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THE IMPACT OF PROCUREMENT METHOD ON CONSTRUCTION TIME WASTE

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ABSTRACT

Selection of the most appropriate procurement method for a proposed project is challenging because there are many factors to be evaluated in deciding. This study focuses on the impact of procurement method on construction time waste, and it was conducted to find how the time wastage varies according to the selected procurement route. Such knowledge is important in making better decisions when selecting a procurement method. Accordingly, the research aim was set to find the significant differences of time waste between traditional and design and build procurement methods. this research was conducted from a quantitative approach, deductive theory data collected through an online survey, and for data analysis using descriptive statistics. Twenty-two (22) number of time waste factors were identified through literature review. survey respondents weighted the significance of each factor between traditional and design and build procurement methods. Ten (10) factors caused significantly higher time waste in traditional method and none of the factors caused higher time waste in design and build method. Accordingly, the study concludes that time waste in traditional procurement is generally higher in traditional procurement method compared to design and build procurement method.

Keywords: *Design and Build Method; Procurement; Time Waste; Traditional Method.*

1. INTRODUCTION

Construction is the industry of constructing built facilities such as buildings and roads. The construction process differs from that of manufacturing (Eve, 2007). Construction of a building or an infrastructure project is a complex process which requires careful attention from overall process to finer details in it. In order to fulfil the whole process, there are several factors needed to be concerned on, and a major part of this is addressed at the procurement method selection (Myren and Hellers, n.d.).

The definition of the procurement in construction has been developed from time to time (Rahmani, et al., 2017). One commonly used definition is that construction procurement is the process of design, build, management, finance and operation construction projects (Hughes, et al., 2006). It also can be understood that a procurement system defines scope or responsibilities of each party of the construction contract. Furthermore, procurement methods can be classified into four key categories, viz, (a) Traditional Method, (b) Design and Build, (c) Management Oriented, and (d) Collaborative; PPP, PFI (Hamma-adama

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and Ahmad, 2021). Each procurement method has different advantages and disadvantages over other methods. These are accounted in selecting appropriate procurement method (Rahmani, et al., 2017). Considering the Sri Lankan context, traditional procurement method, and design and build method take priority (Nikmehr, et al., 2016).

Even though, how perfectly selected the procurement method, construction waste is an unavoidable issue many researchers have attempted to address (Faniran and Caban, 2007; Nagapan, et al., 2012). Under construction waste there are several types, where time waste is considered as one (Ali and Arun, 2014). It is already accepted that design and build procurement method delivers projects in shorter time compared to Traditional procurement method. However, whether there is a difference in time waste in each procurement method is unknown. The gap in knowledge limits the procurement method selection as the inefficiencies due to time waste is unaccounted in that decision. To address this research problem, the aim was set to find the significant differences of time waste between traditional and design and build procurement methods. To reach the aim, three objectives were developed as below:

1. to find the modes of time waste in construction projects,
2. to identify the level of each mode in between two procurement methods, and,
3. to identify the significant differences in level of each mode in between two procurement methods.

2. LITEREATURE REVIEW

Construction industry, which plays a major role in Sri Lankan economy can be divided into three parts: firstly buildings, secondly infrastructure and thirdly, specialty trades (Myren and Hellers, n.d.).

In relation to construction process we can identify two separate stages as pre-contract stage and post-contract stage. According to the Royal Institute of British Architects (RIBA) plan it is a must to figure out the most suitable procurement method for each project particularly (Royal Institute of British Architects, 2020). As per the point, perfect procurement method is also able to manage the whole project, adding customer satisfaction and business performance are key factors (Hughes, et al., 2006).

Essentially, procurement is the cycle used to acquire development in businesses. It involves the determination of a legal binding system that clearly identifies the bonds for members within the structure cycle and the structure of specialists (Naoum and Egbu, 2015). In general, there are four main procurement methods: (a) traditional method, (b) design and build, (c) management oriented and (d) collaborative; PPP, PFI (Hamma-Adama and Ahmad, 2021). In this study, it mainly focuses on the traditional procurement method and design and build procurement method which are mostly used procurement methods in Sri Lankan construction industry.

2.1 TRADITIONAL PROCUREMENT METHOD

Traditional procurement method which is known as separated procurement method remains the most used method of procuring building works (Rahmani, et al., 2017). It consists of a three-party agreement between the customer, consultants, and contractor. Traditionally, design and construction are separated in the procurement process (Davis, et al., 2008). There are certain advantages and disadvantaged of this method such as, since clients have direct contractual connections with the design team, they could influence the

evolution of the design; therefore, assuming no changes are made, construction costs may be estimated with reasonable certainty before construction begins. However, if any attempt is made to choose a contractor for the work before the design is complete, the plan may fail to some extent due to the potential of several post-contract revisions, which will cause a delay in the progress of the work and an increase in the expenses (O'shea, et al., 2019).

2.2 DESIGN AND BUILD PROCUREMENT METHOD

Design and build which also known as integrated procurement method ~~is~~ slightly differs from the traditional method. On a lump sum fixed price basis, an integrated procurement technique can be described as using a single contractor to operate as the only point of responsibility (Hendrickson, et al., 1989). The appointed contractor is in charge of designing, managing, and completing a construction project on schedule, on budget including whole-life expenses, and in line with a pre-determined output specification. The contractor is expected to have reasonable skill and expertise in order to meet the client's expectations (Zuber, et al., 2019). Apart from that there are several number of variants which are considered as small deviations on the general procedure, some of them are; turnkey, novated design and build and package deals (Rahmani, et al., 2017).

2.3 CONSTRUCTION WASTE

Stakeholders of a construction project pay their attention to select the most suitable procurement method cautiously since it can affect the whole process of construction in both good and bad manner (Rosado, et al., 2019). Even though, construction industry has massive progresses in every aspect but still construction waste has been a concern of researchers for decades (Malik, et al., 2019). The construction industry accounts for 25% of solid waste generated around the globe (Benachio, et al., 2020). As shown in Figure 1, which was identified by Ramaswamy and Satyanarayana (2009), construction waste is classified mainly into four categories.

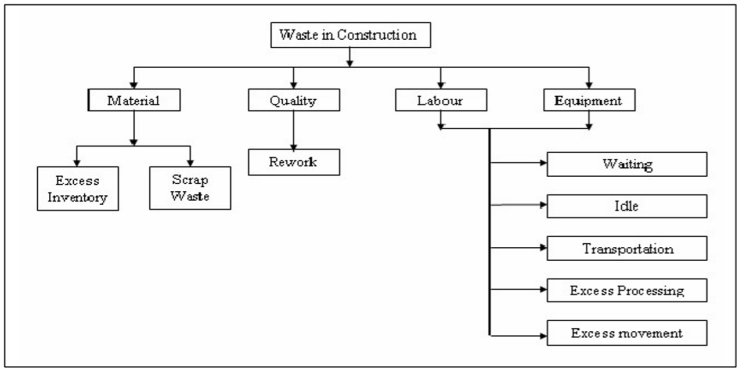

Figure 1: Waste in construction

Source: Ramaswamy and Satyanarayana (2009)

Apart from the findings of Ramaswamy and Satyanarayana (2009) regarding the main types of construction waste, Ali and Arun (2014) have figured out another three classifications of construction waste in 2014. In their study they have separated waste into three categories to make it easier to quantify waste in construction.

1. Money waste/Economic waste
2. Time waste
3. Material waste

During a past study conducted by Alwi, et al. (2002), they have ranked and grouped waste variables. Group 1 of waste variables which contains the variables repair on finishing works, waiting for materials, delays to schedule, tradesmen slow/ineffective, waste of raw materials on-site and lack of supervision/poor quality is ranked as the most important group of variables (Sugiharto, et al., 2002). Those variables were further classified by Ali and Arun (2014) as follows,

1. Repair on finishing work - Responsible for time waste, money waste and to an extend material waste depending on type of work
2. Waiting for materials - Time waste
3. Delays to schedule - Time waste
4. Slow tradesmen - Time Waste and money waste.
5. Waste of raw materials onsite - Material waste
6. Lack of supervision - All wastes can be incorporated as a result of lack of proper supervision,

where most of the variables are classified under time waste (Ali and Arun, 2014).

2.4 CONSTRUCTION TIME WASTE

During their study, Alwi, et al. (2002) stated that experts have figured that there are several inefficient activities during the planning and development process, mostly in construction industry as well. The majority of these activities consume time without providing extra benefits to the process (Sugiharto, et al., 2002).

Although time waste is linked to the overall delay of building projects, a full analysis of time wastes is not a common topic of research. But during their studies some past researchers have identified certain time waste factors in construction industry, which are summarized in Table 1.

Table 1: Causes of time waste

Source	Causes for Time Waste
Design	Interaction between various specialists
	Rework due to design changes and revisions
	Lack of information about types and sizes of materials on design documents
	Error in information about types and sizes of materials on design documents
	Contradictions in design documents
	Delay in approval of drawings
Procurement	Delay in material supply
	Receiving materials that do not fulfil project requirements defined on design documents, and waiting for replacement
	Delay in transportation and/or installation of equipment
Operation	Scarcity of crews
	Unrealistic master schedule

Source	Causes for Time Waste
	Rework due to workers' mistakes
	Scarcity of equipment
	Waiting for design documents and drawings
	Lack of coordination among crews
	Choice of wrong construction method
	Accidents due to lack of safety
Other	Irregular cash flow
	Severe weather conditions
	Bureaucracy and red tape
	Unpredictable local conditions
	Acts of God

(Source: Polat and Ballard, 2004; Ali and Arun, 2014).

Reviewing the sources of waste in detail, Design is one of the main causes of waste and under this, there are other various types which cause waste in construction (Islam, et al., 2016). Basically, there can be a waste due to inexperience designers, lack of design information, poor design quality, last-minute client requirements, design errors due to frequent design changes as well (Meghani, et al., 2011). In spite of that related to time waste in constriction, Polat and Ballard (2004) identified aforementioned six causes for time waste.

Another main source of waste is procurement. In related to procurement there are several methods of waste such as ordering errors, wrong material delivery, item not in compliance with specification, different methods used for estimation, supplier errors, waiting for a replacement, error in shipping. Above mentioned types can consider as main factors which cause waste (Daniels, et al., 2005). In related to time waste there are specifically three causes identified under source of procurement (Polat and Ballard, 2004). Where delay in material supply is a major issue, which is a direct cause for time waste. Receiving materials that do not fulfil project requirements defined on design documents and waiting for replacement also time wasting (Rosado, et al., 2019). Delay in transportation and installing of equipment obviously take time and due to the errors of the procedure it will cost time hence causes a time waste (Arif, et al., 2012).

In regard to the sources of waste operation takes part, where eight causes were identified by Polat and Ballard (2004). There can be a waste due to operation errors of the project. Errors and mistakes can happen regarding supervision, controlling, planning, site management and communication problems (Viana, et al., 2012). Apart from mentioned causes, scarcity of crew, rework, accidents due to lack of safety can be considered (Vitharana, et al., 2015).

With the exception of design, procurement and operation still there are some factors which cause construction waste, such as; irregular cash flow, severe weather conditions, bureaucracy and red tape, unpredictable local conditions which occur unexpectedly, for example pandemics and finally, acts of god, as an example floods or tremor where legally binding language alluding to demonstrations of god are known as power majeure conditions, which are regularly utilized by insurance agencies (Katz and Baum, 2011).

The literature review consists of a basic knowledge in addressing the research question in hand, primarily with a list of causes of time waste. Following this, in order to fulfil the aim of this study, what was left to Identify is the level of each mode in each of two procurement methods and then to Identify the significant differences in level in between two procurement methods.

3. METHODOLOGY

Being a complex topic, 'Procurement system on Construction Time Waste' held a complex set of areas to be considered as productivity measurements significantly vary. The key aspects to be concerned were, research design approach, theoretical approach, strategy of inquiry and research method (Pandey and Pandey, 2015). A quantitative approach was utilized in this research because it was with the aim of identifying the differences in a manner that can contribute to an analytical decision (Pandey and Pandey, 2015). As the time waste causes are already known, the necessity was to find if causes were having significant difference in effects from a hypothesized equal point. Therefore, the theoretical approach of the study was deductive.

The strategy of enquiry comprised of a quantitative questionnaire survey, where the respondents were given the opportunity to scale the time-wasting factors comparatively on a ratio scale. A questionnaire survey with a 9-point scale which was formed adhering to the Analytic Hierarchy Process (AHP) was utilized. The 9-point scale was adopted mainly because it helps in analysing data through a comparison between each factor identified. The nine-point scale structure is given below (Mu and Preyra-Rojas, 2017).

Table 2: 1 to 9 scale table

Intensity of Level (1-9 Scale)	Definition
1	Equal Level
2	Weak
3	Moderate Level
4	Moderate Plus
5	Strong level
6	Strong Plus
7	Very Strong or Demonstrated Level
8	Very, Very Strong
9	Extreme Level

(Source: Mu and Preyra-Rojas, 2017)

Data was collected through a questionnaire survey which was directed to the industry professionals. Factors such as field of engagement, period of experience and academic and professional qualifications were taken into consideration when selecting the respondents. 28 respondents completed the questionnaire. The questionnaire listed 22 time-waste factors under which the respondent had to select if design and build or traditional procurement had higher level of wastage first, then next to it mark intensity of higher against the lower based on 9-point scale (in Table 2). Equal importance could be marked as one in scale.

For analysing purposes, collected data were initially transformed to have negative or positive direction based on Design and Build and Traditional Method respectively, with Zero as the neutral point (Eq. 01).

$$S_{ji} = K_{ji}\left(R_{ji} - 1\right) \qquad \textit{(Eq. 01)}$$

Where, S = transformed Severity Score value that ranged from –8 to +8, K = –1 if Design and Build selected to be with higher level of wastage, +1 if Traditional was selected. R = 9-point scale response for each factor j by i^{th} respondent. Accordingly, if Design build had extreme level of time waste for a factor, the S would become –8. The transformed scores were analysed using descriptive statistical techniques with Box Plots being the primary method. In addition, statistical mean, standard deviation, median and quartiles were used in interpretation.

4. ANALYSIS AND FINDINGS

Severity Scores (S) were first visually analysed on a colour-scaled matrix shown in Figure 2 for a generalized understanding of distribution of scores.

	Response	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	Time waste factors																												
1	Interaction begiven various specialists	-1	-2	2	4	2	-3	6	2	1	6	2	2	-4	8	7	-2	5	8	-2	0	-5	7	6	2	4	-2	-3	-2
2	Rework due to design changes and revisions	0	-2	-1	-4	2	-4	6	2	-6	-8	3	3	-5	2	7	-2	-3	7	0	7	5	7	8	7	8	8	7	-3
3	Lack of information about types and sizes of materials on design documents	2	-3	-4	-3	2	3	4	2	6	-7	3	4	-4	-5	0	-3	-5	5	4	6	5	0	4	6	5	-5	-4	3
4	Error in information about types and sizes of materials on design documents	-1	-2	-1	-8	2	3	5	0	4	-8	4	-5	-2	-7	5	4	-4	5	2	7	-5	5	3	6	4	5	5	-3
5	Contradictions in design documents	1	-3	-4	-5	2	2	4	3	6	7	3	2	1	-8	3	-2	-5	4	0	4	5	3	5	7	7	7	8	4
6	Delay in approval of drawings	0	-3	2	-6	2	-3	2	2	-7	-7	2	3	-4	-3	6	-2	-4	7	-8	7	5	6	8	7	6	8	8	4
7	Delay in material supply	-1	-3	3	0	2	1	2	1	-5	-7	0	4	-7	1	0	-3	-5	0	5	0	5	0	0	0	0	-1	2	-6
8	Receiving materials that do not fulfil project requirements defined on design documents, and waiting for replacement	0	-2	-2	7	2	-2	1	2	4	4	-5	5	-6	-7	0	-2	5	0	8	2	5	0	0	3	0	0	-2	3
9	Delay in transportation and/or installation of equipment	0	-3	2	-3	2	0	0	2	2	7	0	2	-1	-2	-4	-2	-4	0	8	0	5	-4	0	0	0	0	0	-5
10	Scarcity of crews	1	-3	-1	3	2	0	-2	2	8	-7	0	3	-4	8	0	-2	5	1	8	0	5	0	0	0	0	0	-4	-6
11	Unrealistic master schedule	0	-3	2	8	3	-1	-2	3	-7	8	0	4	-5	-8	1	-2	-5	0	4	1	5	1	0	3	0	0	1	-3
12	Rework due to workers' mistakes	0	-2	3	4	2	0	3	5	-4	5	-3	5	-5	-3	2	-2	4	-3	4	0	-5	2	4	3	4	7	6	3
13	Scarcity of equipment	-1	-3	-2	1	2	0	0	2	1	6	2	2	-4	-2	0	-2	-3	-3	4	-2	5	0	-2	0	0	-1	-2	-5
14	Waiting for design documents and drawings	0	-4	3	8	1	2	3	3	-4	7	2	3	-3	-4	6	-2	4	6	-8	7	-5	6	6	4	5	7	7	3
15	Lack of coordination among crews	0	-4	2	3	2	-2	5	3	6	-7	0	4	-4	-8	-2	-2	-4	0	3	-2	5	-2	4	3	-3	-2	-3	2
16	Choice of wrong construction method	0	-3	1	4	2	2	8	4	-5	-6	5	5	-6	-8	5	-2	4	1	8	-1	-5	4	4	4	-2	-3	2	3
17	Accidents due to lack of safety	0	-3	-4	0	2	0	4	3	0	6	0	-2	-3	-7	0	-2	-4	0	8	0	-5	0	0	0	0	0	3	4
18	Irregular cash flow	-1	-3	-4	-5	3	-2	6	3	-3	5	0	-3	-2	-4	0	-2	4	0	5	0	5	0	0	0	1	0	0	-5
19	Severe weather conditions	0	-2	4	-3	3	0	5	2	-2	-6	0	4	-4	-4	0	-2	4	0	0	0	5	0	0	3	0	0	0	-6
20	Bureaucracy and red tape	0	-4	3	7	2	0	6	2	5	6	6	5	-4	-2	3	-2	-4	-1	2	3	5	3	3	6	4	4	3	-6
21	Unpredictable local conditions	0	-5	-5	-5	0	0	5	2	2	7	-4	2	-3	-2	1	-2	4	0	3	0	5	1	0	4	0	-3	-2	-6
22	Acts of God	-2	-4	-4	-7	3	1	6	2	-4	0	0	-3	-3	-4	0	-2	4	0	0	0	-5	0	0	0	0	0	0	8

Figure 2: Severity score of time waste factors

The visual observations showed significant variability in scores among the respondents for large majority of factors. Therefore, it was decided to use the median score as the indicative basic value for the judgement. However, consideration was also given to include the level of variability to make in finding the interpretations. Figure 3 shows the median score (or the second quartile) for the factors.

The median value of scores can be interpreted as the score of the average respondent for each factor. This score is not affected by the extreme scores that would have been given by any other respondent. Thus, it represents a more reliable centre value given the fact that there is a wide variability in most factor scores.

	Time waste factors	Median = Q2
1	Interaction begiven various specialists	2.00
2	Rework due to design changes and revisions	2.00
3	Lack of information about types and sizes of materials on design documents	2.00
4	Error in information about types and sizes of materials on design documents	2.50
5	Contradictions in design documents	3.00
6	Delay in approval of drawings	2.00
7	Delay in material supply	0.00
8	Receiving materials that do not fulfil project requirements defined on design documents, and waiting for replacement	0.00
9	Delay in transportation and/or installation of equipment	0.00
10	Scarcity of crews	0.00
11	Unrealistic master schedule	0.00
12	Rework due to workers' mistakes	2.50
13	Scarcity of equipment	0.00
14	Waiting for design documents and drawings	3.00
15	Lack of coordination among crews	0.00
16	Choice of wrong construction method	2.00
17	Accidents due to lack of safety	0.00
18	Irregular cash flow	0.00
19	Severe weather conditions	0.00
20	Bureaucracy and red tape	3.00
21	Unpredictable local conditions	0.00
22	Acts of God	0.00

Figure 3: Median of each time waste factor

Figure 3 shows that there are ten factors showing level differences between the two procurement methods.

1. Interaction begiven various specialists
2. Rework due to design changes and revisions
3. Lack of information about types and sizes of materials on design documents
4. Error in information about types and sizes of materials on design documents
5. Contradictions in design documents
6. Delay in approval of drawings
7. Rework due to workers' mistakes
8. Waiting for design documents and drawings
9. Choice of wrong construction method
10. Bureaucracy and red tape

It is interesting to find that all 10 factors show higher level of time waste in the tradition procurement method as the scores indicate the positive sign. Balance 12 factors showed equal level of time waste in both procurement methods indicated by the neutral value zero. For all factors, 50% or more respondents had scored at or above Zero. From these results, it could be generalized that time waste is always higher in traditional procurement method, and those waste occur through 10 factors above. However, this interpretation has its limitations since it disregards the variability of scores.

Box Plots shown in Figure 4 were used to identify the nature of variability and to expand the interpretation above.

The factors were reordered from the highest to the lowest based on following statistics in order to support better visualization.

1. Median or the second quartile (Q2) - 50th percentile
2. First quartile (Q1) - 25th percentile
3. Third quartile (Q3) - 75th percentile

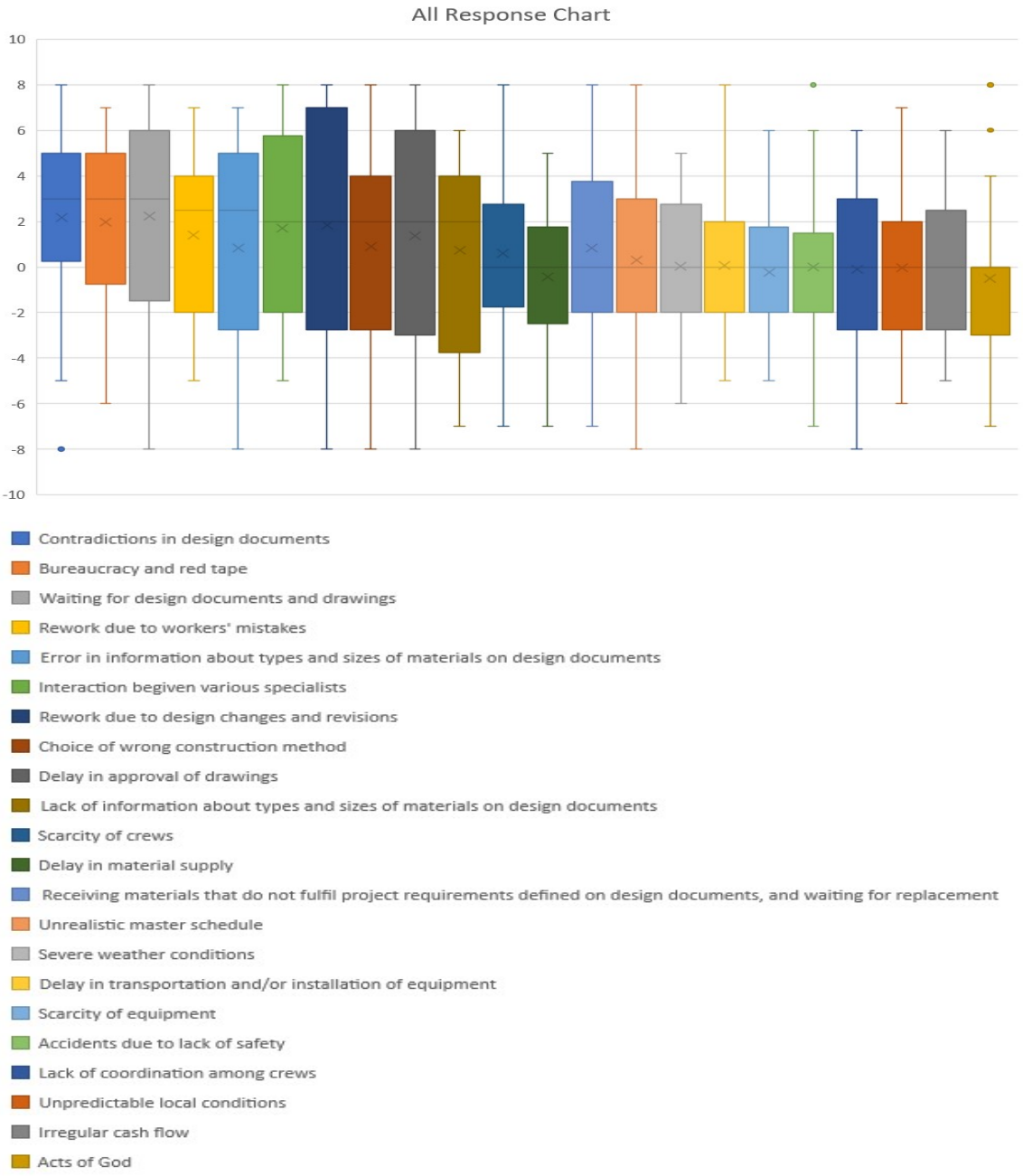

Figure 4: Summary of all respondents

Larger boxes show higher level of variability. The Q2 line always being at or above zero re-iterates the previous interpretation. However, there are some peculiar observations.

Only one factor: "contradictions in design documents" had the middle majority safely above zero. This means, even for the nine factors which had higher level of a score for Traditional procurement method, at least a little portion of middle majority had paradoxical experience or opinion. For the complex context in this, this fact shall not be disregarded. Two other factors have median staying at 3, but one of them (waiting for

design documents) has the middle 50% going lower than negative one. Twelve factors having their median at zero do have relatively a narrower inter quartile range indicating a comparatively a higher-level consistency. This also indicates that half of the respondents ranked equal or higher level of time waste for those 12 factors for design and build procurement method. Interestingly, time waste by Acts of God had been ranked equal of higher for design and build at least by 75% of the respondents. The middle majority of scores ranged from zero to negative three, while the median is still at zero indicating a significant skewness towards design and build.

5. CONCLUSIONS

The study was focused on the impact of procurement methods on construction time waste in the perspective of traditional procurement method and design and build method. Table 3 summarizes the generalized conclusion from the study where 22 time waste factors identified through literature are now identified along with the procurement method having higher level of time waste.

Table 3: Time waste factors how effect to the procurement

Source	Time waste factor	Procurement method with higher level of time waste
Design	Interaction begiven various specialists	Traditional
	Rework due to design changes and revisions	Traditional
	Lack of information about types and sizes of materials on design documents	Traditional
	Error in information about types and sizes of materials on design documents	Traditional
	Contradictions in design documents	Traditional
	Delay in approval of drawings	Traditional
Procurement	Delay in material supply	No difference
	Receiving materials that do not fulfil project requirements defined on design documents and waiting for replacement.	No difference
	Delay in transportation and/or installation of equipment	No difference
Operation	Scarcity of crews	No difference
	Unrealistic master schedule	No difference
	Rework due to workers' mistakes	Traditional
	Scarcity of equipment	No difference
	Waiting for design documents and drawings	Traditional
	Lack of coordination among crews	No difference
	Choice of wrong construction method	Traditional
	Accidents due to lack of safety	No difference
Other	Irregular cash flow	No difference
	Severe weather conditions	No difference
	Bureaucracy and red tape	Traditional

Source	Time waste factor	Procurement method with higher level of time waste
	Unpredictable local conditions	No difference
	Acts of God	No difference

According to the findings of the study, it can be concluded as time waste in traditional procurement in general is higher than design and build method. Factors related to procurement source are unlikely to cause higher level of time waste in either method while all design related factors have higher level of time waste in traditional method in general. A few operations related and other factors would also cause higher level of time waste in traditional procurement method. Design and build method in general would not incur higher level of time waste through any source identified. While acknowledging that this is the generalized conclusion, study identified that there was a large minority who found comparatively a higher level of time waste in design and build method almost under all factors.

On a final remark, from time waste point of view, the choice of procurement method is design and build method. That is, a client who choses design and build method by considering other factors, does not require to be concerned about time waste levels against traditional method. On the other hand, a client who choses traditional method must focus on the above identified sources to judge how much of cost they would bring compared to the benefits identified against the design and build method. Nevertheless, possibility of paradoxical reality should not be disregarded as observed in findings. Such outcomes are not rare due to the complex nature of construction projects procurement.

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