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FACTORS AFFECTING THE SELECTION OF A PROCUREMENT METHOD FOR STEEL BUILDING CONSTRUCTION

G.P.P.S. Perera[1], T.M.M.P. Tennakoon[2], U. Kulatunga[3], H.S. Jayasena[4] and M.K.C.S. Wijewickrama[5]

ABSTRACT

Construction procurement involves organizing processes of acquiring services and products for activities starting from project investigation to completion of a project. Along with the development of new concepts and technologies, construction procurement arrangements were also developed to draw the best value for construction organizations. Selecting the best procurement method for a specific project is a challenge since the availability of diverse procurement options and subjective factors affecting the selection of procurement methods. An inappropriate selection of a procurement method leads to project failure while adversely affecting the expectation of stakeholders and the economy. Since the number of steel building constructions are increasing in the Sri Lankan context this study aims to identify factors which highly influence the selection of a procurement method for steel building construction in Sri Lanka. In order to achieve the aim, initially, a comprehensive literature survey was carried out to identify factors which influence the procurement selection for building construction. Accordingly, 42 factors were identified. Subsequently, a quantitative research approach was followed to list down the factors on their significance in selecting procurement method for steel building construction in Sri Lanka. Consequently, 26 factors were concluded as the most significant factors, which influence the procurement selection of steel building construction through Relative Importance Index (RII). Procurement Path Decision Chart was used to analyses the procurement selection factor and construction management was identified as the most suitable procurement method for steel building construction in Sri Lanka.

Keywords: *Procurement Methods; Selection Criteria; Steel Building Construction.*

1. INTRODUCTION

Construction industry consist of a vast scope of activities that display unique and complex characteristics and establishes a major part in the economy (Behm, 2008). The quality of a construction project affects the success of the construction sector. Thus, the management of project standards in terms of the construction technologies utilized becomes a major a concern (Ali and Kamaruzzaman, 2010).

[1] Department of Building Economics, University of Moratuwa, Sri Lanka, pubuduperera98@gmail.com
[2] Department of Building Economics, University of Moratuwa, Sri Lanka, ra-maheshi@uom.lk
[3] Department of Building Economics, University of Moratuwa, Sri Lanka, ukulatunga@uom.lk
[4] Department of Building Economics, University of Moratuwa, Sri Lanka, suranga@uom.lk
[5] Department of Building Economics, University of Moratuwa, Sri Lanka, mkcsw.mora@gmail.com

Likewise, as underlined by Ali and Kamaruzzaman (2010), scope, cost, time and quality were among the factors of project success which significantly dependent upon the construction technology used. Hence, steel framed building construction had gained popularity as a widely used construction technology considering the advantages in terms of project success factors (Patel and Jani, 2013).

Conversely, steel structural construction projects encounter issues during the construction, transportation, installation and operational stages (Rashid *et al.,* 2016). The procurement of steel is a commercial process that involve the experience and interest of client, detailers, fabricators, architects, and qualified engineers (Farrow, 2007). Selection of a procurement method is a major concern since it defines the role of contracting parties and the extent of innovation in the project (Valence, 2010).

Therefore, steel building procurement is indicative of the overall framework of responsibilities and authorities for participants of the construction process. Selecting a suitable procurement method is a critical point that govern the success of the project (Cheung *et al.,* 2001). Henceforth, the scope of this research paper was delimited to identify and evaluate the selection criteria for procurement methods for steel buildings.

2. STEEL BUILDING CONSTRUCTION

The popularity of steel building construction over the traditional construction technology is observed due to several reasons. Structural steel is a cost effective material for building construction (Glidden, 2000). Recently, new technologies have become available to fabricate and erect steel members by reducing the cost of construction to make quick profits (Besgul, 2006). Unlike the reinforced concrete structures, steel structures have the advantage of a lower structured self-weight, lower cost and cover a larger occupying area (Guangyu *et al.,* 2008). Further, they are durable and easy to assemble (Spacone and Tawil, 2004). Steel structures are very suitable for buildings that require long spans, such as sports facilities, atriums, assembly places and convention centres, since it allows longer spans without requiring columns in between (Mehta, Scarborough and Armpriest, 2012). Despite the availability of researches to enhance the activities related to steel building construction, performance control, steel building cost control and cost optimization, less concern had been given to steel building construction procurement.

3. PROCUREMENT METHODS

Procurement is the process of management and fulfilment of construction projects. Further, it has been described as success of a logical action occurred or performed for the completion of a project (Mathonsi and Thwala, 2012; Ratnasabapathy, Rameezdeen and Gamage, 2006). The most commonly used procurement methods can be identified as traditional method, integrated procurement method and management procurement method (Davis, Love, and Baccarini, 2006). Still, there is no specific procurement method that is applicable to all types of construction projects (Sawalhi and Agha, 2017). Yet, the appropriate selection of a procurement system can be of assistance to minimize problems during the construction (Sawalhi and Agha, 2017). Examining the factors under client requirements, project characteristics and external environment can be beneficial in selecting a procurement method (Gbadebo and Ojo, 2012).

4. CONSTRUCTION PROCUREMENT SELECTION

Based on the literature findings, 42 selection factors are listed in Table 1. Conferring to Table 1, the factors that influence the selection of procurement methods are classified as internal and external factors. The internal factors are again segmented in to client-based selection factors and project-based selection factors.

Table 1: Construction procurement selection factors

Construction Procurement Selection factors		
Internal		**External**
Client	**Project**	
Project completion within budget	Technical complexity of the project	Natural disasters
Short construction period	Design reliability	Material availability
Good quality of construction project	shop drawings process	Industrial actions
Experienced clients	Prefabrication process	Regulatory environment regulating feasibility
Inexperienced clients	Material transportation process	Globalization
Client's specific requirements and objectives can implement.	Erection process	Government policies
flexibility to change design during both design and construction periods	Project funding method	Market forces
Quick response to clients' new requirements	Constructability of design-high	Political considerations
According to client financial capabilities minimum risk	Site risk factors	Environmental issues (Earthquakes)
Allocation of responsibility	Available resources of project	Incensement weather
Qualified professional involvement	Construction method- new construction	Market Competitiveness
Client willingness to take risk	Qualified knowledgeable and experienced contractor	
Payment modality	Minimizes Construction Aggravation	
	Material distribution	
	Project size-high	
	Project site location	
	Skilled / unskilled labour availability-lower	
	Project type residency/commercial	

Source: Adapted from Ratnasabapathy, *et al.* (2008) and Mathonsi and Thwala (2012)

Based on Table 1, it can be identified that most of the selection factors are influenced by various complications during design, construction, transportation, installation and

operation (Rashid *et al.*, 2016). Hence the gravity of the importance of each of the listed factors required to be identified as the initial step of the selection of a most suitable procurement method for steel building construction.

5. RESEARCH METHOD

The literature review clearly outlined construction procurement method selection factors. Hence, a deductive research approach was followed to prioritize the selection factors. A survey research strategy was initialized since it encourages significant number of observations prior to driving conclusions. A quantitative method was determined as the most suitable research choice since there has been a lack of quantitative research related to procurement method selection. The survey was carried out among various construction industry professionals. According to Burns (1994), it is important to select a larger sample size (>= 30) in order to have less errors in the findings. As the data collection technique, a questionnaire was distributed among 70 participants selected through convenient sampling. Subsequently, 45 questionnaires were received denoting a response rate of 64.29%. The questionnaire consisted questions designed with a 5-point Likert scale to mark the importance of each selection factor.

Table 2 elucidates the years of experience, proficient fields and the organisations they are representing.

Table 2: Respondents' profile

Respondents' characteristic	Categories	Count
Years of experience	0-5 years	2
	5-10 years	3
	10-15 years	7
	15-20 years	15
	More than 20 years	18
Proficient Fields	Construction projects administration	18
	Project procurement	45
	Dispute resolution	15
Organisation	Client	9
	Contractor	18
	Consultant	11
	Construction management	7

The collected data via questionnaires was analysed based on the Weighted Mean Rating (WMR) given in formula (01), which reflected the importance given to each of the selection factor by the respondents.

$$WMR = \frac{\sum_{i=1}^{5}(x_i \times f_i)}{R\%} \qquad (01)$$

Where: WMR= Mean Rating for an attribute; f_i = Frequency of responses for an attribute (ranging from 1-5); R%= Percentage response to rating point of an attribute.

Successively, the Standard Deviation (SD) was calculated which quantified the discrepancy of the data set around the mean value. Higher the value of SD, so as the

deviation of the data around the mean value and vice versa. The standard deviation for each variable was derived using formula (02).

$$SD = \sqrt{\frac{\sum(Ri - Mi)^2}{n}} \qquad (02)$$

Where: SD = Standard deviation value, Mi. = Mean value of particular variable, Ri = Weightage given to each variable based on the respondents' level of agreement, n = Total number of respondents

The T value was obtained for each of the procurement method selection factor to identify the relative importance of each factor particularly for steel building construction procurement. The IBM SPSS Statistics software was used to test the null hypothesis; "important" (H_o): $\mu <= \mu_o$ against the alternative hypothesis; "not important" (H_1): $\mu > \mu_o$, where μ_o was the population mean. μ_o was given a fixed value of 3, since according to the Likert scale, point 3 was neutral. The decision rule was applied to determine whether the null hypothesis could be rejected or accepted. Where the degree of freedom is 26, the critical t-value was taken as 2.0325 as derived from the table of t-values 30-2.042 and 40-2.021 in confident level 95%.

Therefore, when the observed t-value is greater than critical t-value, the null hypothesis is rejected. Therefore, in the analysis, when t observed value is greater than the t-critical value, was considered as a very significant factor while the null hypothesis is rejected and the alternate hypothesis is accepted. However, if the t observed value for one factor had been less than the t-critical value, the null hypothesis would have been retained.

Subsequently, the Relative Important Index was used as an analysis technique for questionnaire responses, which had been used by many researchers to determine the relative significance of the attributes. Hence, RII was used to rank the important and very important factors derived through the t-value and verified through the SD. RII equation which has been used in this research study is given in equation (03).

$$RII = \frac{\Sigma W}{A \times N} \qquad (03)$$

Where, W= Constant expressing the weighting given to each response, A= the highest weighting, n = the frequency of responses and N= Total Number in the Responses.

Once the ranking of the procurement method selection factors was completed scope of this paper is realized.

6. RESEARCH FINDINGS AND DISCUSSION

6.1 LEVEL OF SIGNIFICANCE OF THE PROCUREMENT METHOD SELECTION FACTORS

Considering the WMR, SD and t-value, the factors considered when selecting a suitable procurement method for steel building projects were categorized as Very Important (VI), Important (I), and Not Important (NI) as illustrated in Table 3.

Table 3: SD, TV, WMR and the level of significance of considered factors

Ref. No.	Considered Factor	SD	TV	MW	VI/ I/ NI
A	**Client characteristic related procurement selection factors**				
1	Complete project within the established budget	0.7506	12.428	4.475	VI
2	Short construction period	0.3848	29.995	4.825	VI
3	Good quality of construction project	0.7696	5.342	3.650	I
4	Experienced clients	1.2800	0.247	3.050	NI
5	Inexperienced clients	1.0561	-1.497	2.750	NI
6	Client's specific requirements and objectives can implement.	0.5943	12.504	4.175	VI
7	flexibility to change design during both design and construction periods	0.7442	7.6490	3.900	I
8	Quick response to clients' new requirements	0.7579	6.676	3.800	I
9	According to client financial capabilities minimum risk	1.0561	4.491	3.750	I
10	Allocation of responsibility	0.6718	0.941	3.100	NI
11	Qualified professional involvement	0.9443	4.521	3.675	I
12	Client willingness to take risk	0.8738	3.076	3.425	I
13	Payment modality	0.9388	5.895	3.875	I
B	**Project characteristic related procurement selection factors**				
1	Technical complexity of the project	0.6751	11.008	4.175	VI
2	Design reliability	0.6718	10.356	4.100	VI
3	shop drawings process	0.6405	9.874	4.000	VI
4	Prefabrication process	0.6597	9.347	3.975	I
5	Material transportation process	0.9195	-0.172	2.975	NI
6	Erection process	0.4634	15.354	4.125	VI
7	Project funding method	1.0099	5.167	3.825	I
8	Constructability of design-high	0.7161	13.248	4.500	VI
9	Site risk factors	0.8317	5.894	3.775	I
10	Available resources of project	0.7845	4.031	3.500	I
11	Construction method- new construction	0.6718	8.473	3.900	I
12	Qualified knowledgeable and experienced contractor	1.0350	7.180	4.175	VI
13	Minimizes Construction Aggravation	1.5357	-1.956	2.525	NI
14	Material distribution	1.2707	-3.857	2.225	NI
15	Project size-high	1.1206	-0.141	2.975	NI
16	Project site location	1.3085	-4.471	2.075	NI
17	Skilled / unskilled labour availability-lower	0.8022	6.701	3.850	I
18	Project type residency/commercial	1.4106	-0.448	2.900	NI

Ref. No.	Considered Factor	SD	TV	MW	VI/ I/ NI
C	**External characteristic related procurement selection factors**				
1	Natural disasters	0.9594	3.626	3.550	I
2	Material availability	0.6385	5.448	3.550	I
3	Industrial actions	1.0622	0.000	3.000	NI
4	Regulatory feasibility	0.6597	0.240	3.025	NI
5	Globalization	0.7299	0.650	3.075	NI
6	Government policies	1.0013	4.106	3.650	I
7	Market forces	1.0175	0.777	3.125	NI
8	Political considerations	1.0834	-4.816	2.175	NI
9	Environmental issues (Earthquakes)	1.0266	4.005	3.650	I
10	Incensement weather	1.0908	-4.639	2.200	NI
11	Market Competitiveness	0.9997	1.423	3.225	NI

Consequently, different respondents propounded different criteria weights. According to the result of the MWR analysis of the gathered data, very important factors were construction period, ability to complete the project within the set budget and the ability to implement the client's specific requirements. This result was backed by a mean value exceeding 4.00. Moreover, the critical t value was 2.0325 and all the three factors gain values of 12.428, 29.995 and 12.504, which showcased the significance level of the factors.

Similarly, technical complexity of the project, design reliability, shop drawings process, erection process, constructability of design-high and qualified knowledgeable and experienced contractor were the very important procurement method selection factors. The significance level (t- value) of the factors were identified as 11.008, 10.356, 9.874, 15.354, 13.248 and 7.180.

The external factors of procurement selection with significance value more than the critical t- value were natural disasters, material availability, Government policies and Environmental issues. The t-value of the factors were identified as 3.626, 5.488, 4.166 and 4.005. Alternatively, industrial actions, regulating feasibility, globalization, market forces, political considerations, incensement weather and market competitiveness factors were disregarded due to their respective t-values 0.000, 0.240, 0.650, 0.777, -4.816, -4.639 of and 1.423 which were lower than the critical t-value of 2.0325. These results demonstrated the very important factors and the factors to be disregarded in procurement selection process of steel buildings construction.

6.2 RANKING THE PROCUREMENT SELECTION PARAMETERS FOR STEEL BUILDING CONSTRUCTION

Subsequently, there were 26 factors which were very important and important to steel building construction procurement methods. RII value was used to calculate a unique value for each factor and known as, "utility factor". Utility factor represents how much each procurement selection factor successfully achieve the respective procurement method.

Out of the 42 procurement parameters considered for the ranking process, the top 26 procurement selection parameters for steel building are ranked in Table 4 based on the utility factor.

Table 4: Top ranked procurement selection factors

Procurement selection parameters for steel building construction	RII	Rank
Short construction period	0.9650	1
Higher constructability of design	0.9000	2
Complete project within the established budget	0.8950	3
Client's specific requirements and objectives implementation	0.8350	4
Technical complexity of the project	0.8350	5
Qualified knowledgeable and experienced contractor	0.8350	5
Erection process	0.8250	7
Design reliability	0.8200	8
Shop drawings process	0.8000	9
Prefabrication process	0.7950	10
Flexibility to change design during both design and construction periods	0.7800	11
Construction method- new construction	0.7800	11
Payment modality	0.7750	13
Skilled / unskilled labour availability-lower	0.7700	14
Project funding method	0.7650	15
Quick response to client's new requirements	0.7600	16
Site risk factors	0.7550	17
According to client financial capabilities minimum risk	0.7500	18
Qualified professional involvement	0.7350	19
Good quality of construction project	0.7300	20
Government policies	0.7300	20
Environmental issues	0.7300	22
Natural disasters (Earthquakes)	0.7100	23
Material availability	0.7100	23
Available resources for the project	0.7000	25
Client's willingness to take risk	0.6850	26

According to the findings of the survey, short construction period was considered as the most significant factor which affects when selecting a procurement method for steel building construction projects. Gbadebo and Ojo (2012) had emphasised a similar notion in their study, where the time duration consumed by the pre-contract stage for the procurement process was a disadvantage to projects with shorter duration.

Moreover, the factor ranked at the second place; higher constructability of the design, had also fortified, to select a procurement method with limited or no changes to the design, thus also fulfilling the third top rank factor, complete project within the established budget (Luu and Chen 2003). The lowest ranking for client's willingness to take risk can be explained via the same literature mentioned above because, the inflexibility to change in

terms of duration, design and budget through an appropriate procurement method, reduce the risk to the client.

7. CONCLUSIONS

The scope of this paper had been limited to identifying and ranking the selection factors of procurement methods for steel building construction which was a section of a study for selecting a suitable procurement method for steel building construction. The study could be extended to select a procurement method in a qualitative or quantitative way.

As a conclusion the key findings were categorised under two streams. Firstly, the selection factors of a procurement method for steel building construction were identified for their level of importance. Only 9 factors out of 46 factors were recognized as very important since they had a significantly higher t-values than the established critical t-value of 2.0325. The important factors had a t-value which was closer to the critical t-value. Hence, 17 important factors were also selected for the ranking purpose. 20 factors including experience of the client, material distribution, project size, project location, globalization and market forces were disregarded since their t-values were less than the critical t-value. Hence, it was concluded that only 26 factors out of the 46 factors identified in the literature, were important when selecting a procurement method for steel building construction.

Secondly, the ranking process was conducted through RII method, which concluded, a procurement method conforming to the short construction period, higher constructability of design and project completion within the established budget should be given priority in the selection process of an appropriate procurement method for steel building construction. The result of the ranking confirmed the previous literature, which had only discovered qualitatively, the significance of the short construction period and higher constructability of the design of the steel building construction when selecting a suitable procurement method.

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