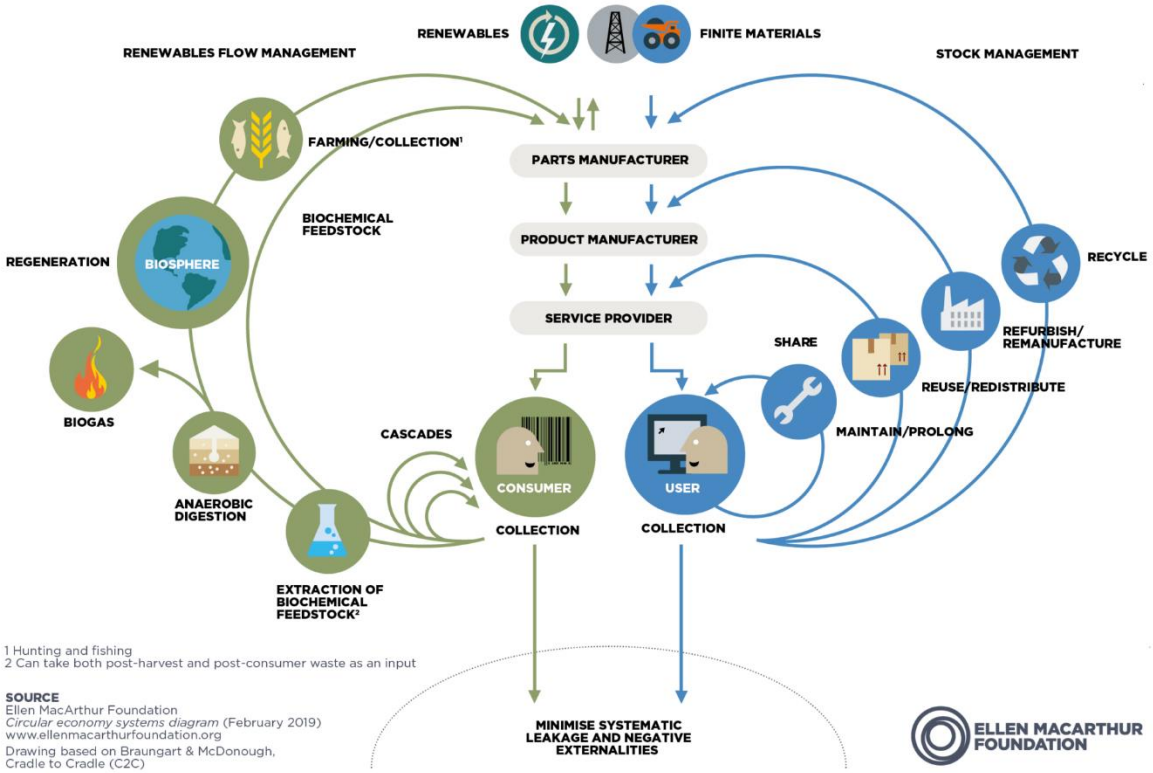

Figure 4: Biological and technical loop of the Circular Economy.

An important change when going from a linear to a circular process is the change from the transactional nature of procurement to longer-term relationships. Therefore, collaboration becomes more important in circular projects. There are two types of collaboration possible within the tendering process:

- Collaboration between the buyer and supplier, which is best facilitated through a conversation within the tendering process. This can be done by a plenary market consultation or by including a formal dialogue during the tendering process.
- Collaboration between value chain partners should often be facilitated as this does not happen spontaneously. This can be done by dividing the process into a selection and an award phase or by enabling a dialogue.

4.1.1 Circularity goals and views

There are different ways in which one can contribute to the circular economy. Firstly, a view on circularity is *'from the present into the future'*. This entails that products should be designed and manufactured in such a way that they will not become waste in the future. This involves using healthy materials that will remain recyclable in the future and are assembled in a way that ensures they can be disassembled with reasonable ease.

Secondly, a view on circularity is '*from the past to the present*'. This seeks to make optimal use of all products and materials that are already in circulation as well. Focusing 100% on the present to future circularity would mean that nearly all physical objects that are currently around us would become waste. It is vital that attention is also paid to extending the functional lifecycle of existing products and reusing materials that are already in circulation (Oppen van, Croon, & Bijl de Vroe, 2018).

The CB'23 is a Dutch platform that wants to connect all parties in the construction sector and created agreements for the entire construction sector around circular construction. This platform has created three goals in circular construction (Platform CB'23, Circulair inkopen in de bouw: Versie 0.95, 2021).

1. Protect material stocks by looking at primary and secondary materials and using renewable materials.
2. Protect the environment by for example looking at emissions and biodiversity.
3. Maintaining existing value by looking at high-quality reuse, detachability, and extending the live cycle.

4.2 Circular procurement

The procurement of circular economy may be slightly different from traditional procurement. This section covers important elements that contribute to CE and should be considered in the circular procurement process.

Below six principles of circular procurement are mentioned, the first four are general principles that are established by law (Oppen van, Croon, & Bijl de Vroe, 2018) (Chao-Duivis, Koning, & Ubink, 2013) and the latter two are specific to circular procurement. These aspects were also acknowledged by CB'23.

1. **Non-discrimination**: it is not allowed to discriminate based on nationality.
2. **Equal treatment**: the same information must be given to every participating supplier in the tendering process. Next to this, each supplier should be evaluated in the same objective manner.
3. **Transparency**: it should be communicated to all suppliers what is expected of them.
4. **Proportionality**: the procedure itself and the subject matter, including the requirements and criteria, must be proportional to the nature and scale of the assignment.
5. **Collaboration**: within the legal framework, a collaboration between buyer and supplier should be encouraged. Furthermore, the tendering process should be used to bridge the traditional gap between buyer and supplier.
6. **Innovation**: facilitate innovation and circular development within the tendering process. This can be done by dividing the procedure into a selection phase and an award phase or by facilitating dialogue.

When tendering it is very unusual to award contracts only based on the lowest price. What is possible is to award a contract based on MEAT, Most Economically Advantageous Tender. In the MEAT additional criteria can be included like sustainability, speed, innovation, or lifespan (House of Tenders, 2021).

4.3 Important elements regarding circular procurement

This section focuses on some disconnected elements from the literature that are all associated with circular procurement. Therefore, this section has no clear cohesion, however, all topics that are discussed are crucial for a further understanding of the research. The following topics are discussed in this section: the ambition web, material passport, life cycle costing analysis, the total cost of ownership, and technical and functional specifications.

4.3.1 Ambition web

At the start of the project, it is helpful to translate your vague ambitions into concrete levels of focus. The ambition web is a visualization tool that helps to display the sustainability themes and their linked ambition levels, which is based on Duurzaam GWW (Duurzaam GWW, n.d.). This helps with giving prioritization to certain aspects of sustainability, including the material used, for example, which is linked to circularity. An example of an ambition web is illustrated in Figure 5. The ambition web distincts three different levels on every one of the twelve themes:

- **Level 1:** Insight in the largest sustainability load to have a minimum impact
- **Level 2:** Concrete reduction goals and a significant improvement on this theme
- **Level 3:** Added value: instead of '*not as bad*' not having a negative impact. This means getting the maximum out of this ambition.

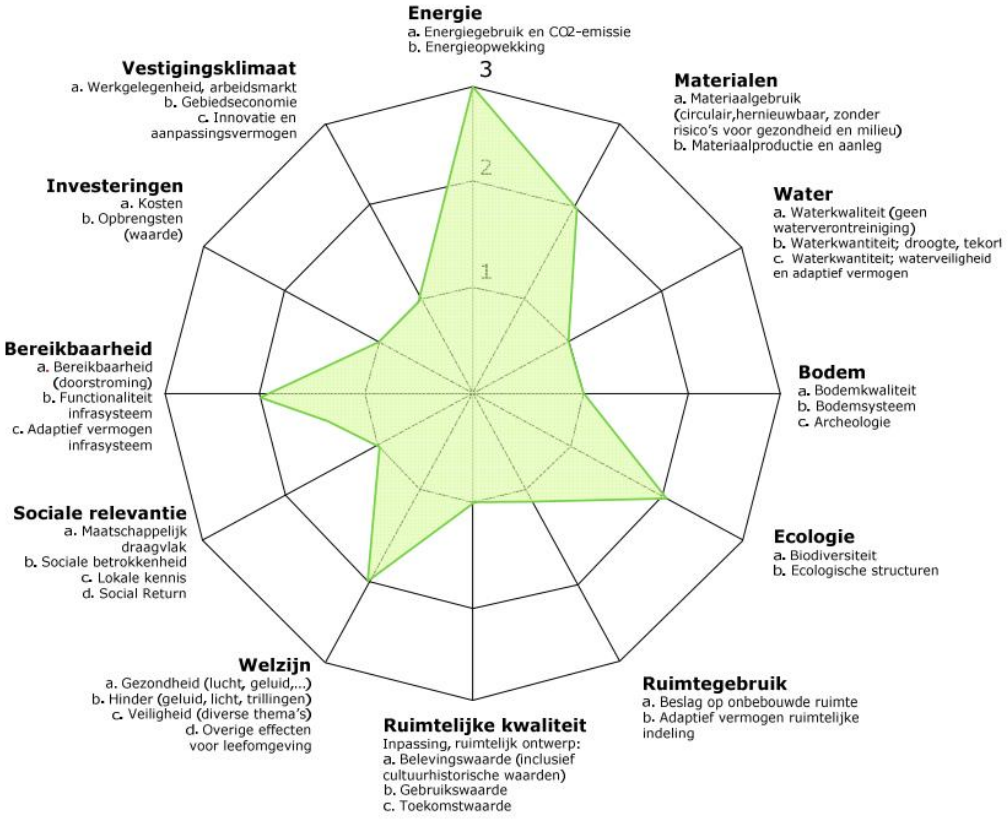

Figure 5: Ambition web. Source: (Duurzaam GWW, n.d.)

4.3.2 Material passports

A material passport gives an insight into which materials are present in the construction and how they are processed. This makes the reuse and reclaiming of materials at the demolition or disassembly easier and it gives constructions more value. There exist several initiatives to apply such as passports, like Madaster and BIM. BIM is a 3D building information model, which also locates the materials. It is important to identify what the potential is for the reuse of diverse materials and components. It is important when (re)constructing something, that this material passport is created (Transitieagenda: Circulaire Economie 2018, 2018). Material passports are necessary to start the transition into a circular economy and have closed loops. A material passport is not obligatory in The Netherlands, however, there is a grant on the material passport (Ollongren, 2020).

4.3.3 Life Cycle Costing Analysis (LCC)

For circular procurement, it is important to consider the whole life cycle. This means that if something is purchased, the costs over the whole life cycle should be considered instead of the investment costs. '*Life-cycle cost analysis (LCC) is an objective method for measuring and managing the lifetime costs of any project or asset*.' It assesses the costs that occur throughout a building's lifespan (One Click LCA, 2021).

In Section 3.1 an explanation is provided on the structure of both the linear and circular procurement process. An important effect this difference has is that the budget for circular procurement processes differs from that for traditional linear procurement processes. The difference lays in the fact that circular procurement is based on life cycle costs rather than just the initial capital expenditure. Currently, the focus is still mostly on the lowest price or costs. This does not necessarily lead to the most sustainable option. Therefore, doing a Life Cycle Costing Analysis may be useful (Oppen van, Croon, & Bijl de Vroe, 2018).

When considering the awarding of a contract to a contractor this is mostly done based on Most Economically Advantageous Tender (MEAT), which is an approach that makes it possible for the procurer to award and compare factors beyond price such as quality and sustainability (European Commission, 2017). Focusing on the entire lifecycle of an object and its costs makes sense and can encourage circularity. However, it may be the case that there are different budgets for upfront costs of purchase and long-term energy and maintenance costs. This means that cross-departmental cooperation is often essential.

4.3.4 Total Cost of Ownership (TCO) and Total Cost of Usership (TCU)

In many cases, long-term circularity can save money due to the Total Cost of Ownership (TCO) and Total Cost of Usership (TCU) being lower than from a linear model. A model that makes use of this is pay for use of products rather than purchasing (Oppen van, Croon, & Bijl de Vroe, 2018).

The total cost of ownership (TCO) is the purchase price plus the costs of operation. Assessing the total cost of ownership represents taking a bigger glance at what the product is and what its value is over time (Twin, 2020). The idea is that when the design of a building is made, the construction cost and cost of operating the build over its lifetime should be taken into consideration and be optimized.

4.3.5 Technical or functional specifications

Another important aspect of the procurement process is the design of tender specifications. Normally this is done using a technical approach which means that the contract to the market contains measurable requirements against which tenders can be evaluated, including minimum compliance data. This means that contractors can often only differentiate themselves by their proposed price and/or approach. Setting technical specifications can also limit the creativity and innovation of contractors (Oppen van, Croon, & Bijl de Vroe, 2018).

It may be very useful to decide whether a functional approach would be more suitable. A functional approach describes the desired result and which outputs are expected, in terms of quality, quantity, and reliability (European Commission, 2017). This latter option leaves more flexibility to the contractors and gives them more freedom to innovate and provide the most effective solution. However, it may be necessary to include technical specifications if a certain goal is desired, like requiring the inclusion of recycled material in production. Especially when an element that must be included in the specifications is already clear, then it may be beneficial to make it concrete and technical to assure that it will be delivered in the end. Next to this, setting technical specifications may also help in a less mature market to help suppliers in defining the concept and implementation options of circularity.

In the figure below the difference is between having functional or technical specifications in the contract is visible. This may be a very important decision to make as a contract manager as it influences the degree of circular innovations as shown in Figure 6.

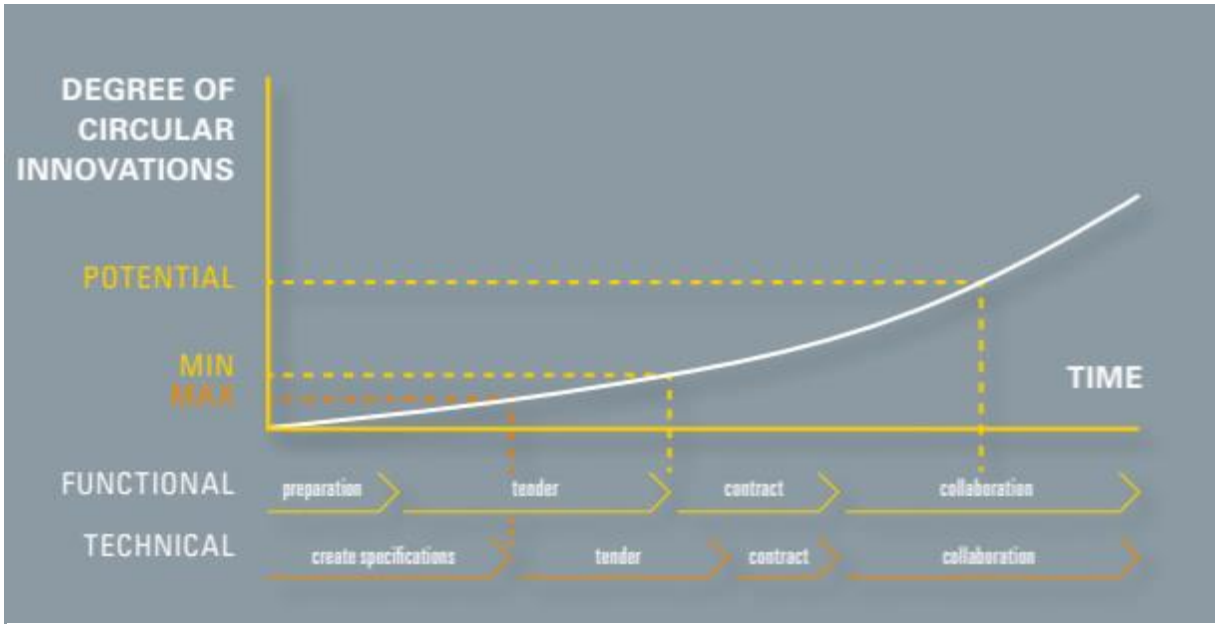

Figure 6: Functional versus technical specifications

4.4 Project management in a circular economy

Circular project management should be different than traditional project management as there are a few important different aspects of circular projects. Some important factors that should be kept in mind when managing a circular project are:

1. **Time**: if it is the first project, ensure sufficient preparation time. The goal is not to try to rush circular pilot projects. There should be room to explore and experiment and to be able to develop new capabilities in circular projects.
2. **Enthusiasm**: enthusiasm, especially for a first project, is important because it is necessary to have positive energy and a manager that believes in the importance of circular procurement.
3. **Risk**: there are multiple important risk aspects to circularity in construction as it is rather new to everyone. Something that may help is having a contract period of 10-12 years with a contractor. It is true that the longer the contract period, the greater the risks and uncertainties. Next to this, it is important to consider who should take the risk, is this the contractor for 100%? (Oppen van, Croon, & Bijl de Vroe, 2018)
4. **Collaboration**: it is necessary to collaborate during the project both internally and externally. Internal knowledge should be shared and externally there should be communication on what the goal is and whether everyone is on the same line. Next to this, also knowledge and opportunities should be shared to become more circular.

4.5 Key barrier and enablers for CE in the construction sector

Currently, there is a need to translate circular economy principles into practices. It is important to identify the key barriers when one wants to improve the current situation in CE for the construction sector. In this way, the transition towards a circular construction sector can be facilitated. This section elaborates on the key barriers of circular economy in the construction sector.

Tebatt Adams, Osmani, Thorpe, and Thornback (2017) analyzed the challenges and barriers of the implementation of the circular economy into the construction sector. Most of these challenges are linked to the change in the 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. This fragmented supply chain and lack of incentives at the start and end phase of the building's life cycle. The biggest challenge on the part of the client for adopting circularity in the construction sector is the unclear financial case. Cost and profit were seen to be the dominant factor in any decision-making process (Tebatt Adams, Osmani, Thorpe, & Thornback, 2017).

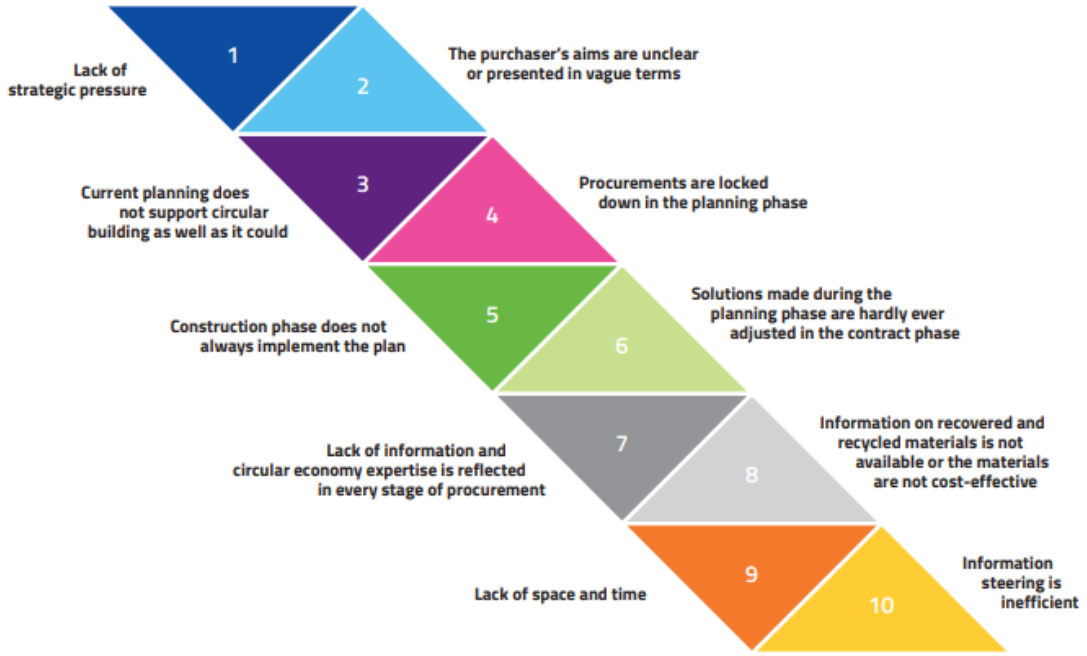

Figure 7: The bottlenecks of (circular) public procurement in construction projects.

Figure 7 displays the most important bottlenecks in public procurement regarding the circular economy. The bottlenecks are elaborated upon and an enabler is presented for every bottleneck (EIT Climate-KIC, 2019).

1. **Lack of strategic pressure**: The absence of strategic pressure makes justifying circular procurement difficult and time-consuming. The circular economy is not highlighted as a key focus area at all times. A **policy environment** should be created that incentivizes and facilitates more circular behavior. Some existing rules and regulatory policies can be barriers to the adoption of circular economy initiatives (Acharya, Boyd, & Finch, 2018). There is a **lack of a consistent regulatory framework**, which includes an absence of global consensus around policy support for CE, and a lack of targets beyond the basics.
    - A solution would be the commitment of the public sector management as higher-level strategic policies promote the circular economy and facilitate lower-level decision-making and implementation of measures. A policy is needed to help to remove barriers, like altering the definition of waste to facilitate the re-use and minimize landfill. This would support the new markets for secondary materials (Arup, 2016). The development of a reverse logistics infrastructure helps with practical issues around the reuse of materials released by refurbishment or demolition. A material marketplace, material storage facilities, upcycling facilities, etc. are all examples that contribute positively to a reverse logistics infrastructure (Hopkinson, Chen, Zhou, Wong, & Lam, 2018).
2. **Purchasers' aim not clear:** The purchasers often do not have enough knowledge of circular building. This can lead to situations in which the purchaser's aims remain unclear.
    - Purchasers need to set clearer goals and provide clearer guidance. To do so a more open-minded dialogue between purchasers, contractors, and material suppliers must be held.

3. **Current planning does not support circular building:**
    - Making room in the planning to introduce other circular solutions that can be tested. Currently, there is no time available to innovate and work on developments and tests for circular materials.
4. **Procurements are locked down in the planning phase**: The procurement of design services and project planning are the most critical steps in the circular building. In the phases that follow there is not much room for improving circular impacts. Therefore, it is important to start communicating and collaborating in an early stage from the initiative phase onwards.
    - Sufficient time and resources must be reserved for the procurement of design services and the design process itself. An important other element is **collaboration**. The construction industry is fragmented by nature, this prevents implementation of CE by separating the decision-makers from the long-term consequences of their decisions. Collaboration is required to come to common preferred outcomes. It helps to build trust and increase engagement between supply chain partners throughout the process (Acharya, Boyd, & Finch, 2018).
5. **The construction phase does not always implement the plan**: The realization of the set targets in the plans is determined by the success of the building contract.
    - It should be clearly defined how the circular targets are set in the procurement of building contracts. Next to this, it is vital to strongly engage the developer and project manager in the circular approach from the very beginning of the project, in order to implement the circular agenda in the construction phase.
6. **Solutions made during the planning phase are hardly ever adjusted in the contract phase**
    - A key enabler would be more frequent utilization of alliance or similar cooperation model, which improves the dialogue between the purchaser and contractor.
7. **Lack of information and circular economy expertise is reflected in every stage of the procurement:** Firstly, there **is a lack of interest, knowledge/skills, and engagement** throughout the value chain. This is a crucial part of the problem as progress on this is necessary to have progress on CE (Kirchher, 2018). Knowledge should be shared to stimulate the transition to a more circular economy. There is a need for greater dissemination of knowledge throughout the construction sector, with a focus on signposting the steps necessary to make the transition (Acharya, Boyd, & Finch, 2018).
    - The key enabler is education, awareness, and communication. Stakeholders throughout the value chain need to be educated and given more awareness to shift their mindset. They must be taught to think in a way that encompasses the whole life cycle (Arup, 2016).
8. **Information on recovered and recycled materials is not available or the materials are not cost-efficient:** At this moment buildings are mostly still being designed in a way that makes recycling of materials difficult once the building has reached the end of its service life. The use of many recycled materials is hindered by their lack of Conformité Européenne marking. The Conformité Européenne marking is a product manufacturer's indication that the product complies with the requirements set for it in the European Union. Next to this, there **are technical challenges regarding material recovery**. The separation of materials for example can be rather challenging. The business imperative is important for a quick clearance of the site during demolition impeding the recovery of materials that are fit for use (Hopkinson, Chen, Zhou, Wong, & Lam, 2018). There is **also insufficient use or development of CE-focused design and collaboration tools, information, and metrics**. This includes design tools and guides covering design for CE, design for disassembly, design for adaptability, a range of collaboration tools, building and material information tools, and circularity metrics.

Standardization can play a vital role in accelerating innovation in the industry as well as reuse will become easier with standardized materials (Preston, 2012).
    - Materials that can be re-utilized after demolition should be used as building materials so they can be used in the future again. It is important to consider the ways the materials are used and fastened, like adhesives. Technology and innovation can accelerate the development of the circular economy. There is a large challenge in the lack of transparency, which causes a knowledge gap in the materials a building contains and which of these can be reused, remanufactured, or recycled. Material passports can help to tackle this by providing information on the value of the material and product, their reusable or toxic content, and the ease with which they can be disassembled (Arup, 2016)
9. **Lack of space and time:** From the perspective of a building contractor there is a lack of on-site space. Next to this, a lack of time is an issue that often comes up in the context of planning, market dialogue, the definition of procurement criteria, interim storage, and on-site sorting during demolition. These are all processes that take more time than standard processes.
    - Planning that takes circularity into account can affect whether there are areas in the city structure that could be used for more effective handling of construction materials. For the lack of time, it is key to accept that learning new ways of doing things takes more time than standard, known procedures.
10. **Information steering is inefficient.**
    - Instead of information steering, the focus should be on cooperation between the environmental expert and procurement specialist and concrete planning and procurement instructions.

Next to these ten key barriers, two other important barriers influence the implementation of circular economy in the construction sector. The first one is, **leadership**, this is necessary to accelerate the transition, it has played a vital part in the delivery of existing circular construction projects. There is a need for frontrunners as they act as beacons that others are willing to follow (Acharya, Boyd, & Finch, 2018). There is confusion on who should lead (e.g. contractors, investors, construction clients) (Acharya, Boyd, & Finch, 2018). What is known however is that it is necessary to get the clients on board to stimulate demand for a circular economy.

Secondly, **finance** was three times more likely to be seen as a barrier than an opportunity. Right now, there is a need to have room for investment opportunities that see the construction sector's specific challenges. Next to this, there are **low virgin material prices** and even lower end-of-life values, which is a barrier because of uncertainties about value in the distant future (Kirchher, 2018) (Adams, Osmani, Thorpe, & Thornback, 2017). This is something that makes the buying of new materials both easier and cheaper and thus in practice, this is done most of the time. For renewable materials, it is necessary to show that the quality of the materials is high enough again, which costs both time and money. However, there are financial enablers that can lower this barrier. Whole Life Costing (WLC) is highlighted as an approach that shifts the emphasis to the value of material assets (Densley-Tingley, Giesekam, & Cooper-Searle, 2018). Furthermore, when it is difficult to win the support of involved stakeholders it may be useful to consider the easy wins, so the cost-saving inputs. These can be designed for disassembly which can simultaneously mean designing for quick assembly or develop with elements that are already there.

4.5.1 Summarized key barriers and enablers

In this section, the most important key barriers and enablers are summarized, filtered, and categorized. A selection has been made on the barriers that were mentioned most often. The key barriers of circularity are:

- Lack of strategic pressure and consistent regulatory framework
- The purchasers' aim is not clear often due to lack of knowledge.
- Solutions made during the planning phase are hardly ever adjusted in the contract phase
- Lack of interest, knowledge/skills, and engagement
- Information on recovered and recycled materials is not available or the materials are not cost-efficient and materials often need to meet a set quality level.
- Lack of space and time as new innovative processes take more time than standard, known procedures
- Information steering is inefficient
- Finance and low virgin material prices.

There are also key enablers that were identified within the literature. These help to make it possible and potentially easier to realize a circular economy in the construction sector.

- The insufficient commitment of the public sector management. This includes a policy that helps to remove barriers, incentivize and facilitate more circular behavior, and promote reverse logistics.
- An open dialogue between the stakeholders should be held to help to get the purchasers' aim straight and to get everyone on one line.
- More time for the testing and research of new circular solutions and to have a dialogue with all stakeholders
- Communicate and collaborate in an early stage and get people engaged from the beginning onwards
- The circular targets should be clearly defined in the contract.
- More frequent utilization of alliance or a similar cooperation model, which improves the dialogue.
- Knowledge should be shared to stimulate the transition to a more circular economy.
- Education, awareness, and communication throughout the value chain
- The modularity of new designs
- Standardization of materials and connections
- Material passports
- Focus on cooperation between environmental expert and procurement specialist
- Whole Life Cycle Costing (WLC)
- Focus on easy wins.

4.6 Responsibility in contracting

When focusing on circular procurement it is important to focus on who has responsibility for which part of the process. The figure below shows the responsibility per phase for a UAV, which entails the uniform administrative conditions all companies in the construction sector in the Netherlands should comply with. Different forms of collaboration are shown that exist in the Netherlands and each collaboration form has a different level of responsibility for the client and contractor.

In Figure 8 the most important collaboration forms in contracting are shown. It emphasizes that the responsibility for a certain phase is different for every collaboration form and this should be considered when choosing a form. What is illustrated is that in a traditional contract like UAV/RAW there is a lot of responsibility and research at the client. When the contract becomes more integrated or Turnkey for example then there is more responsibility attributed to the contractor, meaning that he has to make a Program of Demands, design, and do all necessary research.

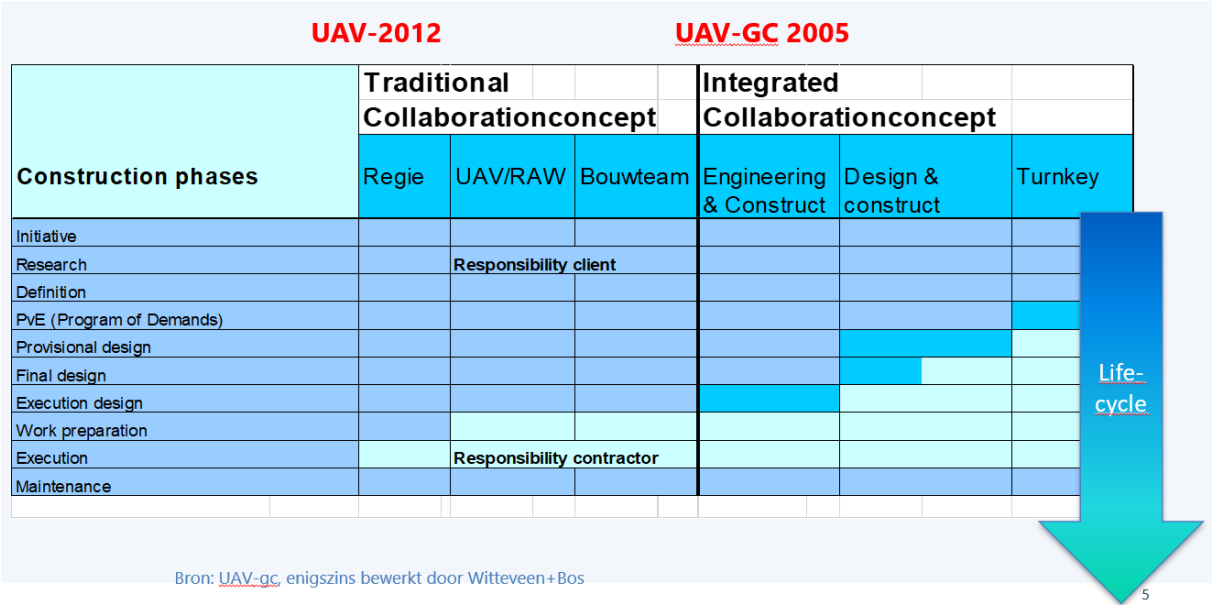

Figure 8: Responsibility per phase. Source: (CROW, 2005)

Figure 9 is created by Witteveen+Bos to show the phases of the procurement process on the horizontal axis and the different collaboration forms and risk division on the vertical axis. The message of the graph is to show that there is a big difference in the amount of influence a client or contractor has when choosing a different contract form. Yet in an early contractor involvement, there is a lot of room in the first phases to have a collective influence and to work together.

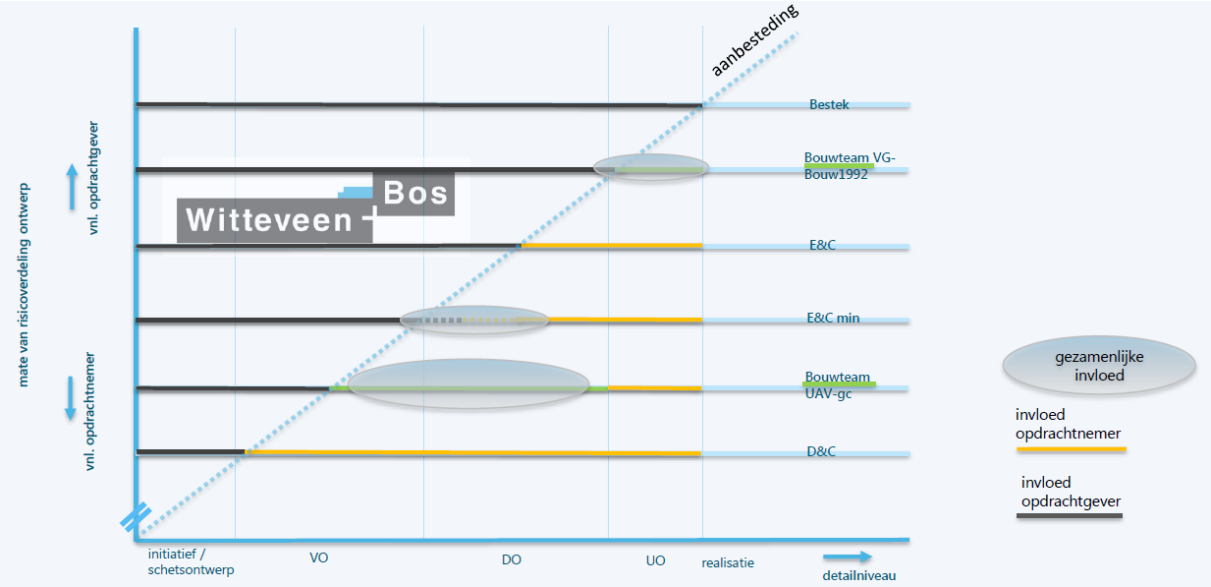

Figure 9: Risk division per collaboration form. Source: Witteveen+Bos

5 Results

This chapter presents the results of the research. The results from the case studies and corresponding interviews are presented and elaborated upon. From these results and the literature, the first version of the flowchart is conferred and then validated by multiple expert panels. In the penultimate sub-section, the final flowchart is presented and this is translated into a poster for Witteveen+Bos.

5.1 Interview results

In this section, the interview results are presented. This is done according to the categories that were created during the axial coding. The following categories arose decisions at the start, decisions regarding barriers, decisions during the preparation, and decisions towards the end. All these elements and decisions combined with the literature make a first version of the flowchart, which is shown in Section 5.3. The results per core category are elaborated upon in Sub-sections 5.1.1 until 5.1.4.

The interview questions are included in Appendix B. The results are then transcribed and this is attached in Appendix C. The questions also have a categorization, this is shown in Appendix D as the succinct answers per category are summarized here.

5.1.1 Decisions at the start

This sub-section discusses the key decisions that should be made at the start of the project.

Clear goal and ambition

All interviewees agree that the start of the project is the most vital phase to start with the ambition of circularity and that it is important to make it an integral part of the process. The ambitions at the start of the project are either extremely specific or vague. The latter happens most often. For example, in the project for the NRU, there was the following ambition: '*We want to make the project as circular as possible'*. There was no clear procurement because the ambition was vague. According to multiple individuals, it is helpful however to have some guidelines and a frame of mind. This helps to give direction to the ambition of circularity, especially when a realistic direction is provided that has an impact. Yet some other projects like the Ritsumasyl have a clear goal, which was using a biobased material. But also at the Cruquiusbridge, there was a clear start ambition with a focus on three themes: circularity, energy neutral, and low maintenance. And circularity soon had an interpretation which was IFD building. This clear goal helps with the translation of the ambition to workable measures and practices.

Early involvement

Another important element according to individual H is that involving people in an early stage is necessary as the ambition should be integrated from the start. Furthermore, a repeated decision was having a concrete ambition and focus at the start as this is seen as helpful for the entire project. Simply stated it is perceived better to have a focus than to try to do everything.

Quantify

The determined ambition, based on the Ambition Web, should be translated into a concrete goal that is measurable when possible. Individual S mentioned that they tried to make circularity

quantifiable, in this way it is easier to make a trade-off between other key elements. Next to this, you can reflect on the success of the project afterwards if you have a clear KPI. The most useful indicators and tools that have been mentioned are the indicators of CB'23, + Circular Design Tool, % Primary materials, future proofness, value maintenance, preventing degradation, and MKI.

Involve stakeholders

Furthermore, every stakeholder has to work towards the same goals and understand the added value. As individual P stated: '*It is important to be on the same page with especially the client and contractor'*. Next to this, several interviewees mentioned that the entire chain should be involved in the decision-making process to make sure everyone has the same concrete goal. Especially involving the maintenance ('*beheer'*) may be of high importance as they often have a different perspective. When focusing on communication the right individuals should be involved from the start and Early adaptors should be included who are motivated and enthusiastic.

Decide what is not necessary to execute

Lastly, another reoccurring element that has a high impact reduction is to not do anything that is not necessary or that does not have to be built. This means that no impact should be made when this is not necessary. For example, when a client asks for an entirely new road and the crash barriers have just been replaced two years ago it is not necessary to entirely replace those as well or another example is when a new building should be built and a repairment of the old building is possible then this should be considered as well.

5.1.2 Decisions during the preparation

This sub-section discusses the key decisions that should be made during the preparation. Once the ambitions and goals and their KPIs are determined and the starting phase ends, the preparation and research phase starts.

Room for innovation

After determining the goals there should be a check on whether there is for innovation. If the decision is made that there is no room for innovation then the easily applicable circular options may be chosen, a few examples and ideas were provided by the interviewees. These decisions include making the object futureproof, not doing more than the set project goals, minimalizing transport distances, applying value engineering, and using materials with a low impact (MKI). A summary of the enabling tools that include easily applicable circular options is included in Appendix E. In the question itself, the option of a material passport was included, yet there were different opinions on this. Some thought this was easy to apply, yet most people thought that this was difficult to implement and maintain. Individual Q stated the following: '*A material passport is often a lot of work and maintenance so when there is no time it is better not to commit to this.'*

No room for innovation

Next to this, the conclusion can also be that there is room for innovation. Then it is important to start considering the opportunities and chances. However, according to Individual U, the functional unit of an object should be determined first. This means that the function of the object should be determined, i.e. when you want something that lets cars go over the water then the function is described. The possible options can be elaborated upon, like building a bridge, pond, etc.

Further key decisions

A few key decisions were mentioned multiple times in this phase. The first key decision is that research should be done on the opportunities and chances that are there, this may be executed by the client, contractor, or Witteveen+Bos based on the contract form that has been chosen. Also when one knows exactly what he wants to tender then doing the research and following steps are not necessary. When reusing materials a zero measurement and +Reuse Quick Scan are both helpful to give an insight into the materials that are there and their state. After researching the opportunities and chances a weighted point analysis should be executed to determine where the biggest impact can be made. In this phase, the different designing options should also be considered and a key element is that the object is circular for the future, meaning that it should be easily reparable, detachable, and reusable. Individual R highlighted this as it makes no sense to design something know that is not circular for the future if we want to go to a circular economy in the future. Then the least that should be done is to make sure that the object can be reused and easily repaired.

Communication

Furthermore, communication and aligning all stakeholders involved is a key element in this process. If people are not on the same page, work towards the same goals and see the added value, it becomes very hard to improve together. To make sure everyone is on one line a dialogue should be held. In which ownership, material passport and risk mitigation are a part. Another integral part should be to determine what you want to do yourself and on what elements you want to collaborate with other parties. This is all part of choosing the right procurement strategy, which is a key element in the process and it is necessary to spend enough time deciding this and communicating with other stakeholders. A piece of advice that was provided by both Individual P, Individual Q, and Individual H is that early contractor involvement is an advantageous collaboration form, especially for innovations.

Long term relationship

In the long term, it may be helpful to have a long-term relationship with a client. Like Individual R mentioned they have a relationship with the province of North Holland in which they do multiple projects together that have a high ambition on sustainability and circularity. This helps to overcome barriers and bottlenecks that were encountered in the previous project and to take that information as input in the new project to make sure the same mistake is not made.

5.1.3 Decisions regarding barriers

This sub-section discusses the key decisions that should be made regarding the barriers that are met during the project.

Three most common barriers

During the process of trying to implement and realize circularity, several barriers are met. There are a few barriers that were mentioned almost unanimously, which are the lack of time, money, and demands that conflict with the circularity goals. The key barriers and enablers are summarized in Appendix E. These three barriers were mentioned in nearly every interview that was conducted, which makes them interesting to delve into. The time and money barrier are strongly connected to the fact that new projects or innovations often need more time to do research and in projects like these this time costs money. Therefore, both money and time are barriers that are being met in almost every project that has a high ambition on circularity. A solution to these barriers is to bring these barriers up and discuss them and search for room for possible extra research. Every stakeholder should be aware of the fact that circularity takes more research time. As Individual U stated: '*More information should become available regarding the life span and materials and this may cost more time.'*

Conflicting demands

The other barrier that was mentioned before is the demands that conflict with the circularity goals. This is something that reoccurred in every interview. These demands vary from standard demands like a life span of 100 years minimum to esthetical demand, which states that an object should have a completely clear surface. It is important to consider the function of the demand and to confirm if there is still room in the demand and there is no clear function, then it may be helpful to adjust the demand to give room to circular alternatives.

Lack of knowledge

A more general barrier that is being met, is the fact that a lot of people do not have sufficient general knowledge regarding circularity. This is something that takes more time to solve and is thus the long term. A short-term solution that Individual R offered is the fact that for know it may be helpful to inform people on who to contact for questions regarding circularity and to share this knowledge.

5.1.4 Decisions toward the end

Lastly, some decisions need to be made or considered. These are shortly summarized. As mentioned multiple times by Individual S, Individual Q, and Individual R for example if you know exactly what you want to realize in the project, write it down in the demands of your contract. When you do not know exactly what you want it may be useful to have a market consultation to research what is feasible. Something that may help when you do not have the exact fitting solution yet is making more functional specifications to leave some room to the market and to let them think along. A big downfall may be that you may get something completely different from what you wanted as it does fit in the functional specifications. Therefore, the functional specification should be specific.

5.1.5 Flowchart

From the previous Sub-section 5.1.1 until 5.1.4 a first version of the flowchart was created which is shown in Figure 10.

5.2 First version flowchart

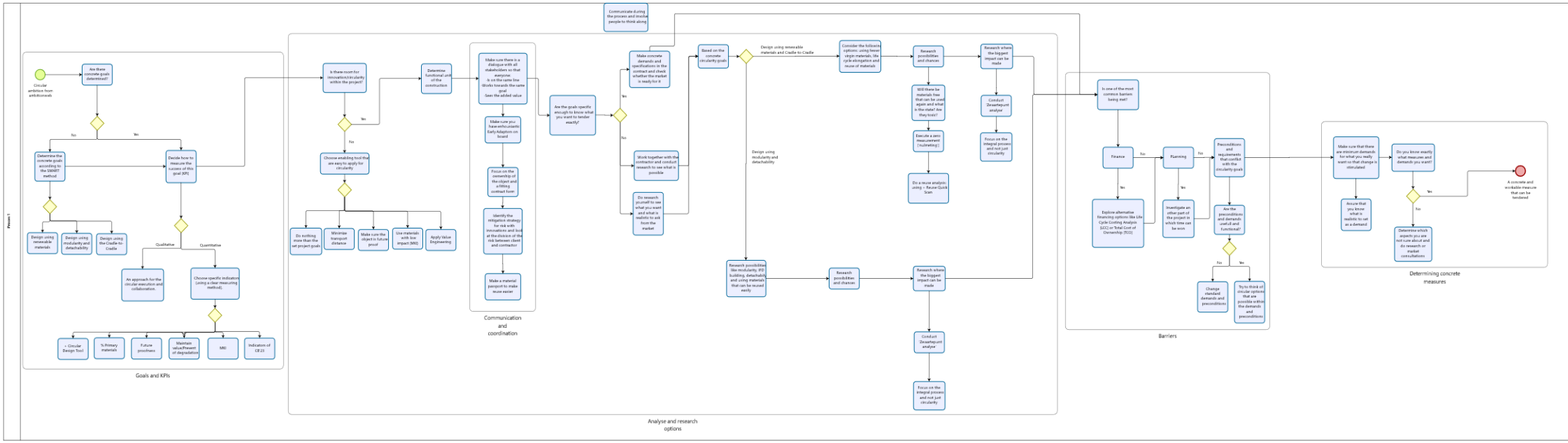

Figure 10: First Version Flowchart

5.3 Expert panel

The goal of the expert panel is to validate the flowchart and give room for possible improvements and comments. There were three expert panels in total. In Section 5.3.1 the results per expert panel are shared and the key improvements are mentioned. These were then altered after the expert panel and those changes were used in the following expert panel. The expert panels were structured by guiding questions, which are attached in Appendix F. Yet an open attitude was persisted as the goal was to gain information on possible improvement and validation.

5.3.1 Expert panel results

The questions that were asked are attached in Appendix F.

Expert panel session 1

This expert panel consisted of Individual Q and Individual B. The concluding feedback and ideas are shared and a new version of the flowchart was made taking the feedback into account. The following feedback was provided:

- Why does the flowchart start with the ambition web as not every project starts with a filled-in ambition web? Maybe add this as a decision.
- It is especially necessary to make sure everyone knows what the goals are clear and where the focus will be.
- Isn't the barriers sub-process a recurring element that should count for multiple phases? The barriers are important in the start as well as a lot of people state things are impossible due to possible barriers. This is even more regarding the prejudices of possible barriers than of the realistic barriers. It is necessary to monitor the barriers continuously if they recur.
- There are five strategies that you can decide from regarding circularity. These are in the *conceptleidraad* of CB'23. If you change them to this they will be more in line with the CB'23.
- For quantifying circularity, leave the indicators and circular design tool out.
- Is it necessary to keep qualitative in the flowchart?
- Make sure that there is room for the clarification of exact definitions, like energy-neutral i.e. It is rather challenging to go from organizational goals to project goals as they can differ. This can also be regarding the phase in which, for example, a building should be energy neutral.
- There is a need for a guide on how to do research
- Maybe it is an option to match the question of room for innovation to the ambition level that is set at the start of a project. The levels can be 1, 2, or 3.
- Change making an object futureproof to making sure that there are no lock-ins.
- The tender procedure has an influence as it can guide the decisions that are made in the process.

Expert Panel session 2

This expert panel consisted of Individual V, a contracting advisor. The concluding feedback and ideas are shared and a new version of the flowchart was made taking the feedback into account. The following feedback was provided:

- In practice, there is always a relation between the tender strategy and what part of the designing and execution is for Witteveen+Bos and what will be done by the contractor.
- The tender strategy should be changed to procurement strategy, this includes the contracting and tendering

- An important side note is that you will always do, a little bit, of research beforehand. Whether you let a contractor design everything or not.
- Add a subgroup for the decision making of circularity goals, which states '*Conform CB'23'*
- Add grants for financial barriers
- Add option of taking more time for planning barrier
- Add policy in the demands and conditions that conflict with circularity
- Change the question of '*Are there conditions…?*' to *'Is there room to change the policy- or boundary conditions?'* This means for example that you should get into contact and have a conversation with RWS.
- If the ambitions are high, at level 2 or 3, then invest time in trying to change the demands and conditions
- The first time with an ambition web you will consider all opportunities. It is good that you see what that means for the project in terms of time, money, demands, etc. as well.
- Think of having a check-in at every design loop to check the KPIs and barriers
- At the part of '*Are the goals specific enough…?*' add the option of a market consultation
- Lastly, it is interesting to consider the interactive document of Individual W, another Industrial Engineering and Management student.

Expert Panel session 3

This expert panel consisted of Individual D and Individual M. The concluding feedback and ideas are shared and a new version of the flowchart was made taking the feedback into account. The following feedback was provided:

- The four separate parts are being recognized and acknowledged
- The language choice should be consistent, i.e. what is sustainability and what is circularity.
- The organizational question is missing. Is there the same wish in the organization as in the project? A key element in this is expectation management, especially when new ideas arise and when there are innovations. It is good to share and talk about the risks.
- The part '*Decide what you want to…*' is crucial indeed
- There are more options for easy circular options. These are some examples, that may even overlap, and it is not exhaustive.
- The question is being asked whether communication isn't a continuous process. It may be good to add that communication is different in each phase and has a different focal point.
- May be good to add a communication block in between decisions (to verify whether you are still on the right track). This can be connected to a design loop.
- You should have market consultations for innovative things, yet it is important that you have a clear goal and focus beforehand and that all stakeholders agree
- Make market consultations a separate step that then helps to decide how to collaborate further.
- The procurement strategy question should be later in the process after communication
- Think of considering whether the design loop can be integrated

5.4 Final flowchart

The feedback provided during the expert panels is the basis of the final version. The most commonly added feedback is linked to:

- The order of decision elements
- Missing or incomplete decisions or elements
- Minor adjustments in language
- Unclear elements in the flowchart

Furthermore, feedback from the University of Twente and the supervisor from W+B also helped to adjust some elements and especially rephrase parts to make them easier to interpret. The feedback resulted in changing of text, sentences, and the order of elements in the flowchart. Furthermore, advice was given on how to translate this version to a poster.

The feedback from the supervisors and expert panels resulted in several adjustments in the flowchart. These adjustments are shown in Figure 11.

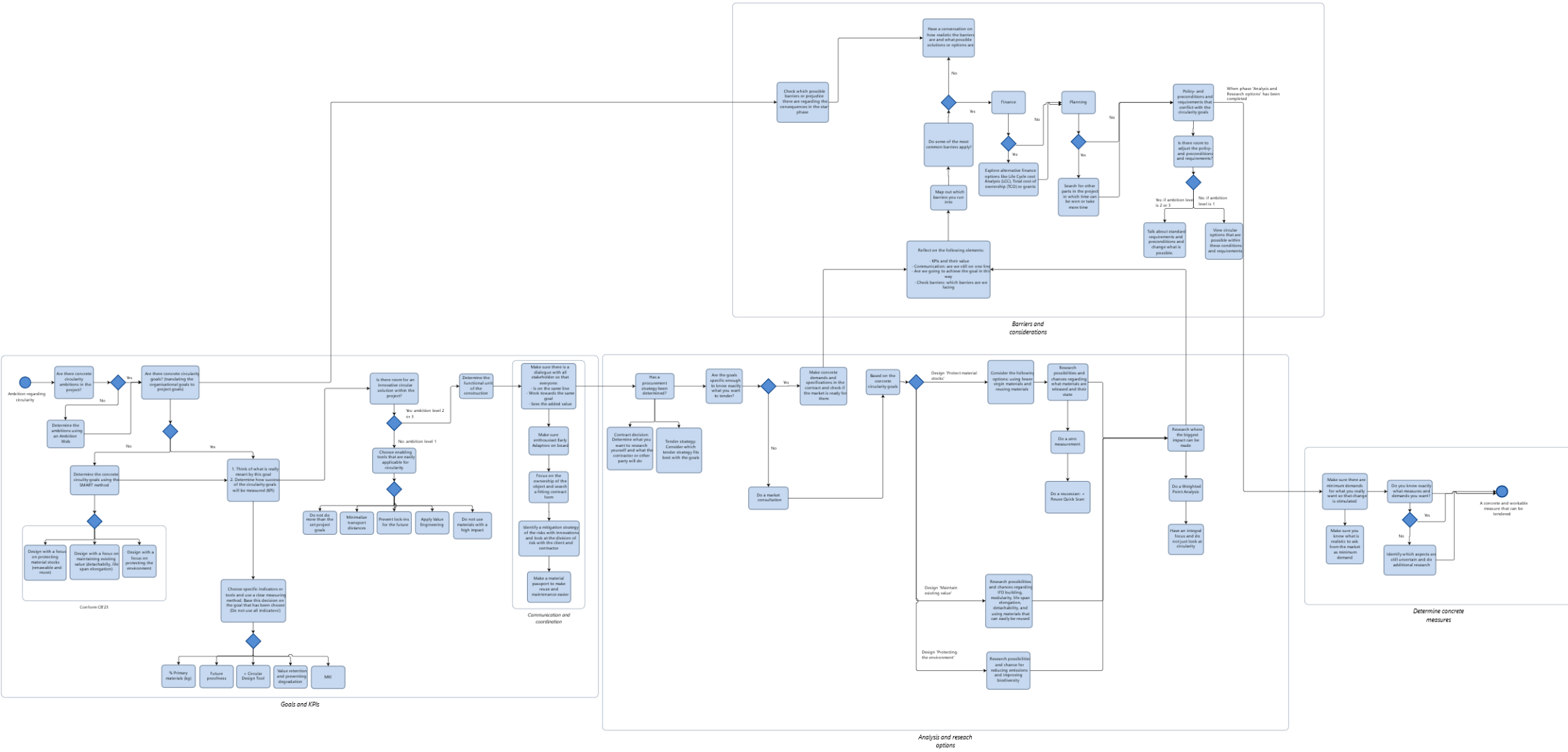

Figure 11: Final Version Flowchart

5.5 Elucidation flowchart

This section functions as an elucidation for the flowchart. This helps to make the interpretation easier. The elucidation is divided into the four phases of the flowchart, which are goals and KPIs, analysis and research, barriers, and determine concrete measures. In each phase, the different elements are explained.

5.5.1 Difficult terms explained

Term	Explanation
SMART	SMART means Specific Measurable Attainable Relevant Time-based
KPI	KPI means Key Performance Indicator
Life span elongation	Life span elongation means making sure an object has a longer lifespan
% Primary materials (kg)	Primary materials are materials that are virgin and directly come from the resource. This percentage is measured in kilograms.
Future proofness	Future proofness means easily to detach, maintain and adjust
+ Circular Design Tool	+ Circular Design Tool is a tool made by Witteveen+Bos that is easy to use and it provides insight into the use of materials in design projects.
Value retention	Value retention means to try to keep materials at a high value for most of their lifetime
MKI (= ECI)	MKI (=ECI) means Milieu Kosten Indicator or Environmental Cost Indicator respectively
Lock-ins	Lock-in means that the option to adjust or reuse the object becomes more difficult becomes it became impossible
Value Engineering	Value engineering is used to eliminate and identify unwanted costs. It is used to optimize initial and long-term investment, searching for the best possible value for the lowest cost.
Functional unit	The functional unit includes describing what aspects the object should fulfill
Early adaptors	Early adaptors are people who are innovating before others
Market consultation	A market consultation is a way of consulting market parties about a proposed tender
Zero measurement	A zero measurement shows the current situation so that defects in adjacent can be easier detected
+ Reuse Quick Scan	The + Reuse Quick Scan is a tool that helps to explore the value of existing assets.
IFD building	IFD stands for Industrial, Flexible and Dismountable, which uses standard connection so that buildings can be easily adjusted and maintained and so that necessary materials can already be produced.
Weighted point analysis	The most relevant attributes and elements are assigned a weighted depending on the

	importance of the overall performance. This is regarding the amount of impact each attribute or element has. An element with a high impact will have a high weight.

5.5.2 Phase 1: Goals and KPIs

In this sub-section, the first phase is explained step-by-step to make sure the reader understands all decisions that are included. This phase concerns the goals and KPIs that should be set at the start of a project.

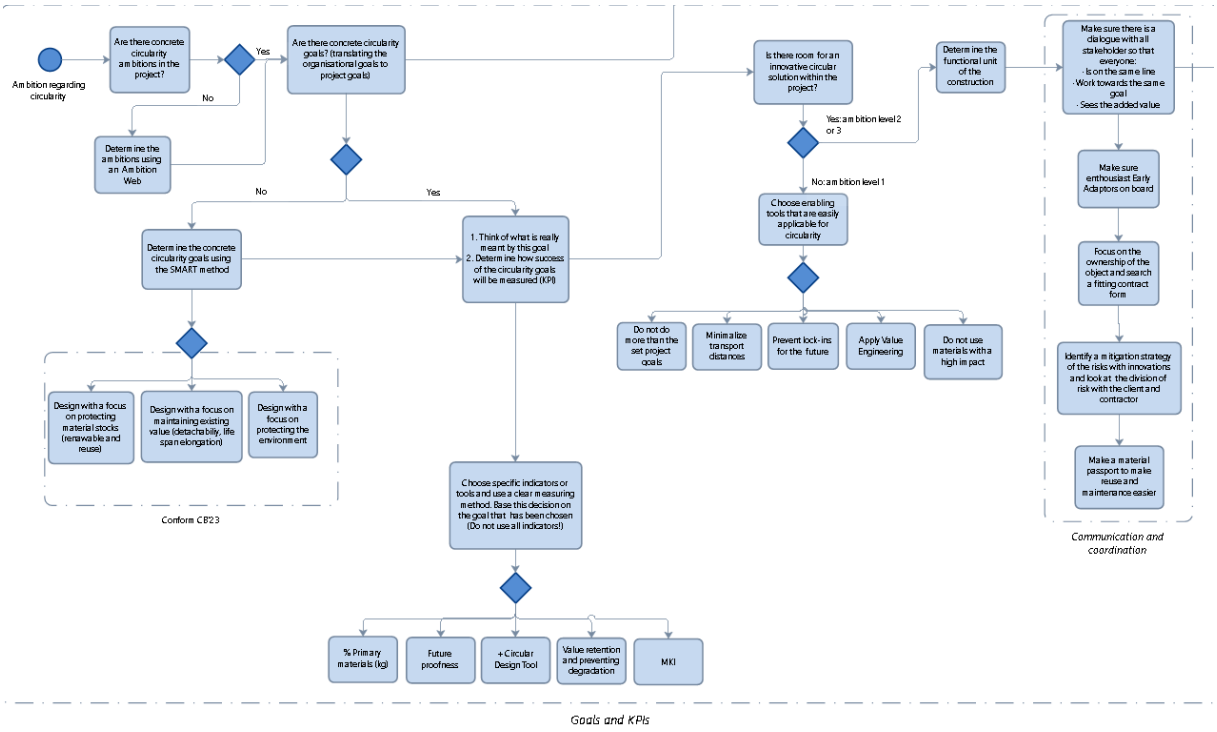

Figure 12: Flowchart Goals and KPIs

Goal

Figure 12 shows the first phase, which is the phase in which the ambition is laid down to a concrete goal that becomes measurable if possible. In this way, it should be determined where you want to work towards and when the goal will be achieved and marked as successful. The concrete circularity ambitions and goals of the project should be determined first if these are not yet determined. The circularity ambitions of the organization and social context of the project are relevant for the determination of the ambitions and goals of the project.

Input

The input of this phase is an ambition regarding circularity.

Decisions

Firstly, be aware of the fact that decisions can be made by different parties. This is dependent on the collaboration form that is chosen, yet the steps in the flowchart need to be executed anyways. Therefore, predetermined decisions must be made. Each decision is elaborated upon in this paragraph.

1. *Are there concrete circularity ambitions in the project?*
   a. Yes → Go to next question
   b. No → Determine the ambitions using an ambition web

The organizational vague ambition should be translated into a concrete ambition for the project as this gives a focus to the project. The Ambition Web is a tool that can help to visualize this.

2. *Are there concrete circularity goals determined? (translating the organizational goals to project goals)*
   a. Yes → Go to next question
   b. No → Determine the concrete circularity goals (According to the SMART method)

In this step, the concrete goals have to follow the SMART method. If the answer to question 2 is no, then the first step is to create a concrete goal. Three focus areas are given based on the CB'23. These include designing with a focus on protecting material stocks, designing with a focus on maintaining existing value and designing with a focus on protecting the environment. These goals can later be used to do appropriate research.

3. *Think of what is really meant by this goal and determine how to measure the success of the circularity goals (using a KPI).*

The first part of this decision covers the aspect of thinking about what is meant by this goal, which should be done to define what the goal means for this project. For example, when something should be energy neutral define whether this is in all phases or only the user phase. Also think of what efforts need to be made to achieve this goal, for example in the areas of budget, planning, etc.

The second part consists of the determination of how to measure success. It is necessary to choose specific indicators or tools and use a clear measuring method. Base this decision on the goal that was chosen. A piece of advice is not to use all indicators. Possible indicators that can be used are:

- % Primary materials (kg)
- Future proofness
- + Circular Design tool
- Value retention and preventing degradation
- MKI

4. *Is there room for an innovative circular solution within the project?*

This is a critical question to ask as you have your concrete goal now but checking whether it is realistic. This decision is based on the ambition level chosen at the first level. If the ambition is only one, then it is good to consider the enabling tools that are easily applicable for circularity. Some examples are:

- Do not do more than the set project goals
- Minimalize transport distances
- Prevent lock-ins for the future
- Apply value engineering
- Do not use materials with a high impact

There is some discussion on how easily these are applicable, however, focusing on these options may help to give a direction and thus have an impact.

On the other hand, if the ambition level is two or three the following step will be entered as the assumption is made that there is sufficient room for innovative circular solutions.

5. *Determine the functional unit of the construction*

The fifth step is to determine the functional unit of the construction. This means that the function of the construction is determined functionally, meaning that if the goal is to create an object that can make sure cars can pass the water then that is the functional unit. Options may be a bridge, pond, aqueduct, etc. This leaves freedom in the design choices without losing the focus on what the final function should be.

6. *Communication and coordination*

Communication is key in this process. Especially regarding new initiatives and innovations, you should make sure everyone is on one line and that everyone works towards the same goal and sees the added value of this. Key elements that should be covered in this sub-phase are to make sure you have enthusiastic people and early adaptors on board. Next to this, ownership of the object should be discussed including a fitting contract form, like as a service or lease. Penultimately, identifying a mitigation strategy for the higher risk profile of innovations should be researched. The additional risk and mitigation are points of discussion that must be included in the process. The contractor often does not want to take the additional risk for his account fully and therefore it is necessary to talk about this to realize circular goals. Lastly, discussing a material passport and the managing of this is convenient for circularity in the future to make reuse and maintenance easier.

5.5.3 Phase 2: Analysis and research

In this sub-section, the second phase is explained step-by-step to make sure the reader understands all decisions that are included. This phase concerns the analysis and research during the project, which means that the set goals at the start should be analyzed and researched. The decisions that are included in this phase are discussed in this section.

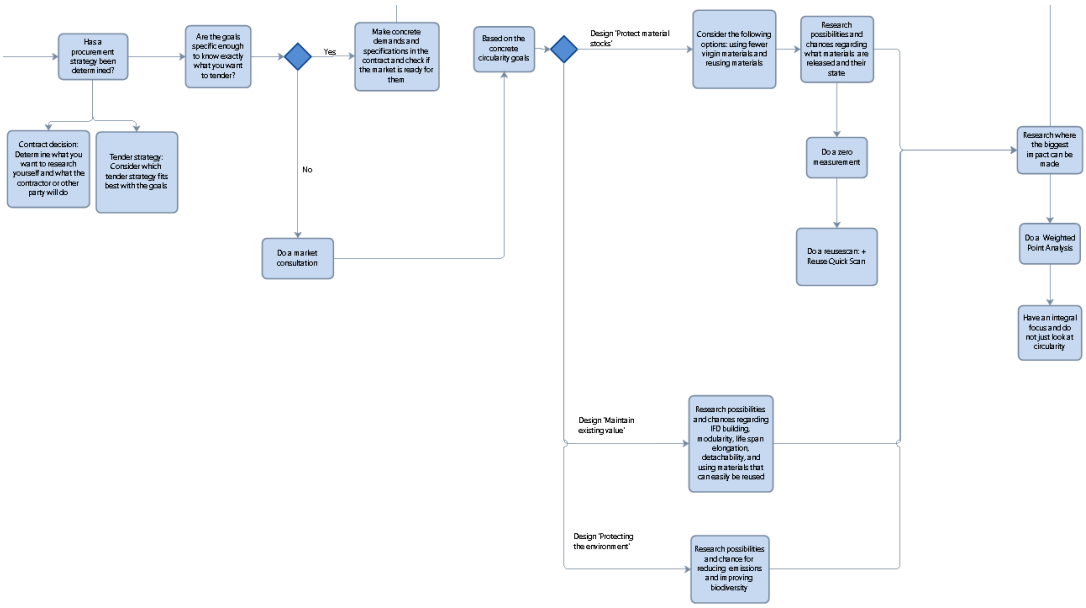

Figure 13: Flowchart analysis and research phase

Goal

Figure 13 illustrates the analysis and research phase. The goal of this phase is to research the goal that is determined in the previous phase. This is mostly being done by asking questions on whether it is realistic and feasible and on where possibilities and chances are. A crucial understanding of this phase is the fact that the decisions in this phase may be executed by different parties based on the procurement strategy that is chosen.

Input

The output of this phase is a clear and SMART goal in which the first, but meaningful, communication between all stakeholders has taken place.

Decisions

The key decisions in the analysis and research phase start with considering a procurement strategy.

7. *Has a procurement strategy been determined?*

The procurement strategy consists of two parts, the contract decision, and the tender strategy. The contract decision means that you determine what you want to research yourself and what the contractor or other party will do. The tender strategy means considering which tender strategy fits best with the goals. These two things should be considered once there is a general idea of what the goal is and how it should be measured, and when a first communication phase has been finished as well. Then the procurement of the project should have a focus.

8. *Are the goals specific enough to know exactly what you want to tender?*

In some projects, there is a clear aim or interpretation of the goal already. There should be a check on whether it is realistic and if this is the case then the demands and specifications should be concretized, and the next phase can be entered.

If the goal is not specific enough yet to know what to tender, then it may be useful to do a market consultation and see what is possible and realistic. This may be a good step if you do not know what to tender concretely.

9. *Research focus based on the concrete circularity goals*

In the previous phase, the goals of circularity were determined and in this part of the process the decision will be made on what area the focus will be given three options:

- Design 'Protect material stocks'
    - This design focus tries to assure that materials are depleted as little as possible and thus the focus will be on using fewer virgin materials and reusing materials. When doing the latter a zero measurement ('*nulmeting'*) and + Reuse Quick Scan are helpful.
- Design 'Maintain existing value'. With this focus, the options may be IFD building, modularity, life span elongation, detachability, and using materials that can easily be reused. These options all take the maintenance of existing value into account and being able to reuse in the future.
- Design 'Protecting the environment'. With this focus, the options are on reducing emissions and improving biodiversity.

After this, it is the focus is on where the biggest impact can be made by doing a weighted point analysis and by integrating circularity as an integral part of the project, but not focusing on circularity only.

5.5.4 Phase 3: Barriers and considerations

In this sub-section, the third phase is explained step-by-step to make sure the reader understands all decisions that are included. This phase concerns the barriers and considerations that are being met during the project. This phase can be entered at multiple moments in the project.

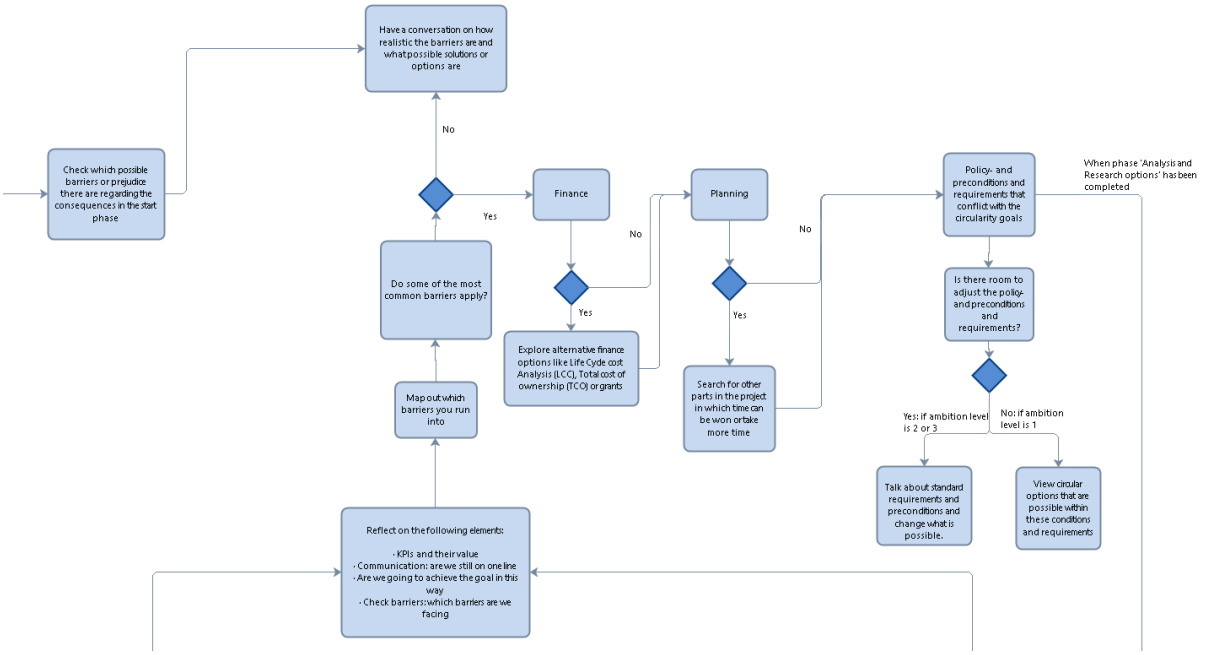

Figure 14: Flowchart barriers and considerations phase

Goal

Figure 14 illustrates the barriers and considerations phase. The goal of this phase is to consider the possible barriers that can be encountered. The three most common barriers from both the interviews as literature are featured. For other barriers, a conversation should be held. This is a key phase as circularity ambitions often end because of these barriers.

Input

Either a circularity goal at the start (1) or a concrete goal that can be tendered (2).

Decisions

Both inputs have a different starting point. (1) starts at decision number 10 and (2) starts at decision number 11.

10. *Check which possible barriers or prejudice there are regarding the consequences in the start phase.*

For (1) it should be checked which possible barriers or prejudice there are regarding the consequences at the start of the phase. Often in projects, people mention a lot of barriers at the start when trying to brainstorm and determining ambitions and goals. It is important to talk about these barriers and see how realistic they are and what possible solutions or options are.

11. *Reflect on the following elements*

There is a continuous reflection loop in the process in which the focus is on how things are going regarding the set goals at the start. This loop is simultaneous to the design loop, in which there is room to reflect on the design in the end with regards to the budget for example. This loop reflects on the following elements:

- KPIs and their value
- Communication: are we still on the same line?
- Are we going to achieve the goal in this way
- Check barriers: which barriers are we facing?

12. *Map out which barriers you run into*

From the last question in the reflection loop, it seems to be important to check which barriers you run into. These can include any sort of barrier.

13. *Do some of the most common barriers apply?*

Once the barriers are mentioned they should be checked on whether they include one of the most common barriers, like

- **Finance**. It is possible to explore alternative finance options like LCC, TCO, or grants.
- **Planning**. Researching the options to either save time on other parts of the project or to make the decision of taking more time.
- **Policy- and preconditions and requirements that conflict with the circularity goals.** For these, there should be a discussion on whether there is room to adjust them. If this is the case, when the ambition level is 2 or 3, you should have a conversation on changing those that are realistic to change. If the ambition level is 1 then there is probably no time to change them and thus you should dive into other circular options that are possible within these conditions and requirements.

If the analysis and research option phase has been completed the last phase should be entered.

5.5.5 Phase 4: Determine concrete measures

In this sub-section, the last phase is explained step-by-step to make sure the reader understands all decisions that are included. This phase concerns the determination of concrete measures and can be seen as the final phase in which just two important decisions should be made and taken into account.

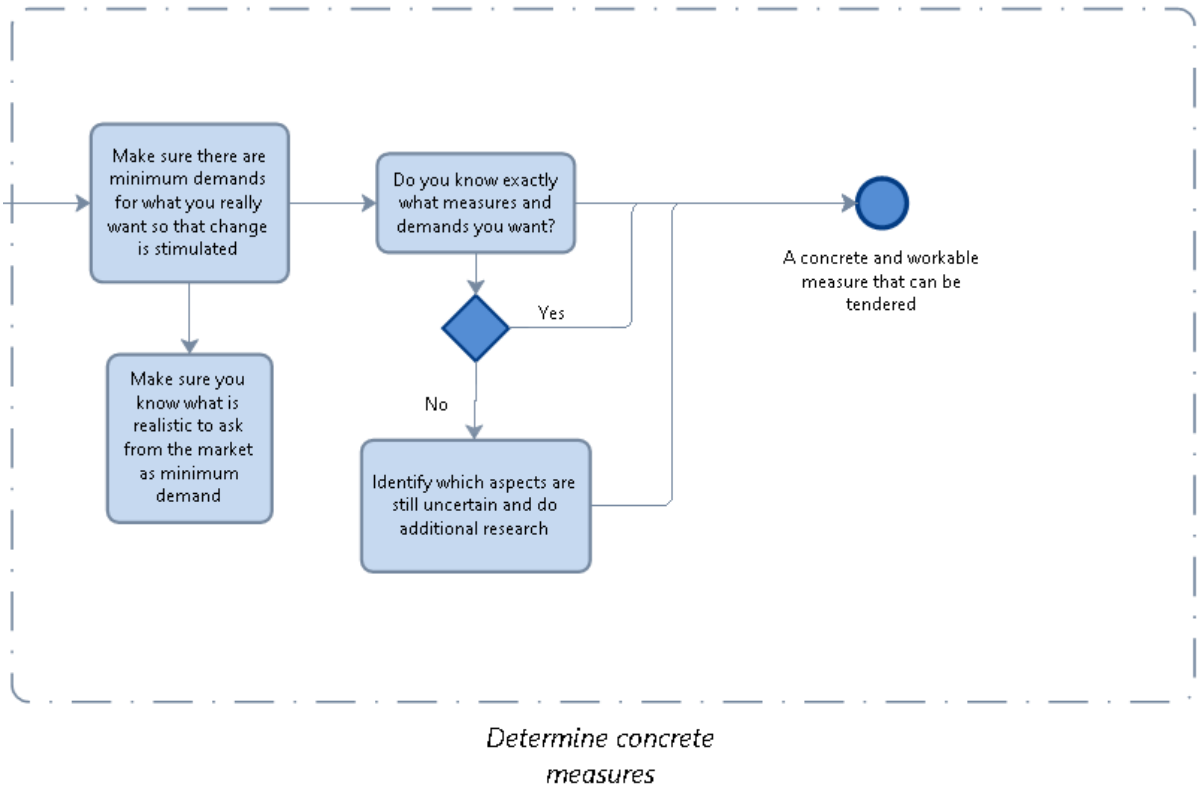

Figure 15: Flowchart determine the concrete measures phase

Goal

Figure 15 shows the phase in which the measure is concretized. A key decision and consideration is whether it is known what the exact demand to tender is. This phase helps to get you to the final goal of having a concrete and workable measure that can be tendered.

Input

Concrete goals that can be tendered and that have finished multiple reflection loops.

Decisions

14. *Make sure there are minimum demands for what you really want so that change is stimulated*

If you know what you want to tender then it is necessary to make sure you set minimum demands for this as it stimulates changes and gives the guarantee of getting what you tendered. A more open tender is possible as well i.e. in award criteria but this may lead to an unfulfilled circularity goal.

15. *Do you know exactly what measures you want?*

If the answer is yes then you are at the final goal of a concrete and workable measure that can be tendered. If the answer is no, then it is necessary to identify which aspects are still uncertain and to do additional research on those aspects and see where your chances are. This may lead to going back to phase 2 again. It can also be the case that there are a lot of barriers to the option you have right now, so when that happens considering alternatives that may be useful.

5.6 Deliverable Witteveen+Bos

A poster is created for Witteveen+Bos, this poster will not be published publicly.

6 Conclusion, discussion, and recommendations

In this chapter, the steps that are taken to conclude the research are reviewed. In Section 6.1 the conclusion of the research is provided. In the conclusion, the main research question is answered including the sub-questions. In Section 6.2 the discussion of the research is given. In the discussion, the major findings and their meaning are reviewed and limitations are mentioned. Section 6.3 highlights the relevance of the research. Lastly, the recommendations are given.

6.1 Conclusion

In this section, the main question, that was composed at the start of the research, is being answered. The main research question is:

> *What are the core decisions with respect to the anchoring process of circularity ambitions of the Dutch government in the form of workable measures or practices in the definition, planning, and design phase in the construction sector?*

We found the following core decisions, which are in line with the four categories that were created in the final flowchart. These categories represent the different phases. The decisions and categories are as follows:

Goals and KPIs

- Determine what the concrete circularity ambitions and associated goals are, whether they are realistic, and how to make the goal measurable using KPIs.
- Communicate and make sure that everyone is on the same page as this is crucial for the success of the realization of circularity.

Analysis and research

- Analyze and research what the opportunities and chances are and where the biggest impact can be made. A note is to determine the procurement strategy and thus the contract and tender forms. The research area is determined by the circularity goals determined in phase 1.

Barriers and considerations

- Make sure there is a reflection on the current idea and initial goals. Furthermore, the barriers that are met should be reviewed.

Concrete measures

- If it is known what you want to tender, then this should be included as a minimum demand.

A flowchart and poster have been created from these core decisions. We do this at the request of Witteveen+Bos as they pointed out that a visual overview of the concrete steps and decisions of the decision-making process creates more insight and supports contract managers.

Further remarks regarding key barriers and enablers will also be shortly answered in this conclusion. From both research and literature, there were some key barriers that arose. One of the largest barriers is the financial reasons as there is often not sufficient budget and virgin materials are cheap. Secondly, there is a lack of space and time as new innovative processes take more time than standard, known processes. This is a key barrier as most projects do not take this extra time into account or simply have no room for this extra time. Lastly, there is insufficient strategic pressure and room within standard demands. Demands from regulatory institutions often conflict with circularity ambitions and often there is no room to change those demands.

Next to this, some key enablers emerged from both literature and the conducted interviews. Having an open dialogue between all stakeholders is a key enabler because each party should be involved to make sure they are all on one line and see the added value for them. This should be done at an early stage already. The other key enabler is to clearly define the goal that the project wants to work towards.

6.2 Discussion

In this section, multiple possible interpretations of the results are provided and combined with findings from the literature. The limitations, generalization and verification, and validation are discussed here.

6.2.1 Validation and verification

The data in this research was retrieved from interviews, literature, and expert panels. The validation of this research was based on three expert panels with five individuals in total. These included people that are considered experts on circularity and people that very experienced in contracting.

A relevant side note is that some of the cases including the Cruquiusbridge and Ritsumasyl have a high ambition on circularity in which more budget and time were available as well. This is not the standard for projects and thus affects the results as they ran into different barriers than most projects and may have made different decisions.

Furthermore, a semi-structured interview was used in this research this gives the interviewer more freedom in the interview. The key information has been gathered in each interview but some topics were left out. However, the downside is that in some interviews several questions were not asked that might lead to relevant information. Next to this, the interviewees' own bias, even though minimal, also influences the interpretation of the results. Especially the literature research and exploratory interviews affect the starting opinion of the interviewee and this then influences the direction of the interview and interpretation and focus of the results. This affects the validity of the entire research. What does help with the validity of the research is the expert panel as this discusses the interpretation of the interview results.

Lastly, the expert panel is a method that helps with the validation of the flowchart and key decisions. The expert panels gave feedback on the first version of the flowchart. This feedback helps to review the interpretations made from the interviews that were converted into the flowchart. The validity and usability can be more assured since multiple people were involved and comments on the first interpretation were given.

6.2.2 Limitations

Limitations of the research are the shortcomings and flaws that it has, which are also present in this research. The research design that is being used is a multiple case study in which the data is gathered through interviews and then analyzed using grounded theory.

The main limitations of this research are:

- A case study is difficult to replicate
- A case study is time-consuming and therefore only four cases and thus seven interviews can be conducted in the given 10 weeks of research. This rather small sample size will make it harder to generalize the results.
- The research is exploratory and therefore it will provide qualitative data, this guides you in the right direction but is usually inconclusive. Therefore, more quantitative research can be recommended to confirm this thesis. This can be done by implementing the flowchart in projects and then measuring the effect it has. For example, measure how often the ambitions are translated into the contract and then realized.
- Researcher bias is another limitation that can have a negative effect on the research, especially confirmation bias. This form of bias occurs when a researcher forms a hypothesis and uses the interviews to confirm this hypothesis. In this research there is no hypothesis, still, there are favorable outcomes in the research and this should be avoided.
- The time span of the research was ten weeks, which limits the research as well. Therefore, not all parts were fully researched. Something that may have been useful is giving guidance on how to research the best opportunities and chances and on how to determine a concrete goal. Yet the goal of this research was to provide an insight into the decisions and process in general.
- Four cases and seven interviews are sufficient to make it valid, however, more interviews or different (external) cases would have increased the statistical validity of the research. Still, these cases do give a good image of what happens in real life within projects regarding the circularity ambitions. Next to this, all four cases were from Witteveen+Bos this may give a limited sight of the possible barriers and decisions there are regarding the translation of circularity ambitions into workable measures and practices. A recommendation would be to use external projects. The decision for four cases has been made due to the amount of time there was as the reliability of the interviews is high the final result is also valid.
- A limitation that is linked to the four cases at Witteveen+Bos only is that only two external individuals have been involved in this research, including Individual A and Individual L. This may give a more narrow perspective as some other companies may approach this problem differently. Still, some external individuals from another perspective, namely that of a contractor and client, are involved. However, this research is mostly from the perspective of Witteveen+Bos and this influences the final results and may be considered a limitation.
- The expert panels would ideally be executed as one expert panel in which all different opinions would arise and a discussion can be started. However, due to the pandemic, this was not possible and multiple smaller expert panels were conducted. This may influence the results of the research as each expert panel led to a different flowchart for the next expert panel.
- Lastly, not all decisions, barriers, and enablers that arose from the interviews were translated into the flowchart. This decision has been made because the flowchart would become too complex else ways. However, some of the elements that were mentioned are true and useful for the process to run more smoothly or just simply important in the process to think of as

well. This includes the list of enabling tools in the flowchart. Furthermore, the communication has a different focus in every phase which could have been included. Yet it has been included that communication is not the only key at the start but a continuous process and needs reflection.

6.2.3 Generalization

The model was created for Witteveen+Bos and made with data and information from this company. However, a similar company could use the flowchart as the same problems are encountered at different companies in the same sector. However, the available tools are different at different companies so these should be adjusted.

Furthermore, an interesting question is whether the model is generalizable for sustainability and not just circularity. The general decisions are key decisions for sustainability as well. Including setting a clear ambition and goal, checking whether there is room, researching opportunities and the biggest impact, and considering all barriers that are faced. Yet the major difference would be the research decisions as the current model includes goals and research of opportunities for circularity specifically and measuring instruments for circularity as well. These should then become more elaborate. Therefore, replicating this model for sustainability is not recommended. However, the key decisions and elements can be useful. Changes that could be made are changing the definitions of circularity to sustainability and adding more focus areas of the goals and therefore new and different paths of research.

6.3 Scientific relevance

In this section, the contribution of this research to theory is discussed.

Even though this research was a case study conducted at Witteveen+Bos, we tried to contribute with findings that are useful to the literature. This research created a flowchart that can be implemented in practice to translate circularity ambitions into workable measures and practices. In literature, there exists no framework yet that gives a clear and visual insight into the key decisions and barriers that are encountered within this translation process. Therefore, the big contribution of this practice is a framework that helps individuals involved in the translation of circularity ambitions to workable measures and practices. Even though the research was conducted at W+B, it may be useful to others from other companies as well as it gives an insight into general aspects that may be encountered.

This research has contributed to the existing literature because existing literature and interviews have been combined into a flowchart that visualizes the process of translating ambitions.

6.4 Recommendations

This section covers the recommendations. First, the recommendations are described for practice at Witteveen+Bos. Subsequently, the recommendations for future research are given.

6.4.1 Recommendation Witteveen+Bos

From this research, some recommendations are advised to support Witteveen+Bos in the translation process of circularity ambitions to concrete and workable measures and practices.

Firstly, circularity should become an integral part of projects and it should be given a central role. An aspect that should be discussed with the entire project team is what the circularity ambitions and goals are. It should be assured that everyone is on the same page during the process. It is good to plan moments and checkpoints for reflection in which people are brought back together to evaluate the process regarding circularity, this should not be done at the start only. Taking time to discuss key elements, like the risk and procurement, should be taken to assure success in a project.

Next to this, the advice to Witteveen+Bos is to start integrating the flowchart in upcoming projects. This should be done from the start of the project. This can help Witteveen+Bos to be able to follow a concrete procedure of steps and decisions that should be followed. In this way, project managers can give a visual overview of essential steps to the client and contractor. Furthermore, also for project managers themselves, this may help with their knowledge on what decisions to make in the process and in which order they should be made. Next to this, the flowchart tackles the top three barriers that are being met and gives options on how to handle them. Still, the flowchart may leave room for improvement in practice. Thus, it is recommended to start testing the usability of the flowchart and to adjust it where necessary.

6.4.2 Recommendation on future research

The recommendation for future research covers the aspects that could be included in future research or those that built on this research.

This research only focuses on what the process should look like for translating a vague circularity ambition into a workable measure or practice. The research did not cover the details of each decision and thus a suggestion for future research is to research what steps need to be made to execute each decision properly. It would be interesting and more useful to find out what the decisions themselves should be and how they can be made best. Next to this, it would be interesting to take this flowchart into practice and to find out whether these steps and decisions actually help with the decision-making process in coming to a workable practice or measure. Therefore, experimental or usability research would be recommended in which the success of the tool can be seen or the usability of the tool and possible improvement can be researched, respectively.

The second recommendation is related to the organization of projects and ownership. It is known that communication is key in this process, yet it is unknown what the effect is of a good organizational structure and communication. This also includes thinking of change management to let the entire division grow on a more fundamental level. Internal change is necessary within the organizations, including the client. This arose from multiple interviews and expert panels. Future research should be executed on the organizational structures.

A large shift is necessary for the entire chain regarding the ownership of objects. A future research suggestion would be regarding the analysis and investigation on how the quality of buildings and objects can be as high as possible. Growing to an ‘as a service’ or ‘lease’ relationship may help to improve circularity in the long run as the residual value becomes more central to the company that leases or rents the object.

Lastly, in the problem cluster, possible core problem number 8 was not further exploited. However, it may be useful to research this problem and to investigate how to bridge the existing knowledge gap between the sustainability department and the contracting department. A suggestion would be to consider what the knowledge gap is first.

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Appendix

A. Systematic Literature Review

A systematic literature review (SLR) is conducted to contribute to sub-question 1: '*What is the definition of circular economy of materials in the construction sector?*'. It is really important within this research to have a good and clear definition of the circular economy of materials in the construction sector. CE is a container concept and therefore it is important that this concept is clearly defined as this will guide through the rest of the research. The inclusions or exclusion of certain elements is important. In the sub-question, it can already be seen that materials are included and the other aspects of CE, such as water and energy, are excluded. This section will elaborate on the scoping, databases, search strategy, results, and integration of theory.

Scoping

It is important for every type of review or research to scope it sufficiently. To do so both inclusion and exclusion criteria are defined.

Table 3: Exclusion Criteria used in SLR

Criteria	Reason for exclusion
Paid sources	Only free sources or sources open to the UT will be included
A circular Economy defined as a non-construction or procurement sector	The concept of the circular economy needs to be defined in the context of the construction sector. In other areas, the definition of CE is not as relevant.
The topic of circularity should be mentioned explicitly	Having sustainability as the main topic of which circularity is a sub-topic will be an exclusion reason as this will not give enough focus on circularity.

Databases

The databases that are used during the SLR are Scopus and Web of Science. Scopus and Web of Science give the option to have a structured search on a certain topic and next to this it provides many different sources and it is user-friendly.

Search Strategy and results

Table 4: SLR search results

Date of Search	Search Terms	Scope	Number of Articles	Duplicates
Scopus				
7-4-2021	(Circularity OR Circular) AND (Procurement OR Tender) AND (Construction OR Built)	Article title, Abstract, Keywords	32	12
Web of Science				
7-4-2021	(Circularity OR Circular) AND (Procurement OR Tender) AND (Construction OR Built)	Topic (Title, Abstract, Author keywords and Keywords Plus)	47	15
Total		**52**		

Duplicates (that appear in Scopus and WoS)	-13
Exclusion Criteria	-19
Excluded after scanning/reading abstract	-9
Unavailable	-2
Total used in SLR	**9**

In the end, nine articles were relevant and available and these were analyzed. The key findings from this are in the overview in Table 5 below. These all summarize the definition of circular economy (CE) used in each research.

Table 5: Resources and key findings

#	Sources	Key findings
1	Bao, Z.; Lu, W. (27-3-2020). *Developing efficient circularity for construction and demolition waste management in fast emerging economies: Lessons learned from Shenzhen, China.*	Circular economy is an industrial economy that is restorative or regenerative by intention and design. It advocates proactive strategies, such as zero-waste design, restoration, and regeneration, organized in a closed loop.
2	Ghaffar, S.H.; Burman, M.; Braimah, N. (20-1-2020). *Pathways to circular construction: An integrated management of construction and demolition waste for resource recovery*	Circular economy is an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling, and recovering materials in production/distribution and consumption processes. It tries to keep the products and materials 'in flow' by means of effective and smart re-use strategies, therefore, reducing the use of virgin materials and negative environmental impacts.
3	Mantalovas, K.; Di Mino, G.; Carrion, A.J.D., Keijzer, E.; Kalman, B.; Parry, T.; Lo Presti, D. (1-9-2020). *European National Road Authorities and Circular Economy: An Insight into Their Approaches.*	Adopting systemic thinking and a cascade approach, end-products, components, and even materials can be repurposed, reutilized, recycled, or have their service life extended while keeping their highest value. Another core aspect of CE is the utilization of renewable resources.
4	Campbell-Johnston, K.; ten Cate, J.; Elfering-Petrovic, M.; Gupta, J. (20-10-2019). *City-level circular transitions: Barriers and limits in Amsterdam, Utrecht, and The Hague.*	Initially, CE focused on waste management and treatment policies later it also shifted towards reusing materials but only since 2010 CE emerged looking at resource prolongment and preservation, lifecycle thinking, and closing material and energy loops.

5	Alhola, K.; Ryding, S.O.; Salmenpera, H. (1-2-2019). *Exploiting the Potential of Public Procurement: Opportunities for Circular Economy.*	The objective of a CE is to maintain the value of products, materials, and resources in the economy by closing material loops and minimizing waste generation.
6	Gorecki, J. (2019). *Market Convinced and What's Next? Prioritized Selection Criteria for Circular Economy Manager in Construction Projects and Model of Recruitment.*	Circular Economy (CE) is a new economic model that is based on the assumption that the value of resources should be maintained in the endless circulation flow for as long as possible to ultimately reduce waste generation to a minimum. According to this concept, to avoid unrestrained waste production, materials should be repeatedly re-put into production systems many times, often passing from one branch of industry to another.
7	Milios, L. (2017). *Advancing to a Circular Economy: three essential ingredients for a comprehensive policy mix.*	[…] an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models. This is only rather vague and difficult to understand in policymaking and therefore the following has been added '… circular economy, where the value of products, materials, and resources is maintained in the economy for as long as possible, and the generation of waste minimized.'
8	Anastasiades, K.; Blom, J.; Buyle, M. Audenaert, A. (1-1-2020). *Translating the circular economy to bridge construction: Lessons learned from a critical literature review.*	The circular economy shifts away from the currently predominant linear economy, in which there is a high demand from nature for resources, whilst the end-products are merely disposed of in the end-of-life stage. "A circular economy describes an economic system that is based on [technological advances and new] business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials[and energy] in production/distribution and consumption processes [in order to

		keep products at their highest possible value], thus operating at the micro-level (products, companies, consumers), meso-level (eco-industrial parks) and macro-level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations.
9	Coenen, T.B.J.; Santon, J.; Fennis, S.A.A.M.; Halman, J.I.M. (2021). *Development of a bridge circularity assessment framework to promote resource efficiency in infrastructure projects.*	The Circular Economy (CE) concept aims to maximize the functional value of resources by considering the entire life cycle of a product and closing resource loops. Rather than "temporarily" using virgin materials as part of an asset and then disposing of them afterward, the goal of the CE is to maximize the value over the entire life cycle of each particular resource used. By adopting these principles, resource efficiency can be drastically increased. In addition, there are major potential benefits regarding environmental impact and life cycle costs.

Conclusion

From these different definitions of circular economy, the key elements are summarized. These are as follows:

- Circular economy is restorative or regenerative
- Circular economy is organized in a closed-loop
- Circular economy aims to have minimum waste
- Circular economy is based on reducing, alternatively reusing, recycling, and recovering materials. (4R's)
- Circular economy wants to have the service life extended while keeping the highest value, so the value of materials is maintained
- Circular economy assures the utilization of renewable resources
- Circular economy considers the entire life cycle of a product and closes this loop.

From these key elements a definition can be generated that will be used in this research and that helps to answer sub-question 1. The definition is as follows:

Circular economy (CE) is based on reducing, alternatively reusing, recycling, and recovering materials. In this way tries to maintain the value of materials and restore or regenerate this value. This is done using a closed-loop system by which the value cannot get lost or only has minimum waste. Next to this, CE aims to use renewable sources more to make sure that all materials still have value in their entire life cycle.

B. Interview questions

Introduction

Hee, ik ben Nienke en momenteel aan het afstuderen op de Universiteit Twente voor mijn Bachelor Technische Bedrijfskunde en ik doe dit bij Witteveen+Bos.

Confidentiality of interview

Voordat ik begin met interviewen wil ik je graag de volgende dingen vragen m.b.t. confidentialiteit.

Als je wordt geciteerd, hoe wil je dan worden geciteerd:

- Met volledige naam en functie
- Anoniem
- Anders…

Na het interview zal ik je een samenvatting van het interview sturen binnen een week. Mag ik ervan uitgaan data als ik niks terug hoor binnen een week dat ik alle informatie dan mag gebruiken en dat je het er mee eens bent?

- Ja
- Nee

Mag ik het interview opnemen? Door de opname zal het interview enkel worden samengevat en daarna wordt de opname verwijderd.

- Ja
- Nee

Je kunt je altijd terugtrekken van het interview en het op ieder moment stoppen zonder aankondiging.

Goal of interview

Het doel van het interview is om inzicht te creëren in de kern beslissingen die genomen worden om circulaire ambities te vertalen naar werkbare en realistische eisen en maatregelen. Hiernaast zullen ook de belangrijkste barrières, kansen en facilitatoren worden onderzocht. Dit wordt gedaan om alle informatie uiteindelijk te verwerken in een flowchart waarin de kernbeslissingen worden laten zien om van een vage circulaire ambitie (vb. ‘We willen zo circulair mogelijk zijn’) naar concrete eisen te komen. Zodat iemand die begint aan een project met een circulaire ambitie een concreet stappenplan kan doorlopen om zo iets te doen met die ambitie.

Structure of the interview

Het interview bestaat uit drie delen en ongeveer 14 vragen en het zal ongeveer 60 minuten duren.

Eerst zullen we het even hebben over het project en circulariteit binnen het project in het algemeen. Daarna zullen we meer focussen op belangrijke beslissingen die er genomen worden en tegen welke barrières je aanloop m.b.t. circulariteit. Als laatste focussen we ons even op belangrijke eigenschappen voor meer succeskansen in de toekomst van het implementeren van circulariteit.

Part 1: General questions and circularity (10 minuten)

Wat was jouw rol tijdens het constructie proces van het project?

Wat waren de circulariteitsambities aan de start van het project?

Hoe werd circulariteit geïnterpreteerd en gefocust binnen het project?

Opties zijn:

- Gebruiken van zo min mogelijk materialen → Kosten
- Gebruiken van pure, non toxische materialen vanuit het gezondheidsoogpunt (cradle-to-cradle)
- Ontwerpen voor afbraak en modulariteit
- Gebruiken van hernieuwbare materialen

Part 2: Key decisions (30 minuten) → 5 a 10 beslissingen

Dus mijn vorige vraag was: 'Hoe werd circulariteit geïnterpreteerd en gefocust binnen het project?'. Jouw antwoord was… , ik wilde je n.a.v. een aantal vragen stellen met de kern beslissingen die jullie moesten nemen of tegenkwamen bij het implementeren van deze circulariteitsambitie.

Dus eerst, welke belangrijke beslissingen moesten jullie nemen of kwamen jullie tegen bij het implementeren van circulariteit ambities? (Het is vooral belangrijk WAAROM jullie deze keuze hebben gemaakt)

- ➔ Waarom is deze beslissing belangrijk?
- ➔ **Welke informatie heb je gebruikt om deze beslissing te maken?**
- ➔ Wat was het doel van deze beslissing?
- ➔ Wat zorgde ervoor dat je deze beslissing maakte?
- ➔ Wie was er betrokken bij de beslissing? → Waarom?
- ➔ Wat waren de beslissingsopties?
- ➔ Wat waren de gevolgen van deze beslissing?
- ➔ Wat zijn de risico's die bij deze beslissing komen kijken?

Part 3: General influencing barriers and enablers (10-15 minuten)

- ➔ Welke samenwerkingsvorm hebben jullie gebruikt? (As a service, buy-rebuy, traditional?)
- ➔ Wat hebben jullie gedaan voor de financiering van de circulaire oplossing?
- ➔ Hebben jullie een dialoog gehad?

Wat limiteert je om circulariteit te implementeren?

- ➔ Waarom is dit een bottleneck?
- ➔ Wat zou kunnen helpen om dit te overkomen?

Welk laaghangende fruit kan volgens jou altijd naar gekeken worden?

Wat zijn succes factoren die gebruikt kunnen worden voor het vertalen van circulariteitsambities naar realistische werkbare eisen en maatregelen?

Wat zijn de belangrijkste leerpunten van dit project op gebied van circulariteit?

Wat zou je zelf nodig hebben om vaker van vage ambities naar werkbare eisen en maatregelen te komen?

Samenvatten (Dus als ik het goed begrijp hebben jullie de volgende stappen…. Doorlopen incl deze beslissingen. Klopt dit?)

C. Interviews summarized

Note that the interviews were conducted in Dutch and therefore the interview are summarized in Dutch as well.

Summary interview Individual H Ritsumasyl

Ambitieweb voor elke brug. Er waren in totaal drie bruggen.

Part 1: General questions and circularity

Wat was jouw rol tijdens het constructie proces van het project?

Duurzaamheidsexpert/-adviseur. Pas heel laat betrokken bij het project. Dus we hebben het ook wat meer over verschillende projecten

Wat waren de circulariteitsambities vanaf het begin van het project?

Eigenlijk niet of alleen bio-based materiaal had de focus. Dus een innovatieve brug op basis van materiaalgebruik, maar geen ambitie om materialen te hergebruiken. Bij dit deel (start van het project) was ik nog niet betrokken.

Hoe werd circulariteit geïnterpreteerd en gefocust binnen het project?

Opties zijn:

- **Gebruiken van zo min mogelijk materialen → Kosten**
- **Gebruiken van pure, non toxische materialen vanuit het gezondheidsoogpunt (cradle-to-cradle)**
- **Ontwerpen voor afbraak en modulariteit**
- **Gebruiken van hernieuwbare materialen**

Hernieuwbare materialen had de focus bij deze brug. Verder wilde ze een statement maken met een nieuwe innovatieve brug.
Soms is er een hoge ambitie op circulariteit bij veel projecten, maar is deze niet specifiek gespecificeerd. Dus zo circulair of duurzaam mogelijk.
Vooral in ambitieweb wordt de focus neergelegd op een deel en dit wordt in het project dan zoveel mogelijk meegenomen.

(Opties zijn: MKI van materialen, hergebruik van bestaande materialen, of ontwerpen voor hergebruik in toekomst)

Ligt er binnen materiaalgebruik de focus ergens op?

Vaak op milieu impact, circulariteit hergebruik van materialen of ontwerpen voor hergebruik in de toekomst.
Er wordt ook wel gekeken naar of een project echt nodig is en of de materialen echt nodig zijn (of minder materialen gebruikt kunnen worden). Dit wordt ook vaak uit kostenperspectief gedaan ipv duurzaamheid.

Part 2: Key decisions

Welke belangrijke beslissingen moesten jullie nemen of kwamen jullie tegen bij het implementeren van circulariteit ambities?

Kijk als eerste ook of het nodig is om iets te gaan bouwen.
Begin met een nul analyse en wat zijn de onderdelen waar je echt een verschil kan maken.
Dus kijk vooral naar grote kansen en die grote kansen ga je daarna uitwerken en met ontwerpers samen zitten.
Ambitie in ambitieweb is vaak de ambitie van de mensen zelf en komt van een doelstelling uit het IMW, die is meegegeven. Maar niet per se al gebaseerd op belangrijke beslissingen.

Je maakt beslissingen op basis van wat er voor je staat dus stel je voor er ligt nog een vrij nieuwe brug dan kun je kijken of je die kunt hergebruiken.
Wat niet vaak gebeurt, maar wat we vaak doen is kijken naar wat er nog staat. Doe een hergebruikscan en niet eerst al een ontwerp maken. Dan kun je ook gaan kijken naar wat er moet gebeuren.
Duurzaamheid is nu geen integraal onderdeel in het project en daarom wordt het ook vaak niet als eerste bekeken. Dit gebeurt alleen als er iemand betrokken is vanuit de duurzaamheidsafdeling of als een projectmanager veel affiniteit heeft met duurzaamheid.

De beslissing is vaak al gemaakt of er iets wordt gebouwd of gerenoveerd en het is goed om ingenieursbureau bij dit beslissingsproces te betrekken.

Kijken naar functionele en technische levensduur (Staat vast bij RWS). Er worden hier wel testen naar gedaan wat de staat is van het materiaal. Vaak bij bruggen zo dat er iets nieuws moet worden gebouwd omdat de functie veranderd en niet omdat het materiaal 'op' is. → Hier wel enige flexibiliteit qua levensduur bij provincies en gemeentes, maar niet bij RWS. Soms is het goed om te kijken naar of er speling kan zijn in de levensduur in de eisen (volgens mij bij Cruquiusbrug).

Ik maak zelf de milieu impact, circulariteitsimpact etc. duidelijk en ik wijs ontwerpers hierop.
Inzichtelijk maken waar grote klappers te maken zijn.
Verder gebruik ik + Circular Design tool om de impact van een beslissing in circulariteit te meten en DuboCalc voor MKI berekeningen.

Belangrijke keuze om naar te kijken is de verbindingen voor losmaakbaarheid. (Bijvoorbeeld IFD bouwen, dit is het standaardiseren van verbindingen). We hebben niet genoeg kennis over snellere slijtage rondom verbindingstukken.

Kijken naar wat voor materialen je gebruikt en de milieu impact en of er evt. wat materialen te hergebruiken zijn.

Wordt er gekeken naar losse onderdelen gebruiken i.p.v. hoogwaardig hergebruiken?
Nee vaak niet, vaak gezegd dat het niet kan en risico vind men te groot of onduidelijk.
Voordat er echt al iets vastgelegd wordt, kijken en analyseren wat er mogelijk is.

Geld is er vaak te weinig en dus vaak ook geen geld voor onderzoek.
Ik krijg vaak de vaak als het ontwerp al klaar is, 'is er nog iets duurzaams mogelijk?'

Part 3: General influencing barriers and enablers

Welk laaghangende fruit kan volgens jou altijd naar gekeken worden? (Bijv. Materialenpaspoort)

Reisafstanden verminderen
Materialen gebruiken die niet een hoge MKI hebben

Wat zouden mensen 'altijd' kunnen doen, als laaghangend fruit?
Kijken naar materiaal met minder impact (vb. vangrails van hout)
Materialenpaspoort gebeurt zeker niet in ieder project. Ook lastig met wie het bijhoudt en wie er voor verantwoordelijk is. Gebeurt heel soms.

Eerst nulmeting en kijken waar de kansen liggen.
Vroeg in proces ambities onderzoeken
Laat mensen meedenken over wat mogelijk is (aannemer)

Wat zijn succes factoren die gebruikt kunnen worden voor het vertalen van circulariteitsambities naar realistische werkbare eisen en maatregelen?

Vroeg in proces oppakken en onderzoeken van circulariteitsambities. Hoe verder je in het proces zit hoe minder er kan. En ze zijn gewoon echt al-tijd te laat met deze ambities. En als het wel vroeg is dan is het ook regelmatig dat er geen budget voor is.

Laat mensen meedenken. Zeker een aannemer is vaak al heel ver en kan veel en ook meer dan wij soms denken. Een bouwteam kan dan ook helpen. Zit het risico aan dat het meer kost misschien en dat je wat anders krijgt dan je wilde.

Belangrijke punten zijn:
1. De ambitie vroeg meenemen
2. Mensen vroeg betrekken in het proces en meenemen

Vragen die Individual H vaak krijgt zijn:
1. Welk materiaal moet ik kiezen, wat is beter (qua MKI)? (vergelijk twee materialen)
2. Waar is nog iets mogelijk op gebied van circulariteit?

Een belangrijke succesfactor is;
Open minded zijn, niet van te voren al alles uitgedacht hebben maar sta open voor andere ideeën
Eigenaarschap (iemand verantwoordelijk voor circulariteit)

Nu wordt een duurzaamheidspersoon betrokken aan het einde van het project en dan is er nog weinig ruimte en niemand van duurzaamheid is betrokken bij het ontwerp en ook niemand is daar verantwoordelijk voor. Duurzaamheid en circulariteit is het meer een zijspoor.

Wat zijn de belangrijkste leerpunten van dit project op gebied van circulariteit?

Focus je niet alleen op circulariteit maar kijk naar het hele plaatje. Uiteindelijk is circulariteit ook maar een middel om de milieu impact te verminderen.
Idee is om één ontwerp te maken wat 100% gericht is om duurzaamheid.

Betrek mensen ook bij duurzaamheid zodat ze geprikkeld worden om na te denken over duurzaamheid.

Part 1: General questions and circularity

Wat was jouw rol tijdens het constructie proces van het project?
Circulair adviseur en ik heb meerdere petten op. Naast adviseren ook aan het sturen en bezig met onder andere circulair asset management.

Wat waren de circulariteitsambities vanaf het begin van het project?

Ik ben niet vanaf het begin betrokken geweest, maar het project is aanbesteed als circulaire RWZI Terwolde. Circulariteit had een hoge prioriteit vanaf het begin van het project.

In het ambitieweb staat de ambitie op 0, 1, 2 of 3. Bij 3 gaan we op alle vlakken kijken naar opties en dat geld in dit project voor circulariteit en dan voornamelijk op materiaalgebruik.

Hoe werd circulariteit geïnterpreteerd en gefocust binnen het project?

Opties zijn:

- **Gebruiken van zo min mogelijk materialen**
- **Gebruiken van pure, non toxische materialen vanuit het gezondheidsoogpunt (cradle-to-cradle)**
- **Ontwerpen voor afbraak en modulariteit**
- **Gebruiken van hernieuwbare materialen**

Dus binnen circulariteit. Welke strategieën gebruik je?
We kijken heel erg per situatie naar wat er mogelijk is en wat past. Soms is het ene beter dan het andere, dus kijken naar hernieuwbare materialen of kijken naar modulariteit of juist naar de gehele levenscyclus. Er werd binnen dit project dus echt gekeken naar meerdere kanten van circulariteit.

Verder probeerden we ook te kijken naar waar hergebruik mogelijk is. Het is dan wel belangrijk naar het hele plaatje te kijken en de afweging te maken of het wel echt duurzaam is. We proberen dan berekeningen te doen om het af te kunnen wegen. Dit is ook nog wel in ontwikkeling, met hoe we dat precies doen. Zo proberen we het integraal te bekijken.

Discussiepunt bij een afwegingskader is de weging. Binnen duurzaamheid hebben we het MKI maar economische aspecten (of andere relevante aspecten) daarin dan afwegen is moeilijk.

Bij circulariteit (en innovaties) vraag je meer van mensen en er moet meer uitgezocht worden. Dit hebben ze vaak nog niet eerder gedaan en is dus nieuw. Er moet meer informatie beschikbaar komen over levensduur en materialen en dat kost soms wat meer tijd. Een belangrijke tip is dat je voor technische disciplines concreet moet maken wat er moet gebeuren.
Het ontwerpproces gaat anders, namelijk we kijken naar welke materialen er zijn en dan ontwerpen we pas. Standaard wordt er een ontwerp gemaakt en wordt er daarna gekeken naar de benodigde materialen.

Part 2: Key decisions

Welke belangrijke beslissingen moesten jullie maken of kwamen jullie tegen bij het implementeren van circulariteitsambities?

Zorg ervoor dat het duidelijk is waar je op wilt focussen en zorg niet dat het té vaag blijft.

Bekijk ook waar je de meeste winst kan behalen.
Let erop dat er ruimte is om te onderzoeken en uit te lopen.
De eerste vraag: wat moet er gesloopt worden? Welke materialen komen er vrij? Wat kunnen we gebruiken en wat moeten we maken?

Hier volgt een opsomming van belangrijke punten en beslissingen:

1. Bekijk of materialen hergebruikt kunnen worden. Vaak is er nog veel onzekerheid en moeten er dingen onderzocht worden.
2. Bepaal allereerst de functionele eenheid.
3. Kijk daarna naar het vermijden van impact
4. Als vervolg zou je moeten kijken naar de opties en hoe we die impactvermijding gaan realiseren.
5. Belangrijk kan zijn een hergebruikscan uitvoeren (daar was ik niet aanwezig: binnen dit project was er budget voor en tijd voor)
6. Kijken naar wat er mogelijk is qua circulariteit (dit is project specifiek). Gebruik logica voor waar je precies naar gaat kijken en kies daarna waar de meeste winst te behalen valt. Aan de voorkant kijken naar of de afweging en analyse het waard is om ernaar te kijken.
7. In dit geval kijken naar energie: (Zwaartepunt analyse)
8. Afwegingen maken voor beste circulaire strategie
9. Hoe? We maken met de info die we hebben maken we inschattingen en bepalen we materiaalverbruik, impact van bouwfase en die vergelijken. Koppel het aan een MKI score.
10. Afweging: circulariteit voor nu of later? (R strategie ladder aanhouden) Je kunt wel een modulair gebouw hebben maar het is dan nog steeds heel erg afhankelijk of er iets mee gebeurt wanneer het gebouw einde levensduur is. Vaak zijn er bij modulariteit ook meer materialen nodig. → **Welke info gebruiken jullie?** Informatie van standaard gebruiksgebouw en dan kijken waar de grootste impact in het gebouw in zit en dan afwegingen maken.
11. Hoelang staan hergebruikte materialen nog (fundering) en blijven ze ook nog in goede staat. Binnen dit project is dat maar een inschatting en wordt het niet geïnspecteerd/berekend.

Impact zit in het proces (Eerst zwaartepunt analyse). Integraal blijven kijken en naar het hele plaatje (dus naast alleen circulariteit ook kijken naar bijv. energieverbruik)

Part 3: General influencing barriers and enablers

We hebben een bouwteam als huidige samenwerkingsvorm. Het is verder belangrijk om duidelijk te zijn naar elkaar in communicatie, zeker omdat er veel mensen betrokken zijn, die ook andere interesses en belangen hebben. Er vind veel overleg plaats binnen dit project, ook op hoger niveau. Het einddoel (circulariteit) overleggen is goed, maar circulariteit verwerken in het project is voor sommige mensen lastiger. Voornamelijk de technische, klassieke disciplines willen concreet iets gevraagd krijgen.
Communicatie is in ieder geval *key* en erg belangrijk en dat kan nog wel eens langs elkaar heen lopen. Veel mensen betrokken met verschillende meningen en dan is het vooral belangrijk om op een lijn te zitten en in ieder geval communiceren.

We hebben vanuit waterschap wel concreet een circulariteitsvraag gekregen en dus weet iedereen wel waar we naartoe moeten werken.

Welk laaghangende fruit kan volgens jou altijd naar gekeken worden?

- R strategieën aanhouden waar mogelijk
- Vermijd impact waar mogelijk en anders verlaag de impact

- Doe niets wat niet nodig is. Dan is het dus belangrijk om een naar de functie te kijken.

Het gebruik van een materialen paspoort kan hierbij ook belangrijk zijn, omdat het hergebruiken van materialen makkelijker wordt door het inzicht. Je weet hierdoor namelijk welke materialen er in zitten en welke verbindingen er zijn.

Wat zijn succes factoren die gebruikt kunnen worden voor het vertalen van circulariteitsambities naar realistische werkbare eisen en maatregelen?

Het is belangrijk om aandacht en ruimte te hebben voor circulariteit en daarnaast bewustzijn.
Dit project werd ook gebruikt als platform om andere dingen te ontwikkelen (zoals 3D modeleren en MKI berekening om snel afwegingen te kunnen maken), dat helpt ook mee aan het mogelijke succes.
Verder is het belangrijk om te inventariseren welke materialen er zijn en gebruikt kunnen worden.
Ook is het belangrijk om de speerpunten aan het begin duidelijk op te stellen met iedereen en daarin ook trade-offs te maken. Je kunt namelijk niet alles doen en op alle gebieden prioriteit leggen. Dus het hebben van een prioriteit.

Probeer circulariteit minder vaag te maken, want bij ontwerpafwegingen vinden mensen het fijn om het concreter te hebben. Circulariteit wordt wel steeds meer concreet gemaakt door bijvoorbeeld het MKI, circulariteitsindicatoren en CB'23 heeft een aantal dingen vastgelegd. Voor dit soort projecten mogen we wat meer vasthouden aan dat soort indicatoren, ondanks dat ze (nog niet meteen) perfect zijn. Ze geven wel houvast en richting. We moeten sowieso wat meer naar MKI en kijken naar het hele plaatje i.p.v. alleen CO2 neutraal sturen bijvoorbeeld.

Wat zou je zelf nodig hebben om vaker van vage ambities naar werkbare eisen en maatregelen te komen?

1. Vroeg in proces meedenken
2. Op basis van functie kijken wat circulair is
3. Vanaf begin af aan een koers hebben (randvoorwaarden nodig)
4. Zorg dat je tijd hebt
5. Durf grove afwegingen te maken zeker in het voortraject wanneer er nog veel kan veranderen. Dit kun je later dan weer in detail uitwerken.

Summary interview Individual T NRU

Part 1: General questions and circularity

Wat was jouw rol tijdens het constructie proces van het project?
Mijn rol is voornamelijk die van duurzaamheidsadviseur. Ik hou me bezig met kwantificeren van milieu impact van projecten. Verder ook de invulling van duurzaamheid binnen projecten.
Door het inzichtelijk maken van milieu impact (MKI of LCA of CO2 berekening), kunnen we laten zien waar echt impact zit. Vervolgens kijken we naar hoe we minder impact kunnen hebben.

Wat waren de circulariteitsambities aan de start van het project?

Volgens mij was de ambitie: '*zo circulair mogelijk project maken.*'

Er was geen concrete uitvraag en dat zien we wel vaker waar circulariteit in de doelstelling is verwerkt. De ambitie is dan vaak nog vaag.

Is het fijn om aan de start ingekaderd te worden/focus te krijgen?
Het is wel fijn om goed in te kaderen en al richting te krijgen aan duurzaamheid of circulariteit. Hier zijn ook instrumenten voor zoals het ambitieweb of de omgevingswijzer. Bepaal aan de start dan ook wat we belangrijk vinden en maak hierna een concrete doelstelling op dat gebied. Dus wat betekend deze doelstelling voor dit project. (‘*50% minder materiaalgebruik’)*

Circulariteit is geen doel op zich, maar een middel om tot minder milieu impact te komen.

Hoe werd circulariteit geïnterpreteerd en gefocust binnen het project?

Vaak wordt circulariteit platgeslagen naar minder primair materiaalgebruik. Maar eigenlijk kun je circulariteit het beste samenvatten in de vijf indicatoren van het CB’23. Zij hebben best wel goede indicatoren omschreven. Kijk naar wat je erin stopt en wat je eruit haalt. Als je netto op nul afval komt dan heb je het goed gedaan.
Je wilt kijken naar de hoogwaardigheid van het hergebruik, want dat is het meest circulair. Dit is circulariteit op de voorkant.

Een andere component van circulariteit is wat je er aan de achterkant mee doet. Wat belangrijk is is ‘*hoe gaan we borgen dat we het later kunnen hergebruiken’*. Dus IFD bouwen, losmaakbaarheid en modulariteit is dan wat meer de focus.

- ➔ Hiervoor kun je kijken naar zekerheid voor hergebruik en ook de contractvorm die er is. (Dus bijvoorbeeld ‘as a service’ of leasen)

Part 2: Key decisions

Welke belangrijke beslissingen moesten jullie nemen of kwamen jullie tegen bij het implementeren van circulariteit ambities?

Barrière: budget, omgeving, planning
Steeds toen er een verdiepingsslag werd gemaakt in het ontwerp werd er een slag gemaakt op duurzaamheidsgebied. Wij kunnen wel alleen gaan rekenen aan duurzaamheid als het ontwerp is afgerond en daardoor loop je dus continu achter de feiten aan. Bij de planning moet je hiermee rekening houden en ruimte houden om duurzaamheidsanalyses te doen en de resultaten mee te nemen in je afwegingen. Duurzaamheid moet zelf ook een centrale positie krijgen binnen het project.
Uitdaging: veel ligt al vast en dat was zeker in dit project zo. Zoals het feit dat er een viaduct of onderdoorgang zou komen. We kunnen dan vervolgens alleen nog kijken naar welk van deze twee opties de meest duurzame is.

Belangrijke aspecten:

- Bewustwording binnen WB (voornamelijk projectleiders)
- Hoe opdrachtgevers dingen uitvragen. Uiteindelijk doet WB gewoon wat de opdrachtgever vraagt. Wij kunnen onze processen wel zo inrichten dat we iets met duurzaamheid doen, want elke opdrachtgever moet daar in ieder geval iets mee doen. We kunnen inspelen op de vage duurzaamheidsambitie door iets aan te bieden wat bijdraagt aan duurzaamheid met weinig extra kosten.

Het is belangrijk om helemaal aan het begin al te kijken naar duurzaamheid (maar ook bijvoorbeeld moet het project uitgevoerd worden?)

1. Als eerste: identificeer wat je belangrijk vindt (ambitieweb).
2. Dan vanuit daar kun je je doelstellingen opstellen, maak dit zo concreet mogelijk. (kwantificeren aan de voorkant '*50% minder primair materiaalgebruik'*).
3. Je wilt vervolgens ook kunnen meten of de doelstelling wordt behaald en daar hoort een soort KPI bij.
4. Hierna gaan kijken naar waar de grootste impact gemaakt kan worden door een zwaartepuntanalyse. Dit kan zowel kwantitatief of kwalitatief gedaan worden.

Steeds focussen op de keuzes die je nu kan maken om duurzamer te zijn en zo min mogelijk impact te hebben. De keuzes waar je tegenaan loopt zullen dan dus wisselen op basis van de fase van het project. Neem vooral circulariteit mee vanaf het begin af aan in het project.

Verder is het ook belangrijk om te kijken of je je focust op circulariteit aan de voor- of achterkant. Of dat je over beide nadenkt.

Andere belangrijke (denk)stappen zijn:

1. Moet het project uitgevoerd worden?
2. Welke instrumenten kun je gebruiken?
3. Kijk naar eigenaarschap → grootste uitdaging: meer samenwerken en in dialoog (wat hebben we echt nodig?)
4. Meer risico nemen voor opdrachtgever. Hij wil z'n risico's afdekken voor de beheerfase. Vaak is een eis van 100 jaar niet realistisch en er komt waarschijnlijk in de komende 50 jaar een verandering waardoor er iets nieuws moet komen. Het is alleen nuttig wanneer het object ergens anders (voor een nieuwe 50 jaar) weer kan worden neergezet.

De opdrachtgever bepaalt de eisen waaraan iets moet voldoen en de uitvoerder is verantwoordelijk voor het feit dat een object daar dan ook aan voldoet. Dus bijvoorbeeld als de opdrachtgever zegt dat iets 100 jaar moet blijven staan dan is de aannemer verantwoordelijk voor dat het object ook daadwerkelijk 100 jaar zal staan. En als de standaard '100 jaar' – eis gewijzigd moet worden dan zal de opdrachtgever dat moeten doen.
Het risico wordt door de opdrachtgever afgedekt door hoge eisen te stellen. Sommige eisen hebben veel impact op duurzaamheid, terwijl ze voor het doel van project niet per se noodzakelijk zijn of wel minder zouden kunnen zijn.

Financiering: is grote uitdaging (hoe veranderen we het systeem) i.c.m. eigenaarschap.
Belemmerende eisen: esthetische eisen, standaard levensduur eisen

Om volledig circulair te zijn zullen we het economische plaatje anders in moeten richten maar ook moeten we naar eigenaarschap kijken en het beheer van objecten.

Verder moet het proces en systeem anders ingestoken worden als we geheel circulair willen worden. We moeten iets veranderen in de manier waarop we projecten insteken. Vooral risico en verandering moeten we meer voor open staan.

Part 1: General questions and circularity

Wat was jouw rol tijdens het constructie proces van het project?
Mijn rol is voornamelijk praktisch hoe we in contracten aan de slag kunnen met circulair ontwerpen en bouwen. Verder help ik mee met het ontwikkelen van meetinstrumenten en het schrijven van leidraden.

Wat waren de circulariteitsambities aan de start van het project?

We wilden een zo circulair mogelijke brug realiseren en daarmee weer een nieuw referentiepunt stellen voor volgende bruggen.
De ambities zijn op twee niveaus uitgewerkt, namelijk 'eisen' als dit sowieso moet worden gerealiseerd (minimum), en wensen voor aspecten waarop de markt kan worden uitgedaagd zo circulair als mogelijk te bouwen.

Wij hebben alleen in de contractvoorbereiding een klein beetje naar het ontwerp gekeken en al vrij snel gekozen dat het beter was om dit in bouwteam verband te doen.

KEUZE*: inkoop strategie*: denk niet te veel aan de voorkant uit maar ga z.s.m. een aannemer te zoeken, die samen met ons de ambitie waar wilt maken. Ook gegeven dat er innovaties nodig zijn is dit een goede insteek van het project om dus samen na te denken over de innovatie. Dit was zo met IFD bouwen binnen dit project.

Er was al wel een inhoudelijke invulling van circulariteit, namelijk IFD bouwen. Dit was meer een soort eis. De Provincie Noord-Holland (opdrachtgever) zag dit als invulling van circulariteit.
Er was dus direct al best wel veel richting aan de invulling van circulariteit.

Het is zo dat IFD bouwen kan conflicteren met de ambitie om zo min mogelijk materialen te gebruiken en een lage MKI score te hebben.
Er werd aan de aannemer gevraagd om (Gegeven dat er IFD gebouwd moet worden) te kijken naar opties om een zo laag mogelijke MKI score te hebben. En dat ze dan uitwerken hoe ze dat precies willen realiseren.
We hebben een dialoog fase gehad. Het doel van de dialoog was om te kijken naar de standaardeisen (die alternatieven blokkeren). De aannemers moesten voorstellen doen om IFD te bouwen en de MKI omlaag te halen en dan vervolgens te kijken naar contracteisen die mogelijk in het gedrang komen. Op die manier kunnen we in de dialoog fase in gesprek gaan over die eisen. Dus de dialoogfase had als doel om de blokkades van de standaardeisen weg te nemen. Binnen dit project werd er uiteindelijk ruimte gegeven vanuit de opdrachtgever op gebied van het gebruik van nieuwe (nog niet geteste) materialen.

Was er tijd en budget binnen het project?
In het realisatietraject was er qua budget 10% extra. Dit was niet alleen voor circulariteit, maar ook voor onderhoudsarm en energieneutraliteit. Waar het IFD bouwen was het meest dominant. De aanname was dat met IFD bouwen de kosten met 10% zouden stijgen. Het extra budget biedt wel meer ruimte om onderzoek te doen.

Hoe werd circulariteit geïnterpreteerd en gefocust binnen het project?

Wij hebben naar alle aspecten van circulariteit wel gekeken alleen werd dit maar in beperkte mate vertaald naar eisen.

Tijdens de levensduur, dus naar onderhoudsarm zijn, werd sowieso expliciet gekeken.
Verder lag er ook focus op IFD bouwen en dit was ook een eis.
Voor de rest hebben we het bij de aannemer gelaten om te kijken wat er verder qua circulariteit nog gebeurde en mogelijk was. Dit was een bewuste keuze om meer kans te maken om het te realiseren in een bouwteam. We willen dat de aannemer er zelf ook achter staat en enthousiast is. Je schrijft daarnaast ook al best wel wat voor met IFD bouwen. En als we het nog meer dicht zouden timmeren is dat niet bevorderlijk.

Wat we wel zien is dat een aannemer niet snel kiest om iets her te gebruiken. Dit is vooral vanwege het risico en de onzekerheid die hiermee gepaard gaat. Als je dat als opdrachtgever niet specifiek ondersteund en een deel van het risico wegneemt dan gebeurt het vaak niet.
Als je wilt sturen op hergebruik, dan zou ik adviseren om in de contractvoorbereiding het al voorbereiden, regelen en voorschrijven. Anders gebeurt het vaak niet. Als het gaat over toepassen van modulariteit dan kun je dat best wel aan de aannemer overlaten en dus open uitvragen. Dit is namelijk minder afhankelijk van tijd, planning en welk materiaal vrij komt.

Part 2: Key decisions

Welke belangrijke beslissingen moesten jullie nemen of kwamen jullie tegen bij het implementeren van circulariteit ambities?

Bewust zijn dat je meer moet uitzoeken dan normaal. Vaak worden er ik contractvoorbereiding nog geen detailkeuzes gemaakt. Verder moet je meer vooruit uitzoeken dan we gewend zijn en je hoeft dan niet alles al voor te schrijven, maar je moet je voorbereiding (huiswerk) hebben gedaan.

Keuze: wil je samen met de aannemer de verkenning doen of doe je dit zonder hen, omdat je de aannemer nog niet wilt betrekken. Als je het alleen wilt doen dan moet je het als ingenieursbureau zelf wat beter uitzoeken.
Onderschat niet hoeveel tijd het kost om research te doen om de ambitie te vertalen naar een concrete eis in het contract.

Een belangrijke blinde vlek is vaak dat er niet wordt onderzocht wat er vrijkomt aan materiaal. En om daar vervolgens een eis over te stellen is dan erg lastig, maar ook het controleren van de haalbaarheid van het aanbod van een aannemer is dan bijna niet mogelijk.

- ➔ Tijd en ruimte nodig om onderzoek te doen naar wat er beschikbaar is op de locatie aan materiaal en wat de kwaliteit en restlevensduur is.

De stappen die je moet doorlopen:

1. Ambitie bepalen
2. Doelstelling (hergebruik of niet)
3. Wat komt er vrij (dit in onderzoek)? Waar liggen kansen? → Dan deze ook echt onderzoeken (Dat is het grote verschil met normaal)
4. Kijken of er dingen aangepast moeten worden binnen het project, zoals bijvoorbeeld eisen.
5. Kansen spiegelen met rest van het project
6. Hergebruikanalyse
7. Zwaartepuntanalyse (impact waar?) → kijkt zowel naar de fase als het onderdeel/materiaal/activiteit waar veel impact gemaakt kan worden.

8. Modulariteit concreet uitwerken. Dus uitschrijven wat jij modulair vindt? (moeten onderdelen los van elkaar zijn of in z'n totaliteit los kunnen). Bepaal wat losmaakbaarheidseis betekenis

Belangrijk vertrekpunt: ambitie op welke fase? Alleen in de aanleg, gebruiksfase, of einde?

➔ Dus wat betekent circulariteit voor elke fase en werk dit uit.

Voor gebruiksfase betekent dit onderhoudsarm, levensduur, makkelijk vervangbaar, energieverbruik.

Aandachtspuntje: er zijn vaak twee verschillende aannemers waarvan eentje voor beheer
Het is belangrijk om beide aannemers vroeg te betrekken bij het beslissingsproces. Daarnaast is het ook goed om te kijken naar het budget, want voor beheer komt dit vaak uit een ander potje.
Barrière: beheerder meekrijgen om iets nieuws en innovatiefs te doen waarbij er meer uitdaging of onzekerheid zit in de beheerfase.

Bekijk of er dingen aangepast moeten worden in de planning of eisen.

Wat je kan overwegen, naast regulier ontwerp een schaduwontwerp (zo duurzaam/circulair mogelijk ontwerp) maken → Doe dit wel als he niet anders kan, want het liefst doe je dit in het proces zodat je samen afwegingen kan maken en zodat ook iedereen daarmee bezig is.

Part 3: General influencing barriers and enablers

Welk laaghangende fruit kan volgens jou altijd naar gekeken worden? (Bijv. Materialenpaspoort)

Materialenpaspoort is best wel veel werk en onderhoud dus als er geen tijd is kun je dat beter helemaal niet doen.
Daarnaast sowieso altijd iets doen met het reduceren van impact en daarnaar kijken.

Summary interview Individual S NRU

Part 1: General questions and circularity

Wat was jouw rol tijdens het constructie proces van het project?
Ik ben doorgerold naar de rol van discipline leider, technisch manager. Het ligt er maar net een beetje aan wat nodig is binnen een project. Binnen dit project was ik technisch manager met de focus op circulaire infrastructuur.

Wat waren de circulariteitsambities aan de start van het project?
De gemeente Utrecht heeft hele hoge duurzaamheidsambities, maar het projectteam van de NRU had dat wat minder. Het heeft daardoor best wel lang geduurd voordat er beslissingen werden gemaakt. Het gekke is dat binnen het kernteam de persoon van duurzaamheid niet bij overleggen aanwezig was, zowel intern als met Witteveen+Bos. Pas nadat er beslissingen waren gemaakt werd er gevraagd wat de duurzaamheid was van het ontwerp. Hij werd niet betrokken binnen het beslissingsproces.
Vaak zit duurzaamheid/circulariteit nog heel erg zelfstandig op een eilandje.
En wanneer er niemand is die er iets om geeft dan gebeurt er ook niks.

Hoe werd circulariteit geïnterpreteerd en gefocust binnen het project?

We vragen het zelf uit in de EMVI en dan komt circulariteit vanzelf. Dit was een klassiek voorbeeld van dat de aannemer het doet en zorgt voor de realisatie van circulariteit.
Het idee was om de aannemer uit te dagen om te kijken naar wat er maximaal mogelijk zou zijn.

Het is dan wel belangrijk om zelf ook onderzoek te doen naar wat er mogelijk is op gebied van duurzaamheid en circulariteit. We hebben in trade-off matrixen duurzaamheid wel meegenomen en we hebben dit ook gekwantificeerd meegenomen. Dus met MKI en CO2 uitstoot.

Verder is het belangrijk dat als je iets per se wilt dan moet je het gewoon uitschrijven.
Daarnaast geld voor minimale eisen: Stel een eis op wanneer het makkelijk, laaghangend fruit is én het is realistisch. Hierdoor maak je het dan ook het minimale wat de aannemer zou moeten doen.

Hoe zou je uit moeten vragen bij een innovatie/vernieuwing?
Dat is wat lastiger, want je weet dan niet welke kant het opgaat. Er moet dan meer ruimte komen om risico te nemen en iets nieuws te doen. (i.p.v. bijvoorbeeld op gebied van beton en het hergebruiken hiervan, omdat we dit al kennen).
Wel werd er binnen de aanvraag van RWS goed open uitgevraagd en niet al voorgeschreven dat beton gebruikt moest worden.
Een ander belangrijk punt is dat MKI soms té belangrijk is en ook hetgeen is waar een weging aan zit. Daarbij is het belangrijk om te onthouden dat de MKI geen doel is maar een middel. En dus mag er ook wat meer integraal gekeken worden.

Het eerste wat je doet als je naar circulariteit kijkt is kijken naar wat niet per se hoeft. En als je daar iets mee doet dan zie je nergens terug dat dat ook beloond wordt. Dit zou eigenlijk ook meegenomen moeten worden. Zo zou ook hoogwaardig hergebruik hoger beoordeeld moeten worden.

Barrière: geen geld, tijd of scope
Esthetische eisen die vastliggen zijn vaak belemmerend voor circulariteit. Het is ook zo dat mensen die zich bekommeren over esthetische eisen vaak andere doelen meekrijgen dan W+B. Neem de architect mee in de algemene doelen van het project. Zo ook als er bijvoorbeeld geld bespaard moet worden, zorg dan dat er een max. budget komt voor esthetica. Maar ook als circulariteit een hoge ambitie heeft, zorg ervoor dat de architect dit meeneemt en kijk naar het materieel bijvoorbeeld.

Het helpt om concreet uit te vragen wat je wilt van een architect, want dan weet hij/zij wat er meegenomen moet worden en wat er vast ligt.

Part 2: Key decisions

Welke belangrijke beslissingen moesten jullie nemen of kwamen jullie tegen bij het implementeren van circulariteit ambities?

- Wat moeilijk is, is dat je niet allemaal hetzelfde doel hebt.
- Daarnaast is het ook lastig dat er veel criteria belangrijk zijn. Zo is bijvoorbeeld verkeersveiligheid heel erg belangrijk en wanneer het niet veilig is wordt het ook meteen afgeschreven. Constructieve veiligheid en verkeershinder zijn ook belangrijke dingen die vaak mogelijke ideeën verhinderen. Het is vooral moeilijk hier compromissen tussen te vinden.
- Over esthetica kun je wel wat meer in gesprek maar dit duurt vaak lang.

We proberen het af te wegen door bijvoorbeeld een trade-off matrix. Door dit te kwantificeren wordt het wat tastbaarder. Het is ook persoonsafhankelijk hoeveel er met duurzaamheid gedaan wordt en het is belangrijk om deze intrinsiek gemotiveerde mensen vooral te betrekken in projecten omdat zij ook de kar kunnen trekken.

Een andere bottleneck is dat er niet heel veel algemene kennis is bij mensen binnen het bedrijf over circulariteit. Wat een eerste stap is of zou zijn is om te vragen aan iemand die er meer verstand van heeft, wat het effect op circulariteit is. Dit gebeurt nu nog te weinig.
Op de lange termijn is het belangrijk dat iedereen deze kennis zelf krijgt, net zoals dat nu bij de kosten is. Men weet welk materiaal duurder is bijvoorbeeld.

Wat zou er moeten gebeuren om circulariteit meer te realiseren:

1. In iedere ontwerploop circulariteit en duurzaamheid meenemen
2. Begin met circulariteitsscan (waar zit de impact?) → Zwaartepuntanalyse. Zo zie je ook of je energie in het goede zit.
3. Zorg dat je de juiste mensen hebt die het willen en enthousiast zijn. Zeker nu nog zodat zij de kar kunnen trekken.
4. Kijk ook naar wat mensen intrinsiek motiveert om bij te dragen aan circulariteit. Dit kan bij iedereen anders zijn.
5. Met z'n allen op een lijn proberen te beginnen en vanaf het begin circulariteit meenemen. En probeer ook iedereen te betrekken in dit proces, dus ook mensen van de duurzaamheidsafdeling.
6. Waarvan je zeker weet wat je wilt, schrijf dat op in de eisen en niet in de EMVI.
7. Voorkomen van impact.
8. Belangrijk om de beheerder te betrekken en niet het ontwerp over de schutting gooien.

Part 3: General influencing barriers and enablers

Welk laaghangend fruit kan volgens jou altijd naar gekeken worden? (Bijv. Materialenpaspoort)
Zorgen dat iets weer uit elkaar te halen is en dus zorgen voor losmaakbaarheid.
Als eerste kun je altijd kijken naar het gebruik van een betere materiaalsoort met een lagere impact.

Wat zijn succes factoren die gebruikt kunnen worden voor het vertalen van circulariteitsambities naar realistische werkbare eisen en maatregelen?

Integraal meenemen van duurzaamheid binnen het project. Het is gewoon een discipline dat meedoet met het technische team.
Daarnaast iedere ontwerploop kwantificeren
Alles wat je weet wat je wil neem het mee in de eisen.

Summary interview Individual P Ritsumasyl

Part 1: General questions and circularity

Wat was jouw rol tijdens het constructie proces van het project?
Toen het bouwteam er was, was ik aanwezig als technisch adviseur. Ik was daarbinnen ook een vertrouwenspersoon, die ze al langer kenden.

Wat waren de circulariteitsambities aan de start van het project? En hoe werd circulariteit geïnterpreteerd binnen het project?
De ambitie was om bio-based composiet te gaan gebruiken. Er was dus veel innovatie. Dus een innovatieve brug op basis van het materiaalgebruik, maar geen ambitie om materialen te

hergebruiken.

Verder werd er ook nog gekeken naar wat er mogelijk was op andere vlakken.
Zo werd er bijvoorbeeld een nieuwe bestemming gevonden voor het verval, het dek, van de brug zodat deze hergebruikt kan worden. Maar zo ook werd het puingranulaat hergebruikt en door het beton gedaan.
Er werd ook wel gekeken naar modulair bouwen en daar is ook een kleine vertaalslag gemaakt en er werd gedaan wat mogelijk was en binnen budget was.
Een grote en belangrijke beslissing is dat er gekeken werd naar levensduur verlenging waardoor de brug niet 50 maar 100 jaar kan staan. Dit hebben we met onderzoek en testen gedaan. Dit heeft enorm veel impact op de duurzaamheid.

De harde eisen in het contractwaren:

- *De hars dient bio-based te zijn*
- *De hars dient minimaal 70% bio-based te zijn*
- *Enkel het gebruik van thermoharders is toegestaan*

We zijn begonnen met het maken van veel trade-offs en het voorontwerp toetsen. Om te borgen dat de haalbaarheid die er gezien wordt ook echt realistisch zijn.

Part 2: Key decisions

Welke belangrijke beslissingen moesten jullie nemen of kwamen jullie tegen bij het implementeren van circulariteit ambities?

Zorg dat je de O.G. en aannemer mee hebt en samen naar hetzelfde doel werkt. Want uiteindelijk zit er toch een hoger risicoprofiel aan innovaties en nieuwe materialen. Ga dus samen met verschillende partijen om tafel zitten om te kijken wat er kan.
Het proces begint met de juiste organisatie en de juiste mensen op de juiste plaats.

We wilden het bio-based composiet gehalte zo hoog mogelijk hebben en hebben het daarom ook als eis neergezet.
Het uitgangspunt was dan ook dat het bio-based composiet moest zijn en daarnaast hebben we nog gekeken naar het maximale doen op gebied van duurzaamheid en circulariteit.
We wilden dus de totale impact maximaliseren.

We hebben ook gekeken naar verlenging van de levensduur, omdat dit veel impact heeft op duurzaamheid en circulariteit.
Verder helpt het ook om te zorgen dat je de CUR richtlijnen aanvult zodat je de weg glad strijkt voor nieuwe project zodat er meer mogelijk is.

Een belangrijk iets om te weten is ook dat je met nieuwe materialen andere eisen hebt waaraan je moet voldoen dan met al bekende materialen. Er zijn namelijk veel wetten en regels waar je aan moet voldoen.

Het is belangrijk om de tools die er zijn een gestructureerde plek te geven in het proces. Ook kwantificeren van duurzaamheid en circulariteit is belangrijk om te doen en de tools helpen daarbij. Maar daarnaast is het belangrijk om ook techniek integraal mee te nemen.

Verder moet je goed kijken naar hoeveel vrijheid je wilt geven of juist hoeveel je al voorschrijft.
Op het moment dat je iets echt wilt, zoals een bio-based composiet dan moet je het gewoon direct uitschrijven.

Wanneer je dingen wilt voorschrijven dan zul je zelf in het voortraject onderzoek en voorbereiding moeten doen.

We zullen steeds meer groeien naar opener aanbesteden doordat regelgevingen ook groeien naar een meer circulaire economie en ook het risico beheerst. Je kunt het dan steeds meer aan de markt overlaten.

Part 3: General influencing barriers and enablers

Welke samenwerkingsvorm hebben jullie gebruikt?

Er was een bouwteam. De mate van innovatie sluit uit dat je het weg kan zetten als traditioneel contract, want er was overleg en samenwerking nodig. Je hebt de kennis vanuit verschillende hoeken nodig om te komen tot het hoogst haalbare te komen.
Een bouwteam geeft verder ook meer vrijheid en ruimte. Dus een handige samenwerkingsvorm als er nog niet veel ontwerprichtlijnen al zijn.
Bouwteam altijd doen bij innovatie.

Welk laaghangende fruit kan volgens jou altijd naar gekeken worden?

1. Kijken naar minder materiaalgebruik
2. Building with nature

Wat zijn succes factoren die gebruikt kunnen worden voor het vertalen van circulariteitsambities naar realistische werkbare eisen en maatregelen?

Contract vrij open laten en EMVI circulariteit zwaar mee laten wegen. (evt. kwantitatief onderbouwen)

➔ Als project nieuw is en duidelijke scope heeft

Of je schrijft al wel veel voor. Dit heeft wel meer voorbereidingstijd.

Summary interview Individual R Cruquiusbrug

Part 1: General questions and circularity

Wat was jouw rol tijdens het constructie proces van het project?
Vaak projectmanager van beweegbare bruggen. Verder ook de contactpersoon met de klant en bezig met IFD bouwen om zowel W+B op de kaart te zetten, maar ook het IFD bouwen zelf.

Wat waren de circulariteitsambities aan de start van het project?
De begin ambities waren:
- Circulariteit
- Energieneutraliteit
- Onderhoudsarm

Part 2: Key decisions

Welke belangrijke beslissingen moesten jullie nemen of kwamen jullie tegen bij het implementeren van circulariteit ambities?

Aantal workshops gehouden en een discussie aangezwengeld. Hierin ook zorgen dat je mensen aan tafel hebt die kennis hebben van circulariteit en er enthousiast van worden en daarnaast betrokkenen met verschillende belangen en perspectieven aan tafel krijgen. We hebben het gehad over wat willen we, wat kunnen we al (zoals MKI en is dat van meerwaarde). We hebben verder gekeken naar wat er mogelijk was. Dus naar herbruikbaarheidskansen bijvoorbeeld.
In het ontwerp en contract hebben continu meegenomen of het een circulaire (en IFD) keuze was.

We hebben nu gekeken naar wat er mogelijk was, maar er zijn ook dingen niet meegenomen hierin. Later in het proces hebben we nog gekeken of we echt kansen hebben laten liggen.
We hebben bij de Cruquiusbrug het IFD bouwen naast het onderzoek van EIB gelegd en gekeken of er nog meer mogelijk was dan wat zij beweren en dat is zo volgens ons. Want als je het goed doet qua IFD bouwen dan kun je het sneller terugverdienen.
We hebben bij de Cruquiusbrug een brug die werd vervangen en de andere werd onderhouden. We hebben daarin gekeken naar een toekomstbestendig masterplan waarin werd meegenomen dat de tweede brug over ongeveer 25 jaar ook moet worden vervangen. IFD bouwen zelf is in ieder geval toekomstbestendig, want wanneer er voor de twee bruggen samen over 25 jaar een nieuw idee (bijv. aquaduct) komt dan kan de brug uit elkaar gehaald worden en dan kunnen onderdelen weer gebruikt worden.
Je weet dat er een hergebruikkans ligt in de toekomst. We hebben geprobeerd financieel in kaart te brengen wat de brug later nog waard is.
IFD bouwen is voornamelijk voor de onderhoudsfase en einde (functionele) levensduur.

Hergebruiken van materialen en objecten is nog meer een uitdaging omdat we daarvan niet precies weten wat er qua materialen in zit en wat de staat is. Maar ook is alles nu gebouwd voor een keer en precies voor die plek. Ieder ontwerp is uniek en anders.

Ik ben er in ieder geval van overtuigd dat als je nu iets gaat bouwen, dat je het zou moeten bouwen zodat het ook hergebruikt kan worden. Want we weten dat we naar een circulaire bouweconomie gaan.
We zouden wat meer naar een standaardontwerp moeten gaan en niet iedere keer met een leeg vel papier moeten starten. Op die manier kunnen we ook de kinderziektes eruit halen.

We gaan ook heel erg aanlopen tegen de grote opgaven van 80.000 bruggen die we moeten gaan vervangen of renoveren en als we dat willen halen dan zullen we het slimmer moeten doen. En IFD bouwen maar ook een standaard ontwerp hebben, waarbij je dus bijvoorbeeld de reling etc. kan aanpassen dat helpt daarbij.
Zo zou IFD bouwen ook kostenbesparend kunnen zijn want er zitten veel kosten in (het ontwerpen en vooral in) het maken van fouten.

We hebben gekeken naar hoe je marktpartijen, en dus de hele keten, ook mee kunt krijgen. Het is daarin ook belangrijk ze op de hoogte te stellen dat bij innovaties een hoger risicoprofiel hoort. Het is daarin belangrijk om te kunnen laten zien wat de meerwaarde is van het idee en van circulariteit. Er komt namelijk wat ruimte als andere partijen ook gaan inzien wat de meerwaarde voor hen is.

Verder is het belangrijk om te weten dat IFD bouwen wel een beetje conflicteert met minder materiaalgebruik, omdat er juist wat meer materiaal nodig is.

Een beheerder gaat vaak voor vernieuwing en innovaties liggen omdat die een hoger risico met zich meebrengen. Iets wat daarin zou kunnen helpen is zorgen dat de beheerder ook gehoord wordt en daarnaast zorgen dat ze extra budget krijgen wanneer mogelijk.

Een barrière blijft toch te weinig budget hebben voor circulariteit.

Een hele belangrijke keuze die je moet maken is '*hoe gaan we dit nu uitvragen bij de markt'*
- Kwantitatief (bijv. MKI)
- Kwalitatief

We hebben voor kwalitatief gekozen omdat er veel ruimte is bij MKI om recht te rekenen en verder zijn er ook veel nieuwe materialen niet opgenomen in het MKI.

Maar daarnaast is het ook belangrijk om bij de uitvraag aan de markt te kijken naar wat er wel en niet mee wordt genomen. Zo hebben we IFD bouwen als harde eis aanbesteed.
Daarnaast hebben we andere ideeën en ambities bij de aannemer gelaten. Want het was wel heel lastig door de hoge eis om je nog te onderscheiden als aannemer.
Voor nu zou je als je de ambitie zo hoog hebt liggen als bij de Cruquiusbrug, het ook zo aan moeten vragen en die ambitie ook in het contract zo hoog moeten leggen.
Een belangrijk punt is wel dat een aannemer wat zekerheid wil hebben dat ze niet gaan innoveren en iets nieuws gaan bedenken en dus investeren in een eenmalig project.

Het bepalen van hoe hoog je de lat legt is lastig. Dus nu was IFD bouwen de lat. Je moet kijken naar wat er mogelijk is, of de markt klaar is of ze het aan kunnen bieden.

Een ander belangrijk iets is dat je echt moet samenwerken en dingen samen doen en vanuit ieder perspectief iemand om tafel moet hebben zodat alle belangen (zoveel mogelijk) worden behartigd.

Part 3: General influencing barriers and enablers

Welk laaghangende fruit kan volgens jou altijd naar gekeken worden?

Probeer de markt uit te dagen en anders kan je ook kijken op welke post je geld kan besparen. Wat vaak gebeurt is Value engineering.
Wat anders ook kan is zorgen dat de brug toekomstbestendig is, dus wanneer de functie veranderd van de brug dat hij zo makkelijk mogelijk aangepast kan worden. Dus bijvoorbeeld een extra rijbaan eraan bevestigen.

Wat zijn succes factoren die gebruikt kunnen worden voor het vertalen van circulariteitsambities naar realistische werkbare eisen en maatregelen?

We werken samen met de provincie Noord-Holland en daardoor kunnen we dus leren van vorige project omdat we vaker samen werken. Iedereen staat dus ook open voor leerpunten of dingen die beter kunnen.

D. Results of interviews summarized per theme

Table 6: Results NRU

Circular ambition (start)	*'As circular as possible'*
Circularity focus	Often less primary material use, but important to consider what we do at the end of life stage as well. In NRU the ambition was in the MEAT.
Key decisions	• When you are sure of what you want, write in down in the contract • Give more space for risk • Functional specification if the market should think along to find a fitting solution • Consider what is not necessary to do or build • Look integral in the process and not just at MKI or circularity • Try to quantify circularity • Ask for knowledge if you do not know what possibilities there are
Key barriers	• Lack of time • Lack of money • Lack of scope • Esthetic demands that conflict • Everyone not having the same goal • Missing general knowledge in the company
Key enablers	• Be concrete in what you want from the market and designers • Seeing circularity as integral part in the project
Low hanging fruit	• Design for easy disassembly • Consider a material with lower impact

Table 7: Results Ritsumasyl

Circular ambition (start)	Make an innovative bridge, especially regarding material use which should be bio-based.
Circularity focus	The focus was on using a new and more circular material, furthermore the reuse options were considered as well. And lifespan elongation.
Key decisions	• Decide whether it is necessary to built something • Start with a '*nul analyse*' • Research at where the big opportunities are • Research at what materials are at the site as 'waste' • Do a reuse scan and don't start with designing right away

	• Make sustainability an integral part of the process • Involve an engineering company in the decision process as client • Be more flexible regarding the end of life time, in terms of life span, research whether the technical or functional lifespan is finished. • Give an insight in where the big impact can be made (use tools for this) • Consider the option of detachability and IFD building • Do not just look at circularity only as it is a means and not an end. • Make sure everyone works towards the same goal • Have room for more risk • Make sure you involve the right people • Consider the CUR guidelines and options • For new materials you should comply to different demands • Give tools a structured place in the process • Try to quantify circularity where possible • Consider the amount of design freedom you give
Key barriers	• Not enough money • Large risk
Key enablers	• Involve circularity from the start • Research what your ambitions are early in the process • Make sure all parties that are involved can think along, like the contractor. In this way people are stimulated to think. • Be open minded and do not have one think direction beforehand that you do not deviate from. In this way you can consider openly to ownership for example. • An early contractor involvement can help for innovations
Low hanging fruit	• Reduce travel distance • Use materials with low MKI to have less impact • Building with nature

Table 8: Results RWZI Terwolde

Circular ambition (start)	Circularity had a high priority on all aspects

	from the start. The ambition level was at 3.
Circularity focus	The focus was on all aspects of circularity so on modularity, detachability, lifespan elongation, reuse of materials. The options were all researched.
Key decisions	• Do not have a vague goal • Research where the biggest impact can be made • Made sure there is room for research and delay • Research what materials will be available after deconstruction • Research whether the materials can be reused • Determine the functional unit of the construction • Reduce impact • Determine options to reduce impact • Do reuse scan • Consider what options there are for circularity • Do a weighted point analysis • Consider the best circular strategy • Try to make a quantitative trade off • Decide whether you want circularity now or later • Look integral to the entire process • Research what materials there are and what can be used
Key barriers	• Circularity is often a vague concept
Key enablers	• Try to communicate as much as possible and involve people to make sure you are on the same page • Have a clear goal of where you are working towards and make something a priority • Make design trade offs concrete • Have room for circularity • Have pilot projects that have circularity as main goal • Use the (not yet perfect) guidelines and tools that are there as they give a direction and focus
Low hanging fruit	• Use the R strategies where possible • Avoid or reduce impact • Do nothing that is not necessary • A material passport is important but not necessarily easy

Table 9: Results Cruquiusbrug

Circular ambition (start)	A bridge that is as circular as possible that serves as an example to others to inspire and set a new reference point.
Circularity focus	IFD building had a high focus in this project and was a demand. Next to this low maintenance and energy neutral were important too.
Key decisions	• Think of your procurement strategy and do not decide everything beforehand already. • Decide what you want as a minimum and demand vs. what is a wish and put it in the contract likewise. • Have a dialogue • Consider standard demands that conflict with circularity goals and options. • Check whether there is more budget available • Be aware that you need to do more research than normal • Decide if you want to research with the market and contractor or not • Determine the ambition • Set a concrete goal • Research where the opportunities are • Consider if things need to be adjusted within the project like demands • Mirror the chances with the rest of the project • Do reuse analysis • Do a weighted point analysis to see where the biggest impact is (include the phase) • Describe what you determine a modular and detachable • It is important to determine on which phase the ambition lays • Include the contractors and maintenance early in the decision process. • Check whether the planning or demands can be adjusted • Option to make shadow design (as circular or sustainable as possible) • Have the right people involved and all perspectives represented • Make sure an object is futureproof and easy to reuse or adjust • Use standard designs more often instead of starting from scratch all the

	time. • Show stakeholders what the added value is for them • Decide is you want to quantify circularity or not • Decide what you want to have in the contract as demand and what is a wish or option
Key barriers	• The materials that become available are often not being researched and this makes the making a demand about them difficult • Getting the maintenance on board and getting more budget if necessary • Too little budget
Key enablers	• Choosing for an early contractor involvement may make innovations easier • Take time to do research on what is realistic and possible. • Work together • Have a long term relationship with a client, so multiple projects.
Low hanging fruit	• Reduce impact • Consider Value Engineering, so where can you save money • Make sure the bridge is futureproof (has no lock ins)

E. Key Barriers and enablers and easily applicable circularity summarized

Key barriers

- Lack of time
- Lack of money
- Lack of scope
- Esthetic demands that conflict
- Everyone not having the same goal
- Missing general knowledge in the company'
- Not enough money
- Large risk
- Circularity is often a vague concept
- The materials that become available are often not being researched and this makes the making a demand about them difficult
- Getting the maintenance on board and getting more budget if necessary
- Too little budget

Key enablers

- Be concrete in what you want from the market and designers
- Seeing circularity as integral part in the project
- Involve circularity from the start
- Research what your ambitions are early in the process
- Make sure all parties that are involved can think along, like the contractor. In this way people are stimulated to think.
- Be open minded and do not have one think direction beforehand that you do not deviate from. In this way you can focus openly on ownership for example.
- An early contractor involvement can help for innovations
- Try to communicate as much as possible and involve people to make sure you are on the same page
- Have a clear goal of where you are working towards and make something a priority
- Make design trade offs concrete
- Have room for circularity
- Have pilot projects that have circularity as main goal
- Use the (not yet perfect) guidelines and tools that are there as they give a direction and focus
- Choosing for an early contractor involvement may make innovations easier
- Take time to do research on what is realistic and possible.
- Work together
- Have a long term relationship with a client, so multiple projects.

Easily applicable circularity

- Design for easy disassembly
- Consider a material with lower impact
- Reduce travel distance
- Use materials with low MKI to have less impact
- Building with nature
- Use the R strategies where possible
- Avoid or reduce impact
- Do nothing that is not necessary
- A material passport is important but not necessarily easy
- Reduce impact
- Consider Value Engineering, so where can you save money
- Make sure the bridge is futureproof (has no lock ins)

F. Expert Panel

The goal of the expert panel is to asses the interpretation and current flowchart together. The focus should be especially on elements that are not fully correct, different order of elements, word choice, or elements that may be more concise. Next to this, there is also room for a discussion on what would help as a tool.

1. Did you have time to look at the flowchart?
2. Do you agree with the current general structure of the flowchart?
3. What are your first thoughts?
4. I will walk you through the flowchart and if you have an remarks or questions feel free to ask.
5. Are the options under the question '*Determine the concrete goals on circularity (SMART)*' complete?
6. What do you think of the quantitative and qualitative division?
7. Would this flowchart be applicable and useful?
8. Which interactive version could help?