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A NARATIVE REVIEW OF CONSTRUCTION WASTE GENERATION AND MANAGEMENT AND EXPLORATION OF EFFECTIVE STRATEGIES FOR MANAGING CONSTRUCTION WASTE IN BANGLADESH

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ABSTRACT

This study aims to investigate the global landscape of construction waste management, assess current disposal practices, and suggest feasible strategies for implementation in Bangladesh. The results of this paper outline the advantages and disadvantages, the harmful effects of mismanaging these methods, and recommendations for promoting sustainability and highlighting the significance of construction waste management. Construction waste refers to the byproducts generated from the construction, renovation, and demolition of structures that utilize concrete as a primary material. A narrative review has been conducted to examine the current state of construction waste management across various countries and then effective waste management strategies for Bangladesh has been identified. The construction industry in many areas consumes large quantities of natural resources and generates substantial amounts of waste. This waste, referred to as construction and demolition (C&D) waste, is a combination of inert and non-inert materials produced during activities like building, excavation, renovation, demolition, and road construction. Inert materials include substances such as soil, earth, slurry, rocks, and broken concrete, while non-inert materials encompass metals, wood, plastics, and packaging. Effectively managing construction waste has become an important environmental issue in many parts of the world. As a developing nation, Bangladesh is experiencing rapid growth, with major infrastructure projects such as the Padma River Bridge and others in progress. However, the issue of construction waste generation and management remains a critical concern that is frequently neglected. Although there is some data available on general solid waste management, there is a lack of specific information regarding construction and demolition waste, making it challenging to predict and manage future waste levels effectively. A large portion of construction and demolition waste ends up in landfills, on roadsides, or in unauthorized dumping areas, with only about 2% being recycled through local scrap dealers and unregulated recycling operations according to our findings. The study provides a basis for future research on construction waste generation rates, emphasizing the necessity of further exploration to create a detailed database inventory.

INTRODUCTION

Construction waste consists of materials that are discarded during the building, remodeling, and demolition of structures and infrastructure. This waste can range from concrete, wood, steel, and drywall to hazardous substances such as asbestos. The generation of construction waste is a major concern due to its significant effects on landfills, environmental pollution, and the depletion of natural resources. Construction and demolition (C&D) waste is significantly burdening landfill systems worldwide. In the European Union, construction waste accounts for 31% of total waste, while in China, 40% of municipal solid waste is C&D waste. Hong Kong also faces challenges with landfills, as a substantial portion of waste (23%) is from construction.(Chowdhury et al., n.d.). The inefficient landfilling of C&D waste leads to resource waste and severe environmental impacts, such as air, noise, and water pollution, as well as loss of efficiency due to additional costs and delays in cleaning. Global landscape of construction waste management suggest that C&D wastes are mostly disposed at landfilled sites across different countries around the world. Since the industry cannot sustain itself if the resources it relies on are exhausted, effective management of construction and demolition waste (C&DW) is essential.

The construction sector in Bangladesh is governed by various regulations, including environmental protection, energy efficiency, safety, taxation, and public procurement. Sustainable and environmentally friendly construction practices are crucial for the country's balanced development. However, construction waste management is poorly practiced in Bangladesh, despite the country's rapid construction growth. Timely steps are needed to implement effective strategies for better waste

management. Urban areas in Bangladesh generate around 16,015 tons of waste per day, projected to rise to 47,000 tons by 2025. (Chowdhury et al., n.d.) This highlights the need for detailed research and effective waste management strategies in construction.

CONSTRUCTION WASTE GENERATION AND THEIR IMPACTS

Waste in construction refers to inefficiencies that lead to excessive use of resources such as materials, labor, equipment, or capital beyond what is necessary. This includes material losses, unnecessary work, delays, rework, poor quality, safety issues, inefficient transportation, improper methods or equipment management, and poor constructability. These issues add costs without adding value to the project (Nazech et al., n.d.). Construction waste at sites can be categorized into physical and non-physical types. Physical waste refers to material losses, such as damaged items that cannot be repaired or reused, or materials lost during construction activities. In contrast, non-physical waste pertains to cost overruns and delays in construction projects, representing losses in terms of money and time rather than tangible materials (Foo et al., 2013). Construction waste generates at various stages of a project lifecycle from various sources. These stages includes Pre-Design Phase (inadequate project planning, incomplete design briefs, and poorly detailed documentation), Design Phase (Last-minute design changes of Drawings, Use of non-standard and low quality materials, Inadequate designer experience with construction sequences), Construction Phase (Inappropriate material storage, Inadequate material handling, Accidents due to negligence, Damage during transportation) (Domingo, 2015).

The rapid increase in construction activities driven by population growth and urbanization in many regions worldwide produces significant amounts of construction waste. The construction industry consumes 35% of global energy production and contributes 40% of carbon dioxide emissions into the atmosphere. It is also the largest user of raw materials sourced from natural resources. Furthermore, the building construction process generates material waste that adversely affects the environment. (Luangcharoenrat et al., 2019). Impacts of construction waste were identified and classified as economic, social, or environmental groups as per (Tafesse et al., 2022).

a) **Economic Impacts:** Construction waste significantly contributes to project cost overruns, as materials need to be replaced, reworked, transported, and disposed of. reduces profitability by increasing costs associated with material wastage. This impacts the financial stability of construction firms, often leading to business failures, especially in developing countries.

b) **Social Impacts:** Construction waste significantly impacts communities, particularly in health, safety, and the environment. Key issues include public health and safety risks, traffic congestion and diseases linked to air pollution. Lesser but notable issues include flooding from debris blockages and disputes among construction parties.

c) **Environmental Impacts:** Construction waste significantly pollutes the environment by releasing chemicals and hazardous materials. This issue is widely recognized as a major environmental impact, with construction activities contributing over 33% of global CO_2 emissions. Construction projects consume approximately 40% of natural resources and energy, posing a substantial environmental burden.

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Table 1 Various types of C&D waste and their Sources of Generation (Bakshan et al., 2015)

Waste Substances	Sources of Waste
Concrete	Site engineers order extra material to account for losses during handling and pumping, testing requirements, and any excess material left in the mixer truck as wastages
Steel	Waste from cutting and bending reinforcing bars is often sorted on-site and resold to secondhand buyers or recycling companies, such as in China and Hong Kong. Due to their economic value, steel waste quantities are typically recorded in project data.
Wood	Wood waste in construction primarily comes from deteriorating formwork, which is often discarded after repeated use.
Masonry Blocks	Masonry block waste is mainly caused by on-site cutting to fit dimensions and breakage during handling.
Plaster	Plaster waste is generated during the application of cementitious mortar in layers on walls and ceilings.
Tile	Tile waste is mainly caused by cutting tiles to fit dimensions and breakage during handling.

CONSTRUCTION WASTE MANAGEMENT: GLOBAL LANDSCAPE

Construction and demolition activities, along with natural disasters, result in the generation of large amounts of waste materials. Worldwide, approximately 35% of the construction and demolition waste (CDW) produced is sent to landfills without undergoing any treatment. (Menegaki & Damigos, 2018). Effective construction and demolition waste (C&DW) management is crucial to minimize its harmful environmental impacts. However, despite the availability of well-developed strategies, the implementation of these strategies remains inefficient. This inefficiency is largely due to a lack of understanding of the key factors that play a vital role in effective C&DW management. However, it is evident that over 75 % of what the construction industry generates as waste has a residual value, and therefore could be recycled, salvaged and/or reused. (Yeheyis et al., 2013). There is a growing recognition of the need for comprehensive and integrated waste management systems, technologies, rating systems, and policies. Due to rising C&D waste volumes, landfill shortages, and the long-term negative impacts of disposed C&D waste, sustainable waste management is becoming crucial to protect public health and the environment.

The following table is arranged according to C&DW type, generation, and disposal method. During the study, it was found that, in most of the waste disposal methods, the ultimate destination of the waste is landfills. Recycle rate of waste is quite low in most of the cases. Countries like Hong Kong implemented Public Fill Reception Facilities for inert wastes, in which areas where construction and demolition (C&D) waste, specifically public fill, can be collected and temporarily stored for recycling or disposal.

Table 2 Waste type, generation, and disposal method collected from articles of different countries.

Country/Region	Type of Waste	Waste Generation Rate	Waste Management Method	References
Dhaka, Bangladesh	With respect to construction area, 302.4 kg/m² for concrete, 129 kg/m² for bricks, and 93.4 kg/m² for mortar	1.28 million tons per year (In the fiscal year 2016-17)	Most waste ending up in landfills or unregulated locations and only 2% being recycled	(Haque et al., 2024), (Habib et al., 2022)
Hong Kong	Inert waste (Concrete, Bricks, Stone, Tile), non-inert waste(Wood, Plastic,Metal), Solid Waste (25%)	1215940 Tonne/year (in 2011)	Landfill Disposal (Non-inert waste), Public Fill Reception facilities(Inert waste)	(Lu & Tam, 2013)
Thailand	Concrete and Bricks (46%), Gypsum (6%), Metal (1%), Paper and Plastics (5%), Insulation(2%), Wood (14%), Others (26%)	1.1 million tons annually on average	Landfill Disposal and mostly improper dumping of waste in uncontrolled sites. Only 7% of Municipal Solid Waste is recycled.	(Kofoworola & Gheewala, 2009)
Malaysia	Concrete (12.32%), Metals (9.62%), Bricks (6.54%), Plastics (0.43%),Woods (69.10%) andothers waste (2%)	Approximately 25,600 Tonnes daily	Landfill Disposal (10-30%), Recycle (5%) and mostly illegal dumping of waste.	(Nagapan et al., n.d.), (Papargyropoulou, n.d.)
Spain	Concrete (12%), Ceramics (54%), Stone (5%), Asphalt (4%), Wood (4%) Metals (2.5%), Plastic (1.5%), Garbage(7%), Aggregates (4%), Others(4%)	39.27 million tons (as per 2010)	Landfill Disposal/ Incineration (approximately 80% of waste), Recycling or Reusing (approximately 20%).	(Llatas, 2011)
United States	Concrete (70%), Wood (7%), Drywall & Plaster (2.5%), Steel, Brick and Clay Tile, Asphalt	534 million tons annually (as per 2014)	Landfilling (30%), Recycle of waste (70%)	(Menegaki & Damigos, 2018), (Aslam et al., 2020)
Canada	Municipal solid waste (50%). Key components include wood, asphalt, drywall, concrete, masonry, metals, plastics, and more	About 9 million tons of C&D waste annually	Landfilling (27%), Dumping and Recycle rate of waste is quite low	(Yeheyis et al., 2013)
China	Mostly Timber formwork; also Concrete, Steel Bar, Brick & Block, Mortar, Tile.	About 2500 million tons annually (as per 2015)	Mainly Landfilling, Recycle rate is about 3-10%	(Li et al., 2013) (Aslam et al., 2020)

RESULTS AND DISCUSSION

Globally, Construction waste constitutes a significant portion of solid waste, with substantial amounts reported annually in different countries around the world. This waste impacts the environment through land use for landfills, pollution, and the depletion of natural resources. With approximately 35% of Construction & Demolition Waste(C&DW) globally ending up in landfills, effective management is critical to minimize environmental harm and sustain resources for future industry needs.(Kabirifar et al., 2020). Global landscape replicates that recycle rate of construction waste is quite low across different countries of the world. The following bar chart shows recycle rate of waste with respect to total C&D waste generated in various countries.

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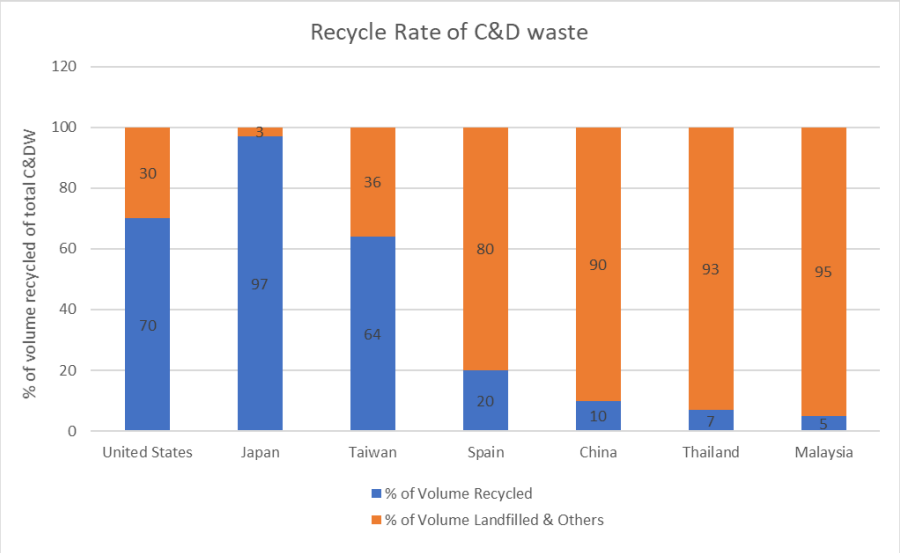

Figure 1 Recycle rate of waste with respect to total C&D waste generated in various countries.

The bar chart & Table:2 shows that most of the countries has lower recycle rate of waste except United States, Japan & Taiwan. In Bangladesh, construction waste management (CWM) is not widely practiced due to a lack of awareness and adoption of sustainable methods by stakeholders. This results in significant waste generation throughout construction projects, contributing to issues such as overburdened landfills, the use of uncontrolled dumping sites, and contamination of waste. A significant amount of construction and demolition waste is disposed of in landfills, along roadsides, or in unauthorized dumping sites, with only approximately 2% being recycled through informal scrap dealers and unregulated recycling processes.

Construction waste should not directly dispose however it needs to pass through several processes before being disposed. It should be treated according to proper waste management hierarchy as proposed by (Yuan & Shen, 2011). To address C&DW issues, the 3Rs strategy—reduce, reuse, and recycle—is central to C&D waste management.

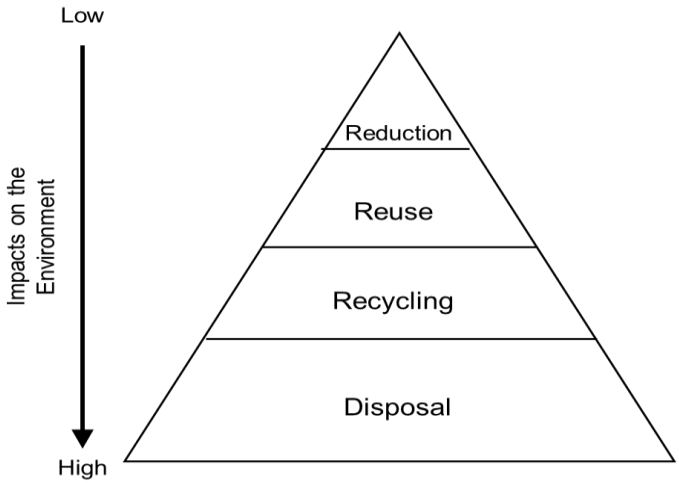

Figure 2 The C&D waste management method hierarchy. (Yuan & Shen, 2011)

The 3Rs strategy—reduce, reuse, and recycle as per (Yuan & Shen, 2011) described as,

a) **Reduction:** minimizes waste generation and associated costs.
b) **Reuse**: involves repurposing materials with minimal processing (e.g., timber formwork or using materials for new functions).
c) **Recycling:** transforms waste into new construction materials, reducing resource demand and preserving land.

The waste management hierarchy suggests that waste should be reduced, reused, recycled then be disposed to proper dumpsite like landfill. While construction waste cannot be entirely avoided, it can be managed by reusing materials like broken bricks and concrete for site access roads and sorting other waste for recycling. Materials such as wood, steel, and plastic can be sent to recycling facilities. These measures help reduce landfill disposal and extend landfill lifespan.

Bangladesh lags behind developed countries in CDW management practices. To improve, the construction workforce must change attitudes and perceptions. Recycling practice of C&D waste is very much inadequate. Effective CDW management requires overcoming significant challenges through coordinated measures tailored to local cultural, socio-economic, environmental, and political contexts. A multi-faceted and long-term approach is essential for success.

CONCLUSION

This review paper highlights several approaches to minimizing Construction & Demolition Waste (C&DW) generation and emphasizes the importance of economical and environmentally friendly disposal methods. It underscores that improper management of MW can have significant negative impacts on the environment. Improper management of construction waste leads to environmental pollution (soil, water, and air contamination), health hazards, resource wastage, increased economic costs, aesthetic degradation, and contributions to climate change. Adopting recycling, reuse, and proper disposal practices can help mitigate these negative impacts. The study's findings make it clear that medical waste management is not carried out by advised standards in Bangladesh. This study identified effective waste management practices that are not currently implemented in Bangladesh. To maximize their benefits, it is crucial to change the attitudes and perceptions of the construction workforce regarding waste management. Our study has focused on the generation rate of C&D waste and its management system in some areas around the world. The study outlines the advantages and disadvantages of various available methods, assisting in the selection of an appropriate method for specific type of comstruction waste.

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