

To Study Models of Construction Waste Management and their Applications on Sites in District Peshawar

Muhammad Farooq Khattak^{#1}, Shabbir Ahmad^{*2}

¹ Department of Civil Engineering, Kabul University, Afghanistan.

² Professional Civil Engineer, Peshawar, KPK, Pakistan.

Received Date: 16 July 2020

Revised Date: 29 August 2020

Accepted Date: 05 September 2020

Abstract

Construction waste is one of the big problems that directly influence the construction industry's financial and environmental conditions throughout the world. Due to dismantling and construction during the last 20 years, waste increasing day by day. Thus researchers and experts also paid more attention to this problem. Different experts and researchers investigated this issue, specifically waste cost, source, and its minimization in the construction industry. For this purpose, to reduce waste and increase their competitiveness in the global market current model survey is used and reviewed. After this study, it is observed that Construction and Demolition of waste are minimized in many developed countries by adopting rules and regulations. This study mainly focuses on waste cost, sources, and management of waste models in district Peshawar. For achieving the objectives, a survey questionnaire is developed, which consisted of twenty questions. The survey forms are distributed among 07 persons (10 forms per person) related to the professional construction industry such as Field/Site engineer, Quality assurance and control engineer, Environment safety professional, site manager, construction business owner, designer, and project manager. After conducting a survey, the obtained data is analyzed and processed. It is observed that all construction companies generated large waste amounts and use oil drums at the site for waste collection. It is also concluded that adopting waste management practices causes a reduction in waste on-site. In addition, fewer training pieces are obtained by respondents on waste management; thus, they required more training for awareness purposes. Civil discipline during a construction project produced more waste on-site instead of another discipline. Based on the results, it is concluded that a waste model contractor is recommended for use.

Keywords: Construction industry, Construction, and Demolition, Financial and Environmental, Management of Waste models.

I. INTRODUCTION

for the best economy of any country, the construction industry played an essential part. To increase the overall standard of living, every project created new publics and renovation of old ones. But due to new construction or dismantling of existing work, wastes were created, which led to enhancing the project budget and the environment by adding pollution to it. Therefore, construction waste problems have an important part of a project to be studied because of the environment and cost. With an increase in waste generation, landfill consumption, unrecoverable natural resources, the cost of construction projects also increased significantly along with the negative effect on the environment. Environmental agencies have assessed waste generated from the construction industry. In 2002, 0.136 billion tons of waste was produced, as reported in the environmental protection agency of the united states of America [1]. To reduce construction waste, many efforts were made in the construction industry for environmental protection and sustainability improvement. The best example of enforcing rules and regulations relevant to waste, which started gradually, is the united nations framework convention on climate change (UNFCCC) [2]. for the elimination of waste, lean construction techniques were also used outlining the process. In the construction industry worldwide, the projects related to construction are increasing day by day due to the increase in population in each country, which is directly related to increases in construction waste on sites. These wastes are ultimately led to disposed of in a landfill. Thus, an effective waste management plan is needed as the need for all contractor and consultant firms. The

aim of all construction firms is to complete the project within the allocated budget and stipulated period. The profit is obtained for construction firms if additional efficiencies are done.

The material waste during production was caused due to factors such as poor handling, incorrect ordering



and storage, design change, manufacturing defects, and rework. Waste losses have been recorded up to 1-1.2 million dollars per project [2]. In addition, lack of training and workmanship are also such factors that contributed to producing of waste. Thus, the reduction of waste at construction sites due to wastage of raw materials and ineffective management became an important area of concern in the construction industry

II. LITERATURE REVIEW

The focus of this study is the construction site waste issues because of environmental and cost awareness.

Construction waste types, cost, construction and demolition causes, and waste models of waste were reviewed during this literature review.

Many scientists and researchers focused on the importance of waste and debris amount management produced during construction work in Construction projects. The waste produced by the construction industry include

- About 14 million tons of waste generated in Australia [3].
- About 136 million tons of waste generated in the USA [1]
- About 70 million tons of waste generated in the UK [1].
- About 4.25 thousand million tons of waste are generated each year in Holland [4].
- About 15-30% of total waste (20-million-ton waste) generated each year in Pakistan, which construction waste [6].

The waste produced on sites pre, during, and post-construction from products/materials that remained unused was defined as construction waste [7]. More ever, waste of construction was described by [8], i.e., products remained on construction site, which is unwanted from construction, dismantling, and renovation works. In addition, waste is obtained from various construction activities at any site, such as building materials, reinforcement, coarse or fine aggregates, concrete mix, timber, etc. [9]. From the above definitions, it was concluded that any extra materials which are produced from activities during construction work were termed as construction waste.

In every developing country, the construction industry plays a very vital role in economic conditions. For every country, the construction industry plays the role of backbone as an economic investment, which is directly related to the country's development in an economical way [10].

Construction Waste types

More ever, it was also well known to everyone that the construction industry is not enviro-friendly. A large part of natural resources was utilized during construction work, leading to the generation of waste in a large amount. According to [11], it was noted that in the construction industry, 25% and 40% of

wood and raw materials were consumed per year, respectively. Besides this, reconstruction work due to low quality/poor work, double handling of materials, delays in work timeline, and late decision making are also other construction waste types. There are two principals components in which construction waste was divided [12].

- Waste of time comprises waiting periods, blockages, clarifications, information variation, reconstruction of work, low quality work, delay plan activities, and abnormal machinery wear.
- Wastes of material including over-ordering, excess in production, handling and storage in the wrong way, and manufacturing faults.

The furnaces produced the waste comprising various types of dioxin compounds, more than 200 in numbers due to which a large amount of carbon dioxide gas emitted into the atmosphere.

Construction Waste Cost

As various activities were conducted during the construction project on the construction site and produced the various type of wastes on the said site, which cause millions of budgets to the project per year. If this waste of construction at the site was properly managed or minimized by the contractor, a valuable amount of money can be saved with this little effort and invest this amount in future work. The total procured materials percentage that ends up as waste is about 9%. For each procured construction material, solid waste left at the construction site by weight is from 1% to 10%) in the Dutch construction industry [13]. After each project, 20% of materials remained unused at the site, which directly affects the project's cost up to 50%. According to a report by Hong Kong's Environmental Protection Department, in 2007, construction waste received is about 2900 tons per day at landfills [1].

Construction and Demolition Waste Causes

The kinds of literature covered that generation of C&D waste showed numbers of sources of generation of construction waste that begin continuously from start to end of the project. Construction waste is classified into six categories [13] such as

- Construction designs
- Procurement before/during construction work
- Handling of materials at the construction site
- Operation
- Construction residual
- Other

In addition, the change in design with delay is also considered one of the main causes of construction waste at the site. Besides this, sources of C and D wastes, information but late or not completed, poorly management of material, labor with low skills and damages caused during transportation but other factors are considered to be C&D waste source, incomplete or late information, poor material management, incompetent labor, and damage during transportation. According to [14], architects are

responsible for on-site up to 33% waste generation because they failed to implement waste reduction measurements during the design stage. Construction waste causes and the list from where it originated was shown in table 1 {15}.

TABLE I
Construction Waste Causes and its Origin

Origins of waste	Causes of waste
Contractual	<ul style="list-style-type: none"> • Errors in contract documents • Contract documents incomplete at the commencement of construction
Design	<ul style="list-style-type: none"> • Design changes • Design and construction detail errors • Unclear/unsuitable specification • Poor coordination and communication (late information, last-minute client requirements, slow drawing revision, and distribution).
Procurement	<ul style="list-style-type: none"> • Ordering errors (i.e., ordering items, not in compliance with specification) • Over allowances (i.e., difficulties to order small quantities) • Supplier errors
Transportation	<ul style="list-style-type: none"> • Damage during Insufficient transportation protection during unloading • Inefficient methods of unloading
On-site management and planning	<ul style="list-style-type: none"> • Lack of on-site waste management plans • Improper planning for required quantities • Lack of on-site material control • Lack of supervision
Material storage	<ul style="list-style-type: none"> • Inappropriate site storage space leading to damage or deterioration • Improper storing methods • Materials stored far away from the point of application
Material handling	<ul style="list-style-type: none"> • Materials supplied in loose form • On-site transportation methods from storage to the point of application • Inadequate material handling
Site operation	<ul style="list-style-type: none"> • Accidents due to negligence • Equipment malfunction • Poor craftsmanship • Time pressure
Residual	<ul style="list-style-type: none"> • Waste from application processes (i.e., Over-preparation of mortar) • Packaging
Other	<ul style="list-style-type: none"> • Weather • Vandalism

Waste Management Models

There is various type of waste models which are used at the construction site. According to [16], The first three models average cost estimation model, the equivalent method of cost estimation, and the activity-based costing model.

When a company or organization produced only one product, the model used is known as the average cost estimation model. The formula used to know average

cost estimation is the total cost of product/ Total production. When a company produced limited products based only on the same raw materials and manufacturing process, the model applied is the equivalent cost estimation method.

ER = (normal cost per unit for a given product) / (normal cost per unit for the product with the lowest cost per unit). Where ER = equivalent rate. When the costs are non-volume-based and rise from various factors, then the Activity-based cost model (ABC) is applied. This model's main aim is to trace costs to products or services instead of allocation costs randomly. The above-discussed models are not used at the construction site because of mathematical equations in which inputs are provided to obtain the results. Thus, they are only applicable to industrial management instead of the waste management process.

According to [1], demolition waste economic, environmental, and social sustainability is proposed for evaluation in this model. The social impact of demolition waste was studied by inputting data into an established model obtained from a practical case. But this model is used less due to less priority of social influence on construction sites of performing waste management construction. The construction waste management models which can apply to a construction project at sites are as given below

C and D Waste Management Investment

Practices of waste management in various ways can be promoted by doing investment in C and D waste management to make workers responsible for the collection of waste on-site, sorting and handling, equipment and machines purchasing for waste management, waste management plans development and implementation, motivating practitioners to minimize C&D waste and improving operatives' skills of waste handling through vocational training.

Space at the site for Performing Waste Management

Site space is defined as the space utilized to collect, sort, and handle waste on-site. Due to the availability of different materials in a mixture of C and D waste, separation of materials for reuse or recycling is difficult, disposed of directly at landfills [11]. Thus, sorting at the site is effective in achieving a higher rate of waste reuse and recycling.

Waste Management Contractor

In this model, the contractor is solemnly responsible for providing bins, drums, and labeling to identify bins use on the construction site to manage the waste. This type of model is highly apricated. Thus, the removal of waste or any payment on reused materials is the property of the contractor.

Waste Elimination

The techniques used to avoid, eliminate, or reduce waste at its source by minimizing waste are known as

waste elimination or designing waste. At the initial stage of the project, this process minimized the huge amount of waste [13].

3 Rs

These models state three numbers of Rs such as reduce, reuse, and recycle. The most efficient and effective method for C and D waste management is reduction. Waste transportation and disposal costs will be minimized with the reduction of waste generation. Material reuse is considered another effective method of waste reduction disposed of in landfills; thus, construction projects have more savings. More ever, recycle materials used for environmental protection and use of unrecovered natural resources.

Prefabrication

This type of model uses industrialized building systems and prefabrication to minimize waste and management issues. Application of this model in building construction activities is advantageous, including B & D construction integrity, unskilled workers and cost reduction, good supervision, initial stage fixed design, and construction site promotion in safe and organized ways. A construction company minimized waste disposal costs, risks on site, and environmental pollution by keeping good WM.

III. RESEARCH METHODOLOGY

To achieve the objectives of this study, questionnaire form is designed to know better about waste management at Peshawar's construction sites. 20 numbers questions were included in this form. The survey forms are distributed among 07 persons (10 forms per person) related to the professional construction industry such as Field/Site engineer, Quality assurance and control engineer, Environment safety professional, site manager, construction business owner, designer, and project manager. For full participation, one month is given to every person. The aim was to reach at least 100% responses from construction professionals after one month. The survey form composed of three parts

- Part first included questions related to all those peoples having a relative filed experience of waste management on-site, including personal experience of respondent, company size, and type of business performed by the respondent company.
- The second part of the questionnaire included finding waste types containers, waste production discipline, and recycled materials use advantage on construction site.
- The third part of the questionnaire form focused on factors supporting Waste management, which is composed of sufficient training availability, waste management plan of organization/firm, and waste management related clause.

After collecting data from construction professionals, the data analyzed in MS Excel

software to know the respondents' responses, and results are obtained.

IV. RESULTS

Based on the above methodology, the obtained data showed that 70% of respondents had more than 10 years in the construction industry, and 76% worked in a company with more than 2000 employees. 96%, 50%, 65%, 10%, and 40% of companies worked in the construction, design, procurement, recruiting, and transportation category, respectively, as the respondent's response. Figure. 1 clearly shows the respondents' experience distribution.

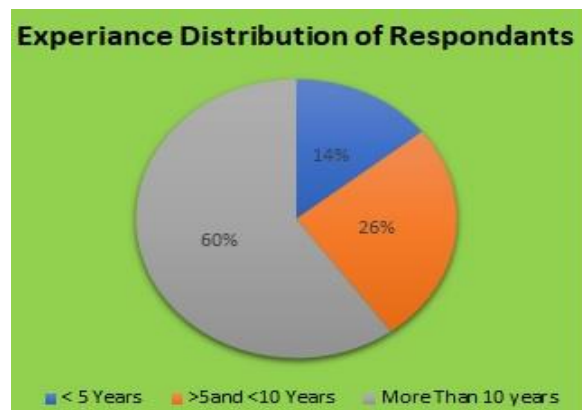


Fig.1 Respondents Experience Distribution

99% of respondents supported the waste management procedure due to the protection of the environment and cost-saving and 20% of companies having waste management procedures. For collecting construction waste, 85% used oil drums, 25% used oil concrete, and 10% used metal bins. 45.5% of participants responded to dispose of waste from the site daily, and 50% of the participants indicated their disposal every week. In the remaining 4.5%, 3%, and 1.5%, respondents suggested bi-monthly and monthly waste disposal, respectively. Also, 10% of people did not know about the construction waste disposal schedule. Figure.2 showed the Schedule of waste disposal.



Fig.2 Construction waste disposal Schedule

In this study, waste management practice is essential to encourage in any company. Regarding supporting waste management practices, 95% of participants response was positive, and 93% of respondents responded that construction waste was minimized with WM practice. Zero waste is the final goal of construction waste. However, participant about 70% responds that a significant amount of construction waste was produced by their projects, which resists the concept of having low waste construction sites. In comparison, for the application of WM, more support was provided as the response was given by 80%. The training of waste management on sites was found less because 50% of respondents indicated they obtained the training. In comparison, 90% of participants showed an interest in learning waste management practices through training.

The technical discipline which produced more waste at site, Civil, mechanical, electrical and environment was ranked as first, second, and so on. The Civil discipline generated 55%, mechanical 40%, electrical 20%, and environmental 15%. The details of discipline and generated percentage of waste were indicated in Figure.3.



Fig.3 Discipline Vs. Generated Waste on Construction sites

Regarding the last three questions in the survey form, 60% of respondents indicated that penalties were charged to contractors with no WM system. Moreover, 90% of respondents showed interest that the inclusion of waste management clauses was important for the contractor to use recycled construction materials because waste amount was also reduced.

V. CONCLUSIONS AND RECOMMENDATIONS

During each year, the production of waste is assessed by the construction industry. Throughout the world, waste of construction has become a more important issue in construction projects. In addition, construction companies reduced the project's cost by improving their waste management production on-site, which must be considered. Most companies disposed of their waste with millions of tons at

identified landfill location every year, which increase the cost and required proper disposal procedure. Waste management plan developed by many countries to reduce waste at a construction site, but only the largest companies adopted procedures to reduce waste and increase its reuse. During this study, this study concluded that this waste enhances the cost of the project and reduces the land area, which badly affects the environment. This study's focus is not only on the construction implementation phase but also on the design phase. Thus, the designer must design the structure according to available dimensions to minimize waste at the site. After analyzing the questionnaire, it is observed that all construction companies generated large waste amounts and use oil drums at the site for waste collection. It is also concluded that adopting waste management practices causes a reduction in waste on-site. In addition, fewer training pieces are obtained by respondents on waste management; thus, they required more training for awareness purposes. Civil discipline during a construction project produced more waste on-site instead of another discipline.

Furthermore, the proper waste management system must be adopted by the contractor at the site. Otherwise, a penalty is charged to the contractor. Based on the above waste management model it is strongly recommended to use the WM contractor model within the company. It is also useful for construction companies in the future for establishing waste management plans. This research paper is the best way to know the waste controlling on sites in the future.

REFERENCES

- [1] Yuan, H. A Model for Evaluating the Social Performance of Construction Waste Management. *Waste Management*, 32, 1218-1228. doi:10.1016/j.wasman.2012.01.028 (2012).
- [2] Dong-Woo, S., Hee-Sung, C., Jae-Moon, K., & Jee-Hye, K. Development of the Construction Waste Management Performance Evaluation Tool (WMPET). Retrieved from <http://www.iaarc.org/publications/fulltext/iaarc>. (2006).
- [3] Site Waste Management Plans in the Construction Industry. Retrieved from <http://www.ukessays.com/dissertations/construction/site-waste-management-plans-in-construction-industry.php?cref=1>. (2013).
- [4] Seydel, A., Skitmore, R. M., & Wilson, O. D. Waste Management in the Construction Industry. *Construction and the Environment*, 2, 879-886. Retrieved from <http://eprints.qut.edu.au/archive/00004540>. (1998).
- [5] Vipin, A., & Shailini, Y. Construction Waste Management Model and Their Application Initiatives in Numerous Country: A Review, *IJETAS*, 3(04) (2017).
- [6] Rachael, L. <https://www.bioenergyconsult.com/solid-waste-management-in-pakistan>. (2020).
- [7] Rahim M H I A, Kasim N, Mohamed I, Zaina R, Sarpin N and Saikah M Construction waste generation in Malaysia construction industry: illegal dumping activities GCoMSE2017 (Johor Bahru) 271 (Bristol: IOP Publishing) (2017) 1-8.

- [8] Tam V W Y, Tam C M, Zeng S X and Ng W C Y Towards adoption of prefabrication in construction Int. J. of Build. Science and Its Applications 42(2007) 3642-3654.
- [9] Shen L Y, Tam V W, Tam C M and Drew D 2004 Mapping approach for examining waste management on Construction sites J. of Const. Eng. and Mngmt. 130 472-481
- [10] Olanrewaju A L and Abdul-Aziz an R An Overview of the Construction Industry. In Building Maintenance Processes and Practices (Singapore: Springer) (2015), 9-32,
- [11] Amaratunga, D., Haigh, R., Kulatunga, U., & Rameezdeen, R. Management of Environmental Quality: An International Journal. Retrieved from <http://www.emeraldinsight.com/journals.htm?articleid=1537410&show=html>. (2006).
- [12] Anis, A. R., Garas, G. L., & El-Gammal, A. Materials Waste in The Egyptian Construction Industry. Retrieved from <http://cic.vt.fi/lean/singapore/Garasetal.pdf>. (2001).
- [13] Bossink, B., & Brouwers, H. Construction Waste: Quantification and Source Evaluation. Journal of Construction Engineering and Management. Retrieved from <http://www.tue.nl/en/publication/ep/p/d/ep-uid/231803/>.
- [14] Danai, G. I., & Panos, K. Survey Regarding Control and Reduction of Construction Waste. Retrieved from <http://www.plea2012.pe/pdfs/T05-20120130-0006.pdf>. (2012).
- [15] Nilesh Jain, Avinash Shingan, Shantanu Paraspatki, Construction Waste Minimisation & Management, SSRG International Journal of Civil Engineering 3(12) (2016) 22-28.
- [16] Glass, J., Osmani, M., & Price, A. Architect's Perspective on Construction Waste Reduction by Design. Retrieved from www.lib.purdue.edu/. (2008).
- [17] Stenis, J. Construction Waste Management Based on Industrial Management Models: A Swedish Case Study. doi: 10.1177/0734242X05050184. (2004).

Appendix A (Research paper Questionnaire)

S. No	Description
1	How many years of experience do you have in the construction industry? Less than 5 yrs, 5-10 yrs, More than 10 yrs
2	What is the size of the company you are employed in?
3	What type of business does your company do? Select all that applies. Construction work, Procurement work, designing work, Transportation work, Recruiting work
4	Do you support the idea of Waste Management? Yes /No, If your answer is No, skip 5
5	Why do you support the idea of Waste Management? Cost-saving, protection of the environment
6	Does your company have a Waste Management Procedure on-site? Yes/No
7	Do you think that the construction waste should be reduced on-site? Yes/No
8	Do you use Separate containers for disposal on-site? Yes/No, if the answer is No, skip question 9
9	What kind of waste container does your project use? Select all that applies. Metal Bin, oil Drum, Concrete bin
10	How often does the project dispose of its waste? Daily, Weekly, biweekly, Monthly
11	Do you think there is enough encouragement from your company to practice Waste Management? Yes/No
12	Do you think that there should be more support to apply Waste Management on construction sites? Yes/No
13	On average, how much waste does your project generate monthly basis?
14	Do you think using Waste Management will help reducing construction waste? Yes/No

15	Did you receive any kind of training of Waste Management? Yes/NO
16	Do you think there should be more training in Waste Management? Yes/No
17	What discipline do you think generates the most amount of waste? Civil, Electrical, Mechanical, Environmental
18	Do you think penalties should be charged against contractors who do not have a waste management plan? Yes/No
19	Do you think the use of recycled material will reduce waste? Yes/No
20	Do you think that there should be a contract clause that requires the contractors to use recycled material where possible? Yes/No