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Consultants' Perspective on Factors Causing Construction Waste Generation in Less Developed Regions

Aftab Hameed Memon[1], Mohsin Ali Soomro[2], Shadab Noor Bhangwar, Abdul Hafeez Memon, Muhammad Usama Memon
Department of Civil Engineering, Quaid-e-Awam University of Engineering, Science and Technology, Nawabshah, Sindh, Pakistan

Abstract:-Waste generation issue in construction has attained an alarming situation globally, as it does not only affect the project success, but also creates an environmental problem. The interior regions of the Sindh, a province of Pakistan, are one of the least developed regions in the country. Due to its low economic development, the traditional construction methods dominates the local industry. In Sindh, now days a lot of development projects are under construction in which huge amount of construction material waste is disposed into the countryside lands. Suchexcessive generation of waste is a result of several reasons associated with different aspects of construction, which are compelling to acquire deeper knowledge for effective control of the waste. This paper has, therefore, focused on uncovering such underlying causes of waste generation through structured interviews of 28 experienced consulting engineers currently handling construction projects. The statistical software package for social scientists(SPSS)is then used to analyze responses to calculate frequency and mean rank value of the factors highlighted by the consulting engineers during the structured interviews. The results have revealed that the topmost factors responsible for construction waste generation are design errors, frequent design changes, the effect of weather, incompetent worker and equipment failure. The findings will help industrial practitioners in improving the performance of construction activities while working in less developed regions; so as to reduce construction waste. This research will also help academic researchers in better understanding of factors responsible for construction waster.

Keywords:-*construction, waste generation, consultants' perspective*

I. INTRODUCTION

Construction waste generation has globally attained an alarming situation, as it not only affects the success of a project, but also creates a drastic situation for the environment and all humanity. In comparison to rural areas, the amount of waste generation in urban areasis high[1]. The waste may be defined as something that is not considered valueless [2]. The waste may be a result of mistakes, working out of sequence, redundant activity and movement, delayed or premature inputs and products or services that do not meet customer needs [3]. The waste indulges environment, project cost, productivity, time, social and economy of the construction industry [4, 5]. In Thailand, yearly average waste generated from construction project was 1.1 million tomes and it contributed as 7.7% of the total waste generated countrywide [6]. Similarly, in the Shenzhen city of the South China waste generation was recorded as 3.275 to 8.791 kg/m2 [7]. In 2013 in South Korea, the waste generated in construction and demolition processes is recorded at about 50% of the total solid waste [8].

Previously, many researches have attempted to identify the factors responsible for the construction waste generation. Such as, the reference [9] highlighted defective products, rework, quantity errors, accidents, damage during transportation, flawed inventories of materials and labor time as the main factors causing waste generation. The reference [10] studied construction projects and noticed that generally the waste is a result of traditional construction method, poor workmanship, poor storage, poor handling, untidy construction site and lack of management techniques to minimize waste. The reference [11] observed, while researching Malaysian construction industry, that 5 momentous sources of construction waste generation were poor site management or supervision, lack of experience, inadequate planning and scheduling, mistakes and errors in design and mistakes during construction. Similarly, a study [12] of building projects of Pakistan revealed that the key factors of waste generation include frequent changes/ revision of design during construction process, poor scheduling, unavailability of storage, poor workmanship, poor layout, inefficient planning and scheduling of resources and lack of coordination among supervision staff deployed on a site. Such studies are indicating that the construction waste generation is a serious issue and rising at a high pace in Pakistan [12]. Therefore, it is very important that construction performance should be enhanced for the controlling waste generation. It is possible to limit the waste generation by means of controlling factors responsible for its creation. But before controlling the factors, it is necessary to unveil them first. Hence, this study has focused on identifying the factors causing waste generation in construction projects in Pakistan. It is ascertained that cultural and geographical contexts may

influence differently over the previously known factors responsible for the waste generation, and therefore, this research seeks to find the severity and significance of such factors with respect to the perception of consultants practicing in the Sindh province of Pakistan.

A comprehensive literature review is carried out that identified 32 common factors, which are then mapped in the table 1:

Table 1 Identified factors responsible for construction waste generation

FACTORS CONTRIBUTING TO CONSTRUCTION WASTE	Reference																					
	Gavilan & Bernold (1994)	Ekanayake & Ofori (2000)	Polat & Ballard (2004)	Garas et al (2001)	Alwi et al (2002b)	Nazech et al (2008)	Bossink & Brouwers (1996)	Zhao & Chua (2003)	Wang et al (2008)	Serpell et al (1995)	Formoso et al (2002)	Tam et al (2007)	Urio & Brent (2006)	Agyekum et al (2012)	Kulatunga et al (2006)	Nagapan et al (2012)	Nikmehr et al (2015)	Hassan et al (2015)	Formoso et al (2015)	Ibrahim & Shakantu (2016)	Memon et al (2014)
Frequent design changes	√	√	√	√	√	√	√	√	√		√	√	√		√	√		√	√	√	√
Wrong material storage	√	√		√	√	√	√		√		√	√	√	√				√	√	√	
Effect of weather	√	√	√		√	√	√	√		√		√	√		√	√		√			
Poor material handling	√	√	√	√	√	√					√	√	√	√			√	√			
Ordering errors	√	√	√	√			√		√		√	√	√	√	√					√	
Poor planning		√	√		√	√	√	√		√	√				√	√				√	√
Workers' mistakes during construction	√	√	√	√			√		√		√	√	√	√		√					√
Design errors	√		√		√		√	√			√	√		√		√			√		√
Damage during transportation		√		√			√		√		√		√		√		√	√	√	√	
Poor quality of materials		√			√	√	√		√	√	√	√			√		√	√			
Poor site management	√	√		√				√	√		√		√	√				√		√	√
Poor supervision					√	√		√	√	√	√		√	√		√				√	√
Equipment failure	√	√					√	√	√			√	√		√	√				√	
Lack of coordination among parties			√	√	√	√					√		√	√	√	√					√
Accidents	√	√	√				√					√	√		√				√	√	
Poor controlling			√	√			√	√		√	√		√			√					√
Late information flow among parties		√			√		√			√					√	√		√		√	√
Lack of design information		√	√	√	√	√				√			√		√						
Poor design quality					√	√		√	√		√								√	√	√
Inappropriate construction methods			√		√	√				√	√	√					√	√			
Lack of experience					√	√										√	√		√	√	√
Delay during delivery			√		√	√		√		√				√						√	
Shortage of skilled workers			√		√						√			√		√	√				√
Incompetent worker			√		√	√					√					√					√
Inappropriate use of materials					√	√	√						√				√	√			
Poor information quality				√	√	√			√	√	√										
Scarcity of equipment			√		√	√		√		√	√										
Lack of waste management plans			√	√			√						√	√				√			
Poor site condition					√	√		√			√					√				√	
Poor attitudes of workers		√		√					√	√				√							
Rework			√	√												√			√	√	
Insufficient training for workers				√					√		√			√					√		

II. RESEARCH METHODOLOGY

This study is based on structured interviews, in which identified factors are presented to the selected respondents from engineering consultant organizations practicing the Sindh province of Pakistan. The respondents are then asked to rate to a particular factor on a five point Likert scale. To maintain the consistency of the collected data, the respondents having minimum bachelors or diploma degree in the field of civil engineering are chosen. Statistical software package (SPSS) Version 20 [22] and Microsoft Excel program are then used for statistical analysis of the collected data.

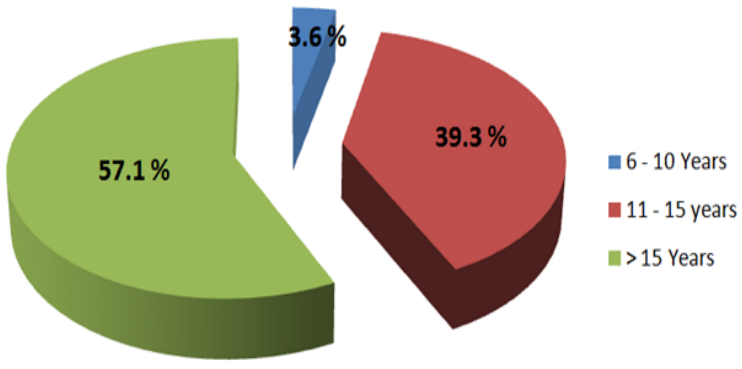

Figure 1 Working Experience of the Respondents

III. RESEARCH FINDINGS

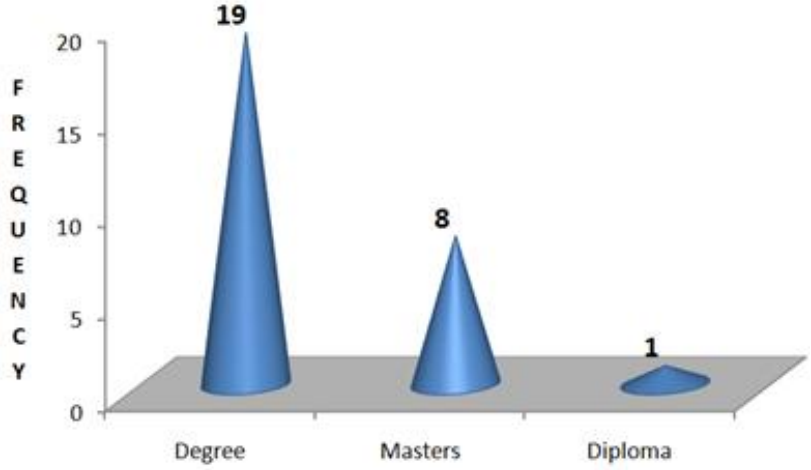

Figure 2 Academic Qualifications of Respondents

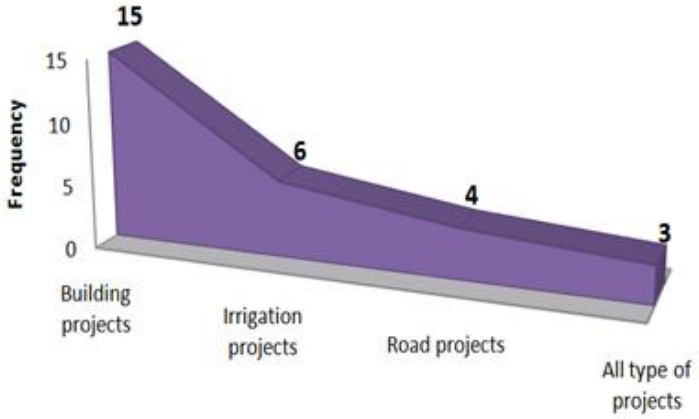

Figure 3 Types of the Projects Handled byRespondents

A) Validity of the consultants interviewed

Historically, all of the selected respondents have remained engaged with various consultant firms. All respondents, i.e., a total of twenty consultants, have demonstrated an experience of various types of construction projects in the Sindh of Pakistan.

Figure1 shows the working experience profile of the respondents in terms of years. Figure 2 illustrate the respondents' distribution with respect to their academic qualifications, while the figure 3 demonstrate their experience with the types of projects.

From figure 3, it is witnessed that the majority of the respondents with (i.e., 57.1%) have experienced handling of the construction project for more than 16 years. Which is then followed by 39.3% of the respondents having experience between 11 – 15 years of working. Only 1 respondent (i.e., 3.6%) of respondents have experience of lower than 10 years. Similarly, figure 2 and figure 3 reveals that all the respondents are well qualified, having obtained engineering and master degree and interacted with all types of civil engineering projects.

B) Consistency and Validity of the Data

Consistency and validity of the collected data is tested for its reliability. Cronbach's alpha statistics are used for this purpose, by using SPSS 20 [22]. The Cronbach's Alpha test yielded the value of 0.951, which is considered as an indicator of higher consistency [20].

C) Ranking of the Factors Causing Construction Waste Generation

The collected data is then further analyzed with SPSS 20[22] to acquire frequency of responses for each factor. A non-parametric statistical test, i.e., Kendall's W [21], is performed to establish Mean rank value of the factors. The mean rank values of the factors based on calculated Kendall's W statistics is illustrated in the table 2.From the table 2 it is observed that the most significant contributors of waste generation are the factors associated with project design issues. This is pragmatic, because it is very common in a construction project that

the contractors complain about the errors and mistakes in the design provided at the time of contract award which are rectified slowly. Such errors occur due to a variety of reasons. For example, [13] identified "in-experienced designer" as one the main reasons causing design problems. The reference [14] has reported that Mistakes and errors in design are significant contributors of waste generation. Change in designs and variation order are the other reasons causing resulting in generation of waste material; especially when it is required to incorporated change or variation order at later project stages. The references [15] and [16] highlighted that waste generation during execution is directly related to the design process, specifically lack of design information leads to assumptions in calculating quantities of material, which may result in over ordering of materials [13].

After factors associated with design, the external factors are the most significant to create waste in construction project. Most dominant external factors is 'weather condition', which is un-controllable in some cases. However, proper planning for prevailing seasonal conditions may be helpful in the reduction of waste. While sudden weather changes may be very dangerous and generate a huge amount of waste by indulging materials. Also, it affects the productivity of labor which causes wastage of time. The reference [18] also mentioned that inclement of weather is one of the important sources of waste generation. The reference [14] also mentioned that effect of weather is a dominant factor in causing waste generation.

Since, construction industry is a resource driven industry, hence performance of manpower and equipment plays a crucial role in effective use of material. For this, competency of labor is very vital for a better performance. Due to many development of works in the region, the availability of competent labor is shortened. Incompetent workers also mishandle equipment and material, which can cause damages and consequent generation of unnecessary waste. The reference [19] has mentioned that one of the source and cause factors of material waste is damage by subsequent trade. The reference [5] intimated that wastage of materials is directly affected by human behavior and poor attitude workers cause leftover materials on a site. Such wastage can be prevented by proper training of the workers deployed on the sites. Similarly, it is very essential to use proper and adequate equipment for work as well maintaining the equipment. If the equipment breakdown/fail, it can cause stoppage of the works and generate waste. Equipment malfunction is amongst the common source of waste generation [18]. Also, it is imperative to select proper equipment and it must be inspect before start of a project. Further, in adequate number of equipment may result in waiting times for performing certain operations resulting in wastage of time.

Table 2 Ranking of the Factors of Waste Generation

FACTORS	No Significant	slightly Significant	moderately significant	very significant	Extremely Significant	Mean Rank Value	Rank
Design errors	2	11	6	5	4	21.14	1
Frequent design changes	3	6	11	7	1	20.80	2
Effect of weather	4	5	13	6	0	19.70	3
Incompetent worker	2	13	3	7	3	19.34	4
Equipment failure	3	11	6	6	2	18.70	5
Poor attitudes of workers	1	14	6	6	1	18.04	6
Poor site condition	1	14	7	4	2	17.63	7
Ordering errors	3	10	11	3	1	17.36	8
Inappropriate construction methods	5	11	3	8	1	17.13	9
Shortage of skilled workers	3	13	7	3	2	16.93	10
Poor site management	5	9	6	8	0	16.84	11
Poor supervision	1	13	10	4	0	16.75	12
Lack of waste management plans	2	16	4	5	1	16.66	13
Lack of design information	7	9	4	5	3	16.52	14
Accidents	1	16	9	2	0	16.39	15

FACTORS	No Significant	slightly Significant	moderately significant	very significant	Extremely Significant	Mean Rank Value	Rank
Lack of coordination among parties	4	11	7	5	1	16.25	16
Late information flow among parties	7	7	7	6	1	16.18	17
Poor controlling	4	11	10	2	1	16.14	18
Poor planning	3	12	10	1	2	16.14	18
Insufficient training for workers	4	15	3	3	3	16.07	19
Workers' mistakes during construction	4	10	10	4	0	15.89	20
Lack of experience	5	11	6	5	1	15.84	21
Poor design quality	5	10	8	5	0	15.63	22
Rework	3	14	7	2	2	15.34	23
Delay during delivery	4	11	11	1	1	15.07	24
Inappropriate use of materials	4	14	6	2	2	15.04	25
Poor quality of materials	5	13	6	2	2	14.61	26
Wrong material storage	7	11	4	4	2	14.59	27
Poor information quality	6	11	7	4	0	14.02	28
Damage during transportation	4	14	8	2	0	13.95	29
Scarcity of equipment	8	10	4	4	2	13.88	30
Poor material handling	6	15	2	4	1	13.46	31

IV. CONCLUSION

This study has investigated the significance level of factors causing generation of construction waste. The significance is evaluated through structured interviews from experienced engineers engaged in consultant organization; and currently are involved in handling the execution works on site. Statistical analysis of collected responses is then performed to examine the frequency of ratings for each factor and then to develop their rank based on Kendell's W statistics. The findings have revealed that the top factors causing waste generation in construction projects of Sindh province are associated with design errors, frequent design changes, the effect of weather, incompetent worker and equipment failure.

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