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Identifying Causes of Construction Waste - Case of Central Region of Peninsula Malaysia

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Abstract: Construction waste becomes a global issue facing by practitioners and researchers around the world. Waste can affects success of construction project significantly. More specifically, it has major impact on construction cost, construction time, productivity and sustainability aspects. This paper aims to identify various factors causing construction waste in Malaysia. Study was carried out through structured questionnaire focusing three major parties (i.e. clients, consultants and contractors) involved in construction project. Data was analyzed with Statistical Software Package SPSS. Reliability of data was found as 0.917 which showed that data collected was highly reliable. The calculation of Mean Rank of the construction waste causes found that the 5 key causes are Poor site management and supervision, Lack of experience, inadequate planning and scheduling, Mistakes and errors in design and finally Mistakes during construction. Spearman correlation analysis showed that Mistakes during construction was highly correlated with Rework (with 0.829 correlation value) and Slow information flow between parties (with a value of 0.60) and vice versa. Through identifying the causes and its correlation of the construction waste it gives better understanding to the construction community for future construction projects which benefit not only in term of economy but also the environment.

Keywords: Construction industry, Causes of waste, Construction waste, Sustainability

1. Introduction

Wastes defined as unwanted or discard materials [33, 34]. The wastes continually causing an environmental troubles and global warming problems to the world [35,36]. There are many categories of wastes produce namely municipal solid waste, commercial waste, medical waste, biodegradable waste and construction waste. The municipal solid waste usually known as garbage and trash for any household [35,37]. Others than that, commercial waste also frequently occurred. The waste mainly results from business and industrial sites[38]. Medical waste also known as clinical. The waste is defined as waste commonly generate from hospital and clinics. The waste is generated in the diagnosis, treatment, or immunization of human beings or animals [39]. The term biodegradable waste is any waste that is capable of undergoing anaerobic or aerobic decomposition. The waste are food processing, paper, textiles, wood, etc. [40]. The area of this research focusing on construction waste. The wastes produced at construction sites in physical form and non physical form. The physical waste are mainly from broken concrete, bricks, metals, packaging waste, etc. Whereas the non physical waste are cost overruns and time delays in construction projects [41].

In 21st century, researchers and practitioners around the world facing the challenges of construction waste. Various researches in develop countries indicate that contribution of construction waste in the urban area tend to increase [1]. Researches in United States and Europe have revealed that considerable amount of waste lies in flow processes of construction as in [2]. In addition, study conducted in Sri Lanka also reveals that the domestic construction industry workforce is ignorant of flow activities that create waste and their causes [3]. Moreover, researchers from Nigeria described waste emanates during different stages of construction which can be during planning, estimating or construction stage [4]. Other problems according to the Singapore researchers, during design, operational, procurement and material handling attributes that leads to site waste [5]. In addition, as in [6] also indicated construction managers often fail to identify or address waste in the construction process.

Thus, as a developing country, Malaysia also has fallen into construction waste problems in line with the rapid development of construction sector. In tandem, with increasing demand of infrastructure projects, residential

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development projects, large amounts of construction waste are being produced in Malaysia [7]. These conditions may give a huge impact on project costs and time due to physical and non-physical waste for Malaysian construction industry [41]. The objective of this on-going research is to identify various factors causing construction waste in Malaysia.

2. Related Works

Construction industry sectors have been experiencing chronic problems such as poor safety, inferior working conditions and insufficient quality as in [8]. Besides that, some researchers identified lack of material, rework, lacks of equipment and supervision delays as factors influencing productivity in the Indonesian construction industry [9]. In Singapore, as in [5] stated new purchases to replace wasted materials, rework to correct mistakes, delays, and dealing with generated waste cause heavy financial losses to the contractor. Meanwhile, researchers found that eight waste sources were deemed to be sufficiently significant [10]. These were waiting due to crews' interference; waiting due to equipment sharing, and setup of equipment; waiting for instruction and inspection; rework due to design change; waiting due to stock problem and material vendor delay. In Sri Lanka, the study also shows these conditions will lead to the construction waste. The conversion activities are a major cause of uncertainty in production, increasing the share of non-value adding activities as in [11].

Researchers and practitioners commit with many wasteful activities during design and construction process without adding value for the construction progress as in [5-6, 12-13]. Besides that, as in [2] and [14], believed the significant problems faced by the construction industry are materials and time wastes. These non-value added works may generate non-physical waste even though the quantity is difficult to measure or ascertain in different construction projects.

A number of researchers and practitioners from the construction family interpret and give meaning of non-physical waste in a different dimension. Waste describes as any human activity that absorbs resources but creates no value, such as mistakes that require rectification, production of items no one wants, process steps that are not needed, unnecessary movement of employees, and people waiting for the conclusion of upstream activities [15]. Furthermore, waste also describes as any inefficiency that result in the use of equipment, materials, labor or capital in larger quantities [16].

In other words, waste in construction is not only focused on the quantity of waste of materials on-site, but also related to several activities such as overproduction, waiting time, material handling, processing, inventories and movement of workers [11, 17]. Similarly, researcher from Indonesia defined waste is not only associated with waste of materials in the construction process, but also other activities that do not add value such as repair, waiting time and delays [18].

There are also other categories of waste that such as accidents, working under suboptimal conditions [19]. Waste can be defined as any inefficiency that results in the use of equipment, materials, labor, or capital in larger quantities than those considered as necessary in the construction process as in [1]. Hence, wastes from the construction, remodeling, and repairing of individual residences, commercial buildings, and other structures are classified as construction wastes [20]. Finally, waste in construction is defined as the difference between the value of those materials delivered and accepted on site and those used properly as specified and accurately measured in the work, after the deducting cost saving of substituted materials and those transferred elsewhere [21]. In this study, 20 articles related to construction waste were referred. From these articles, the contributed factors to construction waste were identified as in Table 1.

Table 1 List of causes contributed to construction waste.

Causes	Reference
Poor site management and supervision	[2];[6];[10];[13];[18];[22] and [25]
Lack of experience	[1];[5];[18]; [22]; [28] and [32]
Inadequate planning and scheduling	[1];[2];[5];[10];[13];[14];[17];[18];[20];[28];[30] and [32]
Mistakes and Errors in design	[3];[4];[5];[13];[14];[20];[25] and [32]
Mistakes during construction	[22];[25] and [31]
Incompetent subcontractors	[1];[2];[5];[6];[14];[17];[20];[22];[25] and [30]
Rework	[1];[2];[3];[4];[14];[18];[28] and [32]
Frequent design changes	[5];[6];[10];[13];[14];[18];[22]; [23];[28];[29];[30];[31] and [32]
Labor productivity	[2];[5];[18];[20] and [30]
Inadequate monitoring and control	[3];[28];[29] and [32]
Inaccurate quantity take-off	[4] and [23]
Shortage of site workers	[6]; [17] and [18]
Lack of coordination between parties	[14];[17];[18];[23];[28] and [31]
Slow information flow between parties	[3];[5];[23] and [30]
Shortage of technical personnel (skilled labor)	[1];[14];[18] and [23]
Changes in Material Specification and type	[5] and [32]
Equipment availability and failure	[1];[2];[5];[10];[14];[18];[25] and [30]
Effect of weather	[2];[3];[4];[5];[6];[13];[14];[18];[30] and [32]

Table 1 shows 18 factors were identified from past researchers. These factors were used to conduct this preliminary study to determine whether the factors are also common to Malaysia construction industry.

3. Preliminary Survey

A preliminary quantitative study was carried out to investigate the perception of industry's players regarding construction waste issue. From the identified factors, a structured questionnaire was developed and distributed in central region of peninsula Malaysia. The questionnaire distribution was done randomly using two approaches, namely via postal mail as well as direct visitations to the respective firms. From the total of 60 questionnaires were distributed, only 41 (68%) of the respondents duly filled and returned the questionnaires. Data was analyzed with Statistical Software Package SPSS. Frequency, Mean Rank and Spearman Correlation Analysis were used in this research.

The purpose of respondent's demography is to review the capabilities of the respondents in understanding the issues of construction waste. The first demography of this survey is the clusters of the respondents. They are either contractors or consultants or client. Fig. 1 shows the background of the respondents. It was found that the majority of the respondents are in the contractor field, 51 %, followed by Consultants, 34% and the lowest is the clients, only 15% of the total respondents. Based on the pie chart, it can be seen that contractor's field plays a major influences in this research.

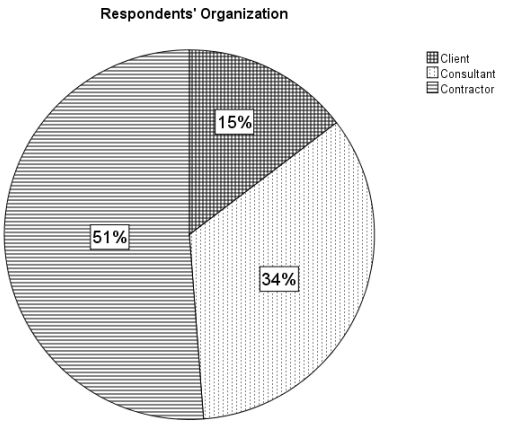

Fig. 1 The Organization of respondents.

In term of experience in the construction industry, this survey found that as much as 39% of respondents had working experience of 6 to 10 years, followed by 32% respondents who possessed working experience of between 11 to 15 years. The minority group of respondents in terms of work experiences was those less than 5 years' experience, is 29%.

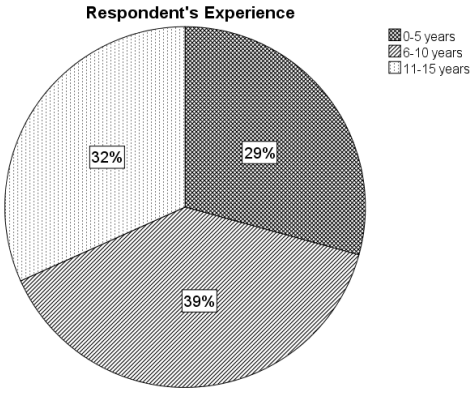

Fig. 2 Respondent's experience in construction.

Fig. 2 of the pie chart indicates that 71% of the respondents are in between 6 to 15 years working experience in Malaysian construction industry. The profile information of the respondents experience reflects their understanding about issues concerning identifying factors causing of construction waste.

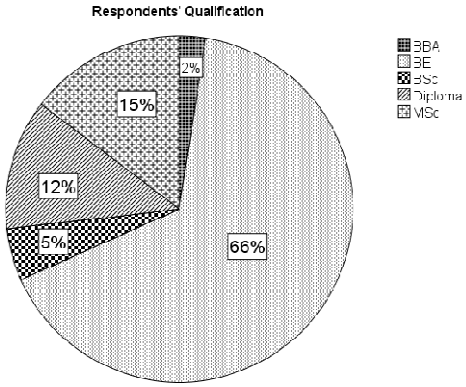

Fig. 3 Respondents' Qualification.

The qualification attained by the respondents as shown in Fig. 3. The chart shows 66% of the respondents obtain Bachelor of Engineering (BE). The second largest of respondents' education level is Masters of Science (MSc), 15%. The Diploma holder comprises of 12% and then followed by BSc, 5%. The smallest percentage is Bachelor of Business Administration (BBA), only 2% of the total respondents. This indicates that majority of the respondents obtain bachelor degree, 73%. Therefore, it can be deduced that all of the respondents were well educated.

4. Significant Causes

The reliability test was conducted on the data to measure its stability and consistency. In this test Cronbach's alpha (reliability coefficient) was determine in order to indicate the reliability of the data. The closer Cronbach's alpha value to 1 the higher the internal

consistency reliability of the data [24]. In this study, reliability test on the data was carried out and it was found that the alpha value is 0.917. This indicates that data collected was highly reliable.

Mean rank

The significant of the factor are determined from the Mean Rank approach. Mean Rank or Kendall's W is a non-parametric statistic. Mean Rank represents, the higher Mean Rank Value, the higher position is placed. The ranking of the factors causing construction waste is calculated using the Mean Rank Calculation as:

$$M_R = \frac{\overline{R}}{M_{MAX}} N$$

Where:
M_R = Mean Rank

$\overline{R}$ = Individual Mean Rank of factor

M_{MAX} = Maximum Individual Mean Rank of factor
N = is the number of factors

From the analysis, was discovered the ranking of each factors due to the Mean Rank Value. The Table 2 shows significant causes of construction waste and its ranking.

Table 2 List of causes with mean rank value.

Causes of Construction Waste	Mean Rank Value	Rank
Poor site management and supervision	7.17	1
Lack of experience	7.71	2
Inadequate planning and scheduling	7.78	3
Mistakes and Errors in design	8.00	4
Mistakes during construction	8.34	5
Incompetent subcontractors	8.76	6
Rework	9.02	7
Frequent design changes	9.24	8
Labour productivity	9.35	9
Inadequate monitoring and control	9.40	10
Inaccurate quantity take-off	9.74	11
Shortage of site workers	10.09	12
Lack of coordination between parties	10.21	13
Slow information flow between parties	10.61	14
Shortage of technical personnel (skilled labour)	10.91	15
Changes in Material Specification and type	10.93	16
Equipment availability and failure	11.83	17
Effect of weather	11.90	18

There are 5 selected significant factors placed the highest ranked or key position among the other factors and they are;

i. Poor site management and supervision,
ii. Lack of experience,
iii. Inadequate planning and scheduling,
iv. Mistakes and errors in design,
v. Mistakes during construction.

Site management and supervision

The Poor site management and supervision was ranked the highest factor causing construction waste by the Mean Rank Value of 7.17. This evidence is supported as in [25], a study in China. They stated that Lack of management skills and Lack of supervision become major reasons in huge waste generation. Moreover in Chile was identified that Poor or lack of supervision cause waste [2]. In another recent study also stated that waste also occurs due to the poor construction management [22]. Moreover, a pilot study also conducted in Sri Lanka and contended that a considerable amount of construction waste is mostly due to improper management and supervision of sites [26].

Lack of experience

Lack of experience (Mean Rank, 7.71), was the second key cause of construction waste, supported by researcher in South China and mention construction works operated by inexperienced mental cutters is the main cause of reinforcement waste [22]. This statement also agreed as in [27] that a significant percentage of foreign contract labor has little or no experience in construction. Thus, inexperienced foremen contribute to more defective works and reworks in Hong Kong construction industry [28]. Researcher also believed that factor that produces waste due to the inexperience field supervisor [1].

Inadequate planning and scheduling

The inadequate planning and scheduling cause was ranked third by the Mean Rank Value Coefficient, 7.78. Meanwhile, poor planning and scheduling were identified as the key variables causing waste [18]. In the study identified that improper planning as the most significant operational contributors to waste generation [5]. Furthermore, imperfect planning of construction results in material waste [14]. Furthermore, poor planning as a key cause lead to the flows wastes [3]. In the study, mean value is 4.13, so a mean value exceeding 3.00, means the respondent agreed that statement. This is reinforced in another study that caused by lack of planning and control may lead to rework to the building (indirect waste) [1].

Mistakes and errors in design

The fourth causing construction waste is Mistakes and errors in design, Mean Rank, 8.00. This supports a similar finding as in [28], which found that "design errors" are major contributors to change orders and rework, which in turn result in a high volume of construction waste. In addition, Australian researchers also revealed a similar result from his survey and categorized typical construction debris cause into design change and design error [13]. Furthermore, research in China found that reworks caused by the design error. This is another fact supported by the researcher, because rework is a waste, due to design error and mistakes [10]. Hence, United Stated researcher also observed and analyzed categorized the sources of construction waste into design [20]. There is a similar survey result and categorized typical construction waste sources into design error and design change [13].

Mistakes during construction

Mistakes during construction with the Mean Rank of 8.34 are placed as fifth factor causing construction waste for this research. Major cause of wastes is default from construction processes [25]. Other studies reveal that Lack of constructability increase cost around 6-10% of total of project cost in United Stated [16]. This factor also often leads to the construction waste. Hence, another researcher mentions that the wastes resulting from wrong construction method, defects, and poor optimization in performing tasks [21].

5. Correlation Between Causes

This study investigated the correlation strength between the determined causes of the construction waste. To determine the strength, Spearman correlation approach was adopted. Theoretically, if there is a correlation between two factors, the range of correlation value (R) must be range between –1 and +1. [24]. Correlation coefficient value goes towards 0 the relationship between the two factors causing construction waste will be weaker.

From the Spearman correlation analysis, 18 factors causing construction waste was correlated can be identify that 13 factors having correlation ≥ 0.600 among them. Otherwise, 5 factors don't have any strong correlation value above 0.600. There are shortage of technical personnel (skilled labor), Frequent design changes, Mistakes and Errors in design, Inaccurate quantity take-off and Effect of weather.

The strongest positive correlation factor for this research finding was Mistakes during construction highly correlated with Rework, the correlation value, R was 0.829. The R value shows a very strong and positive relationship between that two factors causing construction waste. On the other hand, Mistakes during construction and slow information flow between parties found the correlation value only 0.600. Thus, mistakes and rework have strong bonding, tied together for this research finding.

The Lack of coordination between parties also has positive correlation with slow information flow between parties, R value of 0.761. Meanwhile, Poor site management and supervision with correlation value, 0.724 have relationship with inadequate monitoring and control factor. There is a positive correlation between those two factors. On the same time, Inadequate planning and scheduling factor also having positive correlation with Lack of experience factor, with the R value, 0.721; Incompetent subcontractors, with 0.719 correlation value; Inadequate monitoring and control with value of 0.660; labor productivity, R value 0.651; Slow information flow between parties, with 0.649 correlation value and Poor site management and supervision, R value of 0.639.

Results also indicated that Lack of experience factor have a positive relationship with Poor site management and supervision factor at the R value of 0.606; Inadequate monitoring and control with value 0.622 and Slow information flow between parties with the R value of 0.624. Meanwhile, Poor site management and supervision also having a positive correlation between Incompetent subcontractors with the correlation value of 0.689.

Based on the results, Shortage of site workers factor was having positive relationships with the labor productivity factor. The both factors correlated at the value of 0.717. There are positive relationship labor productivity factor with inadequate planning and scheduling, with R value, 0.651 and Incompetent subcontractors with the correlation value 0.628. Beside that's, Incompetent subcontractors with Equipment availability and failure and Rework with Changes in Material Specification and type shows having positive correlation at the same correlation value 0.624.

6. Conclusion

This on-going research has helps to identify factor causes of construction waste in Malaysia. The most significant factors causing construction waste are Poor site management and supervision, Lack of experience, inadequate planning and scheduling, Mistakes and errors in design and Mistakes during construction. Thus, the study proved that Mistakes during construction having strong positive correlation with Rework, 0.829 correlation value. These findings will give a better understanding to the Malaysian construction industry players and create awareness among them for undertaking future construction projects.

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