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Systematic Review

Barriers and Enablers to the Adoption of Circular Economy Concept in the Building Sector: A Systematic Literature Review

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Abstract: The building sector is a major contributor to global resource consumption and waste generation. The circular economy (CE) concept offers a promising alternative to the traditional linear economy by promoting the reuse, remanufacture, repair, and recycling of materials and products. However, the adoption of CE in the building sector faces several barriers. This paper presents a systematic literature review utilising the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach, focusing on the barriers and enablers influencing the adoption of the CE concept in the building sector. Drawing from an analysis of numerous papers published between 2008 and 2023, we identified a high number of barriers and enablers that delay the integration of CE. The barriers were categorised into six categories: awareness, technical, economic and market, implementation, support/promotion, and social. The paper also discusses the interdependence of the identified barriers, using a co-occurrence matrix. The study findings indicate lack of CE regulations, fragment supply chain, and high upfront investment cost as major barriers to the implementation of CE in the building sector. Based on the study results, stringent governance and legislation, financial incentives, and the development of technology and innovation for circular building tools are critical factors for the successful implementation of CE principles. The results of this study provide a comprehensive overview of the feasibility to CE adoption in the building sector, which could also help to develop strategies to accelerate the transition to an integrated CE.

Keywords: circular economy; barriers; enablers; buildings

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1. Introduction

The building sector is a major consumer of natural resources and energy and a significant contributor to global greenhouse gas emissions and waste production [1]. It is responsible for 33% of greenhouse gas emissions, 40% of resource utilisation, and 40% of waste production [2]. With the ongoing expansion of the world's population in urban areas, the demand for new buildings and infrastructure will significantly increase. The concept of a linear economy has been the prevailing paradigm, fostering global growth and prosperity [3], but at the same time, it is expected to be a key factor in the present sustainability crisis [4]. The production of waste is a result of such traditional linear manufacturing processes that have dominated construction over the previous decades [5]. Therefore, the CE concept has gained widespread attention as a solution to address various environmental, economic, and social problems, such as climate change, resource depletion, and waste generation [6,7].

According to the Ellen Macarthur Foundation [6], CE is defined as "*An industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models*". Similarly, the European Commission [8] described the concept of CE as "An economy that preserves the value added to the products for as long as possible and virtually eliminates waste. The resources are retained within the economy when a product has reached the end of its life, so that they remain in productive use and create further value".

The goal of implementing CE is to minimise waste and maximise the value of resources by keeping them in a continuous production loop. This approach is a fundamental shift away from the traditional linear economy, which follows the take–make–dispose model. According to Stahel [9], the CE model can promote economic growth while reducing environmental impact. As a result, the CE has become a widely accepted solution to these challenges among businesses, policymakers, and consumers [10].

In the context of buildings, a circular building can be defined as *"A building that is developed, used and reused without unnecessary resource depletion, environmental pollution and ecosystem degradation. It is constructed in an economically responsible way and contributes to the well-being of people and the biosphere. Here and there, now and later. Technical elements are demountable and reusable, and biological elements can also be brought back into the biological cycle"* [11]. A circular economy approach to building materials involves a continuous flow of materials through procurement, use, deconstruction or dismantling, reuse, recycling, and recovery. Moreover, several circular design strategies can be implemented to enable the deconstruction, replacement, or repair of building components such as designing for adaptability, flexibility, disassembly, and deconstruction [12].

Even though there have been recent advances in building materials and design strategies, there are still notable barriers to implementing CE principles in buildings [13–19]. These barriers have been identified by several studies, which have categorised them into different groups. Adams et al. [14] surveyed industry stakeholders to assess their awareness of the CE and the challenges and enablers to its adoption. Hartwell et al. [20] discussed the key challenges and opportunities in advancing CE principles in façade design. Kanters [21] interviewed consultants and architects with CE experience to discern challenges and drivers in circular building development. Guerra and Leite [22] conducted a qualitative approach to evaluate current construction practices, identify barriers to the adoption of circular strategies, and explore potential enablers of the CE. Shooshtarian et al. [18] conducted a survey of various stakeholder groups in Australia regarding the CE, its challenges, and potential solutions. Akinade et al. [23] investigated building deconstruction processes and provided valuable insights into the barriers to design for deconstruction practices. Other studies have highlighted the challenges associated with the reuse of building construction materials and components [24,25].

This study presents a systematic literature review focused on the barriers encountered in the adoption of CE practices in the building sector. The study aims to identify and address the key barriers to the adoption of circular practices, and to develop cohesive strategies for successfully adopting CE practices in the building sector.

The following two research questions are established for this study:

1. What are the key barriers that hinder the progress of transitioning towards a CE within the building sector?
2. What strategies can be employed to overcome such barriers and enhance the transition to a CE?

2. Methods

2.1. Research Strategy

This study employs a systematic literature review methodology that is a trustworthy method for identifying and synthesising existing literature on a specific research subject [26]. This method enables the critical analysis and evaluation of research on a topic since it is founded on a determined search strategy with clearly stated objectives.

This study followed the step-by-step methodology outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, 2018) checklist. A review protocol was formulated, outlining the criteria for selecting articles, search strategy, metadata extraction, and data analysis procedures. Figure 1 illustrates the entire procedure that guided the present systematic literature review.

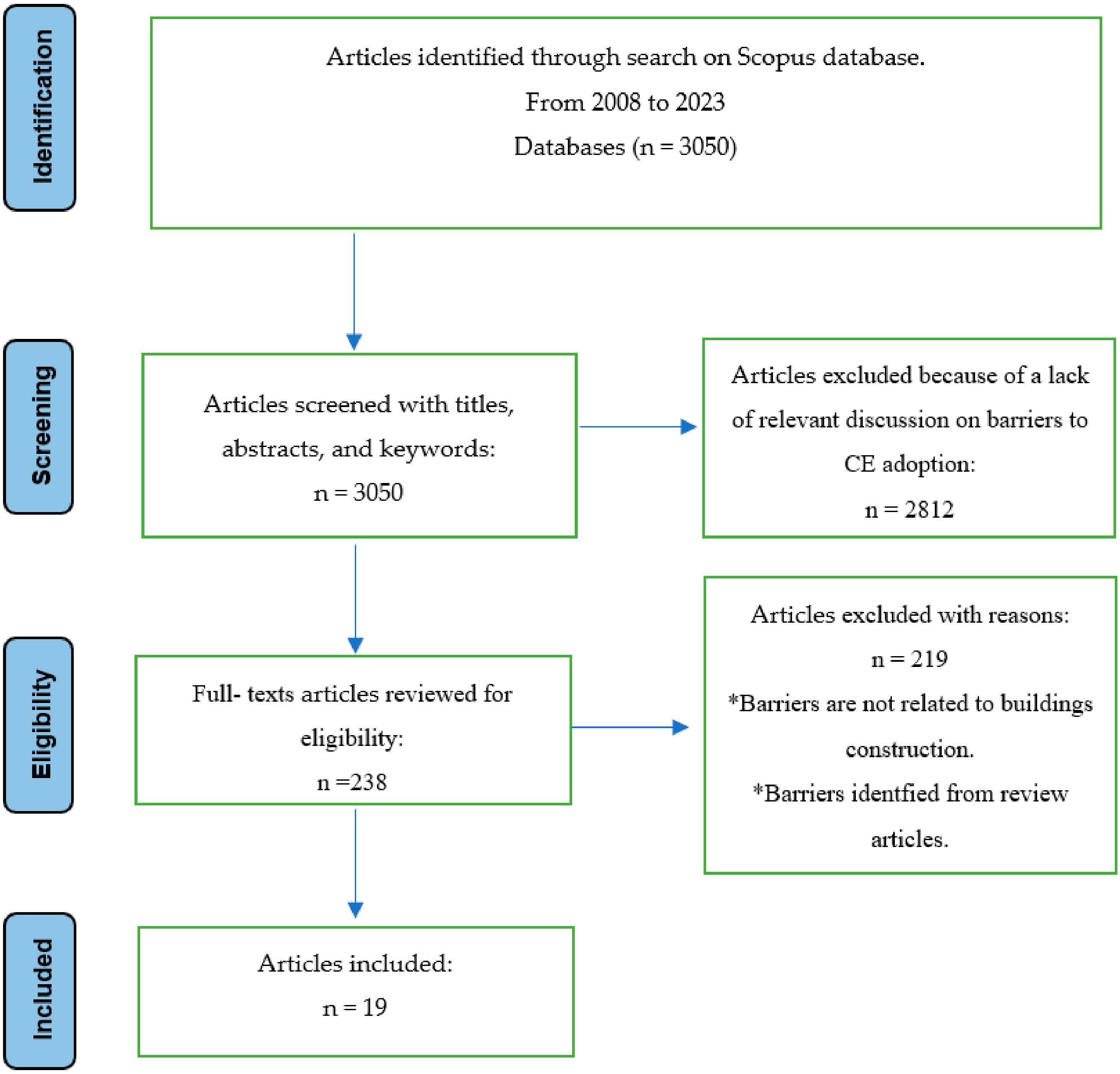

Figure 1. Flow diagram of literature selection for review.

2.2. Data Collection

We adopted Scopus as primary search engine to access relevant studies. The search was limited to specific subject areas to discard irrelevant resources. Both journal and conference proceeding papers published from 2008 were targeted. Scant research was published prior to 2008, which made these irrelevant. This research question was formulated with the following search query in Scopus, limited to research titles.

TITLE ("circular economy" OR "circular buildings" OR "circular construction" OR "circularity" OR "circular supply chain" OR "design for disassembly" OR "design for deconstruction" OR " Design for adaptability" OR "DfD" OR " DfA" OR "Construction and Demolition waste" OR "CDW" OR " built environment" OR "Circularity in Buildings") AND ("barriers" OR "hindrances" OR "inhibitors" OR "constraints" OR "inhibiting" OR "impeding" OR "obstacles") AND (LIMIT-TO (SUBJAREA,"ENVI") OR LIMIT-TO (SUB-

JAREA,"ENGI") OR LIMIT-TO (SUBJAREA,"ENER") OR LIMIT-TO (SUBJAREA,"MATE")) AND (LIMIT-TO (LANGUAGE,"English")) AND (LIMIT-TO (SRCTYPE,"j") OR LIMIT-TO (SRCTYPE,"p")).

2.3. Data Analysis

Through this initial search, 3050 articles were screened. In an initial screening based on titles, 2812 articles were filtered out. This left a total of 238 articles, which were further shortlisted after reading the abstracts as they were not in line with the research questions. Finally, 19 papers were included in the full-text review to identify all barriers. The study retrieved pertinent metadata from each paper, such as the publishing year, journal, and key issues. Each barrier and the appropriate source were recorded on a data summary sheet. The study created categories and sub-categories of the challenges to implement CE practises in building construction. Moreover, a co-occurrence analysis was carried out to assess interdependence amongst various barriers. By mapping out correlations, a nuanced perspective emerged, shedding light on how such constraints might be interconnected. Figure 1 shows the PRISMA process while Table 1 provides an overview of the 19 studies that were selected for inclusion in the study.

Table 1. List of the eligible studies.

No	Reference	Year	No	Reference	Year
1	Oyedele et al. [27]	2014	11	Hartwell et al. [20]	2021
2	Adams et al. [14]	2017	12	Charef and Emmitt [28]	2021
3	Dunant et al. [25]	2017	13	Torgautov et al. [29]	2021
4	Tingley et al. [24]	2017	14	Guerra and Leite [22]	2021
5	Mahpour [15]	2018	15	Luciano et al. [30]	2022
6	Akinade et al. [23]	2020	16	Giorgi et al. [31]	2022
7	Kanters [21]	2020	17	Tirado et al. [32]	2022
8	Bilal et al. [17]	2020	18	Sala Benites et al. [33]	2023
9	Mackenbach et al. [34]	2020	19	Shooshtarian et al. [18]	2023
10	Rios et al. [13]	2021			

3. Results and Discussions

3.1. Data Analysis

This section presents the analysis of the collected data. It also provides valuable insights into the years of publication and geographic representation of the selected studies.

Yearly Distribution of the Studies

From 2008 and 2023, nineteen (19) qualifying studies were published. The scholarly interest in the barriers to implementing CE in buildings only began 7 years ago (i.e., 2017); as shown in Figure 2. It can be clearly seen that there has been a noticeable increase in awareness and focus on the barriers in the past few years. From 2014 and 2023, the average yearly productivity was 1.9. The actual rise in interest began in 2017 and peaked in 2021.

3.2. Barrier's Analysis

This analysis subsection provides a detailed examination of the identified barriers within the context of the study. Understanding and addressing these is crucial for overcoming challenges and implementing effective CE strategies. A total of 25 different barriers were identified in the literature, which was further subdivided based on their categories. The number of barriers identified under each category is shown in Table 2. The first alphabet in the tag name was the first letter of the name of the barrier category followed by a number indicating the sub-category, which is followed by the assigned number in a particular sub-category (e.g., for awareness-related barriers under the sub-category 1, the first encountered barrier would be A1.1).

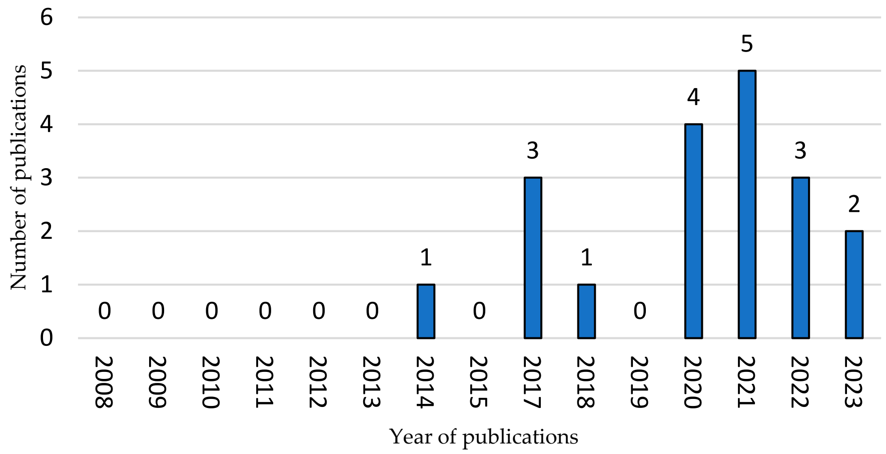

Figure 2. Year-wise distribution of selected studies.

Table 2. Circular economy barriers.

Category	Sub-Category	Barrier Code	Barrier	Reference
Awareness	Knowledge	A1.1	Limited knowledge of CE	[13–15,17,18,24,28,33]
		A1.2	Lack of CE vision	[15,33]
	Supply chain	A2.1	Fragment supply chain	[13–15,17,18,20,21,24,25,32,33]
	Literature	A3.1	Lack of case studies	[13,15,23]
	Metrics	A4.1	Lack of adequate information in building design	[15,20,23,24,27,28]
Technical	Technology	T1.1	Building complexity	[13,14,20,23,24,28,29,32]
		T1.2	Quality of materials at EOL	[13,21,23,24,27]
	Regulatory	T2.1	Policy and legislation	[13–15,17,18,22–25,27,30,31,34]
		T2.2	Lacking standardization/certification/traceability/quality assurance/classification	[13,14,23,25,28,30,31]
		T2.3	Lack of flexibility in building codes and regulations	[20,21,23,33]
	Tools	T3.1	Lack of CE metrics/tools/design	[17,21,23,31]
Economic and market	Market	E1.1	Lack of market mechanisms for recovery	[13,14,23,25]
		E1.2	Cost of virgin materials	[17,20,27]
		E1.3	A mismatch between supply and demand of reused materials	[20,21,23,24,30,31]
	Cost	E2.1	Unclear financial case	[13,14,22–25,28,33,34]
		E2.2	High upfront cost	[17,18,22–25,29–31,33]
	Value for money	E3.1	Cost of removing contaminated materials	[28]
Implementation	Infrastructure	I1.1	Availability and Storage facilities	[23–25,28,32]
		I1.2	Site constraints	[15,22,28]
		I1.3	Inadequate CE infrastructure to support CE management	[14,20,28,33]
	Management	I2.1	Conservative and non-collaborative industry operating within a linear economy	[13,15,20–22,24,25,28,31,32]
Support/promotion	Incentives	P1.1	Lack of incentives	[13–15,17,18,24,33]
	Government Support	P2.1	Lack of government support	[17,24,27,30,33]
Social	Perception/Flexibility	S1.1	Unrealistic hypothesis/Social flexibility	[13,15,20,25,27–29,34]
	Interest	S2.1	Lack of interest in CE	[13–15,20,22,27–29,32,34]

3.3. Barrier's Explanation

3.3.1. Awareness Barriers

These relate to lack of knowledge or attention developed by stakeholders, on basic knowledge, past experience, operation, and management. The most significant awareness barriers found in the literature are the limited knowledge of CE, lack of clear vision of CE, fragmented supply chain, lack of skills and engagement in both supply and value chain, lack of case studies, and lack of adequate information in building design.

Limited knowledge of CE: The lack of knowledge in CE concepts, principles, and potential benefits among stakeholders and policymakers is the second most cited barrier in the awareness category. Adams et al.'s [14] survey findings showed that the level of knowledge in CE is low among clients, designers, and subcontractors. Shooshtarian et al. [18] added that the level of awareness among stakeholders significantly influences various aspects, such as willingness to adopt CE, consensus on viewing CE as part of business ethics, and acknowledgement of CE benefits. Awareness in CE is essential to show its economic and environmental benefits to motivate stakeholders to adopt CE practices. Without this knowledge, stakeholders may overlook the potential economic and environmental gains, missing the opportunity to create more circular and profitable outcomes.

Lack of CE vision: A CE vision serves as a guiding framework, offering a clear strategic direction with specific objectives and measurable targets. The transition to a CE requires a strategic framework that outlines specific objectives and measurable targets to guide actions and monitor progress [35]. Mahpour et al. [15] studied the CE barriers in construction and demolition waste management. They stated that a lack of a well-defined vision to move towards CE in C&D waste management leads to uncertainty and demotivation for stakeholders to participate in CE practices. Hart et al. [16] highlighted the CE challenges in the built environment and claimed that there is an absence of a coherent vision for CE in the industry that influences decision making towards CE. Unclear CE goals and strategies can discourage stakeholders, who may question the feasibility and practicality of CE practices. Without a coherent vision, decision makers may lack a common understanding of CE's values and principles.

Fragment supply chain: Clear communication and coordination towards a common goal between all parts of the supply chain is critical for a CE to work efficiently [36]. The absence of communication and a comprehensive approach within the supply chain has been significant [14,21]. According to Dunant et al. [25], the refusal of a single participant in the supply chain to embrace the reuse of steel can prevent the entire project from progressing. This issue leads to missed opportunities for reuse, recycling, and material recovery. If the supply chain fails to establish effective communication, the successful implementation of a CE within the project's lifecycle may be compromised.

Lack of case studies: Case studies are critical as they provide real-world examples of successful implementation that encourage stakeholders to adopt new practices. The absence of evidence showing the economic benefits of design for deconstruction hinders its implementation [23]. Rios et al. [13] emphasised the need to develop more life cycle cost case studies. Without solid case studies, stakeholders would have limited evidence to demonstrate the feasibility and benefits of adopting CE principles in building projects. This lack of evidence can make decision makers hesitant to invest in or implement these practices.

Lack of adequate information in building design: A significant barrier related to the reuse of building materials and components is the absence of data about their quantity, condition, and availability [37]. Tingley et al. [24] claimed that there is insufficient data regarding the existing structure and the materials. The absence of data regarding the safe and effective reuse of materials hinders stakeholder in making informed decisions, leading to a disincentive to adopt circular economy practices. Furthermore, the lack of data on the availability and sources of reclaimed materials can lead to a poor and inefficient supply chain.

3.3.2. Technical Barriers

These are the challenges that arise from technological limitations that hinder the efficient flow of materials, the development of recycling technologies, or the adoption of circular business models.

Building complexity: Buildings are complicated due to their multi-layered composite structure such as steel-reinforced concrete components and inaccessible joints, and they undergo modifications over time, making it difficult to comprehend from a CE standpoint how to recover the steel or other reusable elements. According to Couto and Couto [38], it can be technically difficult to manage the dismantling, sorting, and recycling of these different materials. Furthermore, the size of construction materials, jointing techniques that do not ease disassembly, and the complexity of material composition are frequent design issues [39]. The difficulties involved with detaching bricks, particularly when combined with Ordinary Portland Cement, and the reuse of reinforced concrete parts are more common [16]. Building data management is challenging due to its complexity [29,40]. Missing or inaccurate building data during the design phase inhibits efficient life cycle assessment (LCA) for the end-of-life phase [41].
Quality of materials at EOL: The poor quality of building materials as they approach the end of their useful life might be an obstacle to the implementation of CE in the building sector. When construction materials reach the end of their useful life, their quality, condition, and readiness for reuse or recycling can have a substantial influence on their circularity potential [16]. Reusing materials frequently necessitates that they be in good condition and suitable for the intended purpose. Poor-quality materials may not match these standards, limiting their recyclability. Another difficulty is that material deterioration on-site during disassembly might render certain components useless. It is caused by incorrect deconstruction procedures due to a lack of adequate training and/or buildings created without taking the deconstruction process into account [42].
Policy and regulatory: Inadequate regulations and management policies impede the achievement of a zero-waste society and exacerbate the development gap in the CE [15]. The construction industry is governed by a plethora of regulations, standards, and norms that vary by location and authority. These regulations' inconsistencies and contradictions might cause confusion and impede the adoption of circular practices. The lack of CE-specific regulation was regarded as a significant constraint [22]. Luciano et al. [30] added that the ambiguous end-of-waste rules, as well as a lack of CE-specific legislation, pose significant challenges to CE implementation. Unclear policies create uncertainty and ambiguity regarding CE regulations regarding the rules and regulations governing CE practices. This uncertainty can deter businesses and investors from committing to CE initiatives, as they may be unsure about compliance requirements and the legal framework for operating in a circular manner.
Lacking standardisation/classification/certification/traceability/quality assurance: Material standardisation, classification, and certification play a crucial role in establishing consistent frameworks and guidelines for circular practices. The absence of standardised methodologies and criteria make the assessment of circularity performance for different buildings or construction projects challenging. The absence of recognised certification schemes for circular products can hinder trust in the market. The quality and performance of materials and products through their lifecycles is essential. If there is a lack of quality assurance processes, there may be concerns about the durability, safety, and reliability of reused or recycled materials. This can deter stakeholders from adopting circular practices due to uncertainty about the long-term performance of circular building components. Moreover, traceability is crucial to understand the origin, composition, and lifecycle of materials and products. It ensures that materials can be properly tracked, assessed for their circularity, and safely reused or recycled. Without robust traceability systems, it becomes challenging to validate claims about the circularity of materials and to ensure they meet the required standards [30].

Lack of flexibility: Building codes are rigid and prescriptive, often favouring traditional linear construction practices rather than adopting circular principles. The inflexibility of building codes can limit innovation and hinder the adoption of circular strategies such as adaptive reuse, deconstruction, and material recovery. According to Kanters [21], there is a lack of flexibility in building codes and regulations as design codes generally favour specifying new materials.

Lack of CE metrics/tools/design: The absence of adequate measures and tools analysing the circularity of buildings becomes a challenging task. The absence of standardised indicators and performance measures for circularity makes it difficult to assess the environmental, social, and economic impacts of construction projects. To promote the widespread adoption of deconstruction, it is crucial to develop suitable tools and techniques for the safe and cost-effective removal of structural components. These tools serve as a necessary prerequisite for facilitating the dismantling process while ensuring safety and economic viability [38]. Benites et al. [33] asserted that current tools (LEED, Green Star, BREEAM) are inadequate in promoting and accelerating circular and regenerative practices in the built environment.

3.3.3. Economic and Market Barriers

These are challenges related to the cost, financing, investment, and market that hinder the adoption of CE in the building and construction industry. Based on the literature, the most significant economic obstacles to implement CE principles in the building and construction industry are the cost of virgin material, lack of market mechanism for recovery, supply and demand of circular materials, difficult costing, unclear financial case, high upfront investment costs, and additional cost of design.

Lack of market mechanisms for recovery: This refers to the absence of efficient and effective mechanisms that enable the recovery and reuse of materials and products in the market. Currently, the availability of markets for reclaimed materials is limited [43], which results in unpredictable fluctuations in the unit cost of reclaimed components [44]. Dunant et al. [25] asserted that there is an absence of a substantial market to sell reused steel, as it is primarily limited to being sold as scrap. The success of building deconstruction and the reuse of components is linked to the availability of distribution points for material sale [23]. The absence of an efficient reused materials market can drive increased demand for resource extraction and the production of new materials to meet market needs, consequently depleting valuable resources and resulting in inefficient resource management.

Cost of virgin materials: The selection of materials is influenced by cost rather than environmental benefits [27]. According to Essoussi and Linton [45], recycling is more expensive than using virgin materials, while Watson [46] believes recycled materials are cheaper. Nevertheless, Addis [47] stated that the price of recycled products cannot be predicted compared to their virgin counterparts, emphasising that the cost of recycled material depends on its nature. Other authors believe the low prices of virgin materials make it desirable for businesses to use them over reused or recycled materials [16,17,20,27,43]. The perception that virgin materials are cheaper in the short term can influence material selection decisions. The impact here is significant, as it can lead to the continued depletion of natural resources and inhibit the growth of circular practices.

Supply and demand: Lack of consumer awareness about CE principles affects the demand for purchasing sustainable materials. In some markets, consumer awareness and demand for these products may still be relatively low. Tingley et al. [24] stated that the emergence of steel stockists is improbable unless there is a demand for reused steel and business advantage. As a result, there is a mismatch between the supply and demand of reused, recycled, and dismountable products [20–22,30,31,43]. The mismatch between supply and demand in reused/recycled materials can lead to inefficiencies and financial burdens. Excess supply can result in storage costs as materials need to be stored, managed, and maintained, incurring expenses related to warehousing and logistics. Conversely, insufficient supply can lead to an increased reliance on virgin materials, which results in environmental impacts.

Unclear financial case: An unclear financial case refers to a situation in which the economic benefits of a particular investment are uncertain or difficult to quantify. Investors may therefore be hesitant to participate in circular construction projects until they perceive a clear economic return. According to Akinade et al. [23], developing a business case for design for deconstruction could be challenging. Benites et al. [33] claimed investments in CE practices are subject to long-term unpredictability as a result of fluctuating or ambiguous regulations. Innovations in circular construction methods and technologies may be slower to develop when there's a lack of investment and incentives due to financial uncertainty.
High upfront cost: Shifting to a CE model requires investment in new strategies, technologies, and infrastructure. Such investments require high upfront costs [16–18,22,39], which makes it difficult for some businesses to shift to more circular practices. Guerra and Leite [22] added that large companies are susceptible to invest in circular strategies, while businesses with limited budgets may face challenges with adopting circular strategies. Higher costs and time are employed when implementing CE practices [13,23,39]. Benites et al. [33] claimed that additional cost is associated with implementing circular practices. The lack of standardisation of reused materials results in a higher construction cost as reused materials often require additional tests and consultations to acquire the required certificates and permissions [37]. Tingley et al. [24] asserted that the deconstruction process requires extra time, more labourers, and the cost of product re-certification.
Cost of removing contaminated materials: Removing contaminated and hazardous materials such as asbestos in existing buildings is costly [48]. Asbestos is a naturally occurring mineral that was widely used in building construction materials due to its strength and durability [49]. Asbestos removal refers to the process of safely removing asbestos from contaminated materials in a building. Couto and Couto [38] claimed that safe and effective asbestos removal in older buildings that are being considered for deconstruction necessitates special training, handling protocols, and specialised equipment. The existence of asbestos in old buildings requires additional costs due to the management of hazardous materials. As a result, the deconstruction process can be both expensive and time-consuming due to the high price of separating recyclable materials from contaminated ones [41].

3.3.4. Implementation Barriers

These refer to the obstacles that could arise while implementing circular principles and practices within the sector. These can encompass various factors, including the lack of storage facilities, site constraints, inadequate CE infrastructure, and the presence of a conservative and non-collaborative industry operating within a linear economy.

Lack of storage facilities: Deconstruction projects often involve dismantling building components over time. Building deconstruction is not usually considered due to material storage and transportation necessity. Storage and transportation charges will eventually raise the entire project expenditure [23]. Materials salvaged from deconstruction require careful handling and storage to preserve their quality and condition. Tingley et al. [24] argue that steel stockists are unlikely to adopt reused steel until there is a significant business advantage in doing so. This suggests that businesses need strong financial incentives to invest in storage facilities for reused materials. Therefore, the absence of storage facilities can be a factor against implementing the principles of CE.
Site constraints: Off-site sorting and direct landfilling could contribute to major environmental consequences, whereas on-site sorting results in net environmental advantages [15]. It is thought that the construction industry is hesitant to undertake on-site sorting in comparison to the existing dominating cradle-to-grave technique due to space and financial constraints, tight timetables, and more labour and administrative efforts [50]. This short-term cost-saving approach associated with off-site sorting may make it a more attractive option from a budget perspective, which can create resistance to adopting more circular construction practices.
Inadequate CE infrastructure to support CE management: A key obstacle is the existing stock of buildings and infrastructure that do not adhere to circularity principles [14]. How-

ever, the challenges to applying CE to conventional structures are mostly connected to their monolithic form, architectural elements that result in a lack of standards, and an inadequate closed-loop supply chain [51]. The existing of non-circular infrastructure may not be economically viable to retrofit for circularity. The high cost and complexity of adapting conventional structures to circular principles can deter investment in CE initiatives. Moreover, monolithic structures in conventional buildings can make disassembly and material recovery challenging, resulting in a significant loss of resources during deconstruction.
Conservative and non-collaborative industry operating within a linear economy: The construction sector is considered conservative, with limited flexibility to adopt new practices due to perceived financial risks. The construction sector's close relationship with other sectors, particularly the financial sector, makes the transition to a CE more challenging because other industries would have to undergo the same change at the same time [21]. The industry's risk aversion leads to a reluctance to embrace and invest in new circular methods and technologies. This results in resistance to any changes that might disrupt established norms.

3.3.5. Support/Promotion Barriers

These relate to the absence or insufficient support from various stakeholders, including governments, businesses, and consumers.

Lack of incentives: It refers to the absence or insufficiency of motivating factors that encourage individuals, businesses, or other stakeholders to adopt or engage in CE practices. There is a lack of well-structured and targeted financial incentives for CE practices [33]. These incentives can offset the initial costs associated with transitioning to more circular processes, making these practices more financially attractive. The absence of these incentives could lead businesses to perceive CE practices as a financial burden, which could potentially reduce their motivation to implement them. The absence of incentives not only affects businesses but also hinders individuals and consumers from participating in the CE. Without clear benefits or rewards for recycling, reusing, or making circular choices, individuals may lack the motivation to change their behaviours.
Lack of government support: Government support, in the form of tax incentives, regulatory frameworks, and policy initiatives plays a vital role in promoting and accelerating the transition to a CE. The lack of tax incentives or government support is a major hindrance to the transition to CE [17,27,30]. The role of governments is important as it encourages businesses to adopt circular practices by reducing the financial burden and offsetting the costs associated with transitioning to circular models. The lack of government support can create uncertainty and reluctance among businesses and investors. Government involvement is important as it provides a clear roadmap and legal framework within which businesses can operate, making it easier for them to align their strategies with CE principles.

3.3.6. Social Barriers

These arise from cultural perceptions, consumer behaviour patterns that favour a linear economy, and social flexibility towards new practices.

Unrealistic hypothesis/Social flexibility: There is a prevalent negative viewpoint towards reclaimed materials, with a preference for buildings constructed using new materials rather than those utilising recovered materials [25]. Additionally, the value embedded within construction and demolition waste is often overlooked, with many industry professionals failing to recognise it as a valuable resource [50]. This limited perspective hampers the realisation of the full potential of reclaimed materials and impedes their widespread adoption in construction practices. Negative perceptions of reclaimed materials can lead to reduced market demand for these materials in construction projects. This limits the economic viability of reusing and recycling materials, which affects the circular economy's progress.
Lack of interest in CE: Stakeholders within the supply chain, including suppliers and distributors, may be hesitant to change established processes or invest in new technologies

required for circularity [14]. The limited interest in the CE is often due to a lack of awareness of its advantages or a misconception that it is incompatible with conventional profit-driven approaches Without compelling incentives for businesses and individuals to engage in the CE, there may be little motivation to change established practices. This lack of interest discourages innovation and investment in the CE. For example, businesses may be less likely to invest in research and development of new circular technologies and business models if they do not believe that there will be a return on their investment.

3.4. Frequency Analysis

Figure 3 provides a visual representation of the frequency with which certain barriers have been referenced in the literature, organised under specific sub-categories. Policy and legislation (T2.1)-related problems are the most frequently referenced one, appearing 13 times. The absence of clear CE policies can create uncertainty for businesses and investors to adopt circular practices. With the absence of government legislation for CE, stakeholders do not face regulatory pressures to adopt circularity.

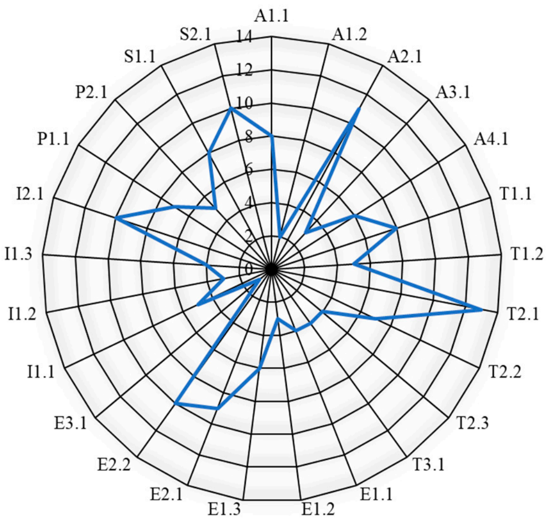

Figure 3. Circular economy barrier frequency.

Fragmented supply chain (A2.1) appeared 11 times. This highlights the lack of coordination and collaboration among various stakeholders within the construction industry, leading to difficulties in sourcing and utilising reclaimed materials or incorporating circular principles into building projects.

High upfront investment cost (E2.2) is another prominent constraint, appearing 10 times in the literature. This indicates that the initial financial burden associated with adopting circular practices, such as investing in new technologies, retrofitting existing structures, or establishing efficient waste management systems, hinders the widespread adoption of circularity in construction.

Conservative and non-collaborative industry (I2.1) is a major issue cited in the literature 10 times. Transitioning to a CE requires a fundamental change in mindset and practices. The construction industry practices often resist such changes, as they may be perceived as risky or costly.

The lack of interest in CE (S2.1) appeared 10 times in the literature. Cultural factors or social norms may discourage participation in certain circular practices. The lack of understanding of the benefits and principles of the CE leads to social resistance to change.

Unclear financial case (E2.1) is referenced 9 times. Businesses may face uncertainty regarding future regulations, taxes, or incentives related to circular practices, which makes it challenging to plan and budget effectively. In addition, businesses may prioritise short-term profits, making it difficult to justify the initial investment in circular practices.

Building complexity (T1.1) is referenced 8 times. This suggests that the intricate nature of building processes, including design, construction, and integration of circular practices, poses a significant challenge to implementing circularity in the built environment.

3.5. Barrier Category Frequency

The most frequently observed barriers under each category are presented in Figure 4. Among these, technical barriers were the most frequently observed with a total count of 41 times in the literature. Economic/market barriers were encountered 33 times, indicating the significant impact of economic factors. Awareness-related barriers were observed 30 times, highlighting the considerable aspect of knowledge on CE. Implementation barriers appeared 22 times, while social barriers were noted 18 times, showing how stakeholders' resistance to change played a significant role in the transition to circular buildings. Lastly, support/promotion-related barriers were encountered 12 times.

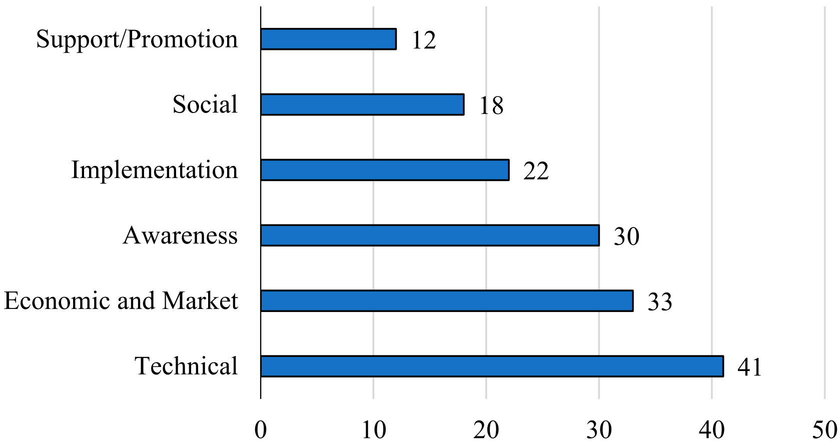

Figure 4. Category-wise representation of CE barriers frequencies.

3.6. Barrier and Enabler Frequency per Article

This section provides a comprehensive overview of the number of barriers and enablers identified in each study as shown in Table 3. The analysis of 19 articles revealed a total of an average of approximately eight barriers and six enablers per article. The variation in the number of barriers and enablers identified across studies is attributable to the different research methodologies employed. Moreover, the objectives and scopes of each study influence the identified number of barriers and enablers. Some articles focus primarily on identifying barriers rather than the exploration of enablers.

Table 3. Barrier and enabler frequency per article.

No	Reference	Barrier	Enabler	No	Reference	Barrier	Enabler
1	Tingley et al. [24]	13	8	11	Oyedele et al. [27]	7	8
2	Akinade et al. [23]	13	6	12	Kanters [21]	6	4
3	Rios et al. [13]	13	10	13	Giorgi et al. [31]	6	6
4	Charef and Emmitt [28]	12	2	14	Guerra and Leite [22]	6	5
5	Mahpour [15]	11	5	15	Luciano et al. [30]	5	3
6	Adams et al. [14]	10	10	16	Shooshtarian et al. [18]	5	6
7	Hartwell et al. [20]	10	5	17	Tirado et al. [32]	5	4
8	Dunant et al. [25]	9	3	18	Torgautov et al. [29]	4	4
9	Sala Benites et al. [33]	9	7	19	Mackenbach et al. [34]	4	4
10	Bilal et al. [17]	8	5				

3.7. Co-Occurrence Analysis

To create a better ranking, the interdependence of categories must be explored. Examining data co-occurrences is a method of determining the influence of various variables in a study subject on one another and revealing probable linkages. Furthermore, determining the relationship between the important factors aids in better creating strategies to meet the study's objectives [52].

By examining the co-occurrence of all 25 sub-categories barriers, we investigated their interdependence. The co-occurrence between any two pairs is determined by quantifying the frequency of their simultaneous appearance in the literature.

The results from the co-occurrence matrix analysis are shown in Table 4. The cells highlighted in red show the pairs with greater than seven co-occurrences in the literature.

Table 4. Co-occurrence matrix of CE barriers.

	Awareness				Technical			Economic Mad Market			Implementation		Support/Promotion		Social	
	A1	**A2**	**A3**	**A4**	**T1**	**T2**	**T3**	**E1**	**E2**	**E3**	**I1**	**I2**	**P1**	**P2**	**S1**	**S2**
A1	0	7	2	3	4	7	1	4	8	1	5	3	5	2	3	4
A2	0	0	2	3	7	10	2	7	7	0	6	5	5	4	4	4
A3	0	0	0	2	2	3	0	2	2	0	2	2	2	0	2	2
A4	0	0	0	0	5	6	1	5	4	1	6	3	2	2	4	4
T1	0	0	0	0	0	12	2	9	10	1	8	5	3	3	5	7
T2	0	0	0	0	0	0	4	12	14	0	10	8	7	5	7	7
T3	0	0	0	0	0	0	0	4	3	0	1	1	1	1	0	0
E1	0	0	0	0	0	0	0	0	9	0	5	6	4	4	4	4
E2	0	0	0	0	0	0	0	0	0	1	7	4	6	4	5	7
E3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
I1	0	0	0	0	0	0	0	0	0	0	0	6	4	2	4	5
I2	0	0	0	0	0	0	0	0	0	0	0	0	3	1	4	3
P1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	3
P2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
S1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
S2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4 shows that cost (E2)- and technology (T1)-associated barriers tended to simultaneously appear 10 times. Building data management is challenging due to its complexity, which counts as a technological issue. The absence of effective construction data management makes it difficult to identify salvaged parts or estimate reclaimed materials, which can create further problems. For instance, estimation challenges and difficulties in promoting the CE approach may hinder the development of a global vision of asset lifecycle cost.

Similarly, regulatory and standardisation (T2)-related and cost-related barriers (E2) appeared 14 times together. According to Rios et al. [40], the lack of a uniform regulatory framework (no standardisation and grading system for salvaged materials; no requirements for recycled materials and repurposed constructions) are obstacles to the widespread adoption of CE in the building sector. For example, the lack of standardisation makes estimating the cost of salvaged material components for different grades challenging.

Regulatory and standardisation (T2)-related and knowledge of CE-related constraints (A1) appeared 7 times together. With the absence of CE legislation, stakeholders have no legal obligation or motivation to educate themselves CE practices. CE legislation can provide clear guidelines and standards for incorporating CE principles, helping stakeholders understand how to comply with CE requirements and integrate them into their business models.

The interest in CE (S2)- and cost (E2)-associated barriers appeared seven times together. The high perceived cost of circular practices can discourage stakeholders to adopt them. When stakeholders believe that switching from a linear economy to CE will require significant upfront investments, they are less interested in exploring these practices. Therefore, stakeholders need to learn about the long-term benefits and potential cost savings of the CE.

The findings presented in Table 4 demonstrate that the co-occurrence of technical and economic obstacles is common. Therefore, it would appear that any future initiatives to encourage CE in buildings should prioritise those problems that fall within these categories. These results also align with the frequency analysis presented above.

3.8. Enablers for Enforcing CE

Another major part of the systematic literature review was identifying and understanding existing enablers that can facilitate the transition to a CE. Based on the literature review, 14 critical CE enablers have been identified, each having its unique impact and potential to address specific barriers. The analysis of this study revealed that the most frequently cited enablers for advancing circular economy practices in the building sector are as follows: circular economy-supportive policy, financial incentives, technology and innovation for circular building tools, stakeholders' collaboration and engagement, and the use of BIM. Figure 5 shows the frequency of each enabler in the literature. Businesses and policymakers can implement these enablers to accelerate the transition to more circular practices. Table 5 presents the identified enablers.

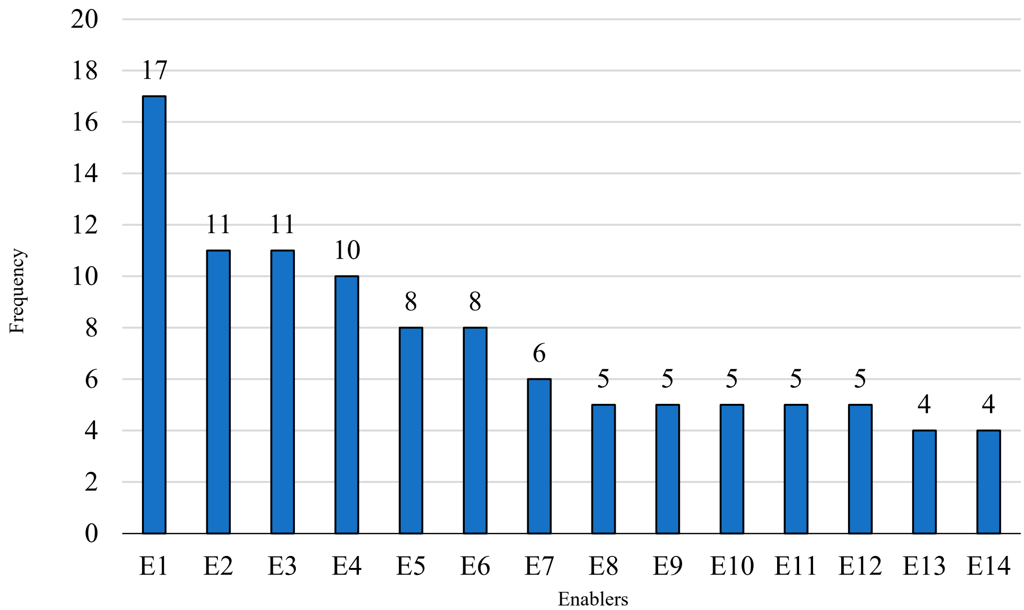

Figure 5. Frequency of enablers for implementing CE.

Table 5. Circular economy enablers.

No	Enabler Code	Enabler	Reference
1	E1	Circular economy-supportive policy	[13–15,17,18,20–24,27,29,30,32–34]
2	E2	Financial incentives	[13–15,17,18,20,22,24,27,30,33]
3	E3	Technology and innovation for circular building tools	[13–15,17,18,24,29,31–34]
4	E4	Stakeholders' collaboration and engagement	[15,18,22,23,25,27,31–34]
5	E5	Use of building information modelling (BIM)	[13,14,18,23,27–29,31,33]
6	E6	Circular business models	[13,14,18,20,21,24,30,31]
7	E7	Awareness campaigns	[13,14,17,22,27,32]
8	E8	Standardization and certification of reclaimed materials	[14,20,22,27,34]
9	E9	Design guidelines for circular buildings	[13,14,18,23,24]
10	E10	Development of reused materials market mechanisms	[14,21,23,25,33]
11	E11	Education and research	[13,15,17,24,27]
12	E12	More materials storage and recycling facilities	[13,20,21,24,25]
13	E13	Circular building case studies	[13,14,23,24]
14	E14	Materials passports	[27–29,31,33]

Enabler's Explanation

BIM: BIM has the potential to help to plan, manage, and supervise the entire building lifecycle [53,54]. BIM can effectively deal with building complexity through the digitalisation of information that can be accessed by stakeholders over the life span of a project. With that information in hand, deconstruction or possible reuse becomes a more viable option for a complex building structure. A BIM digital model can also help develop more realistic estimates of the whole life cycle cost [54–56], which can further promote CE in building construction and help to educate people on circular buildings. BIM can enhance stakeholders' collaboration by providing a common platform for sharing information and making informed decisions [23]. According to Charef and Emmitt [28], the deconstruction information model by BIM can be utilized throughout the lifespan; when the asset is no longer in use, the customer will receive a digital "as-maintained" record comprising full asset history, building drawings, structural characteristics, and an inventory of building components and materials, including their design life and possibility for reuse. Therefore, BIM enhances transparency in the CE, allowing stakeholders to make informed choices about material reuse and recycling.

CE-supportive policy: Circular economy-oriented legislation can set standards covering building design, construction, and operation. This includes requirements for using reused/recycled materials, energy efficiency, waste reduction strategies, and the incorporation of circular principles into building practices. Akinade et al. [23] suggested that strict laws and policies in the construction industry have been effective in ensuring that professionals in the field follow government-set targets and regulations. Bilal et al. [17] emphasised the significance of government support in establishing laws related to the CE that not only specify penalties for non-compliance but also provide incentives for compliance. Stringent regulations and governmental policies can promote the establishment of consistent practices and guidelines for CE. By implementing CE-supportive policy, governments can create an enabling environment that encourages modernising engineering practices.

Financial incentives: Financial incentives are essential in encouraging businesses, organisations, and individuals to embrace circular practices, as they help offset the costs associated with transitioning to more circular approaches [18,33]. Financial incentives can have a significant influence on changing consumer behaviour by lowering costs and increasing the appeal of circular buildings. For instance, if circular constructions receive tax breaks and lower project taxes, this will result in higher demand for the use of reused materials. These incentives can mitigate the stakeholders' concerns regarding the high costs of circular practices.

Design guidelines for circular buildings: Design guidelines could provide a structured framework for various stakeholders, such as architects and engineers, to incorporate circular principles into building projects [13,18]. The lack of design guidelines leads to confusion among stakeholders. Design guidelines address the lack of awareness of CE by serving as educational resources that clarify CE concepts and demonstrate how they can be practically applied in building projects. As a result, professionals become more knowledgeable about the CE, and their interest in implementing circular practices increases. In addition, CE design guidelines can encourage policymakers to use the guidelines as a foundation for developing policy frameworks that promote circularity in the building sector.

More material storage and recycling facilities: A more significant number of storage and recycling facilities helps in providing better logistics and market conditions for reused/recycled products [24,25]. This may eventually aid in making them a better choice from a financial and structural performance perspective. The assessment of secondary resources' quality and availability for reuse, as well as assurance mechanisms for recycled secondary materials, could also overcome several economic and market-related constraints [14]. For example, the availability of storage and recycling facilities contributes to the development of a strong market for reused/recycled construction materials, which in turn encourages more market entrants and investment in circular practices.

Education and research: CE-focused research can inform regulations and lead to better implementation and compliance of CE in building infrastructure. Education is strongly interlinked with increasing awareness amongst building sector stakeholders [15,17]. The development of education and training programs about CE strategies can provide stakeholders with needed skills to implement CE principles. Academic research can lead to the development of new tools and technologies for CE adoption and enhance CE policy development. Policymakers can be enhanced with the evidence from academic researches which results in formulating regulations and incentives that support CE in building construction.

Circular business models: These models can explain the reasoning behind how a firm produces, delivers, and collects value for its stakeholders. Successful circular business models can inspire others by demonstrating what is possible and how circular practices can be profitable [14,24]. Circular business models facilitate cost–benefit analyses that demonstrate the long-term economic advantages of circular approaches, assisting stakeholders in making informed financial decisions. They also incorporate revenue-generating strategies over time, which can help mitigate concerns about the initial high upfront costs of circular practices, thereby increasing interest in CE.

Stakeholders' collaboration and engagement: Stakeholder engagement in the planning phase is important to emphasise its benefits and increase acceptability and interest in CE [34]. Involving stakeholders from different sectors, such as manufacturers, designers, contractors, and suppliers, ensures a holistic perspective. This engagement provides a collaborative supply chain that facilitates learning and knowledge sharing of best practices for delivering circular practices.

Circular buildings case studies: Case studies inspire and raise awareness among businesses, governments, and individuals about the potential of CE practices. Case studies offer practical examples of how to address environmental and economic challenges for more successful circular building projects [13,14]. Finding demonstration projects showing the potential of different circular design approaches, such as design for deconstruction, design for adaptability, and design for disassembly and adaptability, provides practical guidance to stakeholders on integrating CE principles into their projects.

Awareness campaign: Awareness campaigns for promoting CE practices can take various formats such as workshops, seminars, conferences, and social and print media. Campaigns naturally help to develop a foundational understanding of CE and its benefits, therefore motivating stakeholders to adopt circular practices and increase the positive impact of CE on business and the environment [14,17]. These campaigns can address negative perceptions of reclaimed materials and circular practices by providing evidence to clarify the misconceptions. This is very important to educate stakeholders about the economic and environmental benefits of circular practices which leads to more acceptance to implement circular strategies in their projects.

Development of reused materials market mechanism: A reused materials market provides a platform for businesses to buy and sell reusable materials, components, and products. It incentivises the recovery and resale of building products and materials [21,23,33]. The development of circular materials marketplace can increase the supply and demand of reused/recycled materials significantly. This can enhance stakeholders' ability to access to affordable buildings materials, which can positively impact on reducing construction costs.

Standardisation and certification of reclaimed materials: Concerns about the quality and performance of reclaimed materials can deter their wider adoption in buildings [30,31]. Recognised standards and certifications of reclaimed materials can build trust among stakeholders as they ensure the quality, safety, and reliability of reclaimed materials. Reclaimed materials that meet the industry standards are more likely to be trusted and integrated into building construction projects. Certification programs can verify that reclaimed materials comply with safety standards and regulations. This assurance is critical for applications where safety is a primary concern.

Materials passports: The development of materials passports is critical to unlock the reuse materials potential. Materials passports are digital documents that provide comprehensive information about materials and products used in a building [40]. This information includes materials geometry, characteristics, carbon information, and lifecycle [57]. As a result, it enhances traceability and identification of suitable reused materials. They also encourage stakeholders to make informed decisions about the selection of reused materials, which increases the demand for materials that prioritise circularity.

Technology and innovation in circular building tools: Innovative technologies in circular building tools can accelerate the adoption of CE principles. Advanced construction technologies ensure that reused materials meet quality standards and are suitable for their intended purpose. The development of technological circular tools can simplify integrating CE principles into complex designs. For example, incorporating design for manufacture and assembly (DfMA), additive manufacturing (AM), 3D printing, and prefabrication design into circular buildings can further accelerate the adoption of CE. According to Tuvayanond and Prasittisopin [58], DFMA optimises product designs in a way that not only meets functional and performance requirements but also makes them easy and cost-effective to produce and assemble. AM and 3D printing technologies enable the transformation of discarded harmful waste into new and valuable products, providing a circular solution to reduce waste and promote environmental responsibility [59]. Hence, the incorporation of these technologies is essential in waste management to mitigate issues like microplastics in construction and the built environment [60].

Technological advances can also be effective in prefabrication and modular construction techniques, which create standardised building components that can be easily assembled and disassembled. The benefits of these technological advancements include reduced construction time, cost savings, improved quality control, and reduced waste [51]. As a result, these innovations increase the interest in CE among various stakeholders.

3.9. Mapping Enablers to CE Barriers

The section establishes a crucial connection between enablers strategies that can support the successful implementation of CE practices in the building sector with the challenges that need to be overcome. Table 6 provides a comprehensive mapping analysis of 14 enabler strategies in relation to the 25 identified CE barriers.

Enabler strategies, such as the use of BIM, CE-supportive policy, and financial incentives, have been found to be effective mitigating strategies linked to addressing 17, 12, and 12 CE barriers, respectively. The ability of these enablers to overcome a wide range of challenges highlights their importance in promoting circular practices within the construction and building industry. It highlights the need to leverage BIM, policy, and financial incentives to overcome these specific barriers. Understanding how enablers can mitigate CE barriers provides stakeholders with valuable insights for strategic decision making.

Table 6. Mapping enablers to CE barriers.

Barrier Code	Enablers to CE Barriers													
	BIM	Awareness Campaigns	CE-Supportive Policy	Education and Research	Financial Incentives	Stakeholder Collaboration and Engagement	Material Passports	Design Guidelines for Circular Buildings	Circular Business Models	Technology and Innovation for Circular Building Tools	More Materials Storage and Recycling Facilities	Standardisation and Certification Reclaimed Materials	Circular Building Case Studies	Development of Reused Materials Market Mechanisms
A1.1	✔	✔	✔	✔				✔						
A1.2	✔	✔	✔											
A2.1	✔	✔			✔	✔								
A3.1				✔										
A4.1	✔					✔	✔							
T1.1	✔						✔	✔		✔				
T1.2										✔				
T2.1			✔		✔			✔				✔		
T2.2	✔		✔				✔					✔		
T2.3			✔									✔		
T3.1	✔						✔	✔		✔				
E1.1	✔				✔		✔				✔	✔		✔
E1.2			✔											
E1.3	✔		✔		✔		✔				✔	✔		✔
E2.1	✔				✔			✔	✔	✔				
E2.2				✔				✔	✔	✔			✔	✔
E3.1	✔						✔			✔				
I1.1	✔										✔	✔		
I1.2	✔				✔						✔			
I1.3					✔			✔		✔	✔		✔	
I2.1	✔		✔		✔	✔		✔		✔				
P1.1	✔		✔		✔									
P2.1			✔	✔	✔									
S1.1	✔	✔	✔	✔	✔							✔	✔	
S2.1	✔	✔	✔		✔	✔		✔	✔	✔				

4. Conclusions

This study addressed two research questions: (1) What are the key barriers that hinder the progress of transitioning towards a CE within the building sector? (2) What strategies can be employed to overcome CE barriers and enhance the transition to a CE in the building sector?

The study conducted a comprehensive investigation into the barriers associated with the adoption of the CE concept in the building sector. It employed a systematic literature review using the PRISMA protocol to search, evaluate, and extract metadata. Nineteen studies were included in this research, all of which were retrieved from Scopus. These studies were reviewed to provide a comprehensive perspective on the barriers and enablers to the adoption of CE principles in the building sector. The analysis conducted in this study revealed notable trends in scientific research interest of CE barriers between 2017 and 2023.

The study identified 25 barriers categorised into six areas: awareness, technical, economic and market, implementation, support/promotion, and social. This study has identified five major barriers hindering progress in CE in the building sector. These barriers include the absence of comprehensive CE policies and legislation, a fragmented supply chain, the high upfront investment costs, a conservative and non-collaborative industry mindset, and a general lack of interest in embracing the principles of CE. Addressing these challenges is essential for fostering more circular practices.

In addition, a co-occurrence matrix was formed to explore the cross-correlation amongst the 25 sub-categories for barriers. As an outcome of this study, the analysis reveals a strong correlation between regulatory and awareness barriers in the adoption of CE principles, highlighting the importance of mandated CE legislation in driving stakeholders to gain a comprehensive understanding of CE practices. Another strong correlation is evident between regulatory and economic barriers, highlighting the necessity of regulatory frameworks that provide cost reduction incentives for adopting circular practices, thereby encouraging stakeholders to embrace them.

The study also helped to identify 14 enablers to CE that counterbalance the current situation and can facilitate the transition towards more circular buildings. The findings of the study indicate that there is a need for CE legislation stringency to ensure stakeholders compliance, financial incentives to motivate businesses towards CE practices and technological innovation to facilitate successful implementation of CE.

The analysis conducted in this study reveals that enabler strategies, including BIM, CE-supportive policy, and financial incentives, are notably effective in addressing the challenges associated with CE implementation in the building sector. BIM emerges as a powerful tool in mitigating 17 CE barriers, CE-supportive policies play a crucial role in addressing 12 barriers, and financial incentives address 12 barriers.

The findings of this study provide valuable insights that help recognising both barriers and enablers, so that stakeholders can develop more effective strategies for successful of adoption of CE. The research outcomes help to devise pathways towards more circular built environment.

It is important to acknowledge that the study is limited to information found in the literature, with the absence of validation through CE experts' opinion. Future research shall include experts' opinions and discussions to illustrate the interconnexion of the various issues identified for the progression of CE.

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