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TENDER EVALUATION: MCDM TECHNIQUES

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The decision of tender evaluation and allotment is one of the important step of any construction project. There has been a trend away in tender evaluation process from considering quantitative parameters ("lowest price win", "maximum benefit win") to other qualitative parameters (past performance, time of completion). This paper reviewed past and recent literature in order to identify the current tendering process and the various techniques that have been applied previously. The study utilized different MCDM techniques for evaluation of tendering process. Multi-criteria decision making research has become one of the main areas of research for dealing complex and critical decision problems. This paper outlines the use of various systematic decision making tool for the tender selection. Qualitative and quantitative criteria are compared, and the uncertainty associated with the selection of right contractor is highly reduced. By using a case study the tender evaluation is fully investigated applying various MCDM techniques. Results from the different methods are compared and fuzzy extend analysis, fuzzy TOPSIS showed slight difference in results from the other methods.

Keywords: Multi-attribute utility theory, Multiple-regression, AHP, TOPSIS, Fuzzy AHP, Fuzzy TOPSIS.

1 INTRODUCTION

Tender selection and its evaluation process are a critical issue in construction management (Halil 2007). The identification of best contractor for the work is a challenge i.e. performance during challenging situation, Acceptable rates, Quality of work etc. the contractor selection process has received considerable attention to Management and client. Tender evaluation does not involve only quantitative criteria such as rate and time of completion but also qualitative parameters are to be considered such as quality of work, experience, efficiency of contractors etc. (Sun 2010). In most of the cases of contractor selection, turns out to be a bit complex process if both qualitative and quantitative parameters are to be considered. Recently, MCDM techniques have acquired considerable attention in evaluation of tenders, procurement process, bidding and other tenders which take care of both types of parameters. Further the methods commonly practised in many countries is the best value method, called MEAT (Most Economically Advantageous Tendering) (Ramon and Cristóbal 2012), and was further improved by using the weights obtained from AHP (Zhu K., 1983). Previously, Hatush and Skitmore (1998) applied Multi-attribute utility function for evaluation of tender and was further used in case study (Zhu *et al.* 1983). Also the Fuzzy set theory was applied by Nyugen (1985) for first time in evaluation of tender in 1984. Further, Holt (1998) described various methods that can be applied in evaluation of tender i.e. Bespoke's Approach, Multi- attribute analysis, Multi-attribute Utility theory, Multiple-regression, Fuzzy Sets, Custer analysis (Nyugen 1985). The benefits and disadvantages of the described methods were studied. But none of the method was applied or used in any case studies (Nyugen 1985). In

2012, DEA Approach was used for evaluation of tenders, in this Falagario *et al.* (2012) says Cross-Efficiency DEA can be used to remove the uncertainty Among DMU's (Decision Making Unit). The Method was evaluated by a Case study of Italian public procurement where LW (Linear Weighing) method was used and the result obtained were same for the first three cases and changed for the others. The result varied a lot from fuzzy AHP (Halil 2007). Wong (2004) used Logistic regression approach and the performance of the contractor was predict from the previous data. The regression equation was used and the present rating according to the tender details were taken as the input.(Falagario *et al.* 2012). In 2007 Farisah Mohammad Ali said that instead of evaluating the just on basis of minimum rate a cut-off rate should be there, tender below which should be directly rejected, the cut-off rate was decided on the basis of the statistical method (Wang *et al.* 2013). Further Sun (2010) discussed Fuzzy AHP and Fuzzy TOPSIS in evaluation of the tender and applied on a case study(Gupta *et al.* 2016).

This paper studied the effectiveness of various MCDM methods i.e. Bespoke's Approach (Nyugen 1985), Multi-attribute analysis (Wong 2004), Multi-attribute Utility theory (Ramon and Cristóbal 2012), Multiple-regression, AHP (Hatush and Skitmore 1998), TOPSIS, Fuzzy AHP (Chang 1996, Aggarwal *et al.* 2013), Fuzzy TOPSIS (Holt 1998) for evaluation of tender and further some of the methods are applied on a case study of Aakash Ganga project tender in BITS-Pilani. The above methods are not discussed in detail due to paucity of space and directly applied to a real case and results are compared.

2 METHODS AND CASE STUDY

This study has considered a tender floated for "Aakash Ganga", a rain water harvesting project to assist villages in rural India that have little access to clean water. In this project, every homeowner with adequate size of roof top is asked to lease the rights to harvest their rooftop rainwater. So, this is based on public utility model. Then this rain water is collected into underground storage reservoir through various conduits interconnected together. Aakash Ganga IT Network (ITN) aims to store, capture and disseminate information for development, design and scale up of Aakash Ganga network. The four agencies Tender1, Tender2, Tender3, and Tender4 have sent proposals for development of the online database required for the Aakash Ganga Rainwater Harvesting Network. The study includes application of six multi-criteria decision making techniques. Here both qualitative (experience) and quantitative (cost) parameters are considered. The major performance attributes are the criteria for selection of alternative (Tendering agencies) for allocating tender (Gupta *et al.* 2016). Criteria: C1 = economic aspect; C2 = Time for host on server; C3 = Database; C4 = software; C5 = experience.

2.1 AHP

The pair wise comparison matrix for the Aakash Ganga project was formed by experts. Tables 1 to 6 indicate the Saaty's weightage with respect to criterion.

Table 1. Pair wise Comparison of Criteria (Single Dimension).

	C1	**C2**	**C3**	**C4**	**C5**
C1	1	3	5	5	7
C2	1/3	1	3	3	5
C3	1/5	1/3	1	1	3
C4	1/5	1/3	1	1	3
C5	1/7	1/5	1/3	1/3	1

Table 2. Pair wise comparison of Tenders w.r.t. criteria economic aspect.

Economic Aspect	Tender 1	Tender 2	Tender 3	Tender 4
Tender 1	1	3	3	1/3
Tender 2	1/3	1	1	1/5
Tender 3	1/3	1	1	1/5
Tender 4	3	5	5	1

Table 3. Pair wise comparison matrix of Tenders w.r.t. criteria time of host.

Time for Host	Tender 1	Tender 2	Tender 3	Tender 4
Tender 1	1	1/7	3	1
Tender 2	7	1	9	7
Tender 3	1/3	1/9	1	1/3
Tender 4	1	1/7	3	1

Table 4. Pair wise comparison of matrix w.r.t. criteria database.

Database	Tender 1	Tender 2	Tender 3	Tender 4
Tender 1	1	1	2	2
Tender 2	1	1	2	2
Tender 3	1/2	1/2	1	1
Tender 4	1/2	1/2	1	1

Table 5. Pair wise comparison matrix w.r.t. criteria software.

Software	Tender 1	Tender 2	Tender 3	Tender 4
Tender 1	1	1	3	1
Tender 2	1	1	3	1
Tender 3	1/3	1/3	1	1/3
Tender 4	1	1	3	1

Table 6. Pair wise comparison of Tenders w.r.t criteria Experience.

Experience	Tender 1	Tender 2	Tender 3	Tender 4
Tender 1	1	1/3	1/6	1/3
Tender 2	3	1	1/3	1
Tender 3	6	3	1	3
Tender 4	3	1	1/3	1

The final result was obtained by following the AHP procedure and shown in concluding table.

2.2 TOPSIS

The real values were taken for the economic aspect while the other values were given rating from 0-9 based on their performance in individual criteria. The economic aspect was to be minimized while other was to be maximized. In order to carry out maximization for all the criteria the economic aspect was multiplied by -1. The normalized matrix for the Real matrix shown in Table 7.

From the above normalized matrix the distance from the positive ideal point and negative ideal point were obtained and the final ranking were given. The weights used for the TOPSIS were obtained from Fuzzy AHP. The final ranking is shown in Table 8.

Table 7. Real value matrix tender to criteria.

	C1	C2	C3	C4	C5
Tender 1	-8,48,000	3	2	3	1
Tender 2	-15,20,000	9	2	3	3
Tender 3	-15,46,350	1	1	1	6
Tender 4	-4,75,000	3	1	3	3

Table 8. Normalized matrix tender to criteria.

	C1	C2	C3	C4	C5
Tender 1	-0.19319	0.1875	0.333	0.3	0.0769
Tender 2	-0.34629	0.5625	0.333	0.3	0.230
Tender 3	-0.35229	0.0625	0.1667	0.1	0.4615
Tender 4	-0.10821	0.1875	0.1667	0.3	0.230

2.3 Fuzzy AHP

The linguistic pair wise rating matrix was formed for the case study and the evaluation was done using both the Fuzzy AHP approaches i.e. Buckley and Chang method. The modified Chang approach has been used for the rating purpose. The pair wise comparison matrix for fuzzy AHP is shown below in Tables 9 to 14. Linguistic terms are indicated in table: Equal/ Equally Important / Equally weak (E/EI/EW); Weakly important/ Weakly weak(WI/WW); Slightly important/ Slightly Weak (SL/SM); Moderately important /Moderately weak(MI/MW); Fairly important / Fairly Weak (FI/FW); Strongly plus Important / strongly plus weak (SP/SS); Very important/ Very weak (VI/(VW); Very- Very Important / Very-very weak (VV/VS); Absolutely important/ Absolutely weak (AI/SW).

Table 9. Pair wise comparison matrix for criteria.

	C1	C2	C3	C4	C5
C1	E	SI	FI	FI	VI
C2	SW	E	SI	SI	FI
C3	FW	SW	E	EI	SI
C4	FW	SW	EW	E	SI
C5	VW	FW	SW	SW	E

Table 10. Pair wise comparison matrix for tender w.r.t. criteria economic aspect.

Economic aspect	Tender 1	Tender 2	Tender 3	Tender 4
Tender 1	E	SI	SI	SW
Tender 2	SW	E	EI	FW
Tender 3	SW	EW	E	FW
Tender 4	SI	FI	FI	E

Table 11. Pair wise comparison matrix for tender w.r.t. criteria Time of host.

Time of host	Tender 1	Tender 2	Tender 3	Tender 4
Tender 1	E	VW	SI	EI
Tender 2	VI	E	AI	VI
Tender 3	SW	AW	E	SW
Tender 4	EW	VW	SI	E

Table 12. Pair wise comparison matrix for tender w.r.t. criteria Software.

Software	Tender 1	Tender 2	Tender 3	Tender 4
Tender 1	E	EI	SI	EI
Tender 2	EW	EI	SI	EI
Tender 3	SW	SW	E	SW
Tender 4	EW	EW	SI	EI

Table 13. Pair wise comparison matrix for tender w.r.t. criteria Experience.

Experience	Tender 1	Tender 2	Tender 3	Tender 4
Tender 1	E	SW	SW	SW
Tender 2	SI	E	SW	EI
Tender 3	SI	SI	E	SI
Tender 4	SI	EW	SW	E

Table 14. Pair wise comparison matrix for Tender w.r.t. criteria Database.

Database	Tender 1	Tender 2	Tender 3	Tender 4
Tender 1	E	EI	SI	SI
Tender 2	EW	E	SI	SI
Tender 3	SW	SW	E	EI
Tender 4	SW	SW	EW	E

Further the weights were obtained. Final ranking and the weights obtained using both Chang and Buckley approaches are shown in concluding table.

2.4 Fuzzy TOPSIS

The fuzzy TOPSIS matrix was formed by rating the alternative w.r.t. criteria in linguistic terms. The matrix formed for evaluation is given in Table 15. The weights obtained from Fuzzy AHP Buckley's approach were used for calculation.

Table 15. Comparison matrix for Tender w.r.t. criteria Degree of Satisfaction.

Fuzzy TOPSIS		
Alternatives	**Degree of satisfaction**	**Rank**
Tender 1	0.608	1
Tender 2	0.4814	3
Tender 3	0.409	4
Tender 4	0.5443	2

2.5 Result Comparison

The final results are shown in Table 16.

Table 16. Comparison of results obtained by different methods.

Alter-native	AHP	TOPSIS	MCUT	Fuzzy AHP (Buckley)	Fuzzy AHP (Ext. analysis)	Fuzzy TOPSIS
Tender 1	2	2	2	2	3	1
Tender 2	3	3	3	3	1	3
Tender 3	4	4	4	4	4	4
Tender 4	1	1	1	1	2	2

3 CONCLUSION

Tender evaluation being one of the most crucial steps of any construction management process, various MCDM techniques are applied to select the optimum tender based on qualitative and quantitative parameters. The results obtained do not vary in most of the techniques. Tender 4 comes out to be ranked first in most cases. Further, in the multi criteria utility method, it will be more helpful if case individual functions are prepared for individual criteria. Fuzzy AHP Buckley's and Chang's approach provide different ranking.

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