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Selection of Contractor Using Multi-Criteria Decision Making Tools

KEYWORDS: AHP, Bid evaluation, Contractor selection, Decision making, Multi criteria analysis.

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ABSTRACT *The construction scale is growing rapidly; therefore, to contract is a common style in construction industry. Selecting appropriate contractors is a key to assure the success of a construction project. In this research, we use questionnaire to survey about 6 construction companies, which help us to obtain contractor selection factors and their weights. Contractors can fill available price for specific items from Quotation System, meanwhile, Appraisal system will integrate and calculate related data to determine total grades for all companies., Contractors can fill available price for specific items from determine total grades for all companies. Contractor selection system can be used to compile all information about special area. This can make the procurement process be fair, pick better partners, increase competition and create profit for company. Various research methodologies were adopted in several countries to achieve the "Value procurement" to the procures in the selection of contractor. The "value procurement" is one that considers price and other actors in the bid greatest "value for money" to the client. Findings from experts reveal that the tradition "lowest price wins" in practice is being replaced by "multi criteria decision makings". This indicates increasing awareness of procures in selecting contractor attributes via a more multi criteria selection methodologies. Certainly it is not a easy concept to identify the universal criteria for bid selection, as it depends on certain factors such as client demands, contractual issue, project viabilities, authority requirement and construction methods.*

INTRODUCTION

The selection of the contractor is considered to be a critical issue in any construction contract. The success level of any construction project may depend on the basis philosophy of "the right person for the right job". But, in many cases, the selection of contractor are over emphasized on the lowest bid acceptance. In reality, contractor with the lowest tender price is usually awarded a contract. This trend may be valid when the clients are very clear of the "likely cost" of the project and being experienced with similar type of project and working environment. However, it may not work in most of the projects, because the selection of contractor based on the lowest tender price alone may result in a "false economy" to the project. According to the previous research by many experts, there are few types of selection methodologies that can be applied by the procures in the contractor selection by Analytical Hierarchy Process (AHP)

METHODOLOGY AND PROCESS OF THE STUDY

- There are some problems in traditional contractors selection strategies;
- Engineers always pick familiar contractors, therefore, cannot get the best bargain for company.
- The purchasing message can only reach to limited contractors.
- People can easily collude with contractor and commit cheat in close environment.

Table 1.2: Data Collection

	Contractor A	Contractor B	Contractor C	Contractor D	Contractor E	Contractor F
Experience	15Years Experience Two similar Project One International Project	10 Years Experience Two similar Projects, One National Project	9Years Experience, Two similar Project	8 Years Experience One similar Project Special Procurement Experience	5Years Experience Two similar Projects	8 Years Experience Two similar Projects
Financial stability	17Crores Assets 5 Crors Liability	14 Crores Assets 1 Crore Liability	10 Crores Assets 2 Crore Liability	7 Crores Assets 1 Crore Liability	5 Crores Assets No Liability High Growth Rate	8 Crores Assets 2 Crores Liability High Growth Rate
Quality performance	Excellent Organisation C.M Personels, Good Reputation Many Certificates Safety Programs	Good Organisation C.M Personels Good Reputation Government Awards Safety Programs	Good Organisation Many Certificates Good Reputation iv	Average Organisation CM Personels Good Reputation Safety Programs	Bad Organisation CM Personels One delayed Project iv) a	Good Organisation CM Personels Average Quality Safety Programs

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Manpower resources	140 Labourers 25 Special skilled Labourers	120 Labourers 15 Special skilled Labourers	100 Labourers 10Special skilled Labourers 100 by sub contractor	80 Labourers 7 Special skilled Labourers 80 by sub contractor	50 Labourers 5 Special skilled Labourers	95 Labourers 5 Special skilled Labourers 75 by subcontractor
Equipment resources	Hitachi - 5 Nos Mixer Machine – 6 Nos JCB – 4 Nos Tipper -20 Nos Rollers -6 Nos Others -15 Nos	Hitachi - 6 Nos Mixer Machine – 4 Nos JCB – 4 Nos Tipper -25 Nos Rollers -3 Nos Others -10 Nos	JCB – 5 Nos Mixer Machine – 4 Nos Tipper -12 Nos Rollers -1 Nos Others - 9 Nos	JCB – 7 Nos Mixer Machine – 4 Nos Tipper - 8 Nos Rollers -2 Nos Others - 7 Nos	JCB – 5 Nos Mixer Machine – 3 Nos Tipper - 9 Nos Rollers -2 Nos Others - 5Nos	JCB – 5 Nos Mixer Machine – 6 Nos Tipper - 10 Nos Rollers -2 Nos
Current Work Loads	3 Big Projects Ending 4 Projects Mid stage(3 medium projects+ 1- Small project)	2Big Projects Started 3Projects Ending (2 –Big projects+ 1- Medium project)	2 Big Projects Ending 1- Medium project started	2 Big Projects Ending 4- Project Ending(2 –Small project+ 2- Medium projects)	1 Medium Projects Started 2- Project Ending(1 –Small project+1- Medium project)	3 Small Projects Started 4- Project Ending(2 –Small project+ 2- Medium projects)

2. Procedure and Equations

2.1 Evaluation criteria and their weights
2.2 Steps of AHP Analysis
2.2.1 Establishment of the Hierarchical structure.
2.2.2 Weight between the Elements on Different Levels

The calculation of the weight between the elements on different levels is completed though the following four step:

- Establishment of Pair – wise comparison Matrix:

The element comparison is conducted in this step. The parent element of an evaluation criterion for the pair – wise comparison

- Calculation of Priority vector:

$$\sum_{i=1}^{n} \frac{\text{cell-values}}{\text{Column-sum}} \quad \text{----------(1)}$$

Formula (1) shows the sum of the percentage each comparison value occupies in its corresponding row. An nx1 matrix is acquired in this step.

- Calculation of the Maximum Eigen-value (λ_{max}):
- Examination of Consistence:

During the pair-wise comparison, discrepancies might occur between the results of the comparison and the decision. The consistence ration for AHP is used to examine the consistency of the entire matrix.

2.3 Determination of the Consistency

The consistency index determined by using the Eigen value λ_{max} . Calculate the consistency Index ,CI a follows

$$CI = \frac{(\lambda_{max} - n)}{n-1}$$

The consistency Ratio is Calculated as
CR = CI / RI

Where RI will be taken from the following table on the basis of size of matrix. If the value of CR is less than 0.10 , the judgments are consistent, if it is more . the judgments are inconsistence then the judgments should be reviewed to obtain consistence matrix.

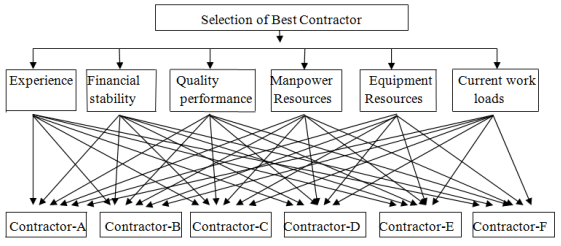
Table 2.1: Random Inconsistency Indices

Size of Matrix	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51

2.4 Arrangement of Evaluation criteria and their weights:

Surveys are done to 6 contractors and the consistency of the weight analyses is examined in the study. When the consistency is confirmed, the arrangement of the Relative weights analysis of the secondary goal and the Relative weight analysis of the Evaluation Criteria" is conducted to acquire the overall relative weight. Shows the relative weight of the entire evaluation criteria

3. Hierarchy tree



4 THE ANALYTIC HIERARCHY PROCESS

4.1 The Analytic Hierarchy Process and its Foundation

The foundation of the Analytic Hierarchy Process [AHP] is a set of axioms that carefully delimits the scope of the problem environment [Saaty 1986]. It is based on the well defined mathematical structure of consistent matrices and their associated right eigenvector's ability to generate true or approximate weights.

4.2 History of the development of AHP

In the late Thomas saaty one of the pioneers of operations research and author of the first mathematical methods of operations research textbook and the first queuing textbook, was directing research project for the Arms control and disarmament agency at the U.S department of state .

4.3 The Three primary AHP functions

AHP has been applied in a wide variety of application multi objective decision making being just one. A look at the three primary functions of AHP are

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i) Structuring complexity
ii) Measurement on a ratio scale
iii) Synthesis

The relative from comparative judgments in the second step the decision maker is required to provide his her performance with respect to upper level decision elements and construct a pair wise comparison matrix by using the relative scale measurements as shows in table

$$A = \begin{pmatrix} 1 & w_1 & w_2 & w_3 & w_4 & \dots & w_n \\ 1/w_1 & 1 & w_6 & w_7 & w_8 & \dots & w_n \\ 1/w_2 & 1/w_6 & 1 & w_3 & w_4 & \dots & w_n \\ 1/w_3 & 1/w_7 & 1/w_3 & 1 & w_{10} & \dots & 1/w_n \\ 1/w_4 & 1/w_8 & 1/w_4 & 1/w_{10} & 1 & \dots & 1/w_n \\ 1/w_5 & 1/w_9 & 1/w_5 & w_{11} & w_{12} & \dots & 1 \end{pmatrix}$$

In this matrix w_1 w_2 w_3 w_4 ..... w_n are the Weight of the elements 1 ,2 ,3 , 4…….n.

Table 5.1: Scale of pair wise comparison. (Standard Preference Table)

Preference in numeric variable	Preference in Linguistic variables
1	Equally Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2 ,4 ,6 ,8	Intermediate values between adjacent scale values

5.3.3 Estimate the Relative weights

Some methods like Eigenvector method and Lease square method are used to compute the relative weights of element in each pair wise comparison matrix.

Determination of the Consistency:

The consistency index determined by using the Eigen value λ_{max} . Calculate the consistency Index ,CI a follows

$$CI = \frac{(\lambda_{max} - n)}{n-1}$$

The consistency Ratio is Calculated as

$$CR = CI / RI$$

5.5.4 Check the consistency:

Where RI will be taken from the table 2.1 on the basis of size of matrix. If the value of CR is less than 0.10 , the judgments are consistent, if it is more the judgments are inconsistence then the judgments should be reviewed to obtain consistence matrix.

5.5.5Obtain the overall ranking :

The consistency of all criteria were checked .From the consistency of all criteria's the Ranking of six contractors will be analyzed in this Project.

6. DETERMINATION OF RELATIVE WEIGHT OF CRITERIA

6.1 Pair wise comparison matrix for Experience

Table 6.1

Contractor	A	B	C	D	E	F
A	1	2	2	3	4	2
B	1/2	1	2	4	3	2
C	1/2	1/2	1	3	4	5
D	1/3	1/4	1/3	1	2	1/3
E	1/4	1/3	1/4	1/2	1	1/4
F	1/2	1/2	1/5	3	4	1

Table 6.2

First Sum all the values in each column of above Matrix.

Contractor	A	B	C	D	E	F
∑ column	3.05	4.55	5.75	14.5	18.0	10.55

Table 6.3

The value of each column are divided by the corresponding column sum .

Contractor	A	B	C	D	E	F
A	1/3.05	2/4.55	2/5.75	3/14.5	4/18	2/10.55
B	(1/2)/3.05	1/4.55	2/5.75	4/14.5	3/18	2/10.55
C	(1/2)/3.05	(1/2)/4.55	1/5.75	3/14.5	4/18	5/10.55
D	(1/3)/3.05	(1/4)/4.55	(1/3)/5.75	1/14.5	2/18	(1/3)/10.55
E	(1/4)/3.05	(1/3)/4.55	(1/4)/5.75	(1/2)/14.5	1/18	(1/4)/10.55
F	(1/2)/3.05	(1/2)/4.55	(1/5)/5.75	3/14.5	4/18	1/10.55

Table 6.4

Determine the Eigen vector for the above matrix .For calculating the Eigen vector convert the fractions into the decimals .The Eigen vector is the average of each rows. Sum of the Eigen vector for the Matrix should be unity.

Contractor	A	B	C	D	E	F	Eigen-vector
A	0.328	0.440	0.348	0.207	0.222	0.190	0.289
B	0.164	0.220	0.348	0.276	0.167	0.189	0.227
C	0.164	0.110	0.174	0.207	0.222	0.474	0.225
D	0.098	0.055	0.052	0.069	0.111	0.028	0.069
E	0.082	0.066	0.043	0.034	0.056	0.024	0.051
F	0.164	0.109	0.035	0.207	0.227	0.095	0.139
∑	1.000	1.000	1.000	1.000	1.000	1.000	1.000

In this step find out the λ max for the Matrix. λ max is calculated by dividing the multiplication of Preference vector and Eigen vector to the criteria vector.

$$\begin{matrix} 1.822 \\ 1.528 \\ = \quad 1.589 \\ 0.423 \\ 0.316 \\ 0.853 \end{matrix} \begin{pmatrix} 1 & 2 & 2 & 3 & 4 \\ 1/2 & 1 & 2 & 4 & 3 \\ 1/2 & 1/2 & 1 & 3 & 4 \\ 1/3 & 1/4 & 1/3 & 1 & 2 \\ 1/4 & 1/3 & 1/4 & 1/2 & 1 \\ 1/2 & 1/2 & 1/5 & 3 & 4 \end{pmatrix} \begin{pmatrix} 2 \\ 2 \\ 5 \\ 1/3 \\ 1/3 \\ 1 \end{pmatrix} X \begin{pmatrix} 0.289 \\ 0.227 \\ 0.225 \\ 0.069 \\ 0.051 \\ 0.139 \end{pmatrix}$$

$\lambda max = 6.4$

Determine the Consistency Index
CI = 0.08

Find out the Consistency Ratio
= 0.06 < 0.1
Hence the Matrix for Experience is Consistency.
Same procedure is followed for the other criteria's

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7 CALCULATION OF PREFERENCE VECTOR:

7.1 Find out the consistency of all criteria and form the criteria matrix
Table 7.1

CRITERIA	Experience	Finance Stability	Quality Performance	Manpower Resource	Equipment Resource	C.Work Load
Experience	1	2	3	4	5	3
Finance Stability	1/2	1	2	4	4	3
Quality Performance	1/3	1/2	1	3	3	1/4
Manpower Resource	1/4	1/4	1/3	1	2	1/3
Equipment Resource	1/5	1/4	1/3	1/2	1	1/2
C.Work Load	1/3	1/3	4	3	2	1

Hence the Matrix for all Criteria is Consistency.

8. Ranking of the Contractor:
For Ranking the Contractors for each Criteria, the Preference Vector is multiply with the Criteria vector .

Ranking the Contractors = Preference Vector X The Criteria vector .

9. Rank of the Contractor:

Contractor A	=	0.326	Rank I
Contractor B	=	0.244	Rank II
Contractor C	=	0.179	Rank III
Contractor F	=	0.124	Rank IV
Contractor D	=	0.077	Rank V
Contractor E	=	0.052	Rank VI

CONCLUSION
The aim of this paper is to review the employed in selection of the qualified contractor. The contractor selection may be done by multi variable decision making process . Therefore the AHP model is one of the multi variable decision making techniques , it should be used in the solution of six criteria's . The ranking of the contractor are as A > B > C > F > D > E . The Result A is the best qualified construction contractor to perform the project . The AHP approach may not fully reflect a style of the human thinking.

REFERENCE 1 Johansson, J. and Mattsson, L. G.,Inter-organizational Relations in Industrial: A Network Approach Comparedwith the Transaction-Cost Approach,"International Studies of Management andOrganization, Vol. 17, No. 1, pp. 34-48,1987. | | 2 .Tserng, H. P. and Lin, P. H., "An AcceleratedSubcontracting And Procuring Model forConstruction Projects," InternationalJournal of Automation in Construction, 2002,pp. 105-125. | 3 . Tapscott, D., The Digital Economy: Promiseand Peril in the Age of NetworkedIntelligence, McGraw-Hill, N.Y., 1996 | | 4 . Goicoechea, A,, Hansen, D. R. andDuckstein, L., Multiobjective DecisionAnalysis with Engineering and BusinessApplications, Wiley Publishing, New York,1982. | | 5. Satty, T.L., "The Analytic HierarchyProcess", McGrawHill, New York, 1980.4. Zhen-Yuan Deng And Guo-Xiong Zeng,"Application of Analytic Hierarchy Process(AHP) on Intension Characteristic AndAnalytic I", National Statistics Report,pp5~22, 1989. | | 6 . Zhen-Yuan Deng And Guo-Xiong Zeng,"Application of Analytic Hierarchy Process | (AHP) on Intension Characteristic AndAnalytic II", National Statistics Report,pp1~15, 1989. |