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Multi-criteria Contractor Selection Framework for Indian Construction Projects

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***Abstract*— In this paper contractor selection practice in India has been analyzed in detail to find out the gaps in the prevailing system & also compared with the selection systems outside India. This study aims to develop a multi-criteria contractor selection framework that can incorporate multiple evaluation criteria along with the relative weightage.**

In this study, it has been identified that in India, as per the guidelines the contractor selection in the case of most popular Design Bid Build (DBB) projects is done based on Least Cost Selection (LCS) only. In LCS, the final selection is based on cost or bid price only. In some cases, Quality & Cost Based Selection (QCBS) is applied for contractor selection. However, QCBS is mainly used for consultant selection or selection of service providers. On the other hand, in many other counties, there are systems that follow multiple criteria for contractor selection to ensure the overall performance of the contractor. Hence, in India, there is a need for a structured, multi-criteria contractor selection system. The system should cater to the objective of contractor selection in the case of DBB projects & also should be responsive to the present need for selection based on multiple criteria.

Keywords- Contractor Selection, Least Cost Selection (LCS), Multi-criteria Selection Framework, Quality & Cost Based Selection (QCBS), Analytic Hierarchy Process (AHP), Relative Importance Index (RII)

I. INTRODUCTION

The construction industry is one of the main backbones of the Indian economy. In the year of 2008, The Indo-Italian Chamber of Commerce & Industry published a report which states that the construction industry is the second largest contributor to the Indian economy just after agriculture. As per a publication by the Reserve Bank of India (RBI) in the year 2020, the construction industry has a share of around 8.2% (estimated ₹670,778 crores) of the overall national GDP. The key to the growth & contribution of the construction industry can be traced to rapid urbanization, overall economic development & people's increasing expectations for improved living quality.

With construction projects becoming large & complex, traditional methods of project delivery are becoming outdated. Contractors being at a pivotal role plays a very important role in the overall performance of a project [1]–[3]. Therefore, selecting the right or suitable contractor for a project is a very crucial challenge & this initial decision can affect the project's success. The traditional system for contractor selection based on the least cost proves to be not suitable for today's project delivery, also selected based on the least cost only can sometimes compromise on quality & other project performance factors [4]–[6]. To have a sound selection of construction contractors several & often conflicting objectives or alternatives are to be considered such as tender price, completion time, the experience of the contractor, responsiveness of the tender price, etc. [7], [8].

In India, contractor selection for any public project is based on the guidelines laid by 'The Ministry of Finance, Government of India in the 'Manual for Procurement of Works' which mentioned that the contractor selection in case of projects delivered under the Design Bid & Build (DBB) model is based on the traditional least-cost selection (LCS) system, which is sometimes referred to as L-1 selection system [9]. To make this system flexible & more adoptive to the present trend, additional concepts of pre-qualification & eligibility criteria are there. But those are based on some simple pass-fail criteria or qualifying marks, and the final selection is done based on least-cost only, without considering other parameters. Whereas outside India there are many prevailing systems of contractor selection where they consider multiple criteria for the selection of construction contractors. In a report published by NITI Aayog, the Government of India states that some model arrangements should be made to improve contractor procurement to ensure better project performance [10]. Other papers also aptly stated that the least-cost selection of contractors can cause serious damage to project performance

causing delay & cost overrun & hence should be revised [11]–[14].

II. LITERATURE REVIEW

A. Contractor Selection in India

As part of the literature review, Indian contractor selection systems are studied from the public procurement guidelines like - (i) 'Manual for Procurement of Works, 2019' by Ministry of Finance, Department of Expenditure, Govt. of India, (ii) 'General Financial Rules (GFR), 2017' by Ministry of Finance, Department of Expenditure, Govt. of India, (iii) 'Defence Procurement Manual, 2009' by Ministry of Defense, Govt. of India, (iv) 'CPWD Works Manual - 2019' by Central Public Works Department (CPWD), India and (v) 'Standard Operative Procedures (SOP) for CPWD Works Manual - 2019' by Central Public Works Department (CPWD), India [9], [15]–[18].

All the public guidelines mentioned above use the system prescribed by the Ministry of Finance, Government of India in Manual for Procurement of Works, 2019 & General Financial Rules (GFR), 2017 partly or as a whole to formulate their contractor selection procedure. The contractor procurement process is divided into three major stages – (i) bidding, (ii) evaluation & (ii) selection. The bidding stage follows different practices based on the number of envelopes to enclose the technical & financial bids & also based on the number(s) of the stage(s) for evaluation of the technical & financial bids. The bid evaluation stage considers all the bid-related documents & information shared by individual contractors including the bid price. It is this stage where the evaluation authority can review the prequalification or eligibility criteria, but based on qualifying or pass-fail marks only. At the selection stage, the work is awarded to the winning contractor based on the least price only.

B. Contractor Selection Outside India

Several works of literature pointed out that outside India, there are many prevailing systems of contractor selection where they consider multiple criteria for the selection of construction contractors. In Canada, the final selection & award of work is based on the combined financial & technical score of the contractor [19], [20]. In the European Union countries, they emphasize the technical capability, experience & past performance of the contractor [21]. Implementing the EU Directives on the selection of economic operators in public procurement procedures, China has a well-structured multi-criteria selection system for contractor selection [22]. Whereas in the USA, the final selection of a contractor is based on a group decision by a panel of evaluators which takes into account multiple criteria to arrive at a decision [23].

C. Gap in Indian Selection System

Several researchers have rightly pointed out some of the major gaps in the prevailing contractor selection practice & suggested mitigation to the same. In a joint study performed by KMPG & PMI in association with the Ministry of Statistics and Programme Implementation (MoSPI), the Government of India has suggested some critical attributes that can result in project failure due to wrong contractor selection [24]. Several other researchers pointed out attributes like - inadequate experience, poor estimation of time by the contractor, project financing issues from the contractor's side, faulty project bidding, rework due to errors, delay in resource mobilization, inadequate equipment support, etc. [25]–[30]. As per Central Vigilance Commission (CVC), Government of India (2002) the major problems in Indian contractor procurement are – (i) tenders issued to ineligible applicants, (ii) justification statements not prepared due to lack of data resulting from faulty prequalification & tender document, (iii) contractors get selected based on the flimsy ground due to lack of strict & structured selection criteria.

D. Previous Research on Contractor Selection System

This study has explored the already existing research works & literature available in the same domain. [6] in their study pointed out that some of the critical success factors for construction projects are directly related to the contractor like - the contractor's experience, cash flow, effective site management, cost control, etc. [31] has stated that several projects are failing because of the incompetency of contractors, which can be a result of inappropriate selection criteria which can finally result in the wrong selection of the contractor. In China, there exists a well-structured multi-criteria contractor selection system. In addition to the tender price, this system takes into account several key factors such as technical solution, contractor's organization, financial capability, management resources, previous experience, performance record, current workload, past client/contractor relationship, safety precautions, and so on [22], [32]. [31] have performed a quantitative study to find out a set of indicators that guide the project owner to select a capable or suitable contractor. [26] investigates the contractor selection in Malaysia & found the relational nature of various factors, price & prequalification in the process of contractor selection. [7] highlighted the existence of complexity of selection criteria leading to the non-selection of the potential contractor.

E. Tool(s)

Several tools have been studied which can help in multi-criteria decision making considering relative weightage & ranking of individual selection criteria or parameters & their interrelation. After comparing the tools, AHP (Analytic Hierarchy Process) has been selected, it is a Multi-Criteria Decision Making Method to derive weights from paired comparisons. It is commonly used for project prioritization and selection. AHP captures strategic goals as a set of weighted criteria that can then be used to prepare a score [33], [34]. AHP has been selected for this study as it can work with group decisions, can incorporate the relative weightage & interrelation of parameters required in this study, also performing AHP analysis doesn't require any special expertise of the respondents & is simple [34]. AHP

has been used in this study to derive the weights of the contractor selection parameters or criteria to further use in the selection process.

III. RESEARCH METHODOLOGY

The overall research has been divided into three major parts – (i) identification of minute attributes for contractor selection and also the major parameters to consider as per the Indian context, (ii) deriving the weights of the attributes & parameters for selection of contractor & (iii) developing the selection framework based on the weightages derived. The detailed flowchart in which research is carried out is presented in Figure 1.

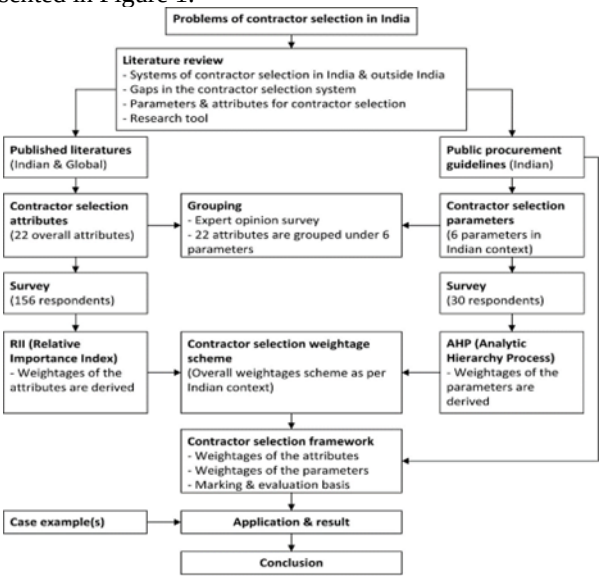

Figure 1. Research Methodology Flowchart

IV. CONTRACTOR SELECTION ATTRIBUTES AND PARAMETERS

A. *Identification & Grouping*

As shown in Figure 1, a total of 22 attributes are identified from published literature across the globe. These 22 attributes can together define the overall performance of a contractor & thus should be considered in the selection framework. On the other hand, from the Indian government & public procurement guidelines, a total of 6 major parameters are Identified that can define the contractor performance in the Indian context.

To group the 22 attributes under the 6 parameters, an expert opinion survey has been conducted among 10 experts with at least 10 years of experience in the field of contractor procurement in India. Based on the result from the expert opinion survey the attributes are grouped under the parameters for further use.

B. *Weightages of the Parameters*

To derive the weightages of the 6 major parameters, Analytic Hierarchy Process (AHP) has been used. A pair-wise comparison survey has been conducted with a total of 30 respondents experienced in the field of contractor selection in India. The survey result has been consistent enough as the inconsistency rate is only 2% as compared to the threshold of 10%. Hence, the weightages in Table 1 which have been derived as the outcome from the AHP, can be considered.

TABLE I. WEIGHTAGES OF CONTRACTOR SELECTION PARAMETERS

Sl.	Parameters	Weightage	% Weightage
1	Bid price	0.37	37
2	Financial capabilities	0.21	21
3	Technical & resource capabilities	0.20	20
4	Experience	0.14	14
5	Quality & performance	0.05	5
6	Environment health & safety (EHS)	0.03	3
Total			**100**

While discussing the weightages of different parameters for the selection of contractors in India, the objective of contractor selection or procurement should be very clear. In the case of Design Bid Build (DBB) projects, a detailed design & specification is already there & the objective of contractor procurement is to select a competent contractor who can carry out the work of construction or execution as per the design & specification with sufficient technical knowledge, experience, quality, etc. & of course within the reasonable or best possible price. Now, if we look into the graphical representation, Figure 2 of the weightages derived above in Table 1, there are three distinct groups, viz. (i) parameters with high importance, (ii) parameters with moderate importance & (iii) parameters with low importance.

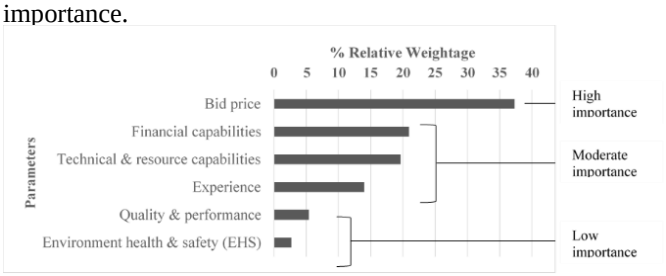

Figure 2. Weightages of contractor selection parameters

After analyzing the above results, it can be inferred that the derived weightages go with the main objective of contractor procurement in the case of DBB projects. It gives importance to bid price to get the best or most reasonable price. On the other hand, unlike LCS or L-1 System, it doesn't offer 100% weightage for bid price at the selection stage. Out of a total of 100%, bid price gets only 37% of the weightage, rest 63% is given to other criteria of contractors like - financial strength, technical & resource criteria, experience, past performance, quality, etc. to ensure a smooth overall contractor performance, by ensuring a sound contractor selection.

C. *Weightages of the Attributes*

To derive the weightages of the minute attributes, a survey based on the Likert scale has been conducted with a

sample size of 156. The survey responses are processed to get the Relative Importance Index (RII) of the attributes. The rationalized RIIs are calculated by converting the RII obtained from a survey to yield a total of 100 for a particular parameter.

$$RII = \frac{\sum_{i=1}^{N} Wi}{N * Wm}$$

Where,

[Wi = ith weightage of the entity, N = number of weightages (here, N = 156), Wm = maximum possible weightage
RII % = RII * 100

D. Overall Weightage Scheme

The overall weightages scheme refers to the overall list of 22 attributes grouped under 6 parameters along with their weightages as furnished below in Table 2.

TABLE II. OVERALL WEIGHTAGE SCHEME OF PARAMETERS & ATTRIBUTES

Sl.	Attributes grouped under the parameters	% Weightage
Parameter - 1: Bid price		37
1	Tender price and estimates	100
Parameter - 2: Financial capabilities		21
2	Profitability	22
3	Yearly turnover	28
4	Ongoing financial penalty	23
5	Financial soundness	27
Parameter - 3: Technical & resource capabilities		20
6	Current commitments	28
7	Knowledge of particular construction method	21
8	Availability of staff	27
9	Plant & equipment	24
Parameter - 4: Experience		14
10	Project manager's experience in similar project(s)	17
11	Size of past project completed	22
12	Experience of working on similar projects	23
13	Age in business	19
14	Experience in local area	19
Parameter - 5: Quality & performance		5
15	Past record of conflict and disputes	27
16	Projects completed on time	26
17	Projects completed on budget	25
18	Blacklisting in past projects	23
Parameter - 6: Environment health & safety (EHS)		3
19	Experience modification rating (EMR)	27
20	Health and safety records	26
21	Waste disposal & management during construction	23
22	Environmental plan during construction	24

V. CASE EXAMPLES

The selection framework has been developed based on the above weightages derived for the contractor selection parameters & attributes. The evaluation scheme has been kept very transparent with as less subjectivity as possible. The framework has been applied to two live projects to get & analyze the results to assess the alternate contractor selection framework developed as part of this study. For comparison purposes, Quality & Cost Based Selection (QCBS) has also been applied to these case examples as sometimes QCBS is considered a better alternative to the Least Cost Selection (LCS). The results are discussed below.

A. Case example – 1

Result from all the three selection systems viz. (i) the original selection through LCS, (ii) through the developed framework & (iii) applying the QCBS are illustrated below in Table 3 for comparison.

TABLE III. CASE EXAMPLE – 1 - SUMMARIZED RESULTS

Contractor	Bid value (Cr.)	Score from the developed framework							Result		
		Bid price	Financial capabilities	Technical capabilities	Experience	Quality & performance	EHS	Total	LCS	QCBS	Framework
1	82	30.23	16.1	8.57	11.8	4.57	0	71.26		Win	
2	78	31.52	13.78	8.8	12.75	4.78	0	71.63			
3	67	37	11.32	6.48	8.14	3.17	0	66.1	Win		
4	88	28.01	16.1	10.7	10.39	3.85	0	69.05			
5	78.6	31.54	14.49	9.36	11.68	4.75	0	71.82			Win
6	74	33.5	12.59	8.4	6.26	3.13	0	63.89			

(i) as per selection through LCS Contractor – 3 should be the winner, (ii) As per selection thorough QCBS Contractor – 1 should be the winner, whereas, (iii) as per selection through the developed framework Contractor – 5 should be the winner. From the numerical data, it can be inferred result from LCS is not suitable as Contractor – 3 has got a very less overall score & thus the likely performance will be considered poor. On the other hand, Contractor – 1 has got a higher overall score, but the bid value is quite high (22.4%). Therefore, it can be inferred that QCBS doesn't give a suitable result & the performance-cost trade-off is inefficient. Finally, Contractor – 5 has got the highest overall score & the bid price is only 17.3% higher. Therefore, the developed framework is giving the most efficient result.

As discussed, after applying the developed contractor selection model to this project, Contractor – 5 comes out

with the highest overall score & hence, should be awarded the work. Now, to assess the efficiency of the developed framework, this study emphasizes the problems & their likely cause during the contraction of this project. The likely chances of these problems getting reduced after using the contractor selection framework are then analyzed. The following major problems were found during the construction, the likely cause of the contractor selection is presented in Table 4.

TABLE IV. CASE EXAMPLE - 1 CONTRACTOR RELATED PROBLEMS

Sl.	Problem	Likely cause
1	The project was delayed by approx. 9 months (approx. 37%).	Quality & performance.
2	Cost overrun of approx. 7 Cr. (approx. 11%).	Quality & performance.
3	The client has to consult separately for project management/ monitoring as the contractor was not competent.	Technical & resource capabilities. Can be a result of less availability of key staff.
4	In some cases, the client arranged for some of the heavy equipment.	Technical & resource capabilities. Can be a result of a lower equipment capability.

Therefore, the problems are likely to be caused mainly due to (i) low technical & resource capabilities & (ii) poor quality & performance of the contractor selected (Contractor – 3).

Now, if we see the summarized result in Table 3 from the framework, Contractor – 5 with the overall highest score has got (i) 2nd highest score in the technical & resource capabilities & (ii) 2nd highest score in the quality & performance. Whereas originally selected Contractor – 3 has got (i) lowest in the technical & resource capabilities & (ii) 2nd lowest in the quality & performance. Apart from that, Contractor – 5 has got a much higher score in other parameters compared to Contractor – 3. Therefore, it can be inferred that in this case, selection using this developed framework can address the gap in the selection system.

B. Case example – 2

Result from all the three selection systems viz. (i) the original selection through LCS, (ii) through the developed framework & (iii) applying the QCBS are illustrated in Table 5 for comparison.

(i) as per selection through LCS Contractor – 4 should be the winner, (ii) As per selection thorough QCBS Contractor – 1 should be the winner, whereas, (iii) as per selection through the developed framework Contractor – 6 should be the winner. From the numerical data, it can be inferred result from LCS is not suitable as Contractor – 4 has got very less overall score & thus the likely performance will be considered poor. On the other hand, Contractor – 1 has got a higher overall score, but the bid value is quite high (8.5%). Therefore, it can be inferred that QCBS doesn't give a suitable result & the performance-cost trade-off is inefficient. Finally, Contractor – 6 has got the highest overall score & the bid price is only 7.4%. Therefore, the developed framework is giving the most efficient result. Not only that, Contractor – 1's overall score is not much above the score of Contractor – 4.

TABLE V. CASE EXAMPLE –2 - SUMMARIZED RESULTS

Contractor	Bid value (Cr.)	Score from the developed framework							Result		
		Bid price	Financial capabilities	Technical capabilities	Experience	Quality & performance	EHS	Total	LCS	QCBS	Framework
1	421	34.1	15.67	9.75	12.26	4.74	0	76.52		Win	
2	478	30.03	15.81	9.99	10.2	4.17	0	70.2			
3	407	35.27	14.8	8.98	9.43	4.74	0	73.22			
4	388	37	13.5	9	5.6	3.28	0	68.38	Win		
5	392	36.62	13.99	9.02	8.68	3.86	0	72.17			
6	417	34.43	15.97	9.77	12.47	4.69	0	77.32			Win

As discussed, after applying the developed contractor selection model to this project, Contractor – 6 comes out with the highest overall score & hence, should be awarded the work. Now, to assess the efficiency of the developed framework, this study emphasizes the problems & their like cause during the contraction of this project. The likely chances of these problems getting reduced after using the contractor selection framework are then analyzed. The following major problems were found during the construction, the likely cause of the contractor selection is presented in Table 6.

TABLE VI. CASE EXAMPLE - 2 CONTRACTOR RELATED PROBLEMS

Sl.	Problem	Likely cause
1	The client had paid some advance payment(s) during the construction to maintain the pace	Financial capabilities. Poor cash flow, liquidity, turnover, etc.
2	The client had to sublet part of the work related to machine foundations & VDF flooring to specialized contractor/ sub-contractor	Experience. Poor experience & technical knowledge in relevant works.
3	Several construction defects get aggravated due to the warm & humid climate of Orissa.	Poor quality & performance

Therefore, the problems are like to be caused mainly for (i) low financial capabilities, (ii) poor experience, (iii) low technical & resource capabilities & (iv) poor quality & performance of the contractor selected (Contractor – 4).

Now, if we see the summarized result from the framework in Table 5, Contractor – 6 with the overall highest score has got (i) highest score in the financial capabilities, (ii) highest score in the experience, (iii) 2d highest in the technical & resource capabilities & (iv) 2nd highest in the quality & performance. Whereas, originally selected Contractor – 4 has got (i) lowest in the financial capabilities, (ii) lowest in the experience, (iii) 2nd lowest in the technical & resource capabilities & (iv) lowest in the quality & performance. Apart from that Contractor – 6 has got a much higher score in other parameters compared to Contractor – 4. Therefore, it can be inferred that in this case, selection using this developed framework can address the gap in the selection system.

VI. RESULTS & DISCUSSION

A. *Results & analysis*

1) Unlike Least Cost Selection (LCS) & Quality & Cost Based Selection (QCBS), the result from the developed framework selects a contractor with a much higher score in individual parameters. For example, in the case of 1st case study, Contractor – 5, the winner with the overall highest score has got (i) 2nd highest score in the technical & resource capabilities & (ii) 2nd highest score in the quality & performance. Whereas originally selected Contractor – 3 has got (i) lowest in the technical & resource capabilities & (ii) 2nd lowest in the quality & performance. Apart from that Contractor – 3 has got a much higher score in other parameters compared to Contractor – 1. Therefore, it can be inferred that in this case, selection using this developed framework can address the gap in the selection system. In the case of the 2nd case study, Contractor – 6, the winner with the overall highest score has got (i) highest score in the financial capabilities, (ii) highest score in the experience, (iii) 2d highest in the technical & resource capabilities & (iv) 2nd highest in the quality & performance. Whereas, originally selected Contractor – 4 has got (i) lowest in the financial capabilities, (ii) lowest in the experience, (iii) 2nd lowest in the technical & resource capabilities & (iv) lowest in the quality & performance. Apart from that Contractor – 6 has got a much higher score in other parameters compared to Contractor – 4. This tells us that, selection through the developed framework is much more responsive to the needs of the project & the contractor selected through this framework is likely to deliver much more efficient performance. The results from both the case studies are furnished below in graphical format (Figure 3, Figure 4).The template is designed so that author affiliations are not repeated each time for multiple authors of the same affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization). This template was designed for two affiliations.

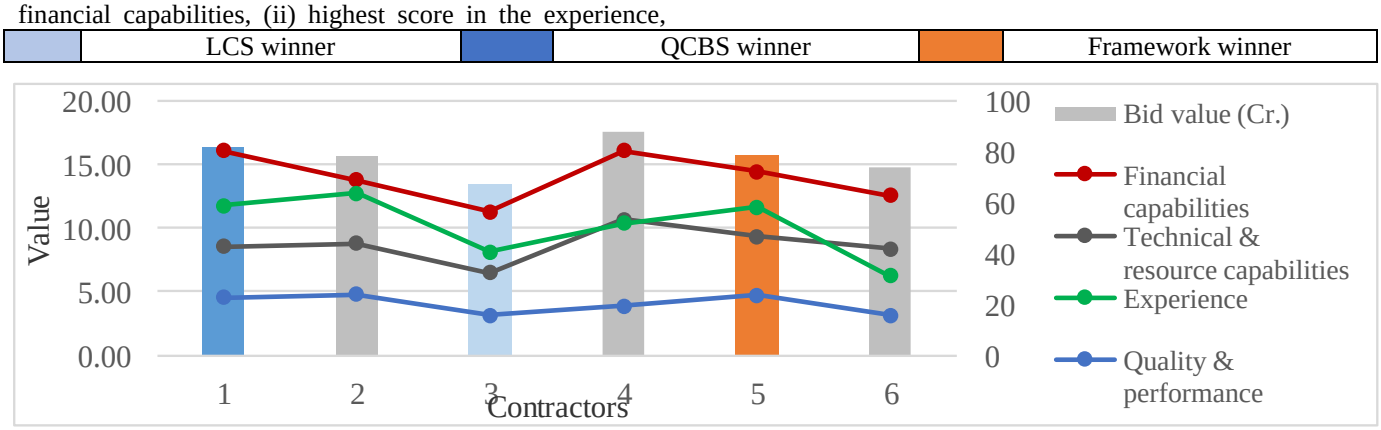

Figure 3. Case example – 1 bid price vs individual parameter score

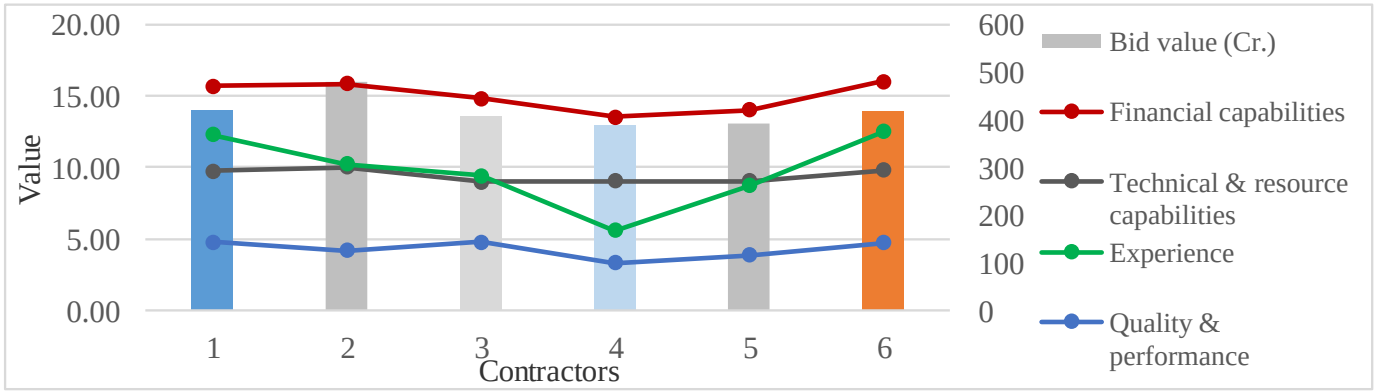

Figure 4. Case example – 2 bid price vs individual parameter score

2) The result from LCS is not giving priority to any parameters other than the cost, so in a way, it is compromising the performance of the contractor. On the other hand, QCBS selects a contractor with a comparatively higher bid price & the overall likely performance assessed from the overall score is lower. Whereas, in the case of selection through the developed framework, it gives the most optimum result with the highest overall score &

reasonable bid price. For example, in the 1st case study, Contractor – 1, selected through QCBS has got a higher overall score, but the bid value is quite high (22.4%) compared to the previous selection through LCS, whereas, Contractor – 5, selected through the framework has got the highest overall score & the bid price is only 17.3% more compared to the original selection through LCS. Similarly, in the 2nd case study, Contractor – 1, selected through QCBS, has got a higher overall score, but the bid value is quite high (8.51%), whereas, Contractor – 5 has got the highest overall score & the bid price is only 7.47% higher compared to the original selection through LCS. The results from both the case studies are furnished below in graphical format (Figure 5, Figure 6).

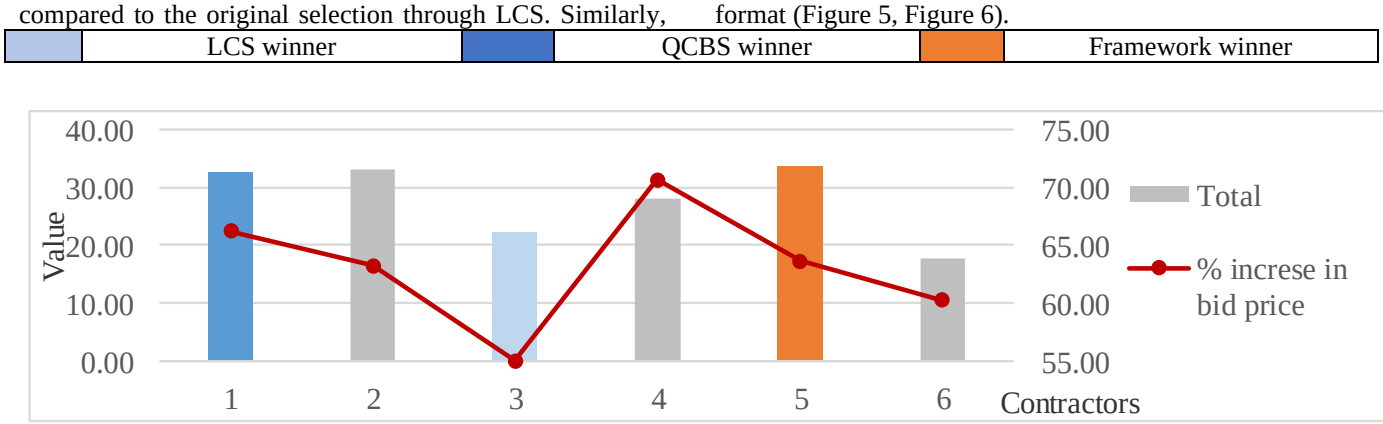

Figure 5. Case example – 1 total score vs % increase in bid price

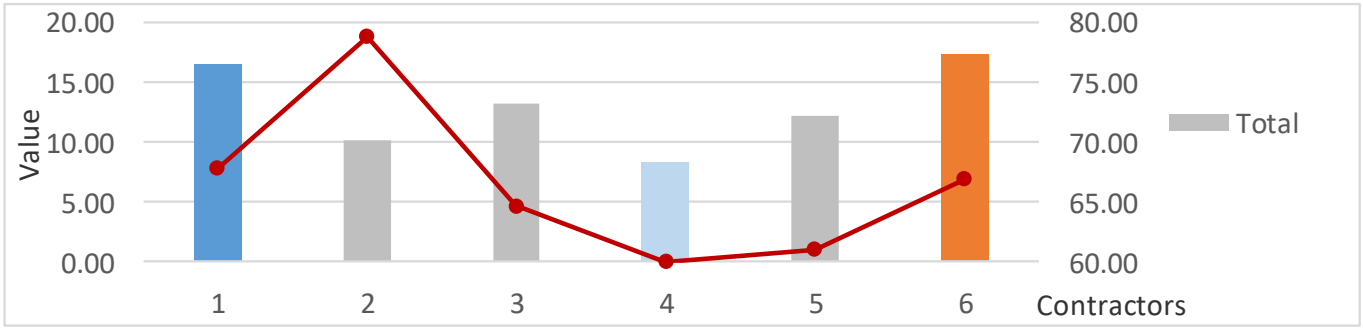

Figure 6. Case Example – 2 total score vs % increase in bid price

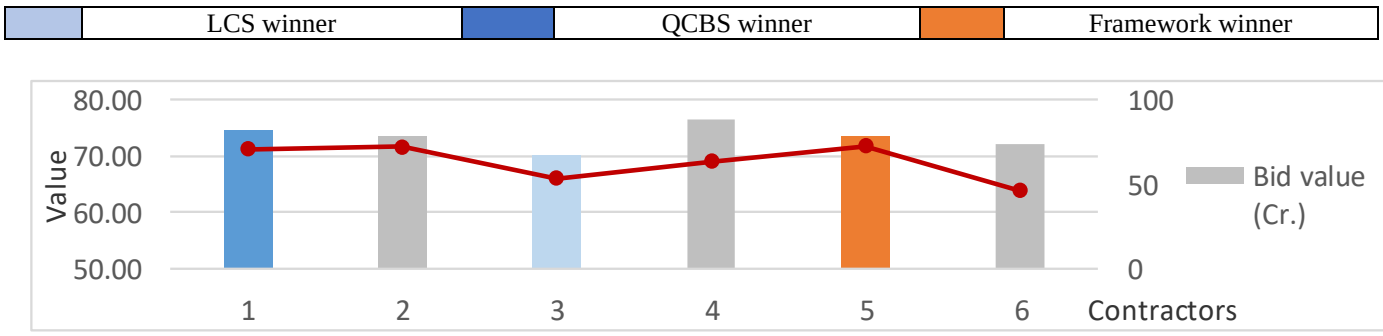

Figure 7. Case example – 1 bid price vs total score

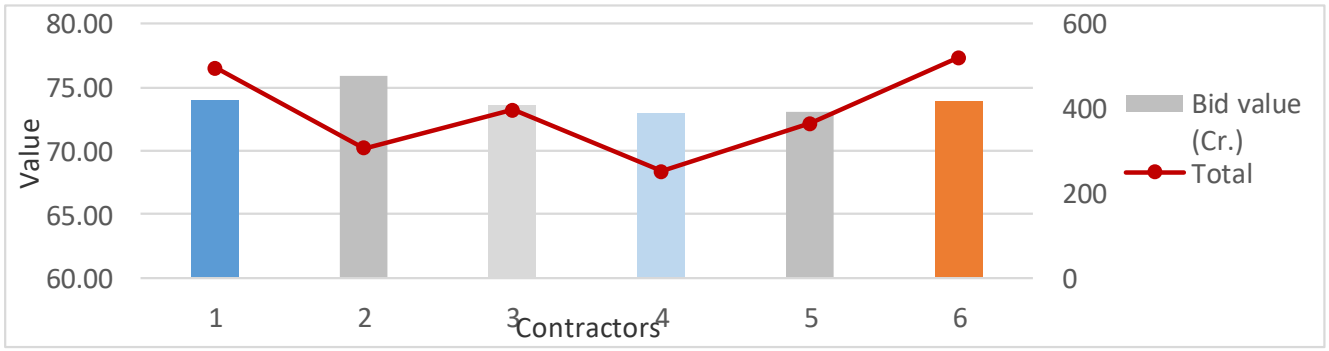

Figure 8. Case example – 2 bid price vs total score

3) Now the most important & evident trend that can be observed is that in both the cases considered here, the overall score of a contractor, which is also an indicator of the likely performance is going much below if the selection is based on the least cost selection (LCS). In both, cases, the contractor selected through LCS was 2nd lowest & lowest respectively when the overall score is considered. Whereas, selection through the developed framework is giving the most efficient result by selecting the contractor with the highest overall score i.e. likely higher or most optimum performance. The results from both the case studies are furnished below in graphical formats (Figure 7, Figure 8).

B. *Inference*

Therefore, from the result & discussion, the following can be inferred.

1) The developed framework is giving much better & efficient results compared to LCS & also QCBS. The contractor selected through this framework has much higher scores in individual parameters & also a maximum overall score to ensure the best project performance.

2) Performance & cost trade-off is also reasonable through this framework. Therefore, the selection of optimum performance for the best possible cost is achieved through it. So the framework is satisfying the need for Value for Money (VfM) & also goes with one of the main agendas of Design Bid Build (DBB) projects, reasonable cost.

3) This framework considers an exhaustive list of attributes to score the contractor so the evaluation is more complete. In addition, the attributes are grouped into some parameters, which helps the evaluator to evaluate the contractor based on minute areas of expertise & decide accordingly.

C. *Future Scope of Work*

At the end of any study, the future scope of the study should be stated. The author finds the following as the scope of future work or study.

1) In this study, traditional AHP has been used to derive specific weightages for the parameters based on their relative importance & interrelations. But, sometimes specific weightages may not be applicable in practical use as it lacks flexibility. Also, the evaluation team will be happy to have some flexibility in deciding the relevant weightage suitable for a particular project. Therefore, a weightage range seems to be a better alternative. But, finding a weightage range is much tedious & requires much extensive interview, which was not feasible for this particular study & can be considered as a future scope to explore.

2) One other thing that the study restricts itself to is the behavior of the contractor selection problem. To comply with the characteristics of the contractor selection systems prevailing in India, this study also considers the linear behavior of individual parameters & attributes in the selection of a contractor. However, if necessary non-linear behavior can also be considered & accordingly the result can then be derived to see the impact of various parameters & attributes on the performance & selection of contractors.

3) This study has focused only on DBB (Design Bid Build) type projects. The attributes, parameters & weightages are thus based on that consideration. However, as an extension to this study, other project types can be explored the framework can be modified accordingly.

VII. CONCLUSION

After all, the discussion above it can be concluded that the developed framework responded absolutely to the need for contractor selection in India. It gives the most optimum result within a reasonable bid price & at the same time maximizes the performance of the contractor selected, by considering multiple parameters.

As stated at the beginning of this paper, the aim was to develop a multi-criteria framework for the selection of a contractor. The framework solved the purpose & achieved the aim. It considers multiple parameters along with bid price to select a contractor. As explained & analyzed in the case studies, the framework gives much better results compared to LCS & even QCBS, which is sometimes considered an alternative to the LCS. The likely performance of the contractor selected through this framework is also very high as explained above. At the same time, it offers a reasonable price which is the main objective of contractor selection in the case of Design Bid Build (DBB) projects.

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