# A Systematic Assessment of Factors affecting on Generation of Construction and Demolition Waste by RII Method

**Asst.Prof. Mamata B Rajgor[1], Pawar A. Anurag[2]**
Faculty of Civil Engineering Department, Parul Institute of technology, Parul University, Vadodara, Gujarat Student of MTech (C.P.M.) 2nd Year, Civil Engineering Department, Parul Institute of Technology, Parul University, Vadodara, Gujarat.

**Abstract:**
Construction and demolition waste (CDW) is defined as a material that inexorably results from C&D activities and must be managed correctly; otherwise, inappropriate management of CDW may have detrimental effects on the economy, the environment, and society. In India, there are significant issues resulting from the greater yield of construction and demolition trash and its dumping. The use of building and demolition wastes is often limited to non-structural concrete, pavements, and backfilling. The need of proper CDWM in construction industry is a major concern as construction is increasing rapidly and so does the amount of generated waste.
CDWM is very important from environmental point of view and much needed in construction sector.
Our main goal is to explore the various construction and demolition trash and to review studies of the management of such waste in various nations and cities throughout the world.
**Keywords:** Construction and Demolition waste, Debris, Waste Recycling, Construction and Demolition Waste Utilization, Construction and Demolition Waste Management, Reduce, Reuse etc.
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## 1. Introduction

Waste resulting from construction, remodeling, explosion activities, surplus and damaged items and materials, and on-site work are all considered to be included in the definition of construction and demolition trash. India's biggest industry is agriculture. Construction is named the second-biggest industry after agriculture in the eleventh five-year plan. The majority of India's skilled/semi-skilled population and a sizable portion of the labor market are dependent on the building industry. Materials play a significant role in all kinds of construction projects.

Every construction project's outcome, whether successful or unsuccessful, largely depends on how the materials are managed.

In a nation like India, where the expansion of development and redevelopment projects has been significantly accelerated, the negative effects of the construction industry on the environment have also been multiplied.

Today's environmental problems include resource depletion, flood levels brought on by unlawful garbage explosion into rivers, and illegal hill slope explosion that is visible in major towns. As a result of the construction, remodeling, and explosion of buildings, bridges, runways, flyovers, highways, factories, industries, hospitals, and other relevant formulations, India's infrastructure facilities are growing. The majority of the waste material is made up of inert, non-biodegradable, and ineffectual materials like plaster, plastics, wood, broken tiles, excavated materials, asphalt concrete, concrete rubbles, steels, and masonry.

In India, numerous metric tons of rubbish are produced each year and disposed of in landfills. However, because this waste is not effectively regulated, enormous amounts of undisposed waste may be seen in many regions of the country. So that future generations can be assured of a bright future, good waste management and traditional methods to recycle, reuse, and reduce are now essential. Thereby disseminating vital information regarding the environment and our reliance on it for survival.

Initiatives to control waste management have recently been made at the national and international levels. Rules have become more stringent, and as a result, infrequently used choices like reducing or recycling waste are becoming more and more financially viable.

The following are the current waste management procedures used by the Indian construction industry at various levels:

- Items recovered during construction or demolitions are sold in the market at a discount.
- In most cases, the viability of recycling is not even given serious consideration. Things that cannot be reused are utilized to fill the land; the municipality does not impose a landfill tax; and garbage is disposed of without being separated.

In this research, we'll analyze how crucial it is to manage and efficiently utilize construction and demolition debris. How C&D waste can be used methodically and what areas India's CDWM falls short in compared to other nations.

## 2. Literature Review

The literature study involves looking for, compiling, and making notes from the literature pertaining to construction and demolition waste management, as well as recycling techniques for this trash. the production of garbage from construction and destruction both internationally and in India. To find relevant, important literature for research, the first step is to find the source by using keywords like "construction and demolition waste," "C&D waste management," "C&D waste recycling," "utilization of C&D Waste," "recycled aggregates," "properties of recycled aggregate," "recycled aggregate in concrete," and "paver block manufacturing." Search engines like Google, Google Scholar, and Yahoo are employed. Various literatures have been found and examined. Government reports, reports from private institutions, building and demolition waste rules and guidelines, journal articles and research papers, and conference proceedings make up the literature.

The literature review explains the theoretical underpinnings of this research and aims to investigate and obtain ideas for the efficient utilization of construction and demolition waste and its various applications, including the 3R principles for developing and managing various methodologies and strategies for the efficient utilization of construction and demolition waste for recycling and reuse by studying CDWM in various countries.

## 3. Summary Of Literature Review

The following literature reviews have been taken by studying various research papers and thesis about CDWM of different countries.

### 3.1 Implementing a site waste management plan - A case study of a medium sized building contractor in Ireland.

**Author- Jan Gottsche**

In order to provide economic, social, and environmental benefits, the goal of this thesis was to study how a small to medium-sized construction company in Ireland could apply and develop

waste management techniques both internally and practically on site. This study also looked into the implementation of a waste management plan within an Irish medium-sized construction firm. Using a case study, a literature review, and surveys, the implementation of a waste management strategy has been shown to be an effective way to reduce construction waste on site and the overall environmental impact of construction.

Examining the waste hierarchy prospects for construction and demolition waste in Ireland as well as the influence of management techniques on construction and demolition waste reduction at the project level were two goals of this thesis.

Although waste should be separated, waste generation should be kept to a minimum initially. Waste minimization can have financial benefits for a firm because it can reduce the operating costs of the organisation. Implementing waste minimization on site is about applying common sense and a change in attitudes; it does not necessary involve the introduction of new technologies. In many cases, putting waste minimization techniques into practice is both free and immediately beneficial. Three fundamental elements are typically needed to implement waste minimization techniques: source reduction, recycling, and waste minimization during the design stage.

According to the authors, legislative and regulatory reforms will be needed to make waste management a requirement on all building sites across the nation in order for waste management to be taken seriously. It is projected that small- to medium-sized businesses in Ireland would start using similar tactics as a result of legal changes and the understanding that financial gains may be made through good waste management methods. This will eventually result in the construction sector becoming more environmentally friendly and contribute to reducing the effects the process has on the environment.

**A Construction waste generation model for developing countries**

**Author- Abarca Guerrero**

Many diverse parties with a variety of interests are involved in waste management. They all play a role in shaping the system of a city, but typically it is considered only as a responsibility of the local government. In the ideal scenario, both the municipality and the inhabitants are held jointly accountable. To develop a productive and efficient system, it is crucial to have a thorough grasp

of the stakeholders and their roles within the structure. A successful waste management system in cities depends heavily on the transmission of communication between the many players.

Even though they work informally, waste pickers are an essential component of the waste management systems in many poor nations. They contribute significantly to the environment, society, and economy. Public policies, association models, capacity development, corporate strategies, social recognition, and similar factors should all be taken into consideration when recognizing and integrating these informal employees into formal institutions. The steps that must be taken depend on the nation. The creation of accurate data and appropriate information routes both within and between municipalities is fundamental. In order to make positive changes and develop integrated waste management strategies that are tailored to the needs of the citizens while taking into account their ability to pay for the services, government officials who are in charge of planning and policy-making need to be well-informed about the situation of the cities.

**An Interpretivist Approach for the Development of a Behavioural Framework to Support the Adoption of Waste Minimisation Behaviour of Contractors: The Case Study of Jordan**
**Author- Mahmoud Alhawamdeh**
In this study the author employed The Delphi interview approach to be used as the primary mode of data collection to study the CDWM of Jordan objective as it delivers a well-informed look at the current and potential status of the adoption of CWM behavioral among Jordanian contractors.

The writer additionally talked regarding Sustainable construction (SC) that also relates toward the construction stage which encompasses the known concepts of sustainable development. Sustainable development in the construction sector is one of growing attention all around world.

According to the authors, legislative and regulatory reforms will be needed to make waste management a requirement on all building sites across the nation in order for waste management to be taken seriously. It is projected that small- to medium-sized businesses in Ireland would start using similar tactics as a result of legal changes and the understanding that financial gains may be made through good waste management methods. This will eventually

result in the construction sector becoming more environmentally friendly and contribute to reducing the effects the process has on the environment.

Second, it was determined that the construction phase was the most crucial one for CWM. This is so that any waste that results directly from the building stage or indirectly from the design stage can be minimized through the proper implementation of on-site methods. Moreover, waste generation during the construction stage can be avoided and decreased, whereas demolition debris is sometimes viewed as unavoidable waste. Third, because typical causes of CW are directly or indirectly influenced by the behavior of the individuals working in the construction industry, human factors were identified as a significant element in waste generation and minimization in construction projects.

Fourth, CW has grown to be a more urgent problem in Jordan as a result of resource depletion, the ensuing unstable energy supply, and Jordan's dismal economic state, with CW being seen as a financial drain on government spending. Fifth, I t was noted that Jordan's construction sector continues to struggle with a lack of sustainable measures, as seen by low output, subpar performance, and a wasteful mentality. It has also been anticipated that Jordan's lack of effective waste management policies will cause more and more problems. Very little is known about the current state of CWM in Jordan.

**Current Practices of Construction and Demolition Waste Management(CDWM): Based on observation at Swedish Construction Site**
**Author- Mahlet Tesfaye Haile, Yudhi Dwi Hartono**

Sorting is cited as the primary waste management approach in this study and is regarded as a good CDWM practice in the case area. Moreover, on-site sorting can raise the rate of reuse and recycling, reduce the cost of trash transportation and disposal, and extend the life of landfills (Wang et al., 2010). They found that because there is on-site sorting at the construction site, it is feasible to obtain the aforementioned benefit. Although waste materials are transported to the recycling company to be further separated to have clear fractions, it appears hard to lower the cost of trash transportation as this depends on how far the recycling company is from the construction site. To handle the wastes, the recycling business is in charge of collecting and recycling CDW. Recycling is one of the 3R concepts of waste management.

Reuse and recycling can be employed if wastes cannot be avoided, however waste minimization should come first in waste management efforts. Easy measures, such as the use of color-coded trash disposal bins, should be put into place on building sites to make it simple to separate different categories of trash and increase the amount of recyclable construction and demolition waste.

Additionally, they asserted that the use of BIM could enhance CDWM since it fosters greater cooperation among project stakeholders. There is a paucity of CDWM understanding of BIM in this industry. Yet, there is a positive attitude at the corporate level towards the implementation of BIM for CDWM for future projects. BIM is essential for enhancing CDWM's present procedures. First off, by giving material data from the design phase, it can benefit the deconstruction and demolition effort. Second, the amount and kind of trash at the construction site can be estimated using BIM. Last but not least, by validating the design or considering design variations, the waste generation can be decreased with BIM adoption in the design process.

This study made the case for changing and enhancing present procedures in CDWM in order to achieve a good conclusion. It is necessary to provide awareness, certification, and conferences on the subject of CDWM, BIM, and waste management techniques in hopes of enhancing present practice. Executing waste management techniques and BIM at the planning stage in the construction industry is vital for reducing CDW. This, in turn, aids in obtaining benefits from CDWM practices in terms of the economy, society, and the ecosystem. Consequently, to control CDW effectively, future research should concentrate on the proper application of BIM and waste management approaches in the construction sector.

**Adopting the Zero Waste Concept for Eliminating C&D Waste in the Construction Industry**
**Author- K.L.A.K.T Liyange, K.G.A.S Waidyasekara, H. Mallawaarachchi**

In their research the authors used the concept of "Zero Waste" . The absence of resource conservation, pollution control, and waste reclamation in integrated waste management are the present waste management problems that have given rise towards the novel waste management strategy known as "Zero Waste." The Zero waste idea calls for resource recovery and recycling at high levels, as well as waste prevention. By rethinking the resource gestation period to ensure that all products are reused through the zero waste idea, the C&D waste

problem can be efficiently resolved. Waste materials are turned into valuable assets through the zero waste concepts. The application of the zero waste idea challenges the conventional perspectives of waste management.

According to their research, waste may be effectively managed through preventative measures and minimization. If indeed the production of C&D waste is unavoidably uncontrollable, C&D waste management techniques like using scrap metal dumpsters and recycling the scrap, adding waste products to corporate inventories and providing unutilized supplies for future developments, and attempting to sell the unused materials to recyclers may be effective. The management of C&D waste in the construction sector can also benefit from strategies for material handling and control, education and oversight, purchasing tactics, subcontractor and employee management, and communications and paperwork tactics.

To operationalize the zero waste idea in the construction sector, a range of enablers may be met. The construction industry has recognized the following factors as enablers for C&D waste management: laws and policies, understanding and awareness, manufacturing of construction materials, design and managing buildings, commerce, recoveries of products and materials, and economies. Furthermore, enablers could be categorized into four categories: institutional, technological, internal action, and market impact. An institutional enabler establishes a setting that both encourages and imposes change. Similarly to how technological enablers offer chances and means for change, market influence enablers are necessary for change. Moreover, resources and adaptability are thought of as institutional enablers.

The adaptation of the zero waste idea may encounter some obstacles. Appropriate C&D waste management is hampered by a variety of obstacles, including a lack appropriate policies, a deficiency of a legal framework, a poor degree of public education, inadequate compensation and training for waste employees, a bad public image, and the availability of illegal dumping spots.

So according to their studies, with the help of implementing new CDWM strategies, bringing the enablers as a major role-players in the industry and identifying the barriers and eliminating them with proper solutions, there can be great improvement in the future of CDWM.

**Material Waste Minimization techniques in building construction projects(Ethiopia)**

According to the results of this study, hiring waste management officers for the building site to deal with waste problems might greatly lower the production of material wastes. In Ethiopia, it is uncommon to appoint personnel to every construction site with the express purpose of handling trash problems. Based upon that research's findings, it is crucial to assign an individual responsibility for managing the variables that contribute to material waste in order to reduce it. The survey suggests that one method to reduce total wastes generated at a construction site is to incorporate prefabricated or off-site fabrication of components. The study also provided proof that efficient waste management at the construction site considerably lowers losses. Materials might be effectively handled to avoid improper disposal and soil mixing, reuse for the intended purpose, identification of recyclable material, and recycling somewhat on worksite.

From this study we can find that, the waste management strategy for achieving material waste effectiveness is supported by the incorporation policies of the material waste minimization strategy. Having proper ground laws or regulations concerning waste, such as providing incentives for each waste-efficient construction sites along with additional directions, including a penalty for all those generating a substantial waste stream well above permissible amount, are all beneficial. The effective reduction of material wastes is further ensured by policy governing waste generation, disposal methods, and dumping charges for the sector's material waste. The research additionally demonstrated how precise measurement of the dimensions and quantity of material on-site lowers the amount of effort required to modify, refurbish, and replace an items. Material wastage could be reduced by improving efficient material storage and adequate, regular site supervision.

Also, providing regularly scheduled training on material waste minimization techniques for construction enterprises regarding the seriousness and hazards involved as well as the management practice plays a significant part in minimizing waste. Additionally, employing an experienced and reliable design team, delivering the required quantity of material according to the schedule, and purchasing material that needs to comply with the specification are critical tactics for avoiding the formation of material wastes. Employees ought to be educated to know how to handle and assemble materials, abide instructions, and carry out the necessary in accordance with the contract. The most significant actions that might be implemented for handling material wastes at building construction sites were generally portrayed by this study.

**DIFFERENT KIND OF WASTE GENERATED FROM CONSTRUCTION MATERIALS:**

**4.1 Kinds of wastes:**

When correlated with various sorts of waste, construction and demolition debris is examined as large volume and contributes to social and environmental issues. Because it relies on the construction methods, building kinds, nations, and other factors, the composition of construction waste is frequently distinct. Assessing what kind of trash from construction and demolition is challenging due to different building technologies and construction methods. But there is still work being done to categorise and identify C & D garbage.

**4.2 Categorize of construction waste:**

Effective waste management of these materials depends on an evaluation of their constituents. Waste from construction projects is separated into 15 categories, including (1) components associated with asphalt, (2) components associated to soil, (3) components associated to electrical work, (4) components connected to insulation, (5) components associated to bricks and concrete, (6) components associated to steel, (7) components related to paint work, etc. (8) Materials relating to paper; (9) Materials relevant to petroleum products; (10) Material referring to roofing work; (11) Material pertaining to vinyl; (12) Material referring to gypsum; (13) Material pertaining to wood; (14) Material pertaining to wood having contamination; and (15) Other forms.

**4.3 Factors Affecting the Generationn of Construction & Demolition Waste:**

The amount of waste produced during construction varies based on the project's size, associated activities, and location. Construction waste can develop at any stage throughout the construction process, including during worksite cleaning and the completion of the project. The primary sources of the waste comprised design, acquisition, handling of materials, execution, and remaining trash on site.

The research of the literature revealed that numerous prior research efforts had been carried out to determine the root causes of the production of construction debris. An approach for reducing construction waste that involves surveying the industry. The studies revealed that many businesses had a defined policy to decrease waste, while those that did made an effort to cut waste at its source, such as by minimising trash production during construction. The analysis of the results revealed that design changes, residual materials, waste from packaging, mistakes in design or detailing, and adverse weather are the five main sources of construction waste.

According to the research, the reasons of construction waste included inaccurate data about plans, a lack of knowledge, complex designs, unconventional plans, and a lack of synchronisation across the entire construction development lifespan.

**4.3 Classification of C&D wastes generating factors:**

Wastefulness during construction work has been a topic of study over years among academics worldwide. Researchers identified & categorised important contributing elements to the development of building trash. In ensembles of as many as nine classifications, comprising design, procurement, construction methods, equipment, material, labour, and behaviour among individuals, owners, endeavour, and the climate, the different aspects can be categorised, according to a study of previous research and literature. The aforementioned elements were regrouped into four distinct sections for this study: designing and paperwork (DEPW), materials and acquisition (MATA), methods of construction and planning (MOCP), and human assets (HUMA).

**4.4 Designing and paperwork (DEPW):**

Prior to commencing the building process, construction projects must first go through the planning and design phases. Insufficient architect participation in the building cycle & capacity are two factors that contribute to construction waste. Due to order minimums or manufacturing demands of the vendors, choosing an excessive number of kinds of components and dimensions via the building job may result in purchasing a lot of material. Since it can't be utilised in the practical building, the material is ought to be left on the job site and become garbage. If conventional sizes aren't taken into account, trimming materials to fit the dimensions or form of an established region may result in waste.

**4.5 Materials and acquisition (MATA):**

The factors that contribute to the production of construction waste during the procurement process include ordering (1) more materials than are actually required, ordering (2) fewer materials than are actually used due to underestimates, and ordering (3) incorrect supplies as a consequence of interaction or knowledge oversights. Waste from construction was a result of inadequate materials management and storage. The two main causes of waste materials were faulty conveyance and insufficient oversight. Refraining from following protocol, moving materials from the production facility to the construction worksite or inside the location could

cause harm and ultimately result in waste. Four characteristics—suppliers' engagement in waste reduction measures, wasteful material acquire administration, efficient management of materials, and loss-efficient estimates of quantity—define a waste-efficient method of purchasing and logistics.

**4.5 Methods of construction and planning (MOCP):**

Due to the design and operation of the buildings, the construction process, the project timetable, the scope and scale of the project, site circumstances, and the surrounding environment, complication is an essential component of construction projects. The level of difficulty dictates the general plan of attack for a project, including the assets and planning that will be needed, in addition to the processes and instruments. Every construction job is different and intricate, and they all demand a significant lot of work. The quantity of waste produced by construction operations has been directly influenced by these projects. Initial construction planning was a major contributor to waste during the construction period, but there were still a lot of other factors at play.

**4.5 Human resources (HUMA):**

The business of construction is seen as being labor-intensive. The cooperation, mindsets, and behaviours of participants throughout the construction procedure are essential for efficient waste management and reduction. Construction waste levels were more influenced by labour and people issues than by other variables. Workers that lack instruction and training, are unqualified for their jobs, and have an unfavourable mindset will produce poor-quality work, which will necessitate rework and repairs. The shortage of competent advisors, engineers, and employees was one of the issues causing the construction of buildings to take longer. Lacking experience, inexperienced designers may choose the incorrect materials or building techniques, misjudge the needs of project owners and stakeholders, and result in design revisions during construction.

## 4. Methodology:

Construction waste generation elements are being studied to determine how significant they are and from the perspective of contractors.

**5.1 Data Collection:**

Contractors and architects and construction managers are contacted with a Google Forms-based questionnaire. Email submissions of the answers to the surveys were acknowledged and MS Excel was intuitively transformed into a record of the results. The following steps were taken in order to create the questionnaire:

An in-depth overview of the 28-building waste generating elements found in the source material. Cross-referencing of such variables was done. Based on their origins, these reasons have been classified among four groups. Table 1 below lists the causes of building waste discussed in this paper.

To ensure that the responses were clear and pertinent, academia and construction industry professionals assessed the subject matter validity and relevance of the questions included in the survey.

A pilot poll was carried out to evaluate the validity of the poll's information and format. The responses of thirty professionals in the construction industry received the questionnaires.

Two sections make up the final questionnaire. The general history of the people who responded is covered in the initial section. The second section of the survey asks responders to consider on the degree of relevance, impact, and value of the elements that contribute to the development of construction waste in each of their building construction projects. One statement is shown to the respondents, and they are asked to score it on a scale of one to five: strongly disagree, disagree, neither agree nor disagree, agree, and highly agree.

**Table 1. Factor categories, factor labels, and factor nam**

| Factor Category | Factor Label | Factor Name |
|---|---|---|
| Designing and Paperwork (DEPW) | A1 | Design modification |
| | A2 | Document issues |
| | A3 | Design flaws |
| | A4 | Mistakes in construction drawings |
| | A5 | Complex design |
| Materials and Acquisition (MATA) | B1 | Incorrect material archiving |
| | B2 | Issues with material quality |
| | B3 | Issues with material ordering |
| | B4 | Unsuitable material handling |
| | B5 | Challenges with material transportation |
| | B6 | Packaging issues |
| | B7 | Faulty materials |
| | B8 | Broken materials |
| Construction Methods and Planning (COPL) | C1 | Coordinating issues |
| | C2 | Regulatory and oversight |
| | C3 | Constructing techniques |
| | C4 | Inadequate waste management |
| | C5 | Utilising or failing to use tools and equipment |
| | C6 | Materials exploitation |
| | C7 | Incorrect choice of teams or subcontractors |
| | C8 | By-product trash |
| | C9 | Faulty construction |
| | C10 | Inefficient scheduling and planning |
| | C11 | Rework |
| Human Resources (HUMA) | D1 | Inexperienced workers |
| | D2 | Designers' lack of expertise |
| | D3 | Working attitudes and behaviour that lack attention |
| | D4 | Lack of involvement of suppliers |

### 5.2 Data Analysis:

Because this technique can reorder the components under study, the relative importance index (RII) was employed to create an index. The corresponding significance of the factors that influence adjustments to the construction project requirements were ascertained using RII. Construction project delay variables were ranked using RII.

The ratings that the respondents provided for each factor were recorded using the Statistic Package for Social Science (SPSS). The responses to the surveys were then statistically analysed.

The impact of all components to the development of construction waste was assessed, and the respondents' rated importance of the traits was used to score them using the RII, that was calculated using Equation (1).

$$RII = \Sigma W/(A \times N), (0 < RII < 1), \quad (1)$$

W stands for the respondents' weight (which varies from 1 to 5); (1) denotes strongly disagree, and (5) denotes strongly agree; A denotes the maximum weight (in this example, 5); and N is the total number of respondents.

## 5. Results:

### 6.1 Relative Important Index (RII):

The findings of the survey are shown in the following table (2): Construction waste generation elements are ranked by their relative The total number of responses for each choice made based on the analysed factor is shown in Table 2 for data analysis. Per factor, the relative important index (RII) method was applied. Equation (1) was utilised to calculate the index. The mean RII and the order of all categories are displayed in Table 3.

**Table 2. Relative important index (RII) and ranking of construction waste generation factors (n = 48).**

| Factor Label | Factor | Number of Respondents Scoring | | | | | RII | Factor Rank |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| A1 | Design modification | 2.00 | 22.00 | 50.00 | 70.00 | 34.00 | 0.726 | 1 |
| D3 | Working attitudes and behaviours that lack attention | 9.00 | 35.00 | 42.00 | 61.00 | 31.00 | 0.679 | 2 |
| B1 | Incorrect material archiving | 11.00 | 28.00 | 51.00 | 65.00 | 23.00 | 0.669 | 3 |
| D2 | Designers' lack of expertise | 7.00 | 42.00 | 45.00 | 54.00 | 30.00 | 0.665 | 4 |
| D1 | Inexperienced workers | 6.00 | 43.00 | 47.00 | 52.00 | 30.00 | 0.664 | 5 |
| A5 | Complex design | 9.00 | 36.00 | 53.00 | 51.00 | 29.00 | 0.662 | 6 |
| A3 | Design flaws | 6.00 | 46.00 | 48.00 | 51.00 | 27.00 | 0.653 | 7 |
| C10 | Ineffective scheduling and planning | 9.00 | 39.00 | 63.00 | 38.00 | 29.00 | 0.644 | 8 |
| C2 | Regulatory and oversight | 10.00 | 42.00 | 62.00 | 36.00 | 28.00 | 0.634 | 9 |
| C4 | Inadequate waste management | 20.00 | 31.00 | 46.00 | 61.00 | 20.00 | 0.634 | 9 |
| C7 | Incorrect choice of teams or subcontractors | 12.00 | 46.00 | 52.00 | 38.00 | 30.00 | 0.631 | 10 |
| B3 | Issues with Material ordering | 11.00 | 42.00 | 55.00 | 53.00 | 17.00 | 0.626 | 11 |
| A4 | Mistakes in Construction drawing | 13.00 | 51.00 | 42.00 | 46.00 | 26.00 | 0.624 | 12 |
| B4 | Unsuitable material handling | 13.00 | 40.00 | 56.00 | 54.00 | 15.00 | 0.620 | 13 |
| A2 | Documents issues | 8.00 | 52.00 | 54.00 | 44.00 | 20.00 | 0.618 | 14 |
| C3 | Construction techniques | 13.00 | 50.00 | 46.00 | 49.00 | 20.00 | 0.615 | 15 |
| B5 | Challenges with Material transportation | 13.00 | 42.00 | 61.00 | 49.00 | 13.00 | 0.608 | 16 |
| C11 | Reworks | 14.00 | 45.00 | 59.00 | 40.00 | 20.00 | 0.608 | 16 |
| C8 | By Product trash | 20.00 | 40.00 | 55.00 | 50.00 | 13.00 | 0.596 | 17 |
| C1 | Coordinating issues | 19.00 | 52.00 | 50.00 | 37.00 | 20.00 | 0.585 | 18 |
| C5 | Utilisingor failing to use tools and equipments | 16.00 | 48.00 | 63.00 | 35.00 | 16.00 | 0.585 | 18 |
| B7 | Faulty materials | 18.00 | 47.00 | 56.00 | 49.00 | 8.00 | 0.580 | 19 |
| C9 | Faulty Construction | 21.00 | 53.00 | 49.00 | 35.00 | 20.00 | 0.578 | 20 |
| B6 | Packaging issues | 20.00 | 53.00 | 50.00 | 46.00 | 9.00 | 0.567 | 21 |
| D4 | Lack of involvement of suppliers | 22.00 | 55.00 | 50.00 | 38.00 | 13.00 | 0.561 | 22 |
| B8 | Broken materials | 24.00 | 57.00 | 48.00 | 36.00 | 13.00 | 0.552 | 23 |
| B2 | Issues with Material quality | 33.00 | 53.00 | 42.00 | 34.00 | 16.00 | 0.540 | 24 |
| C6 | Material exploitation | 38.00 | 52.00 | 42.00 | 28.00 | 18.00 | 0.528 | 25 |

**Table 3. Mean RII and ranking of categories of construction waste generation factors (n = 48).**

| Factor Category | RII | Rank |
|---|---|---|
| Designing and paperwork (DEPW) | 0.656 | 1 |
| Human Resources (HUMA) | 0.642 | 2 |
| Methods of Construction and Planning (MOCP) | 0.603 | 3 |
| Materials and Acquisition (MATA) | 0.595 | 4 |

**6.1.1 Designing and paperwork (DEPW):**

Table 2 presents the ranking and corresponding RIIs of the five components comprising "DEPW". According to the respondents, the primary contributor to construction waste production is the "change to design" factor, which has an RII of 0.726. Among all the factors investigated, changes in design had the greatest impact, underscoring their significant role in generating construction waste.

**6.1.2 Human Resources (HUMA):**

Table 2 displays the ranks and corresponding RII values for the four factors classified under "HUMA." The respondents identified "inattentive working attitude and behaviors" as the most significant contributor to construction waste production, with an RII of 0.679. This factor ranked second among all the explored factors in terms of its impact, highlighting its crucial role in generating construction waste. Furthermore, three out of the four factors in this category were also among the top five factors with the most substantial effect on construction waste generation. Table 7 displays the ranks and corresponding RII values for the four factors classified under "HUMA." The respondents identified "inattentive working attitude and behaviors" as the most significant contributor to construction waste production, with an RII of 0.679. This factor ranked second among all the explored factors in terms of its impact, highlighting its crucial role in generating construction waste. Furthermore, three out of the four factors in this category were also among the top five factors with the most substantial effect on construction waste generation.

**6.1.3 Methods of Construction and Planning (MOCP):**

Table 2 presents the ranks and corresponding RII values for the eleven factors categorized under "MOCP". According to the respondents, the factor that contributes the most to construction

waste generation is "ineffective planning and scheduling," with an RII of 0.644. However, this factor only ranked eighth in terms of its impact among all the explored factors, indicating its relatively lesser influence on construction waste generation.

#### 6.1.4 Materials and Acquisition (MATA):

Table 7 displays the RII values and ranks for the eight factors classified under "MATA". As per the respondents, the most significant contributor to construction waste production is the "improper material storage" factor, with an RII of 0.669. This factor ranked third among all the explored factors in terms of its impact, highlighting its critical role in generating construction waste.

## 6. Discussion:

Table 2 presents the identified and ranked factors based on the survey respondents' ratings regarding their impact on construction waste generation, using their relative importance index (RII). The top five factors with the highest RII were "Design modification," "Working attitudes and behaviours that lack attention," "Incorrect material archiving," "Designers' lack of expertise," and " Inexperienced workers." This outcome suggests that design changes, which may result from owners' and designers' direct changes, or due to construction site conditions or errors, could be a crucial factor in contributing to construction waste production.

Table 3 displays the mean RII values and ranks of various categories of construction waste generation factors. The DEPW category, which includes factors related to design and documentation, has the highest impact on construction waste generation, followed by the HUMA category consisting of human resources factors. Interestingly, the MOCP and MATA categories, which include factors related to construction methods and planning, and material procurement, respectively, have relatively lower impact on construction waste generation.

## 7. Conclusion and recommendation:

In order to reduce construction waste in building projects, it is crucial to identify the primary factors that contribute to its generation. This study conducted an analysis of twenty-eight (28) factors associated with building construction waste generation, which were classified into four main categories: (1) Designing and paperwork DEPW (2) human resources (HUMA); (3) Methods of Construction and Planning (MOCP); and (4) Materials and Acquisition (MATA).

The study used relative importance indices to quantify and rank the factors based on their level of importance, grouping them accordingly.

According to the study's results, the primary cause of construction waste generation is related to design and documentation factors. The top three contributors in this category are design modifications, complex design, and design errors. It is essential for designers to play a critical role in preventing waste throughout the entire construction process. Clearly defined drawings and documents can help reduce discrepancies, leading to fewer changes and rework during construction. The second leading cause of construction waste generation is human-related factors. Inattentive working attitudes and inexperience of designers are the top two factors in this category and are also among the top five overall factors. To minimize waste during construction, it is crucial to consider the attitude, behavior, and expertise of all construction process participants towards waste management. Construction methods and planning, as well as material procurement, are ranked third and last, respectively. The study recommends that all stakeholders in the construction industry should address these factors at every level of their construction processes and devise waste management plans to effectively minimize building construction waste in Thailand. The main focus should be on design and document management to provide clear and comprehensive information for the construction stage, as well as human management through well-trained staff and workers in the field.

Based on the findings and interviews with experienced building construction contractors, the following recommendations can help minimize and manage waste in building construction projects: (1) Contractors must carefully review construction documents and drawings to identify any discrepancies and seek clarification from the owner or designers before beginning construction. (2) Contractors should strive to understand the project owner's and designer's intentions to minimize rework. (3) Contractors should have adequate knowledge and expertise, gained through experience, to locate necessary resources before construction begins. (4) Proper storage and inspection of materials on site can prevent waste. (5) Regular site supervision and management can prevent mistakes, rework, and poor workmanship due to lack of oversight. (6) Effective coordination among all parties involved in the construction process can significantly reduce waste. Proper coordination must be maintained throughout all phases of construction. Additionally, future studies can focus on other types of construction projects to further understand waste generation factors.

## 8. Findings from the different Research papers studied:

Discussing CDWM is a fairly broad topic. Future periods may see a progressive decline in natural resource availability, making the need for effective CDWM a greater problem. Despite the fact that this topic has been the subject of numerous studies around the globe, there is still much to be learned about this field in order to develop an effective CDWM model that can be used globally. Government action is urgently needed, especially for developing countries, to ensure that suitable norms and regulations are followed regarding the disposal of CDW and the extensive use of recyclable materials in the building sector. Reusing recyclable materials during construction is, in our opinion, the most effective strategy to reduce CDW. Hence, encouraging knowledge on the 3 R's—Reduce, Reuse, and Recycle—should be a key topic of conversation among the professional staff in the construction sector.

Using tools like BIM can be very helpful in finding solutions to the CDWM's difficulties. As BIM may aid in reducing waste to a higher extent if the designers take the CDW generation in mind, such application can assist us in implementing proper structure of a CDWM plan simply from the designing phase. Since the first stages of any project's construction, the quality and amount of the materials utilized must be closely controlled. Planning is the first and most important step in starting a project, and if CDW is taken into account throughout the planning and designing stages, it can significantly alter how waste will be generated and used in the future.

It can be a fantastic idea to introduce concepts like the "Zero Waste" concept in this industry. The CDWM can be greatly enhanced by identifying the sources of waste generation, developing appropriate strategies to reduce it, putting those strategies into practice using best practices, introducing enablers into the CDW sector who can lead the implementation of the Zero Waste concept for CDWM, and identifying the challenges and obstacles that may emerge during this phase. This has the potential to bring about a fundamental shift in the CDWM industry, as we can see that the construction sector is one of the most rapidly growing global industries.

Therefore, encouraging education about effective construction and demolition waste management should be spread not only among students and young people but also among professionals in the construction industry, such as engineers, designers, planners, architects, contractors, site workers, laborers, and all other personnel related to the construction industry. Instead than building more and more dump sites, additional recycling facilities should be built. By turning waste created into useful construction material, these facilities can help reduce

enormous amounts of waste. This can benefit people economically and naturally while also assisting in lowering project costs overall.

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