

Barriers for Implementing Circular Economy in the Construction Industry of Bangladesh: Engineer Perspective

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Abstract: The construction industry is essential in the economic development of Bangladesh. Yet, it poses significant environmental and social challenges, necessitating a transition towards circular economy (CE) in achieving sustainability as a holistic approach. However, the effective implementation of CE principles faces significant challenges, particularly in the context of Bangladesh, associated with high population density and rapid urbanisation despite limited resources. Despite all the problems stated, this research investigates the barriers hindering the adoption of CE practices within the Bangladeshi construction industry (BCI). Utilising a semi-structured interview approach, perspectives were gathered from 20 engineers deeply involved in various sectors of the BCI. The thematic analysis of the interview transcripts yielded five themes of challenges, namely, economic and financial constraints, policy and regulatory challenges, skill and capacity deficiencies, sociocultural barriers and technical barriers. Theoretically, this research contributes to a comprehensive understanding of the complexities surrounding the implementation of CE strategies in emerging economies like Bangladesh. Practically, the findings would aid policymakers, researchers and industry stakeholders in developing, prioritising and implementing policies and strategies to facilitate the transition toward a circular construction industry. It also underscores some significant issues to consider in the pathway in achieving several Sustainable Development Goals (SDGs), especially SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Production and Consumption).

Keywords: Circular economy, Barriers, Construction industry, Bangladesh, Sustainable development

INTRODUCTION

The construction industry is one of the largest industrial sectors, exerting a profound influence on people's lives globally and especially in a developing country like Bangladesh (Ofori, 2007). The rapid expansion of the construction industry, however, has led to significant environmental concerns, including resource depletion, substantial waste generation and increased greenhouse gas emissions. In fact, construction-related activities have always been

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recognised to harm the environment and compromise its suitability for future generations (Osei-Tutu et al., 2023). This sector alone is responsible for about one-third of the natural resource extraction and one-fourth of the solid waste generation worldwide, mainly due to the conventional practices of the linear economic model of “take, make, dispose” (Benachio, Freitas and Tavares, 2020). These issues underscore the urgent need for sustainable practices within the sector.

Conversely, the CE concept proposes an alternative and better approach as it advocates shifting from the linear model to a circular one, where materials and energy are perpetuated in use to elicit new business values and minimise waste generation, ensuring expected development with a reduced resource consumption (Gasparri et al., 2023). As the world population continues to grow and is projected to reach 8.5 billion in 2030 and 9.7 billion by 2050 (United Nations, 2015), combined with a rising urban middle class, it is going to lead to increased resource consumption and heightened pressure on urban infrastructure and government support (Munaro and Tavares, 2023). Implementing CE is therefore an inevitable focus for the construction industry to ensure a viable future. It also supports the United Nations’ Sustainable Development Goals (SDGs), especially, SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth) and SDG 12 (Responsible Consumption and Production) (Schroeder, Anggraeni and Weber, 2019).

Despite the well-documented benefits of CE strategies, their implementation in the construction industry is not easy (Osei-Tutu et al., 2023). Despite the global trend being significantly progressive in terms of CE implementation, it is still relatively underexplored in the context of developing countries (Razak et al., 2025). A similar scenario is observed in the case of Bangladesh as well (Islam et al., 2024). As the eighth most populous country in the world (Mohajan, 2021), it is imperative for Bangladesh to move towards circularity to ensure its role in the global sustainability effort. Additionally, as a diversely interconnected industry, the construction industry requires synchronised improvements across multiple sectors to effectively implement CE, which necessitates a comprehensive study that brings technical, social, economic and other relevant areas under consideration (Ababio and Lu, 2023; Mohd Ali et al., 2024).

The construction industry consists of several stakeholders and the contributions of all parties are significant. However, as CE is still a new concept in the Bangladeshi construction industry (BCI) (Hossain and Khatun, 2021) and the knowledge gap is a significant challenge (Yu et al., 2022), this study opted for the most educated and up-to-date stakeholder, the construction engineers, to fruitfully identify the barriers. The perspectives of the engineers are further valuable as they play a central role in decision-making processes to improve policies in construction operations (Manoharan et al., 2023). They

are responsible for designing, constructing and maintaining infrastructure and play crucial roles in engaging with other stakeholders and advocating for sustainable practices, in addition to providing innovative solutions to problems, contributing significantly to achieving sustainable development (Khan and McNally, 2023).

Therefore, with a focus on determining the barriers interlinking various sectors to CE implementation in the BCI, this study engages professional engineers, who are well-versed in the local context. The main question is: “What are the barriers to implementing circular economy in the construction industry of Bangladesh?”

Objective of the Study

The primary objective of this study is to identify and analyse the barriers to implementing CE principles in the BCI from the perspective of practicing engineers. The research employs qualitative methods, specifically semi-structured interviews and thematic analysis, to gather in-depth insights into the challenges perceived by professionals in the field. The findings of this study are expected to contribute to the development of strategies and interventions that can facilitate CE implementation in the BCI.

LITERATURE REVIEW

The overview of the literature on CE in the construction industry, barriers to CE implementation in the construction industry and the progress of CE in Bangladesh are briefly discussed as follows.

Circular Economy in the Construction Industry

The term “circular economy” was first introduced by Pearce and Turner (1990), when they proposed a model of sustainable economic development that emphasised the interrelation of the economy and the environment, contrasting with the traditional economic model that relied solely on cost-benefit principles. The central idea of CE involves developing systems that transcend the linear “take-make-dispose” approach, focusing instead on closing the loop of materials and energy to preserve resource value within the economy (Pearce and Turner, 1990). It took a substantial time for the concept to grow further and after 2015, when the Ellen MacArthur Foundation advocated for CE, the term gained significant attention (Mhatre et al., 2023). According to the Ellen MacArthur Foundation (2015: 2), CE is “restorative by design and aims to keep products, components and materials at their highest utility and value at all times”. The primary objective of implementing a CE

strategy in any sector is to minimise the use of virgin materials and reduce waste production, all while safeguarding the environment and preventing pollution (Haas et al., 2015).

Construction materials, in a linear economy, are conventionally designed and assembled for one-time use (Ghisellini, Ripa and Ulgiati, 2018). Once these buildings reach the end of their life, their materials are discarded as waste, with no consideration for reintegrating them into the loop, as the linear economy views products as having a limited lifespan (Nasir et al., 2017). This approach of extracting, using and disposing of materials undermines the core principles of sustainable development (Mhatre et al., 2023). On the other hand, CE presents an opportunity to reduce the use of primary materials and their associated environmental impacts by implementing strategies such as reduction, reuse and recycling (3Rs) of materials throughout the production, distribution and consumption processes (Kirchherr, Reike and Hekkert, 2017). These 3Rs principle has often been further developed and recognised as 10Rs in CE: refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recover and recycle (Peiró et al., 2020). Pomponi and Moncaster (2017) suggested that applying such Rs to the construction industry, while incorporating inputs from governmental, economic, environmental, behavioural, societal and technological dimensions, can significantly help achieve CE. They portrayed the circular construction industry as a “building that is designed, planned, built, operated, maintained and deconstructed in a manner consistent with CE principles” (Pomponi and Moncaster, 2017: 711).

Studies on CE initiatives in the construction industry have been exploring various directions, including design for deconstruction (DfD), construction and demolition waste (CDW) management, secondary materials markets, building information modelling, etc. (Munaro and Tavares, 2023). In a systematic literature review, Benachio, Freitas and Tavares (2020) identified five life cycle stages that the extent studies focused on, i.e., project design, manufacture, construction, operation and end of life. Some CE strategies presented in this study were modular building (Kyro, Jylha and Peltokorpi, 2019), design for adaptability (Mangialardo and Micelli, 2018), life cycle analysis (Hossain and Ng, 2018), material stock (Heinrich and Lang, 2019), material passport (Nußholz, Rasmussen and Milios, 2019), reuse of building materials in new construction (Mangialardo and Micelli, 2018), off-site construction (Adams et al., 2017), water management practices (Pimentel-Rodrigues and Siva-Afonso, 2019) and demolition waste management (Ghisellini, Ripa and Ulgiati, 2018). The diversified focus of the studies indicates the need for a comprehensive drive from the respective authorities and the stakeholders to achieve CE in the construction industry.

Barriers to Circular Economy Implementation in Construction

In terms of adopting CE principles, the construction industry still lags behind other sectors (Guerra et al., 2021). The complex nature of the construction industry poses significant challenges to CE uptake (Charef, Morel and Rakhshan, 2021).

A number of studies have identified and categorised the barriers impeding CE implementation in the construction industry. The identified barriers were found to be expanded on several dimensions of the industry, such as economic, sociological, political, organisational, technological and environmental barriers (Charef, Morel and Rakhshan, 2021). When studying the socio-technical challenges, Gembali, Kumar and Sarma (2024) categorised the identified barriers into five types: people, cultural, infrastructural, technological, and construction process and procedural. Another identification and categorisation of the barriers consisted of social and cultural, political and legislative, financial and economic, technological, framework and theory-related barriers (Ababio and Lu, 2023). In a review, Osei-Tutu et al. (2023) grouped the barriers into six broad categories: economic/financial, technical, social, cultural, technological and environmental barriers. A more detailed review conducted by Wuni (2022) yielded 11 categories: cultural, market, knowledge, financial, management, regulatory, technological, supply chain, stakeholder, technical and organisational barriers. Some categories were recurrently observed in almost all studies which were social/cultural, financial/economic and technological barriers.

Despite several barriers being identified and proposed in the extant studies to enhance the circularity of the construction industry, there is a lack of research conducted in the context of developing countries, as most studies on this topic are from developed countries that already have had more success in CE adoption. This makes it difficult to associate these findings with the settings of a developing economy (Koc et al., 2024).

Circular Economy in Bangladesh

While CE has been studied in Bangladesh in some research, they are mostly conducted on industries other than the BCI, such as the leather industry (Moktadir et al., 2020), textile and clothing Industry (Saha, Dey and Papagiannaki, 2021; Akter et al., 2022), generation of renewable energy from livestock waste (Islam et al., 2021), healthcare waste (Dihan et al., 2023) and food waste recycling (Sarker et al., 2022). A few studies were also carried out on the overall adoption of CE in Bangladesh, i.e., irrespective of any particular industry (Azizuddin, Shamsuzzoha and Piya, 2021; Ahmed, Mahmud and Acet, 2022). It was deduced that compared to the garments, tannery, paper, plastic,

energy, e-waste sector, ship-breaking and biomedical sectors, the construction industry had “no mentionable practices”, although good prospects were found in recycled brick as it showed the potential to satisfy international standards like the American Society for Testing and Materials, Standard Specification for Concrete Aggregates – ASTM C33 (Ahmed, Mahmud and Acet, 2022: 7). Proper coordination between the government and the private initiatives was found helpful in CE adoption, whereas inefficient technological support had been the major impediment (Azizuddin, Shamsuzzoha and Piya, 2021). Some barriers to implementing the CE model in Bangladesh were also grouped into technology, policy and public participation categories (Ahmed, Mahmud and Acet, 2022).

A study that investigated the BCI of Bangladesh regarding CE implementation only provided a “helicopter view” (Hossain and Khatun, 2021: 810) and more comprehensive and in-depth investigations are required. Therefore, to confront these substantial research gaps, the present research explored the barriers to the effective implementation of CE principles in the BCI, which can be valuable for other developing countries as well.

METHODOLOGY

Semi-structured interviews were conducted with 20 selected engineers for this study and the obtained data were analysed by thematic analysis as shown in Figure 1.

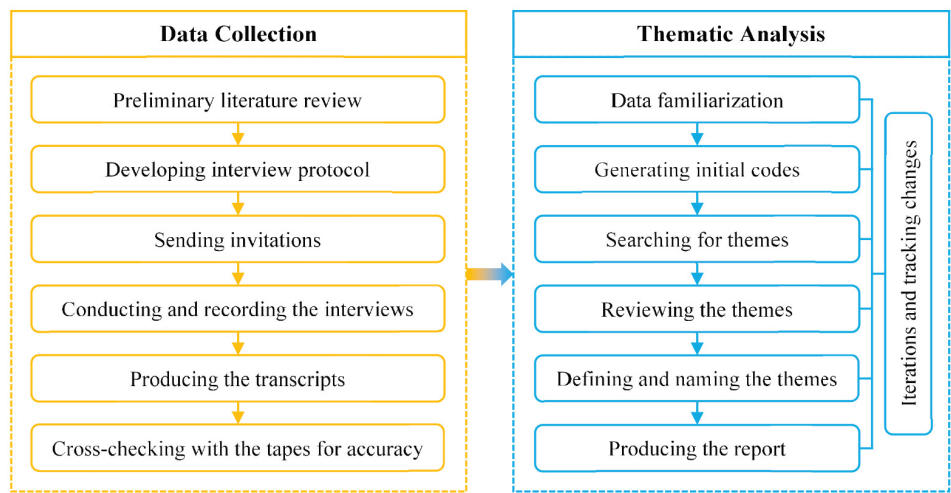


Figure 1. Overview of the research methodology

Data Collection

To conduct the interviews, relevant extant literature was first reviewed to grasp the latest developments in the field. Then a standard interview protocol was developed along with the basic background information on the topic (Harikrishnan et al., 2021). The protocol, along with a formal invitation, was sent to the prospective participants via different networking platforms. Participants who consented to take part were then coordinated to determine the schedule of the interviews through mutual discussion.

A purposive sampling method was employed to ensure the relevance of the responses in this relatively unexplored context (Radzi et al., 2024). Additionally, focus was given to gathering participants from as many diverse working locations as possible to represent the entire country, as despite being a small country, Bangladesh has a diverse geography that sometimes influences construction practices (Morshed et al., 2016; Khan et al., 2024).

Participants were civil engineers working in various sectors of the BCI as shown in Table 1. They included industry leaders, government employees and individuals working in different non-government companies. They also had varied experience, ranging from 3 years to 35 years and age, ranging from 27 years old to 59 years old, facilitating the knowledge and experience of different generations. Participants were from 6 out of the 8 administrative divisions of Bangladesh, with the majority from Dhaka and Chattogram, the divisions with the country's largest cities. The wide variety of participants provided a comprehensive understanding of the BCI regarding circularity.

Most of the interviews were conducted online via audio or video conferencing to overcome the constraints of distance and scheduling, given the diverse locations and work commitments of the engineers. Each interview began with an introductory description of the topic and the motivations behind the study. Then the primary question was presented to the participants. The approach was open-ended, allowing participants ample time to fully express their opinions. Follow-up questions were asked based on the responses to understand the information in detail. Participants were always encouraged to elaborate and in cases where sufficient information was not coming, the questions were rephrased and clarified to aid comprehensive description. Any earlier incomplete responses were revisited in suitable phases during the interviews to facilitate the opportunity to respond in full. At the end of each interview, participants were asked if they had any additional comments and their demographic information was collected.

Table 1. Participants' profile and duration of the interview

Engineers' ID	Age (Years Old)	Education	Years of Experience	Location	Designation	Duration (Minutes)
E1	52	MBA	27.0	Dhaka	Director of operations	49
E2	59	BSc	35.0	Dhaka	Managing director	78
E3	35	BSc	10.0	Sylhet	Project manager	38
E4	30	BSc	6.0	Sylhet	Project coordinator	26
E5	43	MBA	19.0	Dhaka	Head of construction (general manager)	27
E6	44	BSc	19.0	Dhaka	Founder and CEO	31
E7	33	BSc	9.0	Chattogram	Assistant general manager	19
E8	34	BSc	8.0	Chattogram	Upazila engineer, Local Government Engineering Department (LGED)*	20
E9	29	MSc	5.0	Dhaka	Upazila engineer, LGED*	12
E10	42	MSc	18.0	Sylhet	Superintending engineer*	13
E11	37	MSc	13.0	Rangpur	Senior officer (civil engineer)*	33
E12	36	BSc	13.0	Chattogram	Project manager	21
E13	43	MSc	18.0	Dhaka	Executive engineer, Public Works Department*	21
E14	41	BSc	19.0	Chattogram	Project manager, operation*	18
E15	27	BSc	4.0	Dhaka	Structural engineer	28
E16	29	BSc	4.0	Chattogram	Deputy manager, civil section	25
E17	28	BSc	5.0	Khulna	Senior engineer, civil design*	20
E18	27	BSc	3.0	Rajshahi	Structural safety engineer	26
E19	29	BSc	4.5	Chattogram	Assistant engineer (civil)*	22
E20	34	BSc	10.0	Dhaka	Project manager	20

Note: *Government employee.

All the interview audios were recorded with the permission of each of the interviewees and the recordings were transformed carefully into written transcripts. The transcripts were then crosschecked with the audio recordings to ensure accuracy and prevent misrepresentations. This simultaneous transcription process also facilitated the initial stage of data analysis, data familiarisation. The goal was to determine when data saturation was achieved, indicating that further data collection would not yield significant new insights (Radzi et al., 2024). Halfway through the interviews, it was perceived that the majority of the responses were repetition of the information provided by the previous participants. A later analysis regarding the number of subthemes obtained from individual participants, as depicted in Figure 2, also confirmed that after the 11th interview, no significant new contribution emerged. However, interviews continued in search of yet any new points and supporting data for the existing ones. Only participants E16 and E17 introduced a few new points thereafter. Consequently, the data were considered saturated and the interview process was concluded after 20 interviews. Moreover, the sample size was deemed sufficient as similar sample sizes have been frequently used in previous qualitative studies concerning the construction industry, such as 8 (Osman et al., 2020), 16 (Loosemore, Alkilani and Murphy, 2021), 17 (Harikrishnan et al., 2021) and 20 (Omer et al., 2022; Bunjaridh, Rahman and Yusof, 2023; Ebekozen et al., 2023; Farouk et al., 2023) interviews.

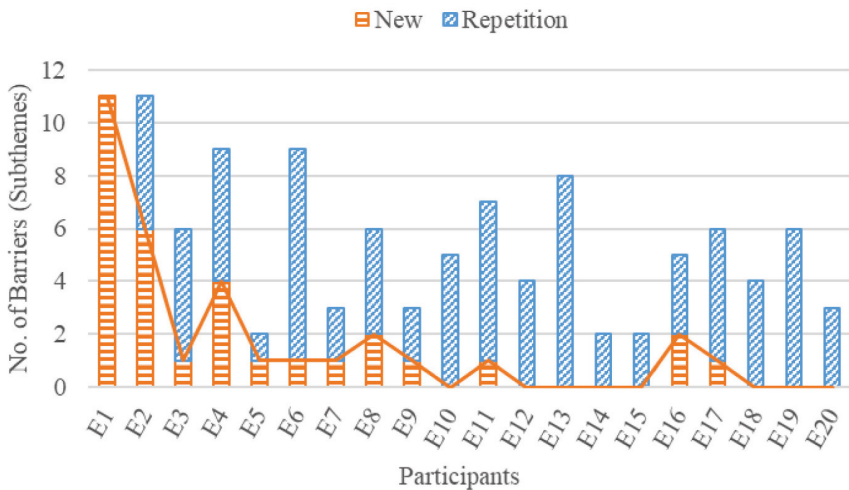


Figure 2. Pattern of subtheme repetition demonstrating data saturation

Data Analysis

This study employed thematic analysis, a qualitative approach using a standard six-phase process adapted from Braun and Clarke (2006). Having the transcripts of the interviews in hand, the initial step was reading and re-reading the content to get acquainted with and gain a deeper understanding of the data. Initial codes were then systematically generated, by identifying significant features across the dataset that represented the opinions of the participants on various barriers. Verbatim excerpts related to each code were collated for further review and analysis. This process produced 251 codes that were condensed into a manageable dataset by merging and grouping the duplicate, similar and related codes resulting in 32 subthemes. The subthemes, considered to be the barriers, were further analysed and categorised to generate the five themes. The steps from generating codes to generating themes are illustrated in Figure 3. The themes represented the key concepts and patterns within the data. A continual review rigorously assessed the themes for consistency and relevance both within the coded extracts and the entire dataset. Subsequently, the themes were refined and clear definitions and names were generated to articulate the core idea of each theme. The final step involved producing the report by analysing the selected extracts and relating them back to the research questions.

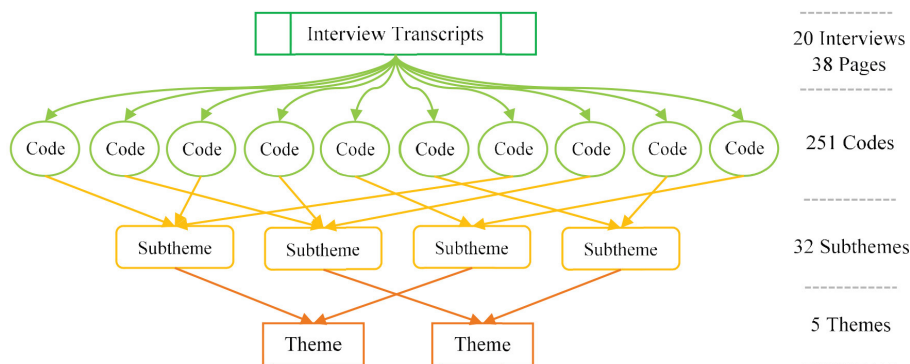


Figure 3. Generation of themes

Throughout the whole process, each change and step were kept track of and the versions were saved for further reference. Between the stages, there were several iterations to reach the best representation and categorisation of the participants' opinions. This concise and systematic approach ensured reliability and a comprehensive understanding of the engineers' perspective on CE dynamics within this specific industry context.

RESULTS AND DISCUSSION

By conducting interviews with 20 civil engineers and performing thematic analysis of the interview outcomes, this study identified the barriers to implementing CE in the BCI. The findings were further categorised into some central themes to facilitate a comprehensive discussion of the issues.

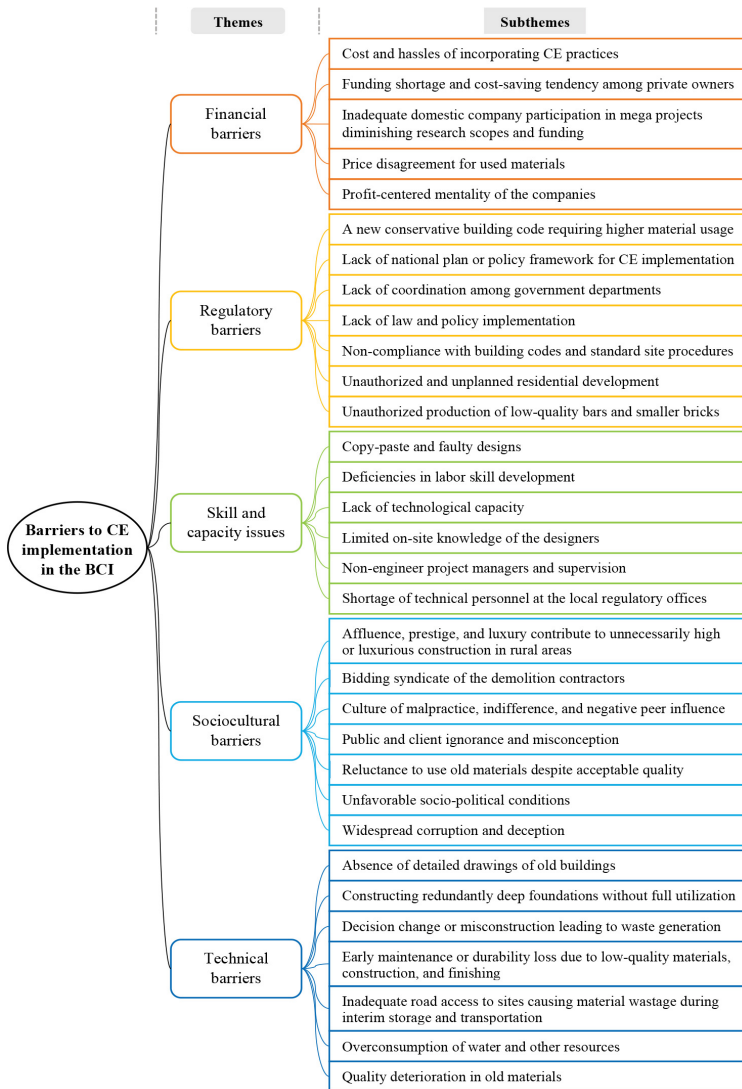


Figure 4. Barriers to CE implementation in the BCI

The adoption of CE principles in the BCI encounters multifaceted barriers as shown in Figure 4. After analysing the participants’ opinions, 32 barriers were identified and further categorised into five themes: financial barriers, regulatory barriers, skill and capacity issues, sociocultural barriers and technical barriers. Explanations of the responses regarding the barriers under each theme are provided in the following subsections.

Financial Barriers

Financial issues often pose obstacles to incorporating CE in construction practices. Five financial barriers were identified from the participants’ opinions as shown in Table 2.

Table 2. Financial barriers

No.	Financial Barrier	Participant	Best Verbatim Excerpt from the Participants
1.	Cost and hassles of incorporating CE practices	E4, E7, E10 and E19	Sometimes the cost of recycling becomes more expensive than using new materials. If some spare rebars remain unused, collecting them, cleaning them and finding suitable opportunities to use them will cost labour and other costs. (E4)
2.	Funding shortage and cost-saving tendency among private owners	E2, E4, E6, E10, E11, E12, E13 and E18	Due to the cost-saving tendency or shortage of funding, the owners do not employ an engineer for supervision. (E6)
3.	Inadequate domestic company participation in mega projects diminishing research scopes and funding	E16	But the problem is that the majority of megaprojects are done by foreign companies. The local companies cannot get involved in the megaprojects to that extent. They have a limited scope and within that, there is hardly any opportunity for research or innovation. In small projects, as they normally have scarce funding, research is also not possible. (E16)
4.	Price disagreement for used materials	E4	Suppose an old gate is available to be sold. The owners will expect a huge price and the buyers will see that it is half-ruined and want to pay very little. Due to disagreement, it will remain unused and will be wasted. (E4)
5.	Profit-centered mentality of the companies	E1, E4, E8 and E13	But the companies are doing work with a focus on profit by any means. Service is not their main target. (E1)

Utilising the construction and demolition waste and other old materials in a new building requires a certain amount of extra work. This costs space, time and labour and the cumulative hassles sometimes surpass the cost of using new materials instead. Similarly, adopting green technologies like water treatment plant (WTP) or sewage treatment plant (STP) increases the overall cost of a project and acts as a barrier in opting for such options, as opined by some participants.

Multiple participants expressed dissatisfaction with funding shortages and cheapness preference among building owners, particularly in the private sector, which significantly compromises the quality of work. The owners consider the fees associated with professional consultancy burdensome and opt for unprofessional options. They also prioritise low-cost materials over quality and durability, often avoiding required material tests due to testing fees. One participant particularly explained the situation, noting that individuals, especially in the middle-class range, save money gradually throughout their working lives, only being able to build a house upon retirement. This financial struggle pushes them to be frugal when it comes to adhering to proper methods of construction.

In Bangladesh, almost all mega projects are undertaken by foreign companies rather than domestic ones. Due to the huge funding available for such projects, domestic companies could enjoy some flexibility to focus on research and incorporate advanced concepts and technologies. However, they do not get the opportunity and remain confined to smaller projects, hampering the national capacity and progress. This trend contributes to domestic companies being stuck in conventionalism, limiting their growth and innovation potential.

Another financial barrier found impeding the recycling of old materials is price disagreement between owners and buyers. Owners often expect unreasonably high prices for the old materials, while, due to multiple intermediaries in the value chain, the peddlers or hawkers cannot offer much price because of their own margins. Thus, the owners lose interest in selling and materials get spoiled while remaining unsold.

Additionally, according to some participants, both the construction and the material companies are mainly after financial gain, which acts as a barrier for them to consider circularity and other improvement options.

Regulatory Barriers

The government and other regulatory bodies are confronted with several regulatory barriers. Seven barriers were clustered under this theme as shown in Table 3.

Table 3. Regulatory barriers

No.	Regulatory Barrier	Participant	Best Verbatim Excerpt from the Participants
1.	A new conservative building code requiring higher material usage	E17 and E18	Compared to *BNBC 2006, BNBC 2020 requires more materials. The new code is even more conservative than the Indian Standard (IS). The BNBC is requiring much more pile length, hence more rebars, cement and soil usage. I am just giving an example, as India is a neighbouring country. (E17)
2.	Lack of national plan or policy framework for CE implementation	E1 and E3	In our construction industry, there is no module or policy focusing on the CE. (E3)
3.	Lack of coordination among government departments	E2, E8 and E19	The coordination among different governmental departments is very poor. Another project of mine in the LGED department was to dig a canal. When we went to the location after planning and getting approval, we found that the canal had already been excavated by Water Development Board. (E19)
4.	Lack of law and policy implementation	E1, E3, E6, E12 and E17	But although there are laws, there is no implementation. It is the main barrier. (E1)
5.	Non-compliance with building codes and standard site procedures	E1, E2, E4, E6 and E19	In our country, at the private level, they cast the whole column at once sometimes, whereas it should be done in two steps. In some buildings, they do not use any vibrators; instead, they use bamboo or rods. Most of the time, they hand-mix the concrete and use excessive amounts of water while mixing. So, there is no slump. (E02)
6.	Unauthorised and unplanned residential development	E1, E10 and E11	Especially in unplanned residential areas, people are building without any consideration of the capacity of electricity, roads, sewerage lines, or emergency safety factors. This situation is enough to make the cities unliveable. (E1)
7.	Unauthorised production of low-quality bars and smaller bricks	E2 and E8	Due to the smaller size of the bricks, (each brick is 0.5 in smaller, the number of bricks increases and the cost grows. Then, during plastering, due to the uneven surface and smaller size, we need to plaster a lot. Also, people have some sort of workshop, where, by mixing wastes, they are making bars. (E2)

Note: *Bangladesh National Building Code

According to some participants, the latest version of the Bangladesh National Building Code (BNBC), BNBC 2020, is perceived to be more conservative compared to its predecessor, BNBC 2006, especially for seismic vulnerability considerations. The new code mandates longer pile lengths and increased reinforcement, leading to higher material consumption. The public is feeling resistance to complying with the new code due to associated cost increments.

The participants also highlighted the lack of holistic national planning and policy, particularly focusing on CE in the construction industry, as a significant barrier impeding the progress in transitioning towards CE practices.

Several participants reported a severe lack of coordination among different ministries and governmental departments regarding construction works. They noted frequent construction of one or two-story buildings for each separate department in the districts and subdistricts. Providing offices in a combined multi-story building, for all the departments in an area, could save land, materials and other costs. The lack of coordination is also evident in the repetitive excavation of the roads for various departmental works separately, such as electrical, Water Supply and Sewerage Authority (WASA) and roads and highways, causing wastage and other troubles. Additionally, occurrences of wrongly allocating a single spot for projects of multiple departments were reported. One participant even went ahead to mention the presence of a superiority complex among the departments that hinders them from coordinating with others.

Another major concern raised by the participants was the significant lack of laws and policy implementation in the country, despite the presence of various suitable laws. This diminishes the effectiveness of any policy adopted by the regulatory authorities.

Most participants discussed the sub-standard construction practices and violation of codes on-site as a significant barrier. They provided various examples, including lack of curing, casting the entire column at once instead of two steps, reliance on manual mixing rather than a mixer machine, using bamboo sticks or rods instead of a mechanical vibrator, excessive water usage during concrete mixing, failure to maintain precise mix ratios by approximating material quantities and changing the building's designated occupancy after construction.

Moreover, unplanned residential area development is diminishing the liveability of the region. People are constructing without regard for electricity, water and sewerage capacity, neglecting emergency safety measures and setback length requirements. Apart from the capital and a few other major cities, there is little tendency for authorisation before commencing any project. Consequently, numerous anomalies, mismanagement, materials wastage and environmental degradation occur.

Several participants mentioned the illegal production of smaller clay bricks in the factories as a cause of increased cement and brick consumption. Additionally, unauthorised local workshops produce low-quality steel rebars and sell them at low prices. These bars are used in the window grills necessitating frequent repairs. Despite some measures from the regulatory authorities, such practices still persist widely.

Skill and Capacity Issues

Six barriers related to skills and capacity issues needed to ensure proper quality, durability and circularity of the Bangladeshi Building Construction Industry were identified from the responses of the interviewees (as shown in Table 4).

Table 4. Skill and capacity issues

No.	Skill and Capacity Issue	Participant	Best Verbatim Excerpt from the Participants
1.	Copy-paste and faulty designs	E1, E6, E11, E12 and E18	So, the designer also provides a typical copy-paste design. Here, overuse of materials occurs. Let's say it was doable with less materials, but as "that building" used such an amount, use it here too. (E11)
2.	Deficiencies in labour skill development	E1, E15 and E19	In our country's perspective, there is no proper training for them. They work as helpers from a very young age and after a certain period, they become masons. (E15)
3.	Lack of technological capacity	E5, E16 and E19	We also lack personnel skilled in updated new technology like WTP/STP. So, sometimes the contractors take on the job but cannot complete it on time. (E19)
4.	Limited on-site knowledge of the designers	E4 and E6	In most cases, those who design have limited knowledge about on-site situations. (E4)
5.	Non-engineer project managers and supervision	E4, E6, E11 and E13	The owners sometimes employ a non-technical project manager who does not have sufficient knowledge. Recycling and reuse are tough in Bangladesh because of them as they do not have any consideration for aspects of CE. (E4)
6.	Shortage of technical personnel at the local regulatory offices	E11	Another issue is that if we consider our local authorities, let's say Pouroshova, there is a scarcity of technical manpower—one or hardly two engineers. With this, the design may be approved, but planned urbanisation is not possible. (E11)

Design deficiencies were reported by some participants where higher or lower materials than the ideal amount were proposed which directly hampers circularity. Particularly in rural areas, where people do not value professional design much, copy-pasting designs from other buildings are common.

To perform quality construction, Bangladesh lacks adequate skilled labourers and masons. Also, there are no institutionalised and organised facilities to train them properly. Many individuals begin working as helpers at a young age and gradually become masons after spending some years working under senior masons.

According to some participants, there is a lack of capacity in terms of technology and experienced personnel proficient in advanced technologies such as building information modelling (BIM), digital twin technology, WTP, STP and others, which hampers the pace of improvement. Designers sometimes treat their roles as desk jobs, lacking on-site experience and avoiding site visits. This creates a gap between the site engineer and the designer, occasionally resulting in impractical designs that require corrections or reworks, leading to wastage.

Moreover, the participants noted that oftentimes, especially in rural areas, non-engineer persons or masons are entrusted to lead the projects, who eventually fail to ensure proper quality and do not have any consideration for circular aspects. The owners do not bother to employ an engineer due to cost-saving tendency and being misguided by the apparent confidence and experience of the masons in taking on the role of an engineer.

At the local regulatory offices like Pouroshova and Union Parishad, there is a scarcity of technical personnel available to ensure proper monitoring of the construction projects. These offices only sit intermittently to approve the designs and other paperwork without conducting proper site visits or other subsequent checks.

Sociocultural Barriers

Seven barriers were identified from the responses of the interviewees that have negatively grown roots in the sociocultural orientation of Bangladesh as shown in Table 5.

Table 5. Sociocultural barriers

No.	Sociocultural Barrier	Participant	Best Verbatim Excerpt from the Participants
1.	Affluence, prestige and luxury contribute to unnecessarily high or luxurious construction in rural areas	E3 and E11	In our Kurigram, there are lots of cases where people have built five-stories, but the upper four and five numbers remain empty. Here, prestige and luxury are issues. Suppose someone lives in a city and only goes to the village once or twice a year. But he has built a luxurious house only for those days. (E11)
2.	Bidding syndicate of the demolition contractors	E9 and E20	Regarding the demolition syndicate, without the local contractor, although his quality might not be that good and his price might be higher, no other contractor is allowed by them to work. If someone submits a quotation without knowing, he will be assaulted. As these are political matters, the companies also do not want to cause hassle. (E20)
3.	Culture of malpractice, indifference and negative peer influence	E1, E2, E4, E9, E13, E16, E17 and E20	But the biggest problem with implementing this is our practice. In Bangladesh construction practice, it is rare to build such sustainable buildings. Additionally, others are also learning to do the same. So, it continues. (E1)
4.	Public and client ignorance and misconception	E2, E3, E4 and E11	The owners also would not agree to lessen the dimension. Can this be called ignorance of the owners? Yes, it can be. (E4)
5.	Reluctance to use old materials despite acceptable quality	E8	Despite the better quality of the old bricks, I could not use them. Nobody agrees; they just say these are old bricks. (E8)
6.	Unfavourable socio-political conditions	E1, E2, E13 and E17	The government authorities are not able to force the companies, as the company authorities sometimes have dominance even over the government authority. It is a major barrier. (E1)
7.	Widespread corruption and deception	E2, E3, E6, E9, E13, E19 and E20	The authority only checks the architectural view and the column position. If the column position is not OK, they will take 5 lakh taka as a bribe and leave. So, corruption is also a problem. (E2)

In rural areas of Bangladesh, sometimes affluent individuals build unnecessary tall buildings despite ample space available on lower floors, resulting in upper floors remaining unused. Emigrants or city dwellers who own land in villages sometimes build large luxurious houses solely for their prestige and recreational vacation stay. All of these practices lead to material wastage as depicted by some participants.

This issue of bidding syndicate is directly influenced by the culture of misuse of political power in Bangladesh. Before any auction for selling the old materials of a to-be-demolished building is held, the demolition contractors form coalitions regarding the price of the materials. Additionally, there is often a monopoly held by contractors with political backing, leading to area-wise control where other contractors may not even be allowed to submit bids. Consequently, the authority becomes obligated to the dominant contractor, even if their conditions and prices are unsatisfactory, resulting in the loss of potential value from the old materials.

According to many participants, one of the main barriers in Bangladesh is the prevalent culture of indifference, with very few individuals sincerely considering sustainability and circularity. There is a notable resistance towards change, with a tendency to go along with the conventional malpractices. Moreover, newcomers are often negatively influenced by their surroundings and absorbed into the existing system, diminishing the hope for improvement.

Significant ignorance and misconceptions are also persistent among local people which often lead to wastage and efficiency loss. There is a belief that usage of more materials will make a building stronger, as reported by multiple participants.

One participant particularly shared his experience of encountering obstacles from the surrounding people in utilising old materials in his projects, despite the materials being in good condition. There is a prevailing assumption that old materials are always of low quality and cannot be used, which directly hampers CE adoption.

In Bangladesh, the major portion of the population comprises low-income or middle-class individuals, with only a fraction being wealthy and possessing considerable influence over much of the affairs. This situation is exacerbated by the active involvement of businessmen in politics and media, as well as their connections with bureaucrats. They exploit their power to evade legal and regulatory consequences, as they often pose more power than the regulatory officials. This imbalance in the socio-political spectrum, as stated by some participants, significantly undermines any policy or attempt to bring about improvement, making progress much slower.

Many participants identified corruption and its root causes as major barriers to quality assurance and regulation. A significant portion of regulatory officials, companies and the general public are complicit in either giving or taking bribes, as accused by the participants. Both material companies and construction workers have a tendency to deceive inspection by initially showcasing selective materials or works and later deviating from the established standards. The local material shop owners also attempt to secretly mix low-quality materials

with high-quality ones. One participant mentioned that although regulations require certain tests before casting, testing is often skipped and the test reports are fabricated through manipulation, consequently leading to the spread of corruption across various sectors from top to bottom.

Technical Barriers

Seven barriers related to technical issues were reported by the participants as shown in Table 6.

Table 6. Technical barriers

No.	Technical Barrier	Participant	Best Verbatim Excerpt from the Participants
1.	Absence of detailed drawings of old buildings	E7	The difficulties were calculating and finding such opportunities and convincing the management. There was no detailed drawing of the building for pre-demolition estimation. (E7)
2.	Constructing redundantly deep foundations without full utilisation	E8	This scenario is also true for school buildings; the foundation is for four stories and we are building two stories. After some years, when the need arises for more rooms, another two-story is built nearby. (E8)
3.	Decision change or misconstruction leading to waste generation	E16 and E17	Sometimes, due to ignorance, they cast the pile all the way up to ground level. But the pile cap top is supposed to be 3 m or 10 ft below the ground level. Hence, that length is required to be broken, resulting in much waste. I have seen this happen myself. (E17)
4.	Early maintenance or durability loss due to low-quality materials, construction and finishing	E1, E2, E5, E6, E10, E13, E14 and E18	In any case, say for tiles and paintings, if we cannot maintain the quality, it necessitates maintenance within a short time, which is not sustainable. (E1)
5.	Inadequate road access to sites causing material wastage during interim storage and transportation	E2 and E17	There is no proper road access for trucks to enter. So, it needs to be stored somewhere near the local area. Here, cost increases in two ways: transportation to the storage from the factory, and, transportation from the storage to the site by cart. Besides, the number of broken bricks also increases. (E2)

(Continued on next page)

Table 6 *Continued*

No.	Technical Barrier	Participant	Best Verbatim Excerpt from the Participants
6.	Overconsumption of water and other resources	E1, E2, E3, E8 and E10	In construction, a huge amount of underground water is lost. The biggest amount is lost for curing purposes. In some cases, the water pump runs the whole day while casting. (E8)
7.	Quality deterioration in old materials	E6, E7, E12, E13, E14, E15 and E16	Another thing is that the strength of the old concrete is not that good. They get contaminated by various environmental agents. (E6)

One participant highlighted the difficulties in estimating the materials of the old to-be-demolished buildings due to the unavailability of detailed drawings. This often results in decision delay, confusion and inaccurate pricing.

The phenomenon of constructing redundant foundation, as noted by one participant, occurs mainly in governmental offices and school buildings. Initially, low-rise buildings with deep foundations are built with the intention of future vertical expansion. However, this planned expansion often remains unfulfilled indefinitely. When the need for more rooms arises, a new budget is proposed and another building is constructed nearby instead of expanding the existing structure.

Sometimes due to lacking proper and in-depth planning, decision changes occur on-site. The ignorance of the on-field workers also causes misconstruction, leading to the necessity of partial early demolition and rework. These occurrences eventually produce wastage.

Several participants depicted the loss of durability due to quality complications as a significant barrier to CE. In many cases, untreated wastewater is discharged directly into rivers, contaminating the riverbed, while chemicals and salt get mixed with the sand that is being used in construction. Additionally, due to the project handover deadline, paint is sometimes applied before the walls are ready, leading to poor finishing and necessitating early maintenance. Water quality is not checked, non-brand low-quality rebars are used and construction quality is compromised in various ways to cut costs. All of these factors contribute to the loss of the lifetime of the projects and significant damage to the national resources.

Besides, the roads in local residential areas are often narrow which are further reduced by the unplanned utility poles. Consequently, material-carrying trucks from factories are unable to access sites directly, requiring interim storage in local shops. Improper storage methods and subsequent transportation processes often lead to a portion of the materials being wasted, as noted by some participants.

Some of the participants voiced concerns over the losses of natural resources especially by the clay brick factories and use of woods. Additionally, there were discussions about the excessive consumption of groundwater for curing purposes and electricity for steel rebar and shuttering works. Lack of water recycling in the post-construction occupancy phases is also causing the lowering of groundwater levels in the cities. These issues pose significant obstacles to achieving resource efficiency and, consequently, circularity.

Many participants highlighted that concrete and rebars deteriorate over time due to leakage and other contamination, resulting in a loss of strength and potential for being reused in new buildings. This was mentioned as a persistent barrier to CE application in the Bangladeshi Building Construction Industry.

Comparison with Previous Studies

The comparison of the identified barriers with the extant literature is shown in Table 7. The comparison facilitates the understanding of the importance of considering the context of Bangladesh to implement CE in the BCI effectively. Most of the selected previous studies are literature reviews and hence are expected to represent a comprehensive gathering of the barriers. However, although a significant portion of the identified barriers in this study are also found in the previous studies, there are 13 barriers unique to this study.

Table 7. Comparison with previous studies

No.	Barrier	Previous Studies*							
		1	2	3	4	5	6	7	8
1.	Cost and hassles of incorporating CE practices	✓	✓	–	✓	✓	✓	✓	✓
2.	Funding shortage and cost-saving tendency among private owners	✓	–	–	–	–	✓	–	–
3.	Inadequate domestic company participation in mega projects diminishing research scopes and funding	–	–	–	–	–	–	–	–
4.	Price disagreement for used materials	✓	–	–	–	–	–	–	✓
5.	Profit-centered mentality of the companies	✓	–	✓	–	–	✓	✓	–
6.	A new conservative building code requiring higher material usage	–	✓	–	–	✓	–	–	–
7.	Lack of national plan or policy framework for CE implementation	✓	–	–	✓	✓	–	✓	✓

(Continued on next page)

Table 7 *Continued*

No.	Barrier	Previous Studies*							
		1	2	3	4	5	6	7	8
8.	Lack of coordination among government departments	–	✓	✓	✓	–	–	✓	✓
9.	Lack of law and policy implementation	–	✓	–	–	–	✓	✓	✓
10.	Non-compliance with building codes and standard site procedures	–	–	–	–	–	–	–	–
11.	Unauthorised and unplanned residential development	–	–	–	–	–	–	✓	–
12.	Unauthorised production of low-quality bars and smaller bricks	–	–	–	–	–	–	–	–
13.	Copy-paste and faulty designs	✓	✓	–	–	–	–	–	–
14.	Deficiencies in labour skill development	–	✓	✓	–	–	✓	✓	✓
15.	Lack of technological capacity	✓	✓	✓	✓	–	–	✓	✓
16.	Limited on-site knowledge of the designers	–	✓	–	–	–	–	–	–
17.	Non-engineer project managers and supervision	–	–	–	–	–	–	–	–
18.	Shortage of technical personnel at the local regulatory offices	–	–	–	–	✓	–	–	–
19.	Affluence, prestige and luxury contribute to unnecessarily high or luxurious construction in rural areas	–	–	–	–	–	–	–	–
20.	Bidding syndicate of the demolition contractors	–	–	–	–	–	–	–	–
21.	Culture of malpractice, indifference and negative peer influence	✓	–	–	–	–	–	–	–
22.	Public and client ignorance and misconception	✓	–	✓	✓	✓	–	✓	✓
23.	Reluctance to use old materials despite acceptable quality procedures	✓	–	✓	✓	–	–	✓	✓
24.	Unfavourable socio-political conditions	–	–	–	–	–	–	–	–
25.	Widespread corruption and deception	–	–	–	–	–	–	–	–
26.	Absence of detailed drawings of old buildings	–	–	–	–	–	✓	✓	–
27.	Constructing redundantly deep foundations without full utilisation	–	–	–	–	–	–	–	–
28.	Decision change or misconstruction leading to waste generation	–	–	–	–	–	–	–	–

(Continued on next page)

Table 7 Continued

No.	Barrier	Previous Studies*							
		1	2	3	4	5	6	7	8
29.	Early maintenance or durability loss due to low-quality materials, construction and finishing	-	-	-	-	-	-	-	-
30.	Inadequate road access to sites causing material wastage during interim storage and transportation	-	-	-	-	-	-	-	-
31.	Overconsumption of water and other resources	-	-	-	-	-	-	-	-
32.	Quality deterioration in old materials	-	✓	-	-	-	✓	-	-

*Notes: 1 = Ababio and Lu (2023); 2 = Charef, Morel and Rakhshan (2021); 3 = Gembali, Kumar and Sarma (2024); 4 = Mhatre et al. (2023); 5 = Munaro and Tavares (2023); 6 = Oluleye et al. (2023); 7 = Osei-Tutu et al. (2023); 8 = Wuni (2022).

Moreover, several instances are found where the issues are discussed in the previous studies, but the present study represents them in a more specific and contextual way. For example, the issue of lack of initiative from the company management is described as “short-term investment outlook of investors” (Ababio and Lu, 2023: 9), “poor environmental consciousness among construction players” (Gembali, Kumar and Sarma, 2024: 12) and “lack of top management support and leadership toward circular design” (Oluleye et al., 2023: 6). But the present study identified the issue as the “profit-centred mentality of the companies” underlining the core reason of such remissness in the Bangladeshi context. Absurdity and failure of regulations (Charef, Morel and Rakhshan, 2021) and unflexible building codes (Munaro and Tavares, 2023) were specified as “a new conservative building code requiring higher material usage”. “Lack of effective supervision from the government” (Munaro and Tavares, 2023: 5) found a more precise depiction as a “shortage of technical personnel at the local regulatory offices” which is causing the eventual lack of monitoring and supervision. Challenges in demolition prediction, auditing (Oluleye et al., 2023) and estimation (Osei-Tutu et al., 2023) are denoted as “absence of detailed drawings of old buildings”, a term more inclined to the root of the barrier.

It is also apparent from the comparison that the context of Bangladesh does face some barriers common to the global scenario. Cost and hassles of CE practices, lack of holistic national policy, lack of coordination, lack of regulatory implementation, deficiencies in skill and technology, lack of public awareness and resistance to reusing and recycling old materials are some of the notable barriers frequently identified in the past studies that resonate with this study as well.

Overall, despite the context of Bangladesh in implementing CE in the BCI being somewhat similar to the global scenario, it has a substantial number of distinct barriers that need to be focused on separately to ensure successful implementation.

CONCLUSION

This study employed semi-structured interviews with professional engineers and a thematic analysis to identify a comprehensive set of barriers to the effective implementation of CE principles in the BCI. The identified barriers encompassed various issues including financial barriers, regulatory barriers, skill and capacity issues, sociocultural barriers and technical barriers.

Besides the common barriers, this study contributes to the existing body of knowledge by highlighting some specific issues unique to the Bangladeshi context. Need for growth and increased participation in mega projects by domestic companies, national policy and framework development, challenges related to corruption and deception, non-technical supervision, copy-paste designs, smaller clay bricks, inadequate road access, non-compliance, redundant construction, ignorance and indifference, bidding syndicate, workmanship and training issues, new conservative building code and lack of coordination among departments are some of the country-specific concerns that should be shed light upon. The government, policymakers, industry stakeholders and academia would get valuable insights from these findings in formulating comprehensive strategies and frameworks to facilitate the transformation towards a circular and sustainable construction industry in Bangladesh. Other developing countries with similar socio-economic backgrounds can also benefit from the experiences and perspectives shared by industry professionals in this study who have diversified experience in such a context.

As this study utilised a qualitative approach and aimed to explore the whole industry holistically, it might lack sector-specific depth. Further studies can narrow their focus to specific sectors within the industry to uncover more detailed and in-depth issues. Additionally, the implementation of quantitative surveys could be beneficial in obtaining a broader sample size and prioritising the identified issues.

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