Identifying the Root Causes of Effective Waste Management to Reduce Waste to Landfill

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Abstract - The building industry is the largest producer of trash that is disposed in landfills and consumes a considerable amount of the earth-mined minerals. In all phases of building construction, this research tries to identify the fundamental variables that will make an efficient framework for waste-reduction solutions. Due to the harmful environmental impacts of waste generation as well as the financial advantages connected with its reduction, the sector's waste intensity has been a significant cause of worry around the world. According to the guidelines of the qualitative technique, the study blended primary and secondary approaches at every level. Information was acquired early on in the study by reading and evaluating the literature. The results of the critical literature review were used to build a questionnaire, which was then assessed using structured interviews with experts in the subject. In order to conduct a comprehensive investigation into the key elements of waste minimization, the participant responses were analyzed, compiled, and presented as conclusions. Professionals must possess expertise in waste behavior, in-depth building knowledge, and interprofessional collaboration ability given how important design is for waste minimization. By taking into consideration its essential elements for developing waste-effective projects, such as waste-efficient procurement, supplier relationships, and waste competent bill of quantities, the procurement technique might promote waste reduction. Waste may be minimized during building operations in a variety of methods, including modular construction and offsite technologies, contractual requirements, and maximizing material reuse. By providing methods to cut trash, this research hopes to assist construction businesses in decreasing their use of landfills. Additionally, businesses may find that waste reduction offers significant cost benefits in the present economic context.

Index Terms - Sustainability, Challenges, Site Planning, Construction Waste Management Strategies, Landfill, Procurement.

I. INTRODUCTION

Unwanted stuff is often referred to as waste. Its purpose has been fulfilled, and the substance is no longer usable in its present state or location. One third of all garbage, or 36.4% of total material waste (120 million tonnes), is generated by the building sector. When numbers like these are considered, it is clear why the construction sector has a bad reputation for generating unneeded trash.

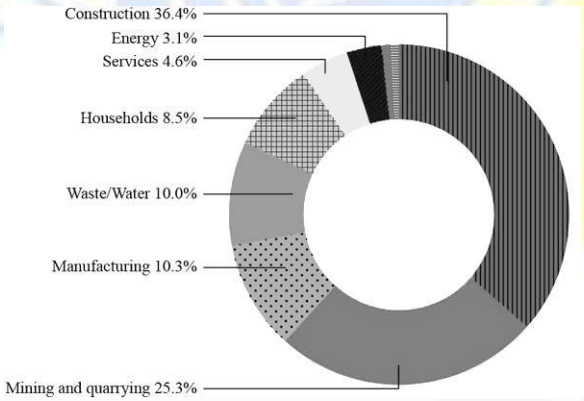


Fig.1 Percentage of waste produced

The strategy for waste management typically entails working out how to move and dispose of the waste utilizing a variety of techniques. The majority of the waste has traditionally been disposed of in landfills. The availability of land made this a less expensive alternative for disposing of waste in the past, but things have changed.

The amount of waste we create and the amount of resources we use on Earth can both be measured according to the Global Footprint Network. We already consume resources and take in waste at a rate that is 75% higher than what the world can sustain in the long run. The number is still increasing. If significant adjustments are not done, it is anticipated that global garbage creation would increase by 70% yearly between 2018 and 2050, which will make the problem much more challenging.

There are a lot of significant development-related aspects that are impacted by waste management that is environmentally friendly. Solid waste management, on the other hand, is frequently overlooked when creating livable, healthy, and inclusive cities and communities. Governments and the corporate sector must move rapidly to address waste management for the benefit of their population and the environment. The need to understand the basic principles of waste generation and management in the construction industry served as the driving force behind this study. It also examines how the circular economy and the lean concept impact global development and waste.

The volume of waste is increasing so quickly that other waste management techniques must be employed. In order to encourage recycling and deter landfill use, the landfill fee was implemented in 1996. The tax rates have since been raised, and additional hikes are anticipated. Initially set at a low level to optimize their behavioral effects, the tax rates have now been raised. This tax has an effect on construction. The DETR found that only 24 percent of construction debris was dumped in landfills, down from 51.2 percent in 2000. In June 2008, the "Strategy for Sustainable Construction" was created. Positioning ourselves as global leaders in sustainable construction is the overarching goal of this collaborative government and industry plan. The strategy puts a lot of focus on waste reduction, with one of the key objectives being to reduce the amount of construction, demolition, and excavation (CD&E) waste that is disposed of in landfills by 50%. In order to help reach this goal, the research seeks to uncover the fundamental and key success aspects in a building project that contribute to successful overall waste management.

This study's major goal is to identify the most efficient ways for building projects' design, construction, and procurement. A few of the many operations that make up the construction sector include building construction and the development of infrastructure facilities. Construction projects involving structures are the only ones that fall under the project's scope.

Although waste was not examined from a lean perspective, the research's theoretical underpinning was the philosophy of lean techniques. Lean takes time loss, as well as waste from a material and non-materials frame of reference, into consideration. It is interesting that just the waste from materials aspect has been covered given that the study's objective is to improve the environmental performance of the building sector. Since physical waste tends to increase the amount of waste that ends up in landfills and has a big influence on the environment, no effort was made in the study to examine non-physical waste in this situation.

II. LITERATURE SURVEY

Waste in the building industry is a topic that has been covered in a lot of literature. According to sustainable waste management techniques that have been thoroughly explored in the literature, waste prevention is the ideal option when compared to reductions, reusability, repurposing, and landfilling.

During building, it's important to understand the sources of trash. The four-primary waste-producing processes in the construction industry that have been studied in the literature are design, operations, material handling, and procurement. Waste is generated at every stage of building, from design through demolition. According to the hierarchy of waste management, waste can be avoided during the stages of design, procurement, and construction. The causes and solutions for each of these phases will be examined in this study.

(1) Design

Architects believed that contractors misinterpreting the architects' drawings and specifications, as well as on-site and operational activities, was the main cause of waste produced during a building project, as Osmani et al. (2007) found. In addition, it was found that designers would only collaborate with construction companies on this process if clients offered incentives, especially monetary ones, and that minimizing waste during design was seen as an ad hoc activity.

Processes to assist decrease waste during the design phase have been identified by WRAP (2008b). Designing for site conditions and avoiding design variations are two of them. To do so, one must understand the client's needs and take into account the clearly defined ideas. Osmani (2006) asserts that the main sources of waste throughout the design process were nearly usually late alterations brought on by client requests and technical variations. Their findings confirm the requirement for fewer design modifications. The intricacy of buildings has an effect on the number of design revisions as well. It is more likely that modifying one feature of the design will call for redesigning other aspects of the design due to higher component integration (Keys et al., 2000). WRAP (2008a), which promotes design standards to reduce complexity, backs this up. All stakeholders concerned should be adequately and effectively informed if design adjustments are necessary. Most importantly, it is important to keep in mind that waste reduction opportunities are greatest during the design process.

(2) Procurement and Material Handling

According to Jones and Greenwood (2003), damage brought on by poor management, inadequate storage, and weather is one of the main causes of waste. Waste might come from inadequate storage on site. Contractors are unaware of the advantages of providing suitable storage. Furthermore, pricey supplies should only be delivered on-site when necessary, and there should be secure off-site storage.

Storage of materials can be replaced with just-in-time (JIT) deliveries. It makes it possible to cut back on expenses, flaws, and overall building time (Akintoye, 1995). Contractors and suppliers can develop the trust and discipline necessary for JIT production through long-term relationships and a willingness to share information. This highlights how JIT production in the construction industry requires supply-chain management. The essential tenet of supply chain management, according to Vrijhoef and Koskela (1999), is to acknowledge the interconnectedness of the supply chain and then enhance its structure and components, such as business process integration.

One method for facilitating supply-chain integration is collaboration. a systematic process used by companies to draft business contracts that are advantageous to both sides, whether they are for short-term initiatives or long-term partnership prospects. According to WRAP (2008a), supply chain participation can also be used to decrease material packaging, motivate suppliers to cut waste at the source, and support the development of "take-back arrangements" that allow the construction company to return extra materials to his suppliers.

(3) Construction

The traditional building method, which involves a lot of cast-in-situ procedures, is another source of material waste. The studies support the use of modular construction methods because it is found that prefabrication generally results in less waste than conventional construction, particularly when it comes to the processes of concreting, plastering (which can be reduced by up to 100% through prefabrication), and rebar fixing.

Prefabrication, according to Jaillon (2009), has a number of further benefits, such as speeding up project completion and improving health and safety. Material handling has also been identified as a construction stage waste contributor. To help contractors better understand their inventory management action plan, which should contain thorough records of material handling, a waste level monitoring system should be set up.

III. METHODS

To come up with a design that is appropriate for the study, the three primary categories of research design approaches—qualitative, quantitative, and mixed methods—were studied. In-depth analysis and conceptual frameworks are required for the research problem in order to be further investigated. To comprehend the viewpoints and impressions of industry professionals, an investigative sort of investigation was necessary. It appears that the statistical approach is inappropriate for the research issue. Therefore, mixed-method and quantitative research are inappropriate for this study.

Since qualitative research may be utilized to more thoroughly study the viewpoints of industry professionals in the construction sector regarding waste management, that strategy was chosen. In order to explain acceptable design, procurement, and construction techniques for a waste-effective construction process, it is essential to recognise the state of the construction industry today. Only a qualitative approach is able to achieve all of this.

It offers several points of view on the subject and aids in the formulation of hypotheses for potential future studies. Deeper investigation of issues will be beneficial to the research because it reveals novel concepts and different perspectives from those of the field's norms. This approach makes use of a range of tools for data collection, including critical literature reviews, structured interviews, and comprehensive questionnaires. It involves observing and assessing replies and written works in order to identify problems and present remedies. This strategy has been specifically developed to investigate the target audience's perspectives and how their behavior connects to the identified waste management problem. It develops theories by thoroughly examining small groups of individuals. Qualitative research yields data that are more descriptive than predictive, which was necessary to carry out this investigation.

IV. DATA COLLECTION

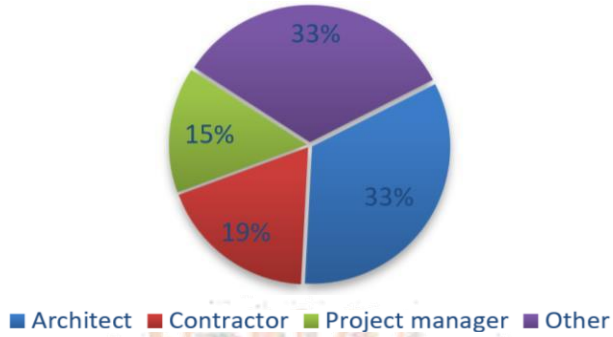
Structured interviews were chosen as the method for gathering qualitative data. In order to gather exploratory data for a qualitative research project, participants were given questionnaires and engaged in formal interviews (see sample questionnaire in appendix). Because they allow for the formation of unique concepts rather than requiring researchers to rank already identified criteria that might not be all-inclusive, these techniques are particularly essential for exploratory research (Wimpenny & Gass, 2000). This decision was made in order to gain more knowledge than the literature research had to provide on actual waste management methods utilized in project delivery on a regular basis. In order to gain a balanced viewpoint, it was decided to seek the opinions of the architect, procurement manager, and contractor—three significant industry actors that are involved in the majority of building projects.

The participants were informed of the purpose and parameters of the study before the interview. Three main components made up the interview. The respondents' ages, positions in the industry, levels of experience, and types of contracts were all covered in the first section, which was devoted to their personal information. Professionals from the construction business, including designers, suppliers, builders, project managers, and other specialists, provided a total of 30 responses. Participants with three to twenty years of experience were chosen from small to major design and construction firms. The majority of the specialists whose opinions were sought for are actively engaged in residential housing projects that are subject to design-build clauses in contracts.

The waste-reduction strategies used by their business were covered in Section 2 of the report. This was an effort to learn about the tactics currently being used to reduce industrial waste and the propensity of experts to do so. The purpose of the third portion was to gather in-depth knowledge from professionals regarding their perspectives on the underlying causes and how waste can be controlled more successfully by applying a few important elements. The comments gathered made it possible to pinpoint potential root causes, which laid the groundwork for formulating a thorough plan for efficient waste management in construction.

V. DATA ANALYSIS

Nine architects, four project managers, five contractors, three suppliers, and nine other construction specialists contributed to the 30 responses that were received.



The 30 structured interviews produced a large amount of data overall. The most crucial elements of the interviews were distilled down to those that weren't included in the literature study in order to prevent repetition.

The relationship between competencies and intended objective attainment in many project-based organizations in the construction industry is becoming clearer. Based on this, the study examined the greatest leadership skills for projects with low waste after examining the feedback from construction specialists. Additionally, a lot of first-hand information about the opinions of the industry experts was gathered through the interviews. Using this data, the primary underlying strategies for adopting waste management in the market were determined. The following factors were discovered as a result of the feedback's recurrent themes:

- Waste behavioural competency - Professionals' willingness to decrease waste.
- Knowledge of construction - related issues Contractors' commitment.
- Coordination between experts.
- Modern construction techniques.
- Reduced - waste documentation.
- Site that manages waste planning.
- Cultural change in the construction industry.

The research suggests that the root of the problem is a culture of inadequate collaboration and deeply ingrained fragmentation within the construction industry. The chapter covers the value of encouraging early collaboration and participation from all necessary specialists at all delivery phases.

VI. RESULTS

(1) Pre-Design

The client must require that waste prevention be given high priority in the project design, it has been established. The client's perspective needs to be modified by persuasion, promises of financial gain, environmental considerations, or the requirement to follow government planning standards.

According to studies, general waste reduction strategies should be considered from the outset of the design process. Unless there is a legal necessity, a large cost advantage, or a client demand, it is doubtful that this will receive more attention. It is crucial to stress in cost-benefit analyses that prevention reduces the amount of waste produced, which should lead to cost savings by lowering the expenses of treating or disposing of needless trash. Numerous architects have noted that choosing materials for endurance is a simple process. The majority of customers favor this trash management approach. It makes obvious that they would choose this approach because stronger materials will last longer, entail fewer modifications to the building, result in fewer inconveniences, and ultimately cost less money. Contractors assert that they are discouraged from investing time in environmental management because of the severe fines the customer imposes for schedule overruns. Reuse and recycling are made more difficult by the inability to separate garbage. But it seems that in order to better fulfill their social obligations, contractors need to be aware of both material and immaterial benefits. It is acknowledged that segregation is difficult in some situations, such as tiny enterprises or sites. Recycling garbage in these situations will eventually end up in landfills. If the architect used a more consistent strategy, accounting for the intricacies and expressing them as thoroughly as feasible, this problem might be handled. Additionally, by exploiting the contractor's knowledge of potential problems during construction, early contractor involvement could reduce complexity.

(2) Design

The data show that there are four critical processes involved in waste elimination. Standardization and dimensional coordination of construction elements, which includes factors like designing for standard supplies of building materials and optimizing space, constitute the main approach. By effectively implementing this crucial strategy, material offcuts—which have been identified as a significant factor in the production of construction waste—will be stopped. Collaborative design is the next important tactic for reducing waste, which necessitates early contractor involvement in the design process as well as efficient teamwork and communication. This tactic is crucial because it helps avoid the waste that results from rework, which is frequently caused by design flaws, design conflicts, delayed information transfer, and, among other things, poor design comprehension. It would be able to ensure that all stakeholders contribute

their expertise from the start of the design process through increased collaboration, which also helps to ensure a smooth exchange of information across the various trades.

Designing for contemporary construction methods is the third essential strategy for waste reduction. This plan necessitates knowledge of off-site design, prefabricated material standards, and volumetric modular design. Even though using modular building could significantly reduce waste production, it is essential to effectively design for contemporary construction methods. The fourth tactic is to cut waste by accurately and completely documenting the design process. Waste-efficient design documents have features such as error-free and constructible papers that offer enough details for waste-efficient building techniques.

(3) Procurement

One of the most important steps in cutting waste in building projects is the acquisition of resources. This is because materials are a significant percentage of project expenditures and a number of waste-producing elements might be connected to the procedures of acquiring resources. The study highlighted three crucial underpinning strategies to inspire waste prevention through material procurement practices. Low waste materials buy management has been identified as the first essential method for improving waste minimization through material procurement. It comprises the purchasing of products that produce little waste and the repurposing of resources in order to facilitate trash diversion from landfills. Additionally, it encourages the use of the JIT delivery method, in which items are brought to the job site as needed. Offcuts, materials breaking, and leftovers—all significant waste producers—can be stopped by the plan. Another technique for promoting waste minimization is called suppliers' alliance and commitment, and it requires materials suppliers to be heavily involved in project delivery processes. By taking part, a take-back program may be developed, and material sellers may be persuaded to be flexible by offering smaller quantities of supplies, preventing material offcuts and damage. The waste efficiency of the bill of quantities is cited as the third factor for decreasing waste through the materials procurement operations. This necessitates a precise and accurate material takeoff that ensures material overordering, is waste allowance-free, and is correct.

(4) Construction

During the construction process, important elements for avoiding waste generation were confirmed. An environmentally friendly project will reuse as much material as is practical while it is being built. efficient material separation, refraining from using certain materials, and efficient communication of material reuse techniques are necessary for this. The second reason that is a foundational element for waste-efficient construction projects is the site planning, which may significantly drive waste prevention. Site planning tools for promoting waste minimization include project specification reviews, site planning, and site waste management strategies. Another significant underpinning tactic for reducing waste during the construction process is the use of prefabrication techniques. These methods follow the principles of lean construction by utilizing precast elements and modules, the prefabrication technique, and other offsite technologies. By taking this action, waste from leftovers, material damage, and reworks might be reduced.

The abilities and dedication of contractors have been proven to be another strategy for encouraging waste prevention in construction projects. According to the report, successful waste management methods would be impossible without devoted and committed contractors. This is particularly true considering that a bad work flow could jeopardize previously produced work, requiring reworks and resulting in waste production. Contractors who are committed to reducing waste may also consider material reuse or secondary resources. However, legal and contractual provisions that penalize waste production and encourage minimization may encourage such a commitment. Waste minimization usually comes in second in construction projects. This is especially true given that the effectiveness of projects is assessed using metrics like time, quality, and cost. The study finds that by include waste minimization in key performance measures, considerable amounts of waste might be kept out of landfills.

Along with techniques for waste minimization in building projects, increased cooperative effort within the industry is a traditional method for preventing waste. Poor project stakeholder participation and fragmentation characterize the current situation of the construction sector. This results in information loss, a lack of communication, and blame-shifting rather than encouraging a collaborative work atmosphere. This is true even if each profession has a unique viewpoint that could be useful while delivering projects. Accordingly, the research endorsed the notion that promoting a collaborative culture is a crucial element in encouraging waste control in the construction business.

(5) Critical competence for holistically reducing waste in construction

The results have demonstrated that, despite the design field's well-established relevance in minimizing construction waste, designers lack the abilities needed to lead low waste projects. The study has therefore examined the essential competencies required to plan waste out of construction projects. The study's conclusions backed up the four essential skills for waste reduction. The ability to lead zero waste projects has been widely acknowledged as requiring behavioural competency. The level of behavioural competency among designers reflects their own commitment and conviction. This is especially important because whether or not people believe that design is the main cause of waste production will determine how likely it is that waste-designing tactics will be implemented. It is also established that one of the fundamental principles for minimizing waste is design proficiency, which is the primary responsibility of the designer. Learning essential design skills including conflict prevention, error-free design, dimensional coordination, and detailing, among many others, will help you avoid waste-causing problems.

Because design is primarily a schematic portrayal of buildings for subsequent construction, understanding building projects is regarded as a vital ability for designers to design out the waste. This information would be useful for correct detailing, specification, and the use of recyclable materials into the design. Similar to this, inter-professional collaboration competency is recognized as a crucial technique for planning out waste. The ability to coordinate design across all professions and the efficient interchange of design information in a team environment are two examples of this.

The ability to coordinate the measurements of building elements is the top design competency. The capacity to create designs free from errors and knowledge of design trade coordination follow, respectively. Additionally, the ability to provide comprehensive design information and the knowledge to avoid collisions. These skill sets are essential for preventing the causes of waste, hence having them is vital for eliminating waste in building projects.

Through qualitative research, these findings justified the use of already-in-use literature reviews, data gathering techniques, and analytical methods. The material was provided by experts who were actively involved in building construction projects from beginning to conclusion. The research suggests that the root of the problem is a culture of inadequate collaboration and deeply ingrained fragmentation within the construction industry. The results highlight the value of encouraging early collaboration and participation of all necessary specialists at all delivery phases.

Based on the results of numerous construction industry scenarios, the design phase is acknowledged as being the most significant phase for encouraging waste minimization. Other project delivery stages and practices, on the other hand, were shown to be essential for preventing considerable volumes of construction waste from ending up in landfills, particularly when the decisions made at one stage have an effect on following stages. Two key methods that were created as a result of the recurrent identification of these concerns by industry practitioners are the usage of the modular building technique and encouraging increased participation of all project stakeholders. The chapter examines the significance of these efforts in addition to their broad impacts on lowering construction waste.

(6) Discussion

The findings of this study have significant ramifications for all phases of the project delivery process. The study shows how crucial the design stage is for cutting down on construction waste. Since waste must be considered during the design process, it is vital to enhance the degree of dedication among designers. A plan for the designers' continued professional growth is based on the known established competency. Designers should work to increase their expertise and conventionalism in essential design activities as well as their awareness of how construction is carried out and the materials used, even if design managers must have a high level of inter-professional collaborative competency. These abilities are essential for designing waste out.

To minimize waste, designers should adapt their design concepts to the standard materials that are readily available. The design process generally entails poor professional coordination and cooperation at the project level. According to this study, an integrated strategy is required for the design process rather than the customarily fragmented method. Within the construction industry, the use of BIM for design coordination is growing in importance. This approach would enhance the collaborative effort required to encourage waste minimization throughout the designing stage.

To reduce construction waste, procurement techniques for materials need to receive more attention. The construction industry traditionally views material suppliers as external stakeholders, yet effective waste minimization calls for a tighter interaction with these parties. By doing this, businesses may ensure that their pre-cut, pre-assembled, and suitable materials contribute to reducing waste. A partnership like this might implement JIT deliveries and take-back programs, which have been proved to reduce waste generation and material waste.

Prefabricated construction techniques must be used more frequently in order for the construction sector to become less wasteful. This is particularly valid in light of the fact that research suggests the construction approach can greatly cut waste. Building materials are created off-site and assembled on-site thanks to the construction procedure.

Utilizing collaborative procurement is another crucial step that might equally aid in waste minimization, even though it is evident that modular building cannot be used on every single development due to its greater cost. The study found that by utilizing collaborative procurement techniques, it is possible to effectively prevent the majority of waste-generating variables since these techniques encourage effective stakeholder dialogue and information sharing. This will also ensure that each individual offers their own experience, which is essential for cutting waste and impacting vital project performance benchmarks like quality, time, and cost.

Prefabrication and cooperation were found to be the key factors in reducing construction waste. This illustrates the benefits of the prefabrication and enhanced teamwork promoted by the Lean construction principle. The analysis confirms the hypothesis that a pervasive, deeply ingrained culture of non-collaboration is principally responsible for the industry's wasteful behaviour. Project stakeholders who don't work well together lack project coordination and hold each other accountable for waste management. Mistakes are made as a result, work is redone, and waste is created. Instead of concentrating on social behavioural intention at the person level, it is vital to encourage waste minimization through contractual terms. Participants in the study would be more inspired to cut back on waste as a result.

Therefore, rather of proposing solutions that are imagined from a unitary point of view, it is necessary to analyze dynamically interrelated processes like construction.

VII. CONCLUSIONS

It is advised that the client, who plays a significant role in the construction project, be informed of the benefits of waste management. Architects can reduce waste by using a range of techniques, like as prefabrication, to produce less complex designs that are easier to build. Another factor that might cut waste is the contractor's engagement at this point. Despite the fact that waste was discovered at every stage of the construction process, it was found that the design stage might be the most important for minimizing waste because, in accordance with the waste hierarchy, prevention is always preferable than treatment.

Throughout the construction process, emphasis was also placed on subcontractors who are not dedicated to waste targets, as well as other waste contributors like the logistics and economics of recycling and reuse, items that were damaged when they arrived, improper handling of resources, and bad site management. Potential solutions included subcontractor incentives, quality assurance, the application of SWMPs, and supplier cooperation. The best overall approaches to waste control also included prefabrication, improved communication, and the use of design freezes. The amount of demolition and construction trash that cannot be recycled or repurposed has been found to be reduced through segregation and SWMPs. SWMPs ought to be considered as well at the design stage. Deconstruction should be used in place of demolition when time permits.

There isn't enough room for landfills. Government intervention will need to be more active if the existing goal is not achieved. This shouldn't be the case, since this study discovered that there are many solutions and alternatives that may be used to prevent waste from being dumped at landfills. Furthermore, cost reductions might eventually be attained if these methods are followed. Now, when construction businesses frequently have to lose money on projects just to stay afloat, this is especially crucial. Preventing issues before they emerge is the most advantageous course of action, but doing so involves collaboration from all stakeholders. The best course of action is to head off issues before they develop, but this calls for collaboration amongst the key actors in the building industry.

Future research could analyze the existing conclusions to the large-scale construction sector by collecting data from many nations and comparing its findings with those of this study.

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