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A Review of Strategies to Prevent On-Site Construction Waste

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Abstract: One of the most crucial issues that increase building profitability is the adoption of a proactive strategy to prevent construction waste. The rise in construction waste primarily leads to inadequate waste management strategies in construction projects. This paper will discuss the roots of construction waste, current waste reduction strategies, and lastly the possible use of waste management. Furthermore, the key environmental priority for this issue should be to control and mitigate construction waste generation. The purpose of this study is to provide prevention measures, and the rising tide of public awareness is all conspiring to modify the face of waste. This research suggests strategies of 5R principles that can result in on-site waste prevention. Also, the construction industry must develop appropriate strategies for managing on-site construction waste. The outcomes of this study will assist academics in furthering their knowledge of important management strategies for reducing on-site construction waste.

Keywords: Construction waste prevention, strategies of the 5R principle, landfill site effects, environmental impact

1. Introduction

The construction industry is critical to any country's socioeconomic success. Because of rising living standards, infrastructure demands, changing consumption habits, and natural population growth, the building business is booming today. This expansion has resulted in a large increase in waste production including all materials discarded, whether or not they are later recycled or disposed of in a landfill. Waste generation rates for residential and commercial activities can be used to estimate the impact on the local waste stream [1]. As reported by Johansson & Corvellec, [2], waste management is a method that entails changing product manufacturing or customer behavior in terms of buying, utilizing, and reusing things. Waste reduction eliminates the need for recycling and disposal by reducing waste at its inception. All waste generators have at least some potentials to implement waste preventive measures that reduce waste generation. Construction waste prevention can take place at many stages of a project's life cycle, and all supply chain stakeholders, including clients, designers, contractors, and suppliers, have opportunities and responsibilities [3]. Afolabi et al., [4], highlighted that construction material resources undergo several transformations before being used in civil and building structures. These transformations highlight the shortcomings of construction materials in that not all of these entities are used for the purposes for which they are requested [5]. Waste prevention generally provides substantial potential advantages for efficient waste management by addressing the issue of resource savings and landfill limitations. While this is true, the practice still needs a lot of improvement before realizing its full potential. Although technical development has aided in attempts to protect the environment and conserve natural resources, trash creation has continued to rise, in part due to a lack of individual participation in waste management programs [6]. This study

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posits that construction waste may exist before the construction operation begins, despite the fact that construction waste is generated during the construction delivery process.

2. Literature Review

2.1 Construction Waste Prevention

According to [7], the meaning of construction waste prevention, is a term used to describe any material that had to be transported from the construction site or used on the site itself other than the intended specific purpose of the project due to damage, excess, or non-use, or that could not be used due to noncompliance with the specifications, or that is a by-product of the construction process [8]. The goal of waste prevention is to reduce the amount of trash produced at the source. It entails examining your manufacturing, processing, packaging, storage, recycling, and disposal operations to find ways to manage waste and reduce its environmental impact. Waste prevention is also known as waste minimization and source reduction [9].

Essentially, construction waste must be pre-treated method before being disposed of in landfills. It must be handled according to the accurate waste management hierarchy illustrated in Fig. 1 [10]. There are five R concepts that waste must go through before it can be dumped in landfills. The waste management criteria began with waste reduction, reuse, recycling, recovery, and finally, disposal in landfills [2]. The construction waste management method will eventually end up in a landfill. As a result, it is critical to effectively implement construction resources in order to reduce waste generation.

Fig. 1 - Waste Management Hierarchy. Source Google: [11]

2.2 Strategies of Reduce, Reuse, Recycle, Recovery, and Disposal

Corvellec [2] presented the 5 R's, four actions that should be taken before 'recycling,' if possible: reduce, reuse, recycle, recover, and disposal. Including this methodology in your company's waste reduction and recycling efforts will reduce landfill waste and help you take your recycling program to the next level. In waste management, there are five R principles that waste must follow before it can be disposed of in landfills. The waste management criteria began with trash reduction, then reuse, recycling, recovery, and finally landfill disposal [12].

2.2.1 Reduction

Waste prevention refers to practices that goal to reduce waste generation at its source. This ensures that waste is minimized before it becomes a big problem. It could be done in a construction project by reducing or avoiding any activities and processes that generated waste [12]. Minimizing techniques can be implemented as early as the planning

phase and continuously embedded throughout the construction lifecycle. The best and most efficient way to manage construction waste is seen to be construction waste reduction. Prior to implementing the reduction method, it is crucial to determine the variables that affect waste generation. These factors included modifications to the design, poor material handling, labor shortages, inadequate management planning, unfavorable site circumstances, the purchase of building materials, and external variables (weather) [13].

2.2.2 Reuse

The next process to consider is reusing some of the building's waste materials, such as using broken brick and concrete as a sub-grade for an access road to the construction site because waste is not entirely avoidable [14]. Reuse is further described as the use of construction materials, such as wood formwork, more than once, whether or not for the same purpose. The act of gathering used, re-used, and underused objects that were once regarded as waste but have been turned into useful new items is known as a recycling plan [15].

2.2.3 Recycle

Construction trash is separated using the on-site recycling method and is subsequently used as a raw material in other construction processes. Construction waste is being separated and transported to other companies using off-site recycling techniques so that it can be used as raw material. An effective recycling programmer in the building industry requires government support. Recycling will lessen its negative effects on the environment while also ensuring that the materials are still available in the future [16].

2.2.4 Recovery

Afolabi [4], described recovery as the step of removing materials or components from the waste stream so that their original form can be used again exactly as it was. Recovery can reduce the quantity of waste that is dumped in a landfill. Metal waste recovery in Germany has benefited from burning technology. Although prevention is the greatest strategy to manage trash, recycling and reusing do not stop the creation of garbage.

2.2.5 Disposal

Nagapan [1], identified that many countries, however, dispose of construction waste in landfills. In Malaysia, for example, the Department of National Solid Waste Management indicated that the country had approximately 289 landfills. International efforts by governments, businesses, and academic institutions to promote waste reduction thinking in construction have met with inconsistent adoption. The next step should be to ensure that as much construction waste as possible is reused and repurposed if waste generation cannot or can only be partially controlled. According to one study, recovery reduces waste and GHG emissions, saves energy, and reduces the use of raw materials.

3. Challenges of Waste Prevention Via Landfill Sites

Waste reduction is considered by politicians and environmental organizations as the most sustainable way to reduce the environmental impact of waste generation. However, waste reduction is the product of millions of choices made by people in their everyday lives, not only administrative activity [17]. Despite the fact that waste prevention programmers can come in a variety of shapes, including awareness-raising and educational activities, eco-design, extended producer responsibility, green public procurement, labeling and certification, marketing, favorable and unfavorable financial stimuli, prevention targets, product standards, reusing, technology standards, or voluntary agreements. The phases of a product or service's lifespan, such as design, extraction, production, distribution, usage, waste, and end-of-waste, can also be referred to as waste protection [18].

Bremere [16], discussed the unique challenge for waste minimization or disposal in regard to material composting and policy execution is the existing control focuses on trash volumes rather than the environmental performance of a waste solution. For example, if recycled material replaces poor materials or cannot substitute virgin material at all, the general environmental advantages of recycling are relatively low, if introduce at all. In the context of a circular economy, this could imply that simple waste material reuse assuming regulatory approval may be prioritized over the solution with the greatest environmental benefits. While LCA provides a methodology that may directly deal with this issue, waste LCA studies also struggle with figuring out how to account for resource quality and displacement in addition to material quantities [14].

4. Environmental Impacts

Environmental effects are a result of construction activities throughout the development life cycle. These effects are felt during the building phase, the usage phase, and the eventual demolition when a structure reaches the end of its useful life. Despite being relatively brief in comparison to the next phases of a building's life, construction has a number of significant environmental effects. Concern about the effects of construction activities on human and environmental health is also growing [19]. According to Chen et al. [5], construction-related pollutants and risks should classify into seven broad categories: dust, toxic gases, sounds, solid and liquid wastes, fallen objects, ground movements, and so on. Shen and Tam [2] stated the extraction of environmental resources such as fossil fuels and minerals; the expansion of consumption of generic resources such as land, water, air, and energy; the production of waste that necessitates the consumption of land for disposal; and pollution of the living environment with noise, odors, dust, vibrations, chemical, and particulate emissions, and soli. Chen et al. [6] categorized construction impacts into eight categories: soil and ground contamination, subterranean water contamination, construction, and demolition waste, noise and vibration, dust, hazardous emissions and odors, wildlife and natural feature impacts, and archaeological impacts. According to Newaz, [20], common negative effects of building operations include trash generation, mud, dust, soil, and water contamination, damage to public drainage systems, plant destruction, visual impact, noise, traffic increase, parking space shortage, and harm to public space. Zolfagharian et al., [21], suggested the many areas of environmental consequences. Two of the respondents called Wang, & Tam, [22] generally agreed that the top three groups of impacts are:

- Resource consumption.
- Effects on biodiversity.
- Local issues.

4.1 Resource Consumption

Sakai, [23], stated the environmental effect category of resource consumption received the highest overall rating from all respondents. Within the category of resource consumption-related environmental consequences, all respondents mentioned above cited raw material consumption as the first significant environmental impact of construction activities in Ghana. Building construction uses 25% of the world's virgin wood and 40% of the world's raw stones, gravel, and sand annually, according to the World Watch Institute (2003). Additionally, it uses 16% of the water and 40% of the energy each year.

4.2 Effects on Biodiversity

Zillante, [24], explained that the impact on biodiversity is the third most significant environmental impact of construction activities, according to the three categories of respondents. The loss of edaphic soil, disruption of ecosystems, and removal of vegetation are among the environmental repercussions impacting biodiversity.

4.3 Local Issues

Zacho, [25], discovered that local concerns were collectively ranked as the third most significant environmental impact of construction activities by architects, quantity surveyors, and structural engineers. The most important environmental impact of building operations in this group, according to architects, is noise and vibration generation. Quantity surveyors and structural engineers ranked noise and vibration creation as of the utmost importance.

5. How to Prevent and Reduce Waste

Ahankoob, [26], mentioned preventing waste from being produced in the first place and reducing it as much as is practical are the two most effective ways to lessen the environmental impact of building waste. This lowers the need for reuse, recycling, and disposal, which saves money. Though it will be a challenging goal to accomplish in the building industry, achieving "zero waste" will be a game-changing strategy for a planet in crisis. But by involving and dedicating all stakeholders to decreasing waste at the source and applying efficient waste management techniques through the reuse and recycling of materials and components, the industry may get closer to the "zero waste" ideal. Furthermore, waste is generated during the construction, alteration, and demolition phases of a building's life cycle. As a result of these construction wastes, many countries are facing serious environmental concerns. The generation of construction waste is dynamic. A study of the literature revealed no previous attempts to do solid waste and pollutants are produced at every stage of a building's life cycle for a variety of reasons and forecasting waste quantities is difficult [3]. According to Rani, [19], the US EPA, modification and demolition account for approximately 92 percent [%] of all construction and demolition waste. The initiatives to reduce, reuse, recycle, recovery, and disposal wastes created, are

often known as the 5R's of construction waste management. Construction wastes, in general, must be pre-treated before being disposed of in landfills.

According to Hutner, & Tuma, [27] the construction industry is waste-intensive with potential environmental consequences at every stage of the process, including raw material extraction, manufacturing, transportation, construction, and highly dangerous waste disposal. The decision to reduce and improve waste disposal is not only financially but also environmentally responsible. Companies are increasingly needed to contribute solutions to systemic problems, as putting responsibility on individuals has proven ineffective. Zhang, [18], explained the use of landfills has a negative impact on the environment. Companies that plan ahead of time and implement some of the tips listed above will make a significant difference in waste management on-site construction and in reducing the amount of construction waste disposed of in landfills. Moreover, construction waste is extremely hazardous to the environment. As a result, the construction industry must develop appropriate methods for managing construction and demolition materials that generate waste during construction activities. Using trash chutes to transport waste away from the site is one method of safe waste disposal [28]. Table 1 is the suggestion for reducing on-site construction waste by previous researchers.

Finally, this paper suggests the most suitable way to prevent on-site construction waste through the 5 R principles, such as reduction, reuse, recycle, recovery, and disposal.

Table 1 - Previous studies for strategies in preventing on-site construction waste

No	On-site waste prevention strategies	Code	References
P1	Human resources		[29], [30]
	Improved education/ awareness regarding on-site waste management of workforce or/and staff	A1	[9]
	On-site waste manager appointment	A2	[31]
	Appointment of laborers solely for waste disposal	A3	[32], [33]
	Preventing waste materials by labors	A4	[34]
P2	On-site construction strategies		[35]
	Keeping the site clean to reduce material loss and waste generation	B1	[36]
	Set up an effective communication line at the construction site to eliminate poor practices	B2	[37]
	Provide sufficient space to ease the management of C&D waste	B3	[38]
	Use of demolition and excavation materials for landscape	B4	[39]
	The time scale of the project can ensure effective waste reduction onsite	B5	[34]
P3	Material and equipment		[33]
	Using mechanical handling to reduce damage to the material during delivery (proper handling)	C1	[15]
	Proper selection of materials (e.g., avoiding fragile material being used)	C2	[40]
	Prevention of over-ordering of material	C3	[41]
	Prevention of double-handling materials	C4	[29]
	Just in Time Deliveries (JIT) ensure less material waste	C5	[35]
P4	Administrative		[15]
	Waste auditing to monitor and record on-site waste management	D1	[30]
	Standardization of design and material to improve buildability	D2	[32]
	Adequate supervision of waste management activities with clear instruction	D3	[35]
	Ensure fewer design changes during the construction process	D4	[41]
	Plan the layout of construction projects properly (site planning)	D5	[32]
P5	Regulation		[38]
	The use of a Site Waste Management Plan (SWMP) is important.	E1	[42]
	Contractual clauses to penalize poor waste performance	E2	[40]
	Usage of off-site products and components (low-waste construction technology)	E3	[30]
	Additional tender where waste initiatives are to be implemented	E4	[41]
	Issuing waste management levels from owners/clients to contractors	E5	[42]

6. Conclusion

Waste is a major environmental, social, and economic issue that is becoming more prevalent. Waste prevention encompasses a variety of policy options and has numerous benefits. It reduces the amount and toxicity of waste before recycling, composting, energy recovery, and landfilling become viable options. Waste prevention also includes measures to mitigate the negative effects of waste generation on the environment and human health. The waste

minimization prevention campaign is a top priority in order to meet all of the Municipality's waste production reduction targets. This Review evaluated the current techniques of waste reduction at construction sites in terms of material waste, as well as some actions that have been done to lessen the impact of material waste. When it comes to dealing with construction waste, illegal dumping has now surfaced as a big concern. To attain these aims, construction waste should be reduced, reused, recycled, and appropriately disposed of, and regional and national policies and guidelines should be developed and executed. Waste management will benefit the environment as well as the economy. Instead of cutting new materials, repurpose old ones. To limit waste disposal, it is vital to employ recycled materials as much as feasible on construction projects.

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