A Comprehensive Review on Waste Generating Attributes: Way Forward for Pakistan's Construction Industry

ISSN (e) 2520-7393
ISSN (p) 2521-5027
Received on 18 Sept, 2018
Revised on 04, Oct, 2018
www.estirj.com

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Abstract: *Construction waste is a worldwide problem and is produced at most of the construction sites. Every year, a large quantity of construction waste is being produced at construction sites due to C&D activities. They have a huge impact on cost, time, productivity and sustainability. in Pakistan's construction industry, the construction waste is of great concern like many other countries. This industry is focusing on waste management efforts like recycling, and reuse programs. Environmental degradation is the ultimate effect of this waste. To maintain the environment by the disposal of construction solid waste from their working area demolition waste is a major waste in some construction industry. The aim of this study is to identify the construction waste generation on site and to determine the construction waste management plan that has been applied in the same project. Several researchers found different attributes in different regions. In this study, the review has been conducted in four stages. A general review has been done to identify various waste generating attributes across the globe. this study has highlighted the waste generating attributes across the globe, developed countries, developing countries and especially in Pakistan. 78 such factors are enlisted based on comparative analysis. Findings of this research work are related to current construction waste attributes in Pakistan.*

Keywords: *Construction Waste; Construction & Demolition Activities; Waste Attributes and Pakistan*

1. Introduction

The construction industry is the important contributor to the economy of a country. There are several issues in this industry. The main problem facing the construction industry is the construction waste generated in its field. They have a huge impact on cost, time, productivity and sustainability. It is greatly influenced by practitioners and researchers around the world. Construction waste management research includes the identification, analysis, and management of construction waste during construction projects. Reduce construction waste by successfully completing projects. In this study, effective factors were identified that were coded as key success factors for managing waste and then ranked for factors.

In Pakistan's construction industry, the construction industry is a major contributor. Millions of ton of construction and demolition waste (CDW) is produced on daily basis, which is a threat to the socio-economic growth of the country. A huge amount is being expended on the management recycling and dumping of this waste. There is a strong need to identify the significant attributes, causing this menace. This study aims to critically review the similar problem occurring globally and responsible attributes of CDW worldwide.

Different perspectives on CDW lead to different waste management concepts. For example, in Japan, CDW is not considered a waste, but a by-product of construction. Therefore, waste management efforts focus on recycling and reuse programs. In Hong Kong, there are two types of CDW, which are inert materials (such as soil, concrete, debris, etc. and non-inert waste (such as bamboo, wood, vegetation, etc. [1]. [2], consider construction waste to be an element or subset of CDW that contains waste generated during new construction. Conversely, [3] argue that the term CW and CDW are used interchangeably when the source of waste is not the center of attention.

Construction Site waste is a non-hazardous by-product of new construction and renovation activities. It is produced due to such factors as construction preparation, site preparation, material damage, material use, over-purchase, and human error. Examples include construction materials such as packaging materials, area cleaning and excavation materials, metal, plaster, concrete, brick, insulation, wood, plastic, glass, asphalt, composite materials, and onsite cleaning. In this definition, due to nature, certain types of wastes are not found. Liquid waste such as asbestos and lead, paint and kerosene, hazardous materials such as food waste, tires and residue containers are some of the materials. The buildings are located at the heart of all our needs for water, energy, and materials, but at the same time, there is a waste.

This waste, which emerges during the construction, maintenance and destruction stages of a building, is called construction and demolition (C & D) waste. This is due to the demolition of building waste, the renovation of the real estate sector and the development of roads, airplanes, bridges [4].

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The construction sector is considered an effective activity whose environmental impact is a global political goal [5 - 6]. Direct environmental impacts include the widespread use of non-renewable energy and mineral resources [7 - 8] and the indirect effect is related to the disposal of construction and demolition waste (C&DW) [9]. In the European Union (EU), this sector accounts for about 25-30% of total solid waste in all economic activities [6]. In other countries like China, C & DW data is located in the city.

Every year, A large quantity of construction waste is being produced at construction sites due to C&D activities. Present developments create a lot of harmful and negative environmental impacts to the ecosystem. It was found that the waste generated at the construction site caused two cost factors for the construction workers, namely the cost of transportation and disposal of on-site waste and the cost of procurement. Reducing the amount of waste on construction sites can reduce the cost of purchasing raw materials and the cost of processing waste generated on site. This may also result in reduced waste due to inefficient fields [10].

Waste recycling from recycling and reuse methods can significantly reduce the amount of waste disposed of the landfill. This can also be used as a secondary resource stream for building materials. It is estimated that about 80% of the waste stream at the construction site is recyclable. Average C&D waste accounts for 15-30% of total waste, which ultimately leads to landfills in many countries [11]. At the project level, the on-site waste is estimated to be approximately 10% of the material originally purchased [12]. The waste generated at the construction site is less expensive, such as 0.5% of the typical residential budget. Contractors have realized that this cost will significantly affect their profits, as contractors typically operate at a tight margin of 5% [13]. The main aim of this study is to identify the construction waste generation on site and to determine the construction waste management plan that has been applied in the same project.

2.Attributes for Construction Waste Generation

2.1 Developed

In 2018, [14] conducted a questionnaire survey to investigate the current state of construction waste power generation in the Greek construction industry. The results of this study indicate that there is a lack of waste treatment facilities, poor communication, and coordination between the relevant parties, lack of awareness and behavior of project stakeholders, lack of understanding of the environmental impact of waste disposal, and a cultural boycott of CDW transfer. Poverty project processes and activities are found to be the main cause of construction waste in Greek construction projects.

Another study by [6 and 15] analyzed a large amount of data on demolition projects in Hong Kong from 2011 to 2015, and found that DW power generation (DWG) is greatly affected by external factors of the building, such as the cost of demolition and the duration of the demolition project and internal factors, including construction. The geographical location of the object/category and the nature of the project (public or private). Regarding the latter factors, they said that in Hong Kong and Kowloon, compared to other categories, in certain categories of buildings (such as industry), and in private projects, compared to public projects, DW The number is greater than the New Territories. The latter seems to be more inclined to C&DWM. This confirms the results of [15], which prove that public projects should play a leading role in environmental protection, while private projects seem to focus only on using environmental issues to achieve profits.

A survey conducted by [16] determined the factors affecting the waste management business of Sweden. the site manager developed a waste management strategy based on environmental inventory and project size. It is found that the Site administrator's waste management work is affected by project-related factors, organizational and personal factors, technical factors, industry culture, and legislation. The level of contract detail, specific customer needs for waste management and the size of the project are important factors.

Similarly, A survey was done by [17] in Singapore, to determine the attributes according to their potential contribution to the onsite waste generation. The finding is that under ‘Design’ related waste sources, four of the attributes had most significant impact on construction waste generation on site were lack of attention paid to dimensional coordination of products, design changes while construction is in progress, designer’s inexperience in method and sequence of construction and lack of knowledge about standard sizes available on the market. [18], studied the architects’ perspectives on construction waste reduction in the UK. The findings reveal that waste management is not a priority in the design process. Additionally, the architects seemed to take the view that waste is mainly produced during site operations and rarely generated during the design stages; however, about one-third of construction waste could essentially arise from design decisions. While [19] studied the literature to explore the same issue in Australia.

The [20], studied the causes of construction waste in Australia by questionnaire survey. The result showed that waiting for instruction was found to be the most significant waste variable. In addition, the finding gives clear evidence that the most significant variables in causing the incidence of waste during the construction process to be are poor quality site documentation, weather, unclear site drawing supplied, poor design, design changes, slow drawing revision, and distribution and unclear specifications.

2.2 Developing

Several researchers found different attributes in different regions. A questionnaire survey is conducted in Jordan by [21] to find out the causes and magnitude of wastage of materials on construction sites. The attributes are in accordance with other countries. [22], found similar factors for Nigeria. [23] have found attributes for Uganda. And Jia-Yuan Wang et al (2008) analyzed these factors for China. Besides that, [24] conducted an extensive review to identify barriers and motivations for implementing good CDW practices in low- and middle-income countries.

Recently a study conducted by [25] in construction projects of Egypt. The findings of this research study

related to the material procumbent waste. The topmost construction waste attributes in Egypt's construction projects are, Frequent design changes and poor design, Poor materials storage system, Theft or vandalism, Poor site conditions, Poor strategy for waste minimization, poor procurement management (wrong purchasing order – quality, number, time of order), unpleasant weather, poor and insufficient implementation of waste management plan, poor materials handling on site and poor quality and non-availability of equipment.

Similarly, [26], conducted a research study in Malaysian construction industry projects, the findings of this research work are related to current construction waste attributes in Malaysia construction projects. The most responsible waste generation attributes are insufficient legislative enforcement, insufficient classification of CDW, the contingencies of CDW management, concerns about using CDW as raw materials, poor awareness regarding the requirements of CDW management, disconnect between policies and practices, insufficient proper recycling markets, and the lack of funds.

[27], has found that Construction industry is a major source of producing waste in Philippine. To maintain the environment by disposing of construction solid waste from their working area demolition waste is a major waste in some construction industry. The contractor is the responsible person to manage the construction waste in site.

One of the similar studies conducted by [28], in Iran aimed to identify the main factors affecting the production of waste on Iranian construction sites. The survey results show that construction sites generate important attributes for construction and demolition waste, including the lack of skills and experience of construction workers and the lack of knowledge of waste concepts and building materials.

In 2015, [29] conducted a study through interviews to determine the root cause of construction waste in India during the implementation phase. The results indicates that factors which generate waste are improper transportation, use of outdated equipments, poor patch, poor layout, lack of material flow, insufficient treatment, unreasonable design, lack of planning and control, poor teamwork, mismatching of work with specification, reworks, overproduction of concrete mix, overlapping in work timings, over hiring of labour, improper storage, improper inventory, worker's attitude, and poor legislation. While the incidence of material losses and the execution of unnecessary work are the main sources identified by [30]. [31] considers 4-M (Material, Manpower, Money, Machine) as the waste generating sources.

Similarly, [32] highlighted defective products, rework, quantity errors, accidents, damage during transportation, flawed inventories of materials and labor time as the main factors causing waste generation in Brazil. While [33] identified the main causes of waste design changes, slow decision-making and lack of skilled labor in Indonesia. In the same way, 70 prime factors are identified for Nigerian construction industry by [34] main categories of waste generation are recognized as procurement, environmental conditions, site supervision and management, material handling and storage, transportation and design and documentation.

[35], discovered timber, metal, mortar, packaging, concrete and bricks as most commonly wasted materials at construction sites of Malaysia. [36], found traditional construction method, poor workmanship, poor storage, improper handling, unclean construction site, and lack of management techniques as main causes of construction waste at the site. While [37] determined poor management or supervision, lack of experience, inadequate planning and scheduling, and design errors are the main cause of waste in Malaysian Construction Industry.

[38], found The main attributes for the investigation of construction waste are unimplemented waste management measures, material conservation, and environmental protection awareness, low building material performance and construction technology, and lack of communication and coordination between building contractors. Irritating and lacking supervision of market interests. [39], evaluated the form, causes, and factors associated with waste in a study. Results determine that customer demand at the last minute is the factor that leads to design variation.

2.3 Pakistan

In Pakistan, construction management is at its childhood. New emerging issues are the barriers in the way of sustainable construction management. Though the above-mentioned attributes are much similar with the issues in Pakistan's construction industry, no any documented literature is found on waste generating attributes in the construction industry of Pakistan. This study is a way forward to illustrate the waste generating attributes to opt for the optimal solutions for them. An initiative has been taken in this regards, and a few researchers have found some main categories of waste generations, but as a whole, a comprehensive list of attributes is still needed for the purpose of decision support system design.

In 2018, a research study has been carried out by [40] in the construction industry of Pakistan, the finding of this research work based upon six main categories, these six categories are management, operation, design, handling, procurement, and other construction waste related attributes. The most responsible attributes for construction waste projects on these groups are poor supervision, operation, design, handling, procurement, and other waste attributes respectively.

In 2016, research on Pakistani construction projects conducted by [41] showed that the key factors of waste generation include frequent changes/modifications in the construction process, poor scheduling, insufficient storage, poor process, poor layout, and resources. Inefficient planning and scheduling and lack of coordination between supervisors deployed on-site. These studies have shown that the generation of construction waste is a serious problem and Pakistan is growing rapidly.

[42], research findings depicts, a benchmarking approach has been introduced to identify the most critical causes of waste generation in different construction projects of Pakistan. The most significant causes of waste materials were "Improper worker's skill", "Poor supervision", "Lack of management", and "equipment malfunction".

3. Research Methodology

Several studies have been conducted through the globe to identify waste generating attributes. These attributes vary country to country and location to location. In this study the review has been conducted in four stages. A general review has been done to identify various waste generating attributes across the globe. After that, an extensive review of the articles from developed countries has been done to visualize the factors in established countries. In the third stage conditions and attributes in developing countries are sighted. And at the fourth stage, studies conducted on waste generating attributes in Pakistan Have been nearsighted.

This issue is more prominent in developing regions because construction industry is not more matured in these countries. The continuous development, and progressive works leads to several waste generating factors which are not observed in developed countries. many of these issues are triggered and resolved in advanced countries. to identify those attributes, it is necessary to accumulate all the factors, which various researchers of the developing regions have quoted and identified. Then in the second stage these attributes will be linked to the adapted solutions in other part of the world. It will require a sophisticated framework, which could relate the issues to the solutions. Scope of this study is to highlight the waste generating attributes only across the globe, developed countries, developing countries and especially in Pakistan.

Waste management studies throughout the world are sighted and grouped in four categories which are general, developed countries, developing countries and Pakistan. Various issues of construction industries specially waste generating issues are narrow sighted. For this attributes about 250 journal and conference articles are read and attributes are enlisted for each category. Industrial reports are reviewed to verify the listed factors. All the enlisted attributes are then grouped as physical or non-physical waste generating contributors. Attributes having frequency more than 10, are listed as common waste generating attributes. Figure 1, presenting the detailed methodology in a framework.

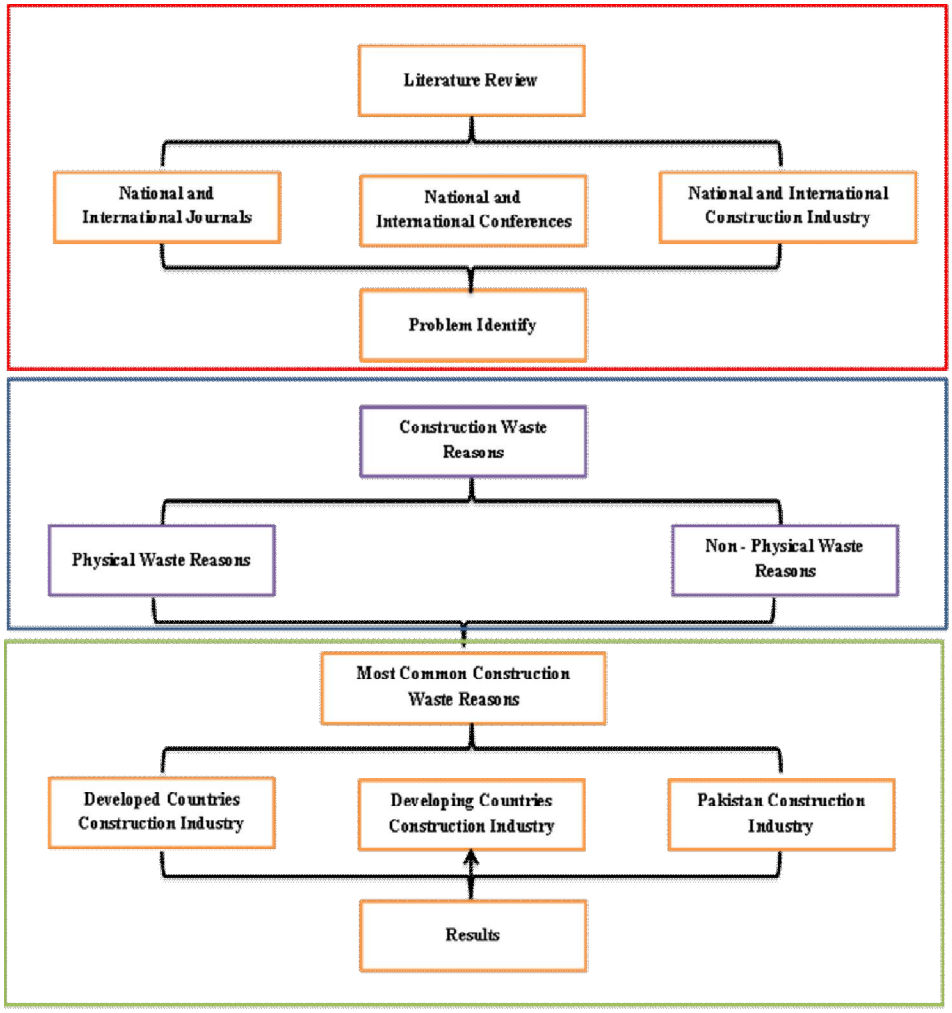

Figure.1. Framework of research methodology

4. Result and discussion

Again the most common waste generating attributes are grouped based on their occurrence in developed, developing and Pakistan. Attributes for developed and developing are compared and the common attributes for both are separated. These attributes are supposed to be probable waste generating attributes in Pakistan's construction industry. 78 such factors are enlisted in table 1, based on comparative analysis.

Table.1. Construction Waste Generation Attributes

No	Attributes Contributing To Construction Waste	No	Attributes Contributing To Construction Waste
1	Abnormal ware of equipment	39	Lack of knowledge about construction
2	Accidents	40	Lack of legislative enforcement
3	Communication problems	41	Lack of material quality specifications
4	Complicated designs	42	Lack of waste management plans
5	Congestion of the site	43	Last minute client requirements
6	Damage caused by workers	44	Late information flow among parties
7	Damage during transportation	45	Left over material on site
8	Damages caused by third parties	46	Lighting problems
9	Delay during delivery	47	Long project duration
10	Design errors	48	Material supplied in loose form
11	Design without integration of waste minimization strategy	49	Mistakes in quantity surveys
12	Designer lack of information about construction	50	Ordering errors
13	Different methods used for estimation	51	Outdates equipment
14	Difficulties in excessing construction site	52	Over allowances
15	Effect of weather	53	Poor attitudes of workers
16	Equipment failure	54	Poor controlling
17	Error in contract documentation	55	Poor design quality
18	Error in shipping	56	Poor information quality
19	Festival calibration	57	Poor material handling
20	Frequent design changes	58	Poor planning
21	Frequent variation orders	59	Poor quality of materials
22	Inappropriate construction methods	60	Poor site conditions
23	Inappropriate use of materials	61	Poor site management
24	Incompetent workers	62	Poor supervision
25	Incomplete contract documents	63	Poor workmanship
26	Inexperience designer	64	Resources problem
27	Insufficient methods of loading	65	Rework
28	Insufficient training for workers	66	Scarcity of equipment / non-availability of equipment
29	Interaction between various specialists	67	Shortage of skilled workers
30	Interference of other crew at site	68	Slow drawing distribution
31	Inventory of materials not well documented	69	Supplier errors
32	Items not in compliance with specification	70	Too much over time of workers
33	Lack of awareness among the workers	71	Unforeseen ground conditions
34	Lack of coordination among parties	72	Unpredictable local condition
35	Lack of design information	73	Vandalism
36	Lack of environmental awareness	74	Waiting periods
37	Lack of experience	77	Workers' mistakes during construction
38	Lack of influence of contractors	78	Wrong material delivery procedures

5. Conclusion

Construction waste is a worldwide problem and is affected by all construction sites. It must cause huge losses to contractors or builders. They control waste management efficiency during construction projects. Many contractors and builders are facing the problem of how to best prevent or reduce waste. Results show 78 attributes which are very important and significantly contribute to construction waste generation.

Therefore, in this case, the project manager should request further research, such as waste management regulations, waste management systems, waste management awareness, low waste building technology,

less design changes, waste management research and development. This kind of research can achieve the performance level of the project, and can also control or reduce unnecessary waste. Project management needs to provide workers with advice on various waste management plans, plans, and construction projects that minimize waste of construction methods. Such knowledge is implemented there to improve the performance of construction waste management there. A simple construction waste management system is recommended that provides information on the amount of waste, identifies areas where there are problems with waste generation, and can analyze the causes of these wastes.

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