

An Insight into the Barriers and Strategies for Waste Management Culture in Construction Sector: A Circular Economy Initiative

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Abstract. Construction industry is witnessing steady expansion due to immense need of infrastructure and development projects in developed as well as developing countries. At the same time, millions of tons of waste are being generated on these projects. These substantial rates of waste generation required a detailed investigation about the root causes and potential mitigation measures. Therefore, different approaches like waste management (WM) and circular economy (CE) emerged to tackle such issues. There are a number of studies encompassing the details about the barriers and strategies for WM and CE culture but there was a need to summarize these studies to get an overview of all the problems in global context. So, objectives of this research is to provide, a comprehensive literature review was conducted. A list of barriers and strategies was developed from some of the most prestigious journals and then frequency analysis was performed from past papers. So, this study provides an insight into the challenges of implementing waste control practices which are further hindering the adoption of CE culture in construction industry. Major barriers include financial issues, lack of awareness, and lack of specifications. Further, important strategies to tackle these barriers include governmental support and development business models. Findings of this study will be helpful for the policy makers of all developing as well as developed countries to formulate guidelines for waste control.

Keywords: Waste generation, Barriers, Strategies, Waste management, Circular economy

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1. Introduction

The massive urbanization and development programs over the course of past ten years, have significantly increased the number of construction activities throughout the world (Voukkali et al., 2024). On average, construction industry contributes around 10% of the economic growth of a country and also provides employment. Since construction industry consumes natural resources, so, it significantly affects the reserves of these resources (Benachio et al., 2020). Construction industry is considered as one of the most waste generating industries (Zimbili et al., 2014). It was estimated that around 200 million tons waste was generated in the UK, where 59% of that waste was of construction waste (DEFRA, 2018). Likewise, around two billion tons of construction waste was generated in China on yearly

basis (Tang et al., 2022) and around 40% of the construction waste came from building sector. So, importance of waste control on construction projects can be imagined. Therefore, construction industry required to put some efforts to reduce the waste and bring systematic changes in the execution of activities. So, the concept of linear economy where materials are produced, used and thrown away, is being discouraged and construction industry is moving towards the new concept of circular economy, where resources are used up to their maximum efficiency by reusing and recycling again and again (Minunno et al., 2018).

Although there were number of research studies which focused on identification of major barriers to waste managements and strategies to promote the culture of

circular economy but an overview of all these studies under a single study was rarely reported. Further, this study will identify the gaps where more research studies are required to focus in future. Therefore, the aim of this review paper is to explore the major barriers and strategies for waste management in construction industry, which were reported globally. Moreover, this research will provide information about the real issues which construction industry is currently facing regarding waste management around the globe. Further, this study will also highlight the major policy guidelines for implementation of waste management culture in construction sector.

2. Research Methodology

Figure 1 explains the flow chart of current research. For this purpose, articles published in highly reputable journals in last two decades are reviewed in detail. Initially, more than hundred (100) papers were retrieved from different journals. Then these papers were shortlisted based on its relevance to the topic. This was done, by reading out the titles, abstract and keywords from these papers. Finally, this study ended up to around fifty (50) most relevant papers to the title. Among these journals most of the paper were taken from Journal of Cleaner Production, Waste Management, Resources, Conservation and Recycling, Sustainability, Buildings and International Journal of Civil Engineering. Other prestigious journals were also consulted. After a detailed analysis of these journal articles, major aspects from literature were formulated. Then a frequency analysis was performed to identify the major barriers and enablers for waste management culture. In the end, gap analysis was performed and missing aspects of this topic were also reported. Major aspects such as barriers and enablers are discussed in detail in following sections.

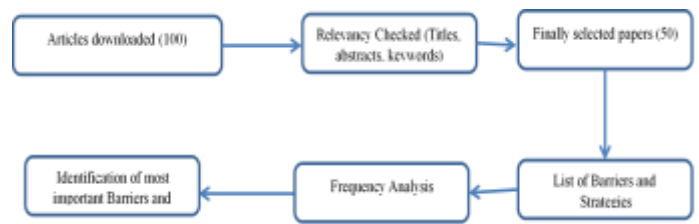


Figure 1: Flow chart of research methodology

2.1 External Barriers to Waste Management

This section is going to explain major barriers in adaptation of waste minimization and circular economy culture in construction industry. In the past, quantification of material waste remained an area of research for a long time but with the increase of environmental concerns, the concept of circular economy is considered a potential area of study in developing as well as developed countries in recent times. Number of studies have been conducted to identify the major barriers in implementation of waste minimization and circular economy strategies. Although circular economy is an emerging concept throughout the world but still it does not have been got requisite attention in so many developing countries.

Table 1. Significant External Barriers to Waste Management

Sr. No.	Barrier's Name	Frequency	References
1.	Absence of policies	14	(Negash et al., 2021 ; Arsawan et al., 2023)
2.	Financial issues	10	(Hart et al., 2019; Ormazabal et al., 2018)
3.	Lack of awareness	9	(Loizou et al., 2021; Low et al., 2020)
4.	Legal enforcement	9	(Yuan et al., 2011 ; Ferronato et al., 2019)
5.	Shortage of resources	9	(Torgautov et al., 2021; Voukkali et al., 2024)
6.	Lack of collaboration	7	(Loizou et al., 2021; Low et al., 2020)
7.	Low cost for waste	5	(Voukkali et al., 2024; Bui et al., 2020)
8.	Quality of recycled materials	4	(Voukkali et al., 2024; Schulte et al., 2023)
9.	Information Management System	4	(Bui et al., 2020 ; Bilal et al., 2020)
10.	Social issues	4	(Menegaki et al., 2018; Bilal et al., 2020)

Major barriers which were identified in past researches can be categorized into two major parts such as external barriers and internal barriers with the respect to the project. External barriers include the problems that construction industry face at national and industrial level. National level problems mean weak political will to implement waste minimization techniques in construction industry. Further, non-availability of environmental bylaws, lack of financial support from governments in the form of subsidies, illegal dumping sites, lack of awareness and national vision are found as most frequently occurring barriers to waste management and circular economy cultures as shown in Table 1. These macro level barriers must be addressed at national as well a industrial levels. So, It can be synthesized that controlling these barriers can have significant impact on introducing and adoption of circular economy culture in construction industry. Because, contractors do not perform any task which involves cost without its claim from client. So, client and policy makers' attitude and seriousness in this regard is very important. Further, once the rules and regulations are formulated, it bound all stakeholders to follow it. So, removing barriers at macro level can have substantial impact at micro level as well. Therefore, strategies to deal macro level barriers are more important than the barriers which exist at micro levels.

2.2 Internal Barriers to Waste Management

Moreover, internal barriers mean which are related to project like barriers which can occur during design, execution and post completion of a project (Shahid et al., 2023). A list of some of the significant barriers which were identified at project level is given in Table 2. These barriers could be further categorized into three; 1) design phase barriers 2) construction phase and post construction phases barriers of a project. In term of design phase, major barriers include illogical design, design and detailing errors, unclear specifications, clash leading to reworks and design changes. So, controlling these

barriers can cut off waste from its source. Because design is that phase of project where vigilant decision can reduce or prevent significant amount of waste from its generation. Because this is the phase where significant amount of waste can be eliminated from its source by considering different design options for the project components.

Table 2. Frequently Occurring Internal Barriers to Waste Management

Sr.	Barrier's Name	Frequency	References
1.	Shortage of resources	14	(Lee et al., 2012; Won et al., 2016)
2.	Construction Practices	9	(Pietzsch et al., 2017)
3.	Illogical Design	6	(Arena et al., 2021)
4.	Innovation in design	5	(Mahamid, 2022)
5.	Behaviour of stakeholders	4	(Eze et al., 2022)
6.	Unclear specifications	3	(Eldeep et al., 2022)
7.	Lack of use of modern tools	3	(Pietzsch et al., 2017)
8.	Lack of waste targets	2	(Low et al., 2020)
9.	Economic incentives	1	(Yuan et al., 2011)
10.	Contractual binding	1	(Bilal et al., 2020)

Next is the construction phase, where number of problems arose during execution of activities such as economic incentives, lack of supervision, behavior of contractors, ineffective sorting, transporting, and recovering processes. Since most of the materials are being used during construction phase of the project, so it is very important to understand these barriers and properly address them. This way maximum number of materials can be saved by following proper waste control strategies. Lastly, post construction phase of project includes lack of waste auditing, preferring off-site wastes sorting, wastes land filling over on-site sorting, insufficient logistics and illegal waste dumping as major barriers to waste control. The involvement of all stakeholders like client, consultant and contractors, in removing these barriers is also very important.

2.3 Enablers for Waste Management Practices and Circular Economy Culture

Waste control strategies which are being used and reported in literature in different countries worldwide are explained in following sections. Building waste control strategies can be categorized into two major sections. One is the external strategies and other is internal ones. Internal strategies mean the practices that will be followed at project level during design, construction and post construction phases of a project. While external mean those practices which are enforced at macro level like national, governmental and industrial levels. So following section explains in detail about the methods how circular economy (CE) can be promoted through waste minimization (WM) in construction industry. Waste minimization strategies can be further divided into two sub-levels. One is at the national or governmental levels in the form of polices and other is at industrial level (Awino et al., 2024; Victar et al., 2024). Application of external strategies is important to develop a waste minimization culture, because commitment and

enforcement from top level stakeholders can be more effective in this regard.

So, in the past studies as shown in Table 3, some of the most important strategies which were reported include governmental support to promote WM, SOPs, environmental management system, legislation and policies, financial support for circular economy research and provide subsidize to projects where recycled materials were used.

So, all these methods can persuade the stakeholders in the industry to follow the guidelines of WM. Therefore, external strategies can have large impact in terms of development and implementation of CE culture through WM in construction industry. It can force the stakeholders to follow circular economy practices. Similarly, industrial level strategies include business models for facilitating all those businesses linked with CE such as material recycling plant and selling of recycled material. Internal strategies may be ineffective in the absence of external strategies because local actors may not take it seriously until enforced by governments and followed by other organizations.

Table 3. Important Strategies/Enablers for CE and WM Culture

Sr.	Barrier's Name	Frequency	References
1.	Business Model	11	(Adelekan et al., 2024; Henry et al., 2021)
2.	Governmental Support	8	(Henry et al., 2021)
3.	Incentives for recycled materials	7	(Blaisi et al., 2019; Bimonte et al., 2023)
4.	Green behavior	7	(Vohra et al., 2020)
5.	Education and training	6	(Kumar et al., 2020)
6.	An advanced research & developments	4	(Dolla et al., 2020; Soto et al., 2023)
7.	Modular designs	4	(Aithal et al., 2021; Zhaoet al., 2024)
8.	Prefabricated construction	3	(Hoveling et al., 2024)
9.	Design out waste	2	(Hoveling et al., 2024; Bimonte et al., 2024)
10.	Follow waste management plans	2	(Victar et al., 2024; Buchardet al., 2024)

3. Conclusions

A comprehensive literature review was conducted to overview the present waste management conditions around the world and to work out the missing areas where more research studies are required. For this, more than hundred articles were consulted. Based on the detailed literature of previous studies and frequency analysis, major findings of this research include:

- External barriers include lack of financial support from governments, non-availability of environmental bylaws, poor business models, and lack of awareness among industry stakeholders.
- Further, internal barriers for waste control are illogical design, discrepancies in drawings, poor supervision for waste control, Shortage of resources, poor construction practices in industry.
- Enablers include supportive business models for wasted materials, legislation, education and training of local stakeholders along with modular design, prefabricated structures and follow waste management plans.

Considering the above sources of waste generations, quantities of wasteful materials and barriers to waste management, future researches should focus on the development and validation of frameworks to promote waste management culture for construction industries.

Since waste management not only have a significant impact for cost reduction of project but also improves the efficiency of these materials and reduce environmental impacts to encourage sustainability in construction industry.

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