EXPLORING TYPES OF WASTE GENERATED: A STUDY OF CONSTRUCTION INDUSTRY OF *PAKISTAN*

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Abstract
The construction sector is responsible for providing fundamental physical structure required for living and survival of human life. Increased development works have led in resulting the massive amount of waste generation in developing countries. Due to poor management system on sites, it has become more crucial and exerts several negative impacts on society and the environment. This Unused waste material has a negative impact on the ecosystem and needs a considerable amount of money for recycling, reusing and disposal of the waste. Like other developing countries Pakistan is spending a significant portion of its GDP on handling construction waste. Among the several other factors, the key contributes are highlighted in this study. This study is exploratory work investigating the types of construction waste generated on site and their relative impact of the project cost in construction projects of Pakistan. Through questionnaire the opinion of clients, consultant and constructor have been taken to identify the major types of waste having more impacts on cost and time. Through Average index, severity index and importance index, the probability of occurrence of waste through different materials, severity level of waste production by these materials, and the overall effect of all waste generating materials have been found respectively. Among the materials sand, concrete, tile is the most common materials, which are responsible for a waste generation while time and cost are the two most common non-physical waste generating factors.

Keywords: construction waste, factors, types and Pakistan

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INTRODUCTION

The construction sector is responsible for providing fundamental physical structure required for living and survival of human life. Increased development works have led in resulting the massive amount of waste generation in developing countries. Due to poor management system on sites, it has become more crucial and exerts several negative impacts on society and the environment. It is also known as the best contributor to the economic development of any country. On average it contributes 5% - 15% in GDP of a country, which is a significant input (Arshad *et al.,* 2017). (Begum *et al.,* 2006; Kulatunga *et al.,* 2006) highlights this sector as one of the highest resource consuming sector needs a considerable amount of resources concerning monetary and non-monetary capitals. About 40% of the material resources consumed in construction (DTIE, 2009), which ultimately generates waste in the same proportion because most of the construction methods are disreputable for their lower efficiency (Sezer, 2017).

Waste is defined as the difference between the value and quantity of materials procured and the quantity of material used as specified and accurately (Enshassi, 1996; Mcdonald and Smithers, 1998; Pheng and Tan, 1998). Similarly, (Shen *et al.,* 2000) defined material waste as all those materials besides earth soil, which needs to transported somewhere from the construction site such as damage of material, an excess of material, non-use or non-compliance of material, or use of the material other than specified purpose.

These unused or waste materials on site have a harmful impact on eco-system (Esin and Cosgun, 20017). A massive waste of about 40% is produced globally due to construction activities (Sharma *et al.,* 2011). Another study by (Amasuomo and Baird, 2016), reports household waste production as 36.73%, and commercial waste production as 21.54%. Similar evidence is reported by (Bossink and Brouwers, 1996) from Hong Kong, which determined that approximately 1-10% of the total acquired material left as a waste on site. Several causes of waste generation may include improper design, incorrect material estimation, poor handling, inconsistent operations, and inefficient procurement. This study is exploratory work investigating the types of construction waste generated on site and their relative impact of the project cost in construction projects of Pakistan.

Similar statistics are reported by (Kartam *et al.,* 2004) from Kuwait, which reports that 1.6 Million tons of C&D wastes are produced annually, which is a considerable amount. Bossink and Brouwers, (1996), highlights that approximately 9% of the total material brought up to the site, left up as waste. Furthermore, Masudi *et al.,* (2011), supported this argument by stating 10 % of important material ends up as wastage in significant projects in Malaysia.

Nagapan *et al.,* (2012), identified timber, metals, bricks, concrete, packaging and mortar are the six common materials which are a major contributor to waste production. In the same way (Urio and Brent, 2006), indicated sand, cement, concrete, steel, crush, and timber as the primary source of material waste generation causes debris at the site. The results of (Kulatunga *et al.,* 2006), included asbestos sheets, rubble steel, paint and lime with cement, bricks, tiles, and timber as most wasted materials.

The scenario in Pakistan is more or less similar, Pakistan possesses a vast investment in the construction sector, which contributes approximately 2.3% of GDP. A significant number of material industries associated with the construction sector. According to (Haseeb *et al.,* 2011), construction sector in Pakistan has an essential role in the overall progress of the country, which contributes in the provision of employment, bringing forward of foreign investment, provision of shelter to the citizens, by providing opportunities to emerge new industries of raw material, and causing money flow in the country. This Industry is responsible for generating a variety of material waste, which is the objective of this study and analyzed in this paper. The objective of this study is to find the most common physical and non-physical waste generating attributes, which should be reduced to enhance the performance of the construction industry.

Definition of waste

Waste has defined in many ways. Rajendran and Pathrose, (2012), defines the waste as any loss resulted by construction activities that cause direct and indirect costs but does not add any value to the product from the customer's point of view. Similarly, (Formoso *et al.,*2002; Manowong, 2012), define the construction waste as the weight of products and materials generating from construction processes.

Types of waste

Some of the essential types of construction waste are discussed briefly in the following paragraphs.

Natural Waste

(Fadiya *et al.,* 2014; Udawatta, 2015), defined natural waste as the minimum amount of waste that always occurs no matter which type of project it is. Natural waste is also known as unavoidable waste. For example, natural waste for reinforcement is 1.91% in private commercial projects which occurs due to cutting. The waste in which the cost of reduction is higher than the cost of its saving is also known as natural or unavoidable waste (Teo and Loosemore, 2001).

Potential Waste

The items which have higher differences between maximum and minimum levels of waste and there is a considerable room available to reduce such difference are called potential or avoidable waste item (Kalatunga and Amaratunga, 2006). For example, formwork waste in private housing projects is 18.21%, so there is much opportunity available to reduce it. However, Ali et al., (2006) defined the avoidable waste as the waste in which the cost of saving is more than the cost of its reduction.

Physical Waste

Physical waste defined as the loss of construction material that is damaged and cannot be repaired during construction process (Poon *et al.,* 2013; Foo *et al.,* 2013). Physical waste is further classified into structure and finishing waste. Structure waste generated during the construction of different structural elements like concrete, steel, bricks, etc. Whereas finishing waste is generated in the finishing stage of the building, for example, mosaics, mortar,broken tiles, paint, etc. Sasithatan *et al.,* 2012).

Inert Waste
It consists of materials that can be deposited at public filling areas for land reclamation such as concrete, brick, sand, etc. These materials are chemically inactive and less harmful to the ground (Poon *et al.,* 2013).

Non-Inert Waste
It consists of materials that are disposed of at landfills as a solid waste like plastics, wood and other organic materials. These materials are chemically active and should be disposed of at landfills (Poon *et al.,* 2013). By sorting waste this way, it helps to reuse the inert waste at public filling areas while non-inert waste is disposed of at landfills so that less landfill space is used.

Source of Waste Generation
Some of the primary sources contributing to the waste of construction materials are discussed below.

Improper handling of materials
Improper handling of the material found as one of the significant construction sources waste generation (Nagapan *et al.,* 2012). Improper material handling includes damages during the transportation, unpacked supply and throwaway packaging (Foo *et al.,* 2013).

Procurement methods
Al-Moghany, (2006), has found that procurement methods contribute to a waste of construction materials. Major causes involved are ordering errors, and over- and under-ordering (Adwuyi and Odesola, 2015). Other causes related to the procurement methods are the use of products that are not according to the specifications and lack of chances to order smaller quantities of materials (Udawatta, 2015).

Change in design
Sasitharan *et al.,* (2012), has identified that change in design is a significant source of waste generation. If the contractor has already purchased the materials based on the original design, there will be a waste if that material is not taken back by the supplier in case of design change. Further, if the structure has already constructed, design change will generate waste as the applied materials would have to be removed due to rework (Serpell *et al.,* 1995). Similar kind of results is found in other studies that design change and design errors are the significant sources of waste generation (Adewuyi and Odesola 2015). Al-Agele and Al-Kaabi (2016), conclude that design-related problems are outside the control of contractors. Important reason can be a lack of awareness of the construction workforce.

Workforce
Tabassicand Bakar (2009), have suggested that behaviour of the workforce towards the waste generation is a significant factor. There are some wastes which are avoidable if workers perform their duty carefully. Workers become careless in the absence of proper control and reward system. Three significant factors identified are their behaviour, enthusiasm, and collectivism towards the waste reduction. Results show that group based Incentive Reward Program (IRP) has significant influence in the reduction of waste.

Similarly, Kulatunga *et al.,* (2006), have identified that the attitudes of the workforce towards waste reduction are negative in Sri-Lankan construction industry. Major factors obstructing the implementation of waste management practices are lack of training and negative attitude of higher management towards the subordinates.

Improper material storage
Improper storage of construction material is also an essential factor in material waste (Ekanayake and Ofori, 2000; Sasitharan *et al.,* 2012; Adewuyi and Odesola, 2015). Adewuyi and Odesola, (2015), identified that the inadequate stacking of material contributes to its waste. Other possible reasons can be storing the material in the wrong place like storing cement in an open area where dampness or rain can damage it.

Theft and vandalism
Construction materials are stolen due to the lack of proper security. Theft and vandalism considered as the sources of waste (Berg and Hinze, 2005).

Waste Generation Measurement

Multiple methods have been adopted to measure waste generation rates as given in bellow (Mah *et al.,* 2016; Akhund *et al.,* 2017). identify many studies which measure construction waste generation rates by adopting one of the following measurement methods:

- As a percent of purchased material;
- As a percent of the material required by the design;
- The weight of material per unit area (kg/m2);
- The volume of material wasted per unit area (m3/m2).

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RESEARCH METHODOLOGY

The quantitative approach is used in this research; through the use of a questionnaire survey as a tool for primary data collection. Secondary Data collected through literature review. Questions in the questionnaire were numerical and were composed to obtain information about opinion, behavior, expectation, and knowledge of the respondent, about waste generation. Four target groups focused on this study, which was clients, consultants, contractors, and town planners to know their perspective. A total of 100 questionnaires distributed in construction sites among different people engaged in different operations at various levels on different Cities in Pakistan. Out of a hundred, we received 80 questionnaires which depict the response rate of 80%.

The collected Data analysed on SPSS and Microsoft Excel. Average Index, the probability of occurrence, severity index, frequency distribution, and other statistical parameters were computed. Reliability index is also calculated using the same software. The results obtained grouped by frequency of occurrence. Average index is ranked, and top-ranked waste generated materials were identified using the standard formula. Twenty-two types of construction waste materials were targeted in this research to find out most critical construction materials, which causes severe waste generation. These construction materials presented, on Likert scale having variation between 1 - 5, and the respondents were asked to rate the materials according to their contribution towards waste generation.

$$\boldsymbol{Severity\ Index} = \frac{\int_1^5 \boldsymbol{ai} * \boldsymbol{ni}}{\boldsymbol{5N}}$$

Where: a = constant expressing the weight assigned to each response (ranges from 1 for No Severe to 5 for extremely), n = frequency of each response, N = total number of responses.

$$\boldsymbol{Importance\ Index} = \boldsymbol{Frequency\ Index} * \boldsymbol{Severity\ Index}$$

This index expresses the overview of factor based on their frequency index/probability of occurrence (F.I) and severity index (S.I). It computed as per following formula:

$$\boldsymbol{Average\ Index} = \frac{\sum(\boldsymbol{5X1} + \boldsymbol{4X2} + \boldsymbol{3X3} + \boldsymbol{2X4} + \boldsymbol{1X5})}{\sum(\boldsymbol{X1} + \boldsymbol{X2} + \boldsymbol{X3} + \boldsymbol{X4} + \boldsymbol{X5})}$$

Where; X1 = Number of respondents for scale 1, X2 = Number of respondents for scale 2, X3 = Number of respondents for scale 3, X4 = Number of respondents for scale 4, X5 = Number of respondents for scale 5.

Evaluation ranges to assess significant level used in this study as follows:

- 4.50 < AI < 5.00 : Extremely Significant (ES);
- 3.50 < AI < 4.50 : Very Significant (VS);
- 2.50 < AI < 3.50 : Moderately Significant (MS);
- 1.50 < AI < 2.50 : Slightly Significant (SS);
- 1.00 < AI < 1.50 : Not Significant (NS).

x

RESULTS AND DISCUSSION

Total 100 questionnaires distributed, and 80 questionnaires received back. It was intended to get data from all four target groups equally, but unfortunately, the responses obtained from the respondents were majorly from contractors and consultants, which comprise 60% and 32 % respectively. Only 5 %

responses were from client side and 3 % from planners. Figure 1 presenting the graphical representation of the data.

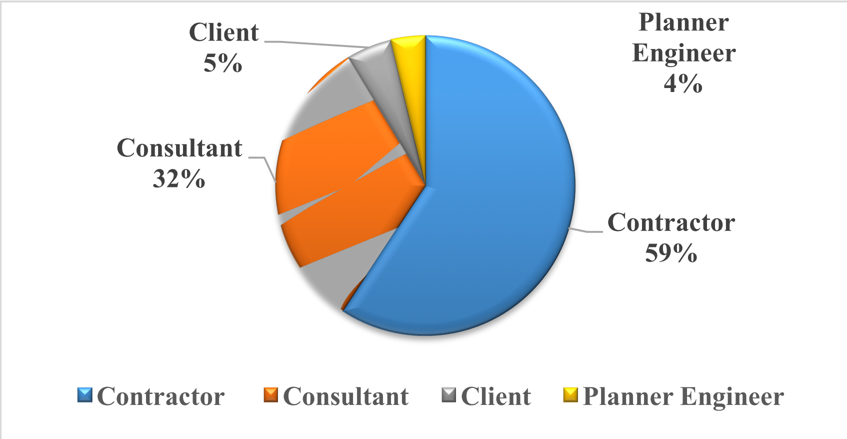

Figure 1: Status of Respondents

In ensuring the reliability of the data, persons with sufficient knowledge is considered as respondents in this research. This minimum threshold limit of education, to participate in the survey, was kept as having a diploma. Based on this restriction, the following graph shows the educational resilience of the respondents. As clearly seen from figure 2, most of the respondents were site engineer, who are the most concern people for waste production. A variety of people working on a different position as, chief engineer, project manager, design engineer, director, XEN, material engineer, resident engineer, site engineer, site supervisor, and superintend engineer considered for data collection. Due to the difference in administrative positions, experience education, and knowledge, a variety of responses have been obtained to grab the most occurring waste generating factor in term of physical and non-physical waste. The number of respondents at each position summarized in Figure 2.

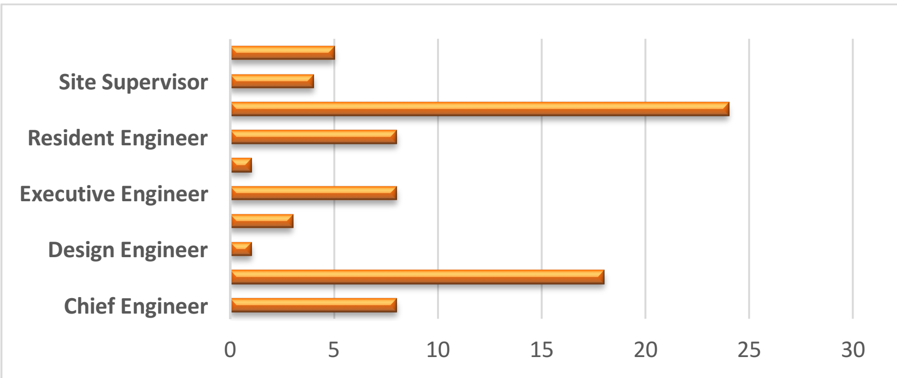

Figure 2: Position of Respondents

Probability of occurrence and severity level were extracted from the data, which was presented on Likert scale having variation between 1and 5. Average index is calculated for both the attributes and for each corresponding factor. Results show that concrete, concrete, sand, metal and tiles are most common waste material. Probability of occurrence lies between 2.89 for Time and 4.1 for dry wall. Average indices for other materials and factors are displayed in the figure 3, which are ranked from high to low. While severity level for these materials is presented in figure 4, which indicates 4.16 for rubble work and 2.65 for time. All factors are arranged in descending order as per their severity level.
Besides, that important index was calculated by above important index formula. Table 1 presenting the level of importance index of each responsible factor those were explored through questioners survey.

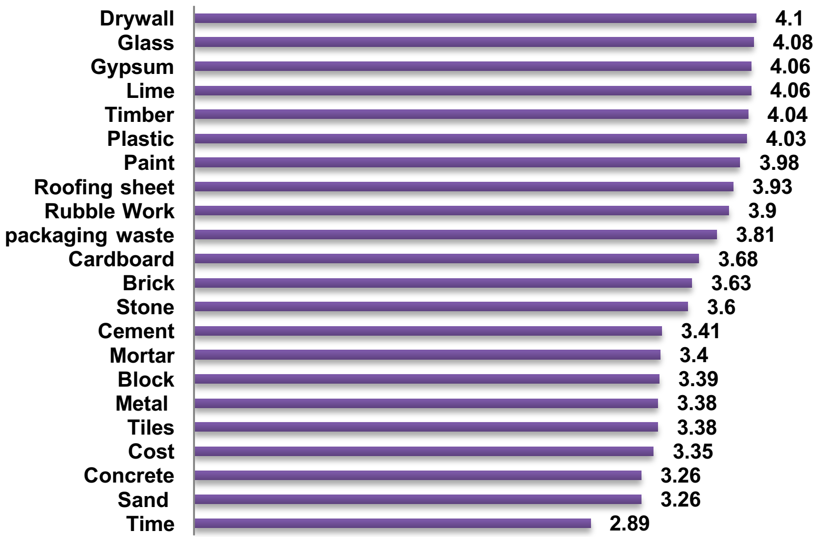

Figure 3: Probability of Occurrence of Waste Factors

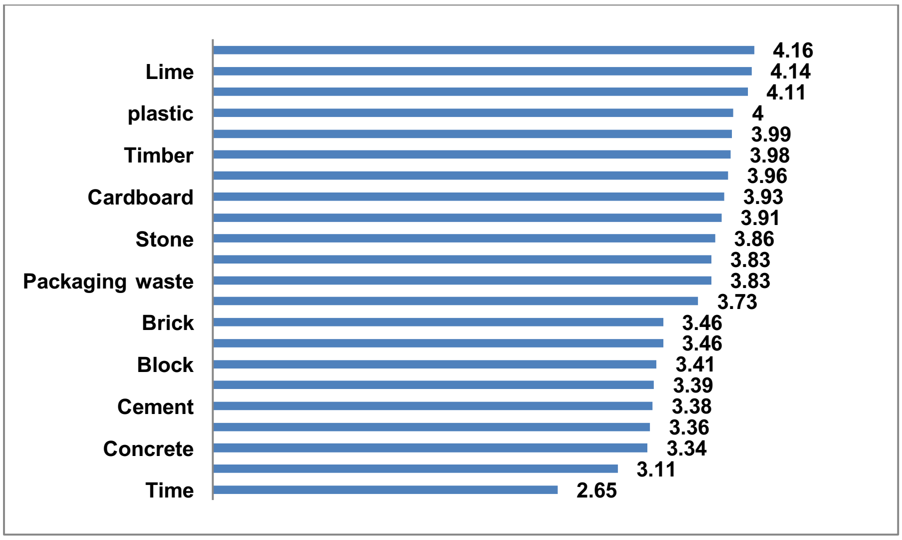

Figure 4: Severity Level of Waste Generating Factors

Table 1: Level of important index of explore factors

No.	Waste Type Material	POC	SI	I.I	Rank
1	Time	0.623	0.67	0.42	1
2	Sand	0.548	0.523	0.29	3
3	Concrete	0.548	0.533	0.29	3
4	Cost	0.53	0.578	0.31	2
5	Tiles	0.525	0.528	0.28	4
6	Metal	0.525	0.508	0.27	5
7	Block	0.523	0.518	0.27	5
8	Mortar	0.52	0.418	0.22	7
9	Cément	0.518	0.525	0.27	5
10	Stone	0.48	0.428	0.21	8
11	Brick	0.475	0.508	0.24	6
12	Cardboard	0.465	0.415	0.19	9
13	packaging waste	0.438	0.435	0.19	9
14	Rubble Work	0.42	0.368	0.15	13
15	Roofing sheet	0.415	0.408	0.17	11
16	Paint	0.405	0.455	0.18	10

17	Plastic	0.395	0.4	0.16	**12**
18	Timber	0.393	0.405	0.16	**12**
19	Lime	0.388	0.373	0.14	**14**
20	Gypsum	0.388	0.378	0.15	**13**
21	Glass	0.385	0.403	0.16	**12**
22	Drywall	0.38	0.435	0.17	**11**

Probability of occurrence for different factors which negatively impacts the project varies between 0.623 and 0.38, which indicates the occurrence of an event is 62% on maximum, and 38% on minimum. Highest probability of occurrence of event is that time and cost of the project will exceed then estimated, or we can say these factors will have the chance of wastage. Theses value are 54%, 53%, 52% respectively for sand and concrete, cost of the project and for metals and tiles.

In the same way, severity index is calculated for all these materials, and factors. Which represents the intensity of wastage or negative impact on the project due to wastage of this specific material. The Severity Index (S.I) is found to be highes again for tie and lowest for dry wall. Other severity indices were between 67% and 43%. On average S.I for concrete, metals, tiles and sand is 51%, which is quite critical.

Probability and severity indices are calculated using above formulae. Importance index in then found using the product of both indices, based on results, all factors are ranked from high to low values. Top 5 factors are time, cost, concrete, sand, metals and tiles. Among which material factors are concrete, sand, metals and tiles, which are of highest critical level or have highest probability to occur in construction projects of Pakistan.

CONCLUSIONS

In construction industries, the wastage of resources and waste generation is unavoidable. Finding most critical physical and non-physical factor of waste generation was the main objective of this study. This will enhance the performance of construction industry by reducing waste contributing factors, which will boost up the economy o the industry and of the country. This study has found that time and cost are the most crucial non-physical factors which can influence the waste production. Beside these factors, certain materials have higher tendency to be wasted, these materials are identified as metals, concrete, tiles and sand, and are most responsible for waste generation. If these materials can be controlled from wastage, or the wastage can be reduced o minimised, the overall waste from the project can be reduced up to 50%. This is a significant reduction and can save overall cost of the project up to an extent and saves time of landscaping as well. The probability of wastage for all identified factors lies between 2.89 for time and 4.1 for drywall. Similarly, The severity level of these factors for causing ill effects on construction are between 2.65 and 4.16. On the basis of these statistics, importance index (I.I) I found to rank the factors as per their significance towards waste generation. Based on the results it is concluded that if time and cost are well managed, concrete, tiles, sand and metals are efficiently used, a high extent of material, time and cost can be saved

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