CHALMERS
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Navigating Towards Circularity

Overcoming Barriers to the Use of Circular Aggregates in the Swedish Construction Sector

Master's thesis in Design and Construction Project Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
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ABSTRACT

Today the construction sector is a central contributor to global environmental challenges, accounting for a significant portion of resource consumption and greenhouse gas emissions. In Sweden, the urgency for sustainable practices in this industry has become increasingly apparent, particularly as the government pushes for a transition towards a circular economy. This report delves into the complexities of implementing circular material flows within the construction sector, emphasizing the reuse and recycling of aggregates as essential strategies to mitigate environmental impact while enhancing resource efficiency.

The primary purpose of this study is to investigate how the Swedish construction industry, with focus on Swerock's and similar companies' national operations, can strengthen the use of recycled materials and eco-products. By understanding the interplay of legislation, industry practices, and market demand, the study aims to identify practical barriers and opportunities for fostering a circular approach towards material use. Through a comprehensive literature review and an in-depth interview study involving key stakeholders within the construction sector, the research uncovers existing challenges, including insufficient regulatory support, financial barriers, and logistical issues that hinder the integration of reused materials into construction projects. Moreover, it highlights the critical need for collaboration among public authorities, private companies, and other actors to support circular practices. The findings reveal that while the Swedish Environmental Code provides a foundation for sustainable practices, gaps remain in its application that hinders innovative solutions for material reuse.

Recommendations for enhancing legislation, encouraging circular practices, and fostering partnerships are provided to facilitate a successful transition into a more resource-efficient construction sector. This research contributes valuable insights not only for Swerock but also for a broader audience in the construction industry, offering a structured approach to promote sustainable material management within the framework of the circular economy.

Key words: circular economy, reuse, recycling.

Vägen mot cirkularitet

Att övervinna hinder för användning av cirkulära ballastmaterial i den svenska byggsektorn

Examensarbete inom masterprogrammet Design and Construction Project management

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Institutionen för arkitektur och samhällsbyggnadsteknik
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SAMMANFATTNING

Idag är byggsektorn en central bidragare till globala miljöutmaningar och står för en betydande del av resursförbrukningen och utsläppen av växthusgaser. I Sverige har behovet av hållbara arbetssätt inom denna bransch blivit alltmer påtagligt, särskilt i takt med att regeringen driver på en övergång till en cirkulär ekonomi. Denna rapport belyser komplexiteten i att implementera cirkulära materialflöden inom byggsektorn, med särskilt fokus på återanvändning och återvinning av ballastmaterial som viktiga strategier för att minska miljöpåverkan och öka resurseffektiviteten.

Studiens huvudsakliga syfte är att undersöka hur bygg- och anläggningsbranschen, med fokus på Swerocks och liknande företags nationella verksamhet, kan stärka användningen av återvunna material och eco-produkter. Genom att förstå samspelet mellan lagstiftning, branschpraxis och marknadsefterfrågan syftar studien till att identifiera praktiska hinder och möjligheter för att främja ett cirkulärt angreppssätt i materialanvändningen. Med hjälp av en omfattande litteraturstudie och en fördjupad intervjustudie med nyckelaktörer inom byggsektorn, synliggör forskningen befintliga utmaningar. Däribland ingår otillräckligt regelstöd, ekonomiska hinder och logistiska problem som försvårar en smidig integrering av återanvänt material i byggprojekt. Studien lyfter även det stora behovet av samverkan mellan myndigheter, privata företag och andra aktörer för att stärka cirkulära arbetssätt.

Resultaten visar att även om miljöbalken utgör en grund för hållbara metoder, kvarstår tillämpningsbrister som hämmar innovativa lösningar för materialåteranvändning. Rapporten presenterar rekommendationer för att förbättra lagstiftningen, skapa incitament för cirkulära arbetssätt samt främja partnerskap, med syftet att underlätta en framgångsrik omställning till en mer resurseffektiv byggsektor. Forskningen bidrar med värdefulla insikter inte bara för Swerock, utan också för en bredare publik inom byggbranschen, genom att erbjuda ett strukturerat angreppssätt för att främja hållbar materialhantering inom ramen för den cirkulära ekonomin.

Nyckelord: cirkulär ekonomi, återbruk, återvinning

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Göteborg June 2025

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This study, which covers 30 ECT, was conducted during the spring semester of 2025 by Clara Bergh and Valentina Jovic as an examining part of the Master Program Design and Construction Project Management, civil engineering, at Chalmers university of technology.

The aim of our project was to gain a deeper understanding of sustainability processes within the construction sector and how more sustainable materials can be implemented in practice. Sustainability has long been a subject of great interest to us, from environmental, social, and economic perspectives. Working in collaboration with Swerock provided us with valuable insights into current material flows and how they can be improved to support a greener future. Throughout the project, we also came to understand the complexity and challenges facing the industry, and that driving change in sustainability is often a long-term effort even when both the motivation and knowledge are present. This project clearly demonstrated that collaboration is one key to progress, and it has significantly strengthened our knowledge and competence in the field of sustainability.

We would like to express our heartfelt gratitude to everyone who contributed to the success of this study. First and foremost, we extend our sincere appreciation to the interviewees who generously shared their time, insights and expertise with us. Their willingness to engage in a meaningful discussion regarding the complexities of reuse and circular economy in the construction sector provided invaluable perspectives that significantly enriched our research. A special thank you goes to our supervisor Dimosthenis Kifokeris, for his strong support and guidance throughout the research process. His expertise and constructive feedback were important in shaping this report and ensuring its academic view. Dimos motivation helped us navigate challenges and refine our approach, and for that, we are truly grateful. We would also like to acknowledge our supervisors at Swerock, Ted Lundberg, Marcus Ljungholm and Frej Hegg, and thank you for making this report meaningful for us and involved actors. With your guidance and encouragement this work has been a joyful experience. As a leading player in the construction sector, Swerock's commitment to sustainability and innovation inspired us to explore the potential of circular materials in the industry. Lastly, we would like to address our colleagues and peers who contributed their thoughts and encouragement during this journey. Their support made this process not only fruitful but also enjoyable.

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Gothenburg June 5th 2025
Clara Bergh
Valentina Jovic

Central Concepts

To facilitate the readers understanding a list of key terms is presented below, describing how they are used throughout the report.

Circular economy	An economic model focused on reducing waste and promoting reuse, recycling and sustainable resource management.
Circular materials	Materials that are reused, recycled or recovered to extend their lifecycle and reduce the need for raw resources. This includes materials such as excavated masses, recycled aggregates, reclaimed concrete, and other components that are reintegrated into new projects.
Procurement	Describes the competitive process where contractors bid to secure a contract with a client
Quarries	Sites where raw materials and aggregates are extracted.
Regulatory authorities	Agencies responsible for enforcing regulations related to waste management, reuse, recycling and environmental protection.
Recycling	The process of converting waste materials into new products, reducing the need for raw resources and minimizing landfill use.
Reuse	The practice of using materials or products again for the same or a new purpose, helping to extend product life cycle and reduce waste.
Stakeholder	A person, group or organization with an interest or involvement in a decision-making process, project or outcome.
Raw materials	Natural resources that have not been previously used or processed.

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1 Introduction

The introductory chapter provides a comprehensive overview of the study's background and the context in which the research has been conducted. It outlines the underlying factors that motivate the investigation, as well as the academic framework to which the study relates. Furthermore, the purpose of the study and the specific research questions guiding the analysis are clearly presented. The chapter concludes with a description of the target groups that are particularly relevant to the study.

1.1 Background

The construction and real estate sector play a crucial role in society's environmental impact, accounting for a significant share of resource consumption and emissions. Statistics from Boverket (2025-a), based on data from Statistikmyndigheten (SCB), indicate that in 2022 the sector contributed between 4% and 39% of Sweden's total environmental impact, depending on the specific environmental factors being measured, see Figure 1. This makes the construction and real estate sector one of the most resource-intensive industries, with substantial potential to influence national environment and climate policies (Shahid et al., 2024). Furthermore, the shift towards a circular economy in the construction industry is currently in an exploratory phase, where circular construction is secondary and a linear way of working is still the norm (Boverket, 2025-a).

An analysis of the sector's environmental footprint, considering both domestic construction activities and imported building materials, reveals two separate trends over the period 2008-2022 (Boverket, 2025-a). Greenhouse gas emissions and nitrogen oxide emissions have decreased due to improved energy efficiency, advancements in construction techniques and stricter environmental regulations (Ministry of the Environment, 2020). However, other environmental concerns have increased significantly, including higher overall energy consumption and a rising volume of generated waste (Boverket, 2025-a).

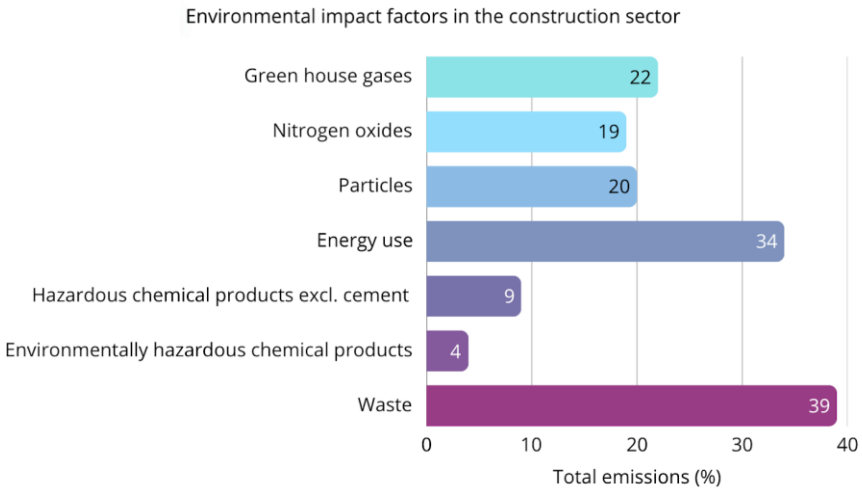


Table 1: Environmental footprint of the construction sector in 2022. Own figure. Source (Boverket 2025-a).

While the amount of waste in Sweden is increasing, there is also a distinctly high share in raw material extraction (Sveriges geologiska undersökning, 2023). According to Fossilfritt Sverige (2024), the average Swede consumes 8-10 tonnes of aggregates each year. Of this amount, 90% is extracted directly from rock and moraine, while natural gravel accounts for the remaining 10%. Sweden has set a target to ensure its supply of rock materials is free from fossil fuels by 2045, aligning with the European Union's climate objectives and addressing the industry's greenhouse gas emission challenges (Naturvårdsverket, 2024-a). To reach these goals, Fossilfritt Sverige (2024) emphasizes the need for a holistic approach that takes multiple factors into account. Among these, the extraction of raw materials should be reduced, with a stronger focus on preserving natural resources, biodiversity and ecosystem services.

The exploitation of raw materials has reached a critical point, necessitating that the industry take action and adopt new approaches, as our previous methods of operation are unsustainable (IISD, 2021). Over the past 30 years, the number of quarries in Sweden has been more than halved, decreasing from 3,440 to 1,117 due to regulations governing material extraction (Fossilfritt Sverige, 2024). The remaining quarries currently produce approximately 90.000 tonnes per quarry. As the number of quarries declines, the need for transportation and environmental impact will increase, as extraction sites become less locally distributed. Figure 1 illustrates the distribution of various materials, showing a downward trend in the use of natural gravel. At the same time, the demand for circular materials is expected to increase significantly over time.

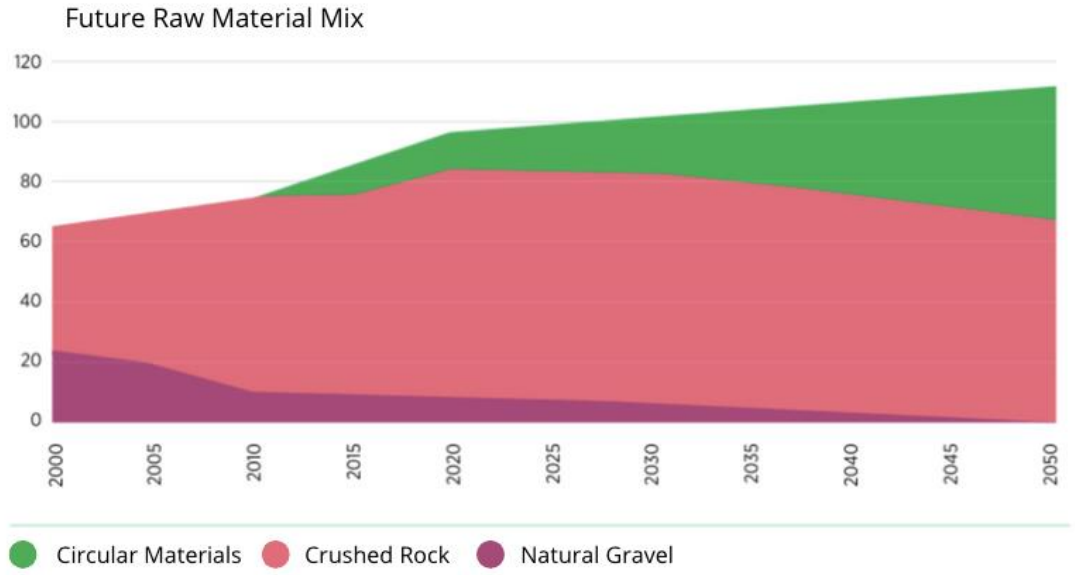


Figure 1: Projected future composition of raw materials for aggregate production. (Fossilfritt Sverige, 2024).

1.1.1 Traditions & Ignorance

According to Balador et al. (2020), raw materials are often viewed as better and are generally preferred, due to concerns regarding whether recycled materials can perform at the same level as raw materials. While the concept of reuse is well known, many stakeholders still prefer new materials, believing that recycled alternatives may not meet the same standards of quality and functionality. Factors such as a lack of

trust in secondary materials and the absence of standardized guidelines for their use therefore also influence material selection decisions (European Environmental Agency, 2020).

Historically, the construction sector has been strongly reliant on raw materials, making it challenging to shift the focus toward reuse and circular alternatives (European Environmental Agency, 2020). Many stakeholders are hesitant to invest time and resources in developing alternative solutions involving recycled materials, as these often require significant changes in work processes and project management strategies. Attitudes toward change and deficiencies in collective collaboration are also key obstacles to overcome (Boverket, 2024-b). Often, professionals in the sector are reluctant to work when changes in methods and material choices require substantial adjustments (European Environmental Agency, 2020). As a result, the potential benefits of a circular economy, such as increased resource efficiency and reduced waste generation, are not fully realized.

1.2 Target Group

This report is intended for stakeholders within the construction sector who are seeking more effective methods for integrating recycled crushed aggregates into their operations. The target group includes both private and public actors, such as municipal authorities and other relevant stakeholders, who have the potential to influence the development of a more sustainable and circular market. By examining the relationship between legislation, industry practices, and market dynamics, the report provides insights that may support both public and private stakeholders in navigating existing regulations and identifying opportunities for improvement. The findings aim to guide efforts toward a more resource-efficient construction sector by highlighting how legal frameworks and municipal strategies can be adapted to promote circular material use.

A major company which can take advantage of this report is Swerock, a key player in the construction and civil engineering industry. Given their active involvement in the construction sector, the findings are particularly relevant to Swerock's ongoing efforts to expand the use of recycled materials within their operations. Swerock has also been a guiding hand and mentor during this work and has provided the report with valuable insights. Therefore, they as a company are also a target group, since the report seeks to understand their operations as well as finding solutions to implement a greater use of recycled crushed aggregates. Given the growing regulatory demands and sustainability goals within the industry, this study seeks to provide insights that support Swerock and similar companies in systematically increasing their use of recycled crushed aggregates.

1.3 Aim & Research Questions

The purpose of this study is to examine how the construction and civil engineering industry, with a focus on Swerock's operations, can promote increased use of recycled crushed aggregates. Furthermore, it will analyze how legislation and municipal guidelines can be adapted to support a more sustainable and resource-efficient development within the industry. The study will therefore analyze how legislation and municipal guidelines can be adapted and changed to support a more sustainable and resource-efficient development within the industry. Lastly, the report aims to look

into the barriers that hinder today's development in the area regarding recycling crushed aggregates.

The following two research questions will be examined in detail to explore their implications and significance:

- *What are the main practical and organizational barriers to implementing circular aggregates in the construction process, and in what way could this be improved?*
- *How does the current Swedish environmental legislation affect the possibilities for increased reuse of aggregates in the construction sector, and what changes are needed to facilitate a circular transition?*

1.4 Delimitations

The delimitations that the study will take into account are to only take the approach from Swerock as a supplier's perspective and the Municipality of Gothenburg's role as a client. The study will also only look into regulations in Sweden and how the government and the different municipalities in Sweden decide for the development in Gothenburg city. Information gathered from documents and data should also not be older than 10 years back in time since it's been a development in reuse the last decade. Another delimitation for the study is that the report will take a general approach and will not examine specific projects where the implementation of reused aggregates may or may not be applicable.

2 Method

This chapter presents the methodology of the study and explains certain strategic choices. Furthermore, it outlines the overall work process, including how relevant literature was identified and selected for review. The chapter also explains the approach taken for conducting interviews and the criteria used for selecting participants. Key aspects of research quality are discussed, with a particular focus on credibility, reliability, and validity. Finally, the chapter addresses the ethical considerations involved in the study, including issues related to the use of AI, data collection, as well as the limitations that affect the study's scope.

2.1 Work Process

The study will take an inductive approach, which aims to create a study based on observations of empirical reality, where general conclusions are derived from specific cases (Collis & Hussey, 2014). Furthermore, this study will be conducted through a qualitative method that aims to gather theoretical data and focuses on understanding concepts, experiences, and processes that cannot be quantified or tested through controlled experiments (Laksham et al., 2000).

2.2 Literature Review

A systematic literature review has been used in this study as it aims to compile information within a defined area and since it aims to choose relevant articles specifically (Karolinska Institutet, 2024). We have critically reviewed and carefully selected them to ensure their alignment with the topic, which we ultimately discuss at the end of the study. To ensure the credibility and accuracy of the literature study, primary sources have been used as extensively as possible. Relying on first-hand sources allows for a more direct interpretation of original data, theories and findings, minimizing the risk of misrepresentation. However, in cases where secondary sources have been used, their content has been carefully reviewed and compared with other reliable sources to verify accuracy and consistency. This approach strengthens the reliability of the research by ensuring that the information is derived from its original context and that any secondary interpretations are well-grounded and trustworthy.

SO-rummet (2025) points to sources with recent writing and regulatory updates that hold greater credibility, as they provide more up-to-date information. The further removed a source is in time, the more validated it becomes. Based on this, the study has chosen to focus on sources that span a maximum of 10 years to ensure they remain relevant and nuanced and to ensure a trustworthy report, since this subject is in the process of change all the time. The oldest and only exception is Brundtland (1987), as it serves as the foundational reference for sustainability and its definition. Sources lacking a publication year have generally been excluded, with the exception of company websites, such as Swerock's, where the study assumes the information remains relevant. Furthermore, literature from both Swedish and international publications has been used to receive a nuanced perspective but also to include multiple ways of thinking and reasoning regarding sustainability and reuse. Since the study aims to investigate the Swedish extraction of crushed and ECO-products, regulations and legislation are based on a national level.

The sources used in this study primarily consist of academic articles and research obtained through Chalmers library, which provided access to reputable databases such as ResearchGate and ScienceDirect. Additionally, information has been gathered from books and academic search monitors, including Google Scholar and Scopus, to ensure a comprehensive literature review. Furthermore, internal reports from Swerock have been analyzed to provide industry-specific insights and practical perspectives, complementing the academic sources and ensuring a stronger foundation for the study. Lastly, information regarding legislation and guidelines was gathered from governmental authorities, such as the European Union and other relevant regulatory bodies.

Specific keywords were used to ensure the study included relevant information and made the search process more refined. These keywords included reuse, circular economy, construction sector regulations, sustainability and waste. The keywords were then combined to identify additional relevant articles and provide broader insights for the study. The search was conducted multiple times to ensure the most relevant and up-to-date information was gathered, as new content is constantly emerging.

2.3 Interviews

10 different interviews were conducted, either on site or via Teams, with suppliers and stakeholders within the Swedish construction industry to receive their insight. The duration of each interview was around 1 hour. Different actors besides Swerock were interviewed to gain knowledge from various perspectives. Representatives from Vinnova, Riksdagen, Delphi and Göteborgs Stad were all interviewed. Vinnova, Sweden's Innovation Agency, was selected to understand the development of circular economy practices in construction from a futuristic point of view. Secondly, Riksdagen, which establishes the legislative framework and regulations in Sweden were interviewed. Their perspectives were crucial in comprehending the creation of laws and regulations. A department specializing in waste and resource management at Delphi, a Swedish law firm, was also a part of the interview study. Lastly, Göteborgs Stad also played a crucial role in understanding the subject of circularity and laws and understanding how they think as a client.

In Table 2, all interviewees along with their roles and companies are presented. In chapter 5. Results the interviewees are referred to as respondent 1 to 10 for ethical considerations and to maintain anonymity. See Appendix A for insights into the asked interview questions. The interviews were held with a semi-structured approach to allow space for questions which came up during the interviews but also to follow a common subject and not fall out of line. The semi-structure also made it possible to send the questions to the interviewees beforehand, since they were predetermined, and then follow up questions came up as the interviews went on (Academic Work, 2025). This structure made it possible to adapt the questions regarding who was interviewed.

Furthermore, the interview study was based on a thematic analysis to identify repeated patterns and key themes within the interview material (Klang, 2024). The process began with systematically coding the transcribed interviews, where relevant statements were highlighted to capture essential insights. These coded segments were then categorized based on their content, allowing for the identification of overarching

themes. Through a successive process of comparing and refining these categories, a deeper understanding of the key challenges and opportunities related to the implementation of reused crushed aggregates emerged. This structured approach ensured that the analysis remained grounded in the data while allowing flexibility to incorporate new perspectives that became apparent during the process.

Table 2: This table lists the interviewees along with their roles and companies.

Interviewees	Role	Company
Respondent 1	Senior project manager	Göteborgs Stad
Respondent 2	Head of department	Göteborgs Stad
Respondent 3	Environmental officer	Göteborgs Stad
Respondent 4	Building inspector	Göteborgs Stad
Respondent 5	Deputy head of department	SWEROCK
Respondent 6	Head of development	SWEROCK
Respondent 7	Lawyer	Delphi
Respondent 8	Desk officer	Regeringskansliet
Respondent 9	Geologist & Senior researcher	RISE
Respondent 10	Officer	Vinnova

2.4 Research Quality

Ensuring the quality of a study is a crucial aspect of research. Therefore, three key criteria have been used to evaluate the report's research quality, which are credibility, reliability and validity. Andersson et al. (2024) define reliability as the ability of a measurement method to produce consistent results when applied repeatedly under the same conditions. On the other hand, Andersson et al. (2024) describe validity as the accuracy with which a method captures its intended measure. High validity indicates that the results accurately represent real-life conditions, whether in a physical environment or a social setting

Ensuring both reliability and validity is essential for assembling the last criteria, credibility, where focus is to produce a credible and trustworthy report through research findings (Andersson et al., 2024). Reliability can be further divided into several types, such as internal reliability, which assesses the consistency of results within a study (Middleton, 2025). Another described part is the external reliability, which examines whether the study can be replicated with similar outcomes in different settings. Similarly, validity can be categorized into internal validity, which focuses on the accuracy of the relationship between variables within the study. External validity determines whether the findings can be generalized beyond the specific research context.

2.4.1 Credibility

The interviewees selected for the study were considered credible, as they are all engaged in circular practices and sustainability in some capacity. Several of them also possess in-depth knowledge of laws and regulations, providing a deeper understanding of how these legal frameworks influence the transition toward increased circularity in the construction sector. To enhance the study´s credibility, the interviews were recorded and transcribed to ensure the highest possible accuracy in the presented material. A total of ten interviewees were selected as a minimum of

participants to ensure a diverse range of responses, as the answers reflect individual perceptions and opinions, creating personal bias.

2.4.2 Validity

To ensure the validity of this report, the interviews were conducted to also detect current challenges within the field. Regarding potential sources of error, one limitation concerns the number of interviews. Including additional participants would have introduced a wider range of perspectives on the topic and contributed to a more nuanced view of opinions regarding the implementation of circularity. Furthermore, a greater number of interviewees would have strengthened the study's validity by incorporating more voices, thereby offering a clearer and more representative picture of the current situation. Another perspective of this, could have been to find more specialists from the client's side. The answers from the municipality were general and therefore this could have been an error, since the answers were not always aligned within the specific area of circular aggregates.

2.4.3 Reliability

The questions asked during the interviews have been thoughtfully written to make the interviewees answer freely, without being affected by biases. What questions suit the report the most and contribute to answering the research questions has been reflected on when writing them. Therefore, nothing has been selected in a way to hide relevant information for the readers. Similarly, the sources included in the literature review were selected based on the same principles of transparency and relevance. Efforts were made to ensure that the literature was as up to date as possible, and no perspectives were deliberately excluded. Moreover, if this study were to be replicated under the same conditions and without the emergence of new research, the results would be expected to remain consistent.

2.5 Ethics

This study has been conducted with careful consideration of ethical principles to ensure transparency, integrity and respect for the individuals involved.

2.5.1 Data Collection

To maintain ethical standards in data collection, all interviews have been recorded with the informed consent of the participants. Prior to the interviews each participant was provided with the interview questions and informed about the purpose of the study ensuring that they had sufficient time to prepare and understand their role in the research.

Furthermore, the study has been conducted with an objective approach, ensuring that neither the selection of sources nor the interpretation of results has been influenced by bias. Efforts have been made to include diverse and credible sources, critically evaluating them to provide a balanced and reliable foundation for the research.

2.5.2 Use of Data

To uphold ethical integrity, all interviewees were given the opportunity to review, read and provide feedback on their responses before the study's publication. Their consent was obtained at multiple stages, both before and after the interviews, ensuring that they were comfortable with the way their input was presented. They were also informed that they did not have to answer questions they were uncomfortable answering. Additionally, to protect the privacy of the participants, all individuals are presented anonymously in the text. This measure was taken to ensure that no personal or identifiable information is disclosed while maintaining transparency in the study's methodology.

2.5.3 Use of AI

AI, in the form of ChatGPT version 4.0, has been used primarily to translate words and sentences from Swedish to English, as well as to check grammatical structure. It has also been utilized to find synonyms for selected words to create a more formal tone in the report. AI has not been used to generate text or answer topic-specific questions, as its reliability cannot be ensured. Since the report is fact-based, AI cannot guarantee that responses are derived from a single, consistent source or that the information is up to date. Additionally, ChatGPT generates different responses depending on how questions are formulated, which is another reason why the reliability of its generated answers cannot be ensured.

2.6 Limitations

Several limitations of the study have been considered when writing the report with time being the most significant. The research was conducted within a limited time frame of 6 months, which inevitably have affected the scope of the investigation. This could also have influenced the findings, as certain potential important perspectives and angles could not be explored. The limited period also impacted the data collection process, particularly the ability to identify and conduct interviews with a broader range of relevant stakeholders. Given more time, more interviews could likely have been included, enabling a more comprehensive understanding of the field with more insights. With more time, efforts could have been made to ensure a greater diversity of voices thereby improving the reliability of the conclusion.

Since the report is based on exploring the Swedish regulatory frameworks other countries' solutions have been excluded. By not incorporating international perspectives or comparative approaches the research may have missed potentially valuable insights or alternative methods. International best practices or innovative solutions implemented elsewhere could offer inspiration or serve as benchmarks for the circular development in the Swedish construction industry. However, due to its national focus the study does not explore whether international approaches could be effectively integrated into the Swedish regulatory context. This limits the study's ability to evaluate potential strategies used abroad, which could have added a wider dimension to the analysis and strengthened the recommendations.

3 Literature Review

Chapter 3 provides a comprehensive overview of current research in the field, divided into several main sections that collectively highlight key aspects of the subject. The chapter begins by introducing the concept of sustainability, followed by an overview of the legislative frameworks that govern reuse in the construction industry, thereby enhancing the understanding of the regulations that influence current practices. Next, the importance of the circular economy and the principles underlying this model are discussed. The chapter also addresses the waste hierarchy and its various levels, highlighting sustainable methods for managing waste. A crucial part of the chapter is dedicated to explaining what reuse entails in practice, as well as identifying the main challenges associated with its implementation. Furthermore, the chapter analyzes the actions and responsibilities of various stakeholders in promoting reuse. Finally, a range of potential solutions is presented to contribute to addressing these challenges and promote a more resource-efficient and sustainable construction sector.

3.1 What is Sustainability?

A widely recognized definition for sustainability stems from the report Our Common Future, published in 1987 by the World Commission on Environment and Development. This report, also known as the Brundtland Report, defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p. 54).

This definition of sustainability emphasizes the two key principles: needs and limitations (Kreye, 2023). The concept of needs focuses on securing a minimum standard of living, particularly for the most vulnerable populations, while limitations refer to the constraints imposed by current technology, social structures and the Earth's biocapacity. The report also highlights the importance of fairness between generations, making sure that future generations can live on a planet that supports a good quality of life (Brundtland, 1987). Expanding this framework globally, sustainability can be understood as creating the condition in which all people, now and in the future, have access to the resources and environment necessary for survival and prosperity. These ideas have formed the basis for today's discussions about sustainability and show how environmental, social and economic aspects are closely connected.

Agenda 2030 is a vision that includes the UN's 17 sustainable development goals, aiming to create a better world by 2030 (FN-förbundet, n.d). These 17 main goals are further divided into 169 measurable targets, making it easier to study and track progress. Many of these targets address the three dimensions of sustainability, economic, social and environmental, to create an inclusive and comprehensive vision. Agenda 2030 applies to all countries and societies worldwide, regardless of their level of development, ensuring that everyone is equally committed to achieving a sustainable future. According to Boverket (2024-c), the Swedish construction sector must adapt its industry based on some of the 17 sustainable development goals to promote circularity and the creation of a sustainable future. These include goal 8: decent work and economic growth, goal 9: industry, innovation and infrastructure, goal 11: sustainable cities and communities, goal 12: responsible consumption and

production, goal 13: climate action and goal 15: life on land. Based on these six goals, Sweden has established a generational goal, aiming to create a society where major environmental issues are resolved before the next generation takes over.

3.1.1 Triple Bottom Line

According to Kreye (2023), sustainability encompasses a broader perspective, which includes not only environmental issues but also social and economic dimensions. This broader approach is summarized in the theory known as the triple bottom line (TBL), a framework that evaluates sustainability through three key components: profit, planet and people (3Ps). The idea behind the TBL framework, introduced by John Elkington in 1994 as noted in Kreye 2023, was to encourage companies to consider three separate bottom lines in their operations rather than focusing solely on financial profits. These bottom lines represent the financial, social and environmental performance of a company over time. By incorporating all three dimensions, TBL aims to provide a more comprehensive understanding of the true costs and impacts of doing business.

3.2 Steering Laws Regarding Reuse in Construction

The construction sector must comply with numerous sustainability regulations to safeguard the world's resources and living standards, and this includes applying a life cycle perspective and reporting a building's climate impact (Boverket, 2020). Targets have been established for waste management to enhance ecological sustainability and improve efficiency (Boverket, 2025-b).

3.2.1 The Swedish Environmental Code

The Swedish Environmental Code (Miöjöbalken), which was enacted in 1999, serves as a legal framework designed to support sustainable development and guarantee that future generations can enjoy a healthy environment (Riksdagen, 1998). The aim with the Swedish Environmental Code is also to emphasize individual and collective responsibility for protecting nature (Göteborgs Stad, n.d-a). The Swedish Environmental Code is a consolidation of 16 environmental laws that were used in Sweden during the 20th century, with the first enacted in 1964 and the last in 1994 (Riksdagen, 1998). To enable a broader application this was developed to cover all types of measures, including those related to individuals' daily lives and commercial activities.

The Swedish Environmental Code highlights five key areas, one of which emphasizes the importance of reusing and recycling materials, raw materials and energy (Riksdagen, 1998). The goal is to create a long-term sustainable cycle where resources are used efficiently and environmental impact is minimized. Chapter 15 of the Swedish Environmental Code addresses waste management and the regulations governing how different actors should handle, transport and process waste. These provisions are, according to Riksdagen (1998) crucial to ensure that waste is managed in a way that reduces negative environmental effects and promotes a circular economy, where resources are reused and recycled instead of being wasted. Additionally, Chapter 15 in the Swedish Environmental Code outlines how waste should be managed. Waste management includes physical handling such as collection,

transportation, sorting, recycling or disposal. Measures should also be taken to facilitate these processes, even without direct physical interaction, for instance, by organizing transportation or transfer of ownership.

3.2.2 The Swedish Waste Regulation (2020:614)

The Swedish Waste Regulation (avfallsförordningen) was made to complement the Swedish Environmental Code and contributes with a broader understanding for waste (Riksdagen, 2020). According to Göteborgs Stad (n.d-a), the Swedish Waste Regulation builds upon the Swedish Environmental Code of 1998 by specifying and clarifying regulations for waste management in Sweden. While the Swedish Environmental Code establishes overarching principles such as the waste hierarchy and the distribution of responsibilities, the Swedish Waste Regulation provides detailed provisions regarding waste management and the classification of hazardous waste.

Because of the Swedish Waste Regulation, waste can be categorized as either hazardous or non-hazardous, which Riksdagen (2020) further determines how it should be handled and treated. Hazardous waste (FA) contains substances that pose a significant risk to human health and the environment, requiring more strict handling, disposal and recycling measures. Non-hazardous waste (IFA), on the other hand, poses minimal risks and can be managed with less restrictive regulations to ensure environmental safety.

According to Naturvårdsverket (2009), a model has been developed to establish guideline values for contaminated soil. The model is based on two main land use scenarios: sensitive land use (KM-känslig markanvändning), such as residential areas, and less sensitive land use (MKM-mindre känslig markanvändning), such as industrial areas. These categories, while not legally binding, guide the management of waste and contaminated soil and serve as a reference for risk assessment. If contamination levels exceed the general guideline values, it does not actually indicate a risk, but further investigation may be required to determine appropriate actions.

3.2.3 Chemical Legislation

Chemical legislation aims to provide more comprehensive control over the risks associated with chemicals, both for human health and the environment (Riksdagen, 2007). The legislation seeks to enhance corporate competitiveness by establishing a common market within the European Union. Under this legislation, companies today bear significant responsibility for reporting their usage and assessment of chemical substances in the market. They are also required to demonstrate that these substances are handled safely and that monitoring is conducted for hazardous substances affecting health and the environment.

In 1999, the Swedish Parliament decided to implement 15 environmental quality objectives, with an additional objective introduced in 2005 to promote a healthier and safer environment (Riksdagen, 2007). Among these objectives, A Non-Toxic Environment, aims to eliminate substances and metals that are man-made or extracted by humans and that pose a risk to both human and biodiversity.

Managing resources in a circular economy is difficult, as different legislations regulate products and waste separately (Naturvårdsverket, 2024-c). While chemical legislation applies to the production and use of materials, waste legislation governs how discarded materials are handled and processed. This distinction is crucial for ensuring both environmental protection and sustainable resource management. Companies must act in accordance with these regulations carefully to comply with legal requirements while promoting efficient use of materials and at the same time minimize waste.

3.2.4 Circular Economy Act

The Circular Economy Act is an action plan, published by the European Commission, whose purpose is to facilitate the work on implementing circular products, secondary raw materials and waste (European Commission, 2025). As part of this plan, the Commission aims to set standardized criteria defining when waste is no longer considered waste, making it easier to transform it into valuable secondary raw materials. Additionally, it will simplify and strategically expand producer responsibility while increasing demand through guidelines for public procurement. The Commission also highlights that to further strengthen circularity and enhance recycling capacity, they are also considering new measures to make recycling of critical raw materials within the EU more attractive than exporting them. This aligns with the 25% recycling target set in the Critical Raw Materials Act. Moreover, efforts will be made to reduce landfill dependency by improving separate collection systems and promoting reuse and recycling initiatives.

3.2.5 Corporate Sustainability Due Diligence Directive (CSDDD)

In the middle of 2024, the European Union's new regulation corporate sustainability due diligence directive (CSDDD) regarding corporate sustainability responsibility came into action (European Commission, n.d-a). The purpose of the directive is to strengthen corporate accountability for sustainability by ensuring that companies operate in an ethical and environmentally sustainable manner. Businesses covered by the regulations are now required to actively identify, prevent, and address risks related to negative impacts on both human rights and the environment.

According to the European Commission (n.d-b) the new CSDDD law serves as a reinforcement of the Corporate Sustainability Reporting Directive (CSRD). The CSDDD, which instead expects companies to take measures to prevent adverse environmental impact, links CSRD's reporting obligation to that responsibility. The new law focuses on regulating companies' actual actions to ensure long-term sustainable and responsible business practices.

The legislation reviewed in this chapter presents the current legal framework governing environmental responsibility, waste management and sustainability within the construction sector (Naturvårdsverket, 2024-d). Together, these laws aim to ensure safer handling of materials, promote recycling and reuse, and guide companies toward more responsible practices. However, different laws regulate different stages of a material's life cycle, such as product use and waste handling, which can affect how reuse is approached in practice. It looks like the laws are not comprehensive enough to inform about problems regarding reuse and recycling. As of today, the laws

are not theoretically informed enough to address these issues. The following chapter introduces the concept of circular economy, which serves as a broader strategy for supporting more sustainable resource flows and complements the legal framework presented here.

3.3 Circular Economy

Circular economy is utilized as a strategy for transitioning toward a more sustainable and resource-efficient future (Naturvårdsverket, 2024-e). It helps guide society in the right direction toward achieving desired environmental and climate goals. The principle of a circular economy is based on using a material or product for as long as possible, including the possibility of breaking it down and transforming it into a new product. Figure 3.1 illustrates the concept of circular economy. In this way, sustainable thinking and actions are promoted in a reality that is currently unsustainable. Within a circular economy, a product gains an extended lifespan, and its utility is carefully evaluated to ensure a sustainable transition (Naturvårdsverket, 2024-e).

Figure 3.1: Circular Economy Model (European Parliament, 2023).

According to Naturvårdsverket (2024-e), implementing a circular economy is essential for transitioning society toward greater sustainability and resource efficiency. The focus lies on conserving raw materials, energy, water and land, while prioritizing the design of products that can be repaired and upgraded. It aligns with the notion that today's products become tomorrow's waste, and by reusing materials, society can significantly reduce waste generation. Further, Naturvårdsverket explains that the concept behind a circular economy is for a material to keep its worth while circulating as long as possible with the same high quality. Naturskyddsföreningen (2021-a) also emphasized that acting sustainably and implementing a circular economy must be incentivized. Policy instruments are needed to encourage

individuals to adopt innovative approaches where reuse becomes the obvious choice. Additionally, such instruments are required to create favorable pricing conditions, as it is often more expensive today to repair than to purchase new products.

3.3.1 Circular Construction

According to Stockholms Stad (2021), circular construction is based on the principles of the circular economy and waste hierarchy. Similar to the circular economy, circular construction aims to optimize the use of existing materials, reduce waste generation, and improve the recycling of resources. Moreover, circular construction plays a crucial role in reducing both economic and environmental costs by promoting resource efficiency and sustainable building practices. Stockholms Stad therefore emphasizes the dire need for new regulations and approaches to make circular construction a reality. The aim of a circular economy is also to implement reused and recycled materials in the building sector, and by 2025, 70% of demolition waste should be reused (Boverket, 2024-e). Buildings should also be evaluated in terms of their lifespan; the goal would be to reduce waste and material loss, ensuring that materials retain their purpose even beyond their original intended use.

According to Göteborgs Stad (2019) in the year of 2030, 50% of all used aggregates in Gothenburg should consist of reused or recycled materials. The implementation of circular aggregates must be further expanded to achieve a more sustainable production chain and economic viability (Fossilfritt Sverige, 2024). This approach also includes reducing the use of raw materials to preserve natural resources and biodiversity, thereby protecting nature and the environment. The holistic perspective aims to decrease the extraction of raw materials and instead focus on expanding the production of circular raw materials, as circular aggregates contribute to greater climate benefits and reduce transportation needs. According to Gorgolewski et al. (2008) a circular process should be planned from the outset to ensure a fully closed-loop system with zero waste. To achieve this, they state that it requires thoughtful design, clear structures, effective methods and a well-integrated system that enables the reuse of all materials, giving them a new purpose.

The Circular Economy Act, which will be published in 2026 by the European Commission, is a way from the EU to implement a circular economy faster and to create an internal market (European Commission, 2025). According to the Commission, some enhancements to the steering law is to create a freer movement of circular materials and waste simultaneously while increasing the supply of high-quality recycled materials. With this law the Commission hopes to drive the demand for recycled resources by introducing clear requirements in public procurement. From this, the new law will establish common guidelines for when waste is transformed to usable secondary raw materials, making both recycling and reuse easier.

3.3.2 ESG

ESG stands for Environmental, Social and Governance and serves as a framework for guiding organizations and companies toward a more sustainable future (RISMA, n.d.). This framework facilitates companies in measuring their climate and environmental impact while aligning with the United Nations global sustainability goals. The three pillars encompass areas such as the management of natural resources, relationships

between organizations and employees, and corporate governance. As sustainability remains a highly relevant topic, it is essential for companies and organizations to engage with these issues and align with societal developments to ensure long-term business success. Additionally, RISMA highlights that there is an increasing discussion about the possibility of ESG regulations becoming mandatory. Consequently, actively addressing these matters is even more critical for companies aiming to maintain a competitive edge in the future.

3.4 Waste Hierarchy

In Europe, the construction industry consumes more natural resources than any other industry and is a major source of waste (Zhang et al., 2021). It is responsible for nearly 50% of all raw material extraction and generates more than one-third of the total waste produced (European Commission, n.d-c). Based on this significant impact, construction and demolition waste has been identified by the EU as a priority area for waste management. To make the construction sector more sustainable, circular economy principles have been incorporated into this topic, aiming to enhance material reuse and recycling (Zhang et al., 2021).

According to the Swedish Environmental Code (1998) waste refers to "any substance or object that the holder disposes of or is obligated to dispose of". Furthermore, it is stated that a substance or object that arises unintentionally in a production process is considered a by-product rather than waste if it: is intended for continued use, can be used directly without additional processing beyond standard industrial procedures, has arisen as a natural part of production and does not violate any laws or pose a risk to the environment or human health. Naturvårdsverket (2022), on the other hand, emphasizes that the material conditions can change over time since they can't guarantee that a risk will not occur in a later stage. Further on, when it comes to the assessment of whether the material poses a risk to the environment or the human health, the intended use location matters.

In accordance with this, the implementation of circular materials is slowed down by regulations on waste and by-products, as their classification varies between different cases (Naturvårdsverket, 2024-b). Another factor that slows down the use of circular materials is, in some cases, that it is quickly classified as waste (Fossilfritt Sverige, 2024). Therefore, legislation needs to be clarified and ensured to prevent such obstacles and to avoid laws themselves becoming a barrier to environmentally sustainable development.

According to Naturskyddsföreningen (2021-b) the waste hierarchy is a model used within the EU to guide waste management in the most environmentally friendly way possible. It is part of Swedish environmental legislation and aims to reduce the impact of waste on nature by prioritizing different handling methods. The hierarchy consists of five levels, with the top steps being the most sustainable and the bottom ones being the least desirable, see figure 3.2 for illustration (Göteborgs Stad, n.d-b).

Figure 3.2: Waste hierarchy (Göteborgs Stad, n.d-b).

3.4.1 Prevention

In the waste hierarchy, preventing waste is considered the most sustainable approach (Naturskyddsföreningen, 2021-b). In the construction sector, waste prevention is primarily measured by reducing the total mass of construction and demolition waste, which can be evaluated using indicators such as raw material consumption and waste generation (Zhang et al., (2021). According to Boverket (2025-c) the requirements for waste in Plan- och bygglagen were revised in 2020 to include a broader range of waste categories and to facilitate recycling and reuse efforts.

3.4.2 Reuse

One of the key strategies for reducing construction and demolition waste is reuse, which extends the lifespan of materials and reduces the demand for new raw materials (Göteborgs Stad, n.d-b). According to Ericsson et al. (2024) reusing materials is often more expensive than using new ones, mainly due to high costs for transport, storage, refurbishment and assembly, especially in countries with high labor costs. Additionally, Ericsson et al. emphasizes that the taxation on reused materials further reduces their economic viability by increasing costs for businesses and discouraging investment in circular economy initiatives.

3.4.3 Recycling

Recycling involves converting waste into new materials or products, reducing the need for raw material extraction and thus saving resources and energy (Naturskyddsföreningen, 2021-b). In the construction sector, recycling often includes processing construction and demolition waste so that it can be used in new building projects (Göteborgs Stad, n.d-b). According to Sveriges Miljömål (2023) the Swedish Waste Regulation outlines various requirements for sorting, applying to both producers and collectors of materials, to minimize incineration and landfill disposal as much as possible.

3.4.4 Recovery

Energy recovery is a step in the waste hierarchy where waste that cannot be reused or recycled is converted into energy through processes such as incineration or biogas production (Naturskyddsföreningen, 2021-b). In Sweden, waste incineration is mainly used for district heating and electricity production, reducing dependence on fossil fuels. However, while energy recovery continues to be a more efficient waste management system, it is still considered less sustainable than waste prevention, reuse and recycling.

3.4.5 Landfilling

Disposal is the least desirable option in the waste hierarchy and should be used as a last way out when no other alternatives are possible (Naturskyddsföreningen, 2021-b). Sweden has one of the lowest landfill rates in Europe due to strict regulations and investments in recycling and energy recovery (Avfall Sverige, 2023). However, certain materials, such as hazardous waste and contaminated soil, may still need to be disposed of in landfills to minimize environmental impact.

3.4.6 Challenges Connected to the Waste Hierarchy

Criticism of the waste hierarchy, according to Fossilfritt Sverige (2024), revolves around the need for clearer definitions of what should and should not be classified as waste, as there is currently a lack of consistent assessments among regulatory authorities in Sweden. This is intended to promote a greater utilization of waste materials and remove the "waste" label, as it hinders progress within the circular economy.

3.5 Life Cycle Assessment

Boverket (2024-f) defines a Life cycle assessment (LCA) as a method used to examine how a product impacts the environment throughout its entire life cycle, from cradle to grave. Meaning from the extraction of raw materials from nature to the point where the product is no longer in use and is managed as waste. By conducting an LCA, it is possible to identify which phase of a product's life cycle contributes the most to environmental impacts. This information can be used to plan and lay the foundation for building in a more sustainable and efficient way. According to Kreye (2023) an LCA consists of three main steps. First, the goal and scope of the analysis are defined, which means setting the boundaries for the study. The next step is to conduct an inventory, where data on environmental impacts from the different stages of the products life cycle is collected and analyzed. The final step is to assess the environmental impacts, examining how various factors such as energy consumption affects the environment.

3.5.1 Cradle-to-cradle

In contrast to the cradle-to-grave approach, cradle-to-cradle ensures that a product's life cycle continues beyond its initial use (Kreye, 2023). Instead of being disposed of as waste, the product or its materials are recycled or repurposed to create new products or components, fostering a circular and sustainable system. According to

Mohajan (2022) the cradle-to-cradle strategy is viewed as a comprehensive approach that integrates economic, industrial and social aspects. Its goal is to develop systems that are not only efficient but also completely free of waste.

3.5.2 End-of-waste Criteria

According to the European Commission (n.d-d), fostering a strong recycling market requires reducing regulatory barriers for high-quality and waste-derived materials so they can circulate freely like primary raw materials. To achieve this, it is necessary to determine the stage in the recovery process where such materials cease to be classified as waste. This is governed by end-of-waste criteria, which are established through detailed assessments of technical, economic and environmental factors to ensure safety and market viability (European Commission, n.d-d).

End-of-waste criteria determine the point at which a material stops being considered waste and is instead recognized as a usable product or secondary raw material (European Commission, n.d-d). Materials can be reclassified from waste to product after undergoing a recovery process, such as recycling, if it meets the following four conditions:

- It serves a clear and recognized purpose.
- There is an existing market or demand for it.
- It meets all necessary legal, technical and regulatory requirements for its intended use.
- Its use does not pose risks to human health or the environment.

While these criteria aim to streamline the transition from waste to resource, their practical implementation presents challenges (Naturvårdsverket, 2024-d). Sweden's national waste plan for 2024-2030 highlights several difficulties in aligning with both EU and national environmental targets. The plan underscores that many key stakeholders lack the necessary insight into how they can contribute to more efficient waste management and circular resource use. One of the main obstacles described is the complexity of evaluating when a material should no longer be classified as waste.

3.6 Reuse in the Construction Sector

Reuse involves the potential to repurpose a product or material for a new application once its original purpose has been fulfilled (Boverket, 2024-g). The material must not wear out or degrade too quickly but should remain fully functional over a long lifespan, even as a reused material. Reuse also refers to the process of developing a new product or material, with considerations from the outset regarding how the material can be repurposed after serving its primary function. This process, presented by Boverket (2024-g), includes preparations for reuse, regardless of whether a product is reused directly without ever being classified as waste or if it has previously been considered waste but undergone a process to once again be defined as a product.

Sweden's high greenhouse gas emissions, caused by the construction sector, highlights the critical importance of implementing new policy instruments for construction materials (Boverket, 2025-a). The Nordic Council of Ministers established, in September of 2023, a new declaration aimed at strengthening Nordic

collaboration on low-carbon construction to ensure a greener way of working as well as promoting circular principles within the construction industry. A system based on reused materials creates long-term and sustainable opportunities for materials to serve new purposes (Byggfakta, 2023).

Construction and infrastructure projects continuously generate surplus rock materials, which can be reused as filling materials, base layers and reinforcement layers (Fossilfritt Sverige, 2024). By harnessing the recycling potential of these materials, essential raw materials can be utilized more sustainably while also reducing transportation needs. Recycled materials play a crucial role in securing a region's material supply, making it essential to take full advantage of these resources. To achieve this, Fossilfritt Sverige highlights that better insights and statistics on the availability and use of excavated rock and soil materials are needed.

3.6.1 Implementation of Reused Materials

By sorting and recycling materials such as concrete, wood, and metals, climate impact can be significantly reduced, and resources can be used more efficiently (Boverket, 2024-h). Boverket also emphasizes the importance of identifying barriers to recycling, such as a lack of standardisation and logistical infrastructure, in order to increase recycling rates and foster more sustainable construction. According to Bygg Naturligt (2023), the construction industry generates large amounts of waste, much of which can be recycled or reused, thus reducing the need for new raw materials and minimizing the waste sent to landfills. Additionally, reusing construction materials can be more cost-effective than purchasing new ones. They also highlight the importance of carefully inventorying and quality-checking materials before reuse to ensure safety and sustainability.

The extraction of natural aggregates is becoming increasingly restricted due to urban expansion, zoning laws, rising costs and environmental considerations (Wilburn & Goonan, 1998). Recycling converts waste into a usable resource and offers several benefits: 1) it helps conserve natural resources by extending their availability, 2) it minimizes environmental impact near construction sites and 3) it supports the sustainable management of raw materials. Traditional aggregate material can often be recycled with relative ease, either by reusing them as they are or by crushing larger pieces into smaller fractions (Dawson, 2014).

3.7 Challenges with Reuse

The concept of reuse isn't something new to the construction sector, it is rather the implementation process that is often considered challenging (RISE, n.d-a). According to Byggfakta (2023), one of the key challenges of reuse and recycling is achieving industry-wide collaboration and transitioning from a linear to a circular approach.

3.7.1 Supply

According to Boverket (2024-g), the availability of reused building material is increasing, and interest in them has also accelerated. However, their use remains limited in scope. This is largely due to the perception that the market for reused building materials is still immature and there is a lack of knowledge regarding how to

implement reuse effectively. While reused materials are currently being utilized, their adoption remains relatively low compared to raw material extraction. To expand the supply of reused materials, greater market knowledge is required, along with new business models that incentivize the conservation of reused products. Furthermore, Boverket (2024-g) highlights that supply constraints can be addressed through reuse, particularly by repurposing existing structural building components, such as wood, steel and concrete. This could lead to costlier projects and delays, since these components are essential for construction projects. This could, according to Boverket, be mitigated if the necessary materials are already available as reused resources on the market. Reuse can therefore reduce project vulnerability by ensuring that critical components are readily accessible while simultaneously making projects more environmentally sustainable through their implementation.

3.7.2 Logistics

One of the main challenges is the difficulty in connecting suppliers with those in need of reused materials, since the reuse market is often seen as fragmented and lacking a well-structured network (RISE, n.d-a). This disconnect can create inefficiencies, making it harder for reclaimed materials to be redistributed effectively and used to their full potential. In the construction industry, a major issue is that surplus material does not always have an immediate use or a clear receiver (Trafikverket, 2022). Without efficient systems for storage and coordination, this therefore becomes problematic when valuable resources risk being rejected rather than repurposed. Currently, it is also often up to the individual projects to identify opportunities for reuse, such as finding other projects or maintenance operations that could benefit from the leftover materials.

Additionally, as more quarries shut down their operations, the distance to remaining suppliers and their products increases, further complicating access to raw materials and driving up transportation costs (Fossilfritt Sverige, 2024). Although there is a strong ambition to phase out fossil-fuel-based transportation and transition toward more electrified alternatives, time remains a critical factor in the industry. Transporting materials over long distances is not only costly but also unsustainable in the long run. Therefore, there is a growing emphasis on finding more localized solutions, potentially even on-site processing and reuse, to reduce dependency on long-distance transport and create a more efficient and circular construction process (Naturskyddsföreningen, 2021-c).

3.7.3 Quality

A significant challenge in increasing the use of recycled construction and demolition waste materials is the trust in their quality (European Commission, 2018). Industry stakeholders remain hesitant to adopt secondary materials due to concerns about their reliability, consistency and performance compared to raw materials. There is a lack of confidence, which slows down the transition to more sustainable building practices and limits the demand for recycled products. The lack of comprehensive and reliable data on both existing and historical buildings also makes it difficult to determine the exact composition of materials recovery during demolition (European Environmental Agency, 2020). This uncertainty can lead to challenges regarding sorting and processing, ultimately affecting the quality of reclaimed materials. Without accurate

records, materials may be mixed, damaged, or contaminated, which limits their potential for reuse.

In an interview study carried out by the European Commission (2018), it was found that one of the biggest obstacles to the increased use of recycled construction and demolition waste (CDW) is the opinion that these materials are of lower quality. Many stakeholders still view CDW as waste rather than valuable resources, which creates resistance to incorporating them into the design and construction of new elements. However, more recent research indicates that recycled materials can indeed meet the same performance standard as new ones (Chen et al, 2024). In fact, recycled materials used in construction adhere to the same quality standards as raw materials, ensuring that they meet all necessary codes and regulations.

A key concern is also the lack of long-term data on the durability and performance of these materials over time (European Commission, 2018). There is a lack of long-term usage data on recycled materials, so their lifespan and function compared to raw materials is uncertain. In contrast to this, Chen et al. (2024) emphasizes that recycled products are regulatory tested to ensure they match or exceed the required criteria for safety, durability and efficiency.

3.7.4 Financial Obstacles

Financial barriers to reuse, according to Fastighetsägarna (2024), primarily stem from the immature quality control processes currently in place on the market. Due to the limited availability of reused materials, these controls are not being sufficiently developed, making them both time-consuming and costly. Therefore, investment in research is needed to establish standardized methods for conducting quality assessments, ensuring that each project does not require its own unique and specific evaluation process. Furthermore, Fastighetsägarna emphasizes the need to update procurement and business models to promote the use and profitability of reused building materials, as current models tend to favor raw materials.

Both the adoption and market expansion of circular materials are further constrained by current costs, as it remains cheaper to purchase new materials than to buy reused ones (Naturskyddsföreningen, 2021-a). With this in mind, economic benefits must be considered, as reuse aims to reduce purchasing costs, as recycled materials are expected to become cheaper over time than newly extracted ones (Boverket, 2024-a). It also lowers waste management costs for society as a whole. This leads to a desired circular economy where reuse is a key component of such a system, where resources are kept in use for as long as possible.

3.7.5 Measurability of Reuse

Sustainability is primarily measured through life cycle assessments, circular economy models, and a product's carbon emission, with the process for reused materials following the same frameworks (Larsson et al., 2016). According to Boverket (2023), a study was conducted during 2020 to assess the climate impact of new construction. The collected data was intended to serve as reference values for climate impact, providing an indication of how new construction affects Sweden's emissions and the industry's overall carbon footprint. Climate declarations are among the key tools used

to measure sustainability impacts in various building materials and these declarations can potentially be compared to assess the effectiveness of reused materials. However, to enable fair and meaningful comparisons, the framework behind climate declarations must be further developed to account for the specific characteristics and benefits of reused materials (Boverket, 2023).

Byggföretagen (2022) also highlights climate budgeting as an additional method for measuring the sustainability impact in different building materials. A climate budget involves calculating a project's total emissions, assessing its environmental costs and identifying how sustainable decisions can be made. Climate budgeting includes key elements previously mentioned, such as LCA, carbon emissions and the collection of environmental product declarations. While these methods enhance the efficiency of sustainability assessments, they are not specifically tailored to reused materials. Boverket (2024-a) highlights that requirements concerning the reuse or recycling of materials can present challenges within the construction sector. In accordance with this, there is currently no clear method for calculating the proportion of reused materials and their environmental impact. This absence of clear guidance creates uncertainty for both clients and contractors, who may struggle to demonstrate environmental performance in a consistent or comparable manner. Furthermore, Boverket (2024-a) also presents that it is not defined whether all materials should be valued equally in such a calculation. This lack of differentiation complicates both documentation and evaluation in sustainability efforts regarding reuse.

3.7.6 Laws & Regulations

Swedish legislation on waste and waste management is based on EU regulations, which guide how member states implement and manage waste. (Naturvårdsverket, n.d.). According to the Swedish Environmental Code, all waste must be handled in a manner that safeguards human health and the environment, ensuring that neither people nor nature are harmed in the process. One of the main barriers to implementing reuse is the legal restrictions surrounding waste and materials, which make it challenging for companies to effectively integrate reuse into practice (Naturvårdsverket, 2024-e). According to Trafikverket (2022) it would also be preferable to further develop the requirements that encourage future reuse and recycling from a more practical perspective. This could include setting specific standards for design and construction methods that facilitate dismantling, sorting and material recovery at a later stage.

3.7.7 Innovation Opportunities

By challenging traditional construction norms and embracing a circular economy, along with new legislation, new visions for a greener future can be promoted (RISE, n.d.-b). Previously, legislation in Sweden hindered the implementation of reuse, but progress is being made with new regulations that aim to encourage the choice of reusing materials. The EU is also imposing requirements on eco-design within the construction sector, creating financial incentives for the reuse and recycling of materials wherever possible. Further factors that can drive innovation opportunities include various types of certifications, which can motivate companies to improve and promote reuse. However, according to RISE, the challenge of innovation in reuse lies in the numerous barriers that obstruct forward progress. These include difficulties in

knowing what materials are available to work with, as they may come from diverse sources.

3.8 Different Stakeholders' Actions & Responsibilities for Reuse

A holistic approach to reuse requires active participation from all actors along the supply chain (Tabas et.al, 2024). Each stakeholder has a distinct yet interconnected role, ensuring that materials and products are efficiently repurposed rather than discarded. A well-functioning reuse system depends on seamless collaboration, where responsibilities are distributed rather than resting solely on one actor. By integrating reuse into the entire supply chain, businesses and municipalities can create more resilient and resource-efficient systems that align with circular economy principles.

3.8.1 Supplier

Suppliers can promote sustainable practices and execution in projects by reducing material usage in processes, minimizing energy consumption and ensuring sustainable transportation (Worldfavor, n.d.). Additionally, they need to strengthen their value chains, meaning their connections with organizations and clients, to facilitate sustainable operations both socially and environmentally. To remain competitive and compliant, suppliers must integrate sustainability into their working methods and mindset, failure to do so may lead to challenges with regulatory authorities and customers. It is also crucial for customers to monitor suppliers' efforts, guiding future sustainability improvements and assessing past performance to optimize their process chains.

According to Business Region Göteborg (2021), an early-stage strategy is essential for implementing reuse and sustainability in construction processes, with suppliers playing a key role. A critical factor is that both property owners and construction companies must function as suppliers of materials while also acting as buyers to support circular practices. Business Region Göteborg further emphasizes that industry actors must be capable of both purchasing and selling reused materials, as well as improving the management of existing resources during potential demolitions, where waste may be generated. To implement greater reuse in the process, suppliers and more stakeholders need to increase knowledge about its benefits, including the economic, environmental and waste-related savings it generates.

3.8.2 The Municipality as Client

The clients are the project owners and have the main responsibility of the overall planning and implementation to receive the wanted outcome of the project (NFU Mutual, n.d.). They also finance the construction project which does make them the ones with the final say in decisions. Achieving the desired outcome requires a combination of well-thought-out design, effective planning and high-quality construction. According to Albarami et al. (2020) clients must ensure complete satisfaction, to foster a clear understanding of quality requirements throughout the process.

When the client obtains land and takes responsibility for the construction, they may sometimes be required to meet specific conditions. For example, this includes adopting a sustainable mindset in which clients are required to use sustainable products and minimise waste (SKR, 2023). Such requirements are often part of broader urban planning policies aimed at promoting sustainability or environmental responsibility (Government Offices of Sweden, 2018). By enforcing these conditions municipalities ensure that new developments align with long-term community goals and regulatory frameworks. Certain initiatives driven by the client may also qualify for subsidies from the municipality (United Nations, n.d.). These financial incentives are often provided to encourage sustainable conditions. By offering subsidies, municipalities aim to support projects that align with the urban planning goals and environmental policies, making it more feasible for clients to meet specific requirements while reducing overall costs.

Municipalities play a central role in all construction projects, serving both as direct clients and as key regulatory authorities (Boverket, 2024-i). Even when they are not directly responsible for a project, they oversee the permitting process and ensure that developments align with the detailed development plan. Their involvement extends beyond administrative oversights, as they also carry significant responsibility for promoting sustainable construction practices. They can for example promote projects and procurement by setting requirements for materials and working methods (Boverket, 2024-a).

It is important to acknowledge that municipal policies and regulations are not established independently but are instead shaped by national objectives and legislative frameworks (Vanhuyse et al. 2023). In Sweden, municipalities are required to align their guidelines with the country's overall sustainability and development goals. These national directives are further influenced by higher regulatory frameworks at a state level, often guided by European Union policies and international agreements (Government Offices of Sweden, 2021). With this in mind, municipal decisions regarding urban planning, environmental standards and resource management are integrated into a broader system of governance, ensuring adherence to both national and international sustainability objectives.

3.9 Potential Solutions to Implementing Circular Economy in the Construction Industry

As of today, both nationally and in the EU, the producer is not responsible for waste management for their own products (Boverket, 2024-a). Through this, the producers have low incentives for driving a change where it is easier to reuse and recycle their materials. This means they do not account for the costs of managing the material once they become waste. A major issue is materials that often end up in landfills, where they cannot be recycled or reused, resulting in high costs for their disposal at waste management facilities. Therefore a solution presented by Boverket is an implementation requiring producers to take responsibility for their products even after they have been used. By offering take-back systems, old products can be collected, recycled and reused instead of becoming waste. This reduces the need to extract new raw materials and encourages better methods that make recycling easier.

Today, the negative environmental impacts are not included in the price of using newly extracted materials, which makes it difficult to make recycled or reused materials profitable (Boverket, 2024-a). This means that producers and consumers do not consider the long-term environmental costs when purchasing or using materials. As a result, the use of materials increases, which can lead to greater environmental and climate impacts, especially if the materials are harmful to the environment. To address this, Boverket highlights that it may be necessary to implement measures where those who produce and sell building materials also take responsibility for the costs that arise when the product becomes waste and needs to be recycled. This could involve companies paying for the management and recycling of the materials when they are removed from the site.

A solution from Naturvårdsverket (2022) is to look into the definition of waste to facilitate the implementation of reused and recycled materials. Naturvårdsverket emphasizes the importance of a management approach that facilitates the creation of a resource-efficient cycle, which in turn will lead to a broader circular economy. Through a clarification of the waste concept in different scenarios, a consistent assessment can be ensured nationwide, and this will contribute to predictability for the affected operators. Another solution that Naturvårdsverket (2022) is actively working on is an analysis of the criteria that determine whether a material should be classified as waste or not. This involves assessing in which situations a material must be treated as waste. For example, when someone disposes of waste, intends to dispose of waste or is obligated to do so, and when waste can be exempt from waste regulations. Naturvårdsverket is currently developing a comprehensive guidance document, which they hope will provide clearer guidelines on how the definition of waste and other key related concepts should be interpreted and handled.

To promote a greater implementation of reused materials, Boverket (2024-a) has proposed that requirements concerning building permits should be incorporated into the Planning and Building Act (PBL) to regulate the use of reused materials in new construction. To ensure a successful implementation, Boverket emphasizes the need for financial policy instruments to encourage sustainable production of circular products and facilitate the transition from linear to circular business models. This proposed transition would incentivize companies to develop more competitive business models while increasing resource efficiency and contributing to reducing environmental and climate impacts.

4 Empirical Study

The following chapter presents the empirical study that forms the foundation for the research question of the thesis, focusing primarily on Swerock as the main stakeholder. The chapter begins with a brief overview of Swerock as a company, including its historical development. This is followed by a more in-depth exploration of the company's sustainable product offerings, such as eco-concrete and eco-aggregates. Lastly, the results from the conducted interview study will be presented.

4.1 Swerock

Swerock was founded in the 1920s and is part of the PEAB Group, one of the largest construction and civil engineering companies in the Nordic region (Swerock, n.d-a). The company is one of Sweden's largest suppliers of aggregate materials and currently operates approximately 150 quarries across the country. In the Gothenburg area, Swerock operates two quarries, Arendal and Kållered. The Kållered quarry was opened in the 1930s and has grown to become one of the largest in the country, extracting approximately 1 million tons of aggregate materials every year (Swerock, n.d-b). Swerock is therefore one of Sweden's largest companies in the construction and civil engineering sector, supplying materials such as concrete, aggregates, material recycling, soil remediation and more, with a clear focus on reducing the overall climate footprint of the industry.

Swerock places significant emphasis on transitioning and working towards the 2030 climate goals, prioritizing the reduction of the construction sector's climate-impacting emissions by half (Swerock, n.d-c). They contribute to this by setting their own climate targets and adopting a circular, fossil-free approach to create a greener industry, where every stage of the supply chain becomes more climate-conscious. To achieve these goals, the company focuses on innovation, transparency and measurability, including the implementation of eco-concrete and eco-aggregates, which collectively help to reduce climate impact.

Swerock also accepts various types of residual materials, such as concrete, asphalt and other waste materials from different construction projects (Swerock, n.d-d). Through the reception and sorting of materials, their work aims to reduce the amount of waste sent to landfill and instead recycle these materials into new products. The idea is also that consumers who drop off surplus materials should be able to take new materials with them, promoting a circular economy and reducing the number of transport movements.

4.1.1 Eco-concrete

Swerock is currently transitioning into a more sustainable operation, with their eco-concrete now established as the company's standard concrete (Swerock, n.d-e). To lower the carbon footprint of their concrete, Swerock substitutes traditional binders like cement with more sustainable materials, such as slag. The concrete is suitable for all types of constructions, both indoor and outdoor, as its properties can withstand the same stresses as traditional concrete. Additionally, according to Swerock there are some advantages of eco-concrete which include easier workability and longer open time in its freshly mixed state, facilitating the casting process. During curing, eco-

concrete generates less heat, reducing the risk of cracking, and develops its strength more gradually, which they believe can be beneficial in certain projects.

4.1.2 Eco-aggregates

Eco-aggregates are made from recycled raw materials, specifically developed for particular construction and civil engineering purposes, with properties designed to be comparable to those of raw materials (Swerock, n.d-f). They are produced from surplus materials generated by construction and civil engineering projects, such as excavation masses or blasted rock. According to them, the aggregates are quality-assured and environmentally declared to ensure more sustainable construction practices and support the goal of adopting a more circular approach. They view eco-aggregates as an innovative concept designed to meet future environmental standards while extending the lifespan of construction materials that would otherwise be discarded. The purpose of eco-aggregates is to replace raw aggregates while meeting the same technical and environmental requirements.

4.2 Results from the Empirical Study

This sub-chapter presents the findings from the interview study, in which the perspectives of 10 different stakeholders on the topic of circular materials are systematically organized. The chapter begins by highlighting the current regulations and legislation that influence the field, providing a foundation for understanding the existing regulatory framework. This is followed by a review of current strategies and the challenges that have been identified in efforts to promote circular material use. Finally, the chapter offers potential future outlooks for developments in this area, providing insight into the opportunities and trends that may shape the circular economy in the construction industry moving forward.

4.2.1 Today's Regulations & Laws Regarding Reuse & Waste

Several respondents from Göteborgs Stad stated that materials are classified as waste too early in the construction process, hindering the municipality's goal of ensuring that 50% of materials used in new production are recycled. Several actors from Göteborgs Stad also express criticism toward the extensive regulatory framework of the Swedish Environmental Code, particularly its strict definition of waste. According to respondent 3, environmental officer from Göteborgs Stad, construction companies are often hindered from using circular materials, such as high-quality crushed stone, once they have been classified as waste. The Swedish Environmental Code has therefore made it more difficult to reuse and recycle materials, and according to interviewee 3, it should be revised to redefine what constitutes waste. Furthermore, all the respondents from Göteborgs Stad argue that the Swedish Environmental Code is often contradictory, where one part classifies materials as waste immediately, while another, related to product legislation, states that the most suitable material should be used, creating a conflict between regulations. Finally, respondents from Göteborgs Stad emphasized the need for clearer guidelines in the Swedish Environmental Code regarding how reuse and recycling should be addressed so that materials are no longer automatically classified as waste.

"THE SWEDISH ENVIRONMENTAL CODE ACTS AS A BIG STICK IN THE WHEEL."- (RESPONDENT 3, PERSONAL COMMUNICATION, 14/3-2025)

Additionally, all respondents from Göteborgs Stad highlight that current laws can be restrictive when projects are expected to be built in a specific manner. For example, regulations tied to standards and material certifications often favor the use of new materials, making it more difficult to incorporate reused or recycled components. Current legislation does not yet provide the flexibility required to enable circular practices. As a result, stakeholders may face legal uncertainty when trying to integrate circular methods into construction projects. The municipality is striving to create conditions for circularity without imposing mandatory requirements on companies. According to all the respondents from Göteborgs Stad, the Planning and Building Act (PBL) should explicitly state how much and to what extent reuse must be included in projects to establish circularity. Currently, it is voluntary, but legal requirements could encourage a more circular future.

According to respondent 5, deputy Head of Department at Swerock, the Swedish Environmental Code constitutes a major barrier as its regulations complicate the implementation of reuse and recycling. It imposes strict requirements on operators by clearly defining what suppliers are allowed and not allowed to do. As a result, the Swedish Environmental Code prevents the efficient handling of materials that could be reused, as many of them are instead classified as waste. Currently, operators conduct their own assessments based on both product and waste legislation, which must align with interpretations from regulatory authorities. However, this creates uncertainty, as authorities often make case-by-case decisions, resulting in inconsistent outcomes.

"IT IS COMPLICATED TO DEFINE WHAT QUALIFIES AS A BY-PRODUCT, SINCE THERE IS ROOM FOR INTERPRETATION, THERE IS A RISK THAT DIFFERENT ASSESSMENTS WILL BE MADE." - (RESPONDENT 5, PERSONAL COMMUNICATION, 13/3-25).

Respondent 10, officer at Vinnova, argued that the market is currently geographically limited due to the lack of national structures and guidelines, with legislation being one such factor. Another aspect to consider regarding current regulations and laws is the technical regulatory framework. According to Respondent 6, Head of Development at Swerock, current regulations are primarily designed for raw materials and must be revised to ensure they do not disadvantage circular materials, but instead promote their use. Respondent 6 pointed out that the industry tends to prioritize safety over uncertainty and relies on experience when using materials. Consequently, respondent

6 argued that non-raw materials are not included in AMA (Allmän material och Arbetsbeskrivning) and technical descriptions because they are relatively new. Respondent 10 also observed that current laws favor raw materials by offering incentives that make them cheaper to use, whereas such incentives are lacking for recycled materials.

"IT IS A RISK, AND SOMEONE MUST TAKE RESPONSIBILITY TO ENSURE A GOOD OUTCOME. THE RISK INVOLVES FINANCIAL COSTS." - (RESPONDENT 6, PERSONAL COMMUNICATION, 17/3-25).

Respondent 7, lawyer at Delphi, further argued that the current legislation is divided and that there is a potential conflict between environmental law and public procurement. They mentioned that the definition of waste is too broad and does not consider the quality or pollution. Respondent 7 suggested introducing a more differentiated definition of waste and focusing on material recycling rather than automatically categorizing materials as waste. Respondent 10 agreed with respondent 7, emphasizing that the Swedish Environmental Code needs to be developed and refined to promote circular processes and expand their application.

"IT IS IMPORTANT TO UNDERSTAND THE EU REGULATIONS AND ITS PURPOSE, SINCE THE CONSEQUENCES OF END-OF-WASTE CAN BECOME NEGATIVE FOR THE ACTORS INVOLVED." - (RESPONDENT 7, PERSONAL COMMUNICATION, 20/3-2025).

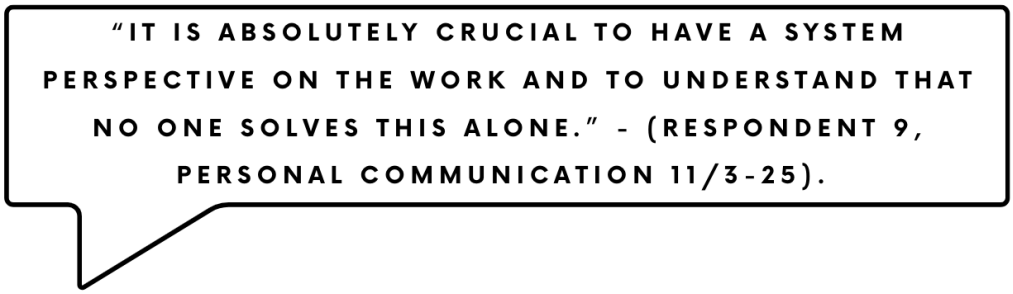
4.2.2 Obstacles with Implementing Reused & Recycled Crushed Aggregates

There are several obstacles slowing down the implementation of circular aggregates in the construction industry. According to several actors from Göteborgs Stad, clients become hesitant when a product is more expensive than usual, especially if it is also new to the market. Uncertainties regarding whether the new material possesses the same qualities as raw materials create reluctance to purchase it, which in turn slows down the adoption of new reused materials.

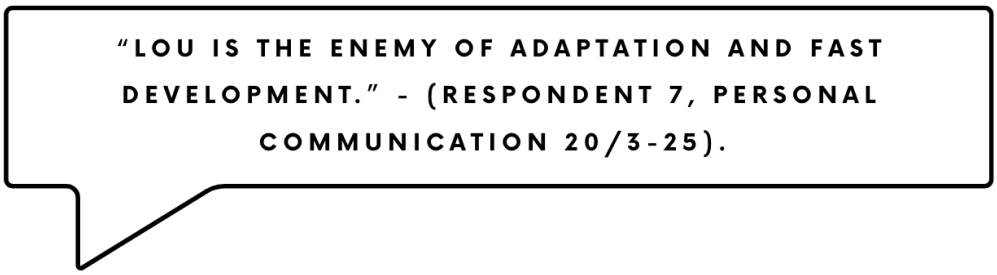
Another obstacle, according to all the respondents from Göteborgs Stad, is the Swedish Environmental Code, whose definitions of waste are vague and lack an understanding of reuse and recycling. Several interviewees from Göteborgs Stad further argue that the Swedish Environmental Code may need to be changed to encourage more companies and suppliers to invest in reuse. Steering the Swedish

Environmental Code in a new direction could, according to them, be crucial for broader implementation on the market in the future.

Respondent 9, a geologist and senior researcher at RISE, often perceived that municipalities are afraid of making mistakes, which automatically complicates processes. It is also believed that uncertainty and lack of knowledge in the field often prevent actors from taking risks and testing new working methods. Even though working with and engaging in circular material flows is currently a hot topic, the actors involved are far from coordinated. A particular challenge that has been highlighted is how certain ambitious goals regarding reuse can counteract climate benefits if applied without a system perspective. Respondent 9 pointed out that reuse is sometimes prescribed in situations where, from a climate and logistical standpoint, it would be better for the material to be recycled or used in nearby projects. They mentioned that one example is crushed concrete, where reuse in new concrete production may require significant resources for quality assessment, even though the same material could contribute to greater climate benefits in other applications.



On the same topic, the representatives from Göteborgs Stad argued that it can be challenging to formulate and demand certain requirements in procurement processes, as they must not hinder competition among actors, which would conflict with the Public Procurement Act (LOU). Respondent 7 highlighted that market distortion can occur, especially if there is only one actor capable of handling the work with reused materials, effectively resulting in the municipality directly awarding the contract. It was expressed that this potentially creates a conflict with the principle of equal treatment and often leads to difficulties.



Respondent 5 explained that although the processes for circular implementation exist today, the working methods remain challenging due to the insufficient availability of reused materials. Furthermore, respondent 5 emphasized that such operations will require both flexibility and specialized equipment, as the process of crushing, sorting, and managing waste residues that cannot be reused is costly. On the same topic, respondent 6 added that circular implementation is currently challenging because the

materials often come from multiple sources, making their composition variable. This makes it more complex to ensure the new material meets the necessary standards.

Another major obstacle for further implementation regarding reused and recycled crushed aggregates, that respondent 5 highlighted, is the collaboration between different actors in the industry. Regulatory authorities, clients, suppliers, and municipalities must work together toward the same local and national goals and share a common understanding and assessment of the issue. These goals need to be clearly defined to create synergy among the parties while adhering to the same guidelines. If this is not established, uncertainty and confusion arise regarding how assessments should be made. According to respondent 5, it is crucial that all parties think in the same way, a point also emphasized by respondent 7. The problem does not lie in the material regulations themselves but rather in the fact that different authorities interpret them differently. Respondent 6 described that there are currently no common end-of-waste criteria at the EU level. Therefore, national end-of-waste criteria must set the standards, and if such criteria do not exist, the general criteria of the Swedish Environmental Code apply.

> "SINCE SWEDEN CURRENTLY RELIES ON THESE GENERAL CRITERIA, THEY ARE DIFFICULT TO INTERPRET BECAUSE THEY ARE PRECISELY GENERAL." - (RESPONDENT 6, PERSONAL COMMUNICATION 17/3-25).

A major obstacle, according to respondent 6, is still the definition of end-of-waste. It was explained that this is because the transition imposes stricter requirements under product legislation, health, and environmental regulations, which leads to legal conflicts. The respondent argued that municipalities are responsible for oversight, but this oversight is inconsistent and varies depending on the municipality's competence. Different municipalities assess cases differently, resulting in a lack of synchronized approaches. The representative continued by explaining that this situation creates significant uncertainty for producers, as they do not know how to navigate end-of-waste regulations in order to satisfy all regulatory authorities. In line with respondent 6, respondent 7 also pointed to problems regarding the concept of waste, reinforcing the need to review and refine the end-of-waste definition to provide greater clarity in future work. Additionally, respondent 6 noted that KM and MKM, criteria often used for assessing hazardous substances in nature, are designed for land use rather than construction products. Consequently, if construction products were assessed based on KM and MKM, it would complicate end-of-waste processes rather than facilitate them.

"THE PRODUCT DOES NOT PASS THROUGH THE SAME NEEDLE'S EYE AS WHEN WASTE IS TURNED INTO A PRODUCT." - (RESPONDENT 6, PERSONAL COMMUNICATION 17/3-25).

A new perspective on obstacles that was brought up by respondent 10, is the industry's culture and values regarding trying new methods, which can also be seen as a potential strategy for moving forward. They argued that the current industry culture hinders progress because traditional working methods are maintained to minimize risks. This is due to the construction sector being risk-averse, fearing potential losses associated with new approaches. According to respondent 10, this is a significant obstacle, as it leaves little room for development and innovation in the area of circularity.

4.2.3 Strategies to Increase the Implementation of Reused & Recycled Crushed Aggregates

Some respondents from Göteborgs Stad described that the most effective solution for minimizing waste is to prevent it from arising in the first place. However, one of the biggest challenges in managing surplus materials is mass calculations. Instead of solely relying on level blasting, development should be adapted to minimize surplus. A central part of this work is coordination, where Göteborgs Stad strives to collaborate with all actors involved in the process. Furthermore, they emphasized that when planning new projects, it is essential to consider the city's topography and conduct thorough mass calculations to determine how much material actually needs to be excavated.

According to the actors from Göteborgs Stad, excavated materials can, in some cases, be reused within the same project at a later stage or in another project where they are needed as fill material. The interviewed actors at Göteborgs Stad further expressed hope for developing more methods and approaches for on-site material recycling. However, what can be returned to the ground depends on the type of construction and regulations. One way to make mass management more effective is to identify temporary storage sites within the city where excavation materials can be stored. Göteborgs Stad is open to using its own land for this purpose, but private actors can also be part of the solution. According to respondents from Göteborgs Stad, demolition materials that cannot be transferred between projects could be processed further by companies such as Swerock, given they are recyclable. The municipality views the actors who seek to develop this type of business positively, as the demand is expected to increase in the future.

The respondents from Göteborgs Stad further described that the municipality actively imposes recycling requirements in procurement processes. These requirements can either be mandatory (binding requirements) or structured so that contractors receive additional points in the bidding process if they implement recycling measures. According to them, the municipality applies both incentives and clear directives in its

procurement processes, meaning a combination of carrot-and-stick approach. The ambition is to gradually tighten the requirements and adapt them to different projects.

"PROMOTE CHANGE BY SETTING REQUIREMENTS." - (RESPONDENT 3, PERSONAL COMMUNICATION, 14/3-2025).

According to respondent 10, the key strategy is to understand how innovation gains force in practice. Respondent 10 argued that this is strongly linked to people's habits, which in turn influence legislation and regulations. For innovation to take hold, more than just technical solutions are required. It is also about fostering a work culture where risk minimization, particularly in the construction sector, aligns with education, guidelines, and values. Companies have a responsibility that extends beyond economic aspects to social considerations as well. A central goal is to integrate the circular economy as a natural part of corporate sustainability efforts. Legislation alone cannot solve everything, but by strengthening incentives, innovation and accountability can be encouraged.

Respondents from Göteborgs Stad emphasized that it is important to measure and evaluate the degree of recycling and reuse in projects, systematic follow-up and statistical tracking are necessary. According to respondent 1, who is a senior project manager at Göteborgs Stad, the municipality of Gothenburg does not currently conduct a comprehensive evaluation of recycling and reuse but needs to develop a holistic method for this. A central challenge is the interpretative issues that arise regarding measurement, such as how different materials should be valued and calculated in the assessment. Since it is currently not feasible to review all projects, the municipality focuses on larger ones and analyzes how reuse and recycling have been generally implemented. An action taken from the municipality could therefore, according to respondent 1, be that 50% of all materials in a project should be reused or recycled.

"CURRENTLY, THIS PROCESS IS NOT SYSTEMATICALLY MANAGED, BUT THE MUNICIPALITY AIMS TO INTRODUCE SUCH A METHOD." - (RESPONDENT 1, PERSONAL COMMUNICATION, 6/3-2025).

According to respondent 5, one of their main strategies is to address the issue at different levels and scales through continuous collaboration between actors, incorporating it into market and sales efforts. Early identification of surpluses and actively working to receive products deemed recyclable are crucial. Another strategy is to develop a market strategy by building trust, advocating for their approach through previous ECO-products, which currently meet high standards. Respondent 10,

supports respondent 5 statement by emphasizing the importance of a collaborative cross-industry initiative, highlighting that collaboration across stakeholders can enhance the efficiency and scalability of sustainable practices. By fostering partnership and aligning goals between operating companies in the field, they believe that innovative solutions can be developed to further integrate circular economy principles into mainstream business models.

"IT IS NOT UP TO INDIVIDUAL COMPANIES TO TAKE ALL THE STEPS, WE NEED TO WORK TOGETHER." - (RESPONDENT 10, PERSONAL COMMUNICATION, 28/3-25).

A strategy proposed by respondent 6 is to facilitate and refine the technical application of circular materials to make them more attractive. More knowledge and knowledge-sharing are needed to convince customers that circular materials are as good as raw materials. Since the industry is regulation-driven, AMA should also be expanded in the future to include more materials, creating security and trust in new materials. In the same context, respondent 10 asserted that research plays a key role in enabling more actors to test, validate, and certify new solutions. Building knowledge and monitoring the climate impact and lifespan of reused materials are crucial for driving development forward.

4.2.4 Future Predictions

Looking ahead, some respondents from Göteborgs Stad stated that the municipality is currently striving to enhance the implementation of circularity by influencing other municipalities to support these efforts and adopt more circular practices themselves. It is also essential for municipalities and private actors to share information between each other to ensure alignment and mutual understanding. Furthermore, they highlighted the need for a common framework agreement to prevent unfair advantages and to avoid hindering competition when the municipality assigns contracts. Additionally, they emphasized that shared environmental requirements must be maintained to foster collaboration among all involved actors, ensuring that they work towards the same goals and follow similar pathways.

"GÖTEBORGS STAD WANTS TO CONTRIBUTE TO CHANGE BY BEING A PIONEER IN THE INDUSTRY." - (RESPONDENT 1, PERSONAL COMMUNICATION, 6/3-2025).

According to respondent 8, desk officer at Regeringskansliet, the revision of the Construction Products Regulation is a key area that needs further development to promote the use of circular and reused materials in the construction sector. Previously,

this regulation primarily covered standards for new construction products. However, the latest revision introduces the possibility of addressing reused materials through a European standard. Currently, there is a lack of harmonized testing standards for reused materials, which poses a challenge for the industry. Respondent 8 therefore argued that the government should support the European Commission in exploring the development of such standards to ensure uniform guidelines for the performance of construction products.

Respondent 8 further explained that while national standards for reuse already exist, the government seeks the establishment of similar standards at the EU level to create a more unified market and facilitate cross-border trade. A step in this direction is the upcoming Circular Economy Act, expected in 2026, which aims to establish a European internal market for reused materials. Preparations are already underway to enable this development and to create better conditions for circular material flows within the construction sector. Respondent 8 thought that potential proposals from the European Commission in this area may affect the Swedish Environmental Code and other Swedish legislation.

Respondent 5 raised the idea of a future business model that includes a rental model for products and materials. This model would allow customers to rent materials for a specific period and return them for further processing at the end of their lifecycle. Currently, customers pay Swerock to manage their waste, but respondent 5 suggested that this could evolve into a different business model in the future. For instance, the reception fee could be reduced if a significant portion of the materials is expected to be recyclable, thereby ensuring a steady inflow of reusable materials.

Regarding future solutions, respondent 9 emphasized the importance of continued education and the development of new guidelines on how to build with new reused and recycled materials. The ongoing awareness campaigns, through information dissemination, education, and pilot projects in different municipalities, will drive progress. By raising awareness, new opportunities and long-term solutions can be created. In the same context, respondent 5 underscored the necessity for all stakeholders to operate under equal conditions and adhere to a common monitoring framework, ensuring that the shared future vision serves as the foundation for all initiatives.

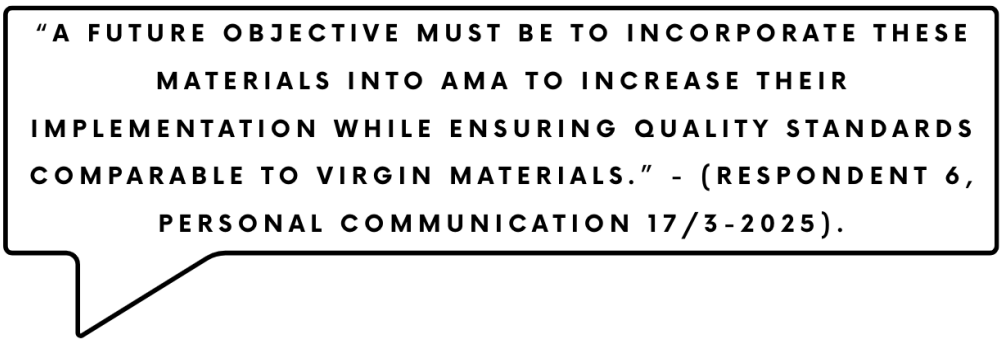
> "A SHARED VISION IS NEEDED TO MAKE IT CLEAR WHAT WE WANT TO ACHIEVE AND HOW." - (RESPONDENT 5, PERSONAL COMMUNICATION, 13/3-2025).

Respondent 5 further described the need for a more straightforward process to apply for amendments to permits, aiming to reduce resource use and allow businesses to adapt their operations based on their specific conditions. Given that Swerock operates on a large scale, respondent 5 argued that they must also have the necessary conditions to adjust their operations to handle larger volumes of recycled materials. Additionally, another suggestion was that a part of the production could and should

take place as much as possible on-site in the future. The interviewee believes this would enable more efficient project processes and workflows.

All representatives from Göteborgs Stad stressed that future efforts must progress at a faster pace and that incentives should continue to be provided to ensure smoother implementation of recycled materials. They asserted that discussions on this topic started several years ago, and given this background, we should have taken action earlier. Therefore, it is crucial to continue working on mass management, as it holds significant potential. Some representatives from Göteborgs Stad asserted that the control plan requires further encouragement. Respondent 7 stated that the municipality must develop a procurement framework that is reasonable to demand from actors on the market, something that is considered particularly realistic in larger cities like Gothenburg. The participant posits that the issue requires more proactive clients who can establish clear requirements for recycled materials.

Respondent 6 believed that procurement requirements must be revised to facilitate the use of circular materials in the future, a task which the representative is currently working on actively. At present, the respondent serves as the national representative for the industry's technical standardization committee and is also involved at the European level in the standardization of aggregate products. They explained that any changes to procurement requirements must first be directed to the Swedish Transport Administration, which, in turn, can submit them to AMA to update the technical specifications. Once this is accomplished, the implementation of circular materials in the market can take place. Currently, AMA categorizes materials such as rock, stone, and gravel into classifications (Category 1, 2, 3, etc.), but circular materials are not yet included since they are not standardized on the market.



Looking ahead, respondent 7 highlighted the importance of changes in regulatory application processes, where a more streamlined environmental approval process must be improved. It was pointed out that discussions within the industry have considered the possibility of merging the Land and Environmental Courts, the Environmental Assessment Delegation, the County Administrative Board, and the Supervisory Authority into a single entity in the future. The interviewee believed such an arrangement could lead to a much faster approval process, ensuring that stakeholders know the expected approval timelines for different materials and have the necessary documentation in place. Respondent 7 stressed that a key priority is to improve the efficiency of regulatory implementation and increase the pace of decision-making. Additionally, they highlighted that there is a need to elevate the status of these processes by enhancing the competence of personnel involved.

Finally, respondent 7 also acknowledged that progress is being made in alignment with the ESG framework, where regulations such as the corporate sustainability due diligence directive (CSDDD) are crucial for broader implementation. These regulations require companies and organizations to operate in a specific manner and demonstrate their environmental and social impact. This is essential for the future, as it promotes a holistic approach and drives the process forward. In the future, a product database should be developed, providing authorities, stakeholders, and customers with transparency regarding how suppliers promote reuse and circularity.

"TRANSPARENCY IS VITAL FOR FOSTERING COLLABORATION AND ENSURING THAT ALL ACTORS WORK TOWARD THE SAME OBJECTIVES." - (RESPONDENT 7, PERSONAL COMMUNICATION, 20/3).

Looking to the future, respondent 10 argued that the Swedish construction industry must undergo a transformation regarding the use of circular materials, and that stakeholders need to broaden their perspectives to consider the bigger picture. They argued that many industry players currently focus solely on financial figures, and when profit margins are low, the lack of economic incentives discourages them from taking risks. The combination of economic pressures, risk minimization strategies, and the absence of legal requirements has stagnated the industry's development. The representative emphasized that the public sector must demand and specify requirements more effectively, as the current approach is limiting private-sector initiatives. Their proposed solution was for the public sector to take greater responsibility by enforcing changes in industry practices to promote climate neutrality. Respondent 10 meant that the public sector has significant influence over procurement requirements, which is crucial for increasing circular material flows.

"THE PRIVATE SECTOR IS WILLING TO DO MORE THAN THE PUBLIC SECTOR DEMANDS." - (RESPONDENT 10, PERSONAL COMMUNICATION, 28/3-25).

5 Analysis

Chapter 5 presents a comprehensive analysis of the study's findings, integrating insights from both the literature review and the results from the interview study to identify key themes and patterns. The chapter aims to connect theoretical perspectives with practical experiences, offering a deeper understanding of the challenges, opportunities, and future scenarios within the field. It discusses issues related to the understanding of reuse and recycling, collaboration between different stakeholders, and the difficulties that may arise when implementing circular solutions. Furthermore, the role of legislation and municipal initiatives in supporting the development of circular practices is explored, along with visions for how the sector may evolve in the future. The chapter concludes with a summary and visualization of the central themes that have emerged from the analysis, providing an overview of the most important insights.

5.1 The Understanding of Reuse & Recycling

The literature review excessively discusses the foundations of the circular economy and the significance of reuse within the framework regarding construction. It also emphasizes that the Swedish Environmental Code serves as a guiding legal framework aimed at facilitating sustainable practices in the construction sector (Göteborgs Stad, n.d-a). The code highlights the importance of minimizing waste and embracing materials recycling, calling for an approach that emphasizes the life cycle of materials (Riksdagen, 1998). In parallel, the interviews conducted revealed a practical understanding of these concepts from industry stakeholders. Interview participants, such as project managers and environmental officers, articulated a clear recognition of the principles underlying the circular economy but also stressed the practical challenges faced in real-life implementation.

Both the literature and the interviewees emphasize a growing awareness of the need for circular processes, shifting focus from a linear "take, make, dispose", model to a more closed-loop system that encourages reuse, repair, and recycling. This transition is further reinforced by new European Union regulations aimed at increasing corporate accountability for sustainability. The introduction of Corporate Sustainability Due Diligence Directive (CSDDD) further reinforces the shift toward corporate accountability, requiring businesses to actively identify, prevent and address environmental and human rights risks (European Commission, n.d-a). Together with the responsibility of reporting from the Corporate Sustainability Reporting Directive (CSRD), these regulations push companies beyond adherence toward concrete actions that minimize environmental harm (European Commission, n.d-b.). However, as highlighted in the interviews, the gap between policy and practice remains a challenge, with a lack of incentives and clear implementation frameworks hindering progress.

Also, all respondents found the definitions of waste and product in the Swedish Environmental Code unclear, as they do not match and complicate interpretation. The interview study indicates that these definitions create significant obstacles, which indicates that they need to be updated to support the transition towards increased sustainability. A related issue is the classification of waste, where the line between waste and by-product, or between hazardous and non-hazardous waste, is unclear

(Riksdagen, 2020). This uncertainty leads to varying interpretations between supervisory authorities and industry stakeholders, which in turn delays processes and creates confusion. To enable a circular economy, the classification system needs to become more transparent, consistent, and adapted to current technical and environmental conditions. Clearer guidance and a revision of existing criteria are therefore necessary to simplify waste management while also promoting reuse and resource efficiency.

5.2 Collaboration Among Stakeholders

The interviewees point out the lack of collaboration between actors in the construction industry regarding the implementation of circular building materials. The aim of achieving a fossil-free supply of aggregates by 2045, together with the national goal that 70% of all waste should be recycled or reused, does make collaboration hard when there are no applicable solutions today (Naturvårdsverket, 2024-a). In alignment, Göteborgs Stad has its own local goals that 50% of all used aggregates 2030 should consist of reused or recycled materials (Göteborgs Stad, 2019). Interviewees from Swerock emphasized that they are ready to adapt their operations to meet the municipality and make their goals reality. Results from interviews with representatives from the municipality showed that there is no existing action plan from their side, therefore making this hard. This indicates weak collaboration between the involved actors, although all parties strive toward the same goal, not all have developed the tools and methods required to achieve it.

To understand the barriers of implementing circular principles, it is crucial to consider the deeper issue of insufficient communication and awareness among industry stakeholders. Although theoretical concepts are well-defined and explained, the interviews showed significant variation in how these concepts regarding reuse and circularity are understood and applied in practice. The interviewees from the municipality viewed reuse and recycling as part of a unified approach, adapting their methods based on project-specific conditions and practical feasibility. In contrast, the private actors tended to differentiate more clearly between the two concepts, adhering to stricter definitions and treating them as distinct processes. Therefore the private actors tend to follow the literature's definitions of reuse and recycling more, where reuse means repurposing a product or material (Boverket, 2024-g). Recycling is, on the other hand, referring to the concept of converting construction and demolition waste into a new product (Boverket, 2024-h). This variance in interpretation highlights a fundamental challenge in aligning circular strategies across different stakeholders, ultimately affecting the effectiveness of implementation.

Despite the fact that there is a need for better communication and collaboration among actors, the results from the interviews showed that the construction industry is conservative regarding the implementation of new models and ways of working. According to interviewees from Swerock, municipalities and other actors often take a careful approach when it comes to using new materials. Therefore, as highlighted in the literature review, prioritizing familiar methods and materials over unproven alternatives is perceived as better in the industry (Balador et al., 2020). This resistance is closely tied to profitability concerns, as highlighted in the literature, particularly in the theory of the TBL, where the economic pillar emphasizes the necessity for businesses to remain financially sustainable (Kreye, 2023). As a result, the industry

tends to favor short-term financial security over long-term sustainability benefits, creating a barrier to the adoption of circular practices.

5.3 Challenges in Implementation

One challenge regarding a faster and adaptable implementation of circularity and reuse is based on a lack of trust regarding the material quality, reliability and performance (European Commission, 2018). There is an underlying uncertainty in the industry which makes actors hesitant to implement secondary materials due to limited data compared to raw materials. Stemming from this, participants in the interview study also noted a lack of confidence in the quality, reliability and performance of reused materials, which influences usage. This uncertainty reflects a broader absence of standards and quality that could facilitate and encourage the adoption of circular materials. Both the literature review and the results from the interviews showed that many projects face difficulties in sourcing and validating the use of these materials, leading to missed opportunities for recycling and reuse.

The absence of standardized quality controls for recycled materials poses a significant challenge to their broader acceptance and implementation in the market. This lack of standardization fosters skepticism among stakeholders and creates an attitude of caution due to concerns about reliability and consistency (European Environmental Agency, 2020). In parallel with the literature the interviews also highlighted the issue of missing standardization for recycled materials, as the current system favors the use of raw materials, both in terms of regulations and time efficiency. Additionally, there is no established method for measuring the portion of recycled materials or determining how different materials should be valued in such calculations (Boverket, 2024-a). The interview findings reinforced this concern, showing that stakeholders believe the lack of a clear framework not only makes it harder to promote the advantages of recycled materials but also strengthens the preference for raw aggregates.

Another key challenge is the financial barriers associated with the lack of well-established quality controls (Fastighetsägarna, 2024). Due to the limited availability of reused materials and underdeveloped processes, assessments become time-consuming and costly. From the interviewees' perspective, the expenses related to establishing systems for recycling and reusing materials are significant and can outweigh the perceived benefits. Respondents also emphasized the strong need for investment in research to enhance recycling methods and improve economic feasibility of reuse. Financial barriers are further linked to uncertainties regarding the quality, performance and standard of these materials. Representatives from Göteborgs Stad openly expressed concerns about the reliability of reused and recycled materials, particularly when their qualities remain unclear and they come at a higher cost. To encourage clients to invest, Fastighetsägarna (2024) highlighted the need for updated procurement and business models to facilitate the implementation of reused materials and demonstrate their profitability.

A final challenge is that, although theory clearly highlights the triple bottom line (TBL) as a key tool for enabling an effective and sustainable circular economy, this was not equally reflected in the results from the interview study with and between stakeholders. A clear gap emerged between theory and practice, especially regarding

the costs of the ecological dimension in this context. A real circular transition requires the integration of environmental goals with economic incentives, rather than viewing them as separate or conflicting aims (Boverket, 2024-a). However, in the interview study, this interaction was rarely mentioned aside from the fact that circular materials are often more expensive compared to raw ones. The limited connection made in the interviews between the TBL framework and its potential to enhance both efficiency and sustainability underscores the gap between theoretical concepts and practical application. The absence of this link and way of thinking in many discussions risks making the transition to circular business models more difficult.

Furthermore, there seems to be a current perception that environmental gains must come at the expense of economic performance, rather than the two being able to go hand in hand. Based on the interview study, the ecological sustainability dimension is often treated as an ethical issue, whether a company should take responsibility for the environment, even if it leads to increased costs. This highlights the need for a fundamental shift in how sustainability is understood and implemented within different organizations. Ecological concerns should not be viewed as separate from the economic dimension, instead circular thinking needs to be integrated into core decision making processes. This includes recognizing that long-term profitability and environmental responsibility are not opposite forces, but interdependent drivers for innovation. Bridging this gap will therefore require not only new tools and policies, but also a transformation in mindset (Worldfavor, n.d).

5.4 Steering Legislation & Municipal Support

A significant aspect shown in the literature is the importance of legislation, particularly the Swedish Environmental Code, whose role is to foster a circular economy to protect the environment (Riksdagen, 1998). The findings from the interviews aligns with this, demonstrating that stakeholders believe legislative frameworks can drive the circular approach forward. Interviewees shared a common understanding that, although the Swedish Environmental Code outlines important principles, the current definition of waste presents challenges. Findings in the results highlighted that all respondents felt that the code's strict classifications often label reusable materials waste too quickly, thereby smothering innovation and the implementation of circular solutions.

According to the literature, the municipality plays a crucial role in promoting sustainable practices by setting requirements (Boverket, 2024-a). They also hold primary responsibility for procurement in project planning, as they own large areas of land within the municipality. Interview respondents consistently emphasized that municipalities should impose stricter requirements on involved actors to encourage the use of recycled and circular crushed materials. However, public sector representatives and legal experts were more critical of the practical implementation, as municipalities are prohibited from favoring a single actor, which would violate principles of fair competition and procurement. As outlined in the Swedish Environmental Code, municipalities must act in a way that promotes diversity and fairness among suppliers, making it challenging to introduce overly specific requirements (Riksdagen, 1989).

In the same context, the literature suggests that laws and guidelines may be improved to become more precise, which should in turn facilitate the implementation of circular methods among stakeholders (Trafikverket, 2022). An example of such a potential improvement is the "Circular Economy Act 2026," which is intended to support the market entry of circular products (European Commission, 2025). When analyzing the interviews, respondents agreed that a shift toward more specific regulations is necessary to facilitate and promote the use of circular materials. Many emphasized that current laws, such as the Swedish Environmental Code, are often too general and sometimes contradictory, making it difficult for actors in the construction sector to navigate effectively. According to the respondents, the key is finding a balance between setting ambitious requirements and ensuring these requirements do not prevent small and medium-sized companies from participating in procurements.

5.5 Future Predictions & Implementation

Currently, there are too few actors working with establishing new methods within the field of reuse and in order to remain competitive in the future transitions will be necessary (Boverket, 2024-g). New business models must be developed to ensure sustainability and to create a viable market in the area of recycled aggregates. Both the literature and findings from the interview study align in the conclusion that such a market needs to be created to establish a more available supply. One possible approach is for more actors to start offering these services, such as reused and recycled aggregates. To ensure efficient distribution to buyers, a well-structured logistics network is required (RISE, n.d-a.). Access to these services should be straightforward and should not pose additional challenges due to limited availability.

The literature also highlights the potential for a more localized, on-site production model in the future, which would help minimize costs in terms of both time and transportation (Fossilfritt Sverige, 2024). The interviews showed that all actors are in agreement with the literature in preferring a more localized solution. However, they also emphasize that space for such production is currently often limited in city centers. Representatives from Göteborgs Stad pointed out that intermediary storage sites could serve as a solution to bring production closer to construction sites. These developments would also facilitate the transition toward a circular construction process (Naturskyddsföreningen, 2021-c).

For future implementation of circular materials to increase, the literature review highlights the need to remove the existing financial barrier (Boverket, 2024-a). This can be achieved by including the environmental costs associated with newly extracted materials in their price and creating economic incentives that make recycled materials more competitive. Interviews with industry stakeholders reinforce this view by highlighting the need for clearer and more supportive regulations to enable a broader implementation. A key aspect is the classification of waste, where Naturvårdsverket (2022) emphasizes the importance of clarifying and harmonizing the definitions of what is considered waste and when a material can be exempt from these regulations.

It became evident that while there are initiatives and an interest in innovation and circularity, the work tends to stagnate as efforts are often confined within individual organizations. Both the literature and the interviews highlight the crucial importance of transparency and collaboration among different stakeholders, in driving circular

construction forward. A key insight from the literature is that the industry's ability to transition to more sustainable practices largely depends on effective cooperation (Boverket, 2024-b; Byggfakta, 2023). While municipalities play a central role in shaping policies, private actors' express frustration over their cautious approach, arguing that the slow pace of decision making hinders progress. This indicates a disconnect between policy ambition and practical implementation, where regulatory uncertainty creates hesitation rather than encouraging innovation. The findings indicate that for circular construction progress, collaboration must move beyond passive dialogue and become a more proactive effort.

More education on circular materials and their impact on the environment and human well-being is needed to create a more sustainable society. The literature review identifies a pressing need to broaden the dialogue surrounding sustainability in construction, and emphasizes that a well-informed workforce is essential for driving change (Boverket 2024-g; Business Region Göteborg, 2021). Training programs should capture the best practices for reusing materials, understanding the benefits of circular economy practices and navigating regulatory requirements. As the interviewees highlighted, professionals within the industry often lack confidence in using recycled materials due to insufficient knowledge and support. Thus, targeted workshops, certifications and continuous professional development opportunities could play a central role in providing professionals with necessary skills, confidence, and competence to implement sustainable practices.

5.6 Summary & Illustration of the Analysis

The mind map in Figure 5.1 illustrates key factors influencing the possibilities for increased reuse of materials in the Swedish construction sector during the transition to a circular economy.

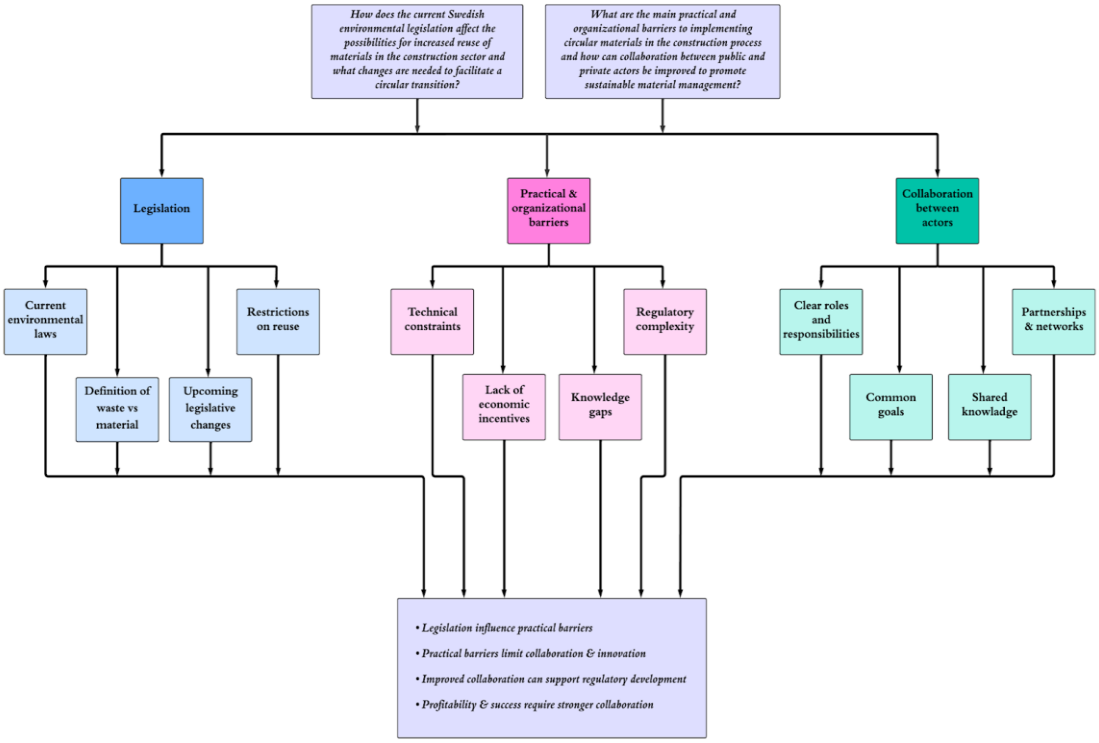


Figure 5.1: Mind Map of central concepts. Own illustration.

As shown in the mind map in Figure 5.1, two central research questions are addressed, which broadly are as follows: how current environmental legislation affects the reuse of materials, and what practical and organizational barriers exist, as well as how collaboration between actors can be improved. The mind map is divided into three main areas, first, legislation, which addresses how current environmental laws, the definition of waste versus material, upcoming legislative changes, and reuse-related restrictions affects the potential for circular material flows. The second area, practical and organizational barriers, covers technical constraints, lack of economic incentives, knowledge gaps, and regulatory complexity as obstacles to implementing circular solutions in the construction process. The last area, collaboration between actors, emphasizes the importance of clear roles and responsibilities, shared goals, shared knowledge, as well as partnership and networks to support the transition. The conclusion summarized at the bottom of the map is that all these areas are connected to each other. Legislation influences practical barriers, practical barriers limit collaboration and innovation, improved collaboration can support regulatory development and both profitability and success depend on stronger collaboration. This mind map is meant to illustrate how legislation, practical conditions, and stakeholder collaboration are interrelated and must be addressed collectively to promote sustainable material management in the construction industry.

6 Discussion

This section of the chapter presents an in-depth discussion based on the study's analysis, where reflections and interpretations form the foundation of the discussion. It highlights not only potential solutions but also identified knowledge gaps, aiming to deepen the understanding of the complex challenges and opportunities involved in the circular transition within the construction sector. The discussion addresses key factors influencing this development, including stakeholder collaboration, the need for regulatory adjustments, and how the three dimensions of sustainability should be integrated to support long-term transformation. Finally, the section explores future measures and innovative solutions that could enhance circular material flows and contribute to a more resource-efficient construction industry.

6.1 The Impact of Collaboration in the Swedish Construction Industry

The ongoing transition to a circular economy in the use of recycled crushed aggregates in the Swedish construction sector is both necessary and complex. At the same time, it highlights challenges that need to be addressed in order to achieve long-term sustainability. Despite increasing awareness in the industry regarding environmental issues, it is clear that real change is progressing more slowly than needed. A recurring theme that emerged from the analysis is the fragmented nature of collaboration within the sector. Although various stakeholders express both interest and engagement in circularity and innovation, many of these efforts remain siloed within individual organizations. This lack of coordinated communication and joint action often slows down progress, despite a shared recognition of the urgency for change. Rather than a lack of ambition, the issue appears to lie in the absence of structured methods that enable collaboration across boundaries. This raises the question, also mentioned in the analysis, of the need for a middleman which functions as a bridge between actors. This person, we see as important to facilitate knowledge exchange between stakeholders, to align efforts and help turn intentions into concrete results. Such an actor could potentially help communicate starting points, current situations, and strategic plans for how progress could be made, both individually and collectively. Ideally, this third party could consist of representatives from both private and public organizations.

Both private and public actors are currently working toward the goal set by Göteborgs Stad that 50% of all crushed aggregates used in construction within Gothenburg municipality should be recycled by 2030. However, despite these efforts, they are still struggling with the missing actions on how to actually achieve this goal in practice, or whether it is even possible. Based on the current situation, it seems that reaching the target will be difficult due to a lack of proven methods and working practices that can drive the transition forward. According to responses from the interview study, the market is currently perceived as being in an experimental phase, where different methods are still being tested, and there is not yet a clear understanding of which approach is most effective. We currently do not see a single solution to this problem, but rather that the method needs to be dynamic, possibly involving a combination of different strategies. Additionally, we see a need for more adaptive working methods that can be adjusted as the Swedish market develops.

As previously stated by the municipality, they are not currently requiring actors to implement recycled crushed aggregates in their operations, although they do encourage it. This presents a major challenge in terms of reaching the goal without concrete requirements that push actors in the desired direction. With this in mind, the municipality should begin to impose stricter requirements for integrating circularity and reuse into business practices, in order to achieve the desired green transition within the industry. For instance, procurement requirements could specify that a certain percentage of construction materials must be recycled or reused. To avoid negatively impacting competitiveness or the principle of equal treatment on the market, the municipality could notify actors in advance, giving them a transition period of several years to adapt their operations before such requirements come into effect. This would give all stakeholders a fair chance to prepare under equal conditions. In this way, the municipality's goal would move beyond encouragement and begin to influence actual mindsets and working methods across the industry.

If the municipality currently lacks the authority to enforce such requirements, they could instead offer financial support or incentives to encourage more actors to work sustainably with crushed aggregates. Companies that are already leading in this area and ready to deliver a reliable product should therefore be rewarded, as this could inspire others to follow their example. As it stands today, the process of working with recycled materials tends to be more time- and resource-consuming than profitable for private actors. A financial incentive from the municipality could potentially help increase development and engage more stakeholders by providing the economic flexibility to try new methods. Unlike private companies, the municipality is not driven by profit, which means they need to recognize that for private actors, the transition must also be financially sustainable. Therefore, economic incentives and funding are essential for enabling private companies to adapt, since money plays, and will always play, a critical role in how their businesses operate.

6.2 Regulatory Changes to Facilitate the Circular Transition

One observation is that the Swedish Environmental Code plays a central role in shaping the conditions for building a circular economy. While the law provides a foundational framework for sustainable practices, it is critical that its effectiveness is questioned and analyzed. Often, there appears to be a significant gap between the law's intent and its actual application, as it is currently perceived as being interpreted too restrictively. To a large extent, this hinders innovation and the recycling of materials, as there is a prevailing sense of uncertainty in the market. The main concern is that new ideas are not supported by the existing regulatory framework, which creates hesitation among stakeholders and limits the adoption of more sustainable practices. Based on the interview study, it is currently easier to do wrong than right with the Swedish Environmental Code in mind, making the process inefficient. A more flexible and adaptable regulatory system could perhaps help stimulate tolerance and the implementation of both new methods and technologies. An update on the existing Swedish Environmental Code could, for instance, contribute to greater engagement in the issue and promote the implementation of reused materials in the construction industry.

Furthermore, there may be a need for a complementary regulatory framework to support the vague definitions in the Swedish Environmental Code. This is of great importance, as both literature and our interview study reveal that there are still many question marks and grey areas creating considerable uncertainty about how the law should be applied in practice. This again relates to the interaction between different actors, where they need to improve how information is shared in order to minimize the repetition of each other's mistakes. Based on our analysis, we believe that clearer directives are first and foremost needed from the European Union, where they must set concrete requirements for how countries should work with reuse and recycling in the construction sector. A potential solution could be the upcoming "Circular Economy Act 2026", which the European Commission is planning to launch next year. Through such a mandate, we believe Sweden as a whole could begin to address and critically examine the issue of reuse in the construction industry, and how we need to revise our regulations in order to drive real change.

Based on prior assessments of the Swedish Environmental Code, we believe that today's regulations regarding the definitions of "waste" and "product" need to be changed. The current regulatory framework surrounding the concepts of waste and product has emerged as a key barrier in the transition toward a circular economy. As highlighted in the interview study, the definitions used in the Swedish Environmental Code are not only inconsistent but also poorly aligned with practical realities, making interpretation difficult for all stakeholders involved. This lack of clarity results in tangible consequences, such as uncertainty in classification; for example, it becomes difficult to distinguish between waste and by-products, and between hazardous and non-hazardous materials. This leads to inconsistent application of rules, extended decision-making processes and ultimately inefficiency. What becomes evident for us is that this is not merely a legal inconvenience, but a structural issue that limits innovation and slows down efforts to reuse and recycle materials effectively. To support circular flows, the regulatory framework and criteria must evolve to reflect current environmental goals and technical capabilities. A more unified and transparent classification system, along with clearer regulatory guidance, would not only reduce uncertainty in daily operations but also build trust among stakeholders.

The circular economy is based on the idea that materials should be kept in use for as long as possible, and what is considered waste today should be transformed into a resource in tomorrow's construction projects. For this to be feasible, a shift in policy is required, one that ensures materials are not unnecessarily classified as waste, but rather supports a circular view of resources. Many current regulations are based on outdated practices, which results in circular materials being at risk of being classified as waste, even if they are of high quality and can fulfill the same function. With this in mind, it is essential that the policy framework evolves alongside developments in the field, meaning that the definition of waste must be reviewed. We also believe that a clearer end-of-waste criteria should be established, along with new guidelines that facilitate and encourage circular practices rather than hinder them. We are convinced that this would lead to innovative business models that prioritize recycling and reuse as a first course of action.

On the same topic, like the respondents in the interview study, we also see a need for governing standards to be developed to include circular materials. Today, AMA is only adapted to raw materials, which undermines the credibility of recycled and

reused crushed aggregates. This also applies to the assessment of KM and MKM, which are based on soil, not construction materials. This leads to incorrect assessments based on faulty premises. Looking ahead, we see the need to introduce such standards to simplify and facilitate the end-of-waste process. We therefore suggest that standards for circular aggregates should be included in AMA and adapted to reflect the actual environmental performance of recycled and reused products. A clearer framework in AMA can also create more predictable procurement processes, which would support actors who strive to work in a sustainable and circular manner.

6.3 The Combination of the Three Sustainability Dimensions

It is both interesting and problematic that sustainability is often highlighted as something desirable, yet rarely linked to concrete business strategies in the interviews. According to us, we can see a connection between the ecological and economical sustainability dimensions not going hand in hand today. This will be a future challenge if mankind does not choose to further work with the question more actively and find financial gains in current operations. More companies, such as Swerock, must adopt these business models to drive change and remain competitive. At the same time, it is important to emphasize and understand that companies fundamentally need to be economically viable, especially in a competitive industry. From a theoretical perspective, we see a potential solution where the economic and ecological dimensions can be aligned. We believe that new working methods and further investments are required to find a balance where sustainability also makes economic sense. The current lack of financial incentives hinders and delays progress, and we believe that adjustments to incentives and policies are needed so that companies benefit from doing the right thing.

Within this area, there are practical examples showing that it is possible to combine these perspectives. Swerock is already actively implementing circular materials in its operations, demonstrating both a willingness and capability to transition. However, their work with circular materials is currently limited in scale, suggesting that there are structural barriers slowing down broader implementation. To ensure profitability and scale up these operations in the future, more strategic processes are required. We also believe that such development could have positive effects on social sustainability, as increased demand for circular processes and materials would likely generate more job opportunities, not only within logistics, sorting, and refinement of materials, but also in technology development and innovation related to new recycling methods. In this way, a circular business model can contribute to both increased economic growth and societal benefit.

6.4 Future Potential Actions to Increase Circular Material Flows

Like some of the representatives from the interview study, we see a large future market in this area for those who dare to take risks. One approach that could be beneficial in giving new practices a chance to be tested is a soft start in the form of a rental system and a deposit-return system. For example, today the customer pays a fee for Swerock to handle the waste, but in the future, the customer might instead receive

compensation for delivering material based on its quality. This situation could change if more stakeholders enter the market to operate similar recycling businesses. For example, a company like Swerock could then distinguish itself as the preferred choice due to its ability to generate profitability, both for itself and the customer. Such a system would not only attract more people to deliver material to these actors and other similar companies, but also create incentives for customers to return, through discounts or similar incentives.

Another solution we see is that stakeholders in the industry need to start recycling more on-site, in order to facilitate further refinement of the material in the next stage. Since more quarries are and will continue to be closing due to expiring permits the transport distances will become longer. We see recycling on-site as being beneficial from both a logistical and efficient perspective. In this case, we believe financing could come from the municipality, as they have set goals they want to see being followed and encourage actors to work towards. So, they should lead in supporting companies with financial incentives and also provide suitable locations for these activities. We also believe that the municipality should support companies like Swerock so they can continue driving this development forward.

Marketing and creating a new business model to promote implementation provide a solution to the challenge of reaching a broader market and spreading awareness of the issue regarding the wider use of recycled materials. A good way for Swerock and similar stakeholders to achieve this, would be to market their sustainability work. For instance, Swerock has made their ECO-concrete their standard, and it has been well accepted by the market. Therefore, we believe that similar circular construction materials should easily be supported based on this. Additional marketing strategies could involve speaking at trade fairs or holding workshops, where they would have the opportunity to inform and educate industry stakeholders on the topic. These events could also serve as platforms to emphasize and demonstrate the quality of their new products, how they achieve the same qualities as raw materials, prove their functionality, and promote climate benefits. We believe that many actors in the industry currently work on an individual level rather than together. Through workshops and fairs where everyone gathers, the message can be effectively communicated to all.

6.5 Action Plan for Swerock & Stakeholders in the Industry

The action plan illustrated in Figure 7.1 outlines a structured roadmap aimed at guiding stakeholders transition to a circular economy within the Swedish construction sector. It identifies four key focus areas, which must evolve in parallel with each other to support large-scale adoption of recycled materials and circular practices. Each area is divided into three stages, where stage 1 includes the most immediately actionable steps. Stage 2 and 3 involve more complex, resource intensive measures that require deeper strategic thinking and long-term commitment from different parties.

The goals outlined in the plan are not only intended for Swerock, but rather aim to provide a broader framework applicable across the Swedish construction industry. We recognize that the transition to circularity cannot be solved at the individual level, it must be addressed collectively at an industry-wide level. These goals are intended to

serve as a foundation for future collaboration within and between actors, reflecting the issues raised in our analysis and discussion, where enhanced collaboration is identified as a crucial driver for impactful and sustainable change.

Table 6.1: Overview of a staged action plan outlining key legislative, economic, collaborative and technical measures to drive circular economy practices in the Swedish construction sector.

	Stage 1	Stage 2	Stage 3
Legislative & Regulatory Adjustments	Improve the application of existing legislation, particularly the Swedish Environmental Code, to clarify the possibility of using recycled materials.	Initiate dialogues between authorities and the EU to harmonize standards for recycled materials, including testing and performance criteria.	Establish a national framework for the certification of recycled materials, including clear criteria and incentives for use in public projects.
Economic Incentives & Financing	Develop short-term financial support or subsidies for companies that use recycled materials.	Introduce tax incentives or other financial benefits for projects that actively promote circular material flows.	Create public and private financing models to develop and commercialize innovative solutions for circular construction.
Collaboration & Partnerships	Facilitate the exchange of information between municipalities, private actors, and suppliers to increase awareness and knowledge of circular opportunities.	Establish formal cooperation platforms and partnerships for joint projects in reuse and recycling.	Develop common standard agreements and collaboration frameworks to ensure fair competition conditions and shared objectives.
Technical Development & Innovation	Invest in research and development of testing methods and performance standards for recycled materials.	Implement digital tools and databases for traceability and certification of recycled materials.	Develop and implement new construction techniques and design principles to optimize the use of recycled materials in building projects.

7 Conclusion & Future Recommendations

Chapter 7 serves as the culmination of the entire report, providing a comprehensive summary of the key findings and insights gathered through the literature review, interviews, and analysis to answer the research questions. Furthermore, it presents recommendations for future research aimed at facilitating a more effective and sustainable transition in the construction sector. The chapter closes with a concluding remark highlighting the significance of the study and the potential for ongoing development in the field.

7.1 Summary of the Study

To summarize the findings of the study and draw relevant conclusions, this section addresses the research questions that formed the foundation of the work. The focus is on highlighting the key insights that have emerged throughout the study and providing answers to the questions posed at the outset.

"What are the main practical and organizational barriers to implementing circular materials in the construction process and in what way could this be improved?"

This report has identified and analyzed key practical and organizational barriers that hinder the implementation of circular materials in the construction process. One major challenge is legislation and regulations. Current environmental laws and material use regulations create uncertainty for stakeholders in the construction industry. Unclear definitions of what constitutes waste vs product, and the lack of a common standard for recycled materials, obstruct the wider adoption of circular material flows. To enable meaningful change, regulations need to be adapted to support innovation and provide clarity. Another obstacle is the uncertainty surrounding the long-term performance of recycled materials. Although these materials often meet technical and structural standards, doubts remain regarding their durability over time. This lack of confidence reduces the willingness of stakeholders to invest in circular solutions.

Many companies are still in an experimental phase, in search of efficient and economically viable approaches. Without a clear path forward, companies may hesitate to adopt innovative and circular practices. One key step to overcome these challenges is to establish a middleman, to promote knowledge sharing and strengthen collaboration between stakeholders. Increased transparency, by openly exchanging insights, experiences and mistakes, so that stakeholders can learn from one another. Lastly, the study identified that it is crucial for actors within the construction industry to strengthen networks and align around shared definitions and objectives, build trust and prioritize innovation. Continuing to promote and test new working methods will be essential for enabling broader and more effective implementations of circular material flows.

"How does the current Swedish environmental legislation affect the possibilities for increased reuse of aggregates in the construction sector and what changes are needed to facilitate a circular transition?"

Swedish environmental legislation currently represents a significant barrier to the development of reuse and recycling of materials in the construction sector. It is clear

that many stakeholders perceive the laws as complex and open to interpretation, leading to inconsistent application. This creates uncertainty and hinders collaboration, resulting in a general perception that it is easier to do something wrong than to do it right. To enable a more effective circular transition, several concrete changes are needed. First, environmental legislation must provide clearer definitions and guidelines regarding waste and recycled materials to ensure a shared interpretation that applies across the construction sector. The Swedish Environmental Code, which currently allows for wide individual interpretation, should be revised to specify how circular materials should be handled. This would address interpretive uncertainties and increase the efficiency and legal certainty of implementation. In addition, Sweden ought to play a proactive part in shaping EU regulations and standards to encourage a more unified and widespread adoption of reuse practices. There is a clear need for concrete guidelines and economic incentives at the EU level to support the adoption of circular solutions and make investments in recycling and reuse more economically viable.

One key area in need of improvement is the definition of the end-of-waste concept. Currently, a material must have a predetermined use before it can be classified as recycled. Revising this definition would allow for greater flexibility and ease the process for those looking to recycle and reuse materials in construction projects. Additionally, product and waste legislation must be revised to function in parallel rather than in conflict. Creating synergy between these legal frameworks would simplify regulatory navigation and improve the conditions for circular material use. Finally, a comprehensive revision of AMA is necessary to include circular materials in technical descriptions. This would help demonstrate that reused materials can be as durable and reliable as raw ones, thereby encouraging more actors to consider circular alternatives in their projects. By implementing these reforms, Sweden can support a more favorable environment for circular economic principles, benefiting not only the construction industry but also contributing to a more sustainable and resource-efficient future.

7.2 Concluding Remarks

This report has examined the central role of Swerock in advancing the use of recycled materials and eco-products within the construction sector. It has also investigated how other stakeholders play a crucial role in achieving the set goals by the Swedish government and municipalities. By analyzing the potential implementation of circular economy principles, we highlighted the substantial benefits that may arise from integrating sustainable practices into operations. Through interviews and analysis, we identified the main barriers that hinder the broader adoption of circular materials, such as economic viability, lack of knowledge and insufficient collaboration among stakeholders. Through the report, it has become clear that Swerock's and other stakeholders' commitment to sustainability is not only a response to increasing regulatory demands but also reflects a proactive approach.

Moreover, the findings suggest that collaboration between public entities, private companies and other stakeholders is essential for fostering a conducive environment for circular material flows. Joint efforts can foster financial incentives and support systems that align with both Swerock's and the municipality's goals, thereby paving the way for a more sustainable construction industry. Ultimately, it is through

collaboration that the industry overcomes the challenges faced today. Although the construction industry is often perceived as conservative, the stakeholders we have engaged with demonstrate a genuine willingness to contribute to and drive necessary change. As long as this commitment exists, we are confident that appropriate business models will emerge, even if they have not yet been fully established. We are optimistic about the future advancements and possibilities in this area. Moving forward, much will depend on the ability to achieve profitability in sustainable practices and to develop business models and methods that form a solid foundation for broader implementation of circular material flows.

7.3 Future Research

This study identifies several key areas for further research that can contribute to advancing sustainability efforts within the Swedish construction sector. Firstly, there is a need for in-depth analysis of consumer perceptions towards recycled materials. Understanding how different stakeholders, including contractors and end-users, value sustainability, which will enable organizations like Swerock to tailor marketing strategies that effectively communicate the benefits of eco-products. Secondly, exploring technical innovations in recycling processes could significantly enhance the efficiency and quality of circular materials. Research into new materials and recycling methods could provide insights into how construction companies can optimize resource use and reduce waste. This supports the overall objective of reducing the industry's emissions to net zero by the year 2030.

Furthermore, long-term studies that assess the actual impacts of implemented circular practices over time would provide valuable data on their effectiveness. Evaluating how Swerock’s initiatives influence not only environmental outcomes but also economic viability could offer a comprehensive view of the benefits of sustainability. Another critical area for future research is the evaluation of regulatory frameworks across different municipalities and regions. Understanding how varying legislation affects the adoption of circular materials can help in advocating for more uniform and supportive policies that facilitate sustainable practices across the industry.

Finally, exploring partnerships with academic institutions and technology firms could pave the way for innovative solutions and collaborative initiatives that advance the sustainability agenda. By engaging in interdisciplinary research, Swerock can lead efforts to shape the future of construction and establish a model for other companies to follow. In conclusion, while significant progress has been made in promoting sustainability within the Swedish construction sector, ongoing research and collaboration are crucial for achieving lasting change. By addressing the identified barriers and embracing new opportunities for innovation, stakeholders can collectively contribute to a greener, more sustainable future for the industry.

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Appendix A

Framework for the interviews

- Describe your current work role and your previous background.
- How do you perceive the current legislation regarding reuse and circular economy in the construction sector?
- According to Chapter 15 of the Swedish Environmental Code, waste is defined as "any object, substance or material that the holder discards, intends to discard, or is required to discard." In what way do you consider this definition to pose a barrier to reuse and circular material flows within the construction sector?
- What changes would you suggest to facilitate the use of eco-products in construction projects?
- In what ways do you collaborate with other actors in the construction sector to promote the use of recycled materials?
- What legal changes or clarifications do you believe are needed to facilitate the use of eco-products in municipal construction projects?
- Are there currently specific incentives, such as financial support or legal facilitations, for companies that use recycled materials in their construction projects?
- If you had the opportunity to influence Swerock's strategy to increase the use of circular aggregate materials, what actions and initiatives would you suggest?
- Is there anything else you would like to highlight that you believe could be important for our work?

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