An Integrated Approach For Contractor Selection Using Topsis - A MCDM Technique

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Abstract- *The selection of most effective contractor is most important for successful and smooth completion of the project. The construction projects often get delayed and run into cost and time overruns as a result of ineligible contractor selection. This generally happens due to flaws in tender selection process Multi-criteria decision-making (MCDM) techniques help us in choosing the best alternative among all in situations where many criteria are present. This is done by analysing scope of different criteria, assigning proper weightage to each criteria and then selecting the best possible alternative by applying any of the MCDM techniques. In this research a MCDM technique named Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is used to yield a final result for selection of most suitable contractor with precise relative closeness to the ideal solution.*

Keywords- MCDM, TOPSIS, criteria, weights, contractor

I. INTRODUCTION

The inaugural step in any construction project is inviting of tenders. Tender is defined as an offer in writing for execution of certain specified work or for the supply of specified materials subject to certain terms and conditions such as rates, time limit, etc. This tender for execution of a work may be invited by advertising in a newspaper or in a website. And then the contractors who are interested in applying for the tender can submit their rated quoted tender. As the contractor play a very crucial role in the overall performance of the project, selecting the right contractor for the right project is the most important challenge for any construction organization. Selection of contractor has primarily been based on the basis of bid price alone. Due to this, the contractor who has quoted lowest amount is selected. But the cheapest contractor is not necessarily always a capable one.This will ultimately cause delays in the planned schedule, cost overruns, serious problems in quality. This further results in increased number of claims and litigation due to sub-standard quality of work, untimely completion, etc. Hence to arrest all these problems, it is imperative to consider all the criteria related to contractor selection. Multi-criteria decision-making (MCDM) techniques are a viable solution to this problem of contractor selection.

The selection of construction contractors is often done by tendering process. Tendering gives client a choice in awarding contract to a company which proposes the lowest price and short construction cycles. But usually this existing process does not allow the client to precisely evaluate a tenderer. At the same time along with this tendering process there are numerous other processes in which decision making is done on the basis of bid price alone. In recent years, many inefficient contractors have made use of these flaws in these process to secure businesses. The research shows that the cheapest contractors thus selected very often have difficulties in successful and smooth completion of the project. Hence we can conclusively say that accepting the lowest price is the primary cause of project delivery problems because lowering the price generally results in lowering of quality. The above conditions guide us to an answer that it is very important to properly evaluate a contractor's capabilities before awarding the contract to him. In this paper, we have analysed the frameworks applied in selection of contractors and summarised the criteria for selecting a suitable contractor. [3]

II. LITERATURE REVIEW

Contractors play an important role in overall performance of a project. Hence selecting the right contractor for the right project is very important for the client. Numerous and often conflicting parameters such as tender price, completion date and experience need to be considered while selection process. Recently, to help owners in decision making, there has been trend away from the "lowest price wins" principle. And there is a subjective judgement to multi-criteria selection approach in the selection of contractors for construction projects. With this aim, multi-criteria decision methods viz. Technique for order preference by similarity to ideal solution (TOPSIS) and vlsekriterijumska optimizacija I kompromisno resenje (VIKOR) are applied to the selection of contractor for road-building project "La Braguía" undertaken during the year 2002. The results show that one of the

contractors is highest ranked by both methods. By being ranked highest alternative by the VIKOR method indicates that this contractor is best among all in terms of ranking index. In addition, being the highest ranked alternative by TOPSIS indicates that it is the closest to the ideal solution. [4]

Contractors play a major role in any construction project; hence, contractor selection is a critical decision to be made at an early stage of the project lifecycle. The selection of a contractor is a complex process, as the construction industry environment is very competitive, complex, and driven by competing stakeholders. Many factors can be assigned to the contractor selection decision; such factors can further be assigned weights, which vary depending on many factors, such as the expertise of the evaluator and the driving objectives of the decision maker. Previous studies of contractor prequalification have emphasized the importance of the subject and addressed the weakness associated with selecting the lowest bidder in an attempt to offer alternatives to the low-bidder approach (e.g., Hatush and Skitmore 1998; Russell and Skibniewski 1990a, b).

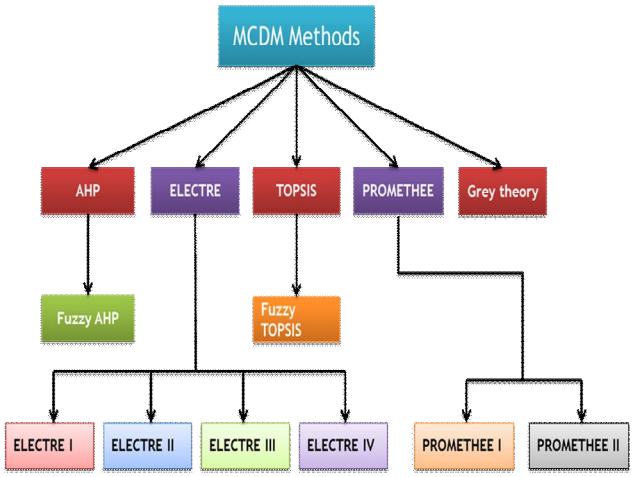
In general, construction practitioners involved in contractor selection tended to favour a quantitative and multicriteria selection approach. Nevertheless, the subject of contractor selection continues to draw attention from researchers. Hence, new research and findings in the subject, including the selection of different attributes that contribute to contractor selection and modeling techniques for making better decisions related to contractor selection confirm that the area needs further study. Although various studies have presented different methodologies of contractor selection, this paper enhances the construction management profession by introducing a new contractor selection method based on multiple decision-makers. Once factors that contribute to the contractor selection decision are determined and appropriate weights are assigned by the decision makers who provide the criteria for contractor selection, qualitative and quantitative attributes, such as experience level and tender price, can be determined for various contractors. The contractor prequalification decision is usually the output of many decision-makers with varying levels of expertise; therefore, a multiple decision-maker input approach needs to be used in modeling the contractor selection process. There is a need for research into contractor selection in terms of both attributes used to identify major criteria in the selection process and the adopted methodology of the selection process.

III. WHAT IS MCDM

Multi-Criteria Decision Making (MCDM) provides strong decision making in areas where a selection of a best alternative is very difficult. This survey paper reviews the main streams of consideration in multi-criteriadecision-making theory and practice in detail. The main purpose is to recognize various applications and the methods and to suggest approaches which are most strongly and effectively used to identify the best alternative. This survey work also addresses the problem in fuzzy multi-criteriadecision-making techniques. Multi-criteria decision making have been applied in many areas. MCDM method helps to choose the best option where there are many criteria, the best one can be obtained by analysing the different scope for the criteria, weights for the criteria and then choose the ideal one using any multi-criteriadecision-making techniques. This survey provides the comprehensive developments of various methods of MCDM and its applications.

In our everydays life, so many decisions are being made from various criteria, so the decision can be made by providing weights to numerous criteria's and all the weights are obtaining from expert groups. It is important to define the structure of the problem and clearlyassessmulti-criteria. For example, in building a nuclear power plant, certain decisions have been taken based on different criteria. There are not only very intricate issues involving multi-criteria, some criteria may have an effect toward some problem, but overall to have an ideal solution, all the alternatives must have common criteria which clearly lead to more cognizant and better decisions.

Multi-Criteria Decision-Making is relating to structure and solve decision and planning problems involving multiple criteria. The main objective of this survey is to support decision makers where there are enormous number of choices exist for a problem to be solved. Typically, it is necessary to use decision maker's desire to differentiate between solutions [1] where there is no unique optimal solution for these problems. Solving the problem can be construed in different ways. It could correspond to choose the "best" alternative from a set of alternatives (where "best" can be interpreted as "the most preferred alternative" of a decision maker). Another explanation of "solving" is to choose a small set of good alternatives, or grouping alternatives into different preference sets. A detailedexplanation is used to find all "efficient" or "non-dominated" alternatives.



Methods of MCDM [1]

1) Analytical hierarchy process (AHP): It gives pairwiseevaluation of different alternatives for different criteria.
2) Elimination and choice expressing reality (ELECTRE): ELECTRE is outranking method which take into account uncertainty and vagueness.
3) Technique for order preference by similarity to ideal solution (TOPSIS)
4) GREY Theory: Use for high mathematical analysis of system which is partly known and partly unknown.

IV. ANALYSIS BY TOPSIS

The TOPSIS method considers that each of the several criteria has anability of increasing or decreasing utility alone, which leads to easy definition of the positive and the negative ideal solutions. To evaluate the relative closeness of the options to the ideal solution Euclidean distance approach is proposed. A series of comparisons of these relative distances will give us the preference order of the options. The TOPSIS method first converts the various criteria dimensions into non-dimensional criteria similar to ELECTRE method [1] The concept of TOPSIS is that the selectedoption should have the least distance from the positive ideal solution (PIS) and the most from the negative ideal solution (NIS). This technique is used to decide ranking among the options available and to squeeze the best ofmulti-criteria decision making field. Fuzzy TOPSIS method is used to evaluate the criteria in each area and then all the criteria have been ranked based on the area.
TOPSIS is suitable for large-scale data and relatively simple. [2] TOPSIS is useful where large numbers of options and criteria are present because algorithm of TOPSIS is straightforward and causes little or no confusionduring calculation. Therefore, calculation using the TOPSIS approach is relatively tranquil to perform and apply. [2] TOPSIS can also give a final result in a net ordering format, with precise relative closeness to the ideal solution. On the basis of the final ranking, comparison of the final score of each alternative is thus allowed, so that decision making can be suppler. TOPSIS also shows the ability of simultaneously considering various criteria with different units. This method can be used regardless of the criteria unit as long as the necessary data are definite numbers.

A. Formulation of MCDM problem

Basic steps for formulation of the problem:
Step 1. Identification of necessary criteria for contractor selection.
Step 2. Recognition of the interdependence between criteria.
Step 3. Assigning the weights of criteria.
Step 4. Developing the problem in terms of matrix
Step 5. Analysing the problem by TOPSIS & get a solution

B. Data required for problem creation:

Alternatives: Different choices of action or entities available to the decision maker.
(Alternative = Various Contractor)
Attributes: Goals or Decision Criteria (In Government Tendering)
Criteria No. 1 (C1):Detailed list of work in hand and work tendered for
Criteria No. 2 (C2):Details of plant & machinery available
Criteria No. 3 (C3):Details of works of similar type and magnitude carried out by the contractor.
Criteria No. 4 (C4): Details of work executed in the interior, backward and hilly areas during 5 years
Criteria No. 5 (C5): Details of Technical Personnel available with the contractor
Criteria No. 6 (C6): Maximum value of civil eng works in any one year during last 3 years.
Criteria No. 7 (C7): Bid Capacity of Contractor.
Criteria No. 8 (C8): Tender Amount quoted by Contractor.
Decision Weights: Assigned weights of importance to attributes.

C. Sample calculation by TOPSIS for contractor selection:

Criteria ➡	C1 Rs. Cr.	C2 No.	C3 Rs. Cr.	C4 Rs. Cr.	C5 Yr.	C6 Rs. Cr.	C7 Rs. Cr.	C8 Rs. Cr.
Weight ➡	4	2	3	2	1	3	4	5
A ⬇								
A1	1.53	4	5.43	10.32	26	5.20	13.0	5.5
A2	1.80	3	7.20	12.82	22	10.78	12.0	4.9
A3	3.44	4	3.87	8.14	24	7.2	14.7	6.2
A4	0.98	5	4.73	7.35	30	8.20	12.8	5.8
A5	2.20	1	0.90	6.42	34	11.04	16.7	5.3
D	+	+	+	+	+	+	+	-

D- Direction,
C- Contractor,
A-1 to A-5: No. of Alternatives (Contractor)

But here values of criteria are not in same standard value.ie some are in rupees, year and in number. So it is necessary to formulate this in standard number say .1-5.
So we giving ranking to this value in criteria.

Ranking No:

1- Very Bad
2- Bad
3- Normal
4- Good
5- Very good

Sample calculation for criteria:

Contractor	C-1 (Rs. In Cr)
A-1	1,53,11,684
A-2	1,80,22,000
A-3	3,44,31,790
A-4	98,08,000
A-5	2,20,47,500
	∑= 9,91,83,884

Average = 9,91,83,884/ 5
= 1,98,36,736 (1.98 cr)
Range = (max value- min value)/ (no. of contractor – 1)
= 2,20,20,000- 98,00,000/ (5-1)
= 30,55,000 (0.30 Cr)
i.e. Range = 0.30
Average = 1.98 Cr.

With help of Range value and Average value we find out we find ranking for criteria:

5 ---------- 1.98+ (0.3/2)+ 0.3 = 2.43
4 ---------- 1.98 + (0.3/2)= 2.13
3 1.98 ---------- 1.98 - (0.3/2)= 1.83
2 ---------- 1.98 - (0.3/2) – 0.3 = 1.53
1

i.e. 5 ↑ 2.43
4 ↕ 2.13
3 ↕ 1.83
2 ↕ 1.53
1

Hence, content become for criteria number 1:

A-1	2
A-2	2
A-3	5
A-4	1
A-5	4

Same calculation is carried out for criteria no. 1 to 7, as they are assigned positive direction.

Calculation for criteria no. 8 (Tender cost quoted) is difference because it has assigned negative direction.

Final formulation of MCDM matrix for solving contractor selection:

Criteria	C1 Rs. Cr	C2 No. of m/c	C3 Rs. Cr.	C4 Rs. Cr.	C5 Yrs. Exp	C6 Rs. Cr.	C7 Rs. Cr.	C8 Rs. Cr.
Weight	4	2	3	2	1	3	4	5
A1	2	4	3	5	4	4	2	3
A2	2	3	1	4	2	5	4	5
A3	1	4	2	1	2	2	4	1
A4	5	5	2	2	3	1	3	2
A5	4	1	3	2	1	1	3	3

D. Stepwise procedure of TOPSIS:

Step1: By using the alternatives m and criteria n we calculate the normalized values (R_{ij})

$$R_{ij} = \frac{A_{ij}}{\sum_{i=1}^{m} Ai^2 j}$$

where i = 1,2,3, …m, j = 1,2,3,….n (1)

Step 2: The normalized values can be obtained by giving weights to the criteria (Vij)

$V_{ij} = W_j * A_{ij}$

where i = 1,2,3, …m, j = 1,2,3,….n (1)

Step 3: Determine the ideal and negative-ideal solutions

A* = {(max v_{ij} / j∈J), (min v_{ij} / j ∈ J'), i =1,2, 3, …. m} = {v_1*, v_2*, ..., v_n*} (3)

A− = {(min v_{ij} / j ∈ J), (max v_{ij} / j ∈ J'), i =1,2, 3,..., m} = {v_1−, v_2−, ..., v_n−} (4)

where:

J = {j=1,2,3, …, n and j is associated with benefit criteria} and J'= {j=1,2,3, …, n and j is associated with cost criteria}

Step 4: For all the criteria, every alternatives distance to the best alternatives (D_i*) using (3) and worst alternative (D_i-) using (4)

$$D_{j*} = \sqrt{\sum_{j=1}^{n}(V_{ij} - V_{j*})^2} \quad j=1,2,3,\ldots m$$

$$D_{j-} = \sqrt{\sum_{j=1}^{n}(V_{ij} - V_{j-})^2} \quad j=1,2,3\ldots m$$

Step 5: Calculate the relative closeness to the ideal solution: (C_{j*}):

$$C_{j*} = \frac{D_{j-}}{D_{j-} + D_{j*}}$$

where $0 < C_{j*} < 1$ and j-1,2,3…m

The biggest (C_{j*}) value is chosen as best selection and solution for the MDCM problem is obtained through TOPSIS.
As result from this analysis is: { 2 > 5 > 1 > 3 > 4 }.

This means that 2nd contractor is most suitable contractor.

V. CONCLUSION

1. During this study we found out various criteria, which are useful for effective selection of contractor for a construction project.
2. In absence of a propertechnique for selecting the most eligible contractor, the enactment and functioning of a project might be hampered, so studiedvarious MCDM methods and selected the mostsuitableamongst all.
3. By TOPSIS found out most suitable contractor who will be able to uphold the quality work.
4. By giving appropriate weightage to each criteria of contractor, most effective contractor is selected which will avoid delay and poor quality of work.

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