P5 report

Organising early development phases to integrate circular strategies in adaptive reuse projects

A multi-case study analysis

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ABSTRACT

In the Netherlands, the built environment is responsible for half of all raw material consumption and contributes 40% of the total country's waste production. This characterizes the current prevalent unsustainable take-make-dispose process. To address the significant impact, a transition to a circular economy that prioritizes materials and circulates resources is essential, operationalized through the application of circular strategies. Adaptive reuse projects offer significant potential to support this transition by extending the lifespan of existing buildings. However, existing literature highlights several barriers that hinder the effective integration of circular strategies in adaptive reuse projects. This includes fragmented collaboration and the absence of structured guidance on organizing the development process. While strong collaboration across the development process is recognized as a key enabler, there is little insight into how it should be organized. This lack of guidance is especially critical in the early development phases, where key decisions are made that shape the project's potential for circular outcomes. Moreover, the developer's important role in facilitating collaboration is often approached from a general perspective, without a specific focus on their viewpoint or position. To address this, this research aims to answer the following research question: '*How can Dutch real estate developers organise the early phases of the development process to support the integration of circular strategies in adaptive reuse projects?'*

To arrive at an answer, this research combines theoretical research with qualitative empirical research. A multiple case study is conducted, drawing on interviews and document analysis to provide in-depth insights. A focus group with real estate developers was undertaken to validate cross-case findings and to explore explanations for results not fully captured by theory or cases. The study identifies the distinct role of each early development phase, inception, feasibility, and design, in supporting circular outcomes. It also outlines key circular strategies, actor roles, and phase-specific activities that enable integration of circular strategies in adaptive reuse projects. The findings emphasize that the early development phases do not follow a strictly sequential order. Instead, feasibility and design often progress iteratively, shaped by project-specific conditions and evolving circular ambitions. Furthermore, the study reveals that a developer can play a proactive role by aligning actors with circular ambitions. These insights are synthesized into a normative framework, providing phase-specific guidance for real estate developers in organising the early phases of adaptive reuse projects to support the integration of circular strategies.

KEYWORDS:

Construction industry, circular strategies, adaptive reuse, development process, actor collaboration, real estate developer

SAMENVATTING

De gebouwde omgeving in Nederland is verantwoordelijk voor de helft van het totale grondstoffengebruik en draagt bij aan 40% van de landelijke afvalproductie. Dit weerspiegelt het gangbare, niet-duurzame, lineaire 'take-make-dispose' model dat in de sector overheerst. Om deze impact te beperken, is een transitie naar een circulaire economie noodzakelijk, waarin materiaalgebruik wordt geminimaliseerd en natuurlijke bronnen in kringlopen worden behouden. Deze transitie wordt onder andere gerealiseerd door de toepassing van circulaire strategieën. Tegelijkertijd biedt adaptief hergebruik van gebouwen hierin aanvullende kansen doordat het de levensduur van bestaande gebouwen verlengt en zo bijdraagt aan circulariteit. Ondanks deze mogelijkheden wijst de literatuur op diverse barrières die een effectieve integratie van circulaire strategieën in adaptief hergebruik projecten belemmeren. Hiertoe behoren onder andere gefragmenteerde samenwerking en het ontbreken van gestructureerde richtlijnen voor de organisatie van het ontwikkelingsproces. Hoewel samenwerking binnen het ontwikkelproces wordt erkend als een cruciale succesfactor, is er beperkt inzicht in hoe deze samenwerking concreet kan worden vormgegeven. Dit gebrek aan richtlijnen is vooral relevant in de vroege ontwikkelfasen, waarin cruciale keuzes worden gemaakt die het niveau van circulariteit in het project bepalen. Bovendien wordt de rol van de ontwikkelaar doorgaans benaderd vanuit een algemeen perspectief, zonder expliciete aandacht voor hun perspectief en positie. Om deze kennisgebreken te belichten, richt dit onderzoek zich op de volgende onderzoeksvraag: *Hoe kunnen Nederlandse vastgoedontwikkelaars de vroege fasen van het ontwikkelproces organiseren om de integratie van circulaire strategieën in adaptieve hergebruikprojecten te ondersteunen?*

Om deze vraag te beantwoorden, is gebruik gemaakt van een combinatie van theoretisch en kwalitatief empirisch onderzoek. Drie casestudies, geanalyseerd op basis van interviews en documentanalyse, hebben diepgaande inzichten opgeleverd. De resultaten zijn gevalideerd via een focusgroep met vastgoedontwikkelaars, waarin ook verklaringen voor bevindingen buiten de theorie of casussen zijn verkend. Het onderzoek toont aan dat de ontwikkelfasen 'inception', 'feasibility' en 'design' elk een onderscheidende rol spelen in het bevorderen van circulaire uitkomsten. Daarnaast worden circulaire strategieën, actoren en fase gebonden activiteiten benoemd die de integratie van circulaire strategieën faciliteren. De analyse maakt duidelijk dat deze fasen niet strikt sequentieel verlopen. Met name de 'feasibility' en 'design' fasen kennen vaak een iteratief karakter, afhankelijk van projectomstandigheden en veranderende ambities. Verder blijkt dat de ontwikkelaar een proactieve rol kan spelen door actoren op één lijn te brengen met de circulaire doelstellingen. Deze inzichten zijn samengebracht in een normatief model dat fase-specifieke richtlijnen biedt voor de organisatie van de vroege fasen in adaptieve hergebruikprojecten ter bevordering van circulaire strategieën.

KEYWORDS:

Bouwsector, circulaire strategieën, adaptief hergebruik, ontwikkelproces, actorensamenwerking, vastgoedontwikkelaar

COLOPHON

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LIST OF ABBREVIATION

ANT	Actor-network theory
AR	Adaptive reuse
Ar	Architect
BP	Building physicist
CBA	Circular building adaptability
CE	Circular economy
CEx	Circularity expert
CO	Contractor
CS	Circular strategies
De	Developer
Di	Dismantler
EMF	Ellen MacArthur Foundation
FU	Future user
IE	Installation expert
In	Investor
QS	Quantity surveyor
RE	Reclamation expert
SD	Salvage dealer
SE	Structural engineer

1 INTRODUCTION

CONTENT

1 INTRODUCTION

1.1 The impact of the built environment

In recent years, the urgency of addressing the impact of climate change has prompted global and national efforts to reduce its impact. The Paris Agreement, which aims to limit global temperature rise to 1.5 ˚C above pre-industrial levels (IPCC, 2019), underscores the need for substantial reductions in greenhouse gas emissions. Achieving these targets requires addressing major sources of emissions, including the construction industry.

The construction industry is one of the largest contributors to climate change, responsible for significant resource consumption and waste generation. According to Yeheyis et al. (2013), the sector accounts for about 40% of raw material extraction. Moreover, the extraction and processing of these materials account for half of the global emissions, significantly driving climate change, rising global temperatures, and biodiversity loss (Su et al., 2022). In the Netherlands specifically, the construction sector is responsible for half of all raw material consumption and 40% of national waste production (Circle Economy & Metabolic, 2022). These current linear production processes in the industry, characterized by the take-make-dispose model, contribute to resource depletion, environmental degradation, and volatile material costs (Eberhardt et al., 2022; Jeyanthan & Ilankumaran, 2019; Morseletto, 2023). These realities highlight the urgent need for radical changes in the construction industry, transitioning towards more sustainable practices.

1.2 The transition to the circular economy

To address the significant impact of the construction sector on resource depletion and waste generation, a transition to a circular economy that prioritizes materials and circulates resources is essential. Recognizing this need, the Dutch government has set the goal to achieve 100% circularity by 2050 (Ministry of Infrastructure and Water Management, n.d.). By minimizing the total amount of extracted resources and produced waste, CE can ultimately generate beneficial outcomes for nature, people, and the economy (Ellen Macarthur Foundation, 2024). Furthermore, it plays a crucial role in reducing the carbon footprint of buildings (Ellen MacArthur Foundation & McKinsey & Company, 2014) and thereby contributes to broader climate mitigation efforts.

The circular economy is operationalized by applying circular strategies, such as the R-ladder, or narrowing, slowing, closing, and regenerating resource loops (Eberhardt et al., 2022). Despite growing interest and awareness, CE's practical implementation in the construction industry remains limited, even though the potential is evident (Eberhardt et al., 2022; Van Uden et al., 2024). At the same time, the application of circular strategies continues to stay behind due to the various barriers and challenges experienced during their integration (Eberhardt et al., 2022; Leising et al., 2018; Van Uden et al., 2024).

1.3 Challenges towards the circular economy

Several key challenges hinder the integration of circular strategies in the construction sector. First, some key challenges regard the current construction industry's structure. This includes the fragmented supply chain (Adams et al., 2017) and insufficient collaboration among stakeholders (Gerding et al., 2021; Hart et al., 2019). This is particularly evident in the development process, where the lack of collaboration is widely regarded as a major barrier to speeding up toward more circular practices in the building industry (Çimen, 2023).

Second, there is a lack of knowledge and adequate guidelines to integrate circular strategies effectively (Amarasinghe et al., 2024; Antwi-Afari et al., 2021; Hart et al., 2019). This challenge extends to the lack of practical guidance on how to organise collaboration and structure the development process to support the circular ambition in practice (Chan et al., 2023; Çimen, 2023; Leising et al., 2018).

These combined knowledge and process gaps underscore the need for further investigation into how circular strategies can be effectively integrated into the development process. Previous research suggests that circularity is most successfully realised when strategies are integrated from the earliest phases of the development process and when key actors are engaged on time (Leising et al., 2018). Nevertheless, there is limited understanding of how the development process can be organised to support the integration of circular strategies and to enable effective collaboration.

1.4 Adaptive reuse projects

A significant portion of the current real estate stock in the Netherlands no longer meets functional demand. This is due to many buildings being outdated and misaligned with modern needs, causing vacancies. Within the Netherlands, the highest vacancy rates are in the retail and office sectors. In the retail market, this consisted of 6% in 2023 and was expected to increase in the upcoming year (CBRE, 2023). Similarly, in the office market, there is a vacancy of 8,4% at the start of 2024, with the highest vacancy rates in Amsterdam (Cushman & Wakefield, 2024). At the same time, the combination of the rising population and increasing outdated buildings further drives the need for adequate buildings in the upcoming years (De Graaf & Schuitenmaker, 2022). To address this, adaptive reuse offers a fitting and inevitable solution for meeting the demand and tackling vacancy rates in the existing real estate stock in the Netherlands. Adaptive reuse is the process of converting the building or parts of it to a purpose other than the function it was designed for to extend the lifespan of the building (CIRCuIT Project, 2023).

Adaptive reuse aligns closely with the principles of the CE as transforming the building into a new function extends the life of existing materials, reduces the need for new resources, and minimizes waste. From the perspective of the real estate developer, adaptive reuse projects are promising as these buildings are often located in inner city areas with limited development possibilities. Additionally, these areas are characterized by higher house values, making the investment more attractive (Remøy, 2010). However, the case of adaptive reuse is more complex than a newly built project. Real estate developers face challenges related to the current condition of the building, the presence of asbestos, current leases, existing agreements with the municipality, and prevalent zoning plans (Remøy et al., 2024).

Several studies have been conducted on adaptive reuse projects. These studies focus on the decision-making tools and the integration of information technologies in adaptive reuse projects (Hamida & Hassanain, 2021). However, the literature provides limited insight into how the development process in such projects can be organised to support the integration of circular strategies and enable structured collaboration. While Hamida and Hassanain (2021) do address the organisation of the development process, their work does not explore its connection to circular ambitions or actor collaboration. Moreover, existing research often prioritises newly built projects, thereby overlooking the complexities associated with adaptive reuse (Chan et al., 2023).

1.5 Real estate developer

In the context of real estate development, the real estate developer plays a crucial role in shaping the development process and influencing the final product. As a central player, they connect all parties involved in the project, ensuring collaboration and alignment. According to Peek and Gehner (2018), it is the real estate developer's role to possess a thorough understanding of the market conditions and translate the demand into a feasible project. Real estate developers often initiate the development process and involve external parties to contribute their expertise. Throughout the process, the real estate developer has a management role, directing and coordinating all stakeholders involved.

A special characteristic of a project developer is their position at the interface between private and public (Peek & Gehner, 2018). The municipality serves as a representative of the public interests. There is a co-dependency role between real estate developers and municipalities (Leffers, 2018). Municipalities rely on developers to realize urban development projects, while developers depend on municipal approval. At the same time, developers must ensure their plans align with private market demands to attract buyers. This highlights the unique position of the real estate developer, navigating between public and private interests while aligning plans to meet both.

Beyond their unique position in the private and public fields, the real estate developer has a central position within the entire supply chain (Peek & Gehner, 2018; Remøy et al., 2024). Figure 1 illustrates the central role real estate developers have. Their central position in the supply chain, in combination with their coordinating role, places real estate developers in a unique position (Peek & Gehner, 2018; Remøy et al., 2024). Acting as the link between end-users, investors, and other stakeholders, they are well-positioned to integrate circular ambitions into the development process by engaging and aligning stakeholders around these goals. However, real estate developers do not always have the final say in adopting circular strategies, as investors may not prioritize these ambitions. Despite this limitation, developers remain a crucial actor in pitching these plans to investors. In conclusion, the central and coordinating role of developers positions them as actors who are expected to be enablers in the implementation of circular strategies.

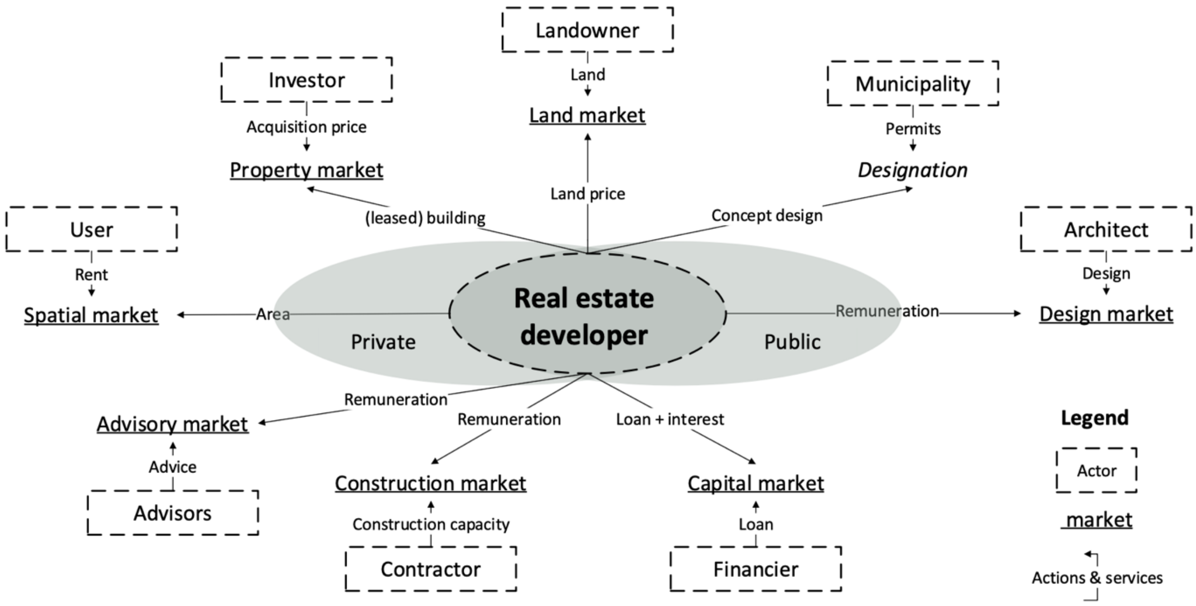


Figure 1 Central position of real estate developer, adopted from (Gehner & Peek, 2018)(own work)

1.6 Problem statement

While the potential of integrating circular strategies in AR to mitigate the effects of climate change and resource depletion is evident, research has shown that their integration in the construction industry remains behind. Significant gaps remain in the literature on how to address the challenges. First, research highlights that enabling the transition to CE requires strong collaboration across the development process (Amarasinghe et al., 2024; Çimen, 2023; Gerding et al., 2021; Leising et al., 2018). However, it lacks an examination of how the collaboration can be organized throughout the development process, particularly in adaptive reuse projects (Chan, 2023). Second, research highlights the important central role of the developer in bringing together the actors in the development process (Leising et al., 2018). Nevertheless, it approaches this role from a general perspective, focusing on multiple actors in the supply chain rather than analysing it specifically from the developer's viewpoint. Third, existing studies tend to focus on isolated phases of the project cycle, offering fragmented solutions that fail to address the interconnected nature of the development process (Benachio et al., 2020; Leising et al., 2018). This fragmentation emphasizes the need for the examination of the broader context in the development process. Fourth, although literature recognises the importance of integrating circular strategies early in the development process (Leising et al., 2018), it provides limited insights into how these early phases can be organised to enable such integration (Adams et al., 2017; Akhimien et al., 2021). This underscores the necessity for clear guidance in the development process. These identified gaps in the literature present the opportunity for further research.

1.7 Research questions

To address the identified gaps, this research aims to provide practical guidance for Dutch real estate developers on how to organise the early phases of adaptive reuse projects to support the integration of circular strategies. By examining the early phases of the development process, this study explores the applicable circular strategies, analyses the dynamics of collaboration, and identifies activities that contribute to circular integration. In this context, the proposed main research question is:

How can Dutch real estate developers organise the early phases of the development process to support the integration of circular strategies in adaptive reuse projects?

The various aspects of this research question will be explored through a set of guiding sub-research questions (SRQ). These seek to identify the circular strategies applicable to adaptive reuse projects, uncover the influence of the early phases, and determine the relevant actors and the ideal project phase for engagement. The last SRQ examines the different activities that contribute to the integration of circular strategies in adaptive reuse projects. The sub-research questions discussed are:

SRQ 1: What circular strategies are applicable in adaptive reuse projects?

SRQ 2: What is the influence of each early phase in the development process on the level of integration of circular strategies?

SRQ 3: What type of actors are involved in circular adaptive reuse projects and how do these actors collaborate in the phases?

SRQ 4: What key activities in each early phase contribute to the integration of circular strategies?

1.8 Societal and scientific relevance

The transition to a circular economy is widely recognized as crucial in addressing the current environmental challenges. Within the construction industry, this shift is particularly urgent due to its emission footprint, resource consumption, and waste generation. At the same time, population growth, high vacancy rates, and changing demands require new approaches to reuse the existing built environment. Adaptive reuse responds to this need and aligns with circular principles, but its potential remains underused without systematic integration of circular strategies.

From a scientific perspective, this study addresses a key gap in the literature, namely the lack of detailed insight into how real estate developers can organise the early phases of the development process to support circular strategy integration in adaptive reuse projects. Existing studies often take a general or multi-actor view, offering limited guidance on the developer's concrete role, or on the phase-specific activities and collaborations needed to enable circular outcomes. This research adds to the field in three distinct ways. First, it contributes by narrowing the focus to the developer's perspective and by detailing how they can actively support circularity through targeted collaboration and engagement efforts in the inception, feasibility, and design phases. Second, it identifies specific activities and actor relationships that support circular integration per phase. Third, it shows that these phases interact in an iterative rather than linear manner. In doing so, the study addresses literature gaps, and both refines and extends the existing research, offering practical guidance for enabling circularity in adaptive reuse practice.

Moreover, this study contributes beyond just academia, as it adds societal relevance by offering practical value to the real estate sector. It provides practical guidance on how the early development phases can be organised to better align actor collaboration and activities with circular ambition, specifically from a Dutch real estate developer perspective. The relevance of this topic is further underscored by the Dutch government's ambitious goal of achieving a 100% circular economy by 2050.

1.9 Structure

This thesis is organized into several chapters, each contributing to answering the main research question. After presenting the problem statement and research questions in Chapter 1, Chapter 2 outlines the research methodology. Subsequently, the theoretical background is discussed in Chapter 3, drawing on existing literature. Chapter 4 provides the empirical findings based on three in-depth case studies and presents the findings from the cross-case analysis. The findings are further analysed in Chapter 5, where they are validated and refined through a focus group with real estate developers. This chapter also introduces the resulting framework that offers practical guidance on organizing the early development phases. Chapter 6 synthesises the findings and provides answers to the research questions. Finally, Chapter 7 discusses the limitations and offers both scientific and societal recommendations.

2 RESEARCH METHODOLOGY

CONTENT

2 RESEARCH METHODOLOGY

2.1 Research design

This research is an exploratory qualitative study that addresses the significant gap in understanding how the early phases of the development process can be organized to support the integration of circular strategies in adaptive reuse projects. Qualitative research is the appropriate way to explore a complex, detailed understanding of an issue, such as collaboration in this research, by capturing the perspectives, experiences, and context of the actors involved (Creswell, 2013).

The research is divided into two parts: the theoretical research and the empirical research. The first part, theoretical research, includes a literature review and informal conversations with experts to gain a comprehensive understanding of the concepts within the research. Simultaneously, this part includes the development of a theoretical analytical framework that serves as the foundation for the second part, the empirical research. The empirical research focuses on the collection of data that is used to analyse and discover further insights into the concepts in practice. The results from the empirical research are used to confirm and extend on the theoretical research and to draw new conclusions that are applicable in practice. The research design of the overall research methodology is graphically shown in Figure 2.

Within the overall research design, each research question fulfils a different role. SRQ1, SRQ2, and SRQ3 are empirical questions. They aim to describe or explain the current practice based on evidence from the case study, explained in chapter 4. SRQ4 is also empirical in nature, as it identifies key activities based on data derived from the case studies. While some of the activities were formulated as recommendations by interviewees, these emerged within the empirical context of the cases. The subsequent cross-case analysis and validation through a focus group confirm that these findings reflect actual practices, underlining the empirical nature of the question. The main research question, by contrast, adopts a more normative character. It synthesizes the empirical findings into a practical recommendation, aimed at guiding real estate developers on how to structure early phases to support the integration of circular strategies in adaptive reuse projects.

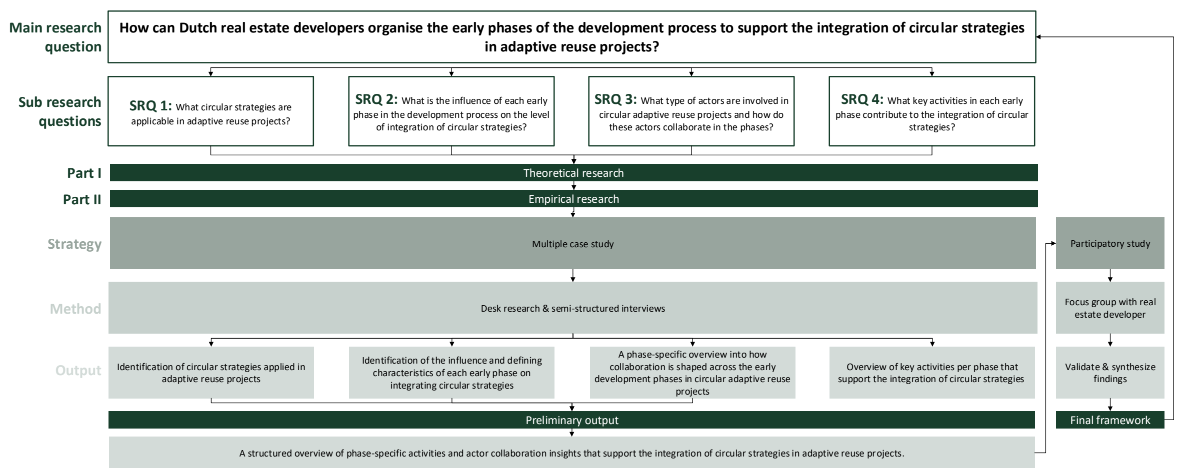


Figure 2 Research methodology design (own work)

2.2 Research process

The research process is divided into 3 different phases, illustrated Figure 3, combining the theoretical and the empirical parts to answer the main research question. The process model emphasizes the sequential order of the process and how the two parts, theoretical and empirical, are brought together to draw conclusions. The first phase, define & design, includes the theoretical research and focuses on developing a theoretical background. Additionally, it prepares for conducting the research for the empirical part, including designing the data collection, selecting applicable cases, and planning the interviews.

The second phase, prepare, collect & analyse, involves the collection and analysis of the derived data. This phase starts by collecting the data from the cases via interviews, internal document analysis, and desk research, after which each case is analysed individually.

The last phase, synthesize & conclude, compares the findings derived from the individual case studies with each other to identify differences and patterns. To ensure the practical relevance of the final output, a focus group with real estate developers is conducted to validate and improve the proposed recommendations. The feedback from the focus group is incorporated into the final recommendations. This phase finishes with drawing final conclusions that address the main research question and making recommendations.

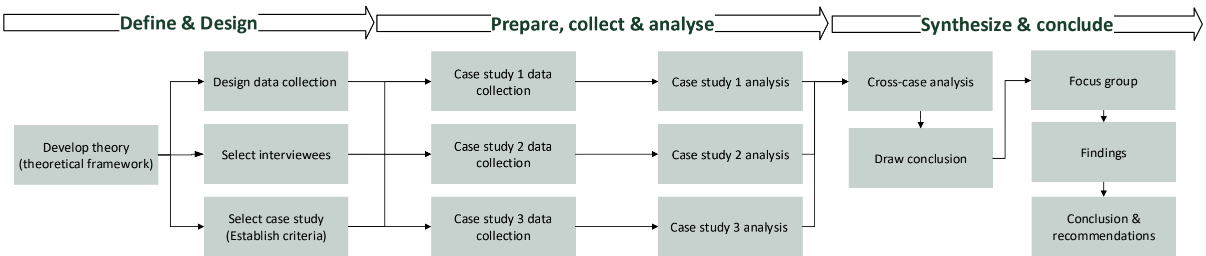


Figure 3 Research process (own work)

2.3 Theoretical research

The theoretical research provides the foundational knowledge required to conduct the empirical research. This part consists of a semi-systematic literature review conducted via search engines such as Google Scholar. Furthermore, informal conversations with actors in the field were used to gain a further understanding of the key concepts.

It starts by introducing the concept of circular economy with its accompanying circular strategies and adaptive reuse. This provides a foundational understanding of the main topics, necessary for both the reader and the researcher. Next to this, the research shifts toward the characteristics of the development process specified for adaptive reuse projects, including the key actors involved and the dynamics of collaboration. To analyse collaboration, the study introduces a multi-actor network analysis, a method for identifying relationships and influence in a collaborative network among actors. This method can be applied in the second part, the empirical research. Finally, based on the theoretical concepts, this part concludes with the developed analytical model. This provides a clear and structured foundation for developing the interview protocol and conducting interviews in empirical research to ensure that the data collection aligns with the theoretical insights.

2.4 Empirical research

The empirical research builds upon the acquired knowledge derived from the theoretical research. To arrive at an answer to all the sub-research questions, a multiple case study is conducted using data from interviews, internal documents received from interviewees, and desk research. The findings derived from multiple cases allow for wider discoveries and stronger evidence (Gustafsson, 2017), enhancing the overall credibility and robustness of the study (Yin, 2003). Although it should be noted that the findings of case studies cannot be generalized, due to the unique aspects of each case (Blaikie & Priest, 2019). For the empirical research, three cases are selected.

The analytical model established in the theoretical research is used as a guiding model to develop the interview protocol and questions. The data derived from the interviews and document analysis in each case is analysed individually, combining both deductive and inductive approaches to identify patterns and uncover additional insights. Afterward, a cross-case analysis is carried out to compare the findings and synthesize them into initial conclusions. These results are validated through a focus group with real estate developers, during which feedback on the findings was collected and unexplained outcomes were addressed.

2.4.1 CASE SELECTION AND PARTICIPANT SELECTION CRITERIA

Selecting a suitable case is an important aspect of empirical research. Since circular construction is not yet a standard practice, only a limited number of projects fully integrate multiple circular strategies. Moreover, there are relatively few projects in the Netherlands where circular strategies have been applied specifically in adaptive reuse projects (Hamida et al., 2023). The absence of a universally accepted definition of what constitutes a 'circular project' further complicates case selection. While adaptive reuse inherently aligns with circular principles by preserving the existing structure and often the facade, this alone does not necessarily indicate a highly circular project. True circularity requires a more comprehensive approach that integrates multiple strategies beyond the reuse of the structure and the facade, which serves as the defining criterion in this research. Additionally, as this research is written from the perspective of a project developer, it was essential to select at least one case where a developer played a significant role in the process.

Three cases are selected to ensure sufficient data for analysis and to enable a comparative approach. These cases are Zandkasteel in Amsterdam Southeast, Edge Olympic in Amsterdam South, and AIR Offices in Rotterdam. This research explores the differences, similarities, and best practices between cases. By comparing cases, this research uncovers how the early phases of the development process were organized, influencing circular outcomes.

To enhance the reliability of this research, the participants are selected based on their comparable roles and influence on circular outcomes. Given the central role of the developer in this research, their perspective is essential to be included in all cases. In cases where a developer was not directly involved, the project manager has been selected as a comparable actor. Additionally, the architect has been included as a relevant participant due to their influence on the design outcomes and the extent to which circularity is integrated. Furthermore, circularity or sustainability advisors are considered important participants as they provide crucial knowledge on circularity during the development process. Finally, the contractors are considered relevant participants due to their potential influence on material choices and practical constraints. However, their inclusion varied across cases: in one case, the developer directly executed the contractor's role and managed the subcontractors themselves due to specific project circumstances. In another case, there was no interest in participating in the interview, while in the third case, the contractor was successfully included. An overview of the selected participants per case is illustrated in Figure 4.

	Zandkasteel	Edge Olympic	Air Offices
Project manager	Z1	EO1	AO1
Designer	Z2	EO2	AO2
Sustainability advisor	Z3	EO3	AO3
Contractor	Z4		
Circular advisor contractor	Z5		
Employers agent	Z6		

Figure 4 Selected participants for interviews

2.4.2 DATA COLLECTION

The collection of the data is based on multiple sources, including in-depth interviews, internal document analysis, and desk research. This triangulation strengthens the reliability and validity of the research (Creswell, 2009). Semi-structured interviews allow for a deeper understanding of certain topics that emerge during the conversations. Moreover, conducting multiple interviews per case forms a stronger and broader understanding, reducing subjectivity (Charmaz & Belgrave, 2012). The interview protocol is provided in Appendix 9.2. The primary aim of the interviews was to gain insights into the collaboration dynamics and activities organized throughout the development process in each case.

To ensure the participants were well-prepared, the interview questions, the research briefing, and the consent form were sent a few days in advance. During the interviews, a MIRO board was used interactively in two distinct ways. First, before the interviews, the circular strategies applied per layer were pre-filled based on desk research and served as a starting point for discussion. Second, the multi-actor network analysis for each development phase was visually prepared in advance to ensure efficiency during the interview. Each interview included a structured discussion of the applied strategies and multi-actor network. To minimize individual interpretation, the diagram legend was first clearly explained. This includes explaining the meaning of the node size, colour, and connection types. Then, the network was discussed systematically per phase. For each phase, participants were first asked to identify which actors were involved. Next, they were asked to reflect on all relevant relationships from their perspective. This was followed by a detailed discussion of each actor's level of knowledge on circularity. Finally, the level of influence each actor had on circular outcomes was assessed. The table of circular strategies per building layer and the network diagrams were reviewed and validated with each participant and refined where necessary based on their feedback.

The interviews took around 1 to 1.5 hours and were conducted via Microsoft Teams or at the participant's office. Before the interviews, the interviewees signed an informed consent confirming their awareness of the study's objectives and data confidentiality. As part of the desk research analysis, several sources were analysed, including publicly available online documents, websites, and newspaper articles. Furthermore, private documents such as BREEAM assessments, internal presentations, and factsheets were provided by participants.

2.4.3 DATA ANALYSIS

After the interviews, the transcript developed by Microsoft Teams is manually checked for typos and errors. As this research concerns human participation, their participation must be protected from any potential risks. Therefore, the transcripts and recordings are stored in a restricted folder at the TU Delft OneDrive, only accessible to the researcher. This folder will be deleted after completion of the research.

The data derived from the interviews is analysed using qualitative data software. The data analysis tool that has been selected is Atlas.ti. This software facilitates organizing codes and exploring their relationships. The data will be analysed using codes derived from the literature, a deductive approach. It uses the analytical model from the theoretical background as a predefined structure (Creswell, 2009). A limitation of the deductive approach is that it relies on a theory developed in advance (Burnard et al., 2008). To address this limitation and remain open to the discovery of new themes, an inductive approach is additionally applied during the analysis of the data.

2.5 Synthesis

After analysing each case individually, the findings are brought together in a cross-case analysis. This synthesis integrates the findings from all cases to identify overarching patterns and relationships, providing broader insights into how the early phases are shaped and how their organisation influences the integration of CS. Subsequently, a focus group with developers was conducted. In this session, participants reviewed the cross-case outcomes and reflected on unexplained results, contributing to the refinement of the final recommendation framework.

2.6 Validation

This research is validated in multiple ways. First, the transcripts are carefully checked manually. As an additional validation step, the transcripts and actor network diagrams are sent to the participants to review and approve them. Second, the use of multiple perspectives during the interviews strengthens the validity of the research. This provides a more comprehensive understanding of each case and minimizes biases by examining the topics from multiple viewpoints (Creswell, 2009). The combination of interviews, internal document analysis, and desk research further enhances the validity of the findings. As collecting data from multiple sources allows for cross-verification, strengthening the findings (Creswell, 2013). Finally, a focus group with real estate developers is conducted to validate and refine the preliminary output.

2.7 Data management plan

This research takes into account the FAIR guiding principles for data management based on Wilkinson et al. (2016). The principles include findable, accessible, interoperable, and reusable. These principles focus on the long-term (re-)usability of the data. This thesis will be stored on the TU Delft repository website, an open-access platform for TU Delft's scientific output. This contributes to the principle of findability and accessibility. Additionally, each source has been referenced using APA 7th, contributing to the findability of the information. The interoperability is ensured by storing the thesis in an accessible PDF format, making it easy for others to open and view the content. Moreover, the thesis is written in English, a widely used language in academia. The quotes from the case analysis have been translated to English to ensure international transparency. The reusability of this research is supported by clear documentation of the research design, methods used, and the context of the data collection, ensuring other researchers can effectively understand and apply the findings. It is noteworthy that only the analysis of the data is included in this research and not the transcripts of the interviews. This is done to protect the privacy and confidentiality of the participants, ensuring ethical compliance.

2.8 Ethical considerations

As this research includes human participants, it is crucial to protect their safety. The cases are analysed from different actors' perspectives, which may lead to conflicting expressions and viewpoints. To address this, this research has established ethical considerations to guide the research process. This sets the principles and guidelines morally and responsibly for conducting the research. According to Blaikie and Priest (2019), key concepts relevant to ethical considerations include secrecy, confidentiality, privacy, and anonymity. Secrecy includes ensuring non-disclosure of information beyond the researcher. Privacy focuses on protecting personal information. Confidentiality involves limiting access to information based on an agreement. Lastly, anonymity safeguards individuals to ensure they cannot be re-identified in the research. These considerations are included in the ethical plan. It is noteworthy that the cases are described in detail, but the names of participants are omitted and replaced by their role (e.g. 'architect'). However, this approach may indirectly make participants identifiable if their role within a project is publicly known. This potential risk is explicitly mentioned in the consent form. Participants are asked to provide informed consent under these conditions before the interview takes place.

Before the interviews and case studies are conducted, an ethical plan is approved by the TU Delft as part of the Human Research Ethics Committee (HREC). This ethical plan consists of the data management plan, informed consent, and human research ethics. The approval of this plan confirms the ethical consideration of this research, including the protection, respect, and safety of the participants.

2.9 Research output

2.9.1 GOALS AND OBJECTIVES

The goal of this research is to contribute to a more sustainable built environment by promoting circular practices, limiting resource consumption, and strengthening the theory around collaboration and early-phase processes in adaptive reuse projects. To achieve this goal, this research aims to provide insights into how developers can organise the early phases of the development process to support the implementation of circular strategies in adaptive reuse projects. The study specifically focuses on the early phases in the development process, as these are the most decisive for determining whether circular strategies are applied in the project.

2.9.2 DELIVERABLES

The final deliverable of this study is a normative framework that advises real estate developers on the organisation of the early phases in circular adaptive reuse projects. It identifies which activities are critical per phase, specifies when and with whom collaboration is advised, and clarifies the role of actors in supporting circular ambition.

2.9.3 DISSEMINATION AND AUDIENCE

This research targets a broad audience. The primary audience is Dutch real estate developers, as it provides guidance on how to organise the early phases of circular adaptive reuse projects by identifying key activities and advising on collaboration with relevant actors. It is particularly relevant for developers who are keen to enter the circular market but have not had previous experience. This study can, therefore, demonstrate how they can set up their development process and inter-organisational relations.

In addition, the findings would be valuable for more stakeholders. Project owners and investors could use this research to understand the benefits of early collaboration and the roles of actors in achieving circularity. Moreover, the findings provide insight into what initiating a circular project entails in practice, specifically, what types of activities, coordination efforts, and actor engagements they can expect. Architects, circularity consultants, and other actors in the development process may benefit from the insights to align their practices with key circular tasks and to foster collaboration to enhance circularity in projects.

3 THEORETICAL RESEARCH

CONTENT

3 THEORETICAL RESEARCH

3.1 Circular economy

The circular economy (CE) is not only a new way of thinking, but it is also essential in fulfilling the objectives of the Paris Agreement. By minimizing the total amount of extracted resources and the produced waste, CE can ultimately generate beneficial outcomes for nature, people, and the economy (Ellen Macarthur Foundation, 2024). Furthermore, it plays a crucial role in decreasing the carbon footprint of buildings (Ellen Macarthur Foundation & McKinsey & Company, 2014) and is thereby contributing to the broader climate mitigation efforts. The CE focuses on keeping materials, components, and products in circulation at their highest value for as long as possible, distinguishing between technical and biological cycles (Benachio et al., 2020). Despite the extensive research about the CE, a universally accepted definition is still lacking for it. Kirchherr et al (2017) reviewed 114 circular economy definitions and concluded that the most widely recognized and developed definition is the one proposed by the Ellen MacArthur Foundation (2013). Their definition is as follows:

"A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models."

Building on this widely accepted definition of the circular economy and given its widespread acceptance, this study adopts this definition as a foundation for further research. The Ellen Macarthur Foundation (2024) also formulated the most established design-driven principles of circularity. These principles are (1) the elimination of waste and pollution to reduce risks to nature, (2) the circulation of products and materials to create space for nature, and (3) the regeneration of nature to support biodiversity. In the construction industry, these principles hold specific relevance. As the industry accounts for 40% of national waste in the Netherlands, waste elimination is essential. Only 8% of materials used in buildings are from secondary sources, and most are downcycled, emphasizing the need to apply the second principle (Circle Economy & Metabolic, 2022). Moreover, with the sector responsible for 35% of CO_2 emissions, its impact on ecosystems and biodiversity is substantial (Nelissen et al., 2018). These principles, therefore, offer clear pathways to reduce the environmental impact of the construction industry.

The CE is both an economic model and a holistic approach to addressing the upcoming social and environmental challenges. It seeks to replace the current prevalent unsustainable 'take-make-dispose' process with a regenerative circular one. While the Ellen MacArthur Foundation's CE principles offer a conceptual foundation, they lack guidance for practical implementation. Translating them into actions remains a challenge in the construction sector. This underscores the need for practical strategies and implementations to bring the CE vision into real-world practices.

3.2 Adaptive reuse

Adaptive reuse (AR) is increasingly relevant in addressing building obsolescence and vacancy. Buildings can experience obsolescence in different contexts, including aesthetic, functional, legal, social, tenure, structural, financial, environmental, locational, and site obsolescence (Remøy, 2010). Functional obsolescence arises when a building no longer meets market demands, often due to changing work patterns and competition from more suitable buildings (Buitelaar et al., 2021). For instance, the rise of remote working and flex workspaces after COVID has reduced demand for traditional office spaces, leading to increased vacancy rates (CBRE, 2023). Functional obsolescence, often combined with other forms of obsolescence, can result in vacancy. A distinction is made between natural vacancy, considered a normal market rate, and structural vacancy, which refers to buildings remaining unoccupied for three years or more (Remøy, 2010). Within this research, the latter, structural vacancy, is most relevant as it highlights the significant oversupply and market imbalance.

Adaptive reuse is a perfect possibility to tackle and prevent structural vacancy and obsolescence. This can take place if the building is suitable for reuse in terms of functionality, technical conditions, and financial feasibility, all in alignment with the legal context (Remøy, 2010). Adaptive reuse is the process of extending the lifespan of the building or building part by changing the building for a purpose other than the initial function it was designed for (CIRCuIT Project, 2023). In the shearing layers model, adaptive reuse typically targets the structure, as it cannot be changed without full demolition (Remøy, 2010).

Adaptive reuse offers significant benefits compared to newly constructed buildings. First, economically, it is more cost-effective, as it makes use of existing structures rather than requiring new construction (Hamida & Hassanain, 2021). Second, environmentally, it reduces greenhouse gas emissions through lower resource consumption and the reuse of materials (Foster, 2020), while also mitigating resource scarcity (Bullen & Love, 2011b). Third, socially, it preserves the urban area and its value and addresses the changing needs of users, preventing degradation (Bullen & Love, 2011a). Besides that, AR also strongly aligns with CE principles by avoiding demolition and extending the building's lifespan.

For building owners, the decision between demolition and adaptive reuse is complex due to the lack of clear evaluation models. Nonetheless, studies show that AR often outperforms demolition in the long term, generates less waste, consumes less energy, and requires fewer materials (Bullen & Love, 2011a). Three critical factors influence the feasibility of such projects, namely capital investment, asset condition, and regulations (Bullen & Love, 2011a), as summarized in Figure 5. For a real estate developer, these factors form the initial conditions for assessing the potential for AR. Addressing these factors involves challenges that require collaboration among multiple actors.

Adaptive reuse decision making		
Capital investment Whole life costs	**Asset condition** Construction costs	**Regulation** Resource consumption
- Aesthetics - Finance - Occupier demand - Marketability - Tax concessions - Coporate image - Market trends	- Location - Residual service life - Internal layout - Structural integrity - Usability/ functionality - Space	- Governance - Legislation - Building code - Planning requirements - Occupational health & safety - Heritage

Figure 5 Factor influencing decision making for adaptive reuse, adopted from (Bullen & Love, 2011a) (own work)

3.3 Circular strategies

Circular strategies (CS) operationalize the principles of the circular economy by translating them into practical actions (Ho et al., 2024). Their application aims to strive for the highest possible form of circularity and ensure optimal CE implementation. While many studies propose different approaches, no universally applicable strategy exists, as the most suitable approach depends on project-specific factors (Foster, 2020; Guerra & Leite, 2021). The literature uses different terminologies for the previously mentioned strategies, such as 'principles'. In this research, circular strategies are defined as 'material centric *approaches and actions that contribute to achieving a circular economy in the built environment, aimed at preserving the value of resources, materials, and products throughout their lifecycle as long as possible and by minimizing waste, optimizing reuse, and promoting regeneration.'* This section introduces several types of circular strategies identified in the literature, outlining their characteristic and presents the resulting overview model used in the analytical model.

3.3.1 NARROWING, SLOWING, CLOSING & REGENERATING RESOURCE LOOPS

Circle Economy and Metabolic (2022) distinguish four resource-oriented circular strategies: narrowing, slowing, closing, and regenerating the resource loop. Narrowing the loop refers to reducing material use through efficient design. Slowing aims to extend the lifespan of materials and products, e.g. using it longer. Closing involves recycling materials at end-of-life to return them into the system. The last strategy, the regenerate strategy, aims to strengthen the use of bio-based and renewable materials, substituting toxic materials in the design. The strategies are visualized in Figure 6.

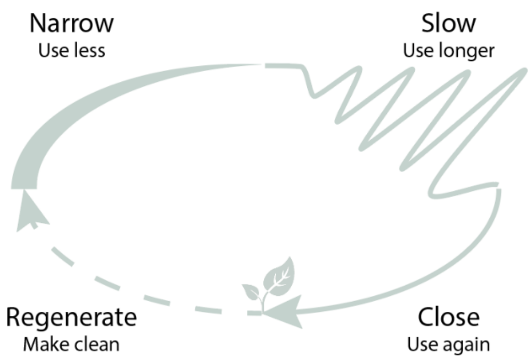


Figure 6 Resource loops, adopted from (Circle Economy & Metabolic, 2022) (own work)

The preferred order of applying circular strategies starts with narrowing, by reducing material use in design. Next, slowing aims to extend material lifespan through reuse and maintenance (Bocken et al., 2016). This potentially reduces up to 99% of greenhouse gas emissions, though this depends on material type, reuse cycles, and process efficiency (Gallego-Schmid et al., 2020). When materials reach end-of-life, closing reintegrates them into the system, ideally through upcycling. This can reduce emissions by 30–50%, influenced by transport distance and recycling efficiency. One should keep in mind two approaches for closing the loop in an adaptive reuse project. Closing the loop can involve immediate reuse of existing materials. Alternatively, it can be enabled for the future by applying disassembly-oriented design, part of the slowing strategy, which allows components to be reused or recycled at the end of the building's lifespan.

Literature highlights the limited potential for closing the resource loop until 2050, primarily due to the current immature market for secondary resources available (Van Oorschot et al., 2023; Van Uden et al., 2024). Additional constraints are related to limited availability, uncertain timing, lack of tools and knowledge, and quality concerns (Adams et al., 2017; Hart et al., 2019). These constraints emphasize the need to complement closing strategies with narrowing and slowing approaches.

Given the constraints of closing resource loops, regenerative strategies are also essential. This strategy aligns with the third principle of CE, emphasizing the regeneration of nature. Shifting toward the use of biobased materials to regenerate the resource loop can, on the one hand, reduce the overall greenhouse gas emissions, but on the other hand, it remains a highly land-intensive activity (Van Oorschot et al., 2023). This illustrates that while biobased materials offer valuable contributions to climate mitigation efforts, they should be implemented alongside other strategies to achieve a balanced and sustainable approach.

In this research, the four circular strategies, narrowing, slowing, closing, and regenerating, form the overarching main categories of CS. They provide a simple yet comprehensive structure, capturing key aspects of CE and aligning with the three core principles of it. Within these categories, supplementary CS are further explored and examined. These sub-strategies are connected and categorized under the four main strategies. This categorization results in an overview model part of the analytical model, used to identify the applied strategies in the case studies in the empirical part.

3.3.2 R-LADDER

Another frequently referenced model is the R-ladder or circularity ladder, which organizes circular strategies in a hierarchy. The highest steps on the ladder offer the greatest environmental benefits, as they aim to eliminate resource use and minimise waste. The ladder distinguishes three types of loops, where shorter loops are considered more sustainable. The literature provides varying definitions for each R-strategy on the R-ladder, leading to different interpretations and confusion. To address this, the definitions are added in Figure 7. This figure visualizes the R-ladder and links each strategy to the main overarching circular strategies.

The first three strategies belong to the short loop and concern the smarter use and manufacturing of products. In this research context, this refers to the efficient use of materials in the building design. They aim to reduce resource input and prevent waste, aligning with the strategy of narrowing resource loops (Gerding et al., 2021). The middle five strategies represent the medium loop and focus on extending the material lifespan. When buildings are dismantled carefully, components can be reused or repurposed in the projects, aligning with slowing the loop (Gerding et al., 2021). The final two strategies form the longest loop, applied when no other options remain at end-of-life. These include recycling, which often involves energy input and material downgrading. If the design allows materials to be recycled (technical cycle) or biodegraded (biological cycle), this reflects closing the loop (Van Stijn & Gruis, 2020). This classification illustrates how the R-ladder corresponds with the broader circular strategies of narrowing, slowing, and closing.

However, the R-ladder is criticized as it overlooks the regenerate strategy, a key aspect of circularity. On the other hand, the R-ladder strategies can be applied to materials and products that are part of the biological cycle. Neither does the model indicate the circular readiness of the building for future changes as reusable and recyclable. Therefore, this model lacks a complete perspective, as it was not specifically developed for the construction industry (Van Uden et al., 2024).

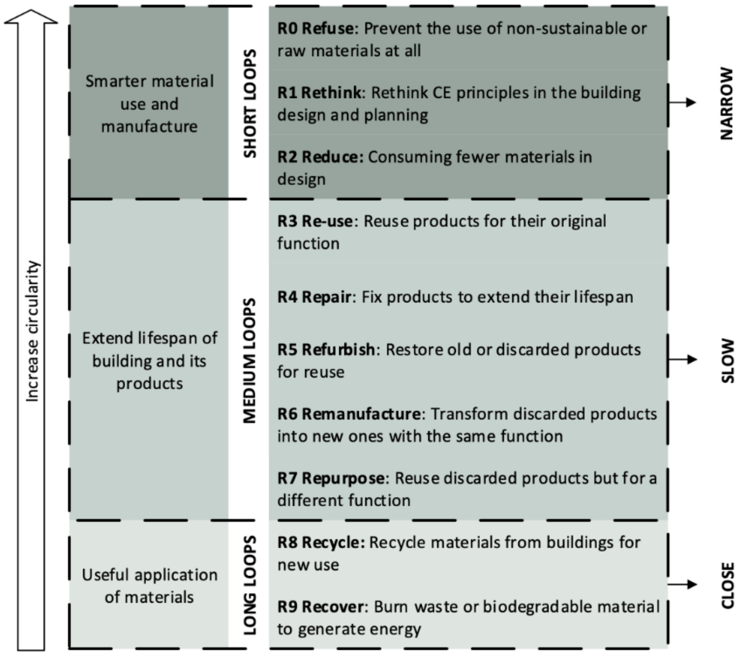


Figure 7 Circularity ladder or R-ladder connected to main CS, adopted from (Evertsen & Knotten, 2024; Ho et al., 2024; Nußholz et al., 2023; Potting et al., 2017) (own work)

3.3.3 CB’23 STRATEGIES

A model specifically developed for the construction industry is the circular design strategies framework created by CB’23 (2023). It defines seven strategies that guide design choices and indicate how circular ambitions can be embedded in projects. The context of the project determines what specific strategy is applied, which is unique and different in each project. The strategies contribute to the circular goals of CB’23, which are protecting resources, the environment, and existing values. The seven circular design strategies are:

1. **Design for prevention**: avoid new construction, and where not possible design more efficiently and optimally.
2. **Designing for quality and maintenance**: preservation of the existing and extending the lifespan of buildings, components, and materials.
3. **Design for adaptability**: the building's floorplan can be adapted for future use, design for spatial-functional adaptability.
4. **Design for disassembly and reusability**: design for technical adaptability of components for reuse without damaging during or after use.
5. **Design with reused parts of construction**: reusing existing building components in design, extending the lifespan.
6. **Design with secondary raw materials**: designing with reused building components and materials.
7. **Design with renewable raw materials**: designing with materials that are renewable (e.g. biobased materials).

These circular design strategies illustrate how circular ambitions can be translated into practical design decisions. They extend the overarching strategies, outlined in this research, offering concrete examples of their application. By connecting these design strategies to the four main strategies, they broaden the understanding of how CS can be integrated into a building project. Six of the seven circular design strategies focus directly on material use. However, strategy 3 'design for adaptability' relates primarily to functional flexibility and only indirectly to materials. In contrast, strategy 4 addresses material adaptability more explicitly. Given the material-centric focus of this study, strategy 3 is excluded from the overview model. Figure 8 illustrates the relationship between the CB'23 CS and the overarching CS.

Narrow	Slow	Close	Regenerate
1 Design for prevention: avoid new construction and where not possible design more efficiently and optimally.	**2 Designing for quality and maintenance**: preservation of the existing and extending the lifespan of buildings, components and materials. **5 Design with reused parts of construction**: reusing existing building components in design, extending the lifespan. **4 Design for disassembly and reusability**: design for technical adaptability of components for reuse without damaging during or after use.	**6 Design with secondary raw materials**: designing with reused building components and materials.	**7 Design with renewable raw materials**: designing with materials that are renewable (e.g. biobased materials).

Figure 8 Circular design strategies connected to main CS, adopted from (CB'23, 2023) (own work)

3.3.4 DETERMINANTS OF CIRCULAR BUILDING ADAPTABILITY

The research of Hamida et al. (2022) defines ten circular building adaptability (CBA) determinants, each supported by passive, active, or operational strategies. One strategy may contribute to achieving multiple of these determinants. The CBA determinants tackle both adaptability and circularity. This research, however, focuses on strategies related to material use, rather than the functional adaptability of spaces. Some determinants extend beyond material use but include relevant strategies. For instance, 'utilization dismountable products', under 'configuration flexibility', contributes directly to material efficiency. Therefore, only the material-relevant strategies per determinant are selected and connected to the four overarching circular strategies, as shown in Figure 9.

CBA Determinant	Strategies	Narrow	Slow	Close	Regenerate
Configuration flexibility	Design standardisation				
	Utilisation of adjustable building components		X		
	Utilisation of dismountable products		X		
Product dismantlability	Utilisation of dismountable products		X		
	Design standardisation				
Asset multi usability	Provision of multi-purpose space				
	Provision of sharable facilities				
Design regularity	Modularisation of spatial configuration				
	Utilisation of standard products				
Functional convertibility	Provision of a core for building services				
	Modularisation of the building configuration				
	Design for mixed use (multifunctional)				
Material reversibility	Utilisation of secondary (reused/recycled) material			X	
	Utilisation of dismountable products		X		
	Application of material passport			X	
	Procurement of the service of building product				
	Selective dismantling		X	X	
Building maintainability	Procurement of the service of building product				
	Implementation of proactive maintance		X		
Resource recovery	Utilisation of renewable energy technology				
	Enabling the use of nature (passive) ventilation/lightning				
Volume scalability	Deisgn for surplus capacity				
	Utilisation of movable building components		X		
Asset refit-ability	Dematerilise the process	X			
	Utilisation of dismountable products		X		
	Procure the service of building products				

Figure 9 circular strategies connected to main CS, adopted from (Hamida, 2022) (own work)

3.3.5 BIOLOGICAL & TECHNOLOGICAL CYCLE

The circular economy aims to retain resources at their highest utility and value. To achieve this, the Ellen MacArthur Foundation (2015) distinguished the circular economy into two types of cycles: technical and biological cycles. The biological cycle includes biodegradable materials that can return safely to nature. In contrast, the technical cycle focuses on maintaining finite resources through reuse, repair, remanufacture, and recycling.

The building sector mainly interacts with the technical cycle, where raw materials are extracted and processed into construction materials (Többen & Opdenakker, 2022). However, circularity is not about choosing one cycle, but about strategic material use. The study of Wouterszoon Jansen et al. (2022) focused on whether one of the two pathways results in the best circular performance. Their research found no clear advantage between cycles. In contrast, they emphasize the deliberate combination of both, thus applying biological materials where possible and technical materials only where it is needed. This hybrid approach supports circular acceleration (Transitieteam Circulaire Bouweconomie, 2020). Understanding both cycles helps in making material choices that align with CE principles. Ultimately, it aims to ensure that each material is used to its fullest potential and preserved in its highest value.

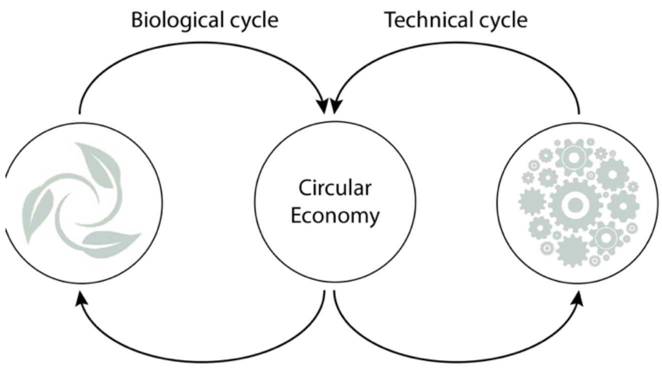


Figure 10 Biological and technical cycle, adopted from (EMF, 2015) (own work)

3.3.6 OVERVIEW MODEL

Based on the literature review, an overview model was developed as part of the analytical model. This model guides the case analysis in the empirical research. The overview model, illustrated in Figure 11, helps to identify the applied CS across the cases. The model builds on the four overarching CS by Circle Economy and Metabolic (2022), supplemented with sub-strategies from the R-ladder, CB'23 design strategies, and CBA determinants. While the main categories are easily recognizable, their specific application may vary at the detail level in each project. It is important to note that achieving the highest level of circularity begins with refusing the use of materials altogether. When materials are used, the focus shifts to keeping them at their highest value for as long as possible and ensuring optimal use (Foster, 2020).

	Narrow	Slow	Close (now & in future)	Regenerate
	Aim for material efficiency and reducing new materials use	*Use material, products and components longer with maximal utilisation of existing value (direct reuse)*	*Use materials, products and components again (processed reuse)*	*Use renewable materials*
R-ladder	**R0 Refuse**: Prevent the use of non-sustainable or raw materials at all **R1 Rethink:** Rethink CE principles in the building design and planning **R2 Reduce**: Consuming fewer materials in design	**R3 Re-use**: Reuse products for their original function **R4 Repair**: Fix products to extend their lifespan **R5 Refurbish**: Restore old or discarded products for reuse **R6 Remanufacture**: Transform discarded products into new ones with the same function **R7 Repurpose**: Reuse discarded products but for a different function	**R8 Recycle**: Recycle materials from buildings for new use **R9 Recover**: Burn waste or biodegradable material to generate energy	
CB'23	**1 Design for prevention**: avoid new construction and where not possible design more efficiently and optimally	**2 Designing for quality and maintenance**: preservation of the existing and extending the lifespan of buildings, components and materials **5 Design with reused parts of construction**: reusing existing building components in design, extending the lifespan **4 Design for disassembly and reusability**: design for technical adaptability of components for reuse without damaging during or after use	**6 Design with secondary raw materials**: designing with reused building components and materials.	**7 Design with renewable raw materials**: designing with materials that are renewable (e.g. biobased materials).
CBA determinants strategies	Dematerilise the process	Utilisation of adjustable building components Utilisation of dismountable products Selective dismantling Implementation of proactive maintance Utilisation of movable building components	Utilisation of secondary (reused/recycled) material Application of material passport Selective dismantling	

Figure 11 Overview model of findings from literature (own work)

3.4 Shearing layers

The shearing layers theory of Brand (1994) divides a building into six layers: site, structure, skin, services, space plan, and stuff. Each layer has a distinct lifespan. Brand argues that the layers should be designed separately, enabling independent adjustments over time to optimize management and adaptability.

A key distinction exists between the long-lived layers (site, structure, skin) and short-lived layers (services, space plan, stuff) (Gerding et al., 2021). This separation is particularly relevant in the context of circularity. The long-lived layers often have a lifespan longer than the building, and are typically reused as a whole. In contrast, short-lived layers have a lifespan shorter than the building and are replaced more frequently. Leising et al. (2018) emphasize the essential role of suppliers in enabling circular strategies for short-lived layers, such as take-back models, including leasing systems. Meanwhile, the products and components part of the long-lived layers offer significant potential for circularity by being placed in marketplaces for secondary materials, promoting reuse (Leising et al., 2018).

Designing each layer for independent replacement or adaptation enhances reusability and flexibility (Transitieteam Circulaire Bouweconomie, 2020). This approach extends the building's lifespan, improves adaptability, and increases resource efficiency, key goals of circularity. In this research, the shearing layers model is used to identify at which layers circular strategies have been applied. It explores whether specific layers are more suitable for certain strategies, based on patterns emerging from the case studies. Figure 12 shows the model and the typical lifespan of each layer.

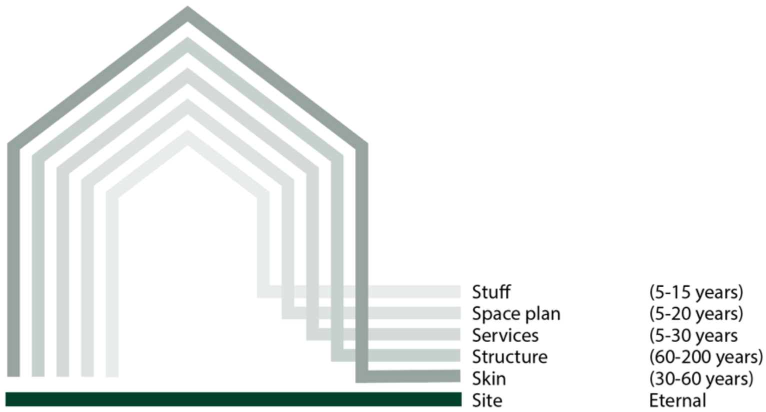


Figure 12 Shearing layers, adopted from (Brand, 1994; Transitieteam Circulaire Bouweconomie, 2020) (own work)

3.5 Project development process

The development process is crucial for the success of adaptive reuse projects, especially when circular strategies are involved. Each phase includes key decision-making moments that influence how well circularity is embedded. Understanding these phases and their impact is crucial for identifying how real estate developers can effectively integrate circular strategies into their projects.

3.5.1 PHASES

The development process is both complex and unique. Its uniqueness lies in that projects often consist of a one-off collaboration between a diverse group of actors. Its complexity stems from the diversity and number of these actors, each contributing essential knowledge at different stages, as well as the variety of tasks carried out during the process (Wamelink et al., 2010).

3.5.1.1 General models of the development process

Several models exist to understand and structure the phases of the development process. One widely used framework is the RIBA Plan of Work (2020), which outlines sequential stages in building development, as shown in Figure 13. While RIBA uses the term 'stages' rather than 'phases', it offers a detailed overview of the sequence and focus of activities throughout the process. The timespan of each stage depends on project size and complexity. The RIBA model also stresses that the success of each stage depends on the quality of the previous one.

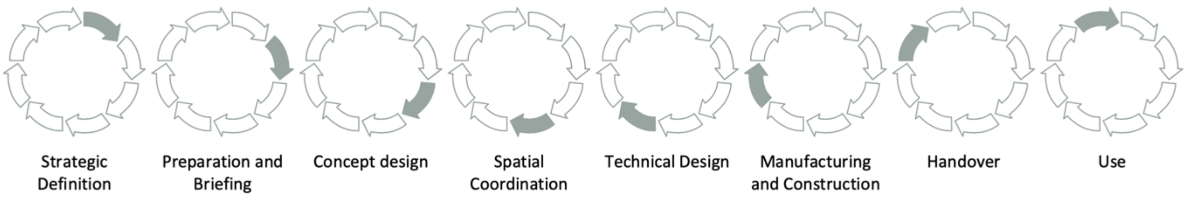


Figure 13 Development stages of RIBA, adopted from (RIBA, 2020) (own work)

A second model, developed by Wamelink et al. (2010), divides the development process into five phases, each with more detailed sub-phases, illustrated in Figure 14. This model acknowledges that phases often lack clear start or end points. Project types, such as design & build, can further blur these boundaries. As a result, the actual process in practice may differ from the structured phases suggested in theory, and overlaps between phases are common.

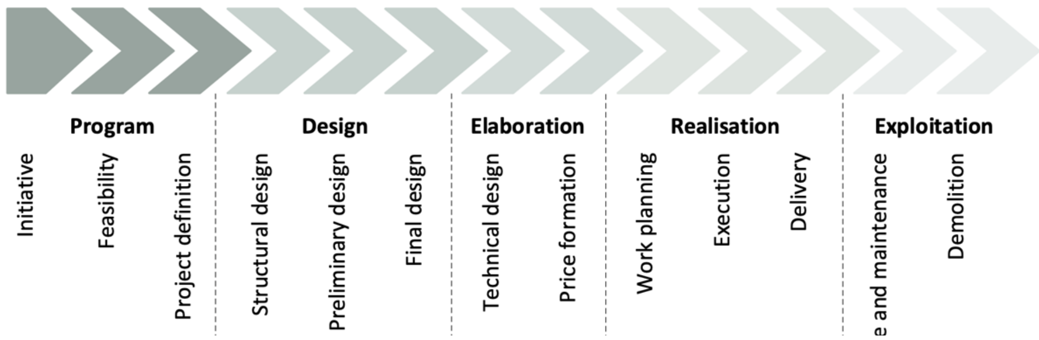


Figure 14 Development phases, adopted from (Wamelink et al., 2010) (own work)

3.5.1.2 Adaptive reuse specific model of the development process

In contrast to the above-mentioned models, the framework developed by Hamida & Hassanain (2021), simplified in Figure 15, deviates from the other as it represents the adaptive reuse development process. The model outlines the project phases in four sequential phases, each consisting of specific process activities represented by nodes. Arrows indicate inputs, outputs, and actors.

The first phase, feasibility, assesses the building's viability across functional, technical, economic, and legal dimensions, aligning with the findings of Bullen and Love (2011a). This includes examining the building's structure, assessing its condition, creating the plan for new use, and evaluating both spatial and financial feasibility for adaptive reuse. Next, the design phase involves preparing detailed specifications and documentation that guide the construction. This phase also includes the permitting process. The third phase, construction, covers the procurement of services within budget, execution of the work, and final delivery. Once complete, the project moves into the final phase: operation and maintenance.

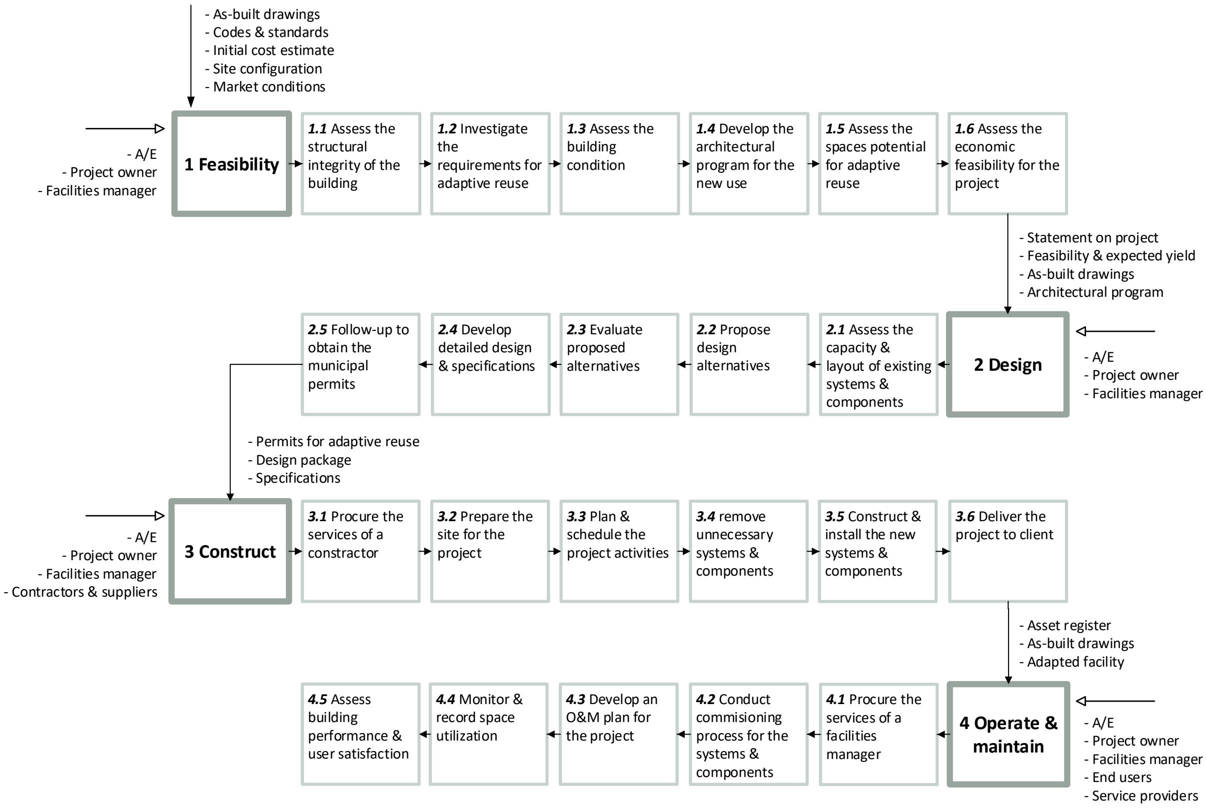


Figure 15 Development process of adaptive reuse, adopted from (Hamida & Hassanain, 2021) (own work)

3.5.1.3 Embedding circularity into the development process

Figure 16 compares the three models and highlights the overlap in their phases. The first two models offer a general view of development and are not tailored to new-build or adaptive reuse. They help structure generic activities but lack the specificity needed for adaptive reuse. The model by Hamida and Hassanain (2021) addresses this gap by focusing on adaptive reuse and includes key steps for assessing an existing building's potential. It differentiates mostly in the initial phases, where the existing building's condition, viability, and potential for reuse must be thoroughly assessed rather than starting from scratch, as in new-build projects. This additional level of complexity asks for more knowledge exchange around opportunities and collaboration in the early phases.

To further embed circularity, literature on CE introduces a pre-feasibility phase for questioning the necessity of development itself, referred to as the 'inception' phase (Çimen, 2023). This phase is essential, as it provides the first opportunity to question the necessity of development, define a circular ambition, and explore low-resource solutions that align with business goals and project objectives (Çimen, 2023). The RIBA refers to this as the strategic definition phase, which includes clarifying outcomes, risks, and client needs. In circular adaptive reuse projects, this step is also critical and has therefore been added to the model of Hamida and Hassanain (2021) as 'inception', shown in Figure 16.

In summary, while the first two models offer a broad understanding of development phases, the Hamida and Hassanain model adds the nuance needed for adaptive reuse. However, it still lacks an explicit inception phase. This phase is vital when applying circular strategies, as it frames the project's goals and evaluates resource efficiency from the outset (Çimen, 2023). Although Hamida and Hassanain's model supports adaptive reuse, it is not fully tailored to the integration of circular strategies and requires adaptation to function as a complete analytical framework for this research.

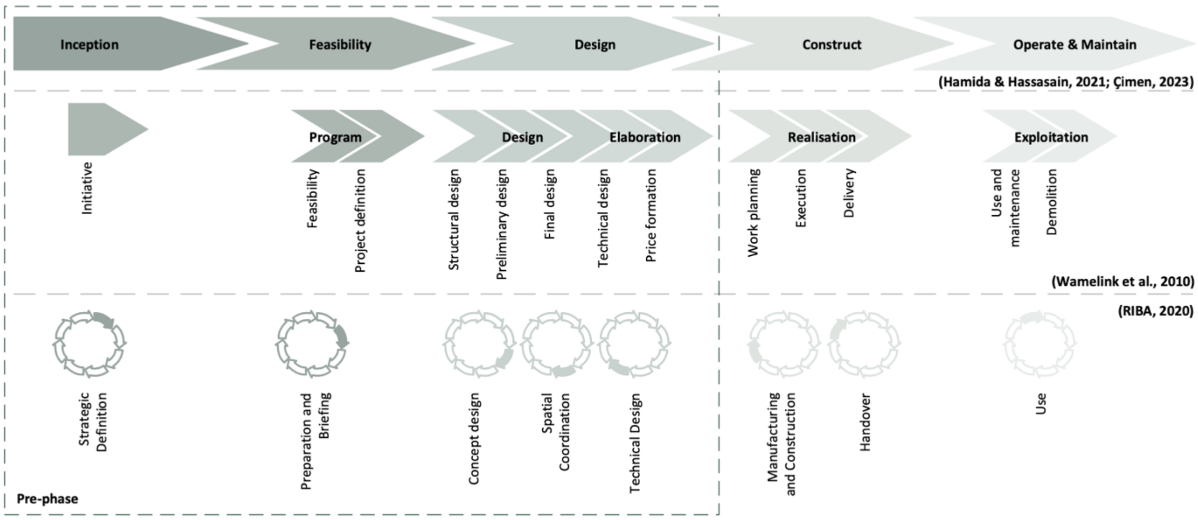


Figure 16 Overview of different development process models and their overlapping phase distribution (own work)

3.5.2 KEY PHASES FOR THE IMPLEMENTATION OF CIRCULAR STRATEGIES

The successful implementation of circular strategies in adaptive reuse projects depends largely on decisions made during the development process. The feasibility phase is especially critical, as this is where most key decisions are taken (Szafranko & Harasymiuk, 2022). Similarly, Gerding et al. (2021) emphasized that circular strategies must be integrated at the early phases of the development process to secure implementation and maximize their impact. These early phases include the design-making phases, involving initiation, preparation, and the design phase. These phases are often referred to as the pre-phase. The pre-phase contains the key decision-making moments that shape the project's direction and support circular outcomes. Success in this phase depends on clear objectives, structured collaboration with stakeholders (Nozeman & Fokkema, 2008), timely involvement of actors, and a flexible plan that can adapt to shifting market conditions.

Although it is essential to consider the entire development process to ensure smooth execution, this study mainly focuses on the pre-phase. Literature identifies these early phases as critical for setting the foundation to integrate circular strategy successfully. In this research, the pre-phase includes the inception, feasibility, and design phases together, based on the model of Hamida and Hassanain (2021), with the inception phase added following Çimen (2023). During the case analysis, special attention will be given to the influence of the phases on circular outcomes, considering both the roles of the actors involved and the project's conditions that shaped them.

3.6 Actors and stakeholders

Literature highlights stakeholders' important role and their collaboration in accelerating the implementation of circular strategies in the construction sector by facilitating effective knowledge transfer (Amarasinghe et al., 2024; Leising et al., 2018). In addition, achieving the higher R-strategies on the R-ladder requires the participation of a diverse group of stakeholders in different phases of the project development (Ho et al., 2024). To address this, this research examines which actors are involved in adaptive reuse projects and how they contribute to integrating circular strategies.

It is important to distinguish between 'actors' and 'stakeholders'. A stakeholder is defined as *'a person or group of people who have a vested interest in the success of a project and the environment within which the project operates' (McElroy & Mills, 2000, as cited in Olander & Landin, 2005).* In contrast, an actor is defined as '*a social entity, person or organization, able to act on or exert influence on a decision'* (Enserink et al., 2022). The key difference is that an actor can take action or influence the project in the decision-making process, whereas a stakeholder does not have the power to directly affect the decision-making process. Consequently, while an actor is always a stakeholder, not every stakeholder functions as an actor in the development process. This study focuses on actors, as their active involvement and collaboration are critical for implementing circular strategies. Understanding their roles and interactions may facilitate more effective collaboration from a developer's perspective.

The complexity of adaptive reuse projects and the current fragmentation in the organizational structure of construction projects cause challenges. Beyond logistics, financial, and design-related challenges, conflicting interests and expectations further complicate the process. To overcome these issues, actors must recognize each other's roles and establish a shared goal (Aigwi et al., 2021; Leising, 2018; Wamelink et al., 2010). Ultimately, this revolves around fostering a collaborative environment where actors actively engage with each other throughout the development process.

To support this understanding, stakeholders are often classified into four categories: investors, producers, regulators, and users. The study of Aigwi et al. (2021) has further specified these roles for adaptive reuse projects. In this research, understanding the actor's roles is particularly important as it highlights those essential for implementing circular strategies. The following section briefly explains each category, focusing on their role and contribution to adaptive reuse projects. It should be noted that those are the stakeholders typically involved, but it is not limited to those only.

3.6.1 INVESTORS

Investors are crucial actors in making the project financially feasible from a business-oriented perspective. Before committing, they assess the projects' non-regulatory and regulatory financial incentives (Aigwi et al., 2021). Their decision is driven by the expected financial return, only if this meets the required returns they will proceed. Typical investors include the building owners, governments, banks, life insurance companies, and pension funds. Real estate developers may also act as investors, developing the project for their own accounts. In this case, their decision depends on the balance between the final sale price and total construction costs (Peek & Gehner, 2018). Alternatively, developers may operate on behalf of external investors. In such cases, the developer bears the development risks, while the investor carries the market risks (Remøy, 2010). As discussed in section 3.2, several factors influence the investment decisions in adaptive reuse. Given the long duration of these projects and the volatility of market conditions, thorough financial planning and risk management are essential (Remøy et al., 2024).

3.6.2 PRODUCERS

Producers include all actors involved in preparing and realizing the adaptive reuse project. Together, they ensure the project's feasibility. This group consists of real estate developers, architects, engineers, experts, advisors, contractors, etc.

Among them, real estate developers play a central role as they typically take the lead in coordinating the actors involved. Real estate developers aim to generate financial returns through development (Wamelink et al., 2010; Bond, 2011). Adaptive reuse projects are appealing to developers as these are often located in urban areas where land for new development is scarce. Moreover, the financial returns in such areas are typically high, making it interesting for experienced developers (Remøy, 2010). The group of real estate developers can be categorized into eight main types (Peek & Gehner, 2018), which are summarized in Figure 17. When a real estate developer is the owner of the project, they have the biggest influence on the decision-making process throughout the development (Peek & Gehner, 2018). If the project is owned by an investor or client, the developer's influence depends on the terms of the agreement. Given the complexity of the development process, developers must respond to changing conditions, maintain feasibility, and align the team's needs (Bond, 2011).

Developer	Description
Independent developer	This type of developer acts independently.
Developer as part of finacial party	This type of developer is part of a financial institution, e.g. a bank.
Developing builder	This type of developer is a former contractor and has extended their service with the development service.
Developing investor	This type of developer is part of an investment company, where third-party capital is initially invested and later returns through the succes of the project.
Developing housing association	This type of developer is a housing association and developes their own projects, mostly in social housing sector.
Delegated project developer	This type of developer operates on behalf of a third party.
Designing or advising developer	This type of developer operates, among other things, in projects for private clients, where architects and others sometimes take on the role of project developer.
Project development as derived activity	This type of developer consists of companies that develop real estate to support their core activities, such as those operating in the transport sector or retail industry.

Figure 17 Types of real estate developers, adopted from (Peek & Gehner, 2018) (own work)

The role of the architect in adaptive reuse projects is to assess the functional feasibility of the existing building for its new purpose. Moreover, they collaborate with the developer to establish the program of requirements (Remøy, 2010). Architectural firms can be classified under different types (Coxe et al., 1987, as cited in Wamelink et al., 2010), summarized in Figure 18. Each type has a different view on the assignment, which the developer should keep in mind. Most often, they work together with strong service or strong delivery firms (Remøy, 2010).

Architect	Description
Strong idea firm	This type of architect adds value by providing expertise and innovative creativity to develop pioneering designs for unique projects of a highly diverse nature.
Strong service firm	This architect adds value by offering reliability and experience, particularly for complex assignments. The expertise provided is tailored to the specific characteristics of the project and the client's requirements.
Strong delivery firm	This type of architect focuses on providing highly efficient services for more routine assignments. Their work is centered on replicating previously developed solutions that are highly reliable in terms of technique, budget, and time. The added value of these firms lies partly in their ability to support risk mitigation.

Figure 18 Types of architectural firms, adopted from (Wamelink et al., 2010) (own work)

The role of advisors and advising engineers varies depending on how they are involved in the project. They may be appointed by the client, architect, or developer, in which the formal, contractual relationship has important consequences on their level of influence (Wamelink et al., 2010).

Similarly, the contractor's role may also vary in each development project. It depends on when they are engaged, whether they act as advisors or executors, and the organizational and contractual structure (Wamelink et al., 2010). There are also distinctions between types of contractors. First, a co-contractor works alongside other contractors under a direct agreement with the client. Second, a subcontractor is hired by the main contractor and has no legal relationship with the client. Subcontractors typically handle specific tasks, such as installation or painting. Contractors are responsible for delivering their part of the project on time, within budget, and in line with the agreed quality standards (Chinyio & Olomolaiye, 2009).

Lastly, suppliers and producers develop and deliver the materials and equipment to the contractor to execute the work on location (Chinyio & Olomolaiye, 2009). These materials range from raw materials to prefabricated components and products (Wamelink et al., 2010). Due to the long production and delivery times, timely involvement is crucial. In a circular built environment, materials must retain value through reuse, repair, or recycling. Suppliers can play a key role in this process by offering take-back models (Leising et al., 2018). These take-back models are seen as enablers toward more circular practices in the built environment (Adams et al., 2017). The same applies to dealers and producers, who can refurbish and resell products. Therefore, engaging suppliers early in the process supports the creation of closed supply chains, in which materials are continuously cycled (Adebayo et al., 2024).

3.6.3 REGULATORS

Regulators are national and local governmental bodies that define the legal and regulatory boundaries. In the development process, they act as external parties granting permits for planning and design. Producers must ensure compliance with these regulations, such as zoning laws, building codes, and sustainability standards. Zoning plans, managed by municipalities, often present obstacles in adaptive reuse, especially when the new function requires plan changes. This highlights the critical role of municipalities in these projects, requiring them to allocate sufficient time and adopt flexible approaches to maintain a smooth development process (Remøy, 2010). Continuous engagement with regulators helps ensure legal compliance and reduces the risk of project delays (Adebayo et al., 2024).

However, tensions may arise as there is a conflicting field of work in which producers often prioritize the benefits and feasibility of adaptive reuse projects, while regulators focus on enforcing rules and standards. This creates tension as producers sometimes struggle to fully comply with current building regulations in adaptive reuse projects (Aigwi et al., 2021). This can result in costly delays from a developer's perspective (Bond, 2011). To mitigate this, clear and balanced regulations are needed. It is proposed that regulations should be between the two extremes of setting highly detailed guidelines and highly flexible guidelines. Developers benefit from objective rules that ensure clarity while still allowing space for innovation and adaptive reuse solutions (Bond, 2011).

3.6.4 USERS

The group of users falls under the terminology of stakeholders rather than actors if they are not directly involved as clients of the project. In such cases, users have an indirect influence on the project and are typically excluded from the decision-making process. However, the choice for a new function is shaped by the demand of users in the market. For developers, addressing users' needs is critical to ensuring long-term success. A successful adaptive reuse project should therefore satisfy both users' current and future demands and needs (Bullen & Love, 2011a). To achieve this, it is recommended to assess the building's performance and user satisfaction in the operation and maintenance phase (Hamida & Hassanain, 2021).

3.6.5 SPECIALIZED CIRCULARITY ACTORS

In addition to the traditional actors, circular projects require specialized expertise. A key barrier in building projects is the limited knowledge about applying circular strategies (Adams et al., 2017; Eberhardt et al., 2022). To overcome this barrier, literature stresses the importance of engaging circularity experts early in the process (Gerding et al., 2021; Van Uden et al., 2024). These specialized actors often perform advisory roles, such as transformation agents, circularity experts, salvage dealers, and reclamation and dismantling experts (Fishta, 2021), summarized in Figure 19.

Salvage dealers identify valuable products or components and make them available for others through a marketplace. Reclamation experts advise how to recover materials from existing structures. Gorgolewski (2008) highlights the importance of collaborating with demolition and dismantler contractors to enhance awareness of reclaimed materials.

They have expertise in deconstructing the building instead of demolishing it and have increasing experience with the potential markets for reclaimed components. For adaptive reuse projects specifically, involving actors experienced in these cases is particularly beneficial. Their knowledge from previous experiences can streamline processes, saving time and costs (Bond, 2011).

Circularity actor	Description
Transformation agents	Oversee the circular building project and lead actors to align with the circular goals
Salvage dealers	Identify and supply valuable products or components and make them available for others through marketplace or platforms
Reclamation experts	Advise on reclaiming and reusing materials from existing structures
Dismantler and demolishing contractors	Recover valuable materials from buildings through careful deconstruction or dismantling
Circularity experts	Provide specialized knowledge and advise on implementing circular strategies

Figure 19 Circularity related actors (own work)

3.6.6 INTERNAL AND EXTERNAL STAKEHOLDERS

Stakeholders in a project are interrelated, as their roles and responsibilities often overlap and influence each other. Based on their level of involvement and influence on decision-making, they can be categorized as internal or external stakeholders. The internal stakeholders are part of the project team and are legally connected with the client or developer (Chinyio & Olomolaiye, 2009; Winch, 2010). In contrast, external stakeholders are those who have an indirect interest in the project. While external stakeholders do not make the decisions in the project, they can, however, significantly influence the project and its outcome. The local and national authorities have a significant formal indirect influence on project decisions as they provide the final approvals (Olander, 2003). Figure 20 illustrates the interrelationships between stakeholders, including the circularity actors. This model serves as theoretical background part of the analytical model, used in the empirical research to identify actor roles and relationships.

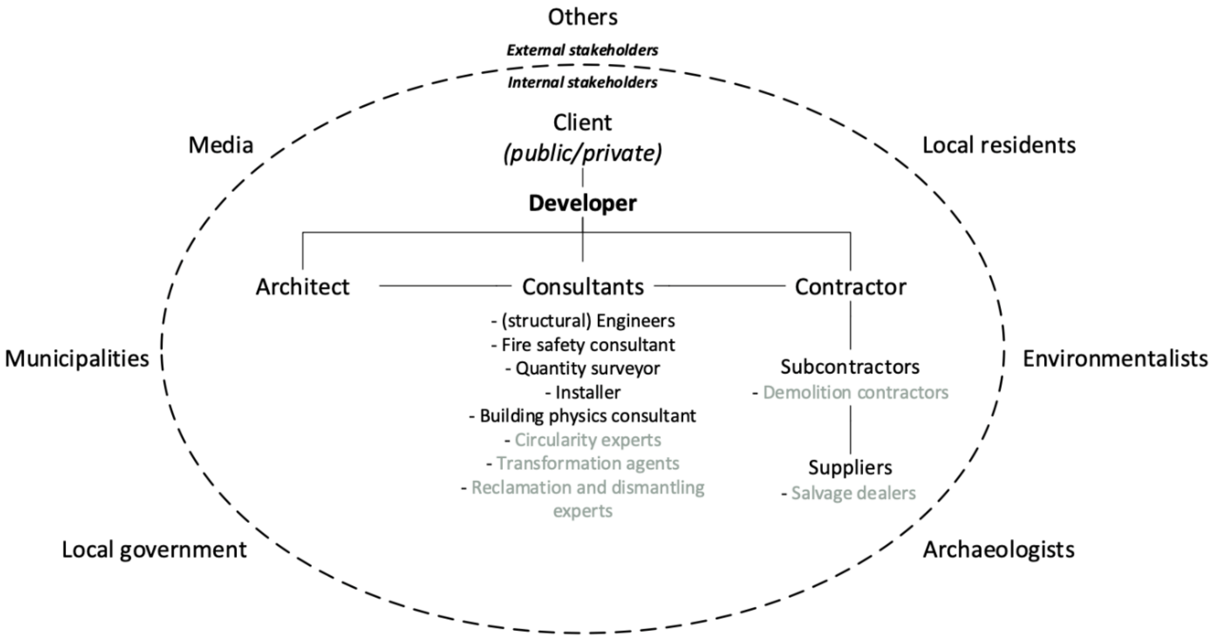


Figure 20 Interrelationship between stakeholders, adopted from (Chinyio & Olomolaiye, 2009) (own work)

3.7 Collaboration

The collaboration between the above-mentioned actors directly influences the project's outcomes. Although each actor may have different roles and interests, they ultimately share the goal of delivering a successful result to the client (Wamelink et al., 2010). In adaptive reuse projects, this collaboration becomes even more critical when circular strategies are involved. Their successful integration depends not only on individual expertise but also on the extent to which actors collaborate and align efforts (Adams et al., 2017; Amarasinghe et al., 2024; Çimen, 2023; Evertsen & Knotten, 2024; Gerding et al., 2021; Guerra & Leite, 2021). This reliance on collaboration highlights the need to understand the dynamics of collaboration.

Collaboration is defined as 'the situation of two or more people working together to create or achieve the same thing' (Cambridge Dictionary, n.d.). While this definition provides a general understanding of collaboration, it does not capture the complexity and dynamics of collaboration in the construction sector in practice. This complexity rests in the fragmented supply chain and diversity of stakeholders (Adams et al., 2017; Çimen, 2023). To better understand these dynamics, London and Pablo (2017) apply the actor-network theory (ANT) to investigate collaboration in the construction industry. Although their study focuses on industrialized construction, its theoretical insights are also relevant to the broad construction industry, such as adaptive reuse. ANT provides a suitable lens, as it emphasizes the interrelations between actors rather than viewing them as isolated entities. This perspective aligns closely with the inter-organizational complex nature of the development process in the construction industry, where actors are more dependent on each other (London & Pablo, 2017).

Collaboration in the construction industry comes with multiple characteristics based on the work of London and Pablo (2017). It begins with multiple prime movers identifying a shared problem and enrolling relevant actors into a collaborative network. Within the established networks, actors aim for coherence instead of conformity. This means that actors work towards creating a shared understanding and aligning their efforts without requiring everyone to think or act in the same way. Furthermore, collaboration is a dynamic and evolving process, not static. It evolves continuously, shaped by tensions between stability and innovation. On the one hand, actors must maintain a stable network. On the other hand, they need to allow for new ideas and expand their collaboration network where needed. This process relates to stabilizing and destabilizing the network. At the same time, actors are part of overlapping networks with potentially competing goals and commitments. This may lead to a (mis)alignment that challenges the stability and adaptability of the network. This emphasizes the concept of multiplicity, the interplay of networks. As a result, collaborative networks must be continually stabilized, extended, or redefined to address new challenges and opportunities.

According to Chao-Duivis and Wamelink (2013), effective collaboration begins with a clearly defined shared goal as the foundation. In their view, individual goals must align with and contribute to that common goal. The quality of the collaboration is dependent on the competencies of individual actors. In addition, trust plays a central role, especially in complex, multi-actor networks typical in construction projects. Therefore, trust is also seen as a contributor to the quality of collaboration. However, trust is not self-evident, as it is developed through the experiences that parties share with each other. These experiences are categorized into three types, namely competencies, intentions, and integrity. Together, these factors form the basis for building and sustaining trust within the collaborative network.

Building upon the work of Chao-Duivis and Wamelink (2013) and London and Pablo (2017), the following definition of collaboration is established:

'Collaboration is the inter-organizational dynamic process between two or more actors involved in a development process, who are committed to a shared goal and collectively identify and address problems, forming a collaborative network. Effective collaboration relies on achieving coherence between individual and collective goals, ensuring alignment without requiring conformity. Collaboration is an evolving process, continuously adapting to changing circumstances by stabilizing, destabilizing, and expanding the network as needed to address new challenges and opportunities. Effective collaboration is enabled by relationships built on trust, which is developed through shared experiences, consisting of competencies, intentions, and integrity.'

3.7.1 PROJECT TEAM AND ROLES

Real estate developers typically possess general knowledge across various disciplines, but often lack the in-depth expertise needed to complete a project independently. Therefore, they must collaborate with actors who provide complementary knowledge and skills. These collaborations form the project team, which is a temporary group established for the project's duration. This team usually includes the developer's employees complemented by external actors from various disciplines (Peek & Gehner, 2018). Because these external actors represent different organizations and bring their own priorities and personalities, conflicting interests may arise (Wamelink et al., 2010). To address this, Wamelink et al. (2010) emphasize the importance of establishing a mutual goal as the foundation to foster collaboration. Furthermore, the size of the project team is dependent on the characteristics and complexity of the project.

It is important to distinguish between an actor's organizational function and the roles they perform within a project team. An actor can fulfil multiple roles, each requiring specific competencies. These roles are not fixed and may evolve as the project progresses (CB'23, 2023). For example, a contractor might initially advise on material reuse but later take on an operational role in executing construction activities. Real estate developers engage actors based on their competencies, which encompass knowledge, expertise, attitude, and personal characteristics (Peek & Gehner, 2018).

Understanding collaboration is central in this research as it underpins the successful integration of circular strategies in adaptive reuse projects. The dynamic and evolving nature of collaboration, coupled with the diverse roles and competencies of actors within project teams, influences the outcomes of these projects. Given this dynamic context, the study analyses how collaboration unfolds over time and how it influences the implementation of circular strategies.

3.8 Multi-actor network analysis

The development process is characterized by high complexity due to the involvement of many diverse actors, each with distinct interests, concerns, and responsibilities (Çimen, 2023; Ho et al., 2024). This highlights the multi-actor environment in the development process, where collaboration is key in accelerating the implementation of circular strategies (Adams et al., 2017; Amarasinghe et al., 2024). Moreover, the success of implementing such strategies strongly depends on effective and timely actor engagement (Adebayo et al., 2024).

Given the complexity of this multi-actor environment, it is essential to gain deeper insight into the dynamic relationships, interdependencies, and influence of actors throughout the development process. At the same time, understanding how engagement shifts across different phases can reveal opportunities for project managers to strengthen collaboration. Research stresses that effective integration of circular strategies relies on involving the right actors at the right moment (Gerding et al., 2021; Leising et al., 2018). This is especially relevant during the early phases, pre-phase, as these phases contain the most decisive moments for circularity (Gerding et al., 2021; Szafranko & Harasymiuk, 2022). Analysing when and who should be engaged, and how their relationships evolve over time, is therefore essential to achieving successful outcomes. A suitable method for this is the multi-actor network analysis developed by Gerding et al. (2021), which combines actor analysis with network analysis to map relations, knowledge, and influence.

The multi-actor network analysis from Gerding et al. (2021) includes six steps based on the work of Enserink et al. (2010). The following steps are adjusted to the context of this research.

1. **Problem definition**: the project requires the implementation of circular strategies in the adaptive reuse of a building
2. **Actor inventory**: identification of all relevant actors involved in the development process
3. **Roles and resources identification**: mapping the (in)formal roles and resources of each actor
4. **Interdependency analysis**: examining the relationships and frequency of interaction among actors
5. **Positioning within the network**: assessing the position of each actor based on their connections and centrality
6. **Influence assessment**: evaluating the degree of influence of the actors within the network

However, following these steps develops static representations of the interactions between the actors. To overcome this, Gerding et al. (2021) visualize the relations as ties, illustrating the most important relations to solve the problem, defined in step one. The identification of the actors involved is those that are determined to be most crucial for implementing circular strategies. Figure 21 represents the multi-actor network analysis model from Gerding et al. (2021) derived from the actor and network analysis. Incorporating this multi-actor network analysis in the case study on each phase in the development process provides a systematic method to explore how the actors' relationships evolve throughout the development process. This provides an understanding of the roles, relationships, and influence of the actors involved. Ultimately, it illustrates the dynamics of the collaboration. The analysis consists of five aspects: actors, relations, position, influence, and knowledge, each of which is briefly elaborated.

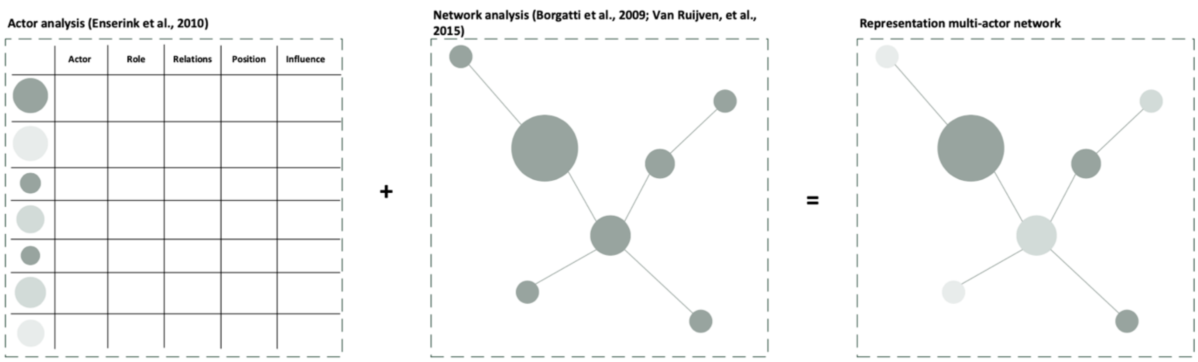


Figure 21 Multi-actor network analysis, adopted from (Gerding et al., 2021) (own work)

3.8.1 ACTOR

The definition of section 3.6 will be used. This includes '*a social entity, person or organization, able to act on or exert influence on a decision'* (Enserink et al., 2022). The actor is represented by a node. An actor has a certain role within the network. If multiple actors from the same organization work on the project within the same role, they are represented by the same node.

3.8.2 RELATIONS

In the construction industry, building development is executed by a project team, consisting of a dynamic network of actors who are (inter)dependent on each other to achieve a successful project. Communication frequency and exchange of information shape the relationships between actors (Gerding et al., 2021; Van Ruijven et al., 2015). The network analysis distinguishes relationships between the project team actors into two types: formal and informal relations. Formal relations involve actors whose role is defined in a contract, while informal relations include relationships between actors not bound by a formal document, such as consultants hired by other parties. Within this research, informal relations are defined as those based on information and knowledge exchange. Additionally, the model distinguishes between the frequency of interaction in the relationship. Frequent relationships are those in which the actors engage with one another weekly, while infrequent relationships happen occasionally. The relations are represented by the tie connections between the nodes (actors). In the context of this research, both forms of relationships are of interest.

3.8.3 POSITION

Network analysis introduces the concept of centrality. It shows the actor with the highest number of connections at the centre of the network, indicating frequent communication (Gerding et al., 2021). This higher level of communication is often linked to a greater degree of influence in decision-making.

3.8.4 INFLUENCE

An actor's level of influence refers to the power of the actor to shape and impact the project's outcomes (Adebayo et al., 2024). An actor's influence is represented by the size of their node within the network, determined by their involvement in the decision-making rounds and their abilities, such as knowledge or formal power (Gerding et al., 2021; Enserink et al., 2022). The level of Influence is based on the amount of communication, namely, increased communication often relates to a higher influence on decision-making (Gerding et al., 2021).

The assessment of influence in this study is primarily qualitative and relies on participants' reflections during the interviews. This includes both how actors described their own influence and how they assessed the influence of others. In evaluating the perceived influence of others, attention was paid to how actively an actor was involved in a specific phase and the extent to which participants interacted with that actor. A higher level of relations often implied a greater ability to shape circular outcomes. This research distinguishes three types of influence on circular outcomes. First, the highest influence, indicated by the biggest node, is assigned to actors who ultimately make the final decisions. For instance, quotes that indicate the highest level of influence include statements such as *'[Z1] takes the final decision if it is implemented or not' and 'Who pays, decides. In the end, it's always the client.'* Second, a medium level of influence is assigned to actors who provide circular knowledge, but who do not decide whether it is implemented. Quotes that are related to a medium level of influence are, for instance, '*However, the architect does not have as much decision-making power as the client*' [Z6]. Lastly, the smallest node indicates actors who provided little circular knowledge and played a decisive role in circular decisions. This approach is subject to a degree of subjectivity as the researcher interprets and determines the level of influence.

3.8.5 KNOWLEDGE

The last aspect includes the different types of actors concerning their level of knowledge about circular strategies. It categorizes the actors as experts with knowledge about circular strategies, conventional actors who have acquired knowledge, and conventional players who know very little or nothing about circular strategies (Gerding et al., 2021). In this research, the actors classified with knowledge are actors who possess expertise on the subject. The actors who have acquired knowledge are the actors who are not specifically specialized in circular projects but have experience in these types of projects. The last category, the actors who do not have knowledge of circularity, are those who have never been part of a project in which circularity was a main concept. The colour of the node represents the classification of the actor. Figure 22 provides an identification of the different forms of knowledge required in the development process. In every domain, knowledge related to circularity is essential to ensure that circular strategies are effectively integrated into all aspects of the project.

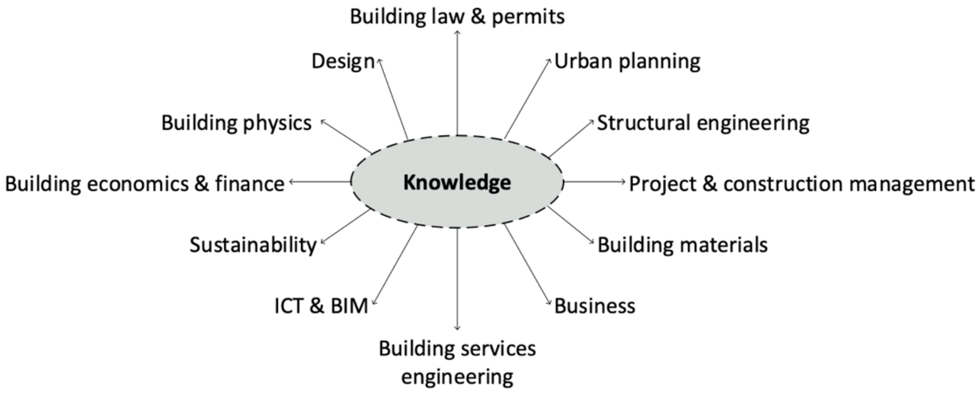


Figure 22 Identification of knowledge domains in the development process (own work)

3.9 Analytical model

The figure below presents the analytical model that synthesizes key theoretical insights into a structured overview for the empirical research. The model serves as the foundation for developing the interview protocol and guiding the subsequent analysis of the case studies. It consists of two main components: a theoretical framework and a methodological approach.

The first component, the theoretical framework, combines four distinct models, each addressing a different dimension of the research. Together, these models address key elements within the research: what, where, when, how, and who. The first model provides an overview for identifying circular strategies. This model addresses the "what" by helping to identify which CS are applied across the cases. The second model builds on Brand's shearing layers (1994). This model clarifies the 'where' by linking CS to specific building layers. This enables the analysis of where in the building these strategies have been implemented. The third model visualizes the development process, drawing primarily from Hamida & Hassanain (2021) and extended with the inception phase based on Çimen (2023). It captures both the 'when' and 'how', by structuring the process and identifying the activities within each phase across the cases. The fourth model identifies the actors involved in the development process, building on stakeholder literature of Chinyio & Olomolaiye (2009). It addresses the "who" by providing an overview of actors that may be involved in circular adaptive reuse projects, including their potential roles in the development process.

The second component concerns the methodological tool used to analyse actor interactions. It applies the multi-actor network analysis approach developed by Gerding et al. (2021), which allows for mapping actor relationships, their influence, and knowledge distribution across the development phases

ANALYTICAL MODEL

THEORETICAL BACKGROUND

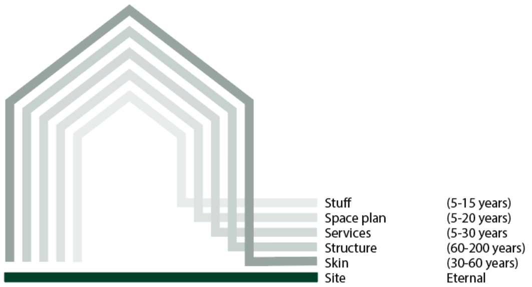
CIRCULAR STRATEGIES

What?

	Narrow	Slow	Close (now & in future)	Regenerate
	Aim for material efficiency and reducing new materials use	*Use material, products and components longer with maximal utilisation of existing value (direct reuse)*	*Use materials, products and components again (processed reuse)*	*Use renewable materials*
R-ladder	**R0 Refuse**: Prevent the use of non-sustainable or raw materials at all **R1 Rethink:** Rethink CE principles in the building design and planning **R2 Reduce**: Consuming fewer materials in design	**R3 Re-use**: Reuse products for their original function **R4 Repair**: Fix products to extend their lifespan **R5 Refurbish**: Restore old or discarded products for reuse **R6 Remanufacture**: Transform discarded products into new ones with the same function **R7 Repurpose**: Reuse discarded products but for a different function	**R8 Recycle**: Recycle materials from buildings for new use **R9 Recover**: Burn waste or biodegradable material to generate energy	
CB'23	**1 Design for prevention**: avoid new construction and where not possible design more efficiently and optimally	**2 Designing for quality and maintenance**: preservation of the existing and extending the lifespan of buildings, components and materials **5 Design with reused parts of construction**: reusing existing building components in design, extending the lifespan **4 Design for disassembly and reusability**: design for technical adaptability of components for reuse without damaging during or after use	**6 Design with secondary raw materials**: designing with reused building components and materials.	**7 Design with renewable raw materials**: designing with materials that are renewable (e.g. biobased materials).
CBA determinants strategies	Dematerilise the process	Utilisation of adjustable building components Utilisation of dismountable products Selective dismantling Implementation of proactive maintance Utilisation of movable building components	Utilisation of secondary (reused/recycled) material Application of material passport Selective dismantling	

Adopted from (Circle Economy & Metabolic, 2022; Cb'23, 2023; Evertsen & Knotten, 2024; Hamida, 2022; Ho et al., 2024; Nußholz et al., 2023; Potting et al., 2017)

Where?

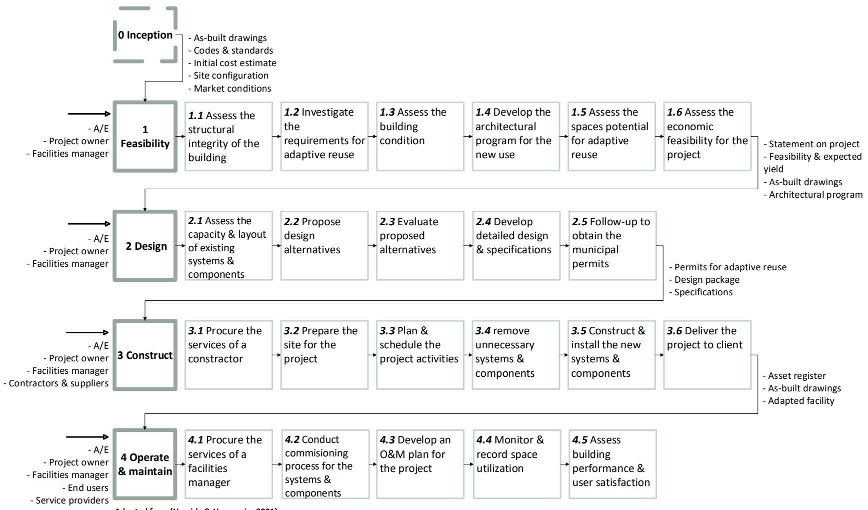


Adopted from (Brand, 1994; Transitieteam Circulaire Bouweconomie, 2020)

THEORETICAL BACKGROUND

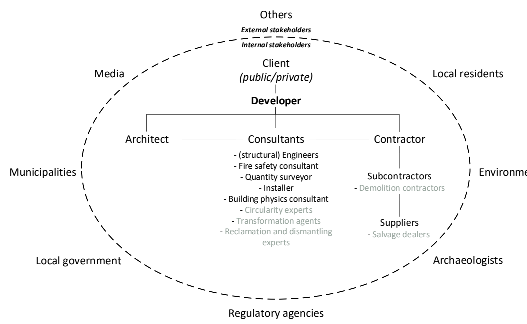
DEVELOPMENT PROCESS

When? How?



Adopted from (Hamida & Hassanain, 2021)

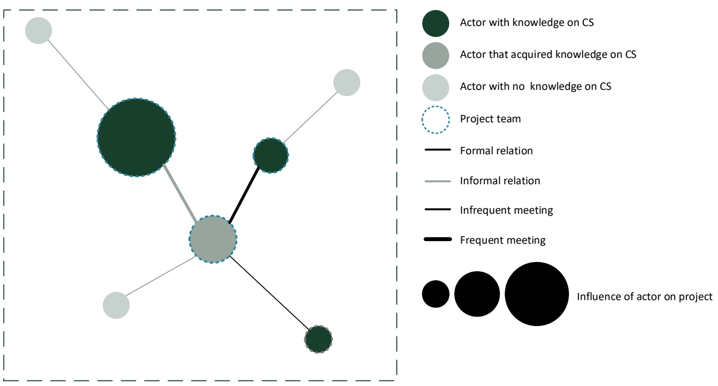
Who?



Adopted from (Chinyio & Olomolaye, 2009)

METHOD

MULTI-ACTOR NETWORK ANALYSIS



Adopted from (Gerding et al., 2021)

Actor: 'a social entity, person or organization, able to act on or exert influence on a decision'

Relations: relations are based on:
- communication frequency & duration
- exchange of knowledge
- formal & informal relations

Position: based on centrality concept.
- actor with the highest number of connections is placed in the center

Influence: Involvement in the decision-making rounds and their influence on it, based on abilities (information, knowledge, formal power)
- higher communication relates to higher influence on decision-making

Knowledge: type of actor and their level of knowledge on circular strategies
- actors with knowledge
- actor who acquired knowledge/ some knowledge
- actor with no knowledge

4 CASE STUDY ANALYSIS

CONTENT

4 CASE STUDY ANALYSIS

This chapter presents the individual analysis of the cases from the multiple case study. The analysis is based on the interviews conducted with the actors involved in the case, internal documents provided by the interviewees, and desk research. The analysis follows the structure of the analytical model. First, each case is introduced, providing relevant context. Next, the applied circular strategies are elaborated, highlighting the 'what' and 'where' part of the analytical model. The analysis then focuses on collaboration within each project phase, identifying key actors and interactions, emphasizing the 'when' and 'who' part. Finally, the last part shifts to the activities per phase, focusing on the 'when' and 'how' part. The results from the analysis are based on quotes from the transcript. To illustrate key findings, selected quotes from the interviews are included throughout the text. However, full transcripts and additional quotes are withheld to safeguard participant confidentiality.

4.1 Zandkasteel

4.1.1 CONTEXT

The Zandkasteel, located in Amsterdam Southeast, was designed by the renowned architects Alberts & Van Huut in 1987. The building consists of ten interconnected towers with a sloped facade and was originally built to accommodate the ING and its 2,500 employees. However, in 2015, the ING announced its decision to relocate to a smaller office in Amsterdam, leaving the future of the Zandkasteel uncertain. Recognized for its architectural design and unique features, the building was awarded the status of Amsterdam Zuidoost's first municipal monument in 2017. Following this designation, the municipality acquired three of the ten towers, which were subsequently transformed into an international school.

Size	**16,800 m^2**
Former function	Office
New function	School
Start inception	2018
Start design	2019
Start construction	2021
Delivery	2023

4.1.2 WHAT & WHERE: CIRCULAR STRATEGIES

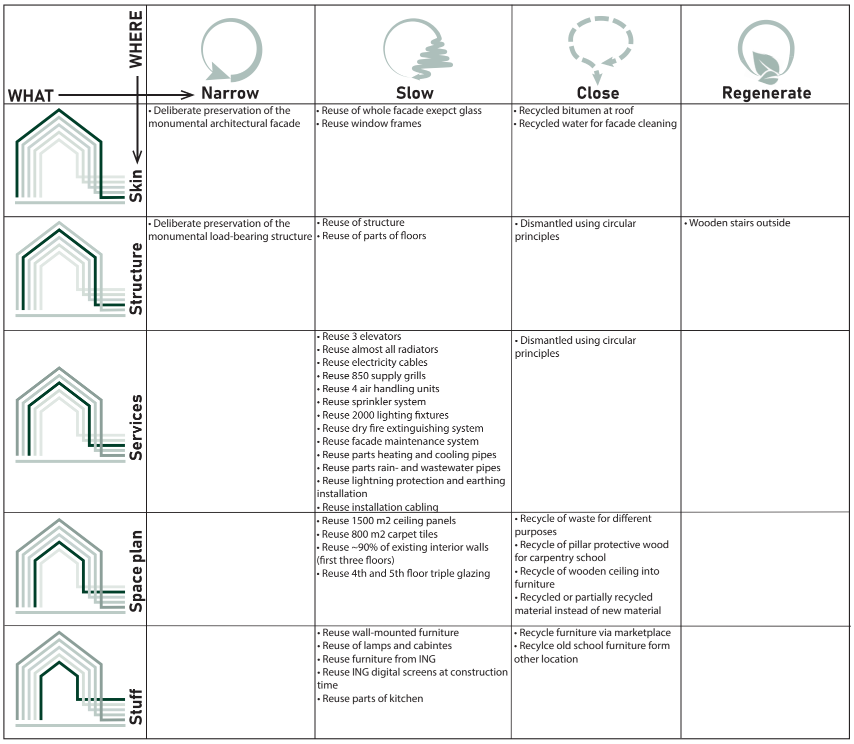


Figure 23 Circular strategies applied in the Zandkasteel, adopted from (Brand, 1994; Circle Economy & metabolic, 2022) (own work)

Within the Zandkasteel project, various circular strategies have been integrated into the design. While circularity was considered from the beginning, it only became a key ambition later in the process, driven by stakeholder motivation and persuasion, as well as the recognition of existing architectural characteristics. The extent to which circular principles were applied varies across different layers of the building. This is illustrated in Figure 23, which has been interactively developed and validated in the interviews with all the participants.

A key factor influencing circularity was the monumental status of the building, particularly its facade and the internal street on the upper floor. Preserving and limiting adjustments were prioritized to maintain the architectural identity. This approach aligns with the narrow strategy, which focuses on minimizing material consumption by retaining and optimizing existing components rather than replacing them. For instance, while initial plans suggested replacing the aluminium window frames, further assessment conducted in collaboration with the original supplier revealed that they could be retained and recoated instead. This approach minimized material use while ensuring long-term durability.

Furthermore, adaptive reuse projects generally prioritize the reuse of the skin and structure. In the case of the Zandkasteel, however, an ambitious approach was being undertaken to reuse materials at the services and space plan level, initiated by the installation expert (circularity expert). This active approach aligns with the slow circular strategy, which emphasizes extending the lifespan of materials.

In addition to reuse, the project explored whether the building materials and components that could not be integrated into the new design, could be processed and utilized elsewhere at the space plan and stuff level. This applied not only to the permanent building elements but also to temporary construction materials used on-site for protective purposes. A dismantler carefully removed both types and either redirected them to a marketplace, or they were sold and processed elsewhere into new products. Moreover, the contractor proposed material alternatives composed of recycled content, ensuring that new materials aligned with circular principles while meeting budget and quality requirements. These practices further contributed to closing the resource loop, reflecting the close strategy within the project.

In contrast with other circular strategies, the regenerate strategy was not a key focus in this project. The use of biobased materials was not explicitly prioritized, with only a minor application in the form of a wooden outdoor structure added for an escape route.

4.1.2.1 Limitations to circular strategies

While multiple circular strategies were successfully integrated into the Zandkasteel project, the project faced some challenges to integrate CS. Four specific limitations were mentioned by interviewees, each discussed either once or multiple times. These four limitations have been further grouped into two overarching categories, as shown in Table 1. The following section further elaborates on each limitation in more detail.

First, a limitation mentioned by multiple participants was the inadequate building evaluation. Because the bank continued to use the building, along with COVID-19 restrictions, it was not possible to thoroughly examine all building components during the early design phases. As a result, design choices were made based on outdated building information and assumptions, leading to unforeseen feasibility issues later in the process. As Z3 explained *'It is a bank, so you weren't allowed to go anywhere. We basically had to make assumptions [about the quality]'.* Additionally, all participants emphasize the lack of destructive inspections, specifically for the services. It was assumed that many existing plumbing and drainage systems and toilets could be reused. However, during execution, their poor condition became evident. Toilets that were initially planned for reuse were later found to be heavily deteriorated. Furthermore, only participant Z2 mentioned the incomplete and outdated building plans as a significant limitation, as they did not reflect the current situation. Early plans considered the transformation of the office rooms into classrooms. However, once the real layout was assessed, it became evident that the original floor plans were inaccurate, making the reuse unrealistic. In summary, these three limitations have been categorized into the first category, assessment and knowledge gaps.

In addition, all participants noted that reuse strategies often proved unviable due to high costs or high labour intensity. Some design ideas proved to be unfeasible once the contractor joined the team, as these ideas were frequently proposed by design members, who lacked sufficient expertise regarding constructability and technical feasibility in the execution. Z5 highlighted this issue, stating, '*That [idea] was just so labour-intensive. It ended up being an absolutely ridiculous price per square meter if you dismantled it and* *reinstalled it.'* This limitation is categorized under financial and development process limitations.

These limitations highlight the importance of early-stage technical assessments to avoid reliance on outdated floor plans or assumptions. Equally crucial is the timely evaluation of proposed reuse strategies in the design phase by an executing actor, for instance, contractor or dismantler, ensuring that design decisions incorporate sufficient expertise on technical feasibility. The importance of both actions has been stressed by multiple participants and is further discussed in 4.1.3.3.

Category	Specific limitation	Explanation
Assessment and knowledge gaps	Inadequate building evaluation	Because the building was still in use by a bank, a thorough investigation of the existing situation was not possible in the early phases. This later led to unexpected problems.
	No destructive inspection of services	Major defects (e.g., in the pipes and toilets) were only discovered during execution because no prior destructive investigation had been conducted.
	Incomplete and outdated building plans	The design team had drawings that no longer matched the actual situation, requiring adjustments to reuse plans later on.
Financial and development process limitations	Unfeasible reuse due to high costs/labor intensity	Reuse of certain materials (e.g., wooden slatted ceilings) proved too expensive or complex to be cost-effective (due to dismantling/installation requirements).

Table 1 Limitations to implement circular strategies in Zandkasteel (own work)

4.1.3 WHEN & WHO: COLLABORATION IN THE DEVELOPMENT PROCESS

Multi-actor network analyses were developed interactively with participants to capture collective insights. However, interpretations of the legend sometimes produced contradictory results, mostly regarding knowledge and influence, highlighting the subjective nature of these visualizations. Final decisions on the network visualizations were based on the frequency of responses, the relevance of participants to each phase, and self-assessments of expertise.

4.1.3.1 Inception

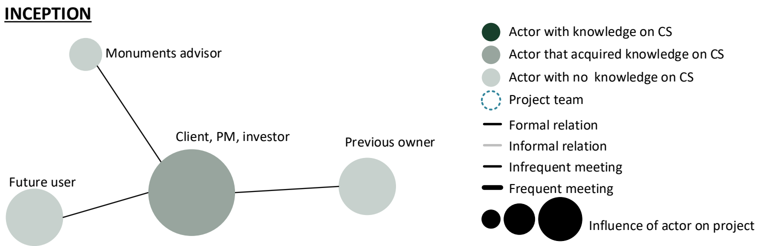


Figure 24 Multi-actor network analysis in the Zandkasteel's inception phase, adopted from (Gerding et al., 2021) (own work)

Figure 24 represents the multi-actor network in the inception phase of the Zandkasteel. This phase focuses on whether to acquire the building based on its condition and functional potential. The central node represents the client, who maintains the highest number of relations. This central position reflects the client's communication with other parties and correlates with greater influence. Indeed, the client holds the formal power to decide on the acquisition. Furthermore, the relations are formal and occur on an infrequent basis, meaning they do not have weekly contact. Notably, the colour of each node reveals that most actors possess only moderate or no knowledge on circularity. This aligns with the fact that circularity is not yet a dominant factor during this phase, as discussions primarily revolve around acquisition feasibility. Remarkably, the inception network highlights two key factors, including the strong decision-making power of the client and the relatively little knowledge of circular expertise at this point.

4.1.3.2 Feasibility

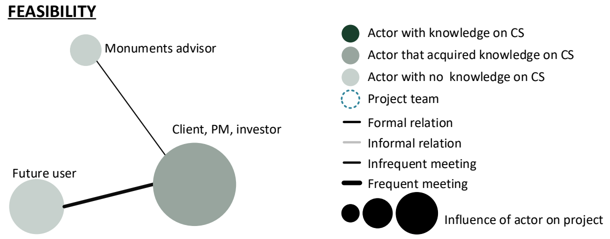


Figure 25 Multi-actor network analysis in the Zandkasteel's feasibility phase, adopted from (Gerding et al., 2021) (own work)

During the feasibility phase, the future use of the building was further defined. As a result, the actors involved focused on refining the program of requirements, organizing spaces within the existing floor plans, and determining how to approach procurement. To achieve this, this phase required detailed inquiries into functional needs, zoning plan constraints, and organizational structure. Figure 25 illustrates the multi-actor network during this phase, including the client, the future user, and municipal departments for the monumental status and zoning plan requirements.

Furthermore, the relationship between the client and future user intensified as the two parties worked to establish project outcomes in terms of a program of requirements. Meanwhile, the client remains in a central position, indicated by the highest number of relations. This centrality reflects their significant influence, as the client holds the financial responsibility and has the final say on whether to proceed with additional investments. Although the school started to influence certain requirements in the program, the size of their node remains smaller than that of the client, consistent with several participants' responses as '*Who pays, decides. So ultimately, it is always the client.' (Z5)*. Interestingly, the level of knowledge on circularity remains limited. Although sustainability was high on the agenda of the client, circular interventions received little attention. Instead, this phase focused on pragmatic issues such as functionality, budget, and scheduling.

4.1.3.3 Design

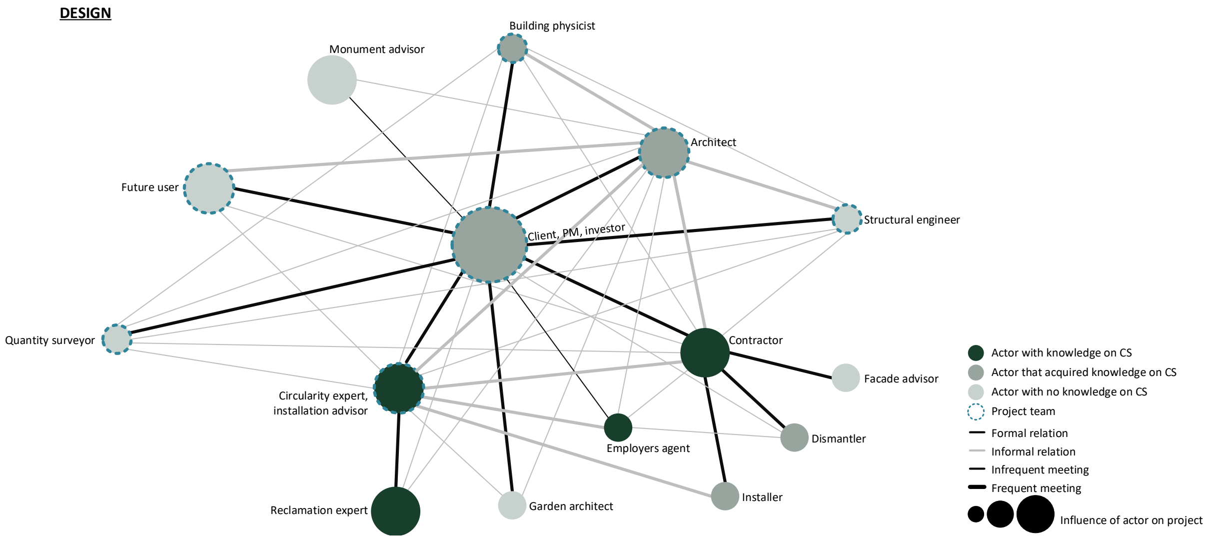


Figure 26 Multi-actor network analysis in the Zandkasteel's design phase, adopted from (Gerding et al., 2021) (own work)

This phase focuses on transforming the program of requirements into a feasible design. To realize this, multiple actors have been engaged in this phase to expand the level of knowledge in all the disciplines. The most significant actors are represented in Figure 26. The project team consists of the client, future user, architect, and experts regarding development costs, structural engineering, and building physics. Additionally, the project team included a circularity expert with expertise in services. Later in the process, after the technical specifications were made, there was a short bouwteam phase, including a contractor, employer agent, and installer as part of the project team. In general, this phase included several circularity-related actors, namely a dismantler, a circularity expert, and a reclamation expert.

Within this network, the client remains the central actor with the most relations. This prominent position highlights the client's responsibility to coordinate with all stakeholders and communicate evolving objectives around circularity. Building on this, the client acts as the transformation agent. Alongside the client, the architect, contractor, and circularity expert also hold a central position, consisting of a high number of relations.

Within the project team, members met regularly, which helped ensure that circular strategies were integrated across all disciplines and that a shared focus on circularity was maintained. Circularity-related knowledge was embedded in the team, particularly through the circularity expert, who also distributed input from the reclamation expert. During the construction team phase, additional knowledge was provided by the contractor. In both situations, the presence of circularity expertise within the team facilitated cross-disciplinary exchange and strengthened the integration of circular strategies throughout the process. The circularity experts who were part of the project team were found to have a medium level of influence, while experts outside the team held varying levels of influence, ranging from low to medium. Although no direct explanation was given for this difference, it may indicate that being embedded within the core project team enhances the visibility of circular knowledge across disciplines.

The following section focuses on the key relationships through which circular knowledge was exchanged and how they shaped the project's circular outcomes. The relationships are based on participants' responses, highlighting those identified as essential for implementing circular strategies. The relationship between the client and the circularity expert was particularly crucial. The circularity expert introduced an ambitious vision for circular objectives, particularly emphasizing the reuse of services. This significantly influenced the client's commitment to circular principles. Furthermore, the circularity expert, acting as the main source of knowledge on slow strategies for services, collaborated with an external reclamation expert. This relation was crucial to identify which materials and components from the existing building could be reused. The circularity expert then shared this information and their knowledge on the reuse potential of the services with the architect. This relationship was critical to transferring the knowledge on reuse into the new design. Moreover, a strong relationship existed between the circularity expert and the installer. Both actors were involved in examining whether building services could be reused and verifying the practical feasibility of implementing these by the installer. The architect's relationship with the contractor was also significant for circularity. The contractor ultimately assessed the technical viability of reusing materials and components in practice. On top of that, the architect maintained important communication with the future user, especially in the sketch design phase, as the circular approach required adjustments to the school's program. Finally, the relation between the contractor and dismantler was essential as the contractor relied on the dismantler's insights on material reuse. The contractor ensured that this information came back to the whole project team. Table 2 summarizes these relations and outlines their significance.

Furthermore, the client has the highest influence on the decision-making around circularity. Thereafter, the architect, future user, monumental advisor, circularity expert, contractor, and reclamation expert have a medium level of influence on circular outcomes. This indicates that they have an indirect influence on circular outcomes but do not make the final decision.

During the design phase, four actors with circular expertise were involved, yet only one, the circularity expert, was part of the project team. The contractor, having an internal circularity department, participated in the project team during the bouwteam phase. However, the contractor's circularity advisor operated as an internal consultant rather than a direct project team member. The reclamation expert was hired through the circularity expert, who transferred the information to the project team. Interestingly, there was little direct communication among the various circularity-related actors. As a result, knowledge was exchanged through reports rather than direct collaboration. Consequently, this has been experienced by some actors as a shortcoming, as Z5 stated '*I hardly spoke at all from my role with the [circularity expert]… I did see the reports, but I didn't discuss them with anyone, which I thought was a pity.'*

Relationship	Explanation
Client - circularity expert	The circularity expert's strong ambition broadened the client's focus to a circular project. This led that the client adopted a fully circular commitment for the project.
Circularity expert - reclamation expert	The circularity expert brought in a reclamation expert to conduct a space-level scan for reuse opportunities, then shared these findings with the wider project team
Circularity expert - architect	The circularity expert introduced reuse strategies for both services and space plan level, ensuring the final design aligned with the building's circular potential.
Circularity expert - installer	The circularity expert proposed circular strategies for services, while the installer verified (technical) feasibility, guaranteeing practical implementation of the circular solutions.
Architect - contractor	The architect integrated the circular strategies into the design, while the contractor verified their technical and practical feasibility.
Architect - future user	The architect integrated the circular strategies into the design, requiring the future user to make adjustments in the program of requirements, ensuring successful circular integration.
Contractor - dismantler	The dismantler offered early insights into the building's deconstruction, ensuring a careful approach for dismantling materials and maximizing reuse potential.

Table 2 Most relevant relations for circularity in the Zandkasteel's design phase (own work)

4.1.4 WHEN AND HOW: ACTIVITIES IN THE DEVELOPMENT PROCESS

This section focuses on the activities per phase in the early phases of the development process. Based on the interviews, for each phase is its primary influence on circular outcomes mentioned, followed by an explanation of the key activities identified for achieving circular outcomes. Finally, it explains the success factors that participants perceived as further enhancing circular results. For each phase, the activities with the relevant actors are identified. A table is created that links the 'how' of the activity to the 'when', based on the interview coding. Each activity is classified as either 'implemented', 'partly implemented', or 'recommended'. In the research context, 'partly implemented' means that the activity either occurred in a different, but comparable, manner. The table reflects the best approach as recommended by the participants.

4.1.4.1 Inception

First, many participants emphasized that the inception phase exerts significant influence on circular outcomes, as it is the stage where the initial ambition for circularity is defined. Although circularity was not yet fully developed at this stage, there was a clear ambition to make the project highly sustainable, within which circularity was considered a component. Participants noted that having this ambition established from the outset was essential.

In the inception phase, various activities were identified, as illustrated in Table 3. Some activities, such as assessing spatial and functional feasibility, evaluating the technical condition, investigating legal requirements, assessing economic feasibility, and acquiring the building, are present in every adaptive reuse process and are not exclusive to circularity. These activities have also been identified by Hamida & Hassanain (2021). In contrast, certain elements are specific to circularity, such as defining a circular ambition and assessing the reuse potential of materials and components. All participants stressed the importance of establishing a circular ambition at the beginning, and many emphasized the crucial role of the client in defining this ambition, as illustrated by Z2, who stated, '*But the most important thing is that … your client is willing to reuse it*.'

Furthermore, all participants underlined the need to assess the reuse potential of materials and components. This evaluation relates to the investigation of the building's technical condition. All participants agreed that this assessment should be conducted during the inception phase, before the acquisition of the building. At this stage, the assessment focuses on evaluating the overall condition of the building to determine whether reuse is a viable option. In a subsequent feasibility phase, a more detailed opportunity scan is performed on each building component. Interestingly, Z6 stated *'Because the point is also that if everything had been known in advance, the whole project might not even have gone ahead. ... I mean, if you knew everything beforehand, would you even take on that project?'* This statement suggests that uncertainty during the early stages of a project may foster innovation and encourage stakeholders to explore adaptive reuse options. The implication is that a certain level of unknown factors can be beneficial and prompts further investigation and detailed analysis in later phases.

In addition to these activities, participants mentioned several factors in the inception phase that strongly influenced circular outcomes. One factor is ensuring intrinsic motivation and commitment to circularity. Z4 emphasized that while circularity can sometimes generate cost savings by reusing materials, it does not always do so, which underscores the need for a deeper motivation to prioritize circularity. Another factor is the development of a clear circular ambition document, as mentioned by multiple participants. Z1 and Z2 stressed that involving the same project managers across different phases helps safeguard earlier circular decisions and ensures consistent execution.

When	How	Status
Inception	Define a circular ambition	Partly implemented
	Assess spatial and functional feasibility for AR	Implemented
	Assess technical condition	Implemented
	Assess reuse potential of materials and components	Partly implemented
	Investigate legal requirements for AR	Implemented
	Assess the economic feasibility for the project	Implemented
	Acquire the building	Implemented

Table 3 Activities in the Zandkasteel's inception phase (own work)

4.1.4.2 Feasibility

The influence of the feasibility phase on circular outcomes has been identified as crucial in assessing the building's final reuse potential in more detail and detailing the ambition. Additionally, Z5 described the feasibility phase as iterative, explaining that it serves as an initial check on the broad circularity feasibility of the project in terms of time and budget. However, as the project moves towards the design phase, this assessment is refined and continuously revisited.

During the feasibility phase, several activities are commonly undertaken in adaptive reuse projects, such as engaging potential future users and allocating financial and planning reserves. In addition to these general activities, some more specific activities emerged from the interviews. Many participants emphasized the importance of aligning the future user with the circular goal, particularly in managing expectations regarding quality. Reuse strategies can sometimes result in different quality outcomes than in new constructions. Participants also frequently mentioned establishing clear boundaries and prioritization lists in the program of requirements. Especially, participants active in the execution emphasized this need as it streamlines the decision-making. Z5 explained that having a shared understanding from the outset facilitates more efficient decision-making. Additionally, Z4, Z5, and Z6 emphasize the need for a prioritization list within this ambition document. Furthermore, participants involved in both the design and construction phases underscored that defining quantitatively measurable targets early on further accelerates decision-making.

Furthermore, Z2 emphasized that formulating a flexible program of requirements for functions is beneficial if a project is aiming to reuse existing spaces. Z2 noted that instead of adhering to strict predefined square meters for each function, the flexibility in the functional requirements allowed for better alignment with the building's existing structure. This ultimately facilitated material reuse and minimized big modifications. Additionally, Z2 emphasized the importance of verifying and correcting existing building drawings early in the feasibility phase. In the Zandkasteel case, reliance on outdated plans led to overestimations of reuse potential, particularly regarding the transformation of office spaces into classrooms. Once the actual layout was assessed, it became evident that certain envisioned reuse strategies were unfeasible. Early verification could have prevented these misalignments, enabled more accurate reuse planning, and reduced design revisions later in the process.

All participants repeatedly stressed the need for comprehensive research in the feasibility phase. This research typically consists of two elements. The first is a detailed opportunity scan for materials and components in the building, ideally conducted by an architect in collaboration with a reclamation expert. As Z3 explained '*I think you really need to develop a research report that includes quantities and a kind of product condition, for instance, its technical state, to which you might assign a certain score. That way, you can make the best decisions about which option has the most potential [for reuse].'* This level of detail distinguishes the feasibility-phase scan from the more general assessment conducted during the inception phase, enabling more informed decisions about which elements are most viable for reuse. The second involves destructive investigations, particularly for the services, where the role of a reclamation expert is deemed crucial to uncover hidden issues or potential for reuse.

Only one participant (Z1) explicitly addressed the importance of developing a circular procurement strategy, including specific selection and award criteria to ensure experienced parties are chosen. Although other participants emphasized the importance of engaging firms with expertise in circularity, only Z1 transformed this into a formal strategy. This difference may be attributed to the fact that only the client possesses the experience and capacity to establish such a procurement strategy, and therefore only noted by the client.

In the context of success factors in the feasibility phase to integrate circular strategies, two main factors were identified. The first is the importance of selecting an independent reclamation expert. Several participants stressed that this expert should operate independently from companies selling salvaged materials to avoid potential conflicts of interest. The second stimulating factor, mentioned by all participants, is the selection of experienced advisors in circularity. This aligns with the activity related to the procurement strategy. This ensures that the project team possesses the knowledge required for effective circular outcomes.

When	How	Status
Feasibility	Engage potential future user	Implemented
	Align future user with circular goal and conduct expectation management	Partly implemented
	Establish clear boundaries, prioritization list and qualitative requirements for circularity in program of requirements	Recommended
	Establish quantative and measurable targets in program of requirements	Recommended
	Establish a flexible program of requirements for functions	Implemented
	Assess reuse potential of materials and components in detail	Partly implemented
	Conduct destructive research	Recommended
	Verify and correct existing building drawings	Partly mplemented
	Establish a circular procurement strategy with circular selection and award criteria	Recommended
	Allocate financial and planning reserves & risks	Recommended

Table 4 Activities in the Zandkasteel's feasibility phase (own work)

4.1.4.3 Design

During the interviews, different themes were mentioned for the influence of the design phase on circular outcomes. Participants highlighted the importance of concretizing the circular ambition. Several participants noted that this occurs through formal documentation, such as specifications and contracts. Z1 stressed the need to continuously reflect and align the design plans against the PoR. Moreover, multiple participants emphasized that feasibility is an iterative process in the development process. This underscores the need to link design decisions back to earlier objectives.

Several activities were identified in the design phase, as illustrated in Table 5. In the design phase of an adaptive reuse project, several standard activities typically occur, such as establishing a project team, proposing design alternatives, developing a detailed design, drafting technical specifications, and obtaining municipal permits. However, the interviews revealed that when circularity is a primary objective, some activities either acquire additional significance or require a different approach. For instance, Z2 and Z6 underscored the need to explore multiple design alternatives since reusing certain spaces may not always be 100% feasible or may not fully meet the program of requirements. This asks for additional flexibility in the program of requirements and creativity of the architect. Furthermore, Z1 and Z2 emphasized the importance of engaging suppliers when there is limited knowledge about the reuse potential of specific components. They suggested that contacting original suppliers could reveal ways to reuse existing components in the new project or elsewhere. Z4 and Z5 also highlighted the value of involving suppliers early on to verify the technical feasibility of proposed designs.

Interestingly, participants offered varying perspectives on how and when to involve contractors. Several participants recommended bringing contractors in early to assess technical feasibility, especially given the complexities of circular strategies. However, Z2 advised that this should not happen before finalizing the definitive design, to avoid excessive influence on design decisions and inefficiency. Z1 pointed out that market conditions also affect the optimal timing for contractor engagement. Simultaneously, earlier involvement can be beneficial when aiming for circular goals, given the relative novelty of these approaches. Z3 further suggested that preparing a technical program of requirements before contractor involvement may allow for more diverse and feasible solutions. In addition, many participants stressed the importance of including a dismantler, who can be a salvage dealer as well, that can facilitate the reintegration of salvaged materials in the market and thus expand circular possibilities.

From the interviews, several factors to implement circularity successfully have been identified for the design phase based on the interviews. First, multiple participants mentioned that all project team members must share a strong commitment to circularity. Second, organizing a kick-off meeting or team-building session at the outset was mentioned by Z6 as an effective way to establish open communication and promote collaboration. Third, all participants noted the importance of selecting experienced quantity surveyors and contractors familiar with circular principles is key to accurately assessing costs and feasibility. As Z1 stated, '*Clients sometimes assume reuse is free because they think, 'we are reusing, so it costs nothing*,' while Z4 explained *'adding circularity does not always reduce costs due to the additional technical work involved*.' This underscores the importance of quantity surveyors having robust reference data for circular projects. Fourth, facilitating continuous knowledge transfer across the project team into the execution is essential. Z2 remarked that if he had attended the initial meetings in the execution, he could have advised on proposals based on prior decisions. Instead, meetings in the execution phase sometimes included people who had not participated in the earlier phases, leading to decisions that diverged from earlier agreements. This underscores the need for consistent team involvement and effective knowledge transfer to avoid unnecessary rework. In addition, many participants also recommended organizing regular physical meetings. Finally, the circularity-related participants emphasized ensuring regular communication between these actors to maintain focus on circular objectives.

When	How	Status
Design	Establish a project team	Implemented
	Propose design alternatives	Implemented
	Consult suppliers in assessing reuse opportunities	Implemented
	Develop detailed design	Implemented
	Develop technical program of requirement	Recommended
	Include experienced contractor early for technical feasibility of design	Implemented
	Offer circular material alternatives	Implemented
	Develop technical specification	Implemented
	Include salvage dealer and dismantler	Recommended
	Develop a demolition specification	Partly implemented
	Obtain municipal permits	Implemented

Table 5 Activities in the Zandkasteel's design phase (own work)

4.2 Edge olympic

4.2.1 CONTEXT

The Edge Olympic, formerly named Olympic Plaza, located in Amsterdam Zuid, has been transformed into multi-tenant offices. The building originally functioned as a sorting centre and a post office. The new building concept focuses on creating an open ecosystem, stimulating sustainable interventions, and using smart technology to foster comfortable and productive spaces. In addition, the design features progressive circularity standards for that time, which remain innovative today. This is further discussed in 4.2.2. Furthermore, the building has received multiple certifications, including a Cradle2Cradle, WELL Platinum, BREEAM Excellent, and Paris-proof certification. These establishments highlight the building's commitment to sustainability and circularity, setting a benchmark for future circular transformation projects.

Size	**12,367 m^2**
Former function	Sorting centre and office
New function	Multi-tenant offices
Start inception	2014
Start design	2015
Start construction	2016
Delivery	2018

Photo 1 By Architekten Cie

4.2.2 WHAT & WHERE: CIRCULAR STRATEGIES

WHAT → / WHERE ↓	Narrow	Slow	Close	Regenerate
Skin		• Reuse parts of existing facade • Cradle2Cradle certified facade on 2 top floors extension • Reuse of natural stone of the facade in the atrium floor	• Dismantled using circular principles	
Structure	• Deliberate avoidance of demolition waste by maximizing the reuse of existing structure	• Reuse of existing structure • Reuse of floors • Cradle2cradle certified constructi-on on 2 floor extension	• Dismantled using circular principles	• Wooden support structure for roof extension • Wooden floor structure at added floor areas
Services			• Building materials and components documented in an online materials library • Dismantled using circular principles	
Space plan			• Building materials and components documented in an online materials library • Dismantled using circular principles	
Stuff			• Interior is leased and is reused elsewhere	

Figure 27 Circular strategies applied in Edge Olympic, adopted from (Brand, 1994; Circle Economy & metabolic, 2022) (own work)

At the time the development process of Edge Olympic began, circularity was not a widely used concept. In fact, during the early stages of the inception phase, the term itself had yet to emerge in the building industry. As a result, circularity was not yet a main ambition, however, as stated by EO1, '*Around 2014-2015, the development began. At that time, circularity was not yet the term used; instead, the focus was simply on building as sustainably as possible and reusing as many materials as possible. Therefore, I would not say that there was necessarily an explicit goal of circularity, but rather the aim was to construct a building on the Zuidas that was as sustainable as possible.'* Later, during the feasibility and design phases, circularity became a widely discussed topic and an integrated part of the design process, inspired by discussions between the TU Delft and the architect.

A key aspect of the project's circular approach, aligning with the narrow strategy, was the decision to retain and optimize the existing structure. This strategy has been integrated due to the municipality's requirements that the existing structure must be reused, limiting demolition and new building possibilities. Therefore, instead of removing large sections of the building to create an atrium, the design team chose to work with the existing building's contour and extend it. This approach minimized demolition waste while ensuring that new additions would maintain circularity principles.

Beyond preservation, the project also applied slow circular strategies by extending the lifespan of materials. In addition to reusing the existing structure and much of the façade, a broader strategy was implemented. Two top floors were designed to be fully demountable at the two top levels, both for the façade and the structure. This enhances future flexibility for future adaptations. Because of this, the project received a Cradle2Cradle certification. Additionally, the project reused the natural stone of the facade in the atrium floor in the new design. Furthermore, all newly added construction components and floors were made of biobased materials, aligning with the regenerate circular strategy.

Lastly, the project applied close circular strategies by documenting all the materials and components in an online material library of Madaster, including a circularity indicator. In addition, a dismantler was engaged to circularly demolish the building and its components. On top of that, the whole building interior, at the stuff level, is leased. This aligns with the close strategy.

4.2.2.1 Limitations to circular strategies

Although the Edge Olympic project has applied progressive standards in terms of circularity, it faced several challenges in implementing circular strategies. These limitations are based on participants' interviews and can be categorized into two main areas, illustrated in Table 6.

First, multiple participants mentioned challenges related to the financial and development process limitations. While the initial circular strategy aimed to reuse all natural stone from the façade, technical limitations ultimately prevented its further reuse. It was already quite challenging to reuse the stone in the floor, making additional reuse efforts unmanageable. Building further on the financial and development process limitations, did EO2 explicitly mention that reuse often exceeds the available financial resources and time constraints, making realization unfeasible.

Second, the project also encountered technical and performance limitations, especially for the services. One major obstacle, mentioned by all participants, was the outdated nature of the existing services, which no longer met the modern climate requirements. In addition, warranty and performance concerns, mentioned by EO3, made the reusability a further constraint, causing the decision not to reuse any of the services. However, the dismantler did assess the components of the services at a material level to determine whether they could be reused elsewhere.

In conclusion, these limitations highlight the importance of integrating financial reserves and time margins to manage unexpected cost overruns and delays from reuse challenges. Besides that, ensuring a structured evaluation and timely involvement of the expertise of a contractor for the practical and technical feasibility of the design prevents later conflicts with execution feasibility. This can be done by the timely involvement of suppliers or a contractor, as underpinned by multiple participants. As EO1 and EO2 stated '*So if an architect comes up with an idea that involves truly unique elements, what we always do is include the key suppliers in the process so they can start monitoring from that point.*' *And 'You need to have the contractor at the table early, because they are the ones who deliver the products, and you must also verify whether something is feasible.*'

Category	Specific limitation	Explanation
Financial and development process limitations	Unfeasible reuse due to high costs/labor intensity	Reuse of certain materials (e.g., facade elements) proved too expensive or complex to be cost-effective (due to dismantling/installation requirements).
	Budget and time constraints	The project prioritized circularity but had to scale back when financial and time constraints became limiting factors
Technical and performance limitations	Outdated installations, not meeting modern standards	Despite the ambition to reuse as much as possible, the existing services did not align with modern climate standards and the project's high health and wellbeing amibitons
	Outdated guarantee concerns for reused materials	Ensuring functionality and warranty of reused materials was a challenge

Table 6 Limitations to implement circular strategies in Edge Olympic (own work)

4.2.3 WHEN & WHO: COLLABORATION IN THE DEVELOPMENT PROCESS

This section explains how collaboration was organized per phase. The development of the multi-actor network models is explained in more detail in section 4.1.3.

4.2.3.1 Inception

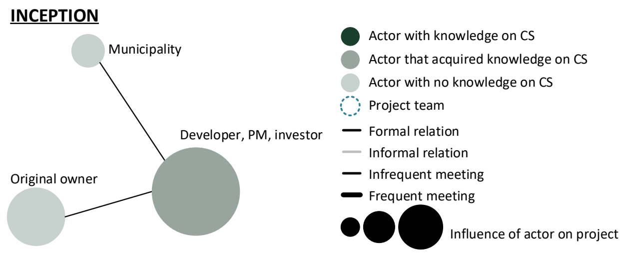


Figure 28 Multi-actor network analysis in the Edge Olmpic's inception phase, adopted from (Gerding et al., 2021) (own work)

Figure 28 represents the multi-actor network in the inception phase of Edge Olympic. In this phase, the developer examined the building's potential and considered its acquisition. The developer holds a central position in this network, reflecting the highest number of relations. This high level of communication is linked to a greater degree of influence in decision-making. As a result, the developer ultimately decides whether to purchase the building. Furthermore, all the relations are formal and occur on an infrequent basis. Circularity is not yet an active ambition for the developer at this stage, primarily because the concept was not widely recognized at the time. However, the developer already had ambitious and progressive sustainability goals, with circularity indirectly part of it. Interestingly, there were no actors yet involved with expertise around circularity.

4.2.3.2 Feasibility

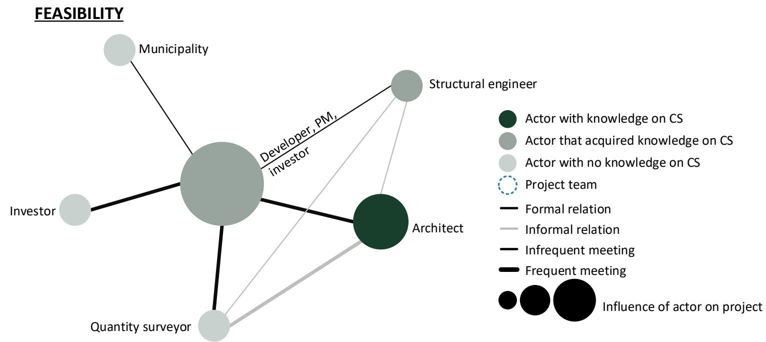


Figure 29 Multi-actor network analysis in the Edge Olmpic's feasibility phase, adopted from (Gerding et al., 2021) (own work)

In the feasibility phase, circularity became a more central component of the redevelopment ambition. Although the concept was still relatively new, the developer took the initiative to integrate circular principles more thoroughly into the design. During this phase, the existing building was analysed in greater depth to determine its potential for reuse. The multi-actor network of the feasibility phase is illustrated in Figure 29.

In this network, the municipality, investor, developer (client), structural engineer, architect, and quantity surveyor were active. The developer maintained the largest node size and occupied a central position, reflecting both the highest degree of influence on circular outcomes and the most relationships. This centrality was also reflected in the developer's role as transformation agent, actively embedding circular ambition into the design process and aligning key actors around these objectives. The relationship between the developer and the architect was particularly important, as the architect brought valuable expertise in circular ideas and possibilities. Furthermore, the close collaboration between the quantity surveyor and the developer was crucial to ensure that all initiatives remained within the financial constraints. Notably, no end-users were involved at this stage. This is because the developer already possessed sufficient insight into the requirements of future office tenants. It is noteworthy that EO1 emphasized that he was not involved in the contact with the investor, therefore, their influence and relationship are based on his assumption.

4.2.3.3 Design

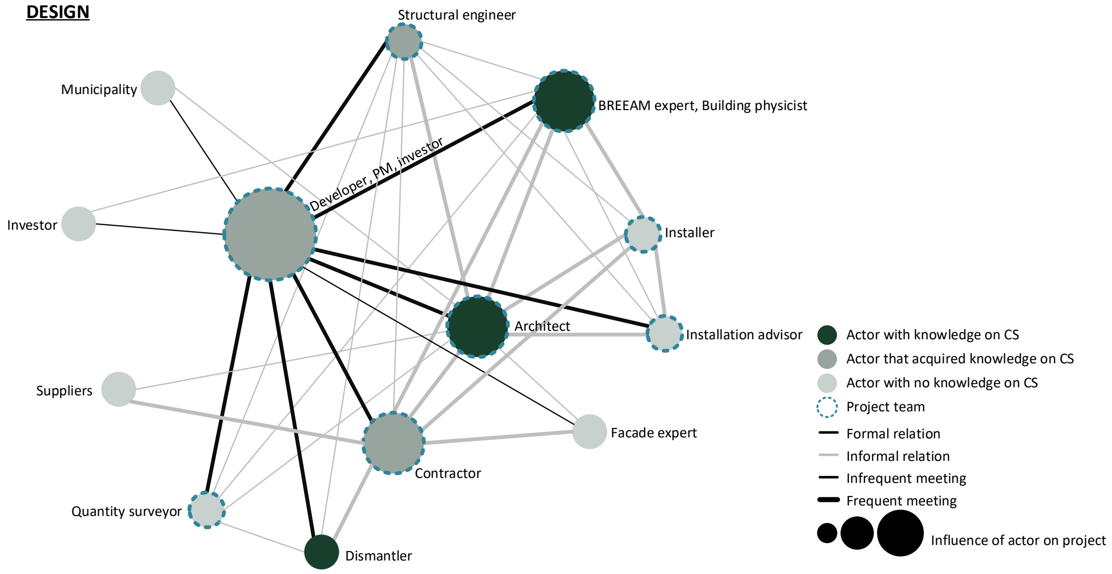


Figure 30 Multi-actor network analysis in the Edge Olmpic's design phase, adopted from (Gerding et al., 2021) (own work)

This phase focused on exploring how the building could be expanded while preserving its existing structure, as well as on how new spaces could be added. At the same time, the detailed development of the circular Cradle-to-Cradle concept was made, including the reuse of façade materials in the new design. The key actors active in the design phase are illustrated in Figure 30. The project team consisted of the developer (client), BREEAM expert, installer, installation expert, architect, contractor, and quantity surveyor. Notably, three actors possessed specialized knowledge of circularity, namely the dismantler, the architect, and the BREEAM expert.

The members of the project team met regularly, which helped to ensure that circularity remained a consistent topic throughout the design process. The frequent meetings also allowed the team to align their perspectives and maintain a shared focus, ensuring that circularity was embedded across disciplines from an early stage. The team had access to the necessary expertise, as both the architect and the BREEAM consultant brought in-depth knowledge of circular principles. The actor-network diagram further illustrates that those with circularity knowledge who were part of the project team held more influence compared to experts outside the project team, such as the dismantler. There is no direct explanation for this difference, but it could suggest that formal inclusion in the team structure may increase the impact of specialised knowledge on project outcomes.

Within the network, the developer occupied the central position and maintained the highest number of relationships. In this role, the developer functioned as the transformation agent, ensuring that all actors were aligned with the project's circular ambition. Additionally, the architect played a central role, forming many relationships, some of which were maintained on an infrequent basis. Besides the architect and developer, both the BREEAM expert and the contractor also possessed a significant number of relationships.

The following section describes the key relationships in the design phase that were relevant for achieving circular outcomes in the project. These relationships are based on participants' interview data, and Table 7 summarizes the findings. First, both the developer and the architect emphasized the crucial nature of their relationship. They described it as highly accessible and open, which allowed them to easily communicate and explore opportunities for circular applications in the new design. In addition, the relationship between the contractor and the developer was important. Although the contractor was relatively new to circularity, they were very ambitious in learning about it. The developer involved the contractor early on to verify that ideas for material reuse were technically feasible and viable within the project's constraints, which was also experienced as beneficial for the project. Furthermore, the relationship between the developer and the dismantler was important. The dismantler provided valuable knowledge about the existing value of materials and helped to find new life for them, thereby enhancing circularity. In addition, the relationship between the BREEAM expert and the developer was crucial for sharing sustainability knowledge, including circularity, with investors. The BREEAM expert clearly explained what pursuing sustainability, thus circularity, entails and managed investors' expectations by detailing the necessary steps and implications. At the same time, the relationship between the architect and suppliers was key during the design phase. The architect consulted suppliers to discuss new ideas and assess their feasibility around circularity, as well as to check whether suppliers of existing services could take back those services. EO2 also highlighted the importance of the relationship with the structural engineer. For example, at Edge Olympic, it was crucial to add two additional floors in a dismountable way. The structural engineer contributed by advising on the possibilities for adding an extra story to the existing structure using wood and ensuring that the design remained dismountable.

In this phase, the developer held the greatest influence over final decisions, followed by the architect, the contractor, and the BREEAM expert. The architect's role was to propose circular design ideas, the BREEAM expert advised on specific circular materials, and the contractor evaluated technical feasibility. During this phase, multiple stakeholders with circularity expertise were involved. All parties emphasized the importance of a quantity surveyor with knowledge about circular practices. As EO3 noted '*At certain points, cost estimates are made, and we decide how to proceed. If it becomes more complicated than expected due to additional requirements, such as needing to make the structure demountable, having extensive knowledge really helps in making the right choices.*' Similarly, EO1 and EO2 stressed the necessity of a contractor with relevant expertise and experience around circularity. According to EO2, '*You need to involve the contractor early on, because they are the ones who have to deliver the products. You also have to check if something is feasible. They also have to be willing and able to work with the existing building.*'

Relationship	Explanation
Developer - architect	The developer and architect maintained a strong, dominant collaboration that shaped the project's circular outcomes.
Developer - Contractor	The contractor actively pursued circular ambition and was crucial in techical feasibility of the design.
Developer - dismantler	The dismantler's expertise was crucial in assessing the value of existing materials and components, ensuring that dismantling maximized reuse potential.
Developer - BREEAM expert	The BREEAM expert played a crucial role in conveying sustainability knowledge, including circularity, to the investor via the developer. This ensured better alignment on requirements and managed expectations regarding the implications.
Architect - suppliers	The architect engaged key suppliers early to explore and assess feasibility for circular ideas, and contribute technical expertise on available solutions.
Architect - structural engineer	The structural engineer provided essential expertise on adapting the existing building for reuse.

Table 7 Most relevant relations for circularity in the Edge Olympic's design phase (own work)

4.2.4 WHEN AND HOW: ACTIVITIES IN THE DEVELOPMENT PROCESS

The following section explains the activities in the early phases of the development process. The structure of activities per phase, as well as the explanation of how the tables were constructed, are described in detail in section 4.1.4.

4.2.4.1 Inception

All participants characterised the inception phase as influential for circular outcomes by setting the first ambition. Accordingly, EO3 stated that first, this ambition is established and in later phases, this ambition is refined and framed more precisely. This was indirectly the case at Edge Olympic. Although circularity was not yet a definition used at that time, it was implicitly embedded in the project's sustainability agenda and ambition to reuse.

Based on the interviews, multiple activities have been identified, illustrated in Table 8. Certain activities are inherent to every adaptive reuse project, such as assessing spatial feasibility, evaluating the technical condition, investigating legal requirements, analysing economic feasibility, and ultimately acquiring the building. These activities are also discussed by Hamida & Hassanain (2021). However, for this project specifically, all participants stressed the importance of defining a circular ambition. Notably, EO3 could not recall precisely when this ambition was set because the project was completed several years ago. Nonetheless, EO3 emphasized its significance, underscoring that it should be defined ideally in the inception phase. In contrast, EO1 and EO2 confirmed that although circularity was not yet a formal term during the inception phase, the principles underpinning it, such as reuse, were already part of the sustainability mindset. As EO2 explained, '*And then the sustainability ambition became even more prominent. Circularity emerged as a topic, and there was also a transition in how we managed these types of buildings, not only with circularity but also concerning the technical components.*'

The interviews revealed several success factors in collaboration. Both EO2 and EO3 highlighted the critical role of the developer in this project, whose intrinsic motivation and commitment to circularity were important. When faced with challenges, the developer did not opt for the easiest non-circular solution. Instead, they sought innovative alternatives and focused on solutions rather than obstacles. This proactive commitment was decisive in shaping the successful integration of circularity. Furthermore, all participants stressed the importance of defining a clear ambition in terms of documentation. EO3, for instance, emphasized the need to document this ambition by establishing clear guidelines and priorities. Contrastingly, EO2 highlighted that it is crucial to first take sufficient time to reflect on the existing building and adjust the design toward it. In addition, EO1 pointed out the significance of setting a concrete ambition, which is later in the development process refined into a comprehensive program of requirements. Thus, the combination of a motivated developer and well-defined, documented ambition is central in the inception phase to achieving integrated circular outcomes.

When	How	Status
Inception	Define a circular ambition	Implemented
	Assess spatial and functional feasibility for AR	Implemented
	Assess technical condition	Implemented
	Investigate legal requirements for AR	Implemented
	Assess the economic feasibility for the project	Implemented
	Acquire the building	Implemented

Table 8 Activities in the Edge Olympic's inception phase (own work)

4.2.4.2 Feasibility

During the interviews, participants emphasized the role of the feasibility phase in refining the circular ambition and conducting in-depth research for the circularity potential of the building. Interestingly, EO1 explained the iterative process related to the feasibility phase. As the feasibility phase involves continuous exploration and adjustments, as new insights are gained through detailed assessments. This iterative process continues into the design phase, where the feasibility of the circular strategies is further refined as more detailed information becomes available.

Some activities, mentioned by the participants, are typical in adaptive reuse projects. These activities mentioned are establishing a program of requirements and allocating financial reserves and risks. In addition, various additional activities important for circularity were mentioned by participants. First, all participants mentioned the importance of aligning the future user and/ or investor with circular goals by conducting expectation management. For example, EO1 explained this alignment by providing end users with an informational booklet outlining the building's circular applications at the delivery. In contrast, EO2 emphasized that end-users or investors must be aware of the quality associated with a circular building. This includes aesthetic and technical aspects such as acoustics. At the same time, EO3 pointed out that expectation management also involves clarifying the time and financial implications of pursuing a circular building. According to EO3 '*What I often notice is that people casually ask for a certain label without really understanding what they are asking for.*' Because of this, the participants recommended that this alignment must take place already when the ambition is said and when the end-users and/or investors are engaged. This also took place in Edge Olympic as the BREEAM expert explained what pursuing circularity entails and managed investors' expectations by detailing the necessary steps and implications.

Furthermore, EO1 and EO3 emphasized establishing clear boundaries of the circular ambition in the program of requirements. Additionally, the EO1 and EO3 mentioned the importance of establishing quantitative and measurable targets in the program of requirements, ensuring all actors are aware of the required performance of the building and its components. Furthermore, all participants noted conducting research on the existing quality of the building. Although this project did not include an external party to conduct this research, EO1 and EO3 did explicitly mention the recommendation to include a reclamation expert. As EO1 pointed out '*My recommendation for this phase would be to simply engage an architect and a reclamation expert to conduct a walkthrough of the building. They can identify which materials still hold value.*' Specifically, EO3 emphasized the importance of conducting research for the services. This is categorized as individual research by conducting destructive research.

Moreover, EO1 and EO2 advised exploring available reclaimed materials on the market, noting the role of the salvage dealer. EO1 highlighted that a salvage dealer is well-suited to explore the market opportunities for secondary materials. However, he cautioned that the same individual should not be tasked with assessing the quality of the existing building materials, as this would create a conflict of interest. Therefore, EO1 advised on a reclamation expert. Besides, this project included the experimentation of specific materials for their reuse potential. The participants recommended incorporating this activity early on, with the architect, contractor, and suppliers playing a facilitating role. EO1 suggested implementing this as early as possible, although it depends on whether the contractor is already involved.

Only EO1 mentioned the importance of establishing a procurement strategy. Other actors indirectly referred to this procurement by naming the importance of choosing experienced actors.

Finally, the success factor emerging from the interview with EO1 is the involvement of an independent reclamation expert. Even if this expert also serves as a salvage dealer, they should have no vested interest in the market value of materials. Instead, their focus should be on objectively assessing which materials are valuable and can be effectively reused from the project's perspective.

When	How	Status
Feasibility	Align future user and investor with circular goal and conduct expectation management	Partly implemented
	Establish clear boundaries, prioritization list and qualitative requirements for circularity in program of requirements	Implemented
	Establish quantative and measurable targets in program of requirements	Implemented
	Establish a program of requirements	Implemented
	Assess reuse potential of materials and components in detail	Partly implemented
	Conduct destructive research	Recommended
	Explore available reclaimed materials in the market	Recommended
	Experiment with materials	Implemented
	Establish an circular procurement strategy with circular selection and award criteria	Implemented
	Allocate financial reserves & risks	Implemented

Table 9 Activities in the Edge Olympic's feasibility phase (own work)

4.2.4.3 Design

The design phase is identified as crucial for defining the final implementations of circularity in the design. As EO3 stated, *'[In the design phase] certain numbers or specific interventions will be definitively included or excluded. The final decision is made in the DO-phase.'* This phase also served to align the final design decisions with the circular strategies set earlier in the process. It ensures that ambitions were not only maintained but also integrally translated into the final design.

While some activities in the design phase are specific to any adaptive reuse project, for instance, establishing a project team, proposing design alternatives, developing detailed design and specifications, and obtaining permits. Additional activities that are specific to circularity were identified, as illustrated in Table 10. First, EO1 and EO2 explained the importance of consulting suppliers to assess reuse opportunities and bring in additional knowledge for specific design details. EO1 explicitly underpinned this engagement as critical because suppliers can advise on how to put the design ideas into practice. Second, EO1 explains that for complex projects, the development of a technical program of requirements can be beneficial. As EO1 noted, '*Specify very clearly what the final deliverable should be, because then [the contractor] can include the right product in the technical specification*.' Building on that, both EO1 and EO2 emphasize the importance of including the contractor early in the design. EO1 highlighted that, especially in circular projects to include the contractor earlier is essential to verify the feasibility of the design. After that, the contractor can contribute their knowledge in writing the technical specifications of the design. It is noteworthy that EO1 explained that the procurement strategy for selecting a contractor is market dependent. When there is little work for contractors, then tendering is the most interesting procurement strategy. However, if there is enough work for contractors and the construction prices are high, then it is advised to organise a personal approach to engaging contractors. Lastly, EO1 advised including a dismantler for the demolition and recovery of materials. However, before dismantling the building, EO1 emphasized that you should ensure you have been properly advised. In this regard, a reclamation expert can independently contribute to assessing what potential remains in the building in an earlier stage.

Several success factors were mentioned by the participants. First, EO1 emphasized that circularity represents a new complex way of building that comes with risks. To address these challenges, EO1 argued that maintaining a flexible attitude and sharing risks is crucial for successfully incorporating new concepts into the design. EO2 further underpinned this by emphasizing the benefits of a pleasant, flexible, and accessible collaboration, which proved essential in navigating the challenges of circular design. Building on that, EO3 also stressed the importance of a flexible and accessible attitude to smooth the information flow around circularity. Furthermore, all participants highlighted the importance of a proactive and knowledgeable quantity surveyor who is closely connected to the market and continually aware of circular designs impacting budgets. Lastly, two perspectives emerged around collaboration between circularity-related actors. On the one hand, AO2 and AO3 stressed the importance of continuous collaboration for effective knowledge exchange. At the same time, EO1 cautions that too many meetings can lead to an overload of rules and details. Balancing these views is key to ensuring that collaboration remains both productive and efficient.

When	How	Status
Design	Establish a project team	Implemented
	Propose design alternatives	Implemented
	Consult suppliers in assessing reuse opportunities	Implemented
	Develop technical program of requirements	Recommended
	Develop detailed design	Implemented
	Include experienced contractor early for technical feasibility of design	Implemented
	Develop technical specification	Implemented
	Include salvage dealer and dismantler	Recommended

Table 10 Activities in the Edge Olympic's design phase (own work)

4.3 AIR Offices

4.3.1 CONTEXT

Air offices, formerly known as Beursgallery, is located in the city centre of Rotterdam. Originally built in the 1950s, the building functioned in the last year before transformation as a shopping mall of the V&D and Hudson's Bay. The building has been transformed into a multifunctional building with 10.000 m^2 of retail space and 25.000 m^2 of office space. The new building design adds two additional floor levels, including rooftop parking facilities. Furthermore, the new building concept emphasizes sustainability and energy performance. Therefore, the building has achieved a BREEAM Excellent certification and is the first Paris-proof office building in Rotterdam. In addition, it aims to obtain WELL Gold and WiredScore Gold certifications. These achievements underline the project's focus on environmental performance and well-being.

Size	**36.000 m^2**
Former function	Shopping center
New function	Multifunctional building (retail + offices)
Start inception	2019
Start design	2020
Start construction	2021
Delivery	2024

Photo 2 By WOMO Architects

4.3.2 WHAT & WHERE: CIRCULAR STRATEGIES

WHAT → / WHERE ↓	Narrow	Slow	Close	Regenerate
Skin		• Reuse and repair of old facade tiles • Reuse of facade tiles in building space plan	• Reuse of facade tiles elsewhere	
Structure		• Reuse of existing structure•	• Dismantled using circular principles	FSC wood used at construction site
Services			• Dismantled using circular principles	
Space plan		• Reuse of terrace tiles	• Dismantled using circular principles • Reuse of ceiling lamps elsewhere	• Wood used for handrails and cladding of the interiors
Stuff				

Figure 31 Circular strategies applied in AIR Offices, adopted from (Brand, 1994; Circle Economy & metabolic, 2022) (own work)

In the redevelopment of AIR Offices, circularity was not the main ambition embedded in the design process. Instead, the focus lay within the broader sustainability approach, for example, on energy performance and user well-being. As a result, circular strategies were not directly targeted but rather emerged as a by-product of other sustainable design choices. Nonetheless, several applications can be identified that align with the four circular strategies. However, no clear application fits under the narrowing strategy. There is little evidence of conscious efforts to reduce material input or avoid the use of new materials during the design phase.

The project implemented several measures that can be categorized under the slowing strategy. As is typical in adaptive reuse projects, the existing structure and parts of the facade were retained and reused. The new design required wider window openings in the facade, which caused a portion of the remaining facade tiles to become unused. These tiles were repurposed within the building's space plan level. Furthermore, the existing terrace tiles were reused in the new design.

Another portion of the removed facade tiles was sold and reused elsewhere, aligning with the closing strategy. Moreover, a specialized dismantler was engaged to structurally dismantle the building at the component and material level. However, it remains unclear whether all these components were eventually given a new function, and if so, where. The project also relocated 25,000 meters of former lighting fixtures, which were sold and reused elsewhere.

Besides that, the new building design focused on the use of healthy materials to meet the requirements of the BREEAM and WELL certifications. As a result, wood elements were incorporated into the design, both at the structure level and in the interior, stuff level.

4.3.2.1 Limitations to circular strategies

Although circularity was not an ambition set in the beginning, the project attempted to include circularity where possible. However, several limitations hindered the implementation of circular strategies. These limitations are based on the interviews with the participants and are grouped into different overarching categories, as illustrated in Table 11. The following section further explains each limitation.

First, several technical and performance limitations were identified. Reusing materials and components was often constrained by outdated warranties. For instance, a significant issue was the inability to reuse roof tiles due to a lack of assurance from the contractor, as mentioned by AO1. Similarly, the quality of specific materials caused another limitation, such as reusing services. As AO1 explained '*We looked into reusing the sprinkler system, but in the end, it wasn't possible. So, we did consider it, but it turned out not to be feasible because it was too old.'* Additionally, the option to construct the floor extension in timber was not feasible due to structural constraints, as advised by the structural engineer. Consequently, timber could not meet the large spans and high weight requirements.

Second, the project faced financial and development process limitations. Although circular strategies such as reusing interior elements were considered, financial constraints ultimately limited their application, as stated by AO1. More importantly, many participants indicated that time pressure and tight scheduling often deprioritized circularity. When project phases required fast completion, the integration of reused materials became a risk for overall process continuity and was therefore avoided.

Third, organizational limitations also played a role in constraining circular opportunities. One key factor mentioned by all participants was the lack of a clearly defined circular ambition at the start of the project. As a result, stakeholders did not explicitly focus on achieving circular outcomes. EO2 stated that if circularity had been established as a goal from the outset, more opportunities might have been explored. As EO2 reflects 'if *agents were asked 'can you provide circularity examples around your disciplines?', they might have had it, but they weren't asked because that wasn't a driver.'* As a result, few opportunities were identified and implemented across the different disciplines.

In conclusion, these limitations underline the importance of the early establishment of a circular ambition in the project. Furthermore, to maximize circularity in the design, incorporating sufficient time buffers and financial reserves is essential. In addition to the technical and performance limitations, these specific cases illustrate that certain limitations may inherently constrain the application of circular strategies. Factors such as outdated warranties, material degradation, and structural requirements set clear boundaries for what is technically feasible.

Category	Specific limitation	Explanation
Technical and performance limitations	Outdated guarantee concerns for reused materials	Ensuring functionality and warranty of reused materials was a challenge
	Quality constraints for using second hand intierior and reusing services	Although the project intended to use second-hand interior elements and aimed to reuse installation, quality constraints ultimately limited their application
	Biobased rooftop extension technically unfeasible due to structural constraints	The use of timber was not compatible with existing structural span, column grid, and rooftop parking load requirements
Financial and development process limitations	Financial constraints for using second hand intierior	Although the project intended to use second-hand interior elements, financial constraints ultimately limited their application
	Time pressure and tight project scheduling limiting circular options	Circular strategies were deprioritized when they risked delaying the overall project flow or clashing with tight construction schedules
Organizational limitations	Lack of early commitment due to absence of a clearly defined circular goal	Because circularity was not defined as an explicit ambition from the start, stakeholders did not focus on achieving circular outcomes throughout the project.

Table 11 Limitations to implement circular strategies in Air Offices (own work)

4.3.3 WHEN & WHO: COLLABORATION IN THE DEVELOPMENT PROCESS

This section provides an overview of how collaboration was structured during each early phase of the development process. Section 4.1.3 elaborates in more detail how the figures are developed.

4.3.3.1 Inception

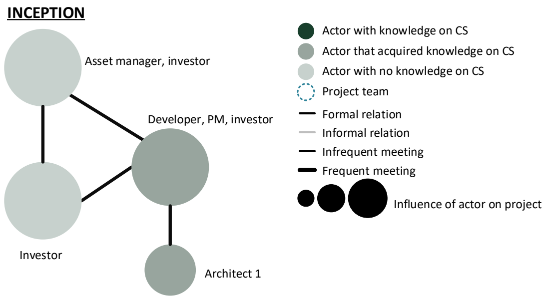


Figure 32 Multi-actor network analysis in the AIR Offices' inception phase, adopted from (Gerding et al., 2021) (own work)

Figure 32 represents the multi-actor network analysis of the inception phase for AIR offices. In the inception phase, no circular ambition had been defined. Instead, the goal was to maintain the existing building and reuse as many elements as possible. To support this aim, three different actors formed a joint venture to combine knowledge, expertise, and capacities. The most central node represents the developer, who drives the project and coordinates with both the financiers and the future development team. While the developer holds a central role in decision-making, the financiers and co-owners were equally influential during this phase, as they jointly decided whether to acquire the building. All relationships in this phase were formal and involved frequent interaction, meaning they were in contact weekly. No actors with specific expertise in circularity were involved at this stage. However, the developer did engage an architect with experience in redevelopment projects. While this expertise supported the project's reuse ambition, AO1 indicated that the architect did not possess a deeper level of expertise in circularity.

4.3.3.2 Feasibility

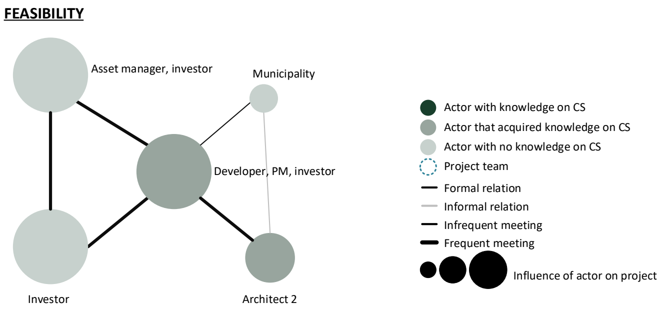


Figure 33 Multi-actor network analysis in the AIR Offices' feasibility phase, adopted from (Gerding et al., 2021) (own work)

During the feasibility phase, the potential of the building is further defined. However, AO1 explained that in their process, they distinguish between an acquisition phase and a development phase. The acquisition phase includes the initiative and focuses on assessing the building's overall potential, including spatial possibilities, functional reuse, and economic feasibility. This assessment forms the basis for whether the building is ultimately acquired. The development phase follows after the building has been purchased. In contrast, AO2 noted that the feasibility phase is a distinct but flexible phase, which can range from a few weeks to several years depending on project-specific conditions. While it may sometimes be short and merge into the design phase, it can also serve as a critical stage for early decision-making, particularly in relation to negotiations with external stakeholders such as the municipality. The focus in this phase lies on refining the intended outcomes and assessing the reuse potential of the building. On top of that, AO3 emphasizes the iterative nature of the feasibility phase. AO3 describes it as the stage where initial ideas and conditions are assessed, suggesting that feasibility is not a static stage, but one that continues to evolve and influence the design phase iteratively.

Figure 33 illustrates the organizational structure of the feasibility phase. In this phase, the developer occupied a central position in coordinating with all active actors. This centrality reflects their strong influence. Nevertheless, this influence is equally balanced by investors and co-owners, who jointly carried financial responsibility and were equally involved in decision-making. Most relationships during this phase were formal and involved weekly interaction with the internal actors. There were infrequent relationships with external actors. Simultaneously, no actors with explicit expertise in circularity were engaged during this phase.

4.3.3.3 Design

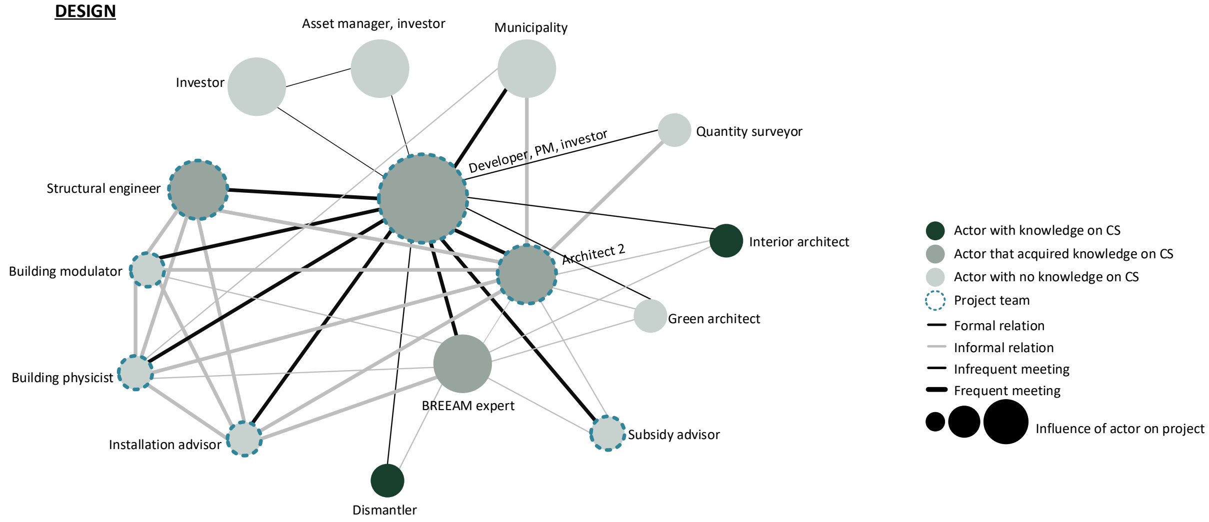


Figure 34 Multi-actor network analysis in the AIR Offices' design phase, adopted from (Gerding et al., 2021) (own work)

During the design phase, the final design was further developed. To support this process, several actors were involved to broaden the project's expertise. Figure 34 illustrates how collaboration was organized during this phase. A project team was established, which held regular meetings. The team included the developer, architect, subsidy advisor, installation advisor, structural engineer, and building physicist. After finalizing the design, a building modulator joined the team to assist with the technical drawings. Furthermore, this phase involved only limited circularity-related actors. Besides a dismantler and an interior architect, no specific actors with in-depth circular knowledge were engaged. However, it is noteworthy that all interview participants emphasized that circularity was not set as a primary ambition in this project. Instead, the focus lay on other aspects of sustainability, such as creating a Paris-proof and healthy building, with the aim of achieving BREEAM and WELL certifications. As AO2 reflected: *"Arguably, the knowledge [of circularity] could have been there, but we were never asked the question [about circularity]."*

The project team members met regularly throughout the process. However, no specific expertise on circular strategies was embedded within the core team. It remains unclear whether this absence of internal circular knowledge influenced the final level of circularity achieved in the project. Additionally, actors with relevant expertise operated outside the project team and had limited influence on key decisions. The extent to which this positioning affected the project's circular outcomes cannot be definitively determined.

Within the network, the developer remained the central actor with the highest number of connections. This central position confirms the developer's key role in engaging and coordinating with all actors involved. As such, the developer was well-positioned to act as the project's transformation agent. While this role was fulfilled to some extent, the emphasis on circularity varied throughout the process and was not always the highest priority. Nonetheless, the developer played a crucial role in aligning the team with the broader sustainability ambitions.

The following section focuses on the key relationships through which circular knowledge and practices were introduced into the project. These relationships are based on participants' responses and highlight how specific actors contributed to enabling circular strategies in design and execution. The relationships are summarized in Table 12. First, the relationship between the developer and the interior architect was important for integrating circularity at the interior level. The interior architect proposed second-hand interior design. However, it is noteworthy that some circular offers from the interior architect were too expensive and were not integrated. Second, the relationship between the developer and the dismantler enabled circular practices related to material recovery. Their expertise in selective dismantling contributed to salvaging materials from the existing structure, skin, and space plan. This created opportunities for reuse and reduced material loss during demolition activities. Finally, the relationship between the architect and the structural engineer played a critical role in exploring circular structural possibilities. The structural engineer provided technical knowledge on using circular concrete. In addition, they advised on the structural feasibility of timber as a material for the rooftop extension.

In the design phase, the developer had the highest influence on decisions related to circularity. Multiple participants emphasized their role in final decision-making within the project team. While the developer was able to make most of the key decisions, important outcomes were still shared with the end investors along the way. In addition, the architect, BREEAM expert, structural engineer, financiers, and the municipality also held influence over circular outcomes. Among these actors, multiple participants indicated that the architect, alongside the developer, had the most significant influence on circularity within the project team.

During the interviews, it became evident that selecting the right actors is crucial when aiming for circularity within the broader sustainability agenda. As AO1 stated, *'[If circularity was a main ambition], then you should organize the project team differently … I would simply involve more parties with greater knowledge on the topic.'* In line with this, all participants specifically emphasized the importance of involving a quantity surveyor with expertise in circular practices. This role is essential, as a quantity surveyor not only monitors costs, but also helps evaluate the financial viability of circular strategies. This ensures that circular ambitions are translated into an achievable design.

Relationship	Explanation
Developer - interior architect	The interior architect contributed circular knowledge related to interior design and proposed the use of circular furniture.
Developer - dismantler	The dismantler was a relatively new circular demolition company with strong practical skills in selective dismantling. Their contribution was important in enabling material recovery.
Architect - Structural engineer	The structural engineer provided valuable expertise on the use of circular and reused concrete and played a key role in assessing structural adaptations for a two-floor extension. In addition, they played a role in assessing the potential of wood as a material option for the rooftop extension by evaluating its structural feasibility.

Table 12 Most relevant relations for circularity in the AIR Offices' design phase (own work)

4.3.4 WHEN AND HOW: ACTIVITIES IN THE DEVELOPMENT PROCESS

This section outlines the key activities that took place during the early development phases. The applied method and explanation of the table design are based on the approach discussed in section 4.1.4.

4.3.4.1 Inception

According to the participants, the inception phase plays a crucial role in shaping circular outcomes, though their perspectives differed slightly. AO1 emphasized that this phase primarily serves to assess the investment potential of the project, determining whether the building will be acquired. In that context, AO1 referred to it as the acquisition phase. At the same time, AO1 stressed that if circularity is to be pursued, the ambition must be clearly established from the very beginning. As they stated: *'You really need to set the goal of building as circular as possible from day one. But then it has to be a goal in itself.'* This indicates that AO1 viewed the inception phase as twofold, thus as a financial decision-making stage, and as the moment to set the circular ambition. Similarly, both AO2 and AO3 highlighted the importance of using the inception phase to express the project's ambition for circularity. AO2 emphasized that setting circularity as a goal from the outset enables stronger outcomes later in the process. Building on that, AO3 stated: *'The initiative is essentially about stating the ambition.'*

From the interviews with the participants, a list of activities either implemented or recommended has been developed, illustrated in Table 13. Certain activities, such as assessing spatial and functional feasibility, assessing technical conditions, investigating legal requirements, assessing economic feasibility, and acquiring the building, are standard activities in any adaptive reuse project and do not specifically relate to circularity. However, as explained before, all participants mentioned the importance of defining the circular ambition initially.

AO2 and AO3 specifically emphasized the client's critical role as a success factor in shaping circular outcomes. AO2 explained that the client should set the ambition and have the commitment to achieving circular outcomes. As explained by AO2, '*I do feel like having an in-house strategy for circularity from [developer] would have set the tone. So, a developer really sets the tone on priorities. They could say, 'there's a crisis on this project on budget' or … 'we have a crisis around reuse and circularity.'* In addition, AO3 highlighted the importance of translating this ambition into concrete terms by integrating it into the financial feasibility assessment. This ensures that circular goals are treated as fundamental project requirements rather than optional sustainability features, allowing for early alignment of costs with the circular vision.

When	How	Status
Inception	Define a circular ambition	Recommended
	Assess spatial and functional feasibility for AR	Implemented
	Assess technical condition	Implemented
	Investigate legal requirements for AR	Implemented
	Assess the economic feasibility for the project	Implemented
	Acquire the building	Implemented

Table 13 Activities in the AIR Offices' inception phase (own work)

4.3.4.2 Feasibility

The feasibility phase, discussed by participants, plays a critical role in refining the intended outcomes, assessing the reuse potential of materials and components, and in defining the financial conditions under which circular ambitions can be realized. Although AO1 did not explicitly refer to a separate feasibility phase, AO1 stressed that after the acquisition, additional research into reuse potential is essential for projects with circular ambitions. Moreover, AO1 highlighted that financial feasibility should be considered early on when refining these ambitions. As explained, *'If circularity had been essential for selling the building after redevelopment, we would have calculated the potential increase in construction costs and adjusted the expected revenues accordingly.'* This illustrates that early integration of circular goals into financial evaluations can significantly shape design and investment decisions. AO2, by contrast, emphasized the feasibility phase as a distinct and influential stage for early decision-making. AO2 noted that this phase is often used to negotiate with stakeholders such as the municipality.

This phase includes core activities that are typical for adaptive reuse projects, such as establishing a program of requirements. Various additional activities were identified based on the interviews. First, AO2 mentioned the importance of aligning investors with circular goals. Building on that, AO2 and AO1 emphasized that circular construction should not only be a sustainability ambition, but also an attractive investment. Therefore, AO2 noted that the circular ambition should be translated into demonstrable asset value, similar to established certifications such as BREEAM. Simultaneously, AO2 emphasized the importance of establishing clear boundaries and both qualitative and quantitative requirements in the program of requirements. As explained by AO2 '*So if you say you want to have circularity in the building, you have to set the parameters of what that circularity is.'* However, this should not turn into a checklist exercise. Instead, the focus should be on whether the best decisions have truly been made for long-term reuse.

Furthermore, all participants explained assessing the reuse potential of materials and components in further detail, where expertise and knowledge around circularity are crucial. AO3 added that materials available on the market should also be reviewed and considered, which has been executed in AIR Offices. While ambitions may be high, the feasibility often depends on what the market can deliver at that moment, as explained by AO3. Moreover, both AO1 and AO2 explained that delivery partners should be selected based on their experience and expertise when circularity is an ambition. As AO2 stated, '*When circularity is a very high ambition in the project. It would start at the client side of course. And then I think strategizing with who the delivery partners are for circularity.*' Lastly, AO1 advised on allocating financial reserves for circularity.

One important success factor derived from the interview with AO2, namely the importance of the on-time engagement of circularity-related actors and their knowledge. As AO2 explained, involving delivery experts too late risks missing the opportunity to steer early design decisions towards circular outcomes. Without early expertise input, circularity risks being written out of the process as it is not such a common component yet.

When	How	Status
Feasibility	Align future user and investor with circular goal and conduct expectation management	Recommended
	Establish clear boundaries, prioritization list and qualitative requirements for circularity in program of requirements	Recommended
	Establish quantative and measurable targets in program of requirements	Recommended
	Establish a program of requirements	Implemented
	Assess reuse potential of materials and components in detail	Implemented
	Explore available reclaimed materials in the market	Implemented
	Establish an circular procurement strategy with circular selection and award criteria	Recommended
	Allocate financial reserves & risks	Recommended

Table 14 Activities in the AIR Offices' feasibility phase (own work)

4.3.4.3 Design

The design phase is identified as the most influential phase on how successful the level of integration of circularity is, as most final decisions are made, whether a CS is integrated or not. AO2 also explained that the design phase is important to align the final design with the possible CS. During the interviews, various activities were discussed, which are specific to each adaptive reuse project. For instance, establishing a project team, proposing design alternatives, developing detailed design and specifications, and obtaining permits. In contrast, numerous activities were discussed that are specific to circular adaptive reuse projects, either implemented in this case or recommended for future projects. Table 15 illustrates the activities for the design phase.

First, many participants highlighted the importance of offering circular material alternatives during the design phase, in which the architect plays a role. All participants explicitly described the architect as best to provide creativity for how to reuse materials. AO1 further emphasized this by pointing to the architect's strong influence on circular outcomes. Building on this, AO3 stressed the need for architects to possess sufficient circular knowledge. Therefore, this enables them to translate circular ambitions into realistic and creative design solutions.

In addition, several participants mentioned that when knowledge gaps exist, suppliers can be consulted to explore reuse opportunities for specific components. AO2 explained that if circularity is set as a goal, identifying salvaged materials, either from the market or from other development projects, becomes crucial. Architects can take responsibility for this, but circularity-related actors may also be involved.

Moreover, all participants underlined the importance of involving an experienced contractor early in the process to verify the technical feasibility of the design. As AO3 noted, *'Sometimes architects design things that are difficult or expensive to construct, or that can only be built using one specific material. If you're aiming to create a circular building, you obviously don't want to limit the design from the start. So, in that case, the input of a contractor becomes very important.'* This highlights the role of the contractor in checking the buildability and technical feasibility of the proposed design. Simultaneously, AO1 stressed the importance of working with reliable contractors. Engaging experimental or inexperienced parties can pose a significant risk. As AO1 explained, such partners need to have enough organizational strength to correct mistakes when things do not go as planned.

In addition, participants stressed the importance of involving a dismantler, either subcontracted through the contractor or as a co-contractor. All participants referred to the dismantler's role in facilitating the reuse of existing materials. AO2 specifically noted the importance of validating the reuse potential of identified materials with a dismantler to assess whether there is actual market demand. Lastly, in collaboration with a dismantler or an experienced demolition contractor, a demolition specification should be drawn up.

Specific success factors related to the design phase were identified based on the interviews. First, all participants emphasized the importance of involving an experienced quantity surveyor. This actor should not only assess the financial feasibility of circular choices, but also have knowledge based on reference values or experience. AO2 added that, in the future, cost consultants may also need to account for environmental impacts such as the carbon footprint. As AO2 explained, '*The world is going to change because a cost consultant is going to become an expert not just on quantities as they relate to like euro value. But they're going to become an expert on quantities as they relate to the carbon footprint of a project.*' This suggests a broader role for quantity surveyors in circular projects.

In this project, the developer executed all subcontracting themselves due to specific circumstances. Still, all participants stressed the importance of engaging a contractor early in the process. Doing so enables verification of technical feasibility and helps avoid design choices that are difficult or expensive to realize. As AO2 noted, '*I think it's really when you want to realize complex things, having specialist experts [contractor] come in earlier, it's only going to improve its viability or realizability.*'

Besides that, AO2 highlighted the value of engaging additional circularity-related actors. However, AO2 also cautioned against relying on temporary specialists alone, stating, '*I would like that not to be a specialist person in the long run because they will be the first person cut from the team.*' Therefore, building long-term internal knowledge within the core team is essential for safeguarding circular ambitions when circularity is more mainstream in the built environment.

When	How	Status
Design	Establish a project team	Implemented
	Propose design alternatives	Implemented
	Offer circular material alternatives	Recommended
	Consult suppliers or experts in assessing reuse opportunities	Implemented
	Identify available salvaged materials on the market	Recommended
	Develop detailed design	Implemented
	Include experienced contractor early for technical feasibility of design	Recommended
	Develop technical specification	Implemented
	Include dismantler	Implemented
	Evaluate identified reuse potential	Recommended
	Develop a demolition specification	Implemented
	Obtain municipal permits	Implemented

Table 15 Activities in the AIR Offices' design phase (own work)

4.4 Cross-case analysis

The following section presents a cross-case analysis that systematically compares the individual case findings to identify differences and similarities. The analysis is divided into three parts, aligned with the structure used in the individual case analysis. This approach enables an understanding of how early project phases are organized and influence the integration of circular strategies in adaptive reuse projects.

4.4.1 WHAT AND WHERE: CIRCULAR STRATEGIES

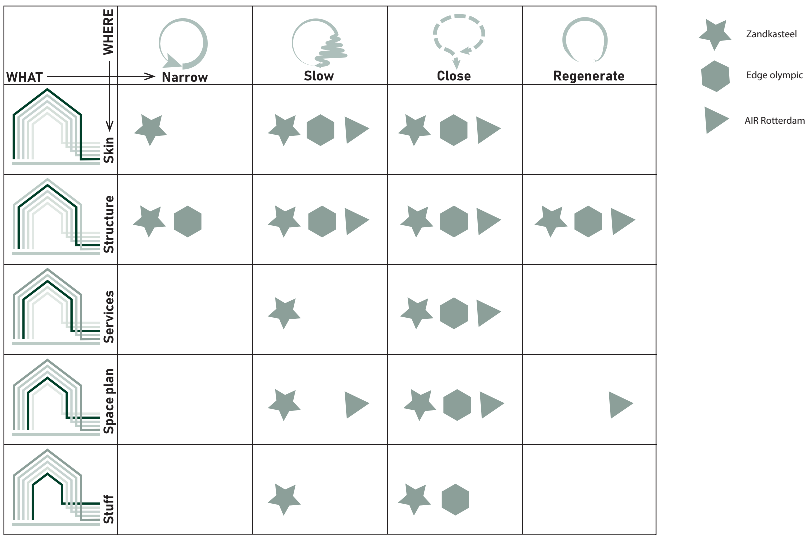


Figure 35 Cross-case analysis of circular strategies, adopted from (Brand, 1994; Circle Economy & metabolic, 2022) (own work)

Figure 35 provides a comparative overview of each circular strategy adopted in the cases, illustrating at which building layer these strategies were applied. First, across the cases, the narrow strategy is applied differently. In the Zandkasteel, the building's monumental status led to a deliberate retention of the façade and the floor plan's structure to preserve heritage values. Similarly, Edge Olympic preserved its existing structure deliberately, guided by municipal requirements. In both cases, strong external incentives prompted internal actors to integrate the narrow strategy. In contrast, AIR Offices displayed a less explicit commitment to the narrow strategy. This difference compared to Edge and Zandkasteel can likely be explained because the design focus centered on a broader sustainability agenda, deprioritizing circularity.

The slow strategy emerged in all the cases, although notable differences are observed. In every project, reuse at the structural and skin levels was evident. The reuse of the structure is common to adaptive reuse, as it concerns the part of the building that can only be changed through complete demolition, according to Remøy (2010). In addition, only Zandkasteel achieved a comprehensive approach by reusing a high proportion of services, facilitated by the engagement of an installation expert with specialized circularity expertise. At the space plan level, both Zandkasteel and AIR Offices implemented the slow strategy. Notably, Zandkasteel demonstrated a higher degree of material reuse, attributed to the commissioning of a reclamation expert for detailed quality assessments of existing materials. In contrast, AIR Offices' reuse was primarily limited to terrace tiles. Furthermore, the Zandkasteel was unique in repurposing existing interiors. This was achieved by utilizing well-preserved furnishings from the previous occupant that met the new functional requirements. In contrast, both AIR Offices and Edge Olympic were delivered empty, which prevented any reuse at the stuff building layer. The similarities of reuse of the skin and structure in all cases may be attributed to the long-lived nature of the layers. This recurring reuse of the skin layer may suggest that skin-level reuse is a common feature in circular adaptive reuse, although the limited number of cases means this cannot be definitively concluded. The differences between the reuse of services may be connected to the fact that only the Zandkasteel had established the slow strategy for the services in the project. In addition, the difference between reuse at the space plan level can be connected to the extent of assessment, determining the level of reuse of the materials.

For the close strategy, all projects applied it across various building layers. In each case, a dismantler was engaged to facilitate the circular demolition of the building and its components at the skin, structure, services, and space plan levels. The dismantler also performed a role similar to that of a salvage dealer, as they were responsible for repurposing reclaimed materials elsewhere, contributing to the close strategy. Furthermore, Edge Olympic enhanced the close strategy by creating a comprehensive materials passport for the entire building, thereby enabling materials to be more easily reallocated at the end of their lifecycle. Zandkasteel and AIR Offices further applied the close strategy by directly repurposing and selling components of the building, in both cases at the space plan layer. Additionally, Edge Olympic adopted a leasing model at the stuff level, enabling circularity. At the same time, Zandkasteel achieved circularity at the interior level by using second-hand furniture sourced from another school. Although AIR Offices initially planned to incorporate second-hand furnishings, as advised by an interior expert, the higher associated costs made this option unfeasible. These applications of the close strategy show a clear engagement with material circularity across the studied cases. However, the integration of externally sourced secondary materials remained limited. This may be attributed to the immaturity of the secondary materials market and uncertainties about the quality and availability of such materials, as noted by Van Oorschot et al. (2023) and Van Uden et al. (2024).

Lastly, the regenerate circular strategy received limited emphasis across the projects. Only Edge Olympic applied biobased materials as a primary strategy in areas that required new construction. This was integrated into the two new floors and the extension next to the building, both of which were constructed using wooden structures. In contrast, Zandkasteel and AIR Offices showed minimal integration of regenerative solutions into the design. At Zandkasteel, the use of biobased materials was not a design priority, as the project focused more heavily on other circular strategies. AIR Offices incorporated wood in certain design elements, but to a significantly lesser extent than Edge Olympic. This choice was not driven by circularity ambitions but rather by health-related design goals, as wood aligned with material guidelines for achieving WELL and BREEAM certifications.

Overall, the application of circular strategies proves highly project-dependent, shaped by contextual factors, established circular ambitions, and actor involvement. The narrow strategy was influenced by external drivers, while central actors played a key role in defining this strategy. The reuse of structural and skin elements was evident in all cases as part of the slow strategy. The reuse of structure reflects a common practice in adaptive reuse projects (Remøy, 2010). Further, the application of the slow strategy at the other layers varied in depth, depending on actor expertise and the extent of material assessments. Additionally, all projects implemented the close strategy across structural, skin, services, and space plan levels, largely enabled by circular dismantling practices. Finally, the regenerate strategy remained the least applied. Its integration depended on whether new additions were required and whether biobased materials aligned with project ambitions.

4.4.1.1 Limitations to circular strategies

Figure 36 represents the overview of the cross-case analysis of the limitations that occurred in the cases. Across all projects, financial and development process constraints were the most frequently observed. These often involved high costs related to the feasibility of reuse and strict timelines that excluded time-intensive activities, which could have supported circular outcomes.

Meanwhile, technical and performance limitations emerged specifically in Edge Olympic and AIR Offices, primarily because of outdated systems that prevented service reuse. Interestingly, Zandkasteel did succeed in reusing its services. This difference may be explained because the services remained in relatively good condition.

At AIR Offices, an additional technical constraint arose when assessing a timber rooftop extension possibility, which proved unworkable due to excessive spans and the weight of a parking garage. In contrast, Edge Olympic realized this wooden extension more easily, possibly because it lacked the additional weight of the rooftop parking.

Only Zandkasteel experienced assessment and knowledge gaps, partly due to the building's occupancy and limited access to complete documentation. This situation did not arise in the other projects, where the buildings were fully accessible during the design phase. Furthermore, Zandkasteel initially faced knowledge limitations regarding service reuse. The project faces this limitation due to the limited destructive assessment of the services, which was seen as crucial by all the participants if the reuse of services is an established ambition. Whereas in the other cases, this limitation was not faced. This difference may be attributed to the fact that the cases did not include the ambition to reuse the services.

Lastly, organizational limitations occurred in AIR Offices, reflecting the absence of a clearly defined circular ambition from the outset. The other cases did not face this limitation, as both cases defined a specific circular ambition.

In short, financial and development process limitations were consistent across the cases. Contrastingly, technical, organizational, and knowledge limitations depended on project-specific conditions.

Limitations	Zankasteel	Edge Olympic	AIR Offices
Technical and performance limitations		X	X
Assessment and knowledge gaps	X		
Financial and development process limitations	X	X	X
Organizational limitations			X

Figure 36 Cross-case analysis of the limitations occurred in the cases (own work)

4.4.2 WHEN & WHO: COLLABORATION IN THE DEVELOPMENT PROCESS

4.4.2.1 Inception

Several patterns emerge across the three cases concerning actor involvement, influence, relationships, and the level of circular expertise. In each project, the developer, or in the case of the Zandkasteel, the actor with a comparable developer role, occupies a central position in the network, characterized by the highest number of connections. This central position indicates frequent communication based on Gerding et al. (2021). Section 3.6.5 defines a transformation agent as an actor who oversees the circular building process and leads stakeholders to align with its circular goals. Because developers occupy this central network position, they are ideally placed to act as transformation agents, convening actors and steering the adoption of circular strategies from the very start of a project. However, the degree to which developers actually performed this role differed between cases. In Edge Olympic, the developer acted as the transformation agent immediately. Although the establishment of circular objectives came later, circularity was an indirect concept of the sustainability agenda. By contrast, in the Zandkasteel project, this role only emerged later, once the circular ambition was adopted during the design phase. In Air Offices, developers rarely enacted this role, reflecting the absence of a clear circular ambition early in the process.

Although the developer has decision-making power in all cases, variations exist. In both the Zandkasteel and Edge Olympic projects, the developer holds the final decision-making power. By contrast, in AIR Offices, decision-making is distributed more evenly among investors and co-owners as part of a joint venture. This difference largely reflects the nature of the financial arrangement. In AIR Offices, multiple actors jointly invest in the project, giving each an equal stake in determining whether the building meets the financial requirements for adaptive reuse. Whereas in Zandkasteel and Edge Olympic, only a single investor, the developer or a comparable role, bears financial responsibility.

The relationships in the inception phase across the three projects were all formal, however, they varied in frequency. In Edge Olympic, only external stakeholders were involved, and these interactions occurred infrequently. Similarly, Zandkasteel featured two external relationships alongside one internal relationship, all of which were also marked by low frequency. By contrast, in AIR Offices, all relationships were internal and characterized by frequent interactions. This contrast likely reflects the different dynamics of external and internal actors. External parties, such as municipal departments, tend to be consulted only at some points, while internal actors must meet regularly to maintain alignment. Only one exception, in the Zandkasteel, one internal link with a future user occurred infrequently. This might be because the user's participation in the project was uncertain.

Lastly, across all three cases, expertise around circularity remained limited. The focus was largely on assessing the opportunities for adaptive reuse and circularity within financial constraints. The collaborative process during the inception phase was exploratory in nature, aimed at mapping the project's potential and identifying key constraints. Rather than seeking concrete circular outcomes, collaboration helped establish a shared understanding of the building's condition and development context. This open-ended approach allowed flexibility in later phases for integrating circular strategies, as seen in both Edge Olympic and Zandkasteel.

In conclusion, collaboration during the inception phase can be characterised as exploratory. It aims to understand the project's potential and create conditions for the future integration of circular strategies. Figure 37 provides a conceptual overview of how the inception phase can be organized based on the cross-case analysis. It is important to note that not all actors depicted in the diagram are necessarily active during the inception phase in every project. Rather, the figure highlights the most important outcomes of the analysis, including influence and relationships. The inception phase is shaped by a developer who occupies a central position in the network, demonstrating the potential to serve as a transformation agent in integrating circular strategies. Relationships with external actors tend to be formal and infrequent. In contrast, internal relationships are often more frequent and formal relations. Notably, in projects with multiple investors, shared financial responsibilities can translate into an equal level of influence on decisions. Finally, specialized circular knowledge is not yet critical at this stage. The phase focus focuses on establishing whether the building meets financial and structural requirements for adaptive reuse. As such, collaboration in this phase is exploratory, aiming to understand project potential and create conditions for future integration of circular strategies.

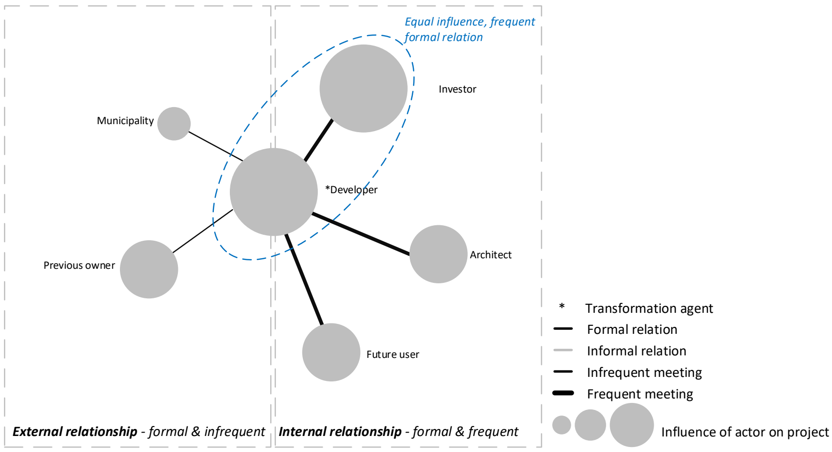


Figure 37 Cross-case analysis of inception phase, adopted from (Gerding et al., 2021) (own work)

4.4.2.2 Feasibility

The feasibility phase of the three cases reveals several common patterns and key differences with respect to actor involvement, influence, relationships, and the integration of circularity expertise. First, across all three cases, the developer plays a central role in coordinating the feasibility phase, reflected in the high number of relationships and the influence they hold. This centrality is visible in all cases, highlighting the developer's ideal position to act as a transformation agent in the process. Only in Edge Olympic, the developer acted as the transformation agent by actively integrating circularity into the design by aligning actors with the objectives. Conversely, in Zandkasteel and AIR Offices, the developer had not yet acted as a transformation agent.

Furthermore, influence on decision-making varies. In Zandkasteel and Edge Olympic, the developer holds the exclusive decision-making power. In contrast, in AIR Offices, this influence on decision-making is shared with the co-owners and investors. While an investor is also present in Edge Olympic, EO1 was not directly communicating with the investor. As a result, the actual level of influence of the investor may not be fully reflected in the analysis. This difference may suggest that, on the one hand, the extent to which decisions are shared correlates with the investor's level of involvement. On the other hand, it may be that decision-making is more equally distributed in general. Because in Edge Olympic, the investor's influence may be underrepresented, as EO1 had no direct contact with them. This could overstate the developer's exclusive role. This equal decision-making could be plausible, since the feasibility phase requires financial boundaries and alignment with circular ambitions.

The relationships during the feasibility phase varied across the cases. In all projects, relationships with external parties, such as the municipality, were infrequent and formal. This may be explained by the fact that, at this stage, no permits are yet being requested, and external stakeholders are typically not yet actively involved. However, contact with the municipality remains important for ensuring the project stays within regulatory frameworks and for alignment with zoning or planning requirements.

In contrast, the frequency of internal relationships varied significantly. In cases with an investor, such as Air Offices and Edge Olympic, the contact was frequent, reflecting the need to align financial boundaries and the project's ambitions. Furthermore, in Zandkasteel, the end user was actively involved, with frequent interaction with the developer to establish the program of requirements. Additionally, in Air Offices, an architect with experience in adaptive reuse was involved alongside the investor, with whom a frequent relationship existed with the developer. In Edge Olympic, three internal actors from the design team were engaged, with frequent interactions between the developer with the architect, and with the quantity surveyor. The developer's relationship with the architect and quantity surveyor was more frequent than with the structural engineer. This may suggest that the initial focus was on financial feasibility and design possibilities, rather than on structural concerns.

Regarding the level of expertise in circularity, there are differences between the cases. Edge Olympic includes one actor with specific expertise in circularity. In Zandkasteel and Air Offices, there were no actors with expertise in circularity in this phase. This may be explained by the fact that in both cases, the ambition for circularity was defined in the next phase, the design phase. However, it is noteworthy that many participants explained the importance of the feasibility phase for conducting circularity-related activities, in which specific circular knowledge is important. Therefore, all cases emphasized the importance of engaging a reclamation expert to assess the reuse potential of the existing elements and include a salvage dealer to explore available secondary materials at the market. This is further explained in 4.4.3.

Across all three cases, collaboration in the feasibility phase served to clarify or was advised to clarify priorities among stakeholders. This occurred through co-definition of the program of requirements, exchange of technical and market knowledge, and the gradual commitment to shared project outcomes. In Zandkasteel, frequent interaction between the developer and end user led to adjustments in functional needs, aligning them with the existing layout to enable reuse. In both Zandkasteel and Edge Olympic, collaboration involved exploring reuse opportunities based on technical assessments and available secondary materials. In Air Offices, the focus was on refining the intended outcomes and assessing the building's reuse potential based on technical knowledge. Notably, in Edge Olympic, the developer adopted an active stance to align all key actors with the project's circular objectives.

In conclusion, collaboration in the feasibility phase focuses on clarifying priorities, with actors co-defining requirements, exchanging technical and market knowledge, and committing to shared circular project outcomes. Figure 38 offers a conceptual overview for organizing the feasibility phase based on the cross-case analysis. It should be noted that not all actors shown in the diagram are always involved. Instead, the figure emphasizes the key findings of the analysis, particularly focusing on influence and relationships, primarily from the developer's perspective. The feasibility phase is shaped by the developer, who occupies a central position in the network, having the ideal position to act as a transformation agent. In projects with investors, their level of influence on decision-making may be different based on their level of involvement. It may be that when an investor is involved, frequent communication continues during the feasibility phase to align on financial boundaries. Furthermore, external relationships, for instance with the municipality, tend to be formal and infrequent, possibly as no permits are requested at this stage. Internal relationships vary depending on the project's context. If an end-user is at the table, frequent contacts occur to collaboratively develop the program of requirements. Finally, the involvement of other actors in the design team varies between projects, with communication intensity influenced by context-specific factors. While specialized circular knowledge was not yet highly included in this phase, interviews revealed that certain activities within the feasibility phase do require specific expertise related to circularity. Therefore, it is advised to include a reclamation expert and salvage dealer.

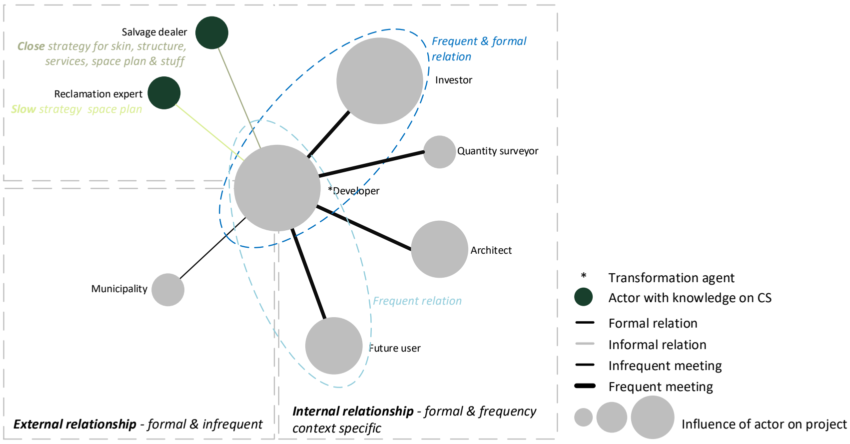


Figure 38 Cross-case analysis of feasibility phase, adopted from (Gerding et al., 2021) (own work)

4.4.2.3 Design

In the design phase, clear patterns and differences emerge in terms of actor involvement, influence, relationships, and the integration of circularity expertise. Across all cases, the developer maintained a central role, indicated by their high number of connections. This centrality positioned them to act as a transformation agent, guiding the integration of circular strategies. However, only in Zandkasteel and Edge Olympic did the developer actively take on this role. In AIR Offices, circular strategies were not prioritized in the design, and the developer did not fulfill this function. Alongside the developer, the architect held a similarly central role in all cases. Their broad network of relationships reflected their responsibility for embedding circularity into the design. This position shows their potential to act as a transformation agent. Only in Edge Olympic, the architect actively acted as a transformation agent by aligning actors around the circular ambition. In Zandkasteel and Edge Olympic, the contractor also held a central position. The contractor's centrality positions them as a transformation agent in ensuring that circular strategies are also technically feasible and executable. Air Offices lacked a contractor, yet all participants in the interviews stressed the importance of involving a contractor early on. Simultaneously, high centrality is connected to a higher level of influence on decision-making (Gerding et al., 2021). This higher level of influence was also visible in all the cases for the architect and contractor.

The developer holds a high influence on decision-making due to their ongoing presence in all project discussions across all cases. This central involvement enables the developer to guide the project's direction closely and maintain greater control.

In both Edge Olympic and Air Offices, the investor's influence appears less prominent during the design phase. Their involvement was more periodic, which may have limited their role in day-to-day decision-making. This reduced visibility does not imply a lack of influence altogether. Investors remained involved in major project decisions and continued to shape the broader financial framework. The apparent difference in influence likely results from the developer's consistent presence, rather than from a structurally lower position of the investor.

The frequency of relationships with actors within the project team was high across all cases. Simultaneously, several actors were consistently identified as key members of the project team. These actors in the project team included the architect, structural engineer, building physicist, quantity surveyor, and installation expert. Their central involvement may indicate that these actors are crucial to a project in every case, playing a key role in driving the design process and often holding substantial influence.

Moreover, the cases reveal that circular expertise was not always present within the project team itself. Often, additional actors were engaged to supplement this knowledge. Given the high frequency of communication within the project team, embedding such expertise internally may improve the integration of circularity into the design process, as higher frequency of communication is often related to greater influence on decision-making (Gerding at al., 2021). This supports Gerding et al.'s (2021) observation that circular knowledge is still largely introduced through experts and ideally should be incorporated within the team to strengthen their influence. This was also underpinned by the architect from AIR Offices, who noted that additional experts are often the first to be excluded over time, reinforcing the need to internalize such knowledge. Across all cases, actors with expertise on circular strategies who were part of the project team held substantial influence. This further indicates that incorporating such expertise within the core project team is key to effectively integrating circular strategies into the design. In contrast to the findings of Gerding et al. (2021), this study did not find consistent evidence that actors with circular knowledge outside the project team held notable influence. Only in the case of Zandkasteel, actors outside the project team with circular knowledge, for instance, the reclamation expert, did clearly contribute to decision-making. This suggests that circular expertise alone does not guarantee influence, rather, the degree of influence may appear to depend on whether the expert is integrated in the project team.

In all cases, additional actors outside the project team were engaged frequently to address specific knowledge gaps regarding circular opportunities. In Zandkasteel, this included a reclamation expert and dismantler. Edge Olympic consulted suppliers and a dismantler. These engagements reflect a proactive and targeted approach, where additional expertise is deliberately introduced to realise circular ambitions. The engagement of additional actors varied across the cases and was dynamic over time. This confirms that collaboration in circular adaptive reuse projects is context-dependent, aligning with London and Pablo's (2017) view of collaboration as a dynamic and evolving process.

Across the cases, several overarching relationships proved critical to circular outcomes in general. The architect consistently emerged as the primary integrator, translating circular objectives into a coherent design. Moreover, early contractor involvement proved essential for validating technical and executable feasibility, while quantity surveyors were important to align circular design choices with financial constraints. Finally, suppliers were engaged across all projects, whether through the architect, the contractor, or directly by the developer, to bridge knowledge gaps about circular options at various building layers.

Specific relationships were also crucial for implementing particular strategies at building layers. These relationships will be explained in connection with the developer, emphasizing why each connection is crucial for the successful integration of the specific strategy. It is important to note that it is assumed each actor possesses the relevant expertise in circularity to effectively implement these strategies. The selective engagement of actors aligns with the theory of Peek and Gehner (2018). They argue that real estate developers involve actors primarily based on their competencies, to match the specific demands of the project phase or strategy being pursued.

For both the slow and regenerate strategies, the structural engineer played a pivotal role in Edge Olympic and AIR Offices. Their involvement was essential in evaluating the reuse potential of the existing structure and skins and whether bio-based solutions were possible. Furthermore, in the Zandkasteel, the installation expert proved critical for enabling the slow strategy at the services layer, while a reclamation expert was essential to identify the reuse potential at the space plan layer.

For the close strategy, certain relationships were essential across all cases. The dismantler was consistently engaged for the close circular strategy at the structure, skin, services, and space plan layers. In Edge Olympic and AIR Offices, an interior architect contributed to reusing components, part of the close strategy, at the stuff layer. Additionally, a salvage dealer played a role in enabling the close strategy for skin, structure, services, space plan, and stuff as discussed in multiple cases. This growing need for specialized actors highlights the knowledge fragmentation described by Adams et al. (2017). It also highlights the increasing complexity of collaboration required to operationalise circular ambitions effectively.

In conclusion, collaboration in the design phase intensifies, requiring intensive coordination among actors to operationalize circular strategies and ensure their application. Figure 39 offers a conceptual overview of the design phase based on the cross-case analysis. It should be noted that not all actors depicted in the diagram are necessarily consistently involved in every project. However, the figure clarifies which relationships are important from the developer's perspective for the effective integration of circular strategies into the design. The figure highlights the key findings of the analysis, particularly focusing on the relationships and influence distribution. The developer has the potential to act as a transformation agent, followed by the architect and contractors, who are also capable of driving actors towards the circular goal. The developer holds the most influence, with this influence shifting more towards the developer when an investor is involved. However, for major decisions, the investor still plays a role in the decision-making process. The contractor and architect both have a medium level of influence, which is justified by their high number of relationships based on Gerding et al. (2021). Finally, the diagram highlights important relationships, critical for the successful integration of circular strategies in general and for a specific building layer.

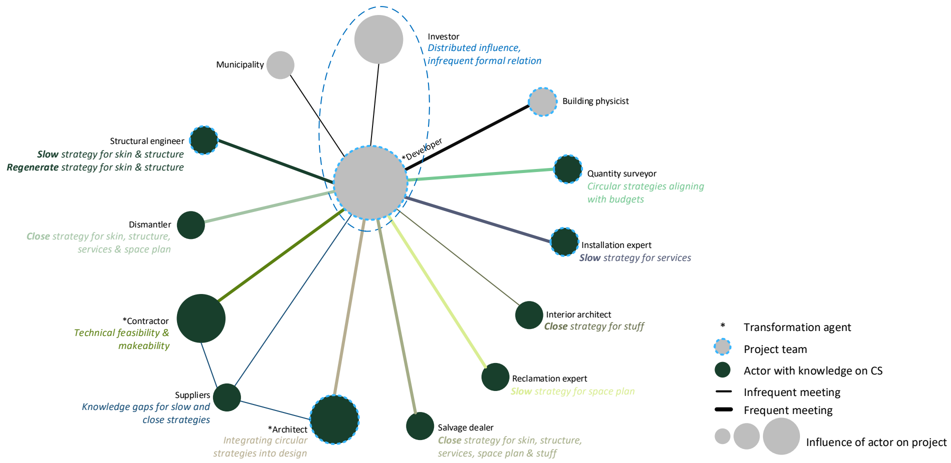


Figure 39 Cross-case analysis of design phase, adopted from (Gerding et al., 2021) (own work)

4.4.3 WHEN AND HOW: ACTIVITIES IN THE DEVELOPMENT PROCESS

4.4.3.1 Inception

When	How	Zandkasteel	Edge Olympic	AIR Offices
Inception	Define a circular ambition	X	X	X
	Assess spatial and functional feasibility for AR	X	X	X
	Assess technical condition	X	X	X
	Assess reuse potential of materials and components	X		
	Investigate legal requirements for AR	X	X	X
	Assess the economic feasibility for the project	X	X	X
	Acquire the building	X	X	X

Table 16 Cross-case analysis of activities in the inception phase (own work)

Table 16 summarizes the key activities discussed or advised during the inception phase across the three cases. An 'X' indicates that the activity was either implemented or advised in the case, while a blank cell signifies that the activity was not mentioned in the context of that particular project.

Based on the cases, the inception phase possesses a significant influence in shaping circular outcomes by defining the circular ambition. A relevant nuance emerging from the AIR Offices case is that this phase also serves as a financial decision-making moment, in which the project's investment potential is evaluated before acquisition. Thus, if circularity is to be a priority, it must be embedded early on and aligned with the financial boundaries. This finding aligns with Çimen (2023), who emphasizes the inception phase as the first critical moment to embed circularity into adaptive reuse projects.

From the cross-case analysis, several activities emerged as central to the successful implementation of circular strategies. In particular, all cases emphasized the importance of defining a circular ambition at the start of the project as a success factor. The developer's role was seen as critical in this process. As the central actor, the developer is expected to take the lead in setting this ambition and ensuring a strong commitment to circularity from the outset. A proactive commitment from the developer was identified as decisive in successfully integrating circularity into the project. This is evident in the AIR Offices case, where circularity was not initially set as the primary ambition. All participants noted that had circularity been pursued, it would have been the developer's responsibility to articulate that ambition. In the absence of such direction, circularity was not meaningfully embedded in the project. This finding confirms that the presence of a circular ambition, especially when initiated by the developer, is a necessary condition for integrating circularity in practice. This is consistent with Gerding et al. (2021), who emphasize the role of the client in setting circular objectives. At the same time, this study shows that other actors can contribute meaningfully to directing and operationalising circular strategies within the project. In Zandkasteel, for example, the contractor and circularity expert made significant contributions to shaping the project's circular direction. Similarly, in Edge Olympic, the architect played an active role in translating the ambition into concrete design actions. In line with Gerding et al. (2021), this underscores that centrally positioned actors, whether or not they initiate the ambition, can exert substantial influence on how circularity is implemented throughout the project. This implies that the developer does not need to have fully detailed the ambition in the inception phase. Rather, the presence of an initial circular intent is sufficient to activate and guide other actors. These actors can then play a complementary role in further shaping and operationalising circular strategies as the project evolves.

Furthermore, multiple participants across different cases emphasized the documentation of the circular ambition. Documenting the ambition helps ensure that the circular objectives remain clear and serve as a reference throughout the project. Moreover, the emphasis on documenting the circular ambition aligns with the theory of Chao-Duivis and Wamelink (2013), who underline the need for clarity in shared goals as a foundation for effective collaboration.

Furthermore, all cases include activities that are specific to adaptive reuse projects, for instance, assessing spatial feasibility and technical condition, investigating legal requirements, assessing economic feasibility, and acquiring the building. However, Zandkasteel made it particularly clear that when circularity is an ambition, assessing the potential for material and component reuse should occur before the building is acquired. Early assessment of the reuse potential ensures that the opportunities are identified and that the circular objectives can be achieved on a larger scale. Once the building is acquired, the assessment of reuse potential should be explored in greater detail during the feasibility phase.

The findings are reflected with the theoretical framework. In the development model proposed by Hamida and Hassanain (2021), the early process consists of a feasibility phase followed by design. However, the empirical data from this study indicate that several feasibility-related activities, as defined in their model, already occur before acquisition. In this study, these activities have been categorised under the inception phase. This observation suggests that, particularly in circular adaptive reuse projects, their adaptive reuse-related activities begin earlier than their framework implies.

4.4.3.2 Feasibility

When	How	Zandkasteel	Edge Olympic	AIR Offices
Feasibility	Engage potential future user	X		
	Align future user and investor with circular goal and conduct expectation management	X	X	X
	Establish clear boundaries, prioritization list and qualitative requirements for circularity in program of requirements	X	X	X
	Establish quantative and measurable targets in program of requirements	X	X	X
	Establish a flexible program of requirements for functions	X		
	Assess reuse potential of materials and components in detail	X	X	X
	Conduct destructive research	X	X	
	Verify and correct existing building drawings	X		
	Explore available reclaimed materials in the market		X	X
	Experiment with materials		X	
	Establish a circular procurement strategy with circular selection and award criteria	X	X	X
	Allocate financial and planning reserves & risks	X	X	X

Table 17 Cross-case analysis of activities in the feasibility phase (own work)

Across the three projects, the feasibility phase plays a decisive role. It is the moment when the initial circular ambition is refined and translated into concrete objectives, and the circular possibilities are thoroughly assessed in terms of both technical feasibility and financial viability. In both Edge Olympic and Zandkasteel, the teams described this phase as iterative. In which possible circular strategies are explored, evaluated, and adjusted each time new information emerges. That cycle of exploration does not stop at the end of this phase. The feasibility is carried into the design phase, where the chosen strategies are re-examined and refined. In contrast to Edge Olympic and Zandkasteel, the feasibility phase in AIR Offices was perceived less as a clearly defined iterative process and more as a flexible stage, varying in duration and scope depending on project needs. This difference may be attributed to the absence of a clear circular ambition in the AIR Offices case, which resulted in a less structured exploration of circular options and less visible influence on the design process.

Table 17 summarizes the key activities discussed or advised during the inception phase across the three cases. The cross-case analysis reveals, on the one hand, several feasibility-phase activities typical for adaptive-reuse projects. On the other hand, some activities appear to be specific to projects with circular ambitions. First, in both Zandkasteel and Edge Olympic, it was emphasized that, when future users are already engaged in the early phases, it is important to inform them about the expected performance of a circular building. In contrast, Edge Olympic and Air Offices placed the main emphasis on conducting expectation management with investors once the circular goal is set. Since circularity comes with time, financial and quality limitations, both the users and investors must understand what pursuing such an ambition will entail from the outset.

Furthermore, all cases emphasized the importance of defining clear qualitative and quantitative requirements in the program of requirements. This allows for more streamlined decision-making. However, only Zandkasteel explicitly highlighted the need to include functional flexibility in the program of requirements. In contrast, at Edge Olympic and AIR Offices, this was less critical, as both buildings already featured open floor plans that allowed for flexible layouts. The need for a flexible program of requirements for functions might therefore be especially important in projects where existing spatial configurations impose constraints on reuse.

Moreover, all cases stressed the importance of conducting in-depth research into the building's reuse potential. This included assessing the quality and reuse potential of existing elements, particularly at the space plan level, where the involvement of a reclamation expert was considered valuable. However, the focus and depth of such investigations differed depending on the predefined circular strategies for each building layer. In Zandkasteel, reusing services was a key strategy, requiring more detailed and destructive assessments. Participants emphasized that such elements cannot be evaluated through visual inspection alone but demand destructive research to determine their true condition. In contrast, at Edge Olympic and AIR Offices, services were not targeted for reuse, and extensive destructive assessments were therefore not pursued. This difference might be explained by variations in circular ambition. When the reuse of technically complex systems is prioritized, as in Zandkasteel, more destructive and detailed assessments may be required to ensure viability.

Additionally, both Edge Olympic and AIR Offices emphasized the importance of exploring reclaimed materials available on the market by involving a salvage dealer. The cases highlight that this step is particularly relevant when the ambition focuses on closing the loop strategy. In such cases, feasibility often depends on what materials are available at that specific moment.

Furthermore, only Edge Olympic highlighted the value of experimenting with materials during the feasibility phase. By contrast, AIR Offices and Zandkasteel did not conduct material testing in this phase. This might have contributed to the technical limitations they later encountered. Early experimentation could potentially have revealed challenges in advance.

Lastly, in all cases, the developer or client emphasized the importance of establishing a circular procurement strategy with circular selection and award criteria. Across cases, the strategy was consistently seen as essential, with multiple participants highlighting the importance of selecting partners with proven circular expertise.

These findings suggest a refinement of the feasibility phase as defined by Hamida and Hassanain (2021). In their adaptive reuse model, this phase serves as a broad stage for project feasibility for adaptive reuse specifically. However, the empirical data from this study show that, within circular adaptive reuse, the feasibility phase takes on a more specific role. It becomes a dedicated period for circularity-related research and activities. This highlights a shift from general feasibility assessment to a more targeted, circular-oriented process.

4.4.3.3 Design

When	How	Zandkasteel	Edge Olympic	AIR Offices
Design	Establish a project team	X	X	X
	Propose design alternatives	X	X	X
	Consult suppliers in assessing reuse opportunities	X	X	X
	Develop detailed design	X	X	X
	Develop technical program of requirement	X	X	
	Include experienced contractor early for technical feasibility of design	X	X	X
	Offer circular material alternatives	X	X	X
	Develop technical specification	X	X	X
	Include salvage dealer and dismantler	X	X	X
	Evaluate identified reuse potential			X
	Develop a demolition specification	X		X
	Obtain municipal permits	X	X	X

Table 18 Cross-case analysis of activities in the design phase (own work)

Based on the cross-case analysis, the design phase influences circular outcomes as it concretizes the final implementations of circular strategies in documentation, such as the floor plan design and specifications. In addition, the design phase influences circularity by making sure it aligns with the defined circular strategies.

Table 18 provides an overview of the main activities carried out or recommended during the design phase across the three cases. The cross-case comparison reveals that some design phase activities are typical for adaptive reuse projects and align well with those described by Hamida & Hassanain (2021), such as the development of design and specifications. At the same time, the cross-case analysis also highlights activities that are specific to projects with circular ambitions. First, all cases recognised the value of exploring alternative design options to accommodate circular strategies. Zandkasteel highlighted the importance of developing multiple design variants early on, as certain circular strategies may not prove feasible later. By placing alternative options on the table from the outset, the likelihood of integrating circular solutions increases, especially given the limited flexibility to introduce new strategies later in the process.

Furthermore, all cases emphasized the role of consulting suppliers to address knowledge gaps and assess the feasibility of reusing specific components at a building layer for a specific circular strategy.

The cases Zandkasteel and Edge Olympic advised preparing a technical program of requirements as part of the procurement documentation when selecting a contractor. While all participants agreed that early contractor involvement is recommended, especially due to the technical complexity of circular projects, opinions differed on the ideal timing. In most cases, participants proposed involving the contractor after drafting the technical program of requirements in combination with a preliminary design, so they could contribute to the development of the final design and specifications. However, only the architect of the Zandkasteel suggested delaying involvement until after the definitive design to avoid undue influence on the design process. In addition, the client of Zandkasteel and both developers of the other cases emphasized that the optimal procurement strategy depends on market conditions. When contractor availability is low and prices are high, a targeted selection approach may be more effective than open tendering. Despite these differences, all cases agreed that involving an experienced contractor early on is essential to verify buildability and feasibility, and to ensure that circular ambitions can be realistically implemented.

Moreover, across the cases, offering circular materials alternatives was discussed. However, the actor responsible for executing this activity differed. In the Zandkasteel, the contractor took the lead in proposing circular material alternatives, whereas in AIR Offices, the architect facilitated this process.

Additionally, in all cases, a dismantling party was involved to carry out the circular demolition of the building. However, only in Zandkasteel and AIR Offices did participants explicitly mention the drafting of a demolition specification. It is possible that such a specification was also used in Edge Olympic, although this was not mentioned in the interviews. In addition, only AIR Offices highlighted the importance of evaluating the reuse potential of identified materials in collaboration with the dismantler. This evaluation helps determine whether the recovered materials meet market demand and can realistically be reintegrated into the project.

5 VALIDATION

CONTENT

5 VALIDATION

This chapter is part of the synthesize and conclude phase of the research process described in 2.2. The outcomes of the cross-case analysis are discussed in a focus group, and its primary aim is twofold. First, it aims to validate the key findings of the cross-case analysis. Second, it seeks an explanation for any results that the theoretical framework or empirical cases could not fully explain.

Three real estate developers took part in the session. They were chosen for their expertise in both the commercial and technical aspects of real estate development and their experience with sustainability. The focus group lasted 2.5 hours and included three rounds. During each round, participants reviewed the findings from the cross-case analysis, with a focus on the circular activities and collaboration dynamics identified per phase. The visualized tables and figures accompanying the findings from the cross-case analysis formed the basis for discussion.

The key insights that emerged from the focus group are presented in sections 5.1 through 5.3. These insights are subsequently used to refine the final recommendation framework, which is represented in section 5.4. This framework constitutes the normative output of this study and serves as the basis for answering the main research question.

5.1 Inception

5.1.1 ACTIVITIES IN THE DEVELOPMENT PROCESS

This section discusses the validation of the empirical findings presented in Table 16, which summarizes the circular activities identified during the inception phase across the three cases in the cross-case analysis. Rather than reviewing all items exhaustively, the session focused on selected findings that were either unclear, inconsistent across cases, or insufficiently explained by the empirical data alone.

The cross-case analysis revealed differences in the depth of investigation for the building's potential for material and component reuse. In one project, the team conducted an assessment of the individual materials and components. In the other projects, the evaluation remained limited to the assessment of technical condition. During the focus group, participants were asked to recommend what detail level of such an early reuse study should entail and to identify project-specific conditions that determine the depth of this investigation.

First, participants noted that a truly detailed reuse investigation is often unfeasible at inception because the developer does not yet own the building and therefore cannot access all elements. Second, they observed that, in practice, circularity requirements frequently emerge only in later phases, which often leads teams to omit early in-depth assessments. Nonetheless, they advised that for externally visible elements, the potential for reusing components should be mapped out at the outset. For hidden components that require destructive investigation to assess their condition, a clear reuse objective should be set in advance. As a result, the focus group confirmed the importance of early reuse investigations. The final result is refined by the insight that, where feasible, investigations should be carried out at the material level for visible elements, while for concealed elements, setting a clear reuse objective is essential. More detailed investigations can then follow once ownership and full access to the building are possible.

5.1.2 COLLABORATION IN THE DEVELOPMENT PROCESS

This section reflects on the validation of the collaboration dynamics identified during the inception phase, as summarized in Figure 37. This figure, developed during the cross-case analysis, presents a conceptual overview of the actor relationships observed in practice. During the focus group, this figure was used to validate the interpretation of these relationships and to explore contextual nuances that were not fully captured in the empirical data alone.

First, all participants agreed that the developer has the ideal position and qualities to act as a transformation agent throughout the early phases of the development process.

Second, they confirmed that relationships with external parties during the inception phase are generally formal and infrequent. However, they stressed one important nuance, when a developer serves as a delegated project developer (explained in Figure 17), the contract is drawn up directly between the client and the current owner. In that scenario, the developer's relationship with the current owner is not based on an agreement, thus informal. Therefore, the external relationships are changed in the final framework into infrequent relationships, and the type of relationship is dependent on project-specific circumstances.

Third, the participants agreed that the internal relationships are typically formal. However, they stressed that the frequency of contact varies by project and by stakeholder role. This is therefore changed in the final framework.

Most notably, the relationship with the investor brought up a discussion. Participants emphasized that the frequency of contact with investors varies significantly from one project to another. Some investors require weekly progress updates, whereas others allow the developer to conduct an initial review of the project's investment potential before engaging further. They explained that an investor's influence also depends on the type of investor and the type of developer. When the developer bears most of the project's risks as an independent developer, investors tend to remain in the background and focus solely on financial returns, without intervening in the circularity objectives. In contrast, for a delegated real estate developer, investors typically play a more active role and exert stronger influence over design decisions, including those related to circular strategies. Nevertheless, the participants acknowledged that specifically during the inception phase, investors have equal influence, since they jointly determine whether the acquisition of the building proceeds. Thus, if an investor is engaged, the focus group showed that it is typically formal. The frequency of interaction depends on the specific context of the project. During the inception phase, the investor and developer share influence in deciding whether the building should be acquired.

5.2 Feasibility

5.2.1 ACTIVITIES IN THE DEVELOPMENT PROCESS

From the cross-case analysis, it became evident that the feasibility phase is essential for refining the circular ambition into concrete objectives and for conducting in-depth research on the viability of circular strategies. At the same time, the analysis highlighted the iterative nature of the phase. To understand how this works in practice, the participants were asked to describe the role of the feasibility phase when circularity is a primary goal. One developer explained that, in reality, the feasibility stage runs in parallel with sketch design. He argued that treating it as a separate phase often proves too time-consuming and costly. Accordingly, he emphasized that the sketch design continues to evolve, and design changes can easily be included based on the in-depth research regarding circularity. Another participant underscored that the pursuit of circularity requires dedicated attention. He emphasized that specialists must be brought in to carry out the research, and a clear circular strategy must be established before detailed design begins. Ultimately, all participants agreed that feasibility and preliminary design are two parallel processes in the development process, with continuous iteration between refining the circular strategy, investigating the circularity potential, and incorporating circular strategies into the design.

This section discusses the validation of the empirical findings presented in Table 17, which summarizes the key circular activities during the feasibility phase across all cases. In the focus group, this table was used as a basis for discussing selected findings, specifically those that were either ambiguous, varied between cases, or insufficiently explained by the empirical data alone. The cross-case analysis showed that assessing the reuse potential of the building is crucial. However, only two cases highlighted the necessity of targeted destructive investigation. The participants in the focus group were asked when destructive research is necessary. They emphasized that such research follows the clearly defined circular ambition and may be required across multiple layers. It must be carried out early enough to be well incorporated into the design. As one participant explained, '*For example, we intended to reuse the existing isolation in a project, confident it was in good condition. When we opened up the facade, however, we discovered large sections were severely degraded. Although we had set our circular ambition, we had not carried out a destructive investigation to verify feasibility. By the time the facade was removed, it was far too late [to refurbish and reuse the existing].*' Ultimately, whether and at which building layer destructive investigation is necessary depends on the circular strategy established for each layer, but it is strongly recommended in the feasibility phase.

Furthermore, only one case experimented with materials during the feasibility phase. The participants in the focus group were asked what factors determine that this activity should take place. They felt that experimenting with materials during feasibility could be too early and premature. However, they agreed that if a specific material or technique is central to the circular concept, early trials are advised but require the engagement of technical specialists earlier. Otherwise, experimenting can be delayed until later when a contractor is involved. Finally, they stressed that material experiments require technical specialists, such as a contractor, rather than being attempted by the developer alone.

Thus, based on these insights, material experimentation was repositioned in the final framework to the design phase. The focus group indicated that such trials are often premature during feasibility and are more effective when a contractor is involved at a later stage.

Lastly, the participants emphasized that the establishment of the procurement strategy fits better at the beginning of the activities of the design phase.

5.2.2 COLLABORATION IN THE DEVELOPMENT PROCESS

The conceptual overview, Figure 38, developed in the cross-case analysis, was presented to the focus group to validate findings and gather feedback. All the individual elements of the conceptual overview were subsequently discussed. First, as explained earlier, the participants confirmed that the developer holds the ideal position to act as a transformation agent during the early phases of the development process.

Second, during the feasibility phase, the participants noted that external relationships can also be informal in this phase, instead of solely formal. For example, they explained that engagement with local residents often happens informally through information or participation events at the start of the sketch design and feasibility phase. Meanwhile, contact with the municipality typically occurs on a biweekly basis. As the design progresses into later phases, those municipal interactions become more frequent. Thus, based on these insights, the external relationships are changed in the final diagram to infrequent relationships, with the type of relationship dependent on project contexts.

Third, the participants agreed that the relationships with internal parties are formal. The frequency of contact is context-specific and may differ in each project. Participants noted that a future user is not always involved during the feasibility phase, as the investor or owner is not necessarily the end occupant. Moreover, whether a user is engaged at this stage depends on the project context. Some projects demand tenant-specific input to shape the programme of requirements, while others can proceed with generic assumptions until later. Thus, once a future user is involved, communication is invariably frequent, as their input is necessary to shape the programme of requirements. Nevertheless, participants cautioned that end-user influence is conditioned by the investor's priorities. An investor may override or limit user-driven changes. As a result, while a future user may have substantial influence, this cannot be generalized across all projects. In addition, if an investor is involved, the participants agreed that the relationship is formal, and the contact is frequent. They explained that, during the feasibility phase, regular interaction is necessary to align project outcomes and objectives, such as circularity. In addition, they emphasized that the investor's influence is significant at this stage, as they play a crucial role in shaping the project's direction and feasibility regarding circularity. Based on these insights, the final model was refined to reflect the flexible nature of actor involvement. It now indicates which stakeholders may potentially be engaged during the feasibility phase, while acknowledging that not all parties are always involved. Internal relationships are typically formal, but the frequency of contact depends strongly on the project context and stakeholder roles.

Lastly, the participants were shown two collaboration diagrams: one including a reclamation expert and salvage dealer, and one without. The first diagram reflected the recommended practice of involving these actors early, while the second reflected what happens in practice. In reality, these actors are often involved too late, which delays the investigation of circular opportunities. The participants were asked to explain this difference. They attributed it primarily to time pressure and financial constraints. They explained that projects often prioritize speed and cost control, making it difficult to schedule early material assessments in a separate phase. Therefore, one participant suggested treating the feasibility phase as parallel to the sketch design phase. In practice, this approach saves time and requires less investment than separating the two phases. Moreover, the sketch design phase remains flexible enough to incorporate the outcomes of circularity assessments into the evolving design. In addition, one participant emphasized that genuine circularity requires intrinsic motivation. Although many actors support circularity in principle, few are willing to invest extra time and money unless clear external pressure exists. Thus, the participants recommended including both actors in the feasibility phase, which is why they are incorporated into the final framework in the feasibility phase.

5.3 Design

5.3.1 ACTIVITIES IN THE DEVELOPMENT PROCESS

This section discusses the validation of the empirical findings presented in Table 18, which outlines the circular activities during the design phase. As in previous phases, not all activities were discussed. The focus group addressed selected findings that required further clarification.

The cross-case analysis revealed that not all cases mentioned the evaluation of the identified reuse potential with the dismantler. This finding was discussed in the focus group to understand how this step is handled in practice and whether it should be part of a circular project. The participants confirmed that this evaluation must become a standard part of the process. They explained that the circular strategy established in the early stages should later be verified together with the dismantler. The aim is to assess whether the identified elements can indeed be reused and whether they still hold market value. Moreover, participants emphasized that this verification is crucial before demolition starts. They mentioned that in practice, a detailed circular demolition specification is always prepared. Therefore, they concluded that the absence of this step in one case was likely an oversight rather than a reflection of actual practice.

5.3.2 COLLABORATION IN THE DEVELOPMENT PROCESS

This section discusses the validation of the collaboration dynamics during the design phase, as presented in Figure 39. To facilitate focused discussion, individual elements from this figure were addressed separately during the focus group. Participants were asked to reflect on specific actor roles, their relationships, and their contribution to achieving circularity in the design phase.

First, the composition of the project team was addressed. The analysis showed that project teams vary depending on the specific needs of each project. However, some roles are present across cases. Participants confirmed that typical members include the architect, structural engineer, building physicist, quantity surveyor, and installation expert. They also agreed that, in practice, one actor may often take on multiple roles.

Next, the role of the transformation agent was discussed. Participants agreed that the developer holds the ideal position to fulfil this role throughout the entire process. They also recognized that the architect and contractor can fulfil an additional role of transformation agents. The architect can take on this role in the design phases. Participants explained that the architect aligns the different actors with the circular goals by reasoning from the design. They coordinate what each actor must contribute to achieve an integrated circular outcome. The contractor can adopt the role later when they are engaged. Participants emphasized that the contractor ensures that subcontractors work in line with the agreed circular ambitions. Nevertheless, they concluded that the developer remains the central transformation agent across all phases, while the architect and contractor play complementary roles at key moments.

The participants explained that when an investor is involved, the nature of the relationship depends on both the type of investor and the type of developer. Some investors are highly engaged and seek frequent updates, while others adopt a more passive role and intervene only at key decision points. As a result, both the frequency of contact and the level of influence can vary significantly. Nevertheless, participants emphasized that, in the projects they worked on, contact with the investor during the design phase was usually frequent. Regular meetings, typically biweekly, were scheduled, alongside informal calls when necessary. Finally, participants noted that although developers have a strong influence on design choices by being consistently present in meetings, investors ultimately decide on major issues, particularly when circular decisions have significant financial implications. Thus, both the frequency of contact and the balance of influence between developer and investor are ultimately project dependent. However, investors always participate in decision-making when choices have a financial impact, including circular design decisions that may affect the project's return on investment.

Further, the focus group confirmed the importance of specific relationships for achieving circular goals. The architect ensures that circular strategies are integrated into the design. The contractor safeguards the technical feasibility of the design. Suppliers provide missing technical knowledge about reuse options. Finally, the quantity surveyor helps assess whether circular strategies can be realised within financial constraints.

The final part of the focus group session includes a more interactive exercise. It zoomed in on a specific subset of the insights from Figure 39, which summarizes all collaboration dynamics observed in the design phase. This part focused particularly on the identified actors that could be directly linked to a specific CS and building layers, as shown in Figure 39. These actors were visually organised in the What and Where table to support discussion. Based on participant feedback, several actors could be associated with multiple strategies and layers. These insights led to the development of Figure 40, which expands on the findings illustrated in Figure 39. Whereas Figure 39 includes a broader set of actors important for circularity, Figure 40 particularly visualises the circular strategy-related actors tied to a building layer. This figure serves as an additional tool to quickly identify the relevant actor for a given strategy-layer combination.

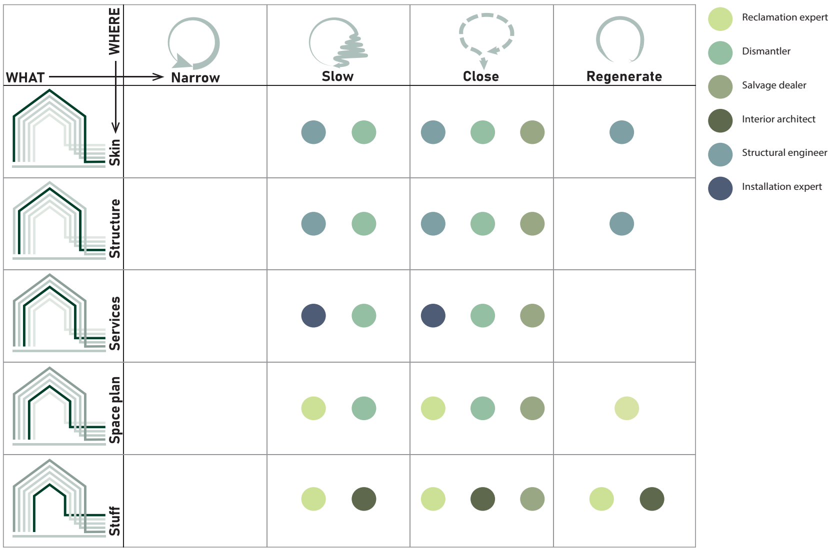


Figure 40 Actors connected to circular strategies and building layers, adopted from (Brand, 1994; Circle Economy & metabolic, 2022) (own work)

First, the reclamation expert was described as playing a key role in identifying the reuse potential and quality of existing materials and components within a building. This actor is important for both slow and close strategies, particularly at the space plan and stuff layers. However, participants noted that while a reclamation expert can recognize material quality, an interior architect is often needed to assess whether reused elements at the stuff layer fit the new design. Moreover, they explained that the regenerate strategies can apply to the space plan and stuff layers if reclaimed bio-based materials are available.

Second, the dismantler was seen as crucial for both slow and close strategies across the structure, skin, services, and space plan layers. For slow strategies, the dismantler must carefully remove elements so they can be reused within the same project. For close strategies, the dismantler ensures that components are extracted in a way that allows them to be reused in other projects. Participants emphasized that precise dismantling is essential to preserve the quality and usability of materials for future applications.

Third, the participants explained that the salvage dealer operates within the close strategy across all building layers: structure, skin, services, space plan, and stuff. The salvage dealer collects reclaimed materials and components and resells them for reuse in other projects. It can also happen the other way around: a salvage dealer has salvaged materials from other projects, which can be used in the current project. However, participants noted a nuance regarding the stuff layer. Whether the salvage dealer also handles furniture and interior elements depends on the type and size of the operation.

Fourth, the interior architect is linked to the slow, close, and regenerate strategies at the stuff layer. In the slow strategy, reuse is only possible if the existing building still contains usable interior elements. In the close strategy, the interior architect assesses whether second-hand furniture and components from other projects can be integrated into the new design. The regenerate strategy is related to evaluating the possibilities for bio-based interior elements.

Furthermore, the structural engineer is identified as holding essential knowledge about the slow, close, and regenerate strategy for both the structure and the skin of a building. In particular, they must assess whether existing structural elements or self-supporting facades and roofs can be reused, part of the slow strategy. Although reusing structural materials from other projects is still rare in practice, participants agreed that structural engineers should have the capacity to evaluate these options, focusing on the close strategy. Moreover, they must be able to calculate whether bio-based materials can be applied to both the structure and the skin as part of the regenerate strategy.

Lastly, the participants explained that an installation expert plays a key role in evaluating the reuse potential of the building’s services. They emphasized that this actor must assess whether existing installations can be reused within the same project (slow strategy) or transferred to or from another project (close strategy). Although the technical inspection itself is often carried out by a specialized company, the installation expert is responsible for initiating and overseeing this process. Moreover, participants noted that applying bio-based installations (regenerate strategy) is currently not feasible, as suitable products are largely unavailable on the market.

5.4 Final framework

This section presents the final framework, which synthesizes the empirical findings from the cross-case analysis with the insights obtained during the focus group validation. While the cross-case analysis revealed patterns in circular activities and collaboration structures across the early development phases, the focus group allowed for the refinement of these findings based on expert feedback as discussed in sections 5.1 to 5.3. As a result, a final framework has been developed that provides concrete guidance for organising the early development phases to support the integration of circular strategies in adaptive reuse projects, focusing on activities and collaboration.

The components of this framework have a different role than the figures used in the cross-case analysis. Those visualisations had an empirical function as they describe how circularity was approached in practice. The final framework has a normative role. It provides recommendations on how activities and collaboration can be structured. These recommendations are based on the validated insights, which have led to adjustments in the collaboration models and activities from the cross-case analysis. The framework is divided into three parts, namely the phases: inception, feasibility, and design. Each phase consists of two components: the activities and a collaboration model connected to each phase.

The activities describe which actions are recommended in each phase when aiming to realise a circular adaptive reuse project. They should be understood as guiding principles. While these actions can support the development of more circular outcomes, they do not in themselves guarantee project success. Rather, they provide direction for what can be considered at each phase of the process.

The collaboration models complement these activities by summarising the key insights on actor collaboration in each phase. They illustrate how collaboration can support circular goals and clarify which types of actor relationships are essential for enabling the circular ambition and specific circular strategies. However, actor involvement always depends on project-specific factors, and therefore, actors involved can vary between projects. Nevertheless, the models provide guidance by showing which collaborations are particularly important when circularity is a central ambition.

The following sections explain the framework per phase and component. The total framework is added to Appendix 9.5 and is used to answer the main research question in Chapter 6.5.

5.4.1 INCEPTION

The inception phase plays a critical role in **defining** the ambition for a circular adaptive reuse project. It sets the foundation for all subsequent decisions by establishing the project's circular objectives and clarifying whether the building is suitable for adaptive reuse in general. One key tool introduced in this phase is the strategy-layer matrix, illustrated in Figure 41. This visual framework helps the developer to concretely define their circular ambition by mapping which circular strategies are targeted and at which building layers. Although specific choices will evolve during the process, the matrix supports early reflection and alignment by making circular intent explicit at the outset.

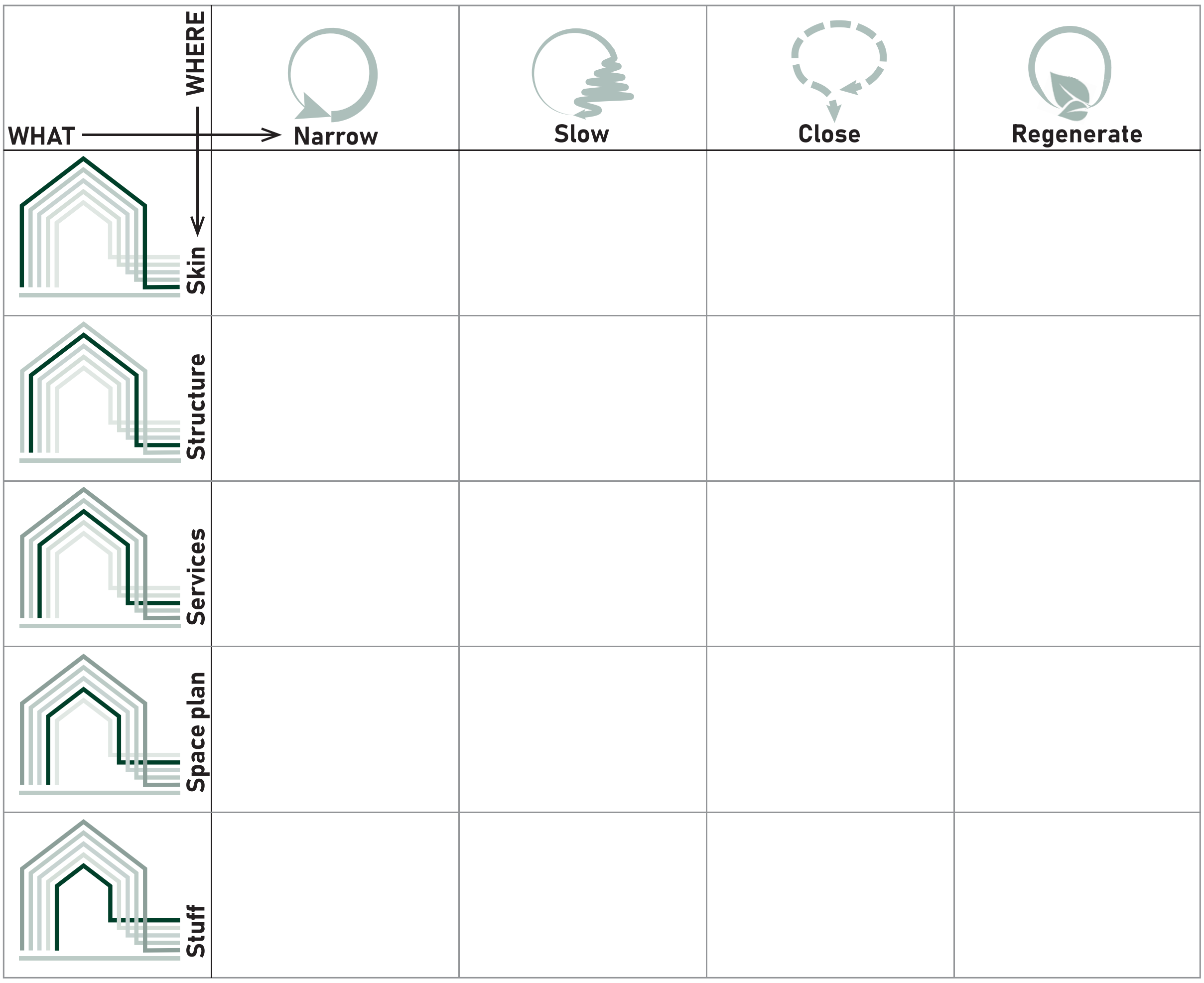


Figure 41 Strategy-layer matrix, adopted from (Brand, 1994; Circle Economy & metabolic, 2022) (own work)

5.4.1.1 Activities

ACTIVITIES

- Define and document a circular ambition
- Assess the spatial and functional feasibility for adaptive reuse
- Assess the technical condition
- Assess the reuse potential of materials and components
  - For visible elements: assess potential and define a reuse objective
  - For concealed elements: define a reuse objective as input for later assessment
- Investigate the legal requirements for adaptive reuse
- Assess the economic feasibility of the project
- Acquire the building

Figure 42 Activities in the inception phase (*own work)*

Figure 42 presents the recommended activities for the inception phase. The activities focus on setting the circular ambition and determining whether the project is suitable for adaptive reuse. The first step is to clearly define and document the project’s circular ambition. This can be supported by using the strategy–layer matrix, which helps to structure the project's circular goals from the outset.

The subsequent activities aim to assess whether the project is spatially, technically, legally, and economically feasible. In addition to these assessments, this phase also includes an early evaluation of the reuse potential of materials and components. For visible elements, the reuse potential can be investigated directly. For concealed elements, the focus lies on setting a reuse objective that informs future investigation. Together, these activities provide the necessary input to make an informed acquisition decision.

5.4.1.2 Collaboration

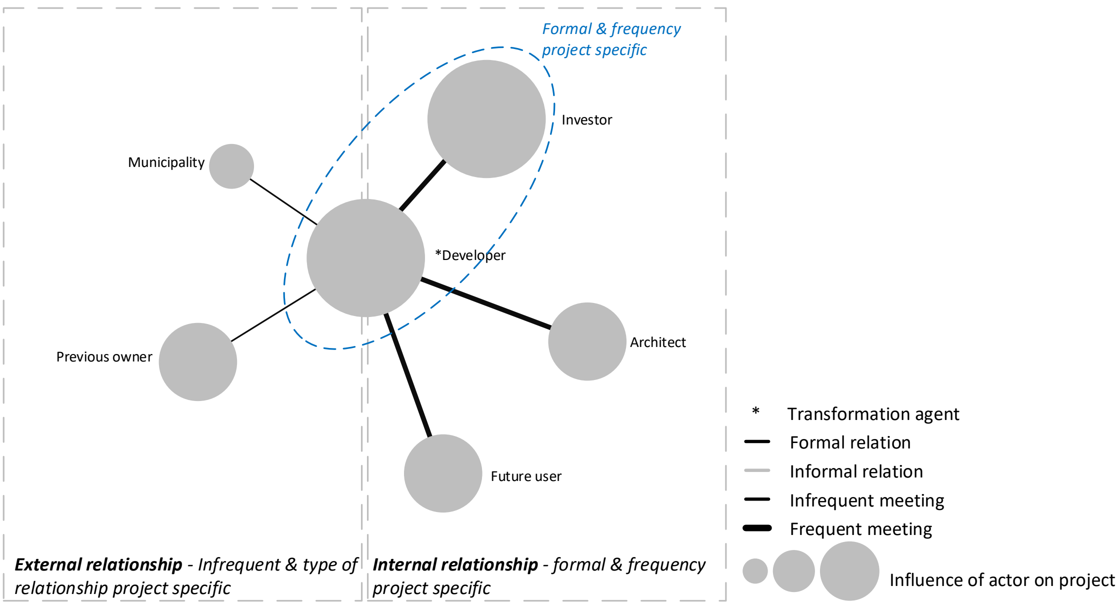


Figure 43 Collaboration in the inception phase, adopted from (Gerding et al., 2021) (own work)

Figure 43 visualises how collaboration can be organised in the inception phase. The model outlines key actor relations. It does not suggest that all actors shown are always involved in every project. Instead, it highlights potential roles and relationships that can be active. In general, collaboration in the inception phase is exploratory in nature, focusing on understanding project potential and development constraints.

The developer is positioned as the central actor and possesses the ideal position to act as a transformation agent for integrating circular strategies. Further, it differentiates between internal and external relationships. Internal collaboration typically occurs formally, and the frequency of contact is dependent on the project's context. When an investor is engaged, their relationship is formal, and the frequency of the interaction varies depending on the type of developer and investor. Their influence is equal, as they jointly determine whether the acquisition of the building proceeds. In addition, external collaboration is generally infrequent. However, the nature of these relationships is also dependent on project-specific circumstances. For example, when a developer acts as a delegated developer, the relationship with the current owner is informal, since no direct contractual agreement will be established between them.

5.4.2 FEASIBILITY

The feasibility phase is essential for **refining** the circular ambition into concrete objectives to enable actor alignment on circular goals and executing in-depth assessments for the project's circular potential. It forms part of an iterative process that runs in parallel with sketch design, in which design and feasibility assessments inform and adjust one another. The iterative nature of this phase lies primarily in the design process: as research reveals new insights into the circular potential of the project, the sketch design adapts accordingly. This continuous feedback loop enables the progressive and integral alignment of circular strategies into the final design.

5.4.2.1 Activities

ACTIVITIES

- (Engage potental future users)
- Align future user(s) and/or investor(s) with circular goals and conduct expectation management
- Establish clear boudaries, prioritization list, and qualitative requirements for circularity in the program of requirements
- Establish quantitative and measurable targets in the program of requirements
- Establish a flexible program of requirements for functions
- Assess the reuse potential of materials and components in detail
- Conduct destructive research
- Verify and correct existing building drawings
- Explore available reclaimed materials in the market
- Allocate financial and planning reserves & risks

Figure 44 Activities in the feasibility phase (own work)

Figure 44 presents the recommended activities for the feasibility phase. These activities focus on refining the circular ambition into a clear and actionable basis for design and decision-making. A key part of this phase is aligning key stakeholders, such as the future user or investor, with the project's circular goals. This includes managing expectations and establishing a shared understanding of pursuing circularity.

The program of requirements (PoR) plays a central role in this phase. It should include a prioritised list of circular ambitions, as well as both qualitative requirements and quantitative targets. Flexibility must also be built in to accommodate the reuse of the existing spatial layout, reducing the need for major interventions due to minor functional mismatches. In parallel, technical research is conducted to assess the feasibility of reuse strategies. This includes detailed material assessments, destructive investigations, and the verification of existing building information.

In addition, the availability of reclaimed materials on the market should be explored, and financial and planning reserves must be allocated to accommodate circular options. These activities provide the foundation for making well-informed design choices in the next phase.

5.4.2.2 Collaboration

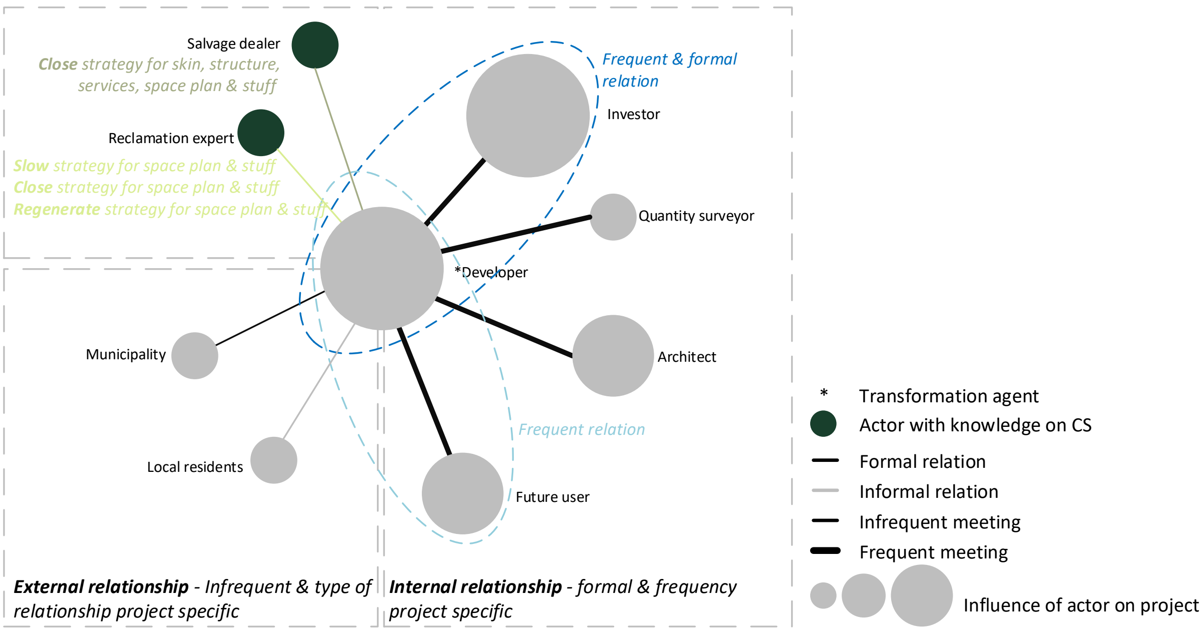


Figure 45 Collaboration in the feasibility phase, adopted from (Gerding et al., 2021) (own work)

Figure 45 visualises how collaboration can be organised in the feasibility phase. The model does not prescribe a fixed actor involvement, but highlights which relationships are essential when circularity plays a central role. Collaboration in this phase focuses on clarifying priorities, with actors co-defining requirements, exchanging technical and market knowledge, and committing to shared circular project outcomes.

The developer remains the central actor and transformation agent in this phase. Internal collaboration typically occurs formally, with the frequency of contact depending on the project context. When an investor is engaged, regular communication is needed to align on feasibility outcomes and financial implications. The investor plays a high influence in shaping the project's direction, and in some cases, financial objectives may limit circular ambitions. When a future user is involved, collaboration is usually frequent. Their input is essential for shaping the program of requirements. However, their influence remains dependent on the investor's priorities, if the end-user is not also the investor. In addition, the engagement of two circularity-related actors is advised. A reclamation expert can support a detailed assessment of material and component reuse potential. The engagement of a salvage dealer may provide insights into the availability of reclaimed materials on the market. Lastly, external relationships are typically infrequent, and the nature of these relationships depends on the specific project context.

5.4.3 DESIGN

The design phase plays a critical role in **aligning** the final design with the defined circular strategies and translating them into concrete, practical design outputs. It gives form to the circular ambition through tangible results, such as the floor plans.

5.4.3.1 Activities

ACTIVITIES

- Establish a circular procurement strategy
  - With circular selection & award criteria
- Establish a project team
- Propose design alternatives
- Consult suppliers in assessing reuse opportunities
- Develop technical program of requirements
- Include experienced contractor for technical feasibility
- Develop detailed design
- Experiment with materials
- Offer circular material alternatives
- Develop technical specifications
- Include salvage dealer and / or dismantler
- Evaluate identified reuse potential
- Develop circular demolition specification
- Obtain municipal permits

Figure 46 Activities in the design phase (own work)

Figure 46 presents the recommended activities for the design phase. The phase begins with establishing a procurement strategy that includes both selection and award criteria aligned with the project's circular objectives. Based on this strategy, a suitable project team is selected.

The design development process proceeds in iteration with the feasibility phase. Multiple design alternatives should be proposed and assessed, with input from suppliers to address knowledge gaps and evaluate reuse opportunities. A technical program of requirements should be developed. Ideally, the contractor is involved earlier after drafting this document and the preliminary design. This allows the contractor to contribute to the development of the final design by assessing technical feasibility and buildability.

However, optimal procurement strategy may depend on market conditions, such as contractor availability and construction costs. Where relevant, experimentation with materials may take place to test applicability. In parallel, circular material alternatives should be proposed and evaluated as part of the design process. Furthermore, the technical specifications is developed that aligns with the circular goals. Involving a dismantler is recommended to ensure that elements are carefully removed and preserved for second-life possibilities. If the dismantler does not act as a salvage dealer, it is advised to engage a separate salvage dealer and assess the actual market demand and usability of the identified materials. This helps to prevent unnecessary efforts and costs by verifying the reuse potential before the dismantling process. Based on this evaluation, a circular demolition specification can be prepared. Finally, the design phase concludes with obtaining the required municipal permits.

5.4.3.2 Collaboration

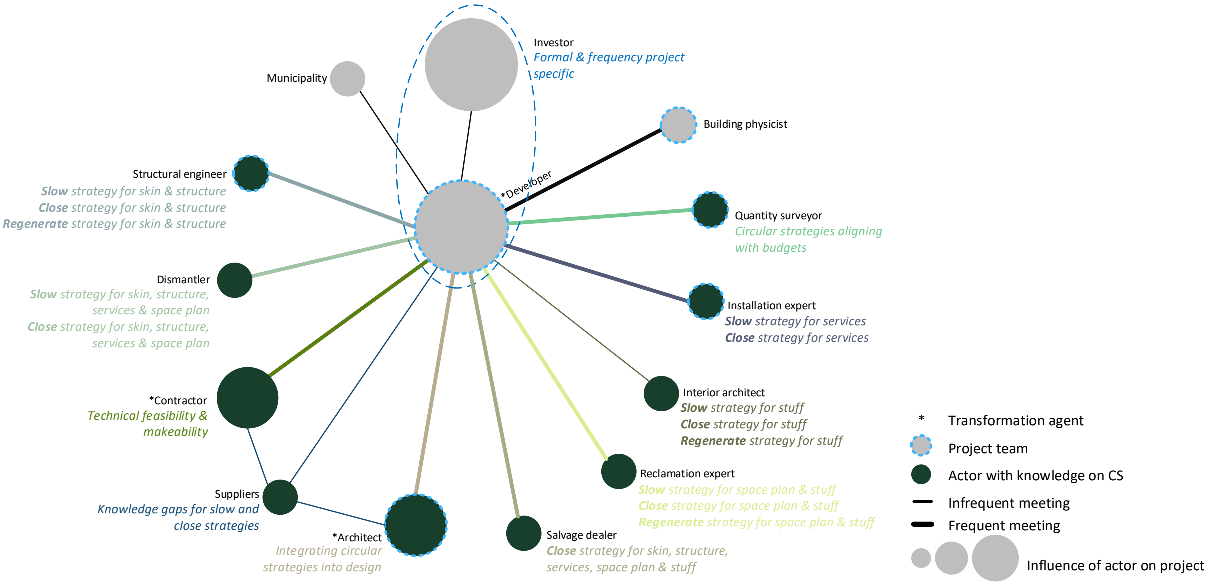


Figure 47 Collaboration in design phase, adopted from (Gerding et al., 2021) (own work)

Figure 47 visualises how collaboration can be organised during the design phase. The model outlines key actor relationships that enable the integration of circular strategies into the final design. It does not imply that all actors shown must always be involved. Rather, it advises on how collaboration can be organised and highlights critical relationships that support circular ambitions and the implementation of specific circular strategies. In general, collaboration in this phase intensifies, requiring close coordination among actors to operationalize circular strategies and ensure their application feasibility.

The figure first shows the typical composition of the project team in this phase. This includes the developer, structural engineer, architect, installation expert, quantity surveyor, and building physicist. Depending on the project, some actors may take on multiple roles, while others may be added to address specific aspects. It is advised to include actors with circular expertise in the project team, as their internal position increases their influence on decision-making and helps ensure to safeguard continuous attention to circularity throughout the design phase.

Furthermore, the developer continues to hold the central position and is ideally placed to act as a transformation agent across all phases. In the design phase, however, the architect or the contractor can also take on this role. The architect contributes by aligning the design process with the circular ambition and integrating it integrally into the design. The contractor can act as a transformation agent by ensuring that circular strategies are not only integrated into the design but are also technically feasible and executable.

The model distinguishes between actors that are generally important for circularity and those that play a more specific role in enabling the integration of particular circular strategies at different building layers. It assumes that each actor possesses the necessary circular knowledge within their area of expertise, allowing them to contribute meaningfully to the project's circular goals.

Among the general actors, the contractor plays a key role in verifying the technical and practical feasibility of circular strategies during the design process. Suppliers are essential for providing missing knowledge, particularly when evaluating reuse options or testing circular materials. The architect ensures that circular principles are embedded in the design and coordinates the integration of input from technical specialists. The quantity surveyor helps assess whether proposed circular strategies can be realised within the project's financial framework.

In addition, the model includes a set of actors whose involvement is tied to specific circular strategies and building layers. These roles are visualised in the strategy–layer matrix in Figure 48. This figure presents a simplified version of the circular specific actors shown in Figure 47, focusing exclusively on how particular actors contribute to the implementation of CS across building layers. It is connected to the strategic choices made during the inception phase (see Figure 41) and offers a clear and structured overview. The figure and its development are explained in more detail in section 5.3.2.

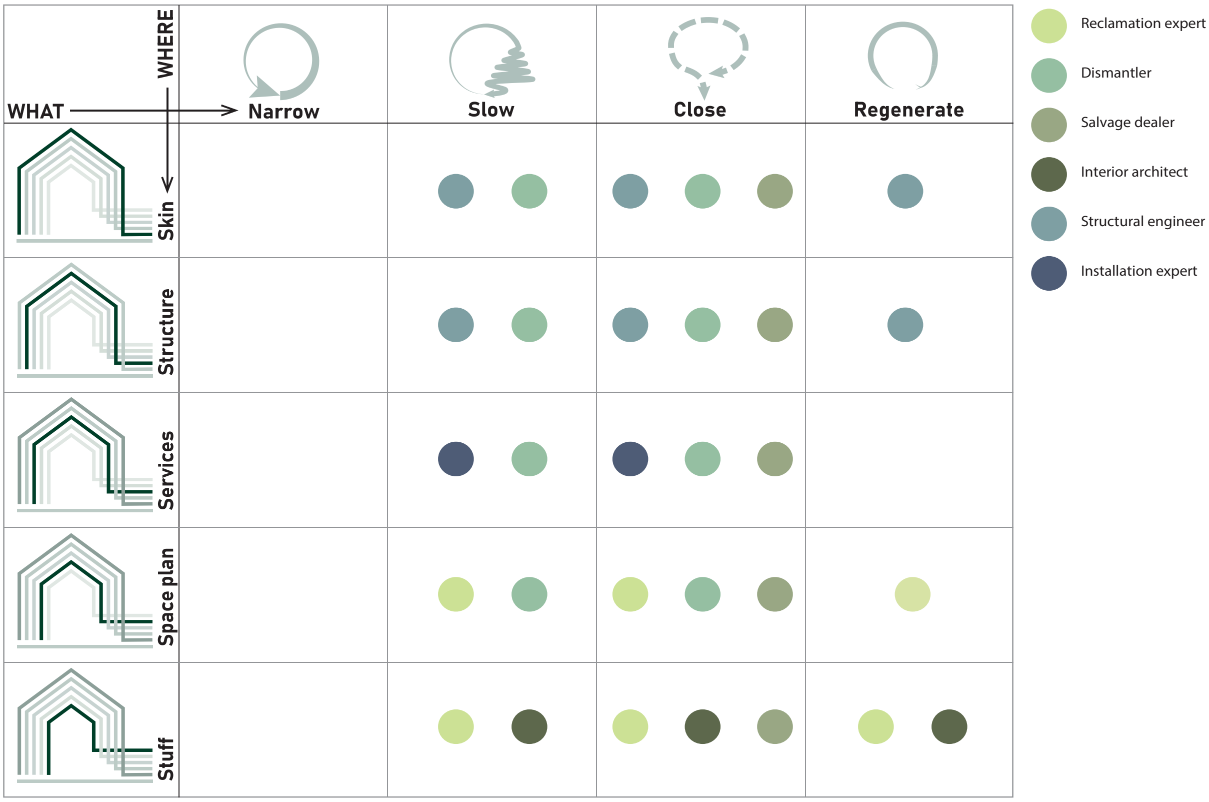


Figure 48 Actors linked to circular strategies and building layers, adopted from (Brand, 1994; Circle Economy & metabolic, 2022) (own work)

6 CONCLUSIONS

CONTENT

6 CONCLUSIONS

6.1 SRQ1 What circular strategies are applicable in adaptive reuse projects?

This sub-research question explored types of CS applicable in adaptive reuse projects. The literature study revealed four overarching CS categories: narrowing, slowing, closing, and regenerating the resource loops (Circle Economy & Metabolic, 2022). These strategies were analysed in combination with the shearing layers model of Brand (1994).

The empirical findings show that the slowing strategy through reuse of the structure is consistently applied, confirming Remøy's (2010) argument that this is inherent to adaptive reuse. In addition, all cases demonstrated skin preservation, which may suggest that skin-level reuse is a common feature in circular adaptive reuse, complementing the literature. However, the generalizability remains uncertain given the limited number of cases. Notably, the closing strategy is described in literature as difficult to implement, due to the immaturity of the secondary materials markets and uncertainty about quality and availability (Van Oorschot et al., 2023; Van Uden et al., 2024). Nevertheless, all cases revealed material harvesting from the existing building, falling under the close strategy. This suggests that harvesting materials from the existing structure may be one of the more accessible forms of the close strategy in practice. In contrast, the integration of externally sourced secondary materials remained limited, indicating that fully closing the loop remains uncommon in practice.

Beyond these recurring patterns, the application of circular strategies differed across cases in terms of building layers and intensity. This variation confirms that the level of application is highly dependent on project-specific circumstances. The cross-case analysis revealed several limiting factors that influenced the degree to which circular strategies could be applied. In all cases, the application was constrained by financial and time limitations. Furthermore, technical constraints related to the quality and performance of the existing building played a decisive role. Buildings in better condition offered more opportunities for reuse, whereas degraded conditions limited circular potential. Additionally, knowledge gaps and a lack of clearly defined circular objectives in the organizational structure further limited the application of strategies.

6.2 SRQ2 What is the influence of each early phase in the development process on the level of integration of circular strategies?

This sub-research question examined how the inception, feasibility, and design phases influence the integration of circular strategies in adaptive reuse projects. These three phases are collectively referred to as the pre-phase, which is considered the most critical period for embedding circular principles into the development process (Gerding et al., 2021). The structuring of the pre-phase builds on the adaptive reuse development model by Hamida and Hassanain (2021), which includes the feasibility and design phases. To this, an inception phase was added based on Çimen (2023), who emphasizes this phase as an additional phase and the first opportunity to integrate circularity objectives.

The empirical findings indicate that each of the three early phases contributes differently to the integration of circular strategies. The inception phase has a significant influence on circular outcomes by defining the overall ambition and assessing its viability with financial boundaries. It marks the first moment where circularity can be embedded, making early commitment essential to include it integrally in later phases. The feasibility phase plays a decisive role in refining the ambition into actionable objectives and conducting in-depth research for the circularity potential. The findings show that this phase is not strictly sequential. Instead, it forms part of an iterative process that runs in parallel with sketch design. As new information becomes available through the assessments and research, circular strategies and the design are continuously refined and adjusted. Simultaneously, the insights from the assessments are integrated into the evolving design. The design phase influences circularity by aligning the design with the defined circular strategies. It makes the circular ambition concrete with practical outputs such as floor plans and technical specifications and ensures its application in the final design.

6.3 SRQ3 What type of actors are involved in circular adaptive reuse projects and how do these actors collaborate in the phases?

This sub-research question examined what actors are involved in circular adaptive reuse projects and how they collaborate throughout the early development phases. To analyse actor collaboration, this study applied the multi-actor network analysis developed by Gerding et al. (2021). This method allows for the identification of central actors, the mapping of relationships, and the assessment of influence and knowledge distribution.

The findings show that circular adaptive reuse projects involve both traditional actors, consisting of the developer, architect, consultants, and contractors, and a set of specialist actors required to integrate circular ambitions integrally. These include transformation agents, salvage dealers, reclamation experts, dismantling and demolishing contractors, and circularity experts. Their presence reflects the added complexity and knowledge demands that distinguish circular projects from conventional adaptive reuse projects. Based on the empirical findings, the developer, due to their central position and decision-making authority, was identified as the actor best positioned to act as a transformation agent and facilitate alignment across the team on the circular ambition.

The findings partly confirm the work of Gerding et al. (2021), who highlight the importance of integrating circular knowledge into project teams. This study supports their argument by showing that actors with circular expertise who are embedded within the team tend to have more influence, likely due to their access to high-frequency communication. At the same time, this study nuances their findings by showing that circular expertise alone does not guarantee influence. Some experts operating outside the core project team had a limited influence. This suggests that influence depends not only on knowledge, but also on the structural position of actors within the project organisation. Therefore, it is advised to include the experts in the project team to increase the integration of CS. In the long term, developing in-house expertise is essential to safeguard circular ambitions, as external specialists are often the first to be excluded when budgets are cut.

Collaboration in circular adaptive projects does not follow a unilateral structure but evolves across the early phases in response to established circular ambitions and context-specific factors of the project. The empirical findings show that collaboration varies in intensity and dynamics depending on the phase and the circular strategies being pursued. This reflects the theoretical view of London and Pablo (2017), who describe collaboration as a dynamic process, continuously stabilizing, extending, and redefining. In the inception phase, collaboration is exploratory, aiming at setting direction and identifying the building's circularity potential. During the feasibility phase, collaboration focuses on co-defining project requirements and exchanging technical and market knowledge around circular possibilities. In the design phase, collaboration becomes more intensive and coordinated, with an emphasis on translating circular strategies into concrete design solutions and ensuring their technical and practical feasibility.

Several recurring patterns were identified, particularly regarding relevant actor relationships and their links to specific circular strategies. To operationalise the findings and translate them into practical guidance, visual models were developed to show how collaboration in circular adaptive reuse projects can be organised in each phase. These diagrams, included as part of the final framework in Section 6.5 and explained in more detail in Section 5.4, synthesize these insights into guiding models. Rather than prescribing fixed teams, they reflect the most critical relationships observed across the cases.

6.4 SRQ4 What key activities in each early phase contribute to the integration of circular strategies?

This sub-research question examined which activities in the early development phases contribute to the integration of circular strategies in adaptive reuse projects. The analysis builds on the same phase structure used in SRQ2: inception, feasibility, and design. The feasibility and design phases were drawn from the adaptive reuse development model by Hamida and Hassanain (2021), while the inception phase was added based on Çimen (2023), who identifies this early moment as the first opportunity to initiate circular ambitions. While SRQ2 focuses on the influences of each phase, this question addresses the specific actions that enable circular integration.

The empirical findings reveal that several activities originally described in the feasibility phase by Hamida and Hassanain (2021) already occur before acquisition. This aligns with Çimen's (2023) view of the inception phase as the first opportunity to embed circularity. This phase combines general adaptive reuse actions, such as assessing spatial and technical feasibility and evaluating legal and economic conditions, with circularity-specific steps like defining the ambition and identifying reuse opportunities for key elements. Across the cases, the early expression and documentation of circular ambitions, particularly by the developer, proved critical in setting the tone for subsequent integration efforts.

In the original adaptive reuse model, the feasibility phase is described by Hamida and Hassanain (2021) as a broad phase for assessing the viability of adaptive reuse. However, the empirical findings of this study indicate a refinement of that definition in the context of circular adaptive reuse. Rather than serving as a general assessment moment, the feasibility phase takes on a more focused role as a dedicated period to circularity-specific assessments and activities. These include setting qualitative and measurable targets in the program of requirements, assessing reuse potential, and exploring reclaimed materials in the market. This shift from general assessment to targeted research reflects the increased complexity associated with integrating circularity into design.

In the original adaptive reuse model from Hamida and Hassanain (2021), the design phase is described as the phase where detailed drawings and specifications are developed to guide execution in the subsequent phase. In circular adaptive reuse, this definition still holds, but the empirical findings reveal the addition of circularity-specific activities. These include the consultation of suppliers, experimenting with materials, offering design and circular material alternatives, and specifying disassembly methods. While the phase still consists of standard design tasks, it ensures that circular ambitions are integrally translated into clear executable outcomes.

A full overview of the recommended activities per phase, synthesised from the cross-case analysis and validated by the focus group, is presented in section 6.5 as part of the final framework. Rather than listing every activity in detail, this overview highlights the most relevant actions that support the integration of circularity in each phase.

6.5 Main RQ How can Dutch real estate developer organise the early phases of the development process to support the integration of circular strategies in adaptive reuse projects?

This research investigated how Dutch real estate developers can organise the early phases of the development process to support the integration of circular strategies in adaptive reuse projects. Based on the literature review, empirical case analysis, and validation through a focus group, the study concludes that these early phases can be subdivided into three distinct phases. These phases are identified as the inception, feasibility, and design phases, with each holding a distinct influence on circular outcomes and requiring specific activities and collaboration forms.

These insights are synthesised into a structured phase-by-phase framework, presented in Figure 50, which outlines phase-specific actions and actor relationships to support circular integration in practice. This framework clarifies in more detail how developers can initiate and guide circular ambitions by taking phase-specific activities and strategically involving circularity actors. In doing so, the framework provides developers with a practical tool to organise the early phases that support circular outcomes. The full framework is explained in detail in Section 5.4.

To complement the detailed framework, Figure 49 provides a summarised visual model that captures the key influence, circular activities, and collaboration focus per phase. It provides an accessible overview of the most important insights on how developers can organise these phases to enable circular integration.

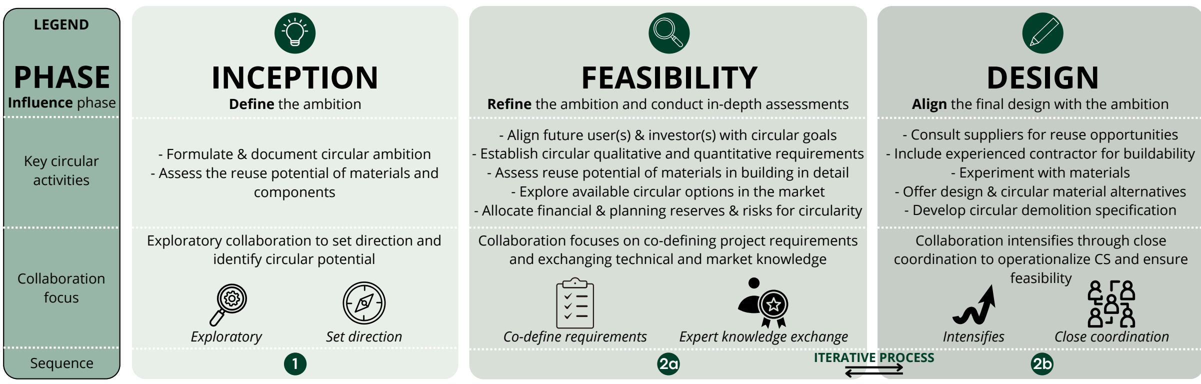


Figure 49 Summary model of framework (own work)

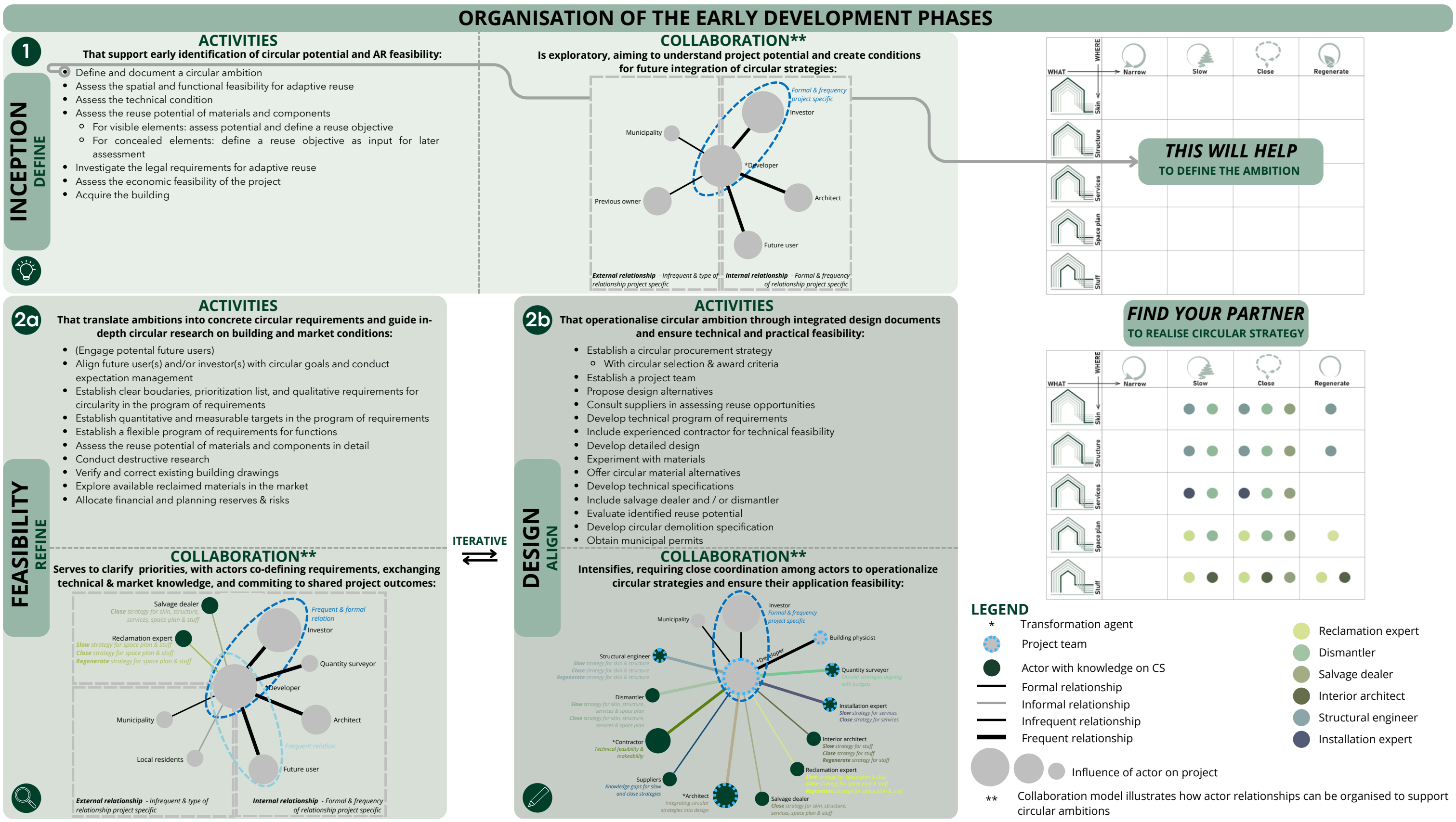


Figure 50 Framework for organising the early development phases for circular adaptive reuse projects (own work)

7 LIMITATIONS & RECOMMENDATIONS

CONTENT

7 LIMITATIONS & RECOMMENDATIONS

7.1 Limitations

This research has focused on the organisation of the early phases of the development process, including collaboration and activities to support the integration of circular strategies in adaptive reuse projects from a developer's perspective. While the research offers a valuable contribution to stimulating the transition towards more circular practices, it also has several limitations that may affect its results.

First, the research was conducted under time restrictions. This constraint affected both the number of cases that could be studied and the overall scope of the research. Although the small number of cases allowed for a more in-depth understanding and exploration of the concepts, it may have limited the representativeness of the results. Each case is shaped by its specific context, and the results are closely tied to these unique circumstances. A larger case selection could have offered broader insights into the concepts across different contexts, creating more convincing results. At the same time, the time limitation also restricted the study to the early phases of the development process. Although the literature emphasized the importance of examining the entire development process to address the interconnected nature, such an analysis was not feasible within the available time. Therefore, this study focused solely on the early phases of the development process. While it succeeded in looking beyond a single phase, thereby reducing fragmentation to some extent, the results still reflect only a partial view of the process. As a result, important interactions and feedback loops with later phases remain outside the scope of this study, which may limit the completeness.

Second, only cases within the Dutch real estate sector were selected. However, few completed projects combine a high level of circular strategy integration with adaptive reuse projects in practice. This limited availability made it challenging to find suitable cases. As a result, one case included in the study had been delivered several years earlier, causing one of the participants to no longer be fully familiar with all project details. In addition, only a limited number of participants could be interviewed for each case. These factors may have affected the accuracy and completeness of the data collected, which in turn could have limited the depth of the cross-case analysis and reduced the certainty with which conclusions can be drawn.

Third, the empirical research relied solely on qualitative research, primarily gathered through interviews. As such, the findings are based on individual experiences and reflect personal views. This may lead to incomplete or biased data, influenced by their role or interest. In addition, the method used to analyse collaboration, the multi-actor network, relies on visual mapping based on respondents' input. This introduces a level of subjectivity, as it depends on how participants perceive relationships and influence within the project. Together, these aspects limit the objectivity and replicability of the findings.

Fourth, the validation of the cross-case results was conducted with a small number of participants, all from a single organisation. While their input was valuable for refining the results, this limited number of participants may have restricted the diversity of perspectives. This reduced the opportunity for broader critical feedback or alternative interpretations of the findings.

7.2 Scientific recommendations

The results of this research offer several directions for future research. First, the results of this research cannot be generalised due to the limited number of cases. To improve the representativeness and strengthen the validity of the conclusion, future studies are encouraged to include more circular adaptive reuse projects. Expanding the number of cases would allow for deeper comparison across project types and a better understanding of the differences and similarities. Additionally, broadening the scope to include international cases could provide valuable new insights into alternative ways of organising the early phases. Such insights may reveal strategies or practices that could be transferable to the Dutch context.

Furthermore, it is recommended to include all phases of the development process in future research. This may facilitate more comprehensive guidance and better reflect the interconnected nature of the development process. Moreover, future research could explore the addition of quantitative research methods to complement the qualitative findings. Since this study relied mainly on interviews and participant perceptions, adding quantitative data could help verify certain outcomes and reduce the subjective nature. Lastly, this research showed that financial limitations were present in all cases. Therefore, it is recommended to further investigate financial barriers and explore which factors can stimulate the implementation of circular strategies in adaptive reuse projects despite these constraints.

7.3 Societal recommendations

This study is particularly relevant for developers and other actors involved in circular adaptive reuse projects in the Netherlands. It offers practical guidance on how to organise the early phases of the development process to support the integration of circular strategies. The first important consideration for practitioners is that each project is subject to its specific context. Practitioners should acknowledge that the implementation and feasibility of certain circular strategies are shaped by these contextual factors.

Second, it is important to align the project team around a shared definition of circularity and a common ambition. Developers, as central actors, are advised to take the lead in initiating this ambition, ensuring that it is both documented and communicated clearly across the project team from the outset. An early definition helps to guide decisions in later phases and improves alignment between stakeholders. To ensure that the ambition is not only formulated but also sustained throughout the process, it is crucial that the developer possesses intrinsic motivation and demonstrates proactive commitment to circularity. In doing so, the developer can actively take up the role of transformation agent, continuously reinforcing shared goals and keeping circularity on the agenda across all phases.

Third, investing in knowledge is crucial when aiming for circular outcomes. The case studies showed that, in the absence of expertise, external advisors were brought in to support the integration of CS. While this proved effective in specific phases, the research also showed that circular experts embedded within the project team tend to have greater influence on decision-making. It is therefore strongly recommended that developers identify knowledge gaps early and engage the appropriate experts proactively in the project team. This helps avoid missed opportunities and ensures that circularity is embedded in the development process. In the long term, it is advised to build in-house circular expertise, rather than relying solely on external specialists. External advisors are often the first to be removed when budgetary pressure arises, which can impact the integration of circularity. Strengthening internal capabilities increases resilience and enables developers to consistently include circularity.

Fourth, practitioners should not expect a linear development process. Circular adaptive reuse projects are inherently complex and require continuous adjustment as new insights emerge. Developers should therefore adopt a flexible approach and be prepared to revise earlier decisions when needed.

Lastly, developers play a key role in bridging the gap between circular ambitions and investor expectations. The research showed that circularity is not always recognised by investors as a priority, especially when its financial benefits remain unclear. However, when circular ambitions are translated into measurable asset value, for instance, through certifications with comparable impact as BREEAM, investor interest increases. Developers are therefore advised to proactively communicate the long-term value of circular strategies, not only in terms of environmental benefits but also through financial indicators. Other market parties, such as governmental bodies and certification institutes, can support this transition by developing recognised certifications for circularity.

8 REFERENCES

8 REFERENCES

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9 APPENDIX

CONTENT

9 APPENDIX

9.1 Appendix I: Analytical Model

ANALYTICAL MODEL

THEORETICAL BACKGROUND

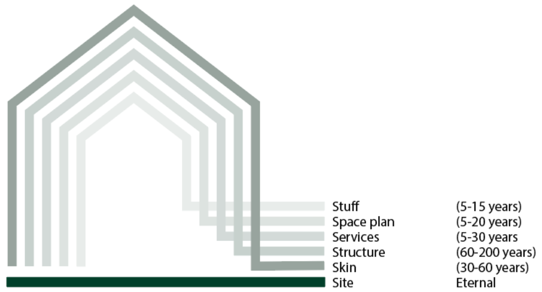
CIRCULAR STRATEGIES

What?

	Narrow	Slow	Close (now & in future)	Regenerate
	Aim for material efficiency and reducing new materials use	*Use material, products and components longer with maximal utilisation of existing value (direct reuse)*	*Use materials, products and components again (processed reuse)*	*Use renewable materials*
R-ladder	**R0 Refuse**: Prevent the use of non-sustainable or raw materials at all **R1 Rethink:** Rethink CE principles in the building design and planning **R2 Reduce**: Consuming fewer materials in design	**R3 Re-use**: Reuse products for their original function **R4 Repair**: Fix products to extend their lifespan **R5 Refurbish**: Restore old or discarded products for reuse **R6 Remanufacture**: Transform discarded products into new ones with the same function **R7 Repurpose**: Reuse discarded products but for a different function	**R8 Recycle**: Recycle materials from buildings for new use **R9 Recover**: Burn waste or biodegradable material to generate energy	
CB'23	**1 Design for prevention**: avoid new construction and where not possible design more efficiently and optimally	**2 Designing for quality and maintenance**: preservation of the existing and extending the lifespan of buildings, components and materials **5 Design with reused parts of construction**: reusing existing building components in design, extending the lifespan **4 Design for disassembly and reusability**: design for technical adaptability of components for reuse without damaging during or after use	**6 Design with secondary raw materials**: designing with reused building components and materials.	**7 Design with renewable raw materials**: designing with materials that are renewable (e.g. biobased materials).
CBA determinants strategies	Dematerilise the process	Utilisation of adjustable building components Utilisation of dismountable products Selective dismantling Implementation of proactive maintance Utilisation of movable building components	Utilisation of secondary (reused/recycled) material Application of material passport Selective dismantling	

Adopted from (Circle Economy & Metabolic, 2022; Cb'23, 2023; Evertsen & Knotten, 2024; Hamida, 2022; Ho et al., 2024; Nußholz et al., 2023; Potting et al., 2017)

Where?

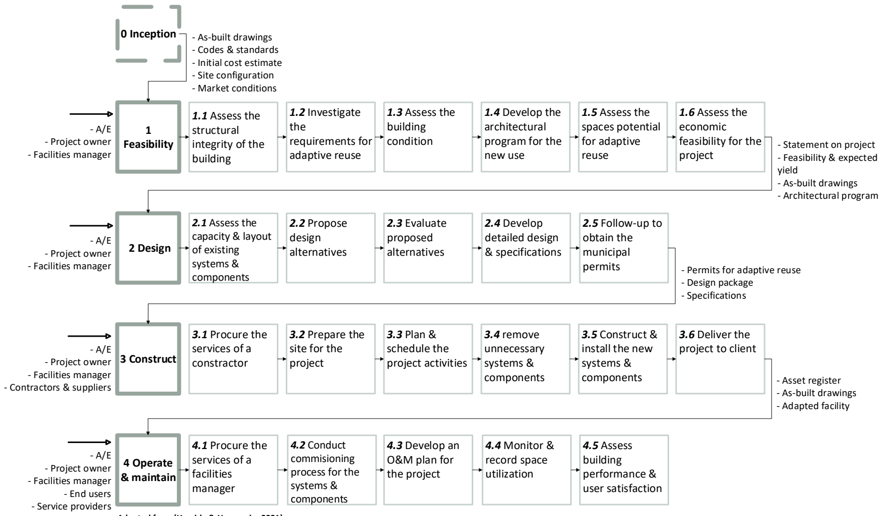


Adopted from (Brand, 1994; Transitieteam Circulaire Bouweconomie, 2020)

THEORETICAL BACKGROUND

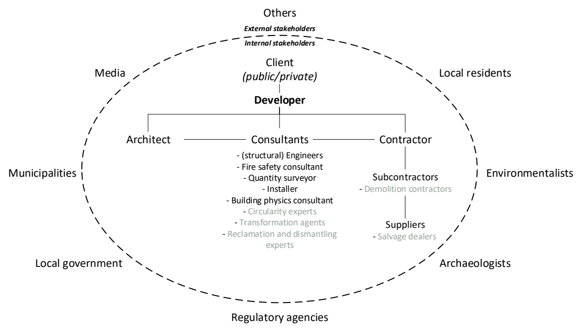
DEVELOPMENT PROCESS

When? How?



Adopted from (Hamida & Hassanain, 2021)

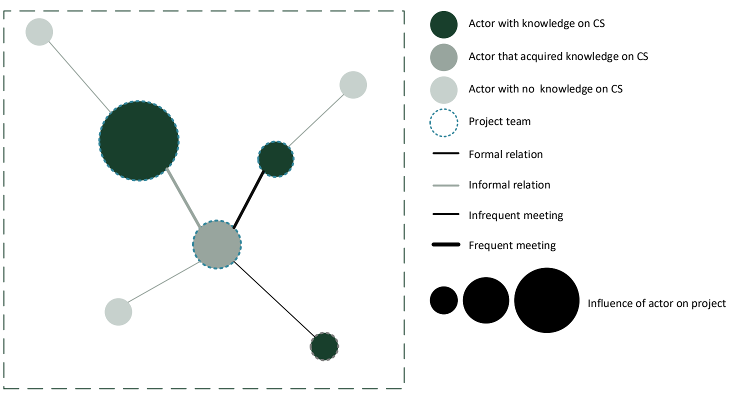
Who?



Adopted from (Chinyio & Olomolaye, 2009)

METHOD

MULTI-ACTOR NETWORK ANALYSIS



Adopted from (Gerding et al., 2021)

Actor: 'a social entity, person or organization, able to act on or exert influence on a decision'

Relations: relations are based on:
- communication frequency & duration
- exchange of knowledge
- formal & informal relations

Position: based on centrality concept.
- actor with the highest number of connections is placed in the center

Influence: Involvement in the decision-making rounds and their influence on it, based on abilities (information, knowledge, formal power)
- higher communication relates to higher influence on decision-making

Knowledge: type of actor and their level of knowledge on circular strategies
- actors with knowledge
- actor who acquired knowledge/ some knowledge
- actor with no knowledge

9.2 Appendix II: Semi-structured interview protocol

Prior to the interview & instructor's notes

- Introduce myself
- Thank the interviewee for participating
- Brief overview of the research objective
- Information on anonymous data handling
- Obtain consent, get approval
- Address questions
- Start recording

INTERVIEW QUESTIONS

0 INTRODUCTION (5 min)

- Could you introduce yourself?
- What was your role in the project?
- When did you become part of the project?
- Who brought you into the project?
- In which other phases of the project were you involved?

1 CIRCULAIRE STRATEGIES (CS) (10 min)

- Which circular strategies are applied in the project?
- Is the table accurate and complete? *SEE MIRO BOARD*
- Was circularity a central concept in the project from the outset? Was there a clear ambition or vision?
- Were there other circular strategies considered but ultimately not implemented?
    - What was the reason this strategy was not implemented?
    - When was this strategy initiated?
    - When is this strategy discontinued?
    - What would have been needed to happen differently for this strategy to have been implemented?
- Was there a specific moment (or moments) when key decisions were made that influenced the project's level of circularity?

2 COLLABORATION (each phase again)

Multi-actor network (10 min)

- How was collaboration organised in this phase? *SEE MIRO BOARD*
- Who were engaged in this phase?
    - What was their role with respect to circularity?
    - Were they part of the project team?
    - What was this actor's relationship with the others?
    - Was the relationship contractual or informal (knowledge exchange)?
    - How frequently was there contact between the actors?
    - What knowledge did they have concerning circularity?
    - What influence did they have on decision-making about circularity?

Decision-making and influence (10 min)

- Which actors were essential for knowledge and input around circularity?
- Which decisions were made about CS in this phase?
- Which actors held the most influence on decisions about CS
    - Was this decision in line with the prescribed advice and why?

    - How were decisions made?
- Was there any knowledge about circular opportunities lacking? If so, how was this gap addressed?
- Did you engage external advisers for input on circularity?
- What aspects of collaboration worked well?
- Were there obstacles in the collaboration? If so, how were they resolved?
- Did the relationships between actors change during this phase? If so, in what way?

Evaluation (5 min)
- What improvements to the actor network would have contributed to a better integration of circularity?
- Were any crucial actors missing, or were they involved too late in this phase?
- In retrospect, should certain actors have had more or less influence?

3 DEVELOPMENT PROCESS (5 min) (each phase again)
- Could you walk me through the activities undertaken in this phase regarding circularity and transformation?
    - Where there any specific challenges or successes related to transformation or circularity?
- Which best practices should be applied in future projects in this phase?
- When did you carry out the following activities? SEE *MIRO BOARD*

4 FINAL QUESTIONS (10 min)
- Which phase had the greatest influence on the project's final level of circularity?
    - When are the key decisions about circularity made, and what do they concern?
- To what extent was there feedback between the different project phases?
    - During design, did you regularly have to return to the feasibility phase?
- What was the contractor's role regarding circularity?
    - Was a dismantler involved?
- What worked well and facilitated collaboration?
- What hindered collaboration in this project?
- What would you have done differently to achieve an even higher degree of circularity?
    - In terms of collaboration: when should someone be involved, who, and with what expertise?
    - In terms of activities that need to take place in the initiation, feasibility, and design phases?
- Was a walkthrough of the building carried out to identify elements that could be reused?
    - In which phase?
    - Who was involved?
- Was circularity on the agenda every week?
- What actions were taken to reuse the services?
- To what extent were the building's end users informed of the circular objectives?
- To what extent did the cost expert possess knowledge of circularity?
- To what extent did long-term partnerships or prior experience contribute to the collaboration?
- Do you have documentation of the decisions made in each phase?

After interview & instructor notes
- Stop recording
- Thank the participant for participating

- Announce a report about the results
- Ask if he/she may know other who would be willing to be interviewed for this research

9.3 Appendix III: Planning

	Total weeks	January		Februari				March				April					May				June				July
Datum		22-24	27-31	3-7	10-14	17-21	24-28	3-7	10-14	17-21	24-28	31-4	7-11	14-18	21-25	28-2	5-9	12-16	19-23	26-30	2-6	9-13	16-20	23-27	30-4
Week		2.9	2.10	Spring break	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10	5.1
Methodology		|P2												|P3					|P4					|P5	|P5
- finalize case selection	2	|P2												|P3					|P4					|P5	|P5
- plan interviews	2	|P2												|P3					|P4					|P5	|P5
- prepare interviews	2	|P2												|P3					|P4					|P5	|P5
		|P2												|P3					|P4					|P5	|P5
Empirical research		|P2												|P3					|P4					|P5	|P5
- Document analysis	2	|P2												|P3					|P4					|P5	|P5
- Conduct interviews	3	|P2												|P3					|P4					|P5	|P5
- Coding interviews	2	|P2												|P3					|P4					|P5	|P5
- Analyse cases individually	3	|P2												|P3					|P4					|P5	|P5
- Cross case analysis	3	|P2												|P3					|P4					|P5	|P5
		|P2												|P3					|P4					|P5	|P5
Findings & validation		|P2												|P3					|P4					|P5	|P5
- Initial results	2	|P2												|P3					|P4					|P5	|P5
- Preparation focus group	2	|P2												|P3					|P4					|P5	|P5
- Conduct focus group	1	|P2												|P3					|P4					|P5	|P5
		|P2												|P3					|P4					|P5	|P5
Results		|P2												|P3					|P4					|P5	|P5
- Conclusion	3	|P2												|P3					|P4					|P5	|P5
- Discussion	1	|P2												|P3					|P4					|P5	|P5
- Limitation	1	|P2												|P3					|P4					|P5	|P5
- finalizing report	3	|P2												|P3					|P4					|P5	|P5
- make presentation P5	3	|P2												|P3					|P4					|P5	|P5

9.4 Appendix IV: Reflection

9.4.1 TOPIC

This research falls under the theme of adaptive reuse as part of the master track Management in the Built Environment from the faculty of Architecture. This choice was driven by personal motivation to support the transition in the built industry towards more sustainable practices and interest in circularity. During my master's programme, I became increasingly aware of the construction sector's significant negative impact on material consumption, waste production, and climate. This awareness led me to investigate how circularity could be operationalized in practice. Alongside this, the perspective of the real estate developer drew my attention. Their influential role in shaping early decisions and operating as a 'spider in the web' throughout the development process offered a valuable lens for investigating the opportunities for circularity in adaptive reuse projects.

This research topic aligns strongly with broader societal and environmental concerns, particularly the urgent need to reduce the construction sector's significant contribution to climate change through resource depletion and carbon emissions. By focusing on adaptive reuse and circular strategies, the study connects directly to the Dutch government's goal of achieving a fully circular economy by 2050. While the developed framework provides structured guidance for developers, its practical application may still face limitations. Circular construction remains an emerging field, and developers often operate within market conditions and regulatory frameworks that do not yet fully incentivize circularity. Therefore, the study tentatively contributes to bridging the gap between theoretical insights and practice, offering developers a direction rather than a definitive solution.

9.4.2 METHOD

Although circularity and adaptive reuse are becoming increasingly present, their combined implementation in projects remains relatively limited. This made the selection of qualified cases challenging. A multiple case study was well-suited for this research using qualitative interviews, as collaboration is difficult to investigate through quantitative research. By analysing existing projects, it was possible to examine not only the outcomes but also the organisational and process-related aspects that shaped them. This method enabled a detailed understanding of how collaboration is structured in real-world projects. At the beginning, I considered including more than three cases for the analysis to increase insights. However, based on my supervisor's advice, I decided to begin with three cases and add cases once the first three cases are analysed. In retrospect, this was a reasonable decision, as the analysis of the three cases proved more time-consuming and complex than expected.

One of the key methodological challenges concerned the case selection process. A central question was: what qualifies a project to be called 'circular'? This proved difficult to determine, as there is no universally agreed-upon definition of circularity in practice. While various tools exist to assess the level of circularity, these are not consistently applied across projects. As a result, it was challenging to compare projects in terms of their actual circular performance and to determine which ones demonstrated the highest levels of circularity. This limited the ability to select cases based on objective criteria.

Initially, the focus group was intended primarily as a validation tool to assess the practical relevance of the findings. However, upon the advice of my supervisors at the P3, the goal of the focus group was broadened to also explore possible explanations for patterns that remained unexplained based on the empirical data. This shift enhanced the focus group's value by both broadening and confirming earlier insights. It also provided an opportunity to test the interpretations against professional experience, especially for elements that lacked clear justification as they appeared in only one case.

9.4.3 PRODUCT

Initially, the intended output of this research was to visualise the actor-network per phase. However, as the research progressed, it became clear that collaboration did not follow a uniform pattern. Instead, it was highly dependent on project-specific conditions. This realisation prompted a shift in the structure of the final framework, moving towards a different format. The research thus directly influenced the development of the advisory product. At the same time, the ambition to produce a usable tool for real estate developers continuously pushed the research to stay relevant in practice. This iterative exchange between research and framework design proved essential in shaping both the content and format of the final output.

The framework developed in this research was designed to be transferable within the field of AR, independent of specific building functions. Based on the phased structure of real estate development processes, it aligns with how professionals typically conceptualise project trajectories, which enhances its applicability. In response to the feedback from my supervisors at the P4, particular attention was paid to making the framework stand-alone and comprehensible without requiring a full reading of the thesis. This adjustment aimed to increase its usability for practitioners, particularly developers. The development of a podcast also facilitated the dissemination and accessibility of the framework. Nonetheless, the applicability of the framework relies on an initial motivation for circularity from the developer. Without such intent, the framework loses much of its power.

9.4.4 PROCESS

The total graduation process took ten months and was divided into two main phases. In the first half, I focused on developing the theoretical foundation and the research methodology. During this period, I experienced a period of uncertainty as I struggled to refine my topic and methodology. I met regularly with my supervisors. These sessions helped me to refine the scope of my research. One of the biggest challenges during this period was managing my time effectively. There wasn't enough time to explore all possible options and literature in depth, which required me to make clear and decisive choices. I learned that in research, there isn't always one "right" way to approach a problem. Instead, the justification and reasoning behind decisions are what matter most. One of the most important lessons I learned was to embrace uncertainty as part of the process. Research often involves navigating ambiguity, and I improved my ability to make decisions even with incomplete information. This experience taught me the importance of flexibility, critical thinking, and trusting the research process.

In December, I started my internship at NEOO. NEOO gave me the opportunity to be involved in real projects. This provided a fresh perspective and broke the routine of academic work. It gave me practical insights and helped me understand the developer's role more deeply. I appreciated working in an enthusiastic and supportive team, which made the experience even more enjoyable. Besides that, NEOO was very flexible and supportive in how I scheduled my time, creating a positive balance between work and study. I want to thank my supervisor, Pim, for his continuous support. Our brainstorm sessions were not only helpful for shaping ideas but also motivated me to stay reflective throughout the project.

The second part of the research included the empirical part of the research and finalising the report. Finding the right cases and getting in touch with the involved actors was more difficult. Fortunately, I started early, which allowed enough time to arrange the interviews and gather the necessary data. In addition, I received valuable support from my thematic group and my colleagues at NEOO.

The research phase was one of the most engaging parts of the project. It allowed me to speak with professionals from different disciplines and learn from their experiences. These conversations not only brought the topic to life but also helped me refine the direction of the research and clarify the intended output.

Finally, I would like to express my gratitude to my supervisors, Vincent and Hans. Throughout the process, they took the time to provide constructive feedback and were well-prepared for our meetings. I appreciated their thoughtful guidance and the way they encouraged me to explore alternative perspectives. Their support played a crucial role in shaping the direction and quality of this research.

9.5 Appendix V: Framework

ORGANISATION OF THE EARLY DEVELOPMENT PHASES

1 INCEPTION — DEFINE

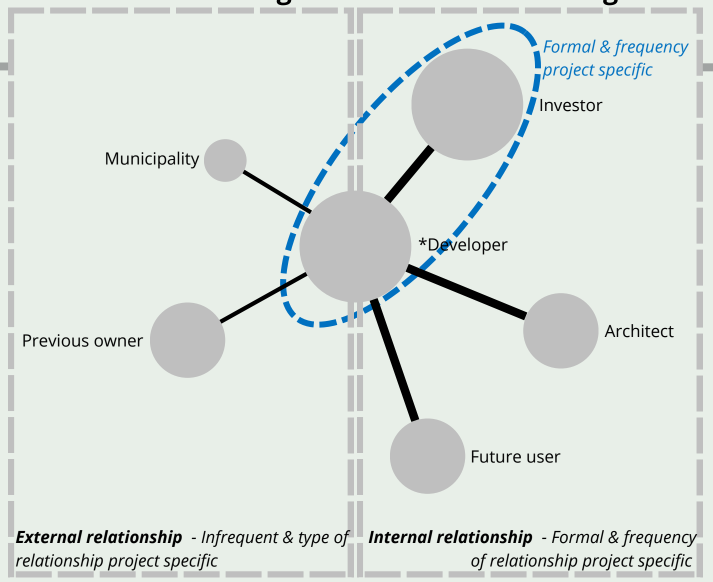
ACTIVITIES

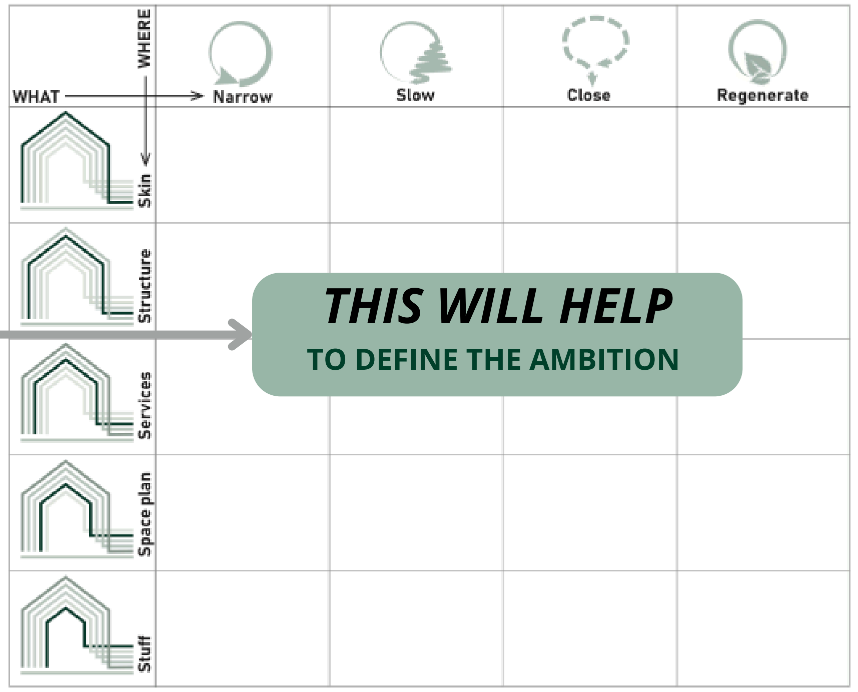
That support early identification of circular potential and AR feasibility:

- Define and document a circular ambition
- Assess the spatial and functional feasibility for adaptive reuse
- Assess the technical condition
- Assess the reuse potential of materials and components
  - For visible elements: assess potential and define a reuse objective
  - For concealed elements: define a reuse objective as input for later assessment
- Investigate the legal requirements for adaptive reuse
- Assess the economic feasibility of the project
- Acquire the building

COLLABORATION**

Is exploratory, aiming to understand project potential and create conditions for future integration of circular strategies:





THIS WILL HELP

TO DEFINE THE AMBITION

2a FEASIBILITY — REFINE

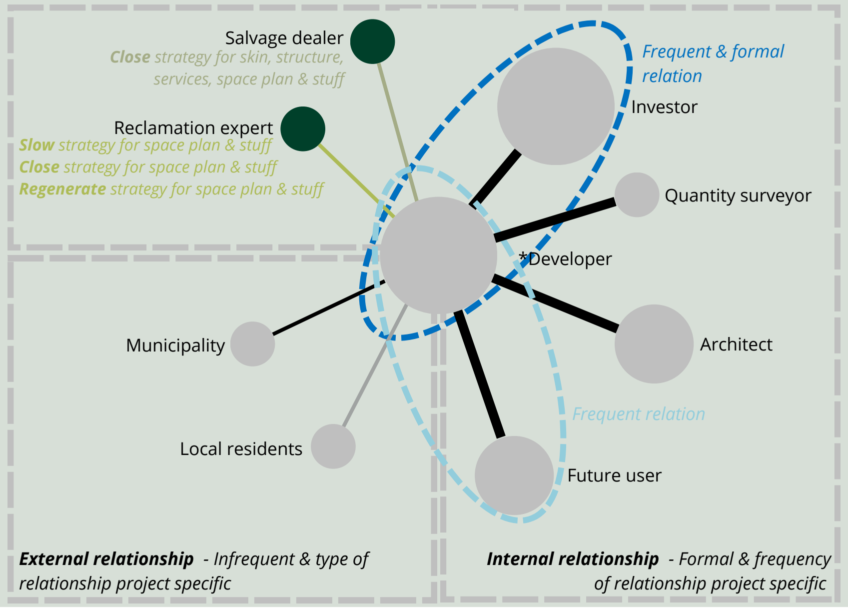
ACTIVITIES

That translate ambitions into concrete circular requirements and guide in-depth circular research on building and market conditions:

- (Engage potental future users)
- Align future user(s) and/or investor(s) with circular goals and conduct expectation management
- Establish clear boudaries, prioritization list, and qualitative requirements for circularity in the program of requirements
- Establish quantitative and measurable targets in the program of requirements
- Establish a flexible program of requirements for functions
- Assess the reuse potential of materials and components in detail
- Conduct destructive research
- Verify and correct existing building drawings
- Explore available reclaimed materials in the market
- Allocate financial and planning reserves & risks

COLLABORATION**

Serves to clarify priorities, with actors co-defining requirements, exchanging technical & market knowledge, and commiting to shared project outcomes:



ITERATIVE ⇄

2b DESIGN — ALIGN

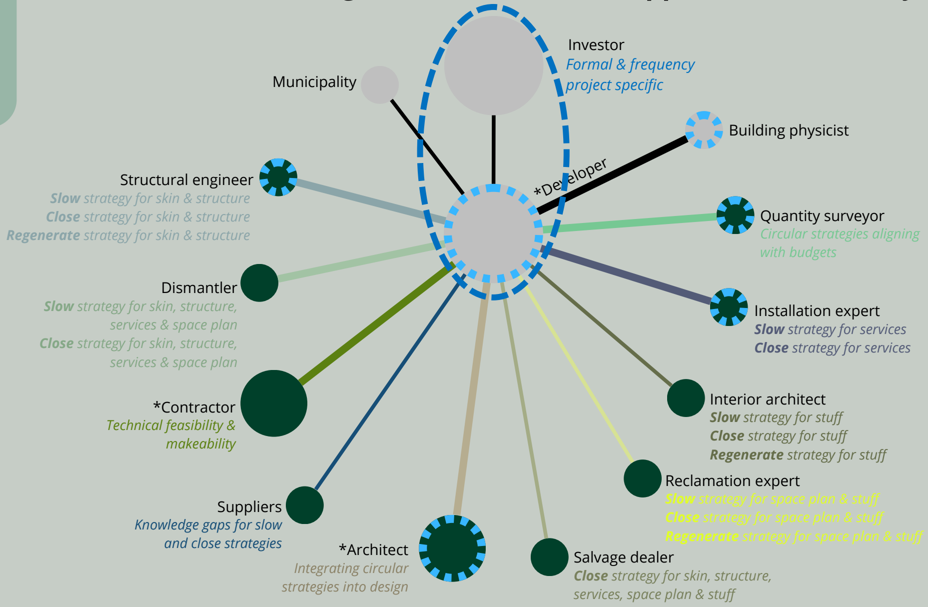
ACTIVITIES

That operationalise circular ambition through integrated design documents and ensure technical and practical feasibility:

- Establish a circular procurement strategy
  - With circular selection & award criteria
- Establish a project team
- Propose design alternatives
- Consult suppliers in assessing reuse opportunities
- Develop technical program of requirements
- Include experienced contractor for technical feasibility
- Develop detailed design
- Experiment with materials
- Offer circular material alternatives
- Develop technical specifications
- Include salvage dealer and / or dismantler
- Evaluate identified reuse potential
- Develop circular demolition specification
- Obtain municipal permits

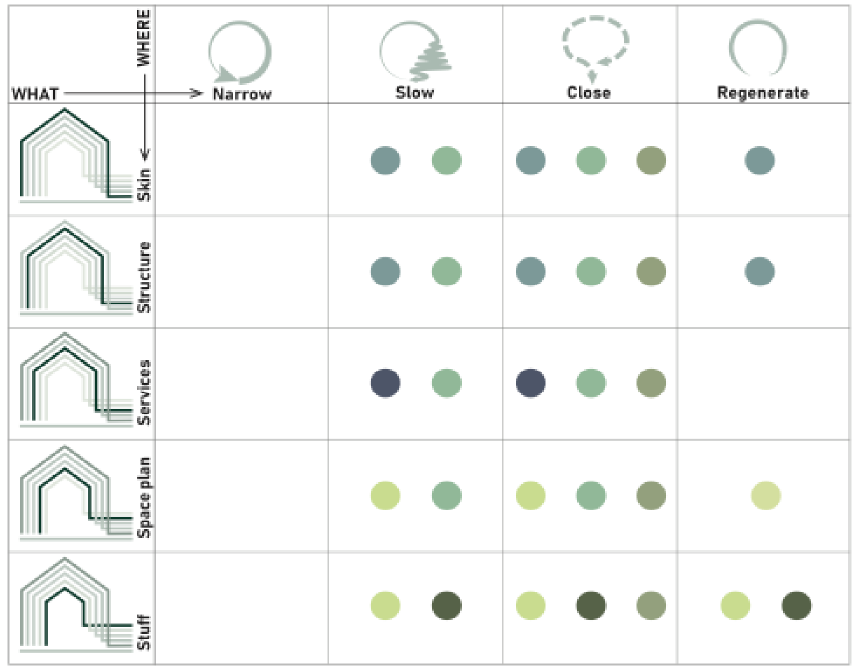
COLLABORATION**

Intensifies, requiring close coordination among actors to operationalize circular strategies and ensure their application feasibility:



FIND YOUR PARTNER

TO REALISE CIRCULAR STRATEGY



LEGEND

- * Transformation agent
- Project team
- Actor with knowledge on CS
- Formal relationship
- Informal relationship
- Infrequent relationship
- Frequent relationship
- Influence of actor on project
- ** Collaboration model illustrates how actor relationships can be organised to support circular ambitions
- Reclamation expert
- Dismantler
- Salvage dealer
- Interior architect
- Structural engineer
- Installation expert