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An overview of circular economy management approach for sustainable construction and demolish waste management

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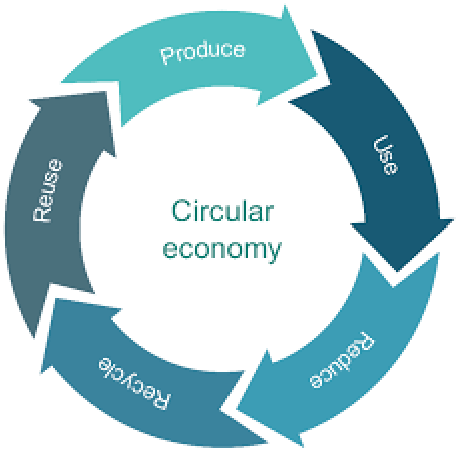
Graphical abstract



Abstract

Waste generation from the construction industry has been recognized as a key factor in environmental deterioration. Excessive waste in the construction field is a direct outcome of unsustainable production and consumption practices, typically ending up in landfills. To tackle this problem, a circular economy management approach has been proposed as a solution for sustainable construction and demolition waste management. This review outlines the strategy of the circular economy to promote sustainable management of construction and demolition waste. The circular economy management strategy emphasizes the importance of reducing waste production and promoting the reuse and recycling of materials. This approach also promotes the use of sustainable materials and the implementation of effective waste management practices during construction and demolition. The circular economy management approach to sustainable handling of construction and demolition waste involves several key strategies. These include embracing sustainable design and construction methods, encouraging material reuse and recycling, and establishing efficient waste management systems. These strategies require the cooperation and involvement of all stakeholders in the construction and demolition process, including architects, contractors, developers, and waste management companies. The circular economy management approach provides a promising framework for achieving the objectives of effective waste management and sustainable construction. By promoting sustainable patterns of production and consumption, this approach can reduce the environmental impact of the construction industry while generating economic benefits for stakeholders. However, successful implementation of this approach requires strong regulatory support and the willingness of all stakeholders to adopt sustainable practices.

Keywords: Sustainability, Circular economy, Construction and demolish waste. 3R. recyclable materials.

1. Introduction

Construction waste, also known as construction and demolition (CDW) waste, is a particular kind of solid waste that results from a variety of building, remodeling, and demolition activities, including new construction, renovation, land excavation, demolition, refurbishment, and infrastructure work (Bao & Lu 2021). Construction waste typically consists of a wide variety of materials due to its heterogeneous character, which is usually differentiated into inert and non-inert by evaluating its chemical activity with the surroundings (Chen *et al.* 2021). Sludge, soil, rubble, concrete, and brick are some examples of inert materials, whereas non-inert trash has organic materials including metal, packaging, flora, wood, and paper(Ali *et al.* 2019).

In any economy, construction waste contributes significantly to solid waste streams. In most developed nations, the percentage of building debris that ends up in landfills typically ranges between 25% and 40% (Lv *et al.* 2021). Construction waste disposal not only has several long-lasting negative effects on society, the environment, and the economy, but it also quickly depletes non-renewable land resources (Ajayi & Oyedele 2017). Construction waste management (CWM) is the result of decades of work by the international scientific community to manage construction trash effectively (Wu *et al.* 2020). '3R' principles (reduce, reuse, and recycle) are always incorporated into CWM (Huang *et al.* 2018). Reduction refers to minimizing waste at the source, reuse refers to using a material at least twice, and recycling refers to giving waste a second chance at use (Wu *et al.* 2019). The circular economy (CE) has been extensively embraced as a guiding philosophy for sustainable development across fields and geographies, echoing the 3 R principles (Mahpour 2018; Ratnasabapathy *et al.* 2019).

In response to increasing demands from resource depletion and environmental degradation, the circular economy has gained traction over the past ten years, giving rise to a wide variety of interpretations of the idea (Kirchherr *et al.* 2017a). The Ellen MacArthur Foundation (EMF) described the CE as "an industrial system that is restorative or regenerative by intention and design" (MacArthur 2013), which is the predominant definition of the term. A CE views waste as potentially useful resources by connecting production and consumption activities in a continuous closed material loop, which is an alternative to the linear economy, which is characterized by a "take-make-use-dispose" pattern and has been found to be increasingly unsustainable (Ghisellini *et al.* 2018). Creating a CE has enormous social and environmental advantages, such as more effective material and energy use, less waste production, less resource depletion, a boost to innovation, and more job opportunities (MacArthur 2013).

Numerous studies have been conducted in recent years to develop strategies for developing the circularity of construction waste in developing countries. For instance, Oliveira *et al.* (2021) presented methods on how to enhance the circularity of building waste with a case study in Manaus, Brazil. These strategies included valorizing construction waste by increasing chances for reuse and recycling as well as enhancing training and surveillance techniques. By combining a literature review with in-depth field research and interviews, Mhatre *et al.* (2021) also proposed strategies for increasing the circularity of construction waste in India. These included encouraging technical organizations to create standards for the reuse of construction waste and enacting taxes on open disposal and mining.

With a case study in Guangzhou, China, Liu *et al.* (2021) also investigated strategies for developing circularity of construction waste, highlighting the significance of promoting and using recycled products. Bao *et al.* (2019) investigation into the development of circularity of building waste included a case study in Suzhou, China, and a recommendation to embrace procurement innovations as a conclusion. With a case study in Shenzhen *et al.* (2020) also suggested a few strategies for fostering circularity of construction waste, including the introduction of cutting-edge recycling technologies and the adoption of accommodating institutional frameworks (Bao 2023).

This review explores and details the CE approach for sustainable CDW management. The review is structured to first examine the generation and composition of CDW, along with the key factors influencing its production. It then highlights the environmental impacts of CDM, with a particular focus on landfill effects. The CE approach is crucial in CDM as it promotes resource efficiency, minimizes waste, and reduces the environmental footprint of construction activities. By implementing CE principles, the construction industry can move towards more sustainable practices. The novelty of this review lies in its comprehensive analysis of recent advancements in the CE concept and the 3R (Reduce, Reuse, Recycle) method for CDM management, providing a holistic view of current practices and innovations. Finally, it presents the challenges and prospects in this field.

2. Construction and demolish waste

Construction waste can be generally divided into two types: physical waste and non-physical wastes. Concrete, aggregate, sand, wood, metal, and plastic trash are examples of physical wastes that are produced during various building processes. Table 1 presents the percentage of each waste category from total Construction waste in different countries. Time and cost considerations are added up for non-physical wastes in the meantime (Jaillon *et al.* 2009). However, according to Jain *et al.* (2012), construction site waste is composed of both inert and non-inert materials. Non-inert combinations included metal, wood, and packaging wastes while inert mixtures included soil, earth, and slurry as examples. Construction waste materials, according to Muhwezi *et al.* (2012), are any building materials that need to be recycled or reused owing to damage, nonuse, abuse, or failure to adhere to the approved construction requirements. Construction waste is produced because of a number of factors, including improper handling, stacking, cutting, and storage of building materials, neglect of product measurement, ignorance of construction during design stage activities, and a lack of contractor interest (Elshaboury *et al.* 2022; Manoharan *et al.* 2020).

Although it is difficult to provide precise numbers for the amount of CDW generated on a typical construction site, previous research studies estimated that 4% to 30% of the total weight of building materials delivered to a construction site is wasted as a result of damage, loss, and overordering (Mercader-Moyano & Ramírez-De-Arellano-Agudo 2013). Depending on the nation and the chosen construction methods, on-site waste streams and their composition can vary greatly. CDW can be broadly divided into three categories: (1) waste that cannot be easily recycled or that poses special disposal challenges, such as chemicals (such as paint, solvents), asbestos, and plaster; (2) waste that cannot be directly recycled in the construction industry but may be recycled elsewhere; (3) waste that is potentially valuable and can be reused or recycled, such as inert waste like concrete, stone masonry, and brickwork (Osmani & Villoria-Sáez 2019). Brick masonry and concrete in the building industry have by far the most potential for recycling in terms of waste streams and weight. The results of extensive study comparing the streams and amounts of building waste in the United States, the United Kingdom, Spain, China, Brazil, Korea, and Hong Kong have been used to support this.

Table 1. Percentage of each waste category from the total generated construction waste in different countries (adapted form Osmani & Villoria-Sáez 2019).

Waste stream	China	India	United state	Portugal	Norway	Italy	United Kingdom	Spain
Soil and rocks	-	35	-	-	-	-	-	-
Mixed concreate and ceramic waste	-	65	72	82.9	67.24	84	33	85
Concreate	8-35	35	70		85.13			
Ceramic	15-50	30	2		10			
Wood	1.5	2	7	-	14.58	-	27	11.2
Paper	5-10	-	-	1.2	-	-	18	-
plastic	-	-	-	0.16	-	-	-	0.2
Gypsum	-	-	3	6.4	-	-	10	-
metals	1.8	5	1	4.5	3.63	0.08	3	1.8
Asphalt		2	14	4.2		6.9	-	-
other	10-20	1	-	-	14.5	8.8	11	1.8

According to estimates, 33% of materials are lost because architects do not account for waste in their designs (Osmani *et al.* 2008). However, because buildings incorporate numerous materials and processes, reducing construction waste through design is difficult. In addition, (Osmani *et al.* 2008) noted that "waste accepted as inevitable," "poorly defined responsibilities," and "lack of training" are the three biggest obstacles facing architects when trying to include waste reduction techniques into their projects. This is complicated by the additional trash that other projects' stakeholders, such as clients, contractors, subcontractors, and suppliers, directly or indirectly produce.

Nevertheless, it is widely acknowledged that one of the major sources of construction waste is changes in design that occur during operational activities. The main reasons for design changes during construction include a lack of understanding of the underlying causes and causes, complex designs, poor communication between the design and construction teams, a lack of design information, unanticipated ground conditions, and lengthy project duration (Osmani 2015). Waste sources in construction procurement processes can be categorized into four key categories: improper early stakeholder coordination, poor project communication and coordination, imprecise responsibility delegation, and inconsistent procurement documentation (Gamage 2009).

3. Factors affecting construction waste management in sites.

According to Kaliannan *et al.* (2018), the top five causes of construction waste include ongoing design changes, improper construction material storage, improper handling of materials, weather-related effects, and supplier ordering mistakes. One of the contributing factors is the 12.51% proportion of used material that was improperly chosen and is easily breakable or crushable when handled or used. While 4.67% result from using insufficient waste management techniques and 11.39% from poor material control at the site, respectively (Elizar *et al.* 2015).Operations for CDW management may be disrupted by stakeholder conduct, a lack of funding, and a lack of programs for rewards and penalties (Chen *et al.* 2002).

Waste occurs because of the lack of comprehensive knowledge and specialized training for building teams. All practitioners in the construction industry must engage in good professional practice to see improvements in CDW management. Construction trash can be generated in considerable quantities during tasks like formwork construction, plastering, and handling if the workers are untrained (Wang *et al.* 2008). The high cost of recycling, the absence of recycled products that meet standards, the lack of contact with stakeholders, and these considerations should all be considered.

Most materials in conventional logistics are stored when they are brought to the construction site. Thus, from the point of storage to the point of installation, the material must be transported twice. These result in time and energy waste by doubling the handling of the materials (Newaz *et al.* 2022) Along with raising the likelihood of material damage, waste generation, and associated costs. Improper storage can result in building materials being damaged or deteriorating because it is inappropriate to store items immediately outdoors. Another source of CDW is packaging trash for building products (Liu *et al.* 2022). According to reports, damaged bags and cement that is still present in the packaging account for about 5% of the waste generated by packaging cement (Eltobgy *et al.* 2022).

4. Environmental impacts of Construction and demolish waste

Construction waste has 38 subcategories according to the European Waste Catalogue. 16 of these subcategories were rated as being absolutely or minimally harmful

(Environmental Agency 2011). Samples of waste materials made of cement contained several different kinds of harmful entries. Chromium (Cr), lead (Pb), arsenic (As), zinc (Zn), mercury (Hg), and vanadium (V) were some of the hazardous entries or heavy metals that were presented. In samples of building and demolition trash, Zn was found to have the highest concentration of all the heavy metals. The degree to which these waste elements were dangerous varied substantially depending on where they were formed (Somasundaram *et al.* 2015). It was clear that the main waste types that contained hazardous compounds were concrete wastes, which were composed of cement, sand, and aggregates, followed by electronic wastes and steel wastes (Manoharan *et al.* 2020).

Especially in the 1970s and 1980s, landfilling was the common treatment option for CDW waste because most of it is made up of inert materials. Landslides at the ultimate disposal site, which have the potential to threaten life and property, are one of the principal negative environmental effects of landfilling garbage in general and CDW waste. Examples of this include the massive landslide of the Dona Juana Landfill in Bogota in 1997, one of the worst failures in history (Caicedo *et al.* 2002); another landslide occurred in the Chinese city of Shenzhen in 2015 because of the collapse of a massive pile of CDW waste, resulting in the deaths of 73 people and the damage of 33 structures (Ferronato & Torretta 2019). Recycling CDW waste would relieve landfilling pressure, lowering the risk of landslides, and extending the life of landfills. Landfills can produce chemicals that are hazardous to human health, such as hydrogen sulfide, which is produced when CWD waste is dumped there and is an issue for the environment (Alsheyab 2022).

Overland water, groundwater, and soil contamination are the three main environmental issues raised by CDW (Cabalar *et al.* 2016). Environmental science and environmental engineering experts have given these a lot of consideration. Through testing the waste's pollutant composition and analyzing how pollutants in CDW affect the environment, these studies aim to investigate the environmental effects of CDW.

Understanding the environmental problems of CDW waste depends heavily on the pollutant compositions of the waste. According to Jang & Townsend, (2001) and Van Praagh & Modin (2016), the pollutant contents of CDW can vary and include heavy metals (such as copper and chromium) and organic materials (such as polycyclic aromatic hydrocarbons, carbon, methane, sulfuret, and hydrogen sulfide). It should be noted that attempts have been made to detect and measure the heavy metals produced through CDW and the effects these have on the environment (Øygard *et al.* 2005).

While other studies (Shin & Kang 2015) focused on the heavy metal migration measures, other studies (Wehrer & Totsche 2008) evaluated the effective rates of heavy metals released from the waste. Since many of the findings are based on experimental studies conducted in the labs of prestigious universities and institutions, the research in this field is generally considered to be solid. However, some toxicity pollutants have been missing because the sample selection was restricted to residential/commercial project sites and landfills. Recently, some toxic organic matter components from the demolition of industrial structures like pesticide factories, such as poly-cyclic aromatic hydrocrack and hydrogen sulfide, have been discovered in mixed CDW (Duan *et al.* 2016). Mixed CDW is extremely complicated in terms of both composition and characteristics. As a result, worries about the potential environmental and health effects of industrial CDW are widespread (Huang *et al.* 2017). Studies on the mechanisms of sorption, adsorption, release, immobilization, incineration, and pyrolysis have been done to manage and mitigate the pollution from CDW (Shin *et al.* 2015). Johnson *et al.* (1999) reported that the CDW landfill would create liquids such leachate including various biomasses and landfill gas based on the long-term monitoring. According to Bergersen & Haarstad (2014), the landfill's mixed demolition waste, which included plasterboard made of gypsum, would produce hydrogen sulfide (H2S) gas, a common gas produced by landfills and other sources of severe odors. It has become urgent to remove organic and nitrogenous waste from landfills. It is therefore essential to implement technical steps to reduce the emission of contaminants from CDW disposal sites.

According to the keywords' frequency, "leaching test" has been widely used to evaluate the effects of pollutants on the environment (Van Praagh & Modin 2016b). The environment of the leaching laboratory might roughly resemble the waste disposal location where CDW would come into contact with liquid from rainfall, according to a two-decade-long study of leaching tests. When examining how pH could affect the mechanism of metal release from CDW, Galvín *et al.* (2012) compared the leaching tests performed in batches. Like this, Kruger *et al.* (2012) performed tests to figure out how leaching could release heavy metals and PAH from the trash. Nevertheless, the leaching behavior is sensitive to the environment and can change dramatically. Consequently, it is possible that a single test method will not be able to satisfy the accuracy requirement for assessing CDW's effects on the environment. According to Roussat *et al.* (2008), this is because it is possible that certain pollutants found in hazardous CDW could produce harmful gases when mixed with other types of trash in landfills.

5. Construction waste management and circular economy

As the world moves closer to the construction of urban infrastructure, sustainability has emerged as a significant concept and/or cause for concern. As a result, pollution is increasing and the ecosystem is being negatively affected (Jhatial *et al.* 2020). Sustainability is crucial to any construction project since it helps the project's economy and environment. So, a typical definition of sustainable development is the guarantee that a project meets the needs of the present generation without jeopardizing the needs of future generations (Anastasiades *et al.* 2020). Three entities—the earth, the people, and the bottom line serve as the principles of sustainability. Ecology and/or environmental conditions are of the utmost importance to the planet, whilst human demands should be met by development to yield the greatest profit possible given the available resources. The goals of sustainable development include making growth practical, tolerable, and fair from a social, ecological, and economic perspective.

A recent notion, the circular economy has been treated in a variety of ways depending on the social, cultural, and political structure (Winans *et al.* 2017). Because it is regarded as an alternative for operationalizing businesses under the concept of sustainable development, the CE concept is widely acknowledged among academics and practitioners in industry and society (Kirchherr *et al.* 2017b). Therefore, the main goal of CE is to eliminate the link between economic growth, environmental degradation, and resource consumption through new production methods and technological advancements, satisfying consumer needs in alternative, more sustainable ways (Ellen MacArthur Foundation 2015). Reduction, reuse, and recycling are referred to as the "3 R" principles and are regarded as the cornerstone of CE (Ghisellini *et al.* 2016). Although there is not just one idea behind CE, it can be broadly characterized as a model in which the value of raw materials, finished goods, and component parts is preserved for as long as possible during the production cycle (López Ruiz *et al.* 2020). As a result, a product's end-of-life can be extended by using it repeatedly as a secondary resource, eliminating or lowering the input of raw materials and energy, and reducing waste formation (Merli *et al.* 2018). The circular economy, according to Geissdoerfer *et al.* (2017), functions as a regenerative system in which leakage of resources, energy, emissions, and waste is reduced by delaying, sealing, and enlarging material and energy loops.

Sustainability Buzzwords widely used in CE should be understood in the following ways. Development that is sustainable is one that satisfies current demands without endangering the capacity of future generations to satisfy their own needs (Brundtland *et al.* 1985). According to the definition given in (Geissdoerfer *et al.* 2017b), CE is a regenerative system in which resource input, waste, emission, and waste of energy are minimized by slowing, closing, and narrowing material loops while using the least amount of energy feasible, preferably from renewable sources.

It is crucial to recognize building construction as the main cause of new buildings' CO_2 emissions and to incorporate reusable construction materials into their designs (Bertin *et al.* 2019). When compared to landfilling, recycling and reuse of concrete can reduce the CO_2 impact by 36% to 59% (Bonoli *et al.* 2021). The waste framework directive (WFD) defines the concepts as prevention, preparation for reuse, recycling, recovery, and disposal. The 10 R's concept takes things a step further and sets up a comprehensive CE by include discard, re-design, repair, refurbish, remanufacture, and repurposing (Oluleye *et al.* 2022; Schützenhofer *et al.* 2022).

When a building has served its purpose no longer, it is time for demolition and dismantling. For the sustainable use of material resources in this phase, waste management and the project design for the deconstruction are crucial. To allow the possibility of reuse, the production of high-quality goods, and the execution of waste management streams, waste management must also be included in the planning process (Buch *et al.* 2021).

In CE, production and waste are intertwined. A modification in the production/processing technology is another way to make material consumption and CE more sustainable, in addition to using materials sparingly or for longer periods of time. Along with a decrease in energy demand (Shen *et al.* 2021). Demacsek *et al.* (2019) illustrates a similar potential for recycling polystyrene. There is a 47% reduction in CO_2 emissions when comparing the feed into a production stream with standard waste treatment incineration. The analysis of the literature reveals a lack of understanding of LCA for CDW and a failure to take CE into account at every stage of the life cycle, starting with the design process (Mesa *et al.* 2021).

The research of several CDW management solutions and stakeholder interviews led to the conclusion that they are not Building Information Modelling (BIM)-compatible, and data for LCA on CDW is not available (Wu *et al.* 2019b). It is also criticized since there are not any comprehensive techniques or statistics for CDW LCA. Andersen *et al.* (2019) track the evaluation of CE's environmental effects. For this, LCA and the Environmental Product Declaration (EPD) are employed. The results indicate that CO_2 emissions could go either up or down. Buildings' LCA to evaluate End-of-Life performance is based on consistent and comprehensive EPDs, particularly module D. However, not all EPDs have modules C and D, making it impossible to compare materials and fully consider their life cycle (Anderson *et al.* 2019). Concrete recycling and reuse have the potential to have a lower CO_2 effect than landfilling by 36% to 59%, according to a LCA (Bonoli *et al.* 2021).

The primary factor driving carbon emissions reduction in the construction sector is the implementation of strategies for the recovery, reuse, and recycling of CDW. The retrieval, reutilization, and reprocessing of CDW are crucial elements of the CE within the construction industry. By prolonging the lifespan of materials through recycling and reusing them, the industry can diminish the amount of waste produced, preserve natural resources, and decrease the release of greenhouse gases linked to material manufacturing (Papamichael *et al.* 2023). Moreover, including recycled materials in construction can effectively mitigate the environmental consequences linked to material manufacturing, including energy consumption, water usage, and carbon emissions (Mariarosaria & Francesco 2023; Norouzi *et al.* 2021). Sustainable development principles in the construction sector also apply to both the design and construction stages of projects. Designing structures with the intention of deconstruction and reuse can enable the retrieval of materials once they have reached the end of their useful lifespan, hence minimizing waste production and promoting circularity. Prefabrication and modular building techniques enable the efficient recovery and reuse of materials by allowing easy disassembly and utilization of components in subsequent projects (Iacovidou *et al.* 2021). The participation of CE and material recovery has significant promise for reducing the amount of CDW that is sent to landfills. This can be achieved by utilizing these materials in a sustainable manner. Additionally, an aspect that complements the 3R of CE is the process of recovering raw materials. By adopting this method, the rate at which raw materials are used decreases, resulting in positive effects on the environment (such as a reduction in greenhouse gas emissions), social well-being (such as a more pleasant environment), and economic advantages (such as cost reduction)(Purchase *et al.* 2022). The constituent components of CDW are regarded as high-value materials that have the potential to be recycled for the purpose of constructing concrete. The compositional analysis of CDW in New Zealand, as reported by the constituent components of CDW are regarded as high-value materials that have the potential to be recycled for the purpose of constructing concrete. The compositional analysis of CDW in New Zealand, as reported by Purchase *et al.* (2022), revealed the presence of concrete, plastic, wood, iron and metals, miscellaneous materials, glass, hazardous materials, and organic waste. These items accounted for 25%, 19%, 38%, 6%, 5%, 2%, and 2% of the total trash, respectively.

A 3R approach is used to handle construction waste, with a particular emphasis on activities to reduce, reuse, recycle, and recover raw materials (Anastasiades *et al.* 2020). Reuse, recycle, and recover operations become more prevalent, which slows down and/or stops the raw material supply chain. This has advantages for the economy as well as a decrease in the quantity of greenhouse gas emissions that are produced during the supply chain and procurement processes. Additionally, reducing waste production is advantageous because it not only does so, but it also averts the negative effects that waste generation will inevitably have on our living environment. Studies on the economic viability of trash reduction have been conducted in various ways. Since CDW is the primary global contributor to landfills, a significant portion of this work takes this into account (Osmani & Villoria-Sáez 2019). For instance, a cost-benefit analysis conducted in Malaysia in 2006 discovered that reducing CDW was commercially viable with a net profit of 2.5% (Begum *et al.* 2006). This study examined the costs and advantages of reducing waste at a Malaysian construction site. According to the report, there are many immediate advantages, including lower purchase costs due to reuse, recycling, and the sale of scrap metals, lower costs for garbage collection and transport, and lower costs for disposal fees. There were also intangible advantages, such as the reduction of landfill space requirements, decreased liability for environmental issues or workplace safety, decreased likelihood of soil and groundwater pollution, and enhanced public perception and environmental awareness. Direct expenses for collection and separation, equipment purchases, equipment storage, and transportation are some of the expenses associated with this. Additionally, there were some intangible costs, such as the health risk to employees and the price of unpleasant externalities like noise and odor.

The economic viability of employing recycled concrete as aggregate was the subject of one study (Tam 2008). Both the existing and concrete recycling methods for waste disposal were subjected to a cost-benefit analysis. The findings suggested that the building sector could receive help from using concrete waste as aggregates rather than disposing of construction debris, particularly concrete, in landfills (Tam 2008). According to the analysis, there would be a $30,916,000 annual net benefit in addition to a decrease in resource depletion and energy use. Thus, it is possible to encourage ecological and economic sustainability in construction projects. The lack of readily available recycled concrete was one problem.

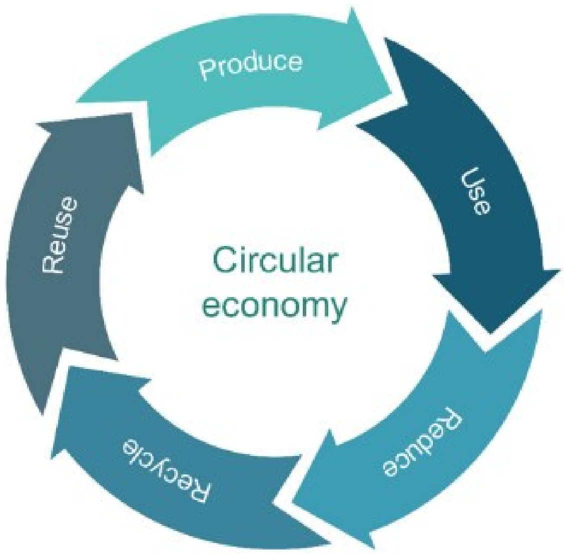


Figure 1. Circular economy principles

6. Reduce, Reuse, and Recycle methods for CDM Management

Strategies Utilizing various circular economy strategies (Figure 1) makes it possible to reduce the amount of waste generated during building construction and demolition (Kabirifar *et al.* 2020). These tactics may be used during the construction phase, the demolition phase, or both the construction and demolition phase(Janani & Kaveri 2020). The solutions could be used separately or in combination to handle different types of garbage produced by building and demolition, according to existing literature evaluations (Materials 2022).

6.1. Reduction

Reduction is the best CDW management strategy out of the three R's because it has the least negative environmental consequences. As a result, the development of reduction strategies is given top importance in CDW management plans (B. Huang *et al.*

2018). If waste is produced, it is essential to find ways to reuse the materials. If this is not possible, it is then crucial to collect the materials for recycling, followed by disposal, which is the final step in managing CDW. Pickin et al. (2018) listed a few advantages of reducing trash, including making income from collecting some materials, saving money by buying less material, lowering CO2 emissions, and lowering the cost of transporting waste to landfills. The best environmentally friendly and economically sensible course of action, according to Bølviken & Koskela (2016) and Llatas & Osmani (2016), is to minimize rework caused by mistakes and subpar workmanship, plan to reduce offcuts, and reduce waste generated during construction activities. Due to the similarities between the reduce, reuse, and recycle strategies, the main obstacles to the proper implementation of waste reduction strategies arise when stakeholders lack a common understanding of 3 R CDW management strategies and actors in the construction industry are unable to effectively communicate and collaborate with one another. If the decrease strategy is incorporated into the CDW management cycle for the purpose of minimizing waste, construction players will benefit from all parts of it. As a result, it is crucial to give the reduce strategy special attention throughout execution. The application of the reduction strategy in the building industry must be given top attention because to the global CDW generation's rapid increase (Esa *et al.* 2017).

6.2. Reuse

Reusing CDW refers to any activity or practice that involves using appropriate building materials more than once, regardless of whether they are used for their intended purpose or for another purpose(Huang *et al.* 2018). After demolition, the majority of CDW can be used again. The best ways to conserve natural resources, protect the environment, and save money are through reduction and reuse. Reusing construction wastes also helps to reduce greenhouse gas emissions, which help to contribute to global climate change, help preserve the environment for future generations, and enable things to be used to their full potential(Park & Tucker 2016). From construction, renovation, and demolition sites, a variety of building materials can be salvaged and then sold, put away for future use, or used on the current project. However, some specific CD materials, such as latex paint, adhesives, and chemical solvents, are thought to be toxic and are categorized as hazardous waste (Oyenuga 2016). The age of the structures included in demolition operations is also an important decision-making consideration when it comes to recycling CDW (Akinade *et al.* 2017). For instance, outdated structures could contain asbestos or other elements that are no longer allowed in new construction. Effective methods of recycling CDW include deploying trained personnel for collection and sorting CDW, providing incentives for recycling construction and demolition waste, using industry-standard building techniques, materials, and technologies, and creating a market for recycled products (B. Huang *et al.* 2018) (Table 2).

Table 2. Suggestion waste management actions for CDW. (adopted from (Janani & Kaveri 2020)

Items	Major reason for waste	Suggestion for reuse and recycled waste
Cement mortar Standard waste- 10.5% by waste	• Material split on ground Left cover mix used that has not been used. • Handling and transportation of mortar Brick work joints Plaster thickness.	• Can be converted to recycled aggregates. • Crusted and wed for recycled sand. • Can be used as a cement replacement.
Bricks and blocks Standard waste – 5% of brick Standard waste – 5% of block.	• Poor handling and transportation. • Delivered the damages of the bricks and blocks.	• Crushed/chipped and used as landscape material. • Ground into powder to make new bricks. • Crushed into fine aggregate. Can build outdoor ovens.
Concrete Standard wastage – 1%	• Poor handling Over – sized foundation. • Poor storage Poor workmen ship.	• Which can be separated and reused as base course in garages and pathway. • Concrete is generally reused. • It is squashed, the support bar is evacuated, and the material is screened for size.
Steel Standard Wastage – 3%	• Change in design Over ordering. • Damaged during the transportation to site/on site. • Lack of good storage location system.	• Steel maximum 100% recyclable. • Steel from reinforcement wire, containers.

6.3. Recycle

The process of dismantling used construction materials to create new ones is known as CDW recycling; however, immature CDW recycling management, inadequate recycling technology, and an immature market for recycled goods are obstacles to CDW recycling (Huang *et al.* 2018). Depending on the project's capabilities and facilities, CDW can be recycled either on-site or off-site at a CDW processor. Materials including concrete, metal, asphalt, wood, roofing materials, plasterboard, and corrugated cardboard can all be recycled from construction sites. The removal of waste and the recurring supply of natural building materials over long distances would otherwise release a significant amount of CO2 that is finally prevented by recycling construction materials (Oyenuga 2016).

The reduction of the need to extract new raw materials is one of the many advantages of CDW recycling, which also helps to reduce the generation of other pollutants and greenhouse gas emissions. Additionally, it preserves landfill capacity, reduces the need for new landfills and the costs associated with them, as well as energy savings and the lessening of adverse environmental effects (Pickin *et al.* 2018). Additionally, recycling has a significant effect on generating employment and economic activity in related industries. Recycled building materials with high quality assurance have a sizable market. To ensure a successful waste recycling outcome, government cooperation is also essential (Esa *et al.* 2017). As a result, recycled building materials have been used in the construction of roads, foundations, sports fields, noise protection walls, and landscapes (Fatemi & Imaninasab 2016).

7. Recommendations and future prospective

There is still a lack of knowledge on the effect of CDW on the environment, and limited controls for these pollutants have been implemented. Future work may therefore focus on (1) trying to understand the complexity of the contaminants in CDW; (2) creating additional tests and procedures to evaluate the effects of CDW on the environment; and (3) creating extensive control strategies for CDW treatment and disposal. Moreover, Incentives or management strategies that encourage CDW diversion have been widely applied (e.g., landfilling charge rates). However, there a little research done on how effective these programs or policies are. A competent CDW management manual that is suited to a specific local setting is therefore needed, as well as more detailed performance monitoring systems for CDW management. Further research into closed loop CDW materials is necessary for a circular economy. This suggests that instead of being dumped in landfills, waste products should be used and recycled as resources in future life cycles. Regional CDW management will also take a substantial turn toward the reverse logistics network with uncertainties in numerous factors (such as the quality of recycled products, recycling rate and cost, and demand and supply rates) or goals (such as social, environmental, and economic advantages). When assessing CDW treatment methods, not enough attention has been paid to social sustainability; instead, the advantages of recycling CDW's economic and environmental benefits have received attention. Future study should therefore concentrate on creating a method that includes a framework, indicators, categories, and assessment indices for assessing social sustainability. A thorough economic, social, and environmental analysis of CDW diversion activities also needs more research. For mixed waste, which consists of numerous components with different life spans and distributions, there is an area of research needed in the use of material flow analysis, which makes data collection and analysis more challenging. To do thorough research on a wide range of materials, it is recommended to combine a variety of data collection methods, sources, and data processing approaches. Further study is advised on figuring out the long-term effects of material stocks and flows on the environment and the economy. Most of the recent research has been on waste treatment and disposal, with little effort put towards preventing the creation of CDW from an early design stage. The attitudes and actions of stakeholders as well as financial incentives have an impact on the CDW generation. However, only a small number of studies have been conducted to determine the impact of using financial incentives/penalties (such as a disposal charging system) to reduce waste generation.

8. Conclusion

The circular economy management approach shows potential in meeting the objectives of effective waste management and eco-friendly construction. This strategy focuses on the necessity of decreasing waste creation, advocating for the reuse and recycling of materials, and integrating successful waste management techniques in construction and demolition processes. The construction sector stands to make a meaningful impact on reducing its environmental footprint and contributing to the transition to a more sustainable future by following this approach. All stakeholders, such as architects, contractors, developers, and companies, must collaborate and engage for the effective implementation of a circular economy management strategy. Policymakers need to enact robust laws and offer incentives to encourage sustainable practices. Furthermore, educational initiatives and awareness campaigns should be established to encourage all stakeholders to embrace sustainable practices. The circular economy management strategy provides a comprehensive solution to tackle the issues surrounding construction and demolition waste management. Collaboration in implementing this approach can lead to environmental improvements and economic advantages for all involved, ensuring a sustainable future for future generations.

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