Making sense of circular design

A case study of a large scale contracting company

Master's thesis in Design and Construction Project Management

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Abstract

Increased demands from sustainability policies have forced construction companies to scrutinize their ways of working and change from the current linear business models. The construction industry is known for the impact regarding waste creation and is responsible for being the largest waste stream in the EU, representing about one third of all waste produced. The take-make-dispose approach used in the industry today is not sustainable and introduction of circular economy concepts might transform the industry to better practices. Circular design is one of those concepts, which is currently lacking prior research and implementation in the construction sector. The report is carried out with a large-scale contractor from Sweden, which is impacted by the introduction of the EU taxonomy. The introduction of circular design in a new ISO standard and the EU taxonomy has led to a need of gaining knowledge around the subject for the contractor, and this paper aims at looking at the concept circular design from the contractor's perspective theoretically. The research aims to identify what the current knowledge of circular design is and where the current knowledge is located, what is done already to embed the concept in the organization and finally presenting actions to further promote implementation. This has been done through analyzing prior research and interviewing 15 employees within the case company. The interviewees were segmented into four different groups, with different areas of work to get a broad understanding within the company. The results from the interviews were examined after transcribing and analyzed to find similarities or differences to the literature.

Results show that a deeper knowledge of the concept of circular design is lacking in the case company, and no clear strategy is currently implemented to embed the concept in the way of constructing buildings. The current barriers preventing implementation and opportunities are identified as a result of the interviews within the case company. The major barriers identified were *economic*, *tied to the client demands*, *technical* and an *underdeveloped industry*, while the opportunities were *environmental impacts*, *usage of buildings as material banks*, and *driving change in the sector*. To conclude the thesis, the identified actions that the case company is recommended to take to overcome the identified barriers and take advantage of opportunities are *fractionalizing the concept*, *share knowledge*, and *identify economic advantages.* These actions will make the transition of a general understanding of the concept easier, whilst in the future also making circular design implementation feasible.

Keywords: Circular design; circular economy; construction sector; linear; waste reduction; taxonomy; design for disassembly; design for adaptability; Skanska

Preface

To finalize the master program this thesis has been written at the Department of Architecture and Civil Engineering at Chalmers Technical University. We would like to firstly show sincere gratitude towards our supervisor Dilek Ulutas Duman, who has helped significantly throughout the whole project and provided us with valuable guidance and expertise.

We also extend our gratitude to thank Skanska for the opportunity, as well as our supervisors at the company Lena Schälin and Mia Åkerlund providing us with knowledge and connections within the Skanska organization. We are grateful for everyone that participated in the study at Skanska with valuable interviews and general conversation providing insight and creating the basis of the study.

Gothenburg, June 2023
Daniel Caris & Johan Främberg

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Glossary/Acronyms

CE	Circular economy
CD	Circular design
DfD	Design for Disassembly
DfA	Design for Adaptability
DfL	Design for Lon

1. Introduction

This chapter provides an overview of the background of circular design within the broader narrative of circular economy and articulates the research problem. It, then, introduces the aim and research objectives, limitations, and the outline of the thesis.

1.1. Understanding the concept of circular design

Construction industry is known for the impact regarding waste creation, and is responsible for being the largest waste stream in the EU, representing about one third of all waste produced (European Union, 2018). According to a recent report, each year, around 100 billion tons of raw materials are collected from earth and around one third is estimated to go into the built environment annually (Circle Economy, 2023). Similarly, a report by United Nations says that approximately 40 percent of the extracted materials ends up as end-of-life material or lost each year in this sector by becoming waste and ending up on landfills (United Nations, 2020). With population growing globally and with a calculated recovery in the construction sector after the COVID pandemic, demands on newly built construction projects will arise. The output from the construction sector is expected to grow by 35 percent globally this decade to 2030 compared to the previous decade to 2020, causing an influx in waste generation and resource extraction. This largely due to residential housing demands and infrastructure investments (Oxford Economics, 2021).

With no change in the traditional business models in the construction sector waste and resource extraction will continue to cause environmental harm. The current work process in the construction sector is described by Cheshire (2019) as linear and is often referred as “take-make-dispose”, which directly refers to the way buildings are typically built today. The Ellen MacArthur Foundation (2023b) describes the linear model as using raw materials for creating components, which are then going to landfills after being demolished, basically treated as waste. Following the patterns off the construction sector today, waste streams and material extraction will continue in an untenable trajectory. This will no longer be a viable option as it would require infinite resources. To enable improvements on this matter, an adaption to circular economy (CE) has been discussed as a key solution. As stated by Ellen MacArthur Foundation (2023a), the CE model highlights three key principles: Elimination of waste and pollution, circulate products and materials and regenerate nature. According to Joensuu et al. (2020) the concept has gained increasing popularity within the construction sector the last few recent years and it is expected to drive the economy in a more sustainable direction in the times to come. In other words, CE is a model designed to help tackle some of the global challenges facing humanity today. Although CE agenda has been prominent in the discussion regarding constructions role in sustainability development, it has not yet been adopted by the construction sector on a wider scale, making climate goals harder to reach (Ababio & Lu, 2023). Resource scarcity, waste creation, CO2 emissions and energy use have been the key concerns underlying the sustainability and circularity goals and is heavily connected to CE implementation (United Nations Environment Programme, 2022).

The current lack of implementation of CE concepts in the construction sector has been linked to the barriers of knowledge, underdeveloped markets, siloed organizations and

change resistance to name the most recurring (Charef et al., 2021; Wuni, 2022). Circular design (CD) is seen the key topic to adapt the notions of CE in the construction sector. Despite being a underdeveloped and vaguely understood concept, CD is starting to gain traction in the sector. This due to the release of the new standard "ISO 20887:2020" and the term being involved in the EU Taxonomy which has led to involvement in certification standards. To implement CD in the practices of construction companies there is a need of creating a common understanding and identifying concrete actions. This thesis aims to understand how CD concept is understood in a large-scale contracting company, which barriers and opportunities emphasized to embed the notions of CD in the current practices. Exploring these will provide identifying possible strategies to achieve the notions of circularity in the practices of the case company.

The thesis is structured in the following manner to address all topics mentioned above. In the following chapter the background to the thesis is introduced. The current definitions of CE and CD will be explained more in depth and the surrounding policies will be introduced. In chapter 3 relevant theory is critically reviewed to form an understanding of the current research within the area. The chapter focusses on identifying the most common themes regarding CD. After that the methodology for the thesis is presented, discussing the thought process of choosing to conduct a qualitative study. It also contains the reasoning around specific actions taken to increase reliability and validity throughout the project. Findings from the empirical data are then presented in chapter 5, containing takeaways from the interviews and selected quotes. The thesis is then finalized with discussing the theory and empirical data. This by comparing the two to identify differences or similarities and concluding what the research has led to and what is needed to be done to implement CD.

The thesis is conducted through a collaboration with Skanska, who deemed the emergence of the EU taxonomy and CD aspects as important areas to gain knowledge about before they get a large-scale implementation in the construction sector.

1.2. Research aim and questions

The purpose of this thesis is to investigate sense making of circular design in a large Swedish contracting company. In order to achieve that, the thesis will seek the answers to the following research questions:

- What does circular design refer exactly within the broader narrative of 'circular economy'?
- What is the current understanding of circular design in the case company? Which circular design practices (if any) has been already implemented?
- What are seen as challenges and opportunities regarding the application of circular design practices?
- What actions are required to embed the concept of circular design in the current business of the case company?

1.3. Delimitations

The study is designed as a single case study explicitly based on the large-scale contracting company Skanska in Sweden. The empirical data consists of company documents and 15 interviews from four different divisions of the company. The decision of limiting the

study to one contractor is done due to the collaboration agreements and being able to focus on adding improvement centrally in the organization. For convenience and logistical reasons, the interviews were also only conducted in the Swedish branch of Skanska, mainly at the Gothenburg office. The implementation of CD in this thesis is referred to buildings. This limitation makes projects regarding infrastructure or similar not a part of the study. This is done because of the complexity of the topic and that CD is identified as having major impact on this segment and also because of the tendency for commercial to be more prone to adaptations during the building's lifecycle, through tenant demands and changes in building usage.

1.4. Outline of the thesis

This thesis consists of seven chapters, namely the following:

Chapter one – Introduction: This chapter introduces the aim and research objectives, highlights the limitations, and also gives a background to the thesis.

Chapter two – Background: This chapter includes the current perception of the concepts CE and CD is discussed and put into context of the construction sector.

Chapter three – Theory: Barriers, opportunities, and implementation: This chapter aims to develop a theoretical framework used as a basis for the thesis, presenting current knowledge, barriers, possibilities and implementation.

Chapter four – Methodology: This chapter presents the process of selecting the methods used for the paper, and how it was executed.

Chapter five – Findings: In this section, a compilation of the most relevant findings from the empirical data is presented. The chapter consists of topics generated from data collected from all interviews where answers are analyzed and used to highlight key findings related to the implementation of the concept CD.

Chapter six – Discussion: The preceding chapter presented the analysis of the empirical data collected through interviews from the case company. The purpose of this chapter is to draw together the findings outlined in the previous section with consideration from the theoretical background.

Chapter seven – Conclusion: To conclude this thesis, the conclusion section puts the findings of the interview study and literature into a larger context by reflecting on the purpose of the thesis.

2. Background

In this chapter the current perception of the concepts CE and CD is discussed and put into context of the construction sector. The chapter starts broad with the explanation of CE in construction and the narrows down to the different CD definitions identified.

2.1. Definition of circular economy

The existing literature that is a part of this study does not provide a unified definition of CE. The concept is very broad and therefore difficult to understand how it can be implemented in the business practices. This brings challenges for the construction sector organizations to develop strategies to understand and initiate change towards circular business practices. The vagueness of the concept and lack of clear strategies to achieve circularity gets complicated with the unresolvable problems regarding knowledge sharing and siloed work processes in the construction sector. The lack of clarity around the concept is highlighted by Kirchherr et al. (2017), who also claim that a vague definition or too many definitions may ultimately cause the concept to collapse and become nothing but another buzzword for the industry. This statement is supported by Eberhardt et al. (2022), saying that a fragmented definitions may act as hindrance for the unified adoption of CE for the construction sector. Kirchherr et al. (2017) identified a total of 114 definitions of CE when exploring how the concept is interpreted. This shows how understanding of CE is very scattered. Blomsma and Brennan (2017) point out stating that CE today is best viewed as umbrella term where already existing concepts can be tied together to create more effective strategies towards different goals. Although CE it is often interpreted in different ways, as a mega narrative, it seems to cover similar aspects such as life-extension of resources, reuse, recycling and repair for example. Problems with too many alternative definitions are highlighted by Blomsma and Brennan (2017) as well, who emphasize the need for further theoretical development for identifying critical success factors, indicators to embed the notions of circularity in traditional linear business processes. In addition, Figge et al. (2023) are critical to some of the most known definitions of today. According to the authors, a good definition should provide an understanding on what CE is, as well as keeping it separate from other related concepts. They further state that CE will be an important concept to bring down resource use in the future, but that it will have to be accompanied by multiple other concepts as well.

One view of the concept is gathered from Khan et al. (2020) which pinpoints that closing of material loops is the most central aspect in CE. They define it as:

"A general term covering all activities that reduce, reuse and recycle materials in production, distribution, and consumption processes."

A commonly used source of information on CE in construction is the Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2013, 2021), stating that CE 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."

The Ellen MacArthur Foundation emerges as a key actor shaping the narrative of circularity in the construction sector. They collaborate with ARUP, a design and engineering consultancy company in the UK, to develop reports and toolkits for the sector organizations. Our research shows that Ellen MacArthur Foundation is a key actor leading implementation of circularity within the construction sector which emerges as a key point of reference in different projects aiming to implement practices in line with circularity. Ellen MacArthur Foundation was founded 2009 with the sole purpose to create a CE and has collaborated with segments from the majority of sectors.

2.2. Definition of circular design

CE is a complex concept that consist of several aspects challenging the traditional methods of construction today. One concept under CE is CD, where the design of products is taken into consideration and aims to reduce raw material losses by letting material circulate in closed loops (Medkova & Fifield, 2016). It is an important aspect of trying to improve the circular material flows in the construction sector, by designing to improve the value of the building material during the lifetime as well as minimizing waste. CD refers to a design approach where existing materials are meant to be used again, for example when a building is to be removed. This design will facilitate and enable the materials and construction elements to be reused in the future by constructing in a way that enables building components and materials to be separated from each other in an effective way. This mindset differs substantially from the standard way design is used today (Kozminska, 2019). This way of designing is not used today, which becomes a major challenge towards enabling more recycling and reuse in the future. According to Ellen MacArthur Foundation (2021), it is mentioned that with no considerations of designing with CD in mind, as things are conducted at the moment, is one of the major hindrances towards enabling more recycling and reuse in the building lifecycle. The fact that only 20-30 percent of construction and demolition waste can either be reused or recycled is due to the linear approach in design.

Antonini et al. (2020) identify two concepts regarding CD as reversibility and durability. Reversibility means that processes used on an object to make it suitable for a particular purpose can be reversed so that the object maintain its highest value possible, preferably restored to its previous condition. According to Caroli et al. (2022) implementing brief actions that promote reversibility enables for recovery of elements after their service life but still within the technical lifetime. They further suggest action to achieve this such as using prefabricated constructive systems, developing material passports and integrating building information models. Durability suggests building elements should be able to outlast the purpose they are designed for over long periods of time, since disassembly is only possible if the materials have withstood wear and tear so that they can be used again.

The different research discussing CD in the literature have resulted in numerous sub concepts such as design for longevity (DfL), design for adaptability (DfA) and design for disassembly (DfD). For Moreno et al. (2016) these concepts cover issues related to design for resource conservation, design for slowing resource loops, design for repair/refurbishment, design for easy maintenance, design for flexibility and design for disassembly

They further argue that the role of designers in construction has gained greater and greater recognition as the industry has moved from highlighting green design, to design for sustainability, to design for circularity to the concept of "circular design" as the most recent term, the most recent term. However, as Lewandowski (2016) emphasizes, there must also be a well-fitting circular business model in place to stimulate circularity. Business models that exist today are limited in their ability to support the practices in line with circularity.

2.3. The different design concepts

As stated above, CD refers to sub-themes such as DfL, DfA and DfD, which are identified as vital to concretize and create a deeper understanding of CD. In addition, both the ISO Standard 20887:2020 (2020) and the Ellen MacArthur Foundation (2013) cover these themes and deem them as important to reach a circular built environment. Drawing on above sub-themes coupled with the Ellen MacArthur toolkit it is possible to simplify the term CD and figure out implementation strategies. The ISO standard is only revolving the aspect of DfD and DfA. The aim of implementing DfD according to the ISO standard is to promote the ease of access to components, supporting re-use business models and safety of disassembly. To achieve this, practices like choosing materials and components which can be easily removed or replaced, providing a disassembly manual and have spare parts available to the more custom-made components (Ellen MacArthur Foundation, 2022). DfA is described in the Ellen MacArthur Toolkit as more focused on the use stage and is divided in specific changes for known or expected adaptation as well as general changes for unknown potential future adaptations. This aims to future proof the building, making it available for other use types, climate changes affecting the building and being more resilient in general. DfL is referred to as designing with material that will stand for a very long time. It requires for high quality and durability in the materials. Benefits that aim to be achieved with implementing either or both DfD and DfA principles is a more efficient way of conducting future rework, thus resulting in less labor time, material, and energy costs, but also in the aspect of optimal recovery of components to maintain the highest value possible.

The Ellen MacArthur foundation adds specific actions in their available toolkit and expands on the strategies and puts them in categories based on their perceived impact level. In the category with the same impact as DfD and DfA, DfL is also added (Ellen MacArthur Foundation, 2022). Together, these three design strategies form a category with actions that are all of high impact level, meaning that there are great opportunities to build according to these, both economically and in regard to sustainability. There is only one category that has an even higher impact, that category is "refuse unnecessary new construction".

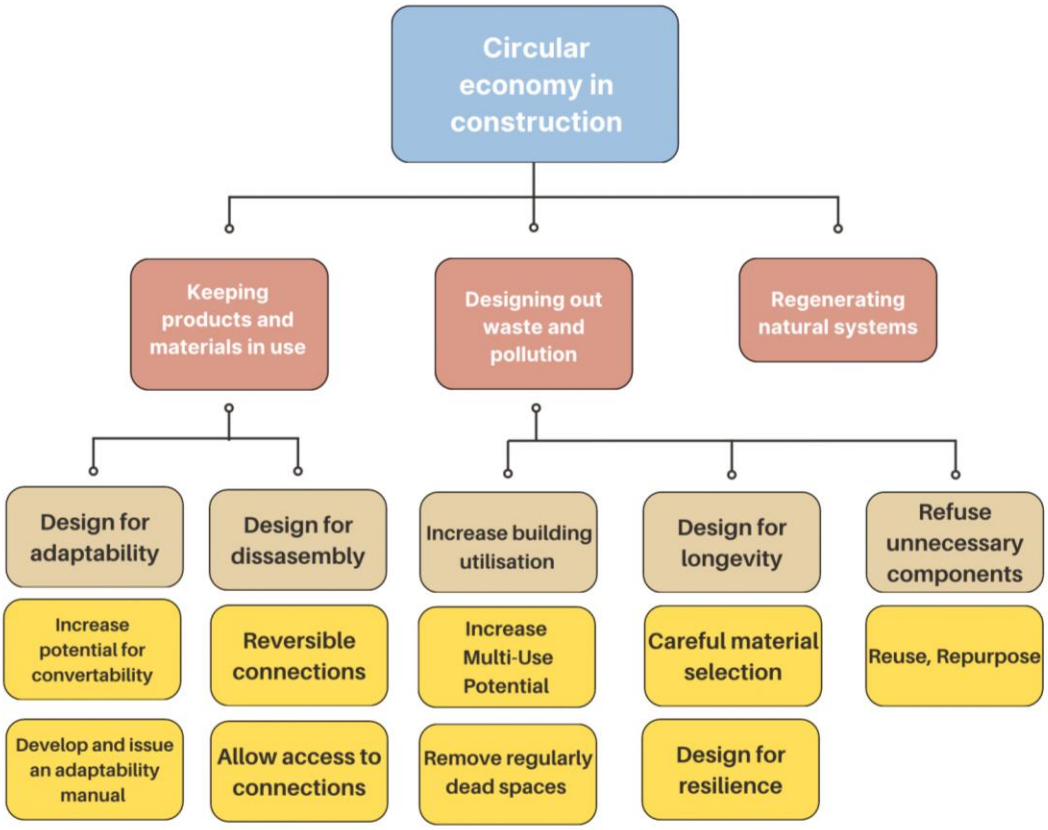

Figure 1. Illustration of CD as a concept, connected with theories and actions.

2.4. Policy aspects: ISO-Standard and the EU Taxonomy

CE and CD emerges as key themes in the most recent policy agendas regarding sustainability. On June 22nd 2020, the EU taxonomy was published and was taking into force 12th of July the same year by EU. The taxonomy was introduced following a need of higher standards in order to meet the EU's climate and energy targets, the introduction of this new classification system is set to clarify definitions and create a common language between sectors regarding economic activities, aiming to prevent greenwashing activities and improve trust between investors, policymakers and companies (European Commision, 2023). The taxonomy is divided into six environmental objectives, all targeting different aspects within the scope of the "European green deal". The objectives are as follows:

1. Climate change mitigation
2. Climate change adaptation
3. The sustainable use and protection of water and marine resources
4. The transition to a circular economy
5. Pollution prevention and control
6. The protection and restoration of biodiversity and ecosystems.

According to the EU Taxonomy, to fulfill the economic activities, it is demanded to make substantial contribution to one of six goals, and no significant harm to the other five goals. CD is part of the fourth objective, the transition to a CE. Adapting practices related to CD

in the construction sector is currently hard to achieve. This is since the concept is yet relatively new and what actions are needed to make a substantial contribution is not clearly defined yet. Not having concrete targets to achieve, or something valued, makes it difficult for the construction sector organizations to set their own agenda and targets to adapt CD practices. Despite the lack of concrete definitions, the term is finding its way into certification systems. LEED, BREEAM, Miljöbyggnad 4.0 (Sweden Green Building Council, 2022) and Svanen (Miljömärkning Sverige AB, 2023) are all certification systems that have added circular design to their evaluation. The certifications have different headings used for similar actions regarding CD, with “design for flexibility “, “functional adaptability”, “flexibility and disassembly”, “transition to a CE” all being used as within the four systems. Despite the different terms in certification systems, their relations to CD builds upon the new ISO standard 20887:2020, “Sustainability in buildings and civil engineering works – Design for disassembly and adaptability – Principles, requirements and guidance”. The standard covers DfA and DfD which is what is referred to in the different certifications as well to achieve CD.

3. Towards circular design practices: Barriers, opportunities and implementation

This chapter aims to develop a theoretical framework used as a basis for the thesis, presenting current knowledge, barriers, possibilities and implementation. The framework will link relevant theory to the report and provide background and discussion to the concept of CD in construction.

3.1. Barriers in construction for circular design

The complexity and wide scope of the CD concept brings difficulties impacting the transition towards circularity in the construction sector. Minunno et al. (2018) states that construction sector is falling behind compared to other industries when it comes to the implementation of CD aspects like recycling, reusability and reducing material waste. There is extensive literature discussing the barriers to adapt the notions of CD. Through this literature five main themes are identified and reviewed critically.

3.1.1. Economic barriers

Investing in CD means making investments with long payback time, as a buildings technical lifetime expectancy is upwards of 100 years. This constitutes a financial uncertainty for construction companies wanting to be profitable short term. According to Selman & Nørkjær Gade (2020) many companies see this as a barrier, as it can be too big of a risk to take. Additionally, Munaro and Tavares (2023) point to the high availability and low cost of raw materials as a hindrance in adopting CD. The authors state that this works against the transitions by offering a cheaper option, thus creating a lack of incentives to invest in CD at the moment. This is agreed upon by Ababio and Lu (2023), stressing that tight constraints in the budgets of projects acts as hindrance for many of the desired CE strategies such as circular design, causing the industry to continue with business as usual. They also highlight that the market for recyclable material is dysfunctional, that the cost for disposal is lower than the cost for recycling or recovering materials and that there is an uncertainty regarding the economic resale value of used materials. According to a survey in the report by Adams et al. (2017), it was shown that the economic challenges are the most important ones, ranked as number one by most stakeholders. The cost and associated profit could be seen throughout multiple construction companies as the single most important factor in decision-making. Since construction companies mainly focus on short-term economic gain, the authors state that it is important to present the economic benefits in real numbers and not just theorical ones. This would be more appealing to companies and could speed up adoption of CD.

3.1.2. Barriers related to regulatory and policy demands

The policies and legislations shaping the practices in the construction sector today is mostly still associated with the notions of the linear model. Main focus points within legislation are connected to waste management instead of forcing companies to act in a circular manner. According to Selman & Nørkjær Gade (2020) and Adams et al. (2017) governments can play a critical role in the transition towards circularity and sustainability. It is also mentioned by Moreno et al. (2016) that stricter policies and regulations aimed at promoting circularity are deemed to be decisive for businesses to adapt to new ways of working and being forced into adapting to the CE business models. The fact that there is

a lack in legislation outside the linear model is causing the industry to fall behind in the adoption of CE. Munaro and Tavarez (2023) also highlight the need for government plans for the construction industry to become more circular in the future. They further argue that the regulations regarding CE aspects like reuse, landfilling, recycling, planning, design, procurement and repair are considered major challenges for the implementation of CE in the sector. According to Adams et al. (2017), regulations at the moment regarding this ultimately benefits business as usual. It is suggested by Charef and Lu (2021) that more emphasis should be put on making changes in the traditional contracts. For them, inclusion of factors like making sure all the building documents that facilitates CE are required by law, stating who has responsibility for components in the building after it has been used and what to do with those components. This step could help to manage and facilitate the end-of-life stage of buildings and would make less materials go to landfill. Also, they further suggest that more regulations could be aimed at manufacturers of building components. This would add further responsibility on manufacturers in making sure to take back their used product from the end user for reprocessing or develop products that are easily separated from other materials. That would keep materials and components away from landfills as well and provide a better possibility for reuse or recycling. Both Charef and Lu (2021) and Munaro and Tavarez (2023) discuss that governments and policies could also further help encouraging shift to circularity by creating new economic incentives. For them, tax deductions or other economic incentive agendas can encourage companies to adapt practices in line with circularity faster.

3.1.3. Technical barriers

The growing literature on circularity emphasizes many technical barriers such as the lack of information regarding the existing building stock, the issues related to reversible assembly of the materials, and inadequate waste management processes. Honic et al. (2021) state that newly built construction projects today are relatively well documented compared to the existing building stock. Older buildings might have been altered and adapted several times during their life cycles, causing the original materials to be replaced without being documented. This lack of documented changes and information regarding materials in the built environment is referred to as one barrier for reuse and recycling by the authors. Knowing what materials are in the buildings when that particular one is to be deconstructed is shown as a key issue to move towards CD and CE.

Technology within the sector such as building information models and digital twins has developed in the recent years and allow for precise control of what materials are in the buildings and constitute a fundamental aspect of construction today. Despite this, development of new circular business models and processes require the existence of appropriate technology to support in the areas where we lack today. Buildings made in complex ways often consist of compounds that are hard to separate, making reusing and recycling hard (Selman & Nørkjær Gade, 2020). It is argued by Dams et al. (2021) that instead of using individual elements and connections for different building components, one could use more standard ones instead. Technically difficult connections between components would make materials harder to separate. Consequently, more material would end up breaking and go to waste instead.

Designing for materials to be circular in construction projects is considered crucial and requires for the relevant material data to be available to the end customer. In addition, an extra focus is needed on construction details when designing and planning for the project, for the materials and elements to be separable when it´s time for deconstruction. In the paper by Ababio and Lu (2023) managing to store all relevant material data and their associated processes and how to share it with the end user constitute one barrier. Lack of information on the quality and properties of salvaged materials is another.

3.1.4. Social and cultural barriers

There are barriers including factors societal trends and different human behaviors. Human behaviors such as change resistance is mentioned as the most frequently mentioned barrier in this segment, and can often be linked to the low-risk culture within the sector according to Charef et al. (2021). Much of these are related to the modern consumerism that exist today, where concepts like reuse and recycling often is undervalued. As argued by Selman & Nørkjær Gade (2020), there is tendency that people prefer the exclusivity of new materials rather than opting for reuse and recycled alternatives. Wuni (2022) point to the general perception that the construction industry is hesitant to new concepts and often resists to change and that there is a lack of interest in reusage of products and materials compared to using raw materials. Dams et al. (2021) also point to the fact that very complex and architecturally innovative design could constitute one barrier that will need a change in mindset from the sector and architects in particular. Although being attractive to the cityscape, this kind of design is less desirable from a circular point of view, since they are harder to design for disassembling purposes and require more unique technical solutions. Kanters (2018) agrees with Dams et al. (2021), stating that CD might need a big change in mindset from architects and other actors in the industry if to be implemented successfully. Buildings need to be viewed as dynamic and flexible enough to satisfy changing requirements, instead of being viewed as static structures.

3.1.5. Barriers regarding the knowledge gap

The vagueness of the CE concept is according to Ababio and Lu (2023) creating information related barriers and misconceptions hindering the actual implementation. In a study by Brussels Environment (2017) it was reported that most stakeholders within the construction industry were not familiar with reversible building design principles, thus difficult to convince them of building towards these standards. Further, Charef et al. (2021) emphasize that different divisions in the same construction company might have varying knowledge and experience of the concept, causing the information flow between them to be insufficient and incorrect. They continue, saying that a lack of knowledge on the benefits with CE would also contribute to fewer clients putting demand on the construction sector, an unimproved perception of the concept, and less dissemination. Both Wuni (2022) and Selman and Nørkjær Gade (2020) insists on the importance of information and collaboration between all involved actors within the value chain, expressing the lack of awareness on CE across this whole network, ultimately making the adoption of CE unnecessarily time consuming. The vagueness of the CE concept creates information related barriers and misconceptions. As long as there is a misconception on what is considered as CE, this will act a challenge hindering the actual implementation (Ababio & Lu, 2023). Charef et al. (2021) emphasize that in addition, the case could also be that different divisions in the same construction company having different knowledge and experience regarding circularity causes misunderstanding.

3.2. Opportunities with CD in construction

Although achieving circularity is met by difficulties mentioned above, there are also some big opportunities accommodating the transition towards circularity. In this section, different kinds of opportunities identified in the literature will be discussed.

3.2.1. Environmental opportunities

CD aims to create continuous material cycles contributing to the decrease of raw material consumption. As stated by Liikanen et al. (2019), a decrease in raw material processing and usage within the construction sector would have a big impact on climate change. This would directly contribute to the reduction of negative environmental impacts on the planet. Therefore, the design phase is important when constructing new buildings as it will achieve these benefits if done properly. Historically though, according to Bertino et al. (2021), buildings have been viewed as permanent objects, with very little consideration to demountability. Although deconstruction of materials and components are happening today, a very small percentage of the worlds existing buildings are fully demountable. Idealistically, future buildings will be fully designed for enabling maintenance, repair and reuse whenever needed during the building's life cycle. A more circular built environment would, as suggested by Stinj & Gruis (2020) leave the industry with better resource efficiency and less climate impact. This also means close analyses will be needed in the planning phase, breaking down the way the building is constructed into single elements. Starting with the load bearing parts, then analyzing other various building components that make up the building, as well as analyzing the ways these parts connect to each other. In addition, Ellen MacArthur Foundation (2018) highlight that flexible, modular and shared spaces will be appreciated and more common as they will increase the total utilization rate of buildings. These actions driven by design ultimately aim at keeping materials used at their highest value possible for as long as possible and thereby keeping the amounts of waste down to a minimum.

3.2.2. Using existing buildings as material banks

In an environment where CD methods are standard in construction projects, the existing building stock could be seen as material banks in which materials and components are meant to be used again after a building's life span. For this to be possible, Sanchez and Haas (2018) claim that a thorough investigation and inventory of buildings needs to be in place. Hopkinson et al. (2018) agrees with this and stresses the importance of a CD if this is to work in the future. To make sure materials retain their high value, which means their quality is good enough for direct reusage, the authors continue by stating that the buildings must be designed for this type of material recovery. They highlight that the existing buildings of today are not designed for this.

It is further discussed by Sanchez and Haas (2018) that for construction companies to know which reused materials that are available for them to build with, an extensive amount of data about existing buildings and their materials is also needed. A lot of data could be found today on the existing building stock, although this information is scattered and difficult to compile. However, this is important to manage for the future as it would offer a big opportunity if successful. Today, as suggested by Eberhardt et al. (2019), only

a fraction of the total material value from buildings is utilized. This means that most value, both economically and regarding sustainability is lost at the end of a building´s life span. This is due to factors like the ones mentioned above, with information above the buildings being scattered or undocumented in the first place. They further state that with access to the relevant information, and with buildings designed to be deconstructed smoothly, a whole new approach and view on existing buildings would emerge. Where material in the built environment would circulate until there was no field of use left for it. This would reduce the raw material consumption, and by this limiting emission creating processes used to turn raw material into usable components for the sector.

3.2.3.Economic opportunities

Literature points out that CD can be associated with economic opportunities. Gorgolewski (2008) claims that companies are now starting to view waste material as lost resources and lost financial profit. This material could be sold or used in other projects within the company, improving profit either way. In addition, Gorgolewski (2008) states that unprocessed reused materials are in general cheaper to buy than new ones, meaning less money spent on material for construction companies. For the material to be cheaper, it is important to what extent the material needs to be reprocessed or remanufactured after deconstruction. This is since reprocessed materials, where material needs to go back and forth from suppliers to be fixed to be used again, tend to cost more than completely new ones when all steps are considered. This proves the importance of planning for the deconstruction team to keep reusable components undamaged and without need of reprocessing.

Simultaneously, López Ruiz et al. (2020) adds that costs linked to landfill are reduced. CD also means designing out as much waste as possible, meaning less material goes to landfill. Gorgolewski (2008) continue by further emphasizing the importance of the whole design of the building in order to make use of the financial opportunities. The level to which a building is designed for disassembly is directly connected to the possible financial benefits at the structure at end-of-life stage. From their study, López Ruiz et al. (2020) concluded that economic benefits can be increased by a higher level of CD, thus agreeing with Gorgolewski (2008). This makes the design phase the utmost important aspect when moving towards future circularity.

3.2.4.Drive development along the value chain

According to Górecki et al. (2019) the development of new circular models and structures require changes in the whole value chain, covering all of the involved actors in construction. Hence, implementing CD principles will help develop other actors in the industry. Actors like suppliers, clients and manufacturers of building elements are some examples of actors that would be affected in different ways by adaptation of CD. This transition could also further increase collaboration between these. For full adoption to CD, Górecki et al. (2019) continue, stating that it will require a far more developed market situation. Manufacturers of materials will need to develop new products that meet the requirements for a more circular design, meaning that products are separable and have separable connections. Further, construction companies must design in a more circular way and there must be companies specifically targeting deconstruction work and making that process more effective in the future. Lastly there is a need for a functioning aftermarket where reused materials can be handled, stored, and sold.

Rios et al. (2015) believes that actors will develop and gain knowledge and skills to stay competitive when clients start putting higher demand regarding CD and more environmentally friendly construction projects. Incentives created from government legislation will play out the same way. Gorgolewski (2008) states that the transition toward CD will create new roles and business lines in the construction sector where holes in the market value chain are identified. For example, stakeholders specialized in deconstruction could be a new demand. Similarly, material handling and marketing of salvaged components will create an alternative business opportunity. Some actors will most likely see a business opportunity in offering these services and this will create new sources of employment. Khan et al. (2020) agrees, suggesting that the full scale implementation of CD principles would create professions not previously needed by the industry.

3.3. Adapting circular design

Implementation of circular design practices needs considering the issue at multiple levels including sector, organization, and project. One key issue regarding the sectoral level is deciding if there is an identified stakeholder and if there is, which stakeholder is responsible to drive the change. This part of the literature was more easily identifiable as prior research often highlight the same actors as responsible. Later in the section instead the focus is on the organizational and project discussions. Regarding this adaptation of CD, there was an identified lack of case examples describing a clear strategy implemented and lack of identified literature.

3.3.1. Sectoral level: Who are the identified main stakeholders?

The transition towards circular design practices requires thinking at multiple levels. As stated earlier in the literature, barriers relating to the sectorial level have been identified and discussed. Buser et al. (2021) emphasize the lack of clarity regarding who is responsible from what in transition towards circularity. In other words, who owns the process regarding the implementation of CE. Identifying this in both the sector and company could be key to reduce confusion on the subject and simplify future adaptation. They further emphasize that with few to no projects involving CD ongoing or involved in past empirical research, the focus on research in the sector today is transitioning the available theory into practice. The Ellen MacArthur Foundation (2018) has identified three potential “first movers”, stakeholders who has the potential to have big impact on the acceleration of a circular built environment in the sector. These stakeholders are policymakers, investors and clients. In the report current and future practices are researched.

According to Ellen MacArthur adaptation of policies to CE has been gaining momentum, but to different degrees in different countries (2018). Policymakers have the possibility to drive change, with simplifying and forcing new ways of working. The policy development is still lacking, with reasons being heavily connected to earlier mentioned barriers regarding siloed work processes and lack of incentives from stakeholders in the sector. The actions that are being mentioned to increase circularity and collaboration in the sector by the respondents in the study are to create economic incentives, enhance private-public collaboration and specify circular public measurements. Policymakers

themselves noted the need for projects involving CE concepts to provide an evidence base to develop the policies.

Since the economic barriers in the Ellen MacArthur study are seen as one of the most common barriers in literature, investors venturing into the circular built environment projects would be a major step to erasing the current economic hindrances. Investors themselves identify twice as many barriers than opportunities proving there needs to be more identified economic benefits before investments are made. Change in valuation standards, pilot projects and new policies are some of the actions put forward by investors.

Due to the fact that construction companies build what the clients include in the tender, they are generally followers rather than leaders in innovation. From a study by Bertozzi (2022) it is identified that when CE has been implemented it was the most common it was through initiatives from the project owners, followed by architects. In the same study, a lack of client initiatives regarding CE aspects is identified as causing of the stagnant increase in implementation. Ellen MacArthur Foundation (2018) mentions that clients are however involved in activities regarding improving of knowledge of CE actions to a larger extent that other stakeholders. However, the current legislation is hindering actions to be taken, being more adapted to regular ways of working i.e., the linear model. The clients are identifying collaboration with other stakeholders as important, where they can show leadership and set new standards in synergy with stakeholders.

3.3.2. Organizational level: Lack of case studies

Although there has been a growing interest in circularity within the construction relevant literature in recent years, the majority has been theoretical (Ababio & Lu, 2023; Joensuu et al., 2020). Only one report on organizational implementation was identified which is demonstrating that there is a need for research showing how to implement CD in practice.

In the report on organizational implementation by Buser et al. (2021) two cases of implementation of CE are studied in the Swedish and Danish context. Commonly in the two cases, is that the implementation has been via the use of specific tools or techniques instead of programmatic events. There is no formalized strategy within circular building, instead the initiatives come from the clients or personal motivation. The organizational steps that have been made in the Danish case are changes in titles and recruitment of new specialists within the area. The Swedish case is similar with lack a of organizational implementation, and a focus on more project-specific cases with no clear practice in the bigger picture.

3.3.3. Project level: Where to start?

CD practices have been implemented in the construction industry, with some recent research highlighting practices and overview. In a study by Bertozzi (2022), CE action was mentioned in many of the project cases, but not seriously considered, due to a lack of knowledge, timing dilemma and difficulties finding actors to support implementation. One part of the project phase that was considered lacking is the early stages, where expertise in technical aspects and experience is currently lacking. Despite the limited success, there were some advances being made regarding understanding and awareness due to the discussions of the topic CE withing the projects, and how they would need to be performed to enhance the chances of success. Further, the implementation of CE in

construction is highly dependent on specific organizations or people leading the change. The current practices are according to Bertozzi (2022), large projects with high visibility to the public or smaller projects with less technical difficulties is currently the most frequent and have most potential. Current studies that have looked at the aspect of DfA in projects has come to the conclusion that most of the buildings that underwent adaptability practices were not intentionally designed for adaptability, supporting the consensus that CD within construction is yet in it's infancy (Rockow et al., 2021).

Kozminska (2019) identified several projects in her report working with reuse and CD implementation, however all of the projects except one was directed towards reuse aspects. The report did not provide insight on what was successful with the particular CD aspects, however within the project on a small-scale building, CD aspects such as construction with reversible joints to allow for flexibility and demountability. It also had prefabricated elements, often mentioned in literature to be in constructing flexible buildings. One project was initiated 2015 and is called Building as material banks (BAMB). This EU funded research is a collaboration between 15 partners and 7 countries, fully focused on maximizing the building materials technical and economical lifespan through circular design. One report from Brussels Environment (2019) provides feedback on four pilot projects that were conducted with CD in mind. The pilot projects were very small modular buildings, ranging from 24 sqm to 180 sqm, with more focus on creating a functioning disassembly than creating commercial buildings. The main takeaways from the projects were mainly focused on the importance of stakeholder management, collaboration and stakeholder interest in testing new models and innovating.

As mentioned, the lack of relevant literature on implementation is still noticeable and causes implications on deciding who will take the next step, identifying what these next steps are and collaborating within the sector is needed to enhance development. Although the mentioned projects are few in numbers, the projects that has involved or involves CE and CD in the future needs to be spread in the sector amongst all stakeholders.

3.4. The importance of developing a strategy

The construction industry has typically been viewed as a slow changing industry with a high resistance to changes. This could be considered justifiable due to its complex nature. Although, in an environment where changes appear faster than historically in the sector, and where external factors affect the way we build and will continue to do so, it is becoming increasingly important for the sector to respond quicker to change and manage change differently. As discussed by Hatum et al. (2010), being able to adapt to new market conditions is always necessary for any company trying to stay competitive and a leading actor in their industry. Construction sector is no different and it will be necessary for construction companies to stay in pole positions and continue to gain market shares. Being aware of upcoming opportunities require companies to actively keep an eye on what is happening around them. According to Teece (2007) things like customer needs, new technology, changes in legislations/regulations or trends could all change what is expected from a company. Trying to disregard old problem-solving competencies in favor of new ones has proven to be very costly and difficult for management to tackle. Although, replacing "business as usual" thinking could occasionally be necessary to adapt and search for new business opportunities. When these occur, management must then decide, based on predictions of future needs, which

opportunities to go for, figure out in what way this is best done and which potential customers to target. Developing new products or offer new sets of services could be results of this assessment. Regardless of what outcome the company decides on, initial investments are in general needed in development of some sort. Established and well-positioned enterprises often have the option to wait and see what the dominant change will most likely look like, before choosing to invest heavily in the winner. Apart from deciding when, where and how much to invest, companies must also prioritize matching together and incorporate the investment with an appropriate business model.

4. Methodology

This chapter presents the process of selecting the methods used for the paper, and how it was executed. This will ensure that the paper has taken into consideration aspects of trustworthiness and authenticity, while also validating the chosen way of conducting the research.

4.1. Research approach and process

The approach to this field of study is founded on the need for more knowledge and information sharing regarding the circular approach in the construction sector, with the concept CD, DfA and DfD being implemented in the EU taxonomy, ISO standard and certification systems. To understand where a large contractor is positioned today in the aspect of CD, a collaboration with Skanska was initiated which had interest in expanding the knowledge about CD and where their organization is positioned. For this study, a qualitative approach was chosen with a literature study and semi-structured interviews. Qualitative studies are characterized by its inductive view on the relationship between theory and research, where theory is generated from research (Bell et al., 2022). Bell et al. (2022) describes the inductive way of working as commonly used for qualitative studies due to the need of further refining the research questions after the interpretation of data. In figure 2 the outline of the main steps of qualitative research is presented.

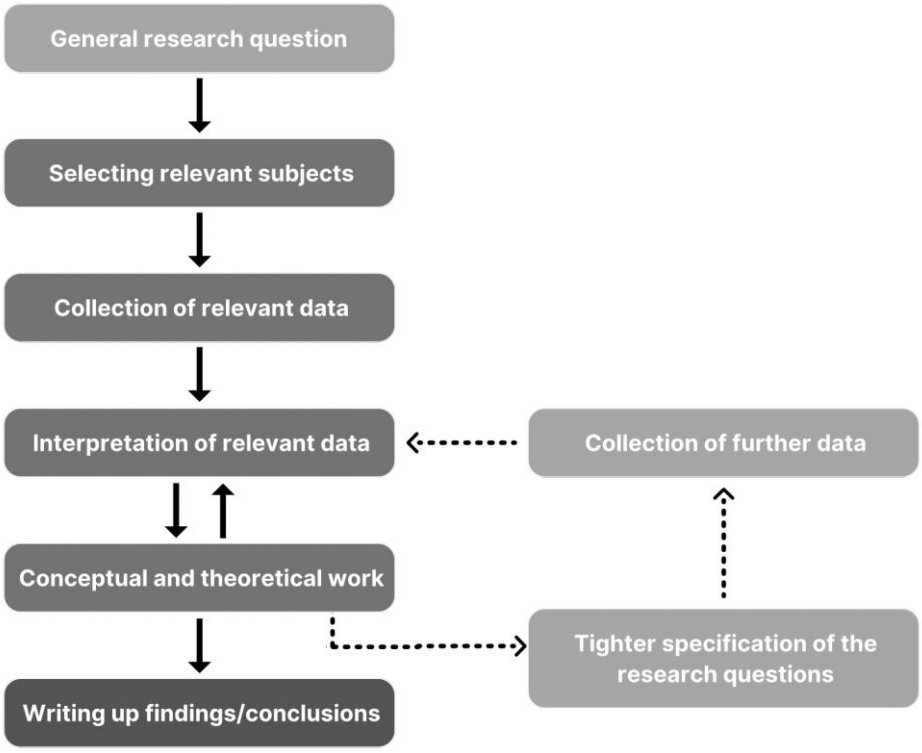

Figure 2 Main steps of qualitative research (Bell et al., 2022)

Through discussions with Skanska and supervisor at Chalmers, general research questions were developed to guide the research further and decide the approach, followed by identifying where in the organization the focus should be aligned to achieve a relevant outcome. With the general research questions developed and the understanding of the context at Skanska and the construction sector through discussions and a variety of scientific reports a decision on the method could be made. This choice of method is based on the fact that the concept CD still is underdeveloped within its surrounding research as well as practical use with Skanska, having no projects incorporating CD to a substantial extent.

4.2. Literature study methodology

To get general knowledge of the research regarding CD empirical data was collected through carefully selected sources. The articles, books and other published material used in the study was found through Scopus, Chalmers library, Emerald and Arcom. The process started looking at more general topics within the area of the topic, using search phrases in different combinations such as “circular, “design”, “construction”, “integration”, “barriers”, “opportunities” and “strategy”, following more precise phrases for such as “disassembly”, “adaptability” and “implementation” among others. This inductive approach allows the scope of the project to be narrowed down and enables the research questions to be specified throughout the process.

4.3. Interview study

The interview phase contained 15 interviewees, with an additional pilot interview with the supervisor at Skanska to ensure the relevancy of questions to the project as well as testing the interview guide in practice. All interviews conducted with both researchers in the room, with one leading the interview and the other participating with making follow-up questions and taking notes. They were recorded with consent and transcribed in their entirety, this to allow for reliable data collection and be able to thoroughly examine the results afterwards. The interviewees were informed briefly about the topic a couple days ahead of the interview, and once again during the beginning of the interview. The interview guide was decided not to be shared with the interviewee beforehand, this to get the current understanding of knowledge at Skanska and the interviewees own thoughts and answers. All interviews were held using the same semi-structured interview guide, with follow-up questions added throughout the interview to gather as much information as possible from the interviewees. This is based on the fact that qualitative research is often driven by the interest of the interviewees point of view, and therefore it is encouraged to let the interviewee express as many thought as possible (Bell et al., 2022).

Due to the nature of our scope, aim and goal of the report, the interviewees were people with a connection to Skanska, with 14 being employees currently and one a former employee working at public real estate company. The group of interviewees was conducted through discussion with supervisors at Skanska, recommendations from the interviewees involved in the study throughout the project as well as through the different Skanska communication services. The information gathered about the interviewees provided through these actions resulted in the possibility of creating a scope of four different groups of the organization with minimum three participants from each group, creating an understanding of the organization from multiple perspectives. The segment

they are representing were decided based on area of employment and prior project involvement. The four segments represented in the interviews are as follows:

4.3.1. Sustainability segment

The interviewees within the segment "Sustainability" were selected within the "Sustainability and innovation" part of the company. The reason to involve this group is to get insight from the employees working with CD today. Three interviews were carried out in this segment and included two sustainability specialists and one climate and sustainability manager.

4.3.2. Early stages

In this segment four interviews were held including project managers, design managers, constructors and project developers. They were interviewed to get a view on the aspect of business, implementation, construction and clients of the construction sector today. The areas of work covered by these interviews would target early stages of a project with the likes of building permits, construction and designing a building.

4.3.3. Production

To get general insight of what people working with constructing the buildings perception is of CD and to examine if there are any project revolving CD today, we interviewed two project engineers and two project managers.

4.3.4. Use-/End-of-life stage

The stages when buildings are either in use or at the end of their lifecycle is an important aspect of CD, where renovation and disassembly is anticipated. The interviewees were one employee at a real estate company, two project managers and a category specialist within demolition.

Table 1. Table of conducted interviews.

Interview #/Title	Segment	Date	Setting
#1 Project manager	Production	13/3-23	In person
#2 Design manager	Early stages	14/3-23	In person
#3 Project engineer	Production	16/3-23	In person
#4 Climate & sustainability manager	Sustainability	17/3-23	In person
#5 Category manager (demolition)	Use stage	20/3-23	Digitally
#6 Sustainability specialist	Sustainability	20/3-23	In person
#7 Business project manager	Early stages	21/3-23	In person
#8 Project manager (PD)	Early stages	27/3-23	In person
#9 Project manager	Production	28/3-23	Digitally
#10 Production engineer	Production	28/3-23	Digitally
#11 Technical mission leader	Early stages	29/3-23	In person
#12 Project manager	Use stage	30/3-23	In person
#13 Sustainability specialist	Sustainability	3/4-23	Digitally
#14 Sustainability specialist	Use stage	3/4-23	Digitally
#15 Project manager	Use stage	4/4-23	In person

4.4. Trustworthiness and authenticity

The importance of assessing the quality of research is accentuated by Bell et al. (2022). To ensure the quality regarding the trustworthiness and authenticity of the research process and analysis, different actions has been taken. In this qualitative research, trustworthiness is divided into credibility, transferability, dependability and confirmability. Credibility of the study is supported by actions such as discussions with respondents during the process to ensure that the authors observations are similar what the respondents believe to have answered in the interviews and transmitted into the theory developed. Another action to raise credibility is the use of multiple sources. Transferability of the study is improved by taking into account how the research can be replicated and generalized across social setting (Bell et al., 2022). Regarding transferability it is identified by Lincoln and Guba (1885) that one of the more complicated aspects in qualitative research is regarding replication of the study, due to the fact that the social setting of the study is subject to change. To enhance the possibilities towards replication of the study, the interview guide was developed and added as an appendix, as well as developing a table from the interviews to give the reader an understanding of what participants were involved. Dependability is managed by keeping all material from the whole research process, such as problem formulation the interview logs, transcript and data available throughout the process to ensure that proper procedures has been taken throughout the study. Lastly, the confirmability is dependent on if the researchers have acted in good faith, meaning not swaying the research in favor of personal values or theoretical inclinations. This has been adapted by using the same interview guide in all interviews, as well as always conducting the interviews with both researchers being present.

4.5. Ethical aspects and sustainability

Ethics is an integral part of research and applying it throughout the full process is essential to ensure the integrity of the participants and the research activities (Bell et al., 2022). To ensure all ethical aspects are considered, measures to prevent any unethical activities in the study was taken before every step of the report, as well as being revisited throughout the research process. Bell et al. (2022) mentions avoidance of harm, informed consent, privacy and preventing deception as ethical principles to adhere to when conducting research.

Animosity is an important aspect of research and actions such as not naming interviewees and making sure the data presented is non-identifiable minimizes the likeliness of causing harm to participants and ensures privacy. All interviewees were ensured that involvement in the study was voluntary and anonymous in a briefing before the interview and agreed to the interview being recorded. These recording were only used to transcribe the interview and no other party was involved. The names of participants have been replaced with the respective job title and other information regarding the participant has been removed to ensure privacy in the publication. To prevent deception all interviewees were informed of the scope, purpose, and method of the study in said briefing before every interview, along with an email a couple of days in advance.

The covered topics in this paper revolves around the construction sectors evident influence on the world's total waste creation and current difficulties and opportunities towards transitioning into a more circular way of constructing for preventing future waste. The emerging goals in the sector, largely from the EU, is demanding change from the sector. With this come the need for organizational changes, innovation and guidelines which will be involved in the development of this thesis.

5. Findings

In this section, a compilation of the most relevant findings from the empirical data is presented. The chapter consists of topics generated from data collected from all interviews where answers are analyzed and used to highlight key findings related to the implementation of the concept CD. These findings will be used later in the report and discussed in relation to the presented theory in chapter 3.

5.1. The definition of circular design: Individual level

In order to map out in what situation Skanska is currently in regarding CD, the first task was to gain insight of the overall level of understanding. This first section presents findings on the overall knowledge and understanding of interviewees.

5.1.1. Interviewees interpretation of the term CD

The interviewees were in the beginning of the interview asked what their understanding of the term CD was today. Analyzing the data from the interviews shows that there is a significant variation in how the interviewees defined the concept. Although many had a broad understanding of the current definition of circular actions in construction, only a few of them acknowledged any of the specific theories and actions regarding CD. One of the interviewees that had more in-depth knowledge said that:

"To me, it is about planning and constructing buildings that can be adapted to future needs, so that they don't have to be demolished and rebuilt. There should be flexibility in the buildings, and when they are eventually deconstructed, the materials used should be able to be reused in future projects, with a focus on disassembly and knowledge of the resources in the building. It is not just about a single lifecycle, but about the potential for a second, third, or even fourth life."

- *Interviewee #4*

The above quote shows that some of the interviewees have a clear insight about CD and the different themes that come with the concept. There is a reference to DfA, DfD, increase building utilization and DfL. Similarly, another interviewee referred to DfD specifically but however emphasized that she/he has limited knowledge about it:

"I'm thinking a bit about this concept called design for deconstruction that I've heard a little bit about. It means that you design something with the intention that one day it can be taken apart and reused. But it's also a pretty broad concept, and I'm not very knowledgeable about it."

Interviewee #11

Despite these two interviewees´ wide awareness of relevant concepts, a majority of the respondents referred to different ways of constructing with reused materials or what to do with materials after the demolition of a building. This shows that there is currently a lack of common ground for the concept between many of the participants. One common point is the complains about the vagueness of the concept, proving CD to be a little bit difficult for some to define. For example, Interviewee #7 says that:

"It's quite broad, but I interpret it as what we've talked about, that when we build, we think that this should be dismantled and preferably reused, but if you can't reuse it, it should be easy to sort for recycling or something like that. To me, that's circular design"

- *Interviewee #7*

There is also a common emphasis on stating that it is hard to motivate oneself to do something when the result can only be seen in a very long time. Below quote explains this clearly:

"It will be a problem we have in 100 years, and it may be challenging to motivate people then."

- *Interviewee #7*

This might be seen as something that inhibits taking action. Interviewees often struggled to see the benefits closer in time than in the end-of-life stage of the building. This shows that knowledge about the concept is still limited among the interviewees. Considering a majority of the interviewees describing CD by referring only to some form of reuse and designing with reused materials, it can be argued that the concept needs further understanding. Below quote is a good example for degrading the concept to practices related to reuse/recycle only.

"I interpret it as somehow reusing something in the design. You must use already consumed and reusable materials. That you should recycle into the design and into new buildings."

- *Interviewee #15*

In total, the empirical data shows that knowledge levels regarding CD varies a lot among different people at Skanska. It ranges from good in-depth knowledge to very limited understanding of the concept and its content and shows that CD is still in the stage of being understood. Apart from interviewees working in the sustainability division, there are quite few having a broader understanding of the term today.

5.1.2. Where knowledge is located in the company

The analysis of the interviews shows that interviewees from different divisions in the company tend to have a different understanding of the term. Participants from the sustainability division have a wider perspective, whilst the interviewees from the production division stressed that there is limited knowledge of the concept of CD on-site. Another interviewee from production mentioned that involving sustainability personnel cost money for the project and this is limiting the development on-site. The interviewees from the other two divisions, early stages and Use-/End-of-life stage, showed varying knowledge due to their personal interest or project involvement.

"I haven't heard anyone throwing those words around at Skanska, at least not now when I'm not in the office that much anymore but only out on projects, so I don't hear it in any way."

- *Interviewee #3*

The above quote shows that knowledge of CD hasn´t been spread down to construction sites and the people working there. It is important that the idea with CD stretches all the way from the early stage division down to the production team who are going to construct the project, since they have the knowledge on what is buildable or not. Some interviewees, like interviewee #10, wishes that more knowledge should transfer down into the projects and production teams, and gives examples of how to do so, saying that :

"As it is now, Skanska's sustainability department is mostly (acting as) consultants. And in some way maybe it needs to be that way, but I think they need to show themselves more in the projects."

- *Interviewee #10*

The interviewees were also invited to talk about the awareness of the concept on the organizational level, where a majority thought Skanska was positioned relatively well in in terms knowledge of CD in the sector. Most of them said that the knowledge of circularity is low, emphasizing the generic comment on "the construction sector is slow to adapt new ways of working".

"I don't think we're really standing out in any particular direction. It feels like there is ambition, which is positive and good, but in terms of knowledge, I think the industry is pretty much in agreement that we need to learn from each other and take steps forward."

- *Interviewee #1*

To conclude, many interviewees seem to agree that Skanska are well positioned in the sector in terms of knowledge on CD. Although, many claim not to know what the term really refers to. Data from interviews clearly shows that there are people with in-depth knowledge on the topic of CD at Skanska. How this knowledge is managed and spread out to reach other parts of the company seems crucial for implementation.

5.1.3. **How is knowledge distributed within the company?**

The current knowledge that participants has amassed through the company is through the different sustainability channels on the Skanska intranet. The interview analysis showed that a large part of the interviewees have not received any information about CD through mandatory events yet from Skanska. Those who have knowledge of the term state that it was either through their own personal interest or that they came in contact with it during a specific project which involved dedicated people and therefore seen as a good opportunity by a few to gain knowledge. With there being no concrete projects regarding CD some participants did not find the time or need to read into the concept. For the interviewees, spending time reading on the intranet means taking time away from something else in an active project, which ultimately means that it is often given a low priority. Below quote is a good example showing the lack of individual interest to explore and learn from the intranet:

"I haven't really searched for it either, maybe. It hasn't been necessary, since we haven't been in that phase. (…) with our entire operational system, it is incredibly extensive and good, but it takes a lot to read it from A to Z, without it just being like okay. now I'm going to be involved in demolition and dive into demolition, etc."

- *Interviewee #*1

The above quote can be seen a good example of spreading the awareness towards taking concrete actions in the company. The tendency is to complain about the limited time and the importance of day-to-day operations over the new concepts such as 'circular design'.

5.2. Circular design agenda on the organizational level

This section of findings refers to the questions asked in regard to identifying where Skanska is today when it comes to engage in CD learning and implementation. This includes examining the current strategy and what drives the changes within the organization.

5.2.1. Current awareness of strategy regarding circular design

The interviewees were asked about whether they have knowledge about if there is a clear strategy or target to achieve regarding CD at organizational level. When striving for improvement regarding CD, one decisive factor is if there is a strategy connected to it, describing what and how things need to be executed. Data analysis shows that most interviewees think that there should be a strategy and that it might exist already but are unsure where to find it. However, from the interviews it can be understood that there is a clear agenda for climate goals that most employees do seem to know of. These mainly consist of reduction of CO2 emissions and were brought up by some of the interviewees. For the interviewees, goals related to CD are more difficult to measure and thus appear a little more abstract. Also, a lack of client demands and pilot projects having clear targets regarding CD adds to the difficulty increasing the awareness. Many interviewees state that if there is a strategy for applying the notions of CD, it has not reached them, or they have not been informed. To further highlight the importance of a clear strategy on CD implementation, it is stated by a few interviewees that a clear strategy is what they would need for implementation.

Data analysis indicates that the actions taken related to CD are currently dependent on the individual incentives who have personal interest/ ambitions regarding circularity. This is further confirmed by these individuals with the most knowledge and interest, stating that there is yet no strategy developed centrally at Skanska today, to their knowledge. Below quotes clearly exemplifies the lack of strategy on an organizational level:

"No, not yet. We in climate and sustainability are now working in clear areas, and circularity is one of those areas. And this year, we will develop plans, short-term plans, a little more long-term plans, and a long-term vision. (…) But whether it will lead to something central, I don't know."

- *Interviewee #6*

"Well, I wish it were so. I haven't really seen it, but of course, there must be something somewhere that I'm not aware of. There are some incredibly talented people both on the staff and at Skanska Technology, for example, if you look at the design aspect. Otherwise, it would be a great thing to start thinking about."

- *Interviewee #9*

The quotes presented above shows that the interviewees are expecting a clear agenda forced at the organizational level. An interesting outcome is also the comments such as 'even there is a strategy somewhere in the company, it hasn't reached to me'. This clearly reflects the difficulty to embed new ideas in an organizational context. One clear outcome might be seen as a clear disconnection between the organizational level decisions and their reflection among the individual actors within the organization.

5.2.2. Key factors to adopt circular design

Interviewees were asked to describe their personal perspectives on what should be done to adapt the notions of circularity in their company. The interviewees referred to the lack of clear information on what exactly circularity means and what actions are needed to achieve it, especially referring to the difficulty of defining clear actions and measurable goals. Different certification systems are mentioned by interviewees, but it is still a doubt on how to achieve the set goals, as these have just been involved in the certification systems such as Miljöbyggnad 4.0. A question regarding the certification actions of CD was answered:

"We have long been using Miljöbyggnad as the certification system we demand and work with. Now there is a new manual for it, version 4.0, and I must honestly say that I can't recall off the top of my head what it looks like."

- *Interviewee #14*

The lack of clear guidelines of conducting CD work in the construction sector and vague goals provided by the policymakers is hindering progress and implementation within the field of CD. Interviewees agree on that to move forward there is a need to find a common ground first and then develop a roadmap for construction on how to fulfill the new demands. Some thoughts from the interviewees on how to move forward with this is to divide todays building process into smaller sections with looking at the different stages or building elements and rating how easy transformation to a CD is for each and to then develop easy and manageable starting roadmaps when implementing CD.

(...) and What is so important for us now to try to focus on... if you talk about Skanska's way of building, for example. The circular design from the EU taxonomy came as a bit of a surprise to everyone, and that it is now included in all EU certifications. Have you read the ISO standard? It's difficult to understand from that standard where to begin."

- *Interviewee #6*

"That's what you often want when you, like me, are driving a project and involved in the early stages. How do we handle this now? Then you could get a roadmap or some good steps or alternative steps to work with to get this going"

- *Interviewee #9*

Above quotes clearly explains the difficulty of understanding the content of the standards and developing strategies to implement them. One repeated comment was the ununified definition of CD in construction. According to interviewees, without the industry reaching common ground on what the concept exactly means, it will be difficult to develop a strategy covering how to become more circular in the design and planning phase. Empirical findings also suggests that there seem to be a willpower to work with this issue, especially on an individual level, but harder to know how to do so. Understanding exactly what to do when there are no clear guidelines yet is another big hindrance according to interviewees, saying that this would be the very helpful for implementation in the future. Barriers identified from interviews

5.3. Barriers identified from interviews

Questions were asked to the interviewees what barriers they have experienced or can see hypothetically regarding the use of CD. Identifying Similar to the literature, there was a clear emphasis on identifying the barriers to implement the notions of CD in the current practices. Below each emphasized barrier will be explained in detail.

5.3.1. Economic barriers

The empirical data shows that issues related to economy is one of the most common barriers. According to interviewees, designing with new concepts like DfA and DfD is bound to take some extra time to execute successfully. This is since future use or changes in use in the building over time needs to be considered as well as designing for the possibility to disassemble. The consensus from the interviewees is that the need for extra time and budget to embed the notions of CD contradicts with the tendency to choose the solutions that comes with least cost. For the interviewees, it is also difficult to find clients willing to pay the extra amount for designing in a more circular way. The identified clients by the interviewees with higher potential to invest in CD practices would be large private facility managers with a sustainability focus and public actors with high sustainability demands. Then, what the clients plan to do with the constructed building after it has been delivered constitutes another uncertainty, according to interviewees. Seen from an economical point of view, clients planning to own a building for a long span of time have more incentives to pay more for a flexible and dismountable building, since being able to change the daily operation in the building could become beneficial in the long run. For the interviewees, implementing CD correctly also adds value to the client before the demolition, which is a point of discussion often not taking into consideration. The possibility to disassemble or adapt a building will most likely benefit the owner of the building when that time comes, causing short time owners to be more hesitant on spending more money in something that might not clearly be shown to benefit their revenue. Below quotes exemplify these points clearly:

“The dismantlability aspect may be more difficult to get paid for currently because it is not certain that the customer who buys the property will be the one who will benefit from it in the future.”(…)“With taking payment for circular design, can one do that currently? Does it require a customer with a long-term ownership perspective?”

- *Interviewee #13*

"So, when we often focus on one intended use, we should focus on two intended uses or possibly three intended uses. Then you have to spend more time on adjusting the product, maybe already in the start phase"

- *Interviewee #12*

The interviewees emphasize that, today, the additional cost that CD brings is not yet fully valued or understood by most clients, leading to slow development of the construction industry in regard to CD. Although the interviewees did not refer to them, some of the practices in Skanska already applies to some aspects of circular design. Examples of this mentioned in the interviews are aspects as not fully finalizing the layout of commercial buildings, minimizing bearing walls and not building before the tenants had their opinions and approval.

5.3.2. The key role of the client

The empirical analysis shows that client's role is seen as key to setting demands for projects, especially regarding sustainability which is covering the issues related to circularity. Most interviewees agrees that the client have the most responsibility, since they decide on the budget of the project. The interviewees strongly emphasize that their company can apply the notions of circularity only if the project budget accommodates such actions. The strong interest to build at the lowest cost directly means ignoring the notions of circularity. This is the case since it tends to be more expensive to design for circularity today. This causes many clients to choose the traditional way of building instead, that is less expensive. At times, contractors are chosen based on price only, leaving very little leeway for including CD in procurement when trying to win a tender. Although there is a complaint about the lowest cost focus of the clients, some interviews also emphasized that there are clients who pays attention to the targets related to circularity. This is confirmed by interviewees.

"We're just looking for how we can get gold or platinum in the cheapest way possible. It's not always about pushing yourself to the limit to be this zero-energy building."

- *Interviewee #3*

Above quote exemplifies the reflections of achieving certain certifications from the practitioners' perspective. It might be said that although most construction project are certified for sustainability at some level or another today, the level of commitment to circularity is often low. Although CD is not specifically referred to the above quote, the level of ambition for sustainability could be sensed and is most likely no different regarding CD. Further, it is emphasized by both interviewee #5 and #7 that the client has a big role to play in demanding circularity in their projects. They say that:

"We can do practically anything our clients want. But those requirements need to be there."

- *Interviewee #5*

It is not we as an entrepreneur who can do it ourselves, there is no real incentive for it. (…) It is important to find customers that are interested.

- *Interviewee #7*

According to most interviewees, the client is the one with most responsibility when transitioning towards CD in construction. However, a frustration can be sensed about clients choosing the cheapest option, leaving little room for circularity in those projects. Although, it cannot be confirmed from interviews that Skanska have big ambitions for CD yet. As stated by interviewee #3 in the quote above, it is not always about pushing yourself to the limit. Alternatively, Skanska can create its own agenda regarding CD rather than expecting the first push from the client.

5.3.3. **Technical barriers**

Data analysis also highlight how the way buildings are constructed significantly determine to what degree it is possible to dismount it. In general, buildings that were built in the past were not meant to be disassembled. The buildings constructed today are no different. In fact, several interviewees confirm that Skanska does not consider the possibility to disassemble when planning for projects today. That part of CD has not yet been utilized by Skanska. Simultaneously, interviewees claim that it is very important that Skanska gets involved as early in the project as possible. The earlier they get involved, the better chance to push for ideas on CD. Having designers and other parties involved in projects already at the planning stages could greatly simplify processes around a buildings end-of-life stage. Then, technically difficult solutions not serving CD could be ruled out and replaced with more suitable ones. Examples of technically difficult solutions regarding CD, provided by interviewees are cast-in-place concrete elements, components glued together or covered screws and bolts. These kinds of solutions are hindering deconstruction to be made efficiently but are still used to a great extent today. Problems caused by this can be understood from interviewee #8, stating that:

"No, they have tried with one project (demolition), because there were a lot of lightweight concrete elements there. But they were so well anchored together that it was not possible to disassemble them properly, and they broke. But there was some thought of using those elements as both walls and floor joists."

- *Interviewee #8*

Above quote shows awareness and steps towards adapting the notions of circularity. However, the emphasis is put on the fact that keeping materials undamaged is critical to achieve circularity. Some interviewees emphasized the need for new technical details and solutions for assembly. However, the case company buys most of their materials from different suppliers, and it seems the problem extends beyond the case company's control. The empirical data shows that there is a need for supply side actors to adopt the changes needed to achieve circularity. This is clearly stated by one of the interviewees, emphasizing the importance of suppliers as well:

"We don't make materials. We're not experts on all the products we build in, each supplier has to think about how to work with it and find their solutions in terms of circular design."

- *Interviewee #7*

Another interviewee mentions that they were part of a seminar where the manufacturers talked about the little needed change to make a structural element available for disassembly:

"They challenged themselves to design or engineer a concrete structure that could be disassembled. It was interesting how little innovation was required to achieve a concrete structure that could be dismantled."

- *Interviewee #6*

It seems when Skanska is not the producer of the component, collaboration with the supplier is important to make sure it is clear what types of joints or attachments would be convenient and desired from Skanska with CD in mind. Since current technical solutions have not been properly evaluated on how they can be adapted to CD, minor changes to today's elements could have low impact on the costs. It is highlighted by the empirical data that technical solutions are viewed as a key barrier in CD. There also seem to be general positivity towards this, with interviewees confirming that this would not be a big issue if it was just being further developed.

5.3.4. Adapting circular design in an underdeveloped environment

For the interviewees, one difficulty is the immaturity of the sector on a wider scale. An immature sector creates less incentives for Skanska to implement the notions of CD as these services are not yet fully valued. Many interviewees explain the critical changes needed to shift towards CD practices. They mentioned issues such as material quality guarantees, material storage, logistics and suppliers. It was understood from interviews that Skanska buy most of their products from suppliers, and that the products offered must be developed as well. Interviewees stated that making demands on these products to be more circular and showing that Skanska value such practices is important. The products and components from suppliers must be designed to meet the requirements of CD to be able to be reused repeatedly. For the interviewees, change in what is demanded from others in the sector is key as it is hard to create change if not demanded clearly. Interviewees mentioned about clients' hesitation to accepted reuse materials as they are concerned with the quality. Below quote explains this clearly:

Many are afraid that the quality of the reused materials, such as radiators and ventilation ducts, may not meet the necessary standards. Have they been properly sealed? They have been mounted once before, with screws or rivets, and when they are dismantled, there may be holes left behind. Are they all properly sealed? What about cleanliness and so on? These are the things that people are afraid of"

- *Interviewee #8*

For the interviewees, even if materials would be of sufficient quality, they would also need to be stored somewhere in between being disassembled at one location and used to construct another building elsewhere. The interviewees further emphasized that timing is important as well, so that materials do not end up sitting in a storage space for too long but gets used as fast as possible. Such emphasis is followed by the comments on logistics. Closely related to the storage issue, dismantled reusable components need to be collected from construction sites and transported to storage facilities. According to interviewees, having companies serving such storage and logistic services is a sectoral need to shift towards circularity. Below quote explains this:

"We have a lot of ventilation ducts that we should be able to reuse, but this part of dismantling them, storing them, reconditioning them, and guaranteeing that they maintain a certain quality. All these steps and then back into a project would have been so much easier if we had a supplier who makes a deal out of it."

- *Interviewee #4*

It seems Skanska does not have the intention to expand their range of services to cover such logistical challenges. For the interviewees, it must be driven by a collaboration between actors in the sector with different niches.

In summary, although the interviewees emphasize certain barriers regarding economic, client related, technical and immature market, they also reflect about critical actions giving insights regarding how such barriers can be overcome. According to interviewees, Skanska have limited influence over some barriers, like those regarding market immaturity. This is leaving the company to first and foremost focus on the ones they can affect directly, like technical barriers and trying to influence and give suggestions to client to get them to choose more circular methods.

5.4. Opportunities and expectations of circular design

In this section the opportunities are discussed. By creating a discussion with the interviewee about the possible contributions that the concept brings the aim is to identify where it could benefit Skanska and the operations.

5.4.1. Sustainability factors

The interviewees were also asked to give their thoughts on what opportunities that could come with CD. A slight majority mentioned factors related to sustainability. The dominating factor were the decrease of CO2-emissions. Other factors brought up less frequently were reduction of need for raw materials in the future and to help create a more sustainable society in general. Although a reduction of raw material is viewed as a big opportunity, it is also mentioned by an interviewee that:

" It can also be a little conflict with our climate challenges because adaptable buildings, that is robust buildings, are often a bit robust, and also maybe a bit more generous with space. But that is directly opposite to our climate goals. That we should build with less volume, not exaggerate with the volume. We should not build with too much material, so there is a conflict that we do not know how to solve right now."

- *Interviewee #6*

Above quote reflects the confusion about where to draw the line on how much extra material should be put in a building to make it adaptable for the future, with respect to this contradictory in raw material waste. It seems the conflicts between the targets for sustainability and circularity can create disagreements.

Some interviewees that did not give examples of benefits regarding sustainability instead provided other point of views, highlighting the competitive advantages that CD could bring for example. Most interviewees seem to view CD as a tool to achieve a more

sustainable future in construction. Although, this opportunity is not recognized by all interviewees.

5.4.2. Improving business competitiveness through experience

In the last decade sustainability work has gone from being something you could work with to being something that you should work with, and the same goes with CD. Today, there is an expectation on big companies like Skanska to work with sustainability. Many interviewees agree on this but emphasizes that CD is a very new concept within sustainability. Parallels are sometimes drawn to when environmental certifications where new. Some interviewees recognize how quickly the demand for certified buildings increased over a short period of time. Suddenly all clients wanted certified buildings to show that they cared about sustainability. Similarly, interviewees suggest CD could have the same outcome. It is mentioned that one big opportunity with implementing CD at Skanska could be an increase in market shares. If clients start to make more demands regarding CD and Skanska can offer these services, that means Skanska has put themselves in a good business position. In addition, it was discussed in some interviews that building in a more circular way could help increase the maximum rent for spaces in a building, ultimately letting Skanska charge more for their projects.

"In the beginning, when you start looking at certifications and stuff, you see it as maybe not value-driving or a little ridiculous, so you only do it for show. But then, later on, it resulted in, well, you could take higher rents, and the projects become more interesting."

- *Interviewee #8*

This statement shows the importance of economic incentives from Skanska even related to CD. If it is not economically sustainable long-term, it will not be part of the business in the future. As stated above, same thing was with the certifications at start. Interviewees claim that CD might have the same development as the certifications did.

5.4.3. Personal fulfillment from working sustainably

One interviewee mentioned that when you work with sustainability, you go home feeling that you have accomplished something and that you are doing something important. This gives an increased meaning and pride of the work you do. Another agrees saying that working more with sustainability really makes you see the value in what you are doing.

"You feel that what you do at work means something a little more if you get to work circular."

- *Interviewee #3*

Interviewee #3 works in production in the projects, practically meaning that he/she has little to none to do with the planning processes of projects that he/she is working on. In addition, interviewee #3 has claimed earlier in chapter 5 that the word CD barely has been heard amongst production team members at all, since their task is just to build what the drawings show. Despite this, statements like the one above shows that building sustainably could have great social meaning amongst all employees, from the earliest stage in planning until the production stage. For production members to have a say in planning, or to feel that there is a possibility to influence towards CD then might create both social and other values.

5.5. Implementing circular design

Implementation of CD today is discussed in this section, looking at what is done and what employees deem as vital to successful implementation in the company.

5.5.1. Implementation of CD today

Almost every interviewee mentioned that in order to implement CD it is key that Skanska can come in as early as possible in the processes. It is said that the situation today in different projects differs substantially in tendering processes. In some projects, Skanska is involved from the very beginning, providing a better opportunity to influence aspects regarding CD. Then, the vision for the building can be discussed with all different actors involved in the project and CD could be incorporated more easily and to a lower cost. Interviewees also suggest that these ideas could be introduced early to clients to open new perspectives that some clients have not considered or valued before. Consequently, when everyone involved is on the same page, the project is more likely to run smoothly overall during construction time. In other projects where the "frame" is already set, interviewees say that the opportunity to use CD is very limited. The frame could consist of existing building permits, detail plans or a budget restricting CD. If the conditions are not there, Skanska will have a hard time taking advantage of CD. The quote below clearly states this:

"I think we need to do it quite broadly across the board, but particularly in areas like planning, for example. I think a lot, a lot needs to be done in the early stages, like that's where the big efforts need to be made."

- *Interviewee #13*

This quotes clearly indicates that it is in the very early stages where the focus needs to be if CD is to be implemented. This belief is widespread amongst all four segments in which interviewees were picked from. Interviewees also state that in terms of time, CD planning takes additional time compared to the linear model. Additionally, interviewees point out that the longer you wait with implementation in a project, the more late changes will need to be made which will cost more time and money. Below quote further highlight importance of early involvement:

"With external customers, we are rarely involved in this very early stage, but we hope to come to a project where the client has had these thoughts even in the very early stages. Then it can probably be a very good journey."

- *Interviewee #9*

Interviewees seem to view clients as a big enabler for CD to be implemented in the company. They also point out that here needs to be the right conditions in the projects for the concept to be used as well. With all projects being different, using CD consistently seem difficult according to empirical data. However, getting involved in the early phase is considered as a key aspect by interviewees.

5.5.2. Drivers of circular design implementation

Interviewees identified key drivers for the implementation of CD. These drivers are meant to be driving the development of the sector forwards towards circularity. It is discussed in several of the interviews that different policies and regulations is needed to take steps towards circularity. Without an obvious economic benefit, regulations in certifications

will be very important. Also, most interviewees stated that there is no clear strategy on how to implement CD and that it must be develop centrally from Skanska top management. Clients of the construction sector were mentioned as key drivers by most of the interviewees. The reason for this was in most cases related to economy since clients are the ones paying for the projects. It was stated by interviewees that Skanska are capable of using CD if that is what the client wants. A very environmentally conscious client can make ambitious and reasonable demands of their contractor, making sure the project is taking CD into consideration. In one interview, one recent public tender had included a 25 percent circularity criterion, forcing contractors to show how they aim to achieve circularity in the construction. Who won the tender and what the public client valued in the end is yet to be decided. This quote shows that policy pushes can help reach climate goals with the use of CD:

"Yes, but I think that by implementing circularity will help us reach our climate goals. We also through that win more future tenders, such as the land allocation competition we participated in."

- *Interviewee #13*

Interviewees clearly request more guidance and clear actions to embed the concept of CD in Skanska. More regulations and policies are identified as drivers, both from inside and outside of Skanska. There is a belief that CD will help reduce negative impact on climate change and that Skanska are capable of doing it if desired.

5.5.3. Actions taken by Skanska to increase CD knowledge

The interviewees were asked to identify the actions Skanska has taken to make the transition towards CD. The answers were often similar ranging from no real knowledge of actions, participation in workshops and general discussion. It is also mentioned that the current information is from top to bottom, resulting in lesser knowledge in the projects. Many interviewees mention an initiative called 'Circular Fridays' as a source of information where different topics regarding circularity are discussed every Friday. This weekly event is open for everyone to join, with Skanska sometimes inviting external actors with more expertise on different topics. However, interviewees claim that it is roughly the same people attending these events every time, since they are the ones with interest in the matter. One interviewee mentioned the initiative with Skanska employing master thesis students to reseach deeper into the subject of circularity as one prominent action. This is stated in the quote below:

"Here at the Gothenburg Building, we have a goal in the business plan for circular construction, I think we wrote that we should develop within that area, and you, thesis workers are part of an action that we see as an opportunity for many to delve into that area during the year."

- *Interviewee #4*
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In summary, empirical data agreed stating that actions taken to accommodate the implementation of CD are mostly based on creating an awareness of the concept. The empirical data shows that Skanska is at the early stage of understanding the CD concept and trying to figure out where to start with implementation, since there are no clear reference projects identified by interviewees.

6. Discussion

The preceding chapter presented the analysis of the empirical data collected through interviews from the case company. The purpose of this chapter is to draw together the findings outlined in the previous section with consideration from the theoretical background. The chapter is structured as 3 sections in accordance with the research questions identified in the introduction. Given that the first research question (What does circular design refer exactly within the broader narrative of 'circular economy'?) has already been addressed in literature review section, the discussion starts with research question 2, presenting how circular design is understood in the case company and how it relates to circular design narrative in the literature. Then, it further concentrates on presenting a discussion on what circular design practices has been implemented and how these relates to what the literature emphasize. Following this, the discussion focuses on the identified barriers and opportunities with circular design practices in line with the findings in literature review. Lastly, different solutions that was presented in the results and theory is discussed.

6.1. The understanding of circular design and current implementations

This section presents how CD is understood in the case company and how it relates to the theoretical background emerged from the literature review. It also highlights some of the actions taken by Skanska to embed the notions of CD in the company.

As newly emerged in the construction industry, the concept of CD can be difficult to understand, and today's understanding is deemed low across the whole sector. Literature state that there are multiple definitions creating a confusion about what it really means. As presented both by Kirchherr et al. (2017) and Eberhardt et al. (2022), having unclear definitions may act as hindrance for a unified adoption and easy implementation of a concept. Having a understanding of the concept CD thus seem important to implement the related theories in projects and drive change in organizations. It was reflected upon in the empirical findings that there seem to be a current lack of knowledge in the organization on the concept today, hindering Skanska to further embed the notions of CD in the company. The varying understanding of the concept ranged from in-depth knowledge to very limited, with no common ground to be identified among interviewees. The interviewees from the sustainability division showed a wider range of knowledge, giving examples of sub-themes such as DfA and DfD, while interviewees from production division said knowledge on the concept on-site is low. Understanding of employees interviewed from early involvement division and use-/end-of-life stage division varied depending on their personal interest in sustainability concepts and what projects they had been involved in. It can be argued that this variation between the divisions is due to how closely the different divisions work with circularity issues and CD in particular. Since people in sustainability division works closest to CD and the especially the new ISO standards 20887:2020 that introduced the concept to the sector, they having a wider understanding was expected. Interviewees from early stage-, production- and use-/end-of-life stage divisions often referred to things like reduction of waste, waste management and reuse of materials when describing their understanding of CD. These are examples of already established processes in the case company that aims to increase sustainability but doesn't fully match with the details of CD explained in the relevant literature. It can be argued that since the three divisions apart from sustainability

divisions don’t work with concepts related to CD yet, this is the reason for the varying understanding. Currently, there are no projects identified in this field, leading to this limited understanding and experience.

It is emphazied by Charef et al. (2021) that when different divisions in the same construction company have varying knowledge and experience of a concept, this can cause information flow between them to be insufficient and incorrect. This is the situation the case company is currently in. Actions identified to embed the concept of CD in the company consist of the spreading of information and knowledge. This currently come from informational events, workshops and a general discussion to prepare for future circularity demands. Although much take place at the office, it is often provided digitally as well. However, reflections based on empirical data suggests that employees in production division are less aware of these events and don´t take part in these occasions and that the participants are roughly the same employees every time. This could further widen the span between the ones with most and least understanding, increasing implementation difficulties with CD. Another action mentioned by interviewees is the fact that master thesis results are focusing on circularity. This could be argued to be the most powerful action in the process of understanding the concept. Since many employees seem to have much to do and limited time, few have the time needed to gain a good enough understanding of CD. Based on this, what is done with the gained information from these different actions and how it is spread throughout the company will matter. Charef et al. (2021) highlights the common belief in construction that managing the prevention of information silos hindering information to flow freely within the company is key to achieve change. This mirrors the reflections made from empirical data, with the varying understanding suggesting that information gained is not spread effectively through the company. Preventing important knowledge from getting stuck is always difficult in big project-based companies like the case company, but managing this is one of the key enablers in successful implementation. In addition, the knowledge gap between people in different divisions and with different levels of interest emerges as an issue requiring close attention. Having a clearer definition and understanding recognized by all employees at the company reduces risks of misunderstandings and would make the process of going towards CD more effective.

6.2. Challenges and opportunities identified regarding the application of circular design practices

In this section, a discussion around the identified challenges and opportunities in the case company will be presented and analyzed in relation to what has been covered in the literature study.

Economic challenges

Economic aspect emerged as one of the most frequently mentioned barrier both in the empirical data and the literature study. It is argued by Munaro and Tavares (2023) that it is cheaper for construction companies to continue with business as usual compared to using CD, partly since prizes for raw materials are still low and designing more circular is claimed to increase costs. Interviewees mainly stressed that extra time is needed to apply the requirements of CD, and this creates the extra cost. Interviewing people from different divisions at Skanska provided a good overall picture about these economic

barriers. Reflections from interviews with employees in production or other divisions who are not working closely with sustainability and circularity was that they tend to focus more on the challenges and negatives than possibilities regarding economic aspects of circularity. This allows for discussion on whether employees with wider knowledge would see more benefits regarding economy and thereby acknowledge more incentives to implement it.

Both literature and empirical data agree that CD is more expensive than designing linear. It could be discussed how inadequate knowledge on CD can result in misleading conclusions regarding economic barriers. Most interviewers failed to think about CD as a long-time span issue. Buildings are currently only seen as investments with a very long technical and economic lifespan. This is causing CD to be undervalued. Many of the economic incentives on why to invest in CD lies in between design phase and deconstruction phase. In between these phases are roughly 50-100 years in which the building in constantly in need for updates, replacement of components or change in floor plans. A well-executed CD could facilitate required changes in an existing building and thereby save money along the whole life span of that building. This could add economic value to clients. This lack of knowledge could be a reason why interviewees tend to struggle on seeing the economic benefits, but rather see the challenges that come with it instead.

Similarly, one can also suggest that since most interviewees did not have a correct definition or knowledge of CD, their estimations of what makes it expensive lack proper foundation and must therefore be critically reviewed. As stated, the empirical study shows that CD is often connected to the reuse of materials when constructing new buildings. Reuse is applied today at Skanska and has proven to be more expensive than buying new materials, according to empirical data. The reason for this according to Gorgolewski (2008) is that reused materials must go through several processes today to be used again. It might need to be disassembled, mended, repainted or stored somewhere. If there is much reprocessing needed in between deconstruction as reuse, materials tend to be more expensive than new ones, all steps considered. Gorgolewski (2008) continued by stating that reused material could be cheaper to buy than new ones. However, this require for CD principles like DfD to have been applied to the building where these materials come from. Unfortunately, this is not the case with the existing buildings being deconstructed today. This most likely adds to the difficulty to see the economic benefits of CD today.

Client related challenges

Related to the economic aspect, interviewees were complaining about client's tendency to go with the lowest project cost which inhibits the application of new ideas like CD. It seems hard to get paid for designing circular today, with clients not yet valuing CD, making companies hesitant to invest in this change. Ababio and Lu (2023) stressed in their article that tight constraints in the budgets of projects acts as hindrance for many of the desired CE strategies such as CD, causing the industry to continue with business as usual. Based on data from interviews, there seem to be a willingness from the case company to adopt to a more circular working process, but drivers allowing them to do so must emerge, like client demands and ambition.

Insufficient knowledge and information with clients could be part of the problem with clients having low requirements and unambitious targets. This is a widespread opinion amongst interviewees. The importance of these demands is also stressed by Charef et al. (2021), arguing that this is needed to move the sector forward towards circularity. Not knowing the benefits with CD from a client perspective can ultimately cause doubts increasing difficulty with implementation of CD. In these cases, interviewees believe Skanska could propose suggestions and alternatives on how to build what the client wants, encouraging the use of CD demonstrate its benefits.

Being tied to budget constraints and the project frame provided by clients increases difficulty with implementing CD, as confirmed by most interviewees. This is a factor less easy to affect for Skanska when discussing drivers for the implementation of the concept. Although developing the sector on their own is not possible, it could be discussed that for most effective implementation, employees should instead focus on the factors most easily influenced from within Skanska. This would help ensure that when the sector is developed enough and ready to start adopting CD principles, so is Skanska.

Policies, regulations and certifications

The lack of clear guidelines is discussed by interviewees and described as a major hinder to implementation of CD. It is also stated by Adams et al. (2017) that policies and regulations can have a big impact on construction companies adopting CD. The authors continue, highlighting that the policies and regulations of today still mostly benefit business as usual but that is has the power to force companies to act in a more circular manner. According to interviewees, vague goals have started to appear in certifications but there are still great uncertainties on how to achieve a more CD. Since there is no clear and detailed information on where to start and how to approach the design phase, these goals are hard to achieve, says interviewees.

From research it was identified that there are incentives towards using CD from the policy side in Sweden construction sector. For example, Sweden Green Building Council (2022) have added CD into some of their certification systems. The certifications such as LEED, BREEAM and Miljöbyggnad 4.0 together with Svanen (Miljömärkning Sverige AB, 2023) now all cover some parameters related to CD in their evaluation. It is important to note that the concept is currently defined differently in the different certifications stated above. This could potentially create unnecessary uncertainties. Having the same definition of CD in all certification systems would increase clarity for the sector when trying to implement it. From some interviews it can be understood that reaching certain certifications as cheaply as possible is sometimes the main objective in projects. Increased requirements in policies and certifications regarding CD would in those cases directly improve companies´ contribution to circularity by forcing them to do more to achieve the same certification standard.

Technical challenges with circular design

To implement the notions of CD effectively, Gorgolewski (2008) emphasizes that it is important that the constructed buildings are also planned for future deconstruction, adaptations and repairs. From interviews it was confirmed that buildings constructed today at the case company does not consider these aspects. As stated by Selman and Nørkjær Gade (2020), this increases the difficulties with disassembling the materials and

components as they are more likely to break during separation. Although not being used yet, most interviewees agree with literature, stating that for CD to be implemented, planning for separation of materials and components would be a key aspect. Some also emphasizes the need for new technical details and solutions for assembly. However, few discussions went more deeply into the technical details, but some examples of less good technical solutions hindering CD to be applied where still provided. These consisted of cast-in-place concrete elements, components glued together or covered screws and bolts.

Despite a need of change in technical solutions and design principles, it could be seen from empirical data that most employees believed that skills required for this already exist in the case company. Some further explain that Skanska is capable of building almost anything in line with CD principles. Interestingly, it was discussed during interviews that no thorough analysis had yet been done on the current technical solutions on how they could be adapted to CD, meaning that potentially, minor changes may turn out to have big impact. This was highlighted by another interviewee, referring to a seminar where manufacturers talked about how little change was needed to make a structural element available for disassembly.

However, since Skanska is buying many of their materials and components from suppliers, it is mostly out of their control whether products are adapted for circularity or not. In those cases, interviewees suggest a closer collaboration with suppliers, clearly stating what is needed in regard to CD. This is supported in the literature by Górecki et al. (2019) stating that implementation of CD will require for material manufacturers to develop new products fitting within model of circularity in the construction sector. Interviewees believe that as a big contractor Skanska have the possibility to influence the development of products from supplier, since the product range is driven by demand. This puts Skanska in a position to change and guide the development of suppliers towards circularity.

Based on both Selman and Nørkjær Gade (2020) and empirical data confirming proper dismantling being difficult due to well anchored and complicated connections between building elements, problem-solving factors were discussed. Interviewees stated that drawings for how to dismantle materials could become useful and that these would be provided by suppliers. The cases where Skanska create their own materials were not discussed regarding this, but arguably, it should be even easier to implement this kind of solution if that is the case. Several interviewees highlight that when a building is to be deconstructed, otherwise fully reusable materials brake since it is not clear how to deconstruct them. Implementing dismantling drawings could save a lot of time and material for the deconstruction team, benefitting environmental issues as well. Another interviewee suggests that building more standard oriented buildings and with less custom-built technical solutions would facilitate deconstruction in the future, since there would be fewer unique technical solutions. Interestingly, Selman and Nørkjær Gade (2020) claim that people tend to prefer exclusivity and Dams et al. (2021) highlight the desire for architectures to draw unique and innovative buildings. Reflections of this result in a clear contradiction, where it seems hard to get both the benefit of easy deconstruction through standard solutions and architectural uniqueness.

Unclarity of the concept

Ababio and Lu (2023) points out that a too vague concept might impact implementation of processes negatively and cause misconceptions. Further, literature claim that CD is still a developing concept with a lack of actual implementation bringing clarity. Findings from the empirical data confirms this, suggesting that Skanska is currently in the sensing stage trying to identify exactly what the concept refers to. Although the unclarity of CD is not specified specifically as a barrier by most interviewees, data indicates that it is. It was often stated that the term CD was new and that its´ meaning and definition within construction yet had not been properly decided. Despite this, most interviewees discussed the barriers based on their own understanding of CD, rather than describing the inadequate understanding as a barrier in itself. As described already in chapter 6.1, Charef et al. (2021) states that unclarity of concepts can lead to variation in understanding in a company and can greatly hinder implementation of CD.

Environmental opportunities

Looking at the opportunities instead, the major findings regarding opportunities from implementing CD were fewer compared to the number of challenges identified in the research. Environmental opportunities were mentioned by the interviewees as one of few. This opportunity with CD is also widely covered in literature by Liikanen et al. (2019) and van Stijn and Gruis (2020), stating CD will have big positive impact on climate change. Interviewees recognized decrease of raw material use and raw material extraction but also higher material efficiency as highly affected environmental impact by the implementation of CD in the construction sector. However, since most interviewees did not provide very elaborate answers on the environmental opportunities, and that there was a lack of deeper discussion around the topic, it could be argued that few really understood the connection between CD practices and the environmental opportunities. Interviewees often failed to prove this deeper understanding of this connection.

Economy and market related opportunities

Although economy is deemed as a big opportunity by relevant literature, interviewees mostly fail to see the these. Instead, many interviewees only see the economic challenges that CD brings. A theory backed by Teece (2007) could be that the "business as usual" model is limiting the mindset of employees of Skanska, hindering them from viewing CD as an economic opportunity. Despite the fact that the findings from interviewees does not find many opportunities, the literature identifies a few. Gorgolewski (2008) and López Ruiz et al. (2020) speaks about the ones such as creating cheaper materials and waste prevention leading to less landfill fees. The possibility for Skanska to contribute to driving the sector forward is another opportunity not specifically mentioned by interviewee but that is mentioned in literature. The role of Skanska in the sector has been touched upon, with many stating that Skanska as a big contractor should have a leading role in the development of CD. Putting demands on other actors in the value chain is to force the sector into a specific direction. Like stated earlier in this chapter, it would have been interesting to see if there would be any change in outcome of the study if interviewees would be swapped out for others. If you were to interview people with more expertise on the subject, one could wonder if they would have the same view on the opportunities. With Skanska being a profit-driven contractor, economy is often what makes or breaks innovation and ideas. For CD to be successful there needs to be an effort in facilitating the process of finding more opportunities.

Also connected to the economic opportunities is the fact that with knowledge on implementing CD in projects Skanska becomes more competitive in tenders that involves circularity aspects. Empirical data supported this, and interviewees mentioned that implementation of CD could also be used to gain market shares through competitive advantages that comes with having expertise in the field. When demands of CD practices from clients increase in the future, and Skanska are prepared to offer these services, that means Skanska will be in a good market position to win more tenders. Interviewees also stated that is some cases designing more circular could help increase the maximum rent for spaces in a building, which means that Skanska can charge more for their projects.

6.3. Suggested actions to embed the concept of circular design in the current business of the case company

In this section of the discussion the identified actions that could be taken to embed the concept CD within the organization are discussed. The actions could be part of a larger strategy to involve CD on an organizational level.

Fractionalize the concept

The concept of CD has proved to be hard to grasp in both the literature and empirical results. This makes it evident that actions are needed to make the concept easier to grasp by a wider audience and narrowed down to the important parts before implementing in projects. As mentioned in the Brussels Environment (2017) report, knowledge is identified as lacking, and while empirical data supports the same outcome it is also noticed that both in previously mentioned study and our own, there is a will within the company to work with CD if it was introduced to them. The lack of knowledge and uncertainty about the concept is reasonably because there has been no further concretization presented about the term CD since its inclusion in the EU taxonomy. The identified unclear definitions in the earlier sections in both the empirical and literature study suggests that actions are needed.

Possibilities of fractionalizing the concept has been identified as an action that could combat the current misconceptions and make decision making easier when choosing what implementation is most favorable in regard to the new standards and policies. With the release of the ISO Standard 20887 clear focus areas can now be identified and focused on, since there are similar actions to fulfill certification and EU Taxonomy criterions. This has not been possible in earlier studies due to the fact that the standard was recently released and thus the prior studies have had no common ground to aim towards. This caused the CD concept to be very widespread, as for example the many definitions identified by Kirchherr et al. (2017) and by the interviewees which is deemed to cause a scattered grasp of the concept. In figure 1, an example of a schematic version of this fractionalization is presented. Developing the focus points of this figure as goals regarding the EU taxonomy and certifications gets clearer will be valuable regarding making the concept to be understood on a wider scale and finding applicable actions in construction.

Knowledge sharing
There is a dilemma identified in the empirical study regarding the knowledge gap within the company between the ones with more and less knowledge within the company today. Preventing key knowledge from getting stuck is always difficult in big companies, but managing this is one of the key enablers in successful implementation. Siloed work processes are mentioned by Charef et al. (2021) as one reason for the difficulties in the construction sector to embrace change. As identified earlier in the results, there is a significant difference between the respondents in the production segment and respondents within the sustainability segment. Sharing the knowledge accumulated so in the company so far between the different segments is deemed by interviewees as one important step to adopt CD actions in the future and gain knowledge.

After making the concept of CD easier to grasp through the theoretical studies, tools such as the Circular Buildings Toolkit (2022) and the new guidelines from policymakers, the next step would be to spread the information through the identified segments with lower engagement regarding the subject. There have been projects where employees mentioned the involvement of the "Sustainability" segment in production has been influential for both the sides of the parties. For one, the employees in the sustainability segment with the most theoretical knowledge of the CD concept would get the chance to spread the aforementioned general discussions about the concept to the employees on-site which is currently mostly located in the office today. They would also get the insight from production employees as to what is possible in practice and where possible starting points could be when implementing CD. Interviews suggested that involving the sustainability segment with the on a project level where the knowledge was deemed to be lower is an appreciated action that has been used scarcely at Skanska today. Since the importance of collaboration and is supported in literature by Selman and Nørkjær Gade (2020) and deemed as beneficial in the empirical studies, it is recommended to look over the actions of enabling more exchange within the organization. One thing to look at is the current business models which adds cost on projects with involvement of sustainability employees, which is deemed to be hurting the possibilities of inclusion in projects due to tight budget constraints.

Focusing on economic advantages in the long term
As the main obstacle of implementing CD today is the economic aspects, some actions to justify extra spendings in the design phase is needed. The construction industry today is mostly driven by economic incentives and competition is heavily focused on price as shown in the report by Brussels Environment (2017) and from the findings of this study. As the respondents mention that it could be argued that in the future flexible and deconstructable buildings could have a higher value, they fail to provide any concrete examples of how CD will increase the economic values of buildings. This shows there is a need of creating a case for how the implementation of CD will be feasible. With the results showing that knowledge of the CD concept as a whole is low, the lack of examples can be argued to be linked to the same reason.

Like stated by Ellen MacArthur Foundation (2018), new ways to value assets that cover a projects lifecycle might be needed and would in that case act as enabler for faster adoption of CD. Taking aspects like cheaper-to-run, flexible and deconstructable into account when valuing would make this more attractive. If Skanska were to add CD

aspects to their own business models and ideas into the aspects of finding new economic gains, they could become frontrunners of implementing CD.

Need for case projects

Through the entirety of this study, an expressed lack of practical examples where CD has been implemented has been identified from the interviewees. In order to fully understand the challenges as well as the possible solutions connected to the implementation of CD, interviewees emphasize that current theoretical discussions need to be associated with something practical and tangible. Engaging in different pilot projects is presented as a good option to accomplish this both by empirical data and by Bertozzi (2022). He further states that smaller and less complex buildings would be a good starting point for implementation. In these pilot projects, technical solutions as the ones mentioned by Kozminska (2019) including construction with reversible joints and prefabricated elements to allow for flexibility and demountability could be applied. This would later be evaluated to see what went well and what needs to be developed further and how. It was also understood from interviewees that there are some materials provided by Skanska themselves. Conducting an analysis regarding those materials would be an important action, to explore what could be affected directly from within the organization in regard to CD practices. Engaging in pilot projects and conducting this level of analysis on materials would widely contribute to the understanding of CD throughout the whole company, since it would affect employees from earliest planning phase all the way down to the production team.

The current lack of projects including CD actions is deemed to be causing the lack of progress in the industry, and for Skanska to excel in the area there needs to be project involvement. Interviewees frequently stated that Skanska has the possibility to engage in their own pilot projects, as they have branches of the organization that acts as clients. In accordance with Bertozzi (2022), smaller projects can be the safest option to start with. By doing these pilot projects within the company, the project is more easily controlled. In addition, Skanska won't have to deal with key issues like finding an interested client, that was highlighted as an enabler in the two cases presented by Buser et al. (2021). However, getting a large client outside of the Skanska organization onboard with implementing CD in high visibility projects is probably the preferred way, since large-scale implementation will be valuable for the future.

7. Conclusion

The purpose of this thesis has been investigating how CD has been understood in a large Swedish contracting company and exploring the barriers and opportunities regarding moving towards CD practices. Further, actions needed to embed the concept into day-to-day work have been explored. From reviewing the relevant literature, the conclusion was made that CD is a newly emerged concept and that it is often defined differently by different sources. With no recognized definition for construction companies by current literature, a thorough investigation was conducted. From this research it was concluded that CD is a concept where the design of products is used to reduce material losses by the closing of materials loops. By designing to retain maximum value of the building materials during its lifetime, materials are meant to be reused again and again, ultimately benefitting sustainability. Designing more circular will facilitate and enable materials and construction elements to be reused in the future by using separable connections allowing for easy maintenance, repairs and deconstruction.

This study has shown that for a large construction company to adopt the notions of CD on an organizational level, a unified understanding of the concept within the company is a key aspect. That includes everyone from employees working in the earliest phase of planning for a building down to the team working in production. It has been concluded that the level of understanding of the concept CD in the case company is low in general, although there are employees with wide understanding. It is also concluded that big variations of understanding of the concept appear between different interviewees at the case company, increasing difficulty with organizational implementation. Many interviewees connected the term to designing with reused building materials or reuse in a more general term, showing there is a knowledge gap. With no common ground of the concept to be identified, this indicates that information is not spread effectively through the company. This is a frequently occurring issue in big companies like Skanska. By creating a unified understanding of CD, Skanska could create specific actions that will embed the concept in their day-to-day processes more easily.

It could also be concluded that current actions related to embedding the CD concept within the case company is limited to occasions used to gain and spread information. This includes workshops, circular Fridays and a general discussion about the concept. In addition, employing master thesis students to research the concept of CD is another strong action to create better understanding within the company. Currently, the study confirms that the information gained from these events have not resulted in any specific actions aimed at further embedding CD in the company. After creating a common understanding within the company, this will be the next step.

This study identified several barriers and opportunities with the implementation of CD. Barriers stated were those related to economy, clients, an underdeveloped sector and technical solutions. Economy was deemed the most mentioned barrier by empirical data although unambitious demands from clients were often mentioned as well. From further analyzing empirical data, the reflection that most employees saw more challenges than opportunities with CD could be made. It was concluded that the reason for this could be assigned to low levels of knowledge within the case company. The opportunities suggested by interviewees were sustainability factors, increased competitive advatages and personal fulfillment from working more sustainably. Interviewees failed to recognize

the economic opportunities stated clearly by literature. This could be considered strange, since economic incentives constitute an important driver of implementation.

Considering the concept being in its infancy and the lack of literature regarding implementation, few examples of actions to use to implement CD in an organization were available in literature and within the company. The study identified four actions recommended to be taken as an answer to the fourth research question. To connect the identified lack of a common ground for the concept within the company it is recommended to fractionalize the concept to be able to easily prioritize what part of CD implementation is achievable and beneficial. This is then easier to use when continuing to share the knowledge currently in the organization. To make the implementation feasible, another finding was that business models regarding DfA and DfD needs to be developed and spread to clients for the value put into the projects to get realized.

Following the aim and scope of the result of this thesis has provided Skanska with a deeper understanding of the current knowledge on the CD concept and its applications in the construction sector organizations. If taken into practice, the recommended actions provided would simplify the transition for the organization to create a business advantage. Considering the current lack of research available regarding the implementation of CD, this thesis can be of interest to anyone trying to implement CD strategies within large scale contracting companies.

7.1. Future research

The future studies regarding the concept of CD and creating circular flown in the construction industry are many, as it has barely reached implementation in projects and the current theory is still underdeveloped as well. Therefore, the first priority should be case studies on future project implementation. Involving researchers in examining the results of project implementation could lead to increased sector-wide knowledge. Having examples of projects has been identified as the enabler of removing some barriers for aspects of CD development. Seeing concrete practical projects where CD could be exemplified and evaluated would encourage and improve the concept as we see it today and could encourage stakeholders in the whole sector. Other research that could be done is envisioning CD business aspects and creating a business environment that allows CD to gain economic value as it is deemed vital in this study to the future feasibility of investing in CD.

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9. Appendixes

9.1. Interview guide

- What is your name, age, and role in the organization?
- What is your background in terms of previous roles and education?
- What is your understanding of the concept of circular design?
- Have you participated in any previous projects where the focus has been on circular design?
- Where in the process do you see yourself, in your role, contributing the most towards circularity?

Questions connected to company level

- What is the current understanding of circular design within Skanska? How does it compare to the sector as a whole?
- What steps has Skanska taken to move towards circular design?
- How was circular design introduced to your agenda/role?
- When did the introduction take place, and was there any specific department leading it? Was there an explanation for why this was introduced?

Questions regarding implementation

- Are you working towards any specific goals regarding circular design? Is it only project-based or is there something at the company level?
- Is the implementation of circular design encouraged as an individual from Skanska?
- What will circular design change in how Skanska works? What do you need to adapt to from today's more linear way of working? What support would you need for that adaptation?
- Do you think there is a clear strategy for how Skanska will become more circular?
- Is the current knowledge/competence at Skanska sufficient to implement circular design?

Questions regarding opportunities and challenges

- Can you describe what you see as challenges to implementing circular design?
- What opportunities do you see regarding circular design?
- Are there any obstacles/conflicts between different departments?
- Who do you suggest needs to be the driver in implementing circular design?

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