TRANSITION TOWARDS CIRCULAR CONSTRUCTION: MAPPING BARRIERS AND ENABLERS OF DIRECT REUSE OF RECLAIMED CONCRETE ELEMENTS

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Abstract. Concrete is the most widely used construction material globally and constitutes a major share of construction and demolition waste, resulting in significant environmental impacts. Direct reuse of reclaimed concrete (RC) elements represents a high-value circular strategy, as it reduces raw material extraction, preserves embodied energy, and lowers carbon emissions associated with new concrete production. Despite these advantages, the practical implementation of RC reuse remains limited due to multiple interrelated barriers. This paper presents a systematic literature review investigating the barriers and enablers influencing the adoption of direct RC reuse within circular construction. The identified drivers were classified into 6 categories: design and structural; process and execution; regulatory; economic and market; environmental; and industry practice and cultural factors. In total, 27 barriers and 20 enablers were identified and analysed. A barrier-enabler relationship map was developed to examine how specific enabling conditions can address the identified barriers. The results indicate that coordinated improvements in technical approaches, regulatory support, and market mechanisms are required to facilitate the wider implementation of RC reuse. The findings provide insights for industry practitioners and policymakers by highlighting critical factors that influence reuse adoption and supporting the development of strategies that promote circular practices in the construction sector.

Keywords. *Barriers; Circular Economy; Direct Reuse; Enablers; Reclaimed Concrete*

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1. Introduction

The construction sector is one of the most resource-intensive industries worldwide. It accounts for approximately 30-50% of global natural resource consumption, generates nearly 40% of total waste, and contributes about 39% of global greenhouse gas emissions (Rakhshan et al., 2020). A major contributor to this environmental footprint is concrete, which is the most widely used construction material in the world. Global concrete production is estimated to be around 14 billion m³ annually (Global Cement and Concrete Association, 2023). The large-scale use of concrete results in significant environmental impacts associated with raw material extraction, manufacturing processes, and end-of-life waste generation. To mitigate these impacts, Circular Economy (CE) strategies have been increasingly proposed for the construction sector. These strategies include extending the service life of structures, reusing structural elements through deconstruction, and recycling materials at the end of their service life. Within the waste management hierarchy, reuse is prioritized over recycling because it preserves the embodied energy and material value of construction components (Crowther, 2018). As a result, the direct reuse of concrete elements has gained increasing attention for global sustainability and decarbonization agendas.

In recent years, several European research initiatives and pilot projects have explored the feasibility of direct concrete reuse. This approach typically involves carefully

https://doi.org/10.31705/ICFMF2026.25

extracting whole structural elements from obsolete buildings and integrating them directly into new structures with minimal processing (Kupfer et al., 2025; Ungureanu et al., 2025). Although reinforced concrete structures are often designed to last over 100 years, social and economic factors such as changing functional requirements, urban redevelopment, and aesthetic preferences frequently lead to premature demolition after only 50-60 years of service (European Cement Association, 2021). This premature demolition creates a significant opportunity to recover and reuse concrete elements that still possess substantial structural capacity. Several case studies have already demonstrated the environmental and economic potential of this approach. A review of 77 reuse projects showed that the piecewise reuse of extracted concrete elements can provide substantial environmental benefits and competitive costs (Kupfer et al., 2023). For example, in Switzerland, 15 cm thick concrete slabs with a span of 3 m recovered from a 1980s residential building were reused as load-bearing floor elements in a new office building, achieving approximately 84% carbon savings compared with conventional construction (Kupfer et al., 2023). Similarly, the Nya Udden project in Sweden reused concrete walls, beams, and foundations from 1960s buildings in the construction of student housing, resulting in 50% lower CO_2 emissions and 40% energy savings (Eklund et al., 2003). Another Swiss case study reported the reuse of concrete elements in the construction of a 233 m^2 parking pavement, achieving up to 81% reduction in CO_2 emissions compared with conventional bituminous pavement systems (Kupfer et al., 2022). These examples highlight the significant environmental potential of concrete reuse and demonstrate the feasibility of this strategy in real construction projects.

Despite these advantages, direct reuse of concrete elements remains rarely implemented in current construction practice (Kupfer et al., 2023). In most cases, concrete structures are demolished, and the resulting waste is crushed to produce recycled aggregates or disposed of in landfills. Although recycled aggregates can reduce the demand for natural aggregates, they often require higher cement content to achieve similar mechanical performance, which partially offsets their environmental benefits (Lee et al., 2020; Marinković et al., 2010). Since cement is the primary binding component of concrete, reducing its consumption has become a key priority in global climate policies aimed at decarbonizing the construction sector (Scrivener et al., 2018). Several barriers continue to hinder the widespread implementation of direct reuse. These barriers include technical challenges related to deconstruction and structural assessment, economic uncertainties, regulatory constraints, and logistical issues within the supply chain (Huuhka et al., 2015; Kupfer et al., 2023; Siriwardhana & Tharmarajah, 2023). These challenges create uncertainty in decision-making processes, thereby limiting the adoption of direct concrete reuse practices. Therefore, identifying the barriers to direct concrete reuse and the enablers to overcome them is essential for advancing CE practices within the construction sector.

While previous research has investigated barriers and enablers related to CE implementation in the construction sector, these investigations typically consider reuse as part of broader sustainability strategies. As a result, the barriers and enabling conditions specifically associated with the direct reuse of RC elements have not yet been systematically synthesized. This study addresses this gap by conducting a systematic review to identify and map the key barriers and enablers influencing the implementation of direct concrete reuse in the construction industry.

2. Methodology

This study adopted a systematic literature review to examine the barriers and enablers of reusing RC elements. Figure 1 illustrates the process of data collection and analysis followed in this study.

2.1. DATA COLLECTION

A systematic literature search was conducted using the Scopus database. Scopus was selected due to its broad coverage of peer-reviewed journals and its ability to provide reliable access to recent, high-quality research across multiple disciplines (Ghaleb et al., 2022). The search was performed within the TITLE-ABS-KEY fields using combinations of the following keywords: "concrete reuse," "reuse of concrete elements," "reused concrete," "precast concrete reuse," "reclaimed concrete elements," and "cut concrete." The search was limited to publications between 2010 and 2026, as research on direct concrete element reuse has gained significant attention in recent years, making this period most relevant for capturing contemporary developments. This review was restricted to articles and conference papers published in English and confined to the subject areas of engineering, materials science, energy, and environmental science. The initial search yielded 50 records.

A staged screening process was then undertaken. First, titles were reviewed to exclude clearly irrelevant studies. Subsequently, abstracts were screened, reducing the sample to 21 studies. Given the emerging and relatively limited body of research on direct concrete element reuse, a backward snowballing approach was applied, where the reference lists of the selected studies were systematically examined to identify additional relevant publications (Wohlin et al., 2022). This process resulted in the identification of an additional 11 relevant publications from the reference lists of the selected papers. Following full-text assessment, a total of 32 studies were included in the final review.

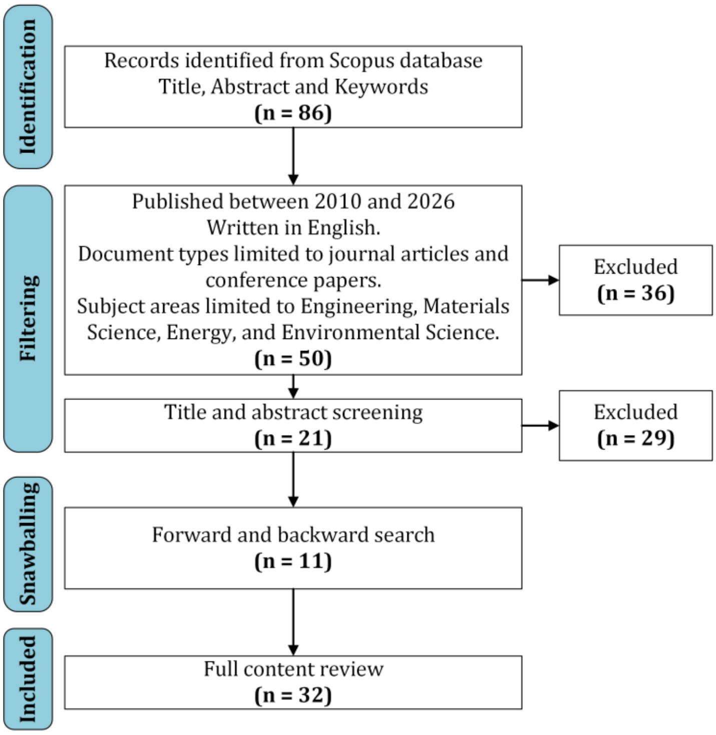

Figure 1, Literature screening and selection process for the reviewed studies.

2.2. DATA ANALYSIS

A qualitative content analysis approach was adopted to systematically identify and analyse the barriers and enablers associated with the reuse of RC elements. All selected studies were carefully reviewed to extract statements, findings, and discussions related to factors that hinder or facilitate the implementation of concrete element reuse. The identified barriers and enablers were initially coded using an open coding approach, where each factor was recorded as an individual code. Subsequently, the barriers were grouped into six categories using an iterative thematic analysis, where similar codes were clustered based on conceptual similarity and context. The relationships between barriers and enablers were established by identifying instances in the literature where specific enablers directly addressed or mitigated corresponding barriers, supported by cross-study validation.

3. Results and Discussion

3.1. TEMPORAL DISTRIBUTION

Figure 2 presents the temporal distribution of publications related to the reuse of concrete elements. The results indicate that research interest in this area remained relatively limited during the early years, with very few studies published before 2018. From 2019 onwards, a gradual increase in the number of publications can be observed, reflecting a growing academic interest in concrete reuse within the broader context of circular construction and decarbonization of the built environment. A notable rise in research publications can be seen after 2022, with the number of publications reaching its peak in 2024. This upward trend suggests that the topic has recently gained significant attention among scholars, driven by increasing global emphasis on resource efficiency, construction waste reduction, and embodied carbon mitigation in the construction sector.

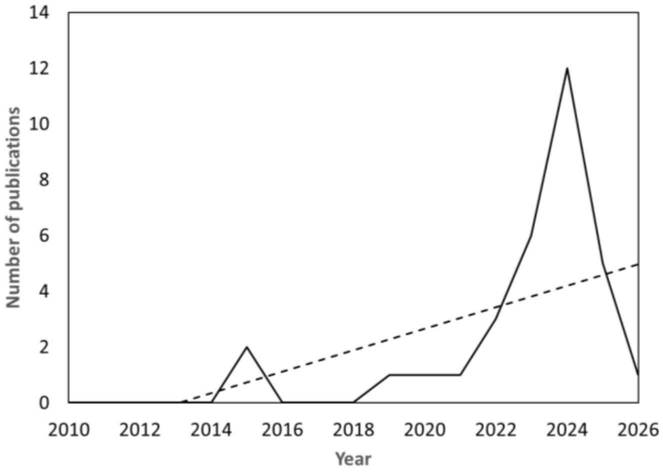

Figure 2, Temporal distribution of publications from 2010 to 2026.

3.2. GEOGRAPHICAL DISTRIBUTION

Figure 3 presents the geographical distribution of publications related to the direct reuse of concrete elements. European contributions frequently address topics such as design for reuse, robotic deconstruction, dry-joint systems, and the life-cycle assessment of reused concrete, indicating a strong integration between research and practical implementation within the region. The results indicate that most publications originate from European countries, particularly Switzerland, Germany, Sweden, Denmark, and Finland. Switzerland and Sweden account for a substantial share of the publications, reflecting the presence of several pioneering research initiatives and demonstration projects focusing on the structural reuse of concrete components.

In contrast, contributions from regions outside Europe remain relatively limited. A smaller number of studies originate from China and Canada, primarily focusing on environmental assessment, structural reliability, and the feasibility of reuse strategies. Other regions, including Sri Lanka, contribute only a limited number of studies, often examining reuse potential from a regional or contextual perspective. This uneven distribution suggests that the advancement of knowledge on direct concrete reuse is currently driven largely by European research programs and circular construction initiatives, while research contributions from other parts of the world are still emerging. Overall, the geographical pattern indicates that the development of research on direct concrete reuse is closely associated with regions where circular economy policies, material reuse strategies, and low-carbon construction initiatives have received stronger institutional and research support.

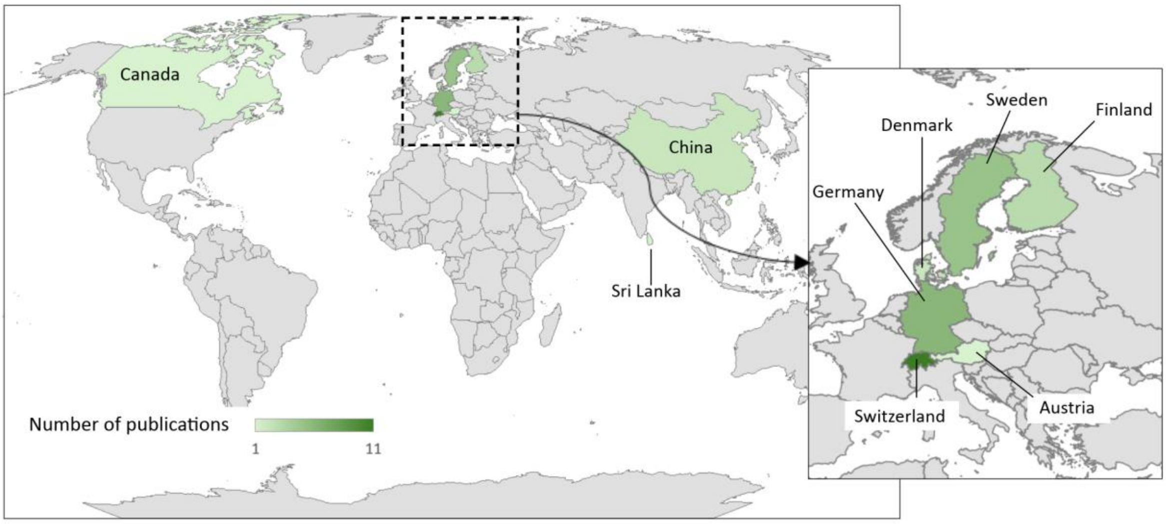

Figure 3, Geographical distribution of publications.

3.3. BARRIERS

This section provides a detailed examination of identified barriers to direct reuse of RC elements. A total of 27 barriers were identified and classified into six main categories, as presented in Table 1. These include design and structural barriers, which arise from the physical characteristics and engineering requirements that limit the safe integration of RC into new structures; process and execution barriers, associated with the practical challenges of dismantling, testing, transporting, and reinstalling concrete components; regulatory barriers, related to legal frameworks, building codes, and compliance requirements governing the acceptance of RC elements; economic and market barriers, which reflect cost constraints and limited market conditions affecting the financial viability of reuse; environmental barriers, linked to the potential environmental impacts associated with recovery and reuse processes; and industry practice and cultural barriers, which stem from established industry practices, sector norms, and stakeholder perceptions that limit the wider adoption of reuse strategies.

Table 1, Barriers to direct reuse of reclaimed concrete elements

Barrier Category	Barrier	Code
Design and structural	Design compatibility challenges with the receiving structure	B1.1
	Reduced structural capacity of RC elements	B1.2
	Difficulties in recovery from monolithic construction	B1.3
	Challenges in designing connections for RC elements	B1.4
	Uncertainty in structural quality and durability	B1.5
	Potential contamination within RC elements	B1.6
	Aesthetic concerns	B1.7
	Missing or incomplete original design documentation	B1.8
	Labour and time-intensive element recovery	B2.1

Process and Execution	Scheduling mismatch between donor and receiver projects	B2.2
	Need for specialised recovery tools and equipment	B2.3
	Risk of damage during handling, transport, and storage	B2.4
	Lack of technical expertise	B2.5
Regulatory	Lack of market-proven liability schemes	B3.1
	Compliance requirements with current design standards	B3.2
	Lack of standardised testing protocols for RC elements	B3.3
Economic and market	High upfront recovery and preparation costs	B4.1
	Underdeveloped market for RC elements	B4.2
	Cost of testing and certification procedures	B4.3
	Economic uncertainty	B4.4
Environmental	Long transport distances between donor and receiving sites	B5.1
	Environmental impacts from additional processing	B5.2
Industry practice and cultural	Low stakeholder confidence in RC elements	B6.1
	Prevailing demolition-oriented industry practices	B6.2
	Preference for recycling over direct reuse	B6.3
	Liability and risk concerns among project stakeholders	B6.4
	Limited awareness and expertise	B6.5
(Al-Faesly & Noel, 2021; Baghdadi et al., 2024; Bertino et al., 2021; Dervishaj et al., 2024; Devenes et al., 2024; Fivet, 2019; Halding & Negendahl, 2023; Heyn et al., 2008; Huuhka et al., 2015; Kupfer et al., 2022; Kupfer & Fivet, 2024; Naber, 2012; Rasanen et al., 2025; Riuttala et al., 2024; Siriwardhana & Tharmarajah, 2023; Suchorzewski et al., 2023; Widmer et al., 2023; Xia et al., 2020; Xiong et al., 2024)		

3.3.1 Design and structural

A major challenge is the integration of RC elements into new structural systems. These components, originally designed for specific load paths, often do not meet the requirements of the receiving structure (Fivet, 2019). For example, cast-in-place reinforced concrete frames create monolithic beam-column joints that cannot be separated without cutting the structure into irregular pieces, making reuse difficult (Bertino et al., 2021). Even when components are recovered, uncertainty about reinforcement layout, material properties, and durability complicates structural verification, especially when original design documents or records are missing (Huuhka et al., 2015; Siriwardhana & Tharmarajah, 2023). Furthermore, developing reliable connection systems for reused elements remains technically complex because reinforcement discontinuities and anchorage limitations can compromise performance (Halding & Negendahl, 2023). Differences in appearance and surface condition may also raise aesthetic concerns in new architectural designs (Al-Faesly & Noel, 2021).

3.3.2 Process and execution

The recovery of concrete elements requires selective dismantling instead of conventional demolition, which significantly increases labour requirements and project duration. For example, careful lifting, cutting, and sequencing of dismantling operations are necessary to prevent cracking or stress concentration in the elements during removal (Sturwald, 2024). Therefore, some recovery processes require specialized technologies, including sawing or precision cutting equipment, which are not commonly available in standard construction practices (Al-Faesly & Noel, 2021). Moreover, the recovery and preparation of RC elements demand specialized technical expertise to assess structural integrity and determine their suitability for reuse in new construction (Huuhka et al., 2015; Siriwardhana & Tharmarajah, 2023). Practical challenges also arise from coordination between donor and receiving projects, as RC elements must often be stored until a new project is ready to use them (Halding & Negendahl, 2023). In addition, the number of RC components rarely matches the exact material requirements of new construction projects, creating constraints in the availability and quantity of reusable elements (Al-Faesly & Noel, 2021).

3.3.3 Regulatory

Regulatory frameworks in most countries are primarily designed for newly manufactured construction materials, creating difficulties when reused structural elements are introduced into new projects (Riuttala et al., 2024). Structural engineers must demonstrate that reclaimed elements satisfy current design standards for strength, durability, and fire performance, even though such elements were produced under older design codes (Huuhka et al., 2015). The absence of standardized testing procedures and certification pathways makes it difficult to verify structural performance in a consistent manner. Liability issues further complicate adoption, as project stakeholders may be reluctant to assume responsibility for structural components with unknown service histories (Suchorzewski et al., 2023).

3.3.4 Economic and market

Recovering elements through careful dismantling, cutting, and transport often requires higher upfront costs than conventional demolition, where structures are simply crushed for recycling (Widmer et al., 2023). Additional costs may arise from structural testing, cleaning, reconditioning, and adapting components to new design requirements (Xia et al., 2020). Moreover, the market for reclaimed concrete components remains poorly developed, making it difficult to match available elements from demolished buildings with demand in new projects. This lack of market infrastructure introduces financial uncertainty for developers and contractors considering reuse strategies (Halding & Negendahl, 2023; Siriwardhana & Tharmarajah, 2023).

3.3.5 Environmental

Although reuse is generally associated with significant reductions in embodied carbon, environmental benefits can be reduced under certain conditions. In particular, long transport distances between demolition sites and new construction locations can offset emission savings due to increased transportation-related greenhouse gas emissions (Kupfer et al., 2022). Similarly, additional processing operations such as cutting, drilling, and surface preparation may increase energy consumption, reducing the overall environmental advantage of reuse (Xia et al., 2020).

3.3.6 Industry practice and cultural

Industry practices and stakeholder perceptions also influence the adoption of reuse strategies. In many construction projects, demolition followed by crushing for recycling remains the dominant practice, as it is faster and cheaper than selective dismantling (Devenes et al., 2024). As a result, recycling is often preferred even though reuse preserves more material value. Concerns regarding liability and responsibility for structural safety further discourage engineers, contractors, and building owners from adopting reuse approaches, as approving projects that incorporate reused concrete components requires stakeholders to assume significant professional responsibility (Al-Faesly & Noel, 2021). This concern is particularly pronounced among building owners, who often perceive liability risks as a major obstacle to approving reuse practices. In addition, limited investment in sustainability initiatives further constrains the adoption of reuse strategies (Siriwardhana & Tharmarajah, 2023). Overall, the literature highlights multiple constraints affecting the implementation of direct concrete reuse in practice. Corresponding enablers that support overcoming these barriers are discussed in Section 3.4.

3.4. ENABLERS

A total of 20 enablers were identified from the literature, each contributing to addressing specific barriers associated with the implementation of direct reuse of RC elements, as presented in Table 2.

Table 2, Enablers supporting the direct reuse of RC elements

No	Enabler	Code
1	Modular structural design	E.1
2	Standardized structural element dimensions	E.2
3	Inherent durability and long service life of concrete	E.3
4	Testing and condition assessment methods	E.4
5	Structural overcapacity in originally designed elements	E.5
6	Post-tensioning and strengthening techniques	E.6
7	Material passports	E.7
8	Robotic cutting and precision recovery technologies	E.8
9	Dry-joint construction systems	E.9
10	Visible and accessible structural joints	E.10
11	Controlled storage facilities for recovered elements	E.11
12	Government incentives promoting material reuse (policies, financial support, or regulatory measures)	E.12
13	Reuse-specific structural codes and standards	E.13
14	Increasing cost or scarcity of virgin materials	E.14
15	High landfill levies encouraging material recovery	E.15
16	Reuse-oriented business models and secondary markets	E.16

17	Proven international reuse projects	E.17
18	Stakeholder willingness to adopt reuse practices	E.18
19	Growing sustainability awareness in construction	E.19
20	Carbon reduction policies	E.20
(Ajdukiewicz et al., 2013; Al-Faesly & Noel, 2021; Baghdadi et al., 2024; Bertino et al., 2021; Devenes et al., 2022; Fivet, 2019; Halding & Negendahl, 2023; Huuhka et al., 2015; Kupfer et al., 2024; Riuttala et al., 2024; Siriwardhana & Tharmarajah, 2023; Suchorzewski et al., 2023; Xia et al., 2020)		

The feasibility of recovering and reusing RC elements is strongly influenced by the design characteristics of the original structure. Modular structural systems and standardized element dimensions facilitate easier dismantling and integration into new structural configurations (Fivet, 2019; Huuhka et al., 2015). Concrete structures are typically designed for long service lives, yet many buildings are demolished before reaching the end of their technical lifespan (European Cement Association, 2021). As a result, structural elements often retain significant residual performance at the time of demolition, which enables their safe reuse in new construction applications. Reinforced concrete components are typically designed with conservative safety factors and structural overcapacity, which results in residual load-bearing capacity even after long service periods (Suchorzewski et al., 2023). Experimental investigations by Ajdukiewicz et al. (2013) further support this observation, demonstrating that precast reinforced concrete roof slabs retained sufficient structural capacity even after 40 years of service. Devenes et al. (2022) demonstrated that post-tensioning can enhance the load-bearing capacity of reclaimed RC elements, enabling them to meet the structural requirements of new applications. In their study, reclaimed RC blocks were assembled into a load-bearing arch footbridge by inserting steel tendons through drilled ducts and tensioning them to generate compressive forces.

The availability of original design drawings and documented service history is essential for the successful reuse of structural elements, as uncertainty regarding past performance can reduce stakeholder confidence. Material passports have been proposed as a solution to store and access such information. Senarathne et al. (2025) stated that, in addition to storing information, a material passport can perform multiple functions, including environmental assessment, circularity assessment, and quality assessment. When documentation is unavailable, structural assessment methods are used to evaluate the condition of reclaimed elements. Non-destructive testing techniques such as rebound hammer, ultrasonic pulse velocity (UPV), and ground-penetrating radar (GPR), together with laboratory tests including compressive strength and carbonation depth, are commonly applied to verify structural integrity, durability, and reduce uncertainties regarding the current condition of the elements. Recent studies indicate that technological advancements are improving the feasibility of recovering structural elements for reuse. For example, Heuer et al. (2025) developed a semi-automated robotic deconstruction system that enables precise cutting and controlled extraction of reinforced concrete components, significantly reducing labour time compared with manual methods. Similarly, Baghdadi et al. (2024) demonstrated that robotic fabrication technologies can facilitate the connection and reconfiguration of reused concrete elements in new structural systems. In addition, design approaches such as dry-joint construction systems and the provision of controlled storage facilities support the safe dismantling, storage, and integration of reclaimed elements into new construction projects (Eschenbach et al., Towards radical regeneration/2022; Halding & Negendahl, 2023).

Establishing reuse-oriented design standards and assessment guidelines provides clearer procedures for verifying structural performance and approving reclaimed elements (Siriwardhana & Tharmarajah, 2023). Policy measures such as landfill levies, carbon reduction targets, and government incentives can further encourage material recovery by shifting economic priorities towards reuse rather than conventional demolition and disposal practices (Al-Faesly & Noel, 2021). Moreover, documented reuse projects provide practical evidence that reclaimed reinforced concrete elements can satisfy structural and functional requirements in new applications. These cases further highlight its environmental advantages, particularly the reduction of embodied carbon compared with conventional construction methods (Kupfer et al., 2022). Increasing costs and supply constraints of virgin materials further strengthen the economic attractiveness of reuse strategies in certain construction contexts (Widmer et al., 2023). The development of reuse-oriented business models and secondary markets for reclaimed components facilitates the exchange of reusable elements (Siriwardhana & Tharmarajah, 2023). Recently, several digital platforms and material banks have emerged to enable the trading and redistribution of reclaimed construction materials. Siriwardhana and Tharmarajah (2023) reported through stakeholder surveys that growing sustainability awareness and willingness to adopt reuse practices support the future implementation of concrete reuse strategies.

3.5. TEMPORAL ANALYSIS OF BARRIERS AND ENABLERS

A temporal analysis of the reviewed studies reveals that several barriers identified around 2010-2015, such as lack of technical expertise, absence of standardized testing methods, and regulatory uncertainty, remain relevant in recent studies, indicating limited progress in overcoming these fundamental challenges. Nonetheless, recent literature emphasizes a shift towards emerging technological and systemic enablers. Specifically, advancements in digital tools (e.g., material passports), robotic deconstruction technologies, and the development of reuse-oriented policies and business models have gained increasing attention since 2020. This signifies a gradual transition from predominantly identifying barriers in earlier studies to proposing practical solutions and enabling mechanisms in more recent research.

3.6. RELATIONSHIP MAPPING OF BARRIERS AND ENABLERS

Based on the barriers and enablers identified in the literature, a relationship mapping was developed to analyse how enabling mechanisms can mitigate the identified barriers to concrete reuse. The resulting relationships between barriers and enablers are presented in Table 3. The mapping analysis shows that several enablers address multiple barriers simultaneously.

Table 3, Relationship mapping between barriers and enablers

Barriers	Code	Enablers																			
		E.1	E.2	E.3	E.4	E.5	E.6	E.7	E.8	E.9	E.10	E.11	E.12	E.13	E.14	E.15	E.16	E.17	E.18	E.19	E.20
	B1.1	✓	✓																		

Design and structural	B1.2					✓	✓														
	B1.3	✓							✓		✓										
	B1.4									✓											
	B1.5			✓	✓	✓		✓						✓							
	B1.6				✓			✓						✓							
	B1.7								✓												
	B1.8							✓													
Process and Execution	B2.1	✓							✓	✓	✓										
	B2.2											✓					✓				
	B2.3								✓												
	B2.4					✓	✓			✓	✓	✓									
	B2.5												✓	✓				✓			
Regulatory	B3.1													✓			✓				
	B3.2		✓											✓							
	B3.3				✓									✓							
Economic and market	B4.1												✓		✓	✓	✓		✓		
	B4.2												✓	✓			✓		✓	✓	
	B4.3				✓			✓													
	B4.4															✓		✓	✓		
Environmental	B5.1												✓				✓	✓		✓	✓
	B5.2												✓								✓
Industry practice and cultural	B6.1			✓	✓			✓						✓			✓	✓			
	B6.2												✓	✓	✓	✓	✓			✓	✓
	B6.3												✓	✓	✓			✓		✓	✓
	B6.4				✓			✓					✓	✓			✓		✓		
	B6.5												✓	✓			✓	✓		✓	✓

Technical barriers associated with structural design, element recovery, and condition verification are closely linked with factors that improve information availability, technological capability, and design adaptability. This indicates that improving technical knowledge, documentation, and assessment capacity can significantly reduce uncertainties that currently limit reuse decisions. The mapping also highlights that several barriers are not purely technical but are influenced by broader institutional and market conditions. Regulatory frameworks, economic drivers, and industry practices interact to shape the feasibility of reuse within construction projects. Overall, the mapping highlights the need for coordinated improvements across technical, regulatory, and market conditions to facilitate the wider implementation of concrete reuse.

4. Conclusions

This study examined the barriers and enablers influencing the direct reuse of RC elements through a systematic literature review. A total of 27 barriers were identified and classified into six main categories, together with 20 enabling conditions. A barrier-enabler relationship map was also developed, revealing that coordinated improvements across technical, regulatory, and market conditions are required to support the wider implementation of direct concrete reuse. The study provides insights for the construction industry by systematically organizing the key factors affecting the adoption of direct concrete reuse and illustrating how enabling conditions can help address existing constraints. The barrier–enabler mapping can support practitioners in identifying critical challenges during project planning, demolition, and material recovery stages. In addition, the findings offer useful guidance for policymakers in developing regulatory frameworks, market mechanisms, and technical guidelines that facilitate the recovery and reuse of RC elements in construction projects. This study is limited to evidence reported in the literature and does not include validation through expert consultation. Future research should incorporate expert input to further examine the relationships among the identified issues and support the advancement of direct reuse of RC elements.

ACKNOWLEDGEMENTS

The authors have reviewed and edited the output and take full responsibility for the content of this publication. The authors acknowledge the support from the "ARC Industrial Transformation Research Hub for Transformation of Reclaimed Waste Resources to Engineered Materials and Solutions for a Circular Economy" and the "ARC Industrial Transformation Training Centre for Whole Life Design of Carbon Neutral Infrastructure".

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