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Factors of Waste Generation throughout Construction Life Cycle

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Abstract

Construction industry has an adverse impact on environment due to its generation of construction waste. Besides the environment, the waste generated also affect the cost, productivity, time, social and economy of the industry. This waste generation is resulted from various factors at different stage of construction lifecycle. Current study has identified 46 factors of waste generation based on extensive literature review. These factors were classified into 7 groups and clustered according to their occurrence relative to various phases of construction lifecycle. It was found that most of these factors occur during construction phase. The significant factors that occur during construction phase are error ordering and poor workmanship. By identifying the crucial occurrence phase of factors which contribute to waste generation, it will help the construction community to avoid or lessen the construction waste generation.

Keywords:

Construction waste, Generation Factors, Construction Life Cycle

1. Introduction

Waste generation is a common phenomenon in construction industry today. It has adverse impacts on the environment and surroundings. Besides that, it has also accounted for negative effects on cost, productivity, time, social and economy of the industry [1–3]. There are various factors that cause construction waste generation at different stages of project. In a research [4], revealed that construction waste is effectively generated along the project from start until completion of construction work. It can be emanated during design, operational, material handling and procurement [5]. Some researchers highlighted that construction waste is commonly generated during design and construction stage [6–8]. Ref [4] cited that 33% of on-site waste is due to architects' failure to implement waste reduction measures during design stages.

As a developing country, Malaysia also is facing with the problem of construction waste which has resulted in illegal dumping and only 20% of waste is disposed in legal landfills [9]. This problem can be worst if not addressed properly. In order to control this problem of construction waste generation, it is very much imperative to understand the sources and factors for this throughout lifecycle of project. Construction life cycle (CLC) is defined as the whole process from creating the construction intention to abolishing the project, which includes the project decision-making stage, implementation stage and operation stage as cited by [10]. Life cycle of a project includes several phases which are conceptual planning and feasibility studies, design and engineering, construction, and operation and maintenance [11]. In another research conducted by [12], the CLC was divided into five stages which are preparation stage, design stage, pre-construction stage, construction and use stage, and post-construction stage. Alshubbak et al consider that a project life cycle consist with five phase which are feasibility phase, design phase, construction phase, exploitation phase and dismantling phase [13].

However, for this research, the CLC was divided into four phases which are planning, design, construction and finishing. Figure 1 below is a diagram that shows the phases of construction project life cycle.

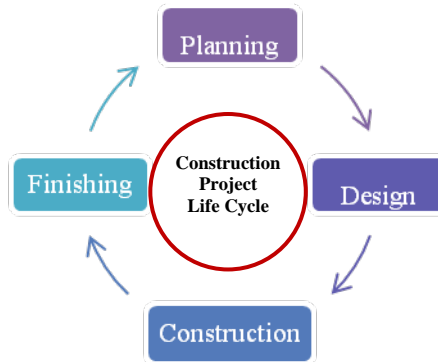


Figure 1: Phases of Construction Lifecycle (CLC)

2 Waste Generation Factor in CLC

Construction waste is resulted from various factors which are occurred during different activities and stages along the CLC. According to Graham and Smithers (1996) as cited from [14], construction waste factors can be classified as design (plan errors, detail errors and design changes), procurement (shipping error and ordering error), materials handling (improper storage, deterioration and improper handling on and off site), operation (human error, trades person, labour, equipment error, accidents and weather), residual (leftover and irreclaimable non-consumables), and other (theft, vandals and clients actions). While, Ref [4] grouped the main sources of waste factors as contractual, design, procurement, transportation, on-site management and planning, material storage, material handling, site operation, residual, and other. In this study, extensive literature review was done in understanding the factors of construction waste generation throughout CLC. A total of 46 common factors were identified, classified in 7 groups as Information and Communication (ICT), Equipments, Project and Contract Management, Material, Delivery/Procurement, External/Unpredictable and Human Resources/Manpower. These were clustered according to CLC phases based on literature review. Description and classification of the waste generation factors with relative CLC phase of occurrence is presented in Table 1.

Table 1: Factors of Construction Waste according to CLC

No	Causative Factors	Causative Factor Occurrence in CLC			
		Planning Phase	Design Phase	Construction Phase	Finishing Phase
Information and Communication (ICT)					
1	Poor coordination between parties		[4][15]	[3][16][17][18]	
2	Poor quality of information		[14]	[19][18]	
3	Delay in information flow among parties			[5][4]	
4	Delay due to too many interactions between various specialists				
Equipments					
5	Unsuitable tools used			[20][21][2]	
6	Shortage of equipment			[20][18]	
7	Equipment failure			[22]	
8	Non availability of equipment				
9	Abnormal wear of equipment			[16][15]	
Project and Contract Management					
10	Lack of legal enforcement			[2][23][24][25]	
11	Error in contract document		[5][15]	[24]	
12	Last minute client requirements		[26][7][6]	[26][27][4][7]	[26][27][4][7]
13	Lack of waste management plan	[7]		[16][7][28]	
14	Mistakes in quantity estimations			[15]	

15	Inexperienced designer		[4][5]		
16	Over allowances paid lead to over budget			[27][4]	
17	Rework			[29]	
Material					
18	Stealing at site			[30][31]	
19	Vandalism at site			[30][7]	[19]
20	Poor quality of materials			[27][32][3]	
21	Ordering errors			[33][34][15][14] [35]	
22	Items not in compliance with specification		[36]	[28][36]	
23	Inventory of materials not well documented			[27]	
24	Inappropriate use of materials				
Delivery/Procurement					
25	Wrong material delivery procedures			[15]	
26	Supplier errors			[15]	
27	Error in shipping			[37][14][35]	
28	Delay during delivery			[3][28][18]	
29	Difficulties for delivery vehicles accessing construction sites			[27]	
30	Damage during transportation			[15][16][7]	
31	Long waiting periods		[28]	[3][28]	
External/Unpredictable					
32	Effect of accidents at site			[37][28][38]	
33	Effect of weather			[27][5]	
34	Damages caused by third parties			[18]	
35	Delay due to Festival celebrations			[18]	
36	Unforeseen ground conditions			[4]	
37	Inappropriate lighting arrangement			[39][27]	
Human Resource/Manpower					
38	Interference of others crews at site			[39][27]	
39	Poor attitudes of workers		[40]	[27][41][2]	
40	Damage caused by workers			[27][28][15]	
41	Insufficient training for workers			[2][19][16]	
42	Lack of experience			[42][22][29][43]	
43	Lack of knowledge on construction		[15][44]	[45][46]	
44	Poor workmanship			[2][35][37] [34][42]	[35]
45	Lack of enthusiasm among workers			[39]	
46	Workers exhausted because of too much overtime			[14]	

Note: Blue coloured cells reflect the occurrence of particular factor in relative phase

4 Discussion and Conclusion

Table 1 show that the waste generation factors occur in each phase of CLC. However, construction phase is most critical phase where majority of the identified factors occurred in this phase. It is followed by design phase and finishing phase. However, in planning phase the chances of waste generation are minimum. These deductions are in accordance with the research findings from [8] that mentioning, waste is primarily produced during site operation and rarely occurred during at the early stage.

Ordering error and poor workmanship are reported as most frequently occurring factors in construction phase. This means that both factors are very significant in generating waste during construction phase. This is because ordering error causes over or shortage of ordering. Over ordering may cause excessive materials and result to material waste [33]. While shortage of ordering may cause insufficient material availability which will lead to

stoppage of construction work at site. The material need to reorder and cause longer of waiting time to receive materials from supplier [34]. In addition, poor workmanship also recorded as the important factor that generates construction waste in construction phase. Poor workmanship may be caused by unskilled labour, inadequate tools and equipment and/or poor working conditions [37]. Ref [34] stated that incompetent supervisor and project manager also lead to poor workmanship. The effect of poor workmanship are abandoned work especially during construction/renovation stage [21] and also may cause to conflict between workers due to deviation from the original intent [42].

On the contrary, construction waste factors are less commonly occurring in planning and finishing phase. There are 2 factors occurring in planning phase and 4 factors occur in finishing phase. The most frequently occurring factors in these phases as reported in table 1 above is “last minute client requirement”. In fact, clients may request any change or additional requirement and facility in their project; however, if the request happens during the construction work is in progress, this may result in demolishing and rework activities. This will require additional time, cost and material.

In essence, this study uncovered 46 factors of construction waste generation which were classified in 7 categories. The factors were studied critically to determine the stage of construction waste and all the factors were clustered according CLC phases based on extensive literature review. It is the construction phase that is the most critical phase in CLC where the practitioners must pay more attention in controlling the waste generation. The findings of this study will be used for further investigation by conducting interview and survey among construction industry players of Malaysia for confirming the occurrence of the factors in CLC phases determined earlier and study their consequence on overall project.

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