
Multi Criteria Decision Analysis for Optimal Selection of Supplier Selection in Construction Industry – A Case Study

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Abstract: The prime important aspect in construction is the supplier selection and without proper accurate method for selecting it the performance of the project will be affected. Multicriteria decision making is a viable method for supplier selection and Analytical Hierarchy supplier selection problem in Indian context. Emphasizing on the problems the suppliers – prequalification – evaluation – selection processes needs to be reviewed to achieve the project objectives based on MCDM. The data collected is used to create hierarchy model for supplier selection. The result findings indicate that contacting company's attributes followed by financial capability of the supplier, past performance of the supplier, project specific criteria, performance potential of the supplier, and experience record is the hierarchy observed. The output parameters from AHP process was used in TOPSIS and MAUT methods in finding out the ranking and optimal selection of suppliers.

Keywords: multi-criteria, analytical hierarchy, prequalification, evaluations, TOPSIS, MAUT.

I. Introduction

The construction industry plays a pivotal role in the socio-economic development of any nation. It is oftentimes regarded as the 'engine' that powers the pace of the socio-economic growth of the nation owing to its significant contribution to Gross Domestic Product (GDP). The Indian construction industry comprises more than 100 organizations in the corporate sector and in adding together to these there is about 0.1million class-A suppliers registered with different government construction bodies. The unorganized and low skilled work force is the characteristic of the Indian construction industry. There have been extensive delays in the planned schedule, cost overruns, serious problems in quality and an increased number of claims and litigation. The construction industry has witnessed the failure of many suppliers due to varying reasons such as financial problems, poor performance, or accidents arising from the lack of adequate safety consideration at worksites. As per 1992 survey report, around two-thirds of construction projects under implementation were observed to suffer significant time and cost over runs (Joy 1993). The time overrun in one of the projects was noted to be as much as 194 months (32.5%) with the corresponding cost overrun of 78.8% (Joy 1993).

Supplier selection is one of the main decisions made by the clients. In order to ensure that the project can be completed successfully, the client must select the most appropriate supplier. The decision problem is decomposed into qualitative criteria and sub criteria that are further analyzed in quantitative indicators on which the candidate suppliers are evaluated. It uses a multi-level hierarchical structure of objectives, criteria, sub criteria, and alternatives. There are three prime causes of inadequate supplier selection. Firstly, inappropriate criteria are selected when evaluating qualification of a supplier. Secondly, unsuitable significance is recognized to the criteria (e.g. to bid price). Thirdly, the appropriate methodology is applied for the supplier evaluation and also for the selection task. The relatable data are derived by considering a set of pair wise comparisons. The evaluated data is used to obtain the weights of significance for the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion. If the data under comparison are not entirely consistent, then it provides an instrument for improving consistency. It describes an investigation of companies on the criteria for Evaluation of suppliers'

qualification and the importance of criteria weight. Technique for order preference by similarity to the ideal solution (TOPSIS) and Multi Attribute Utility Theory (MAUT) are favorable tools for evaluating MCDM. Based on the output parameters of the AHP and liking it with TOPSIS, MAUT methods helps in selecting an optimal contractor.

Objectives of the Present Study:

The present study is focused on the following objectives:

- To investigate the construction clients' supplier selection preferences
- To establish a set of supplier selection criteria to be used in the supplier selection system for project
- To develop a comprehensive decision-making method capable of dealing with uncertainty and vagueness surrounding the supplier selection process and of producing a decision that reflects the preferences of multiple DM's

Significance of the Research

- ✓ It will help construction clients select the most appropriate supplier in a systematic, consistent and productive way
- ✓ Therefore, the risk to the client of project failure resulting from awarding the contract to an incompetent, incapable and inappropriate supplier will be greatly reduced;
- ✓ Computer interaction will facilitate more efficient utilization of resources by all parties associated with the selection process;
- ✓ It will, therefore, help to some extent improve the performance of the construction industry.
- ✓ The proposed technique is suitable for the evaluation of bids where there are conflicting objectives and for sensitivity testing with several stakeholders - a situation that exists in the predominant method (competitive tendering) of construction procurement in the U.K. and in all other countries using this method.
- ✓ It may also be used in other applications, including:
 - i. The selection of construction equipment;
 - ii. Pre-qualification of supplier, where bid price is not only the criteria.
 - iii. The selection of construction and project managers.

METHODOLOGY:

The methodology is a tool for obtaining useful information and acquiring answers to the research questions in order to accomplish the research objectives. In order to achieve the overall objective of the present study, a methodology is designed, in line with key objectives of the project adopting the development of the conceptual supplier selection system with AHP, incorporating the obtained results in TOPSIS, MAUT methods for the comparison of various suppliers and evaluating the best out of the five selected. The fundamental scale in Table 1 is adopted in AHP enables the decision maker to incorporate experience and knowledge in an intuitive and natural way. This scale is insensitive to small changes in a decision maker's preference, thereby minimizing the effect of uncertainty in evaluations. AHP is a complete balance in which people adopt numbers to express the domination of one element over the other with respect to a common criterion. The scale derived from these absolute numbers is a ratio scale. Table 2 depicts the various main criteria's employed in the present study.

The criteria selection is carried out by considering 6 different criteria via. **A**: Experience Record; **B**: Contracting Companies Attributes; **C**: Past Performance of Supplier; **D**: Financial Capabilities of Companies; **E**: Performance potential of the supplier; **F**: Supplier specific criteria as shown below using AHP for 4 different companies is evaluated. The sub criteria parameters under each criteria considered are: B1-Registration of suppliers company, B2-communication system, B3- Manufacturing permits, B4-Validity of the permits, B5-Reputation of the organization, B6-discounts, C1-Reliability of the supplier, C2-Rejections, C3-Previous supply history, C4-Previous supplied companies, D1-Credit strength, D2- Turnover from 2 years,

D3-Assets, E1-Pricing, E2-Payment options, E3-Delivery mechanism, E4-Demanded product, E5-Urgent delivery time, E6- Godowns, E7- Capacity of the supplier, F1-Competitive pricing, F2-QA/AC, F3-Insurance of the materials, F4-Safety practices, F5-Labs/Equipments, F6-Minimum lot size, F7-Lead time. From the AHP model analysis, the ranking of the suppliers is shown in Table 3 and Supplier 5- APTECH is evaluated as the optimal best.

Table 1 Saaty's rating scale

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over other	Experience and judgment slight favor one activity over another
5	Essential or strong importance	Experience and judgment favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed

Table 2: Main Criteria for Selection of Supplier

A	Experience Record
B	Supplying company's Attributes
C	Past performance of supplier
D	Financial capability of the supplier
E	Performance potential of the supplier
F	Supplier specific criteria

Table 3 Final Ranking of Supplier

Supplier	Ranking
Supplier 1- M/s Srinivasa construction company	5
Supplier 2- M/s Harvins Construction Pvt. Ltd	4
Supplier 3- M/s GSR Ventures Pvt. Ltd	3
Supplier 4- M/s SVEC & RK JV	2
Supplier 5 Aptech company	1

Integrating AHP-TOPSIS

The decision matrix or the basic matrix in the AHP-TOPSIS method is considered by evaluating and averaging about 75 survey sheets under 28 different criteria's and alternatives. The normalized decision matrix is prepared that depicts various alternatives and weighted values from the AHP method. From the integrated AHP-TOPSIS method, as detailed in Table 4 the final ranking of the suppliers is evaluated and **Supplier 4- M/s SVEC & RK JV** is the optimal supplier

Table 4 Integrated AHP-TOPSIS Analysis and Ranking Results

Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5
0.2678	0.258	0.5125	0.731	0.597
RANKING				
4	5	3	1	2

INTEGRATING AHP-MAUT

In the multi attribute utility method of analysis, it is necessary to generate basically payoff matrix and the scaling constants such as K1 - 0.0257, K2 - 0.4737, K3 - 0.1579, K4 - 0.02242, K5 - 0.070, K6 - 0.0490 as detailed in Table 5. The final ranking for the suppliers as detailed in Table 6 is obtained from the analysis of normalized payoff matrix and the utility value matrix, which evaluates the Supplier 4 M/s SVEC & RK JV as the best alternative among all the other alternatives.

Table 5 Initial Payoff Matrix

	A	B	C	D	E	F
Supplier - 1	0.16	0.145	0.128	0.186	0.118	0.202
Supplier - 2	0.08	0.155	0.154	0.079	0.180	0.190
Supplier - 3	0.207	0.215	0.192	0.196	0.200	0.136
Supplier - 4	0.231	0.274	0.261	0.241	0.236	0.239
Supplier - 5	0.320	0.211	0.264	0.296	0.262	0.236

Table 6 Final Ranking

ALTERNATIVES	UTILITY	RANKINGS
SUPPLIER - 1	0.463	4
SUPPLIER - 2	0.720	3
SUPPLIER - 3	0.799	2
SUPPLIER - 4	0.830	1
SUPPLIER - 5	0.389	5

SUMMARY AND CONCLUSIONS

- Currently, bid price is the most important criterion in the selection of a supplier both in India and other countries. Although tender conditions list many other evaluation criteria, clients tend to select a supplier with the lowest bid price. Suppliers should not be selected according to the lowest price, but it should be attributed to the highest weight.
- There is a need for a supplier selection technique that is capable of considering multiple criteria. Analytical hierarchy process provides one such approach and is especially useful as it allows the treatment of both quantitative and qualitative criteria.
- An additive model of utility technique is chosen for its simplicity, practicality and appropriateness in risky choice situations. The individual importance of each supplier criterion is specified using a weighting which also incorporates the risk of the decision-maker.
- An Analytical Hierarchy process technique in which Decision Maker is the key role in the whole problem formulation. From the AHP method, it can be observed that the Supplier-5 M/s APTECH stands as the optimal best.

Supplier 1	M/s Srinivasa Construction Company	15.521%
Supplier 2	M/s Harvins Construction Pvt. Ltd	15.92%
Supplier 3	M/s GSR Ventures Pvt. Ltd	18.60%
Supplier 4	M/s SVEC & RK JV	24.92%
Supplier 5	M/s APTECH	24.95%

➤ After evaluating the clients criteria's and sub criteria's using integrated AHP and TOPSIS method the percentages obtained are as detailed below, and the Supplier-4 M/s SVEC & RK JV is obtained to be the optimal best.

Supplier 1	M/s Srinivasa Construction Company	26.78%
Supplier 2	M/s Harvins Construction Pvt. Ltd	25.92%
Supplier 3	M/s GSR Ventures Pvt. Ltd	51.25%
Supplier 4	M/s SVEC & RK JV	73.12%
Supplier 5	M/s APTECH	59.79%

➤ From the integrated AHP- TOPSIS method with the AHP-MAUT methods the results obtained are as shown below, and in this analysis the supplier M/s SVEC & RK JV is again evaluated as the optimal best supplier.

Supplier 1	M/s Srinivasa Construction Company	46.30%
Supplier 2	M/s Harvins Construction Pvt. Ltd	72.00%
Supplier 3	M/s GSR Ventures Pvt. Ltd	79.99%
Supplier 4	M/s SVEC & RK JV	83.02%
Supplier 5	M/s APTECH	38.99%

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