

## Factors Affecting the Accuracy of Pre-Tender Estimation of Road Construction in Sri Lanka

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### Abstract

*Within the sphere of construction, the "estimating process" is a significant element due to the lack of financial resources available, and out of the branches of estimating, pre-tender cost estimating of road construction projects requires extensive knowledge and expertise. The aim of this research is to assist clients and consultants in improving the predictive ability of the cost estimating of road construction in Sri Lanka. This research has been conducted through a literature review of topics related to the cost estimating process, followed by a questionnaire survey. The analyzing of 59 factors conclude that the main factors affecting the accuracy of pre-tender cost estimation of road construction are: accuracy and reliability of cost information, material (prices /availability /supply /quality /imports), clear and detailed drawings and specifications, completeness of cost information, designer's experience level. "Spearman's Rank Correlation Coefficient" test was used as a measure of agreement between the three groups of respondents with regard to factors ranking, and it appears that they are generally in strong agreement. Finally, 15 expert interviews were conducted to identify the existing practices of cost estimation of road construction in Sri Lanka. These conclude that the main existing practices are: comparison with past similar projects based on personal experience, established standards ex. HSR (Highway Schedule Rates) and comparison with similar past projects based on documented facts. The study recommended that both clients and consultants give more attention to the cost estimating process and to hire qualified technical staff in order to obtain the accurate estimate and to keep computerized historical data of completed projects.*

**Keywords:** pre-tender cost estimation, accuracy, clients, consultants

### Introduction

The success or failure of a project is dependent on the accuracy of several estimates done throughout the course of the project (Ahuja, Dozzi & Abou Rizk, 1994). Therefore, the preparation of a cost estimate of the project is one of the most difficult tasks in project management because it must be done before the work is accomplished (Oberlender, 1993). Pre-tender cost estimating is simply the final costing of the work carried out by a consultant (i.e., quantity surveyor or engineer) on behalf of a client (Oduami & Onukwube, 2008) before tenders are received. It sits somewhere between cost planning and post-contract cost control, provides an indication of the probable construction cost prior to contract-awarding and involves collecting, analyzing and summarizing all available data related to the construction of the project (Ashworth, A. & Skitmore, R. M. 1999). Thus, for a contractor to secure a job, his cost estimate must be as accurate and competitive as possible (Marjuki, 2006). Inadequate estimating invariably leads to misallocation of scarce resources.

An estimate can be accurate, low or high. An accurate estimate generally results in the most economical project cost, while either an underestimation or an overestimation often leads to greater actual expenditures. Inaccuracy in the estimate of a project may arise from two sources: bias associated with the project itself and bias associated with the estimating techniques used and the operating environment (Aibinu & Pasco, 2008).

An accurate estimation of construction costs heavily depend on the availability and quality of historical cost data and the level of professional expertise, when compared with many other factors. The limited information available at the early stages of a construction project may mean the quantity surveyor must make assumptions about the design details of a project, which may not eventuate as the project's design, planning and construction evolve (Liu & Zhu, 2007). Professional estimators have access to reliable cost and productivity references for estimating labor, material, equipment and other major work components. These major cost items have a high visibility factor and consequently receive adequate attention in the preparation of the pre-tender estimate. However, there are little-known low visibility factors affecting the estimate accuracy, such as procurement forms and contract arrangements, which should be considered in the preparation of pre-tender estimates. Unfortunately, these factors are either entirely overlooked or neglected by estimators in the Sri Lankan road Construction Industry. Identification of these low visibility factors is very important for improving the overall performance of the Construction Industry. Therefore this research aimed at assisting clients and consultants in improving the predictive ability of the cost estimating of road construction in Sri Lanka. Fulfilling above research aim was done by achieving five research objectives. These objectives are; (1) Identify the existing practices of preparing pre-tender cost estimating, (2) Identify the factors affecting to the accuracy of pre-tender cost estimate, (3) Identify the factors which are not considered enough by clients, consultants and contractors, (4) Investigate the perspective of clients', consultants' and contractors' of the essential factors, (5) Identify the relationship between the perspectives of clients, consultants and contractors about essential factors affecting accuracy of pre-tender cost estimate in Sri Lanka.

#### *Factors influencing the accuracy of estimates: literature review*

Various studies have focused on identifying the factors that have some influence on the accuracy of estimating the costs of construction work. Based on previous studies there are two types of factors that influence and contribute to the cost of a project, namely; control factors and idiosyncratic factors (Liu & Zhu, 2007). Further Control factors are the factors that can be controlled by estimators to improve the performance of estimation. Idiosyncratic factors are factors that influence cost estimation and these factors are outside the control of the estimators including market condition, project complexity, weather, size of contract, site constraints, resource availability, type of procurement system and contract work type

Elhag, Boussabaine, & Ballal (2005) stated that most of the significant factors affecting project costs are qualitative such as client priority on construction time, procurement methods and market conditions including the level of construction activity. Gunner and Skitmore (1999) reviewed previous studies and summarized the factors as follows: type of contract, conditions of the contract, contract sum, price intensity (consistency of price without fluctuating), contract period, number of bidders, good/bad years, procurement basis, project sector (public, private or joint), the number of priced items and the number of drawings. Gunner & Skitmore (1999) analysed the estimates of 181 projects in Singapore and they found that a majority of the factors influenced the accuracy of estimates. The study conducted by Ling & Boo (2001) in Singapore also found similar results when they compared five variables against Gunner & Skitmore's work. Skitmore & Picken (2000) studied the effect that four independent variables (road type, project size, sector and year) had on estimating accuracy and tested these variables against 217 projects from a Quantity Surveyor based in the USA. It was found that bias existed in project size and year, and consistency errors existed in project type, size and year. In a study of 67 process industry construction projects around the world, Oberlender & Trost (2001) identified 45 factors contributing to the accuracy of early stage estimates. They summarized the factors into 11

orthogonal elements. From those 11 factors, the five most important include: process design, team experience and cost information, time allowed to prepare estimates, site requirements, and bidding and labour climate. Al-Shanti (2003) summarized the factors that affect construction cost estimating as follows: project type, special construction (complexity), project accessibility, time of year, labour rates, and material costs. Iyer & Jha (2005) in their analysis of factors affecting cost performance of Indian construction projects state that conflict among project participants, presence of poor project specific attributes, hostile socio economic relations and climatic conditions, aggressive competition at tender stage and short bid preparation time, adversely affect construction costs. Further, it was indicated that coordination among project participants was the most significant of all factors having maximum positive influence on cost performance.

Dysert (2006) mentioned in his study that there are many factors which affect the estimate accuracy such as the level of project definition, the quality of reference cost estimating data (material pricing, labour hours, labour ware rates, etc.), the quality of the assumptions used in preparing the estimate, the state of new technology in the project, the experience and skill level of the estimator, the specific estimating techniques employed, the desired use of the estimate, the level of effort budgeted to prepare the estimate as well as extraneous market conditions (such as periods of rapid price escalation and labour climate factors).

In addition, other factors that affect the accuracy of the estimate are the capability of the project team to control the project, and the capability to adjust the estimate for changes in scope as the project develops. Akintoye (2000) worked on factors influencing project cost estimating and identified that the complexity of design and construction as the most important factor; this is followed by scale and scope of the construction. Odusami & Onukwube (2008) studied the factors that influence the accuracy of consultant pre-tender cost estimates. They indicated that the main factors are: expertise of consultants, quality of information and flow requirements, project team's experience of the construction type, tender period and market condition, extent of completion of pre-contract design, complexity of design and construction, availability and supplies of labour and materials.

Akintoye & Fitzgerald (2000) identified 20 causes of inaccurate cost estimates as insufficient time for estimating, poor tender documents, insufficient tender document analysis, lack of understanding of project requirements, poor communication between project team, low participation in estimating by site team, lack of review of cost estimate by management, poor comprehension of site requirements, poor feedback on accuracy previous estimates, pressure from management, removal of estimate padding by management, poor project cost feedback, lack of diligence by estimators, lack of adequate guidelines for estimating, inaccurate production data used in estimating, lack of historical data on past estimates, poor analysis of cost data for cost estimates, lack of performance reviews of estimators, estimators' lack of data processing techniques and frequent requests for changing of an estimate.

A great deal of research has been carried out on various aspects of estimation and several factors have being identified which effect to the impact to the accuracy of cost estimation worldwide with many country-specific models. These studies have contributed much, adequately covering the topic while orienting both researchers and practitioners towards accuracy of pre tender estimations. These studies were immense of value to those who wish to study the principles and practices of estimating in the Sri Lankan Construction Industry. Since the perception of estimation is subjective while also being affected by the unique political, economic, environmental and cultural conditions of a country, researchers have argued that paying attention to the manner in which these differences in thinking, value systems and living conditions affect the Construction Industry, especially the management cost. Thus, in the case of the Sri Lankan Construction Industry, the conditions affecting the Industry have to be understood as particular to the country's environment.

## Research methodology

### *Sample and Response Rate*

The targeted research population consisted of construction engineers, managers and quantity surveyors from public client, diverse contracting and consultancy organizations experienced in tendering and estimation in the road construction sector. Although this was carried out about pre-tender cost estimating, the contractors were also selected as a part of the sample and the reason for that is even though the contractors are not involved in the pre tender cost estimating process, they are involved in the tender estimating process. Therefore they have a very close rapport with pre-tender estimating techniques and factors because perhaps they would also have to suffer because of the inaccuracy of pre-tender estimates. Further, the other reason is to identify the perspectives of contractors about the factors affecting pre-tender cost estimating of road construction in Sri Lanka, with the aim of aiding the client and consultant. In total, 60 questionnaires were distributed to clients', 35 questionnaires to local consulting firms and 14 questionnaires to major contracting firms which have been dominating in NRCP projects in Northern and Northwestern Provinces. The sample of 14 contracting firms represented 70% of total population of major contracting firms in Northern and Northwestern Provinces

The response rate from consultancy firms was very high, (91%), whereas it was 75% and 71% from client' organizations and contracting firms respectively. 15% of the target population were non respondents. Hence, the obtained response rates should produce reliable results. On average, the respondents have an average of 20 years of experience in tendering and estimating.

Further the discrepancies between the samples size of the respondents group have prejudiced the ultimate outcome of the research in terms of their amount of respondents (32 consultants, 10 contractors and 9 clients). Therefore to avoid this partiality when comparing the group perceptions, the "*t-test and p-value*" was used to determine the significant and the reliability of the obtained result with the use of "*Spearman's Rank Correlation Coefficient*".

### *Questionnaire Design*

A questionnaire survey was undertaken to determine the opinions of clients, contractors and consultants regarding factors affecting the accuracy of pre-tender cost estimation of road construction in Sri Lanka. The questionnaire was constructed based on a literature review and three face-to-face interviews with clients, contractor and consultants.

A total of 64 factors that were identified and reported in 12 previous studies (Al-Thunaiyan, 1996; Akintoye, 2000; Madi, 2003; Trost & Oberlender, 2003; Elhag et al., 2005; Shash and Ibrahim, 2005; Babalola and Mochtar, K., & Arditi, D. 2001; Dysert, 2006; Enshassi, A., Mohamed, S., and Madi, I. 2007; Liu & Zhu, 2007; Odusami & Onukwube, 2008) were considered in this research. These identified 64 factors were common for the estimating accuracy of all types of construction projects. In addition for better reflection of the nature of the local road construction industry, a preliminary survey (semi structured interviews) was conducted with 3 experts from the industry those who have more than 20 years of working experience in road construction. At the end of the preliminary survey 10 factors were deleted, 16 factors were modified and, 5 factors were newly added. In total, 59 factors were concluded and grouped into five groups as follows:

- Factors related to clients' characteristics (Group 01)
- Factors related to consultants, design parameters and information (Group 02)
- Factors related to project characteristics (Group 03)
- Factors related to contract requirement and procurement method (Group 04)
- External factors and market conditions (Group 05)

**Data analysis technique**

**Relative Importance Index (RII)**

The Relative Importance Index technique has been widely used in construction research for measuring attitudes with respect to surveyed variables. Likert scaling was used for ranking questions that have an agreement level. The respondents were required to rate the importance of each factor on a 5-point Likert scale using 1 for not important, 2 for of little importance, 3 for somewhat important, 4 for important and 5 for very important. Then, the relative importance index was computed using the following equation:

$$\text{Relative Importance Index} = \frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N}$$

Where  $W$ , which is the weight given to each factor by the respondent, ranges from 1 to 5;  $n_1$  = the number of respondents for very important;  $n_2$  = the number of respondents for of importance;  $n_3$  = the number of respondents for somewhat important;  $n_4$  = the number of respondents for less important; and  $n_5$  = the number of respondents for not important.  $A$  is the highest weight (i.e., 5 in the study) and  $N$  is the total number of samples. The Relative Importance Index ranges from 0 to 1 (Tam and Le, 2006).

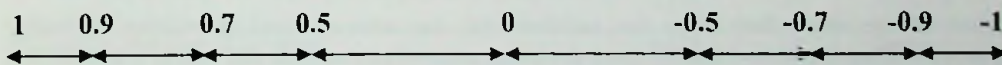
**“Spearman’s Rank Correlation Coefficient” test for degree of agreement between the clients, contractor and consultants**

One of the research objectives is to study the relationship between the perspective of clients, consulting and contracting firms of the essential factors affecting the accuracy of pre-tender cost estimating of road construction in Sri Lanka. In order to reach the requirements, “Spearman’s Rank Correlation Coefficient” tests were used. To determine whether there is a significant degree of agreement among clients, consultants and contractors. “Spearman’s Rank Correlation Coefficient” is used as a measure of agreement among respondents.

Null Hypothesis: Ho: There is an insignificant degree of agreement among the clients and consultants.

Alternative Hypothesis: H1: There is a significant degree of agreement among the clients and consultants.

**Interpreting the Size of the Correlation Coefficient (rs)**



1 – 0.9	Very Strong positive correlation
0.89 – 0.7	Strong positive correlation
0.69 – 0.5	Moderate correlation
0.49 – 0	Weak positive correlation
0 – (-0.49)	Weak negative correlation
(-0.5) – (-0.69)	Moderate negative correlation
(-0.7) – (-0.89)	Strong negative correlation
(-0.9) – (-1)	Very Strong negative correlation

The agreement is significant at a level of significant  $\alpha = 0.05$

## Results and Discussion

The first objective of this section is to identify existing practices of preparing pre-tender cost estimates in Sri Lanka. Fourteen numbers of existing estimating practices were revealed from the literature review and those methods are used for the small expert survey to identify the methods which exist as estimating practices in Sri Lanka.

Fifteen numbers of experts participated in the survey. All of the respondents have more than 15 years of experience in the pre-tender cost estimation of road construction. Out of these fifteen experts, five were further interviewed for the purpose of collecting information about these methods (refer table 1). Finally the survey concluded that in "Comparison with similar past projects based on personal experience", "established standards (Highway Schedule Rates)" and "comparison with similar past projects based on documented facts" are the most popular existing pre-tender cost estimating methods for road construction in Sri Lanka. Whereas, "Range estimating" and "published price information" are mentioned as other existing practices.

*Table 1: Existing practices of preparing pre-tender cost estimating in Sri Lanka*

Existing Pre-Tender Estimating Practices for Road Construction in Sri Lanka	Frequency	%
Comparison with similar past projects based on personal experience	15	100%
Established standards (HSR)	15	100%
Comparison with similar past projects based on documented facts	13	87%
Published price information	10	67%
Range estimating	8	53%
Intuition	1	7%
Guessing	1	7%
Arithmetic formula	0	0%
Estimating software	0	0%
Capital estimating factors	0	0%
Shared information with subsidiary of the firm	0	0%
Estimating standard procedure	0	0%
Shared information from other firms	0	0%
Complex statistical formulas	0	0%

Most of the respondents were not satisfied with the accuracy level of existing estimating practices. They mentioned that the poor documentation of past records and lack of availability of cost data are the main causes. Further they added that the Srilankan road construction industry should maintain a proper cost database and document keeping of finished road projects to enhance the accuracy level of the existing estimating practices. Moreover, they mentioned that these existing estimating practices are not fully suitable for the future road developments and also disclosed that the modifications are required for future needs. Further they pointed out that enhancement of use of estimating software could be a better solution for the massive road construction projects in future.

### *Top ten factors affecting the accuracy of pre-tender estimating in road construction projects in Sri Lanka*

With the use of questionnaire survey the top ten factors affecting the accuracy of pre-tender estimating in road construction projects in Sri Lanka (refer table 2). Relative Importance Index

(RII) was used to rank the factors. According to the respondents' ranking, the "Accuracy and reliability of cost information" ranked in the first position. "Material (prices/availability/supply/quality/ imports)" was ranked as the second important factor affecting the accuracy of pre-tender cost estimates.

**Table 2: Top ten factors affecting the accuracy of pre-tender estimating in road construction projects in Sri Lanka**

Factors	RII	Rank	Group
Accuracy and reliability of cost information	0.929	1	Group 2
Material (prices/availability/supply/quality/imports)	0.925	2	Group 5
Clear and detailed drawings and specifications	0.922	3	Group 2
Completeness of cost information	0.910	4	Group 2
Designer's experience level	0.902	5	Group 2
The experience and skill level of the consultant	0.875	6	Group 2
Applicability of cost information	0.871	7	Group 2
Availability of a data base of bids on similar projects (Historical cost data)	0.839	8	Group 2
Completeness of project documents	0.831	9	Group 2
Quality of information and flow requirements	0.820	10	Group 2

**Factors which are not considered enough by client/ contractor/ consultant in the accuracy of pre-tender cost estimation of road construction in Sri Lanka.**

This objective was achieved with the use of questionnaire survey and ranking was done with the use of Relative Importance Index (RII). Table 3 shows ten factors which are not considered enough in the accuracy of pre-tender cost estimates of road construction in Sri Lanka from the point view of clients, consultants and contractors.

**Table 3: Poorly (are not considered enough) considered factors**

Factors	RII	Rank	Group
Client experience level	0.318	1	Group 1
Type of project (residential, commercial, industrial, etc.)	0.255	2	Group 3
Classification and level of competitors in the tendering	0.227	3	Group 5
Level of involvement of the project manger	0.212	4	Group 2
Tender selection method (open, selected, negotiation, etc.)	0.212	4	Group 4
Type of client (Government/ UN Agencies/ NGOs ...etc.)	0.165	6	Group 1
Number of estimating team members	0.165	6	Group 2
Client's method of payment	0.157	8	Group 1
Content of disputes resolution methods clause (litigation/ arbitration/ others)	0.149	9	Group 4
Financial capabilities of the client	0.129	10	Group 1

According to Table 3, the respondents ranked the "Client experience level" as the least considered factor. The "Type of project (residential, commercial, industrial, etc.)" was also ranked as the second not considered enough factor affecting the accuracy of pre-tender cost estimates. Further, the results show that the clients, consultants and contractors agreed that the "classification and level of competitors in the tendering", "level of involvement of the project manager", "tender selection method (open, selected, negotiation, etc.)", "type of client", "number of estimating team members", "the client's method of payment", content of disputes resolution methods clause (litigation/ arbitration/ others)" and the "financial capabilities of the client" were the other very poorly considered factors affecting the accuracy of pre-tender cost estimating of road construction in Sri Lanka

Table 4: Overall perspective of respondents on the group of factors

Group of Factors	Client		Consultant		Contractor		Overall	
	RJI	Rank	RJI	Rank	RJI	Rank	RJI	Rank
Factors related to consultants, design parameters and information	0.753	1	0.756	1	0.748	1	0.754	1
Factors related to contract requirement and procurement methods	0.593	2	0.608	2	0.671	3	0.617	2
Factors related to external factors and market conditions	0.591	3	0.594	3	0.698	2	0.614	3
Factors related to project characteristics	0.586	4	0.582	4	0.653	5	0.597	4
Factors related to clients' characteristics	0.571	5	0.506	5	0.663	4	0.548	5

Table 5: The relationship between the perspectives of the respondents

Groups	Clients vs. Consultants		Clients vs. Contractor		Consultants vs. Contractors		Sig. p - value
	Coefficient	t- value	Coefficient	t- value	Coefficient	t- value	
Factors related to clients' characteristics	0.786	2.840	0.723	2.342	0.741	2.468	$\alpha < 0.05$
Factors related to consultants, design parameters and information	0.956	14.516	0.953	14.135	0.937	11.970	$\alpha < 0.05$
Factors related to project characteristics	0.881	4.560	0.923	5.859	0.774	2.992	$\alpha < 0.05$
Factors related to contract requirements and procurement methods	0.871	4.687	0.738	2.889	0.717	2.719	$\alpha < 0.05$
Factors related to external factors and market conditions	0.773	4.046	0.721	3.452	0.643	2.783	$\alpha < 0.05$



### ***Overall perspective of respondents on the group of factors***

Table 4 shows that, “factors related to consultants, design parameters and information” was ranked in the first position by the respondents with an RII of (0.754). Further, the client, consultant and contractor separately ranked it in the first position with an RII of (0.753), (0.756) and (0.748) respectively. Nine factors out of the top 10 factors being related to this group emphasized that this is the most important group of factors affecting the accuracy of pre-tender cost estimates. It is also emphasized that, the consultants, design parameters and information are crucial in accurate estimation of construction costs at the pre-tender stage. Further, these findings indicated that construction project costs were more affected by architects and consultants than by others.

On the other hand, it is shown that, “factors related to contract requirement and procurement method” was ranked in the second position by the respondents with an RII of (0.617). The responding contractor ranked this group in the third position with an RII of (0.671) while the client and consultants ranked it in the second position with an RII of (0.593) and (0.608) respectively. Nine factors are included in this group. The top factor in this group is “clear contract conditions” which was ranked as the 19<sup>th</sup> overall.

Further, it is shown that, “factors related to external factors and market conditions” was ranked in the third position by the respondents with an RII of (0.614). The responding contractors ranked this group in the second position with an RII of (0.698) while the clients and consultants ranked it in the third position with an RII of (0.591) and (0.594) respectively. This group consists of thirteen factors, one factor out of the 10 top factors being related to this group. “Material (prices/ availability/ supply/ quality/ imports)” was ranked 2<sup>nd</sup> overall.

Moreover, it is shown that, “factors related to project characteristics” was ranked in the fourth position by the respondents with an RII of (0.597). The responding contractors ranked this group in the third position with an RII of (0.653). While the clients and consultants ranked it in the fourth position with an RII of (0.586) and (0.582) respectively. This group includes eight factors. The top ranked factors in this group are “location of project (town, village camp)” which was ranked 22<sup>nd</sup> overall and “site conditions and requirements” which was rank 25<sup>th</sup> overall.

Finally, it is clear that, the “factors related to clients characteristics” was ranked in the last position by the respondents with an RII of (0.548). The responding contractor ranked this group in the fourth position with an RII of (0.663) while the client and consultants ranked it in the fifth position with an RII of (0.571) and (0.506) respectively. This group contains seven factors. The top ranked factor in this group is “clear scope definition for the client” which was ranked 17<sup>th</sup>. All other factors of this group have a low importance index with respect to other factors in this research. Therefore, it is evident that factors related to this group have little influence in the preparation of construction estimates.

### ***The relationship between the perspectives of the respondents***

The results illustrated in Table 5 show that there is a “*very strong positive correlation*” between the client and consultant in the group of “factors related to consultants, design parameters and information” with (0.956 of  $r_s$ ), whereas there are “*strong positive correlation*” between them in the other remain group of factors. Further, the results illustrated in Table 5 show that the p-values (Sig.) are less than the level of significance  $\alpha = 0.05$ , which lead to the rejection of the null hypothesis,  $H_0$ . Therefore, it was concluded that there is sufficient evidence to support the alternative hypothesis,  $H_1$ . Hence, there is a significant degree of agreement among the clients, and consultants.

Further, the results illustrated in Table 5 show that there is a “*very strong positive correlation*” between the client and contractor in the group of “factors related to consultants, design parameters and information” and “factors related to project characteristics” with ( $r_s$  of 0.953) and ( $r_s$  of 0.923) respectively, whereas there were “*strong positive correlation*” between them in the other remain group of factors. Further, the results illustrated in Table 4.20 shows that the p-values (Sig.) are less than the level of significance  $\alpha = 0.05$ , which lead to the rejection of the null hypothesis,  $H_0$ . Therefore, it was concluded that there is sufficient evidence to support the alternative hypothesis,  $H_1$ . Hence, there is a significant degree of agreement among the clients and contractors.

Moreover, the results illustrated in Table 5 show that the “*very strong positive correlation*” between the contractor and consultant in the group of “factors related to consultants, design parameters and information” with ( $r_s$  of 0.937), while “*moderate correlation*” between them in the group of “factors related to external factors and market conditions” with ( $r_s$  of 0.643). Also there were “*strong positive correlation*” between contractor and consultant in the other remains group of factors. Further, the results illustrated in Table 4.21 show that the p-values (Sig.) are less than the level of significance  $\alpha = 0.05$ , which lead to the rejection of the null hypothesis,  $H_0$ . Therefore, it was concluded that there is sufficient evidence to support the alternative hypothesis,  $H_1$ . Hence, there is a significant degree of agreement among the contractors and consultants.

## Conclusions

An exploratory study of factors affecting the accuracy of pre-tender cost estimate was conducted in order to determine the relative level of influence for each factor. The ranking of 64 factors revealed that accuracy and reliability of cost information, material (prices/availability/supply/quality/imports) and clear and detailed drawings and specifications are the mostly influential factors affecting cost estimate accuracy.

Further, the least influential factors as evaluated by respondents are client experience level, type of project (residential, commercial, industrial, .etc.) and the classification and level of competitors in the tendering

From the above, it was concluded that clients, contractors and consultants generally agree on the ranking order of the factors affecting the cost estimate accuracy. This agreement confirms the influential effect of those factors on the accuracy of cost estimation which provides a level of validation for this research. This was confirmed by the high t-values obtained through the *Spearman's Rank Correlation Coefficient* achieved within each group. According to the p-value (sig) test, it was concluded that there is no difference of the opinions among clients, contractors and consultants in the factors affecting the accuracy of pre-tender cost estimates at a significance level of 0.05.

Further, this study revealed the existing practices of pre-tender estimation in Sri Lanka as the “comparison with past similar projects based on personal experience”, “Established Standards (HSR)” and “comparison with similar past projects based on documented facts” as the most popular existing pre-tender cost estimating methods. In addition to that, this study reviewed the future needs of pre-tender estimating practices for road construction in Sri Lanka.

It is recommended that clients and consultants give more attention to the most important factors that affect the accuracy of pre-tender cost estimates in order to achieve more reliable and realistic estimates. They should monitor the performance of their estimates in terms of accuracy and hire qualified technical staff to obtain accurate estimates. Clear identification of project requirements is essential before the start of the estimating process. Clients and consultants should make sure the accuracy and reliability of the cost information, also obtain information as accurately as possible from manufacturers and suppliers pertaining to the costs of procured materials and/or systems. If clients and consultants have a poor understanding of materials (prices/availability/

supply/ quality/ imports), this would undoubtedly affect the accuracy of cost estimates. Clients and consultants should make sure that contract conditions are very clear to both parties.

It is also recommended that training courses on factors affecting the accuracy of cost estimates should be conducted. These activities would improve the local practice of cost estimating and increase the capabilities of estimators by using estimating software packages. Further, the estimating practices must comply with the need and the type of the project and should also be compatible with changes and evolution of the Construction Industry. Therefore, the new estimating practices should be introduced for the intended future needs of Sri Lankan infrastructure development.

Finally, the findings of this study will help clients and consultants to focus on the main causes which directly affect the accuracy of pre-tender cost estimation and develop effective strategies to develop an accurate cost estimate.

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