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Research Article

Decision Support Model For Construction Through Analytical Hierarchy Process

Udaya Kumar K N[1*] Praveena Kumara K.M[2]

Udaya kumar K N[1] Praveena Kumara K.M[2,]
[1]Department of Mathematics, Reva Institute of Technology and Management, Bengaluru, Karnataka,India.
E-mail: udayakumarakn@reva.edu.in
[2]Department of Mathematics, Reva Institute of Technology and Management, Bengaluru, Karnataka,India.
E-mail: praveenmsk82@gmail.com

ABSTRACT:

The purpose of this paper is to explore selection of the best contractors by the project management by using a decision-support model- Analytical Hierarchy Process (AHP). AHP is used in order to achieve the required purpose. The selection criteria are determined by project managers and experts. Four different contractors are investigated, and best alternative is selected by using AHP. This model can assist project management team in identifying contractors who are most likely to deliver. The benefit analysis is calculated, in order to define decisive result. All calculations are verified by performing a consistency test. Selection criteria and their evaluations can be changed depending on contractors for project.

Keywords: Analytical Hierarchy Process (AHP), Contractor Selection, Multi-Criteria Decision-Making, Project Management.

1. INTRODUCTION

One of the most significant responsibilities of construction client has in order to achieve successful project outcomes is selecting an adept construction contractor. As the construction sector is turbulent and competitive, doing so is difficult. Individual contractors have a high risk of construction failure, according to Kangari and Bakheet (3), and project owners must tackle and manage these risks if they want to achieve successful project results. Unfortunately, this is not always feasible. The selection process should identify a contractor to whom the customer can confidently commit the responsibility of completing the project properly and on time. Acceptance of the lowest offer is stressed in the majority of current selection procedures, and the lowest tender price is frequently stated as the key to securing a contract.
An essential factor of the construction process is the evaluation and selection of contractors prior to the award of a construction contract. A client's representative often performs procedures connected to the pre-qualification of suitable contractors and the evaluation of bids made by pre-qualified contractors, which eventually leads to the selection of a contractor for the project. The creation of adequate and appropriate criteria is required for the eligibility and bid evaluation procedures. In the

[1] Department of Mathematics, Reva Institute of Technology and Management, Bengaluru, Karnataka,India E-mail: udayakumarakn@reva.edu.in
[2] Department of Mathematics, Reva Institute of Technology and Management, Bengaluru, Karnataka,India. E-mail: praveenmsk82@gmail.com

previous two decades, project complexity and development needs have skyrocketed. As a result of this expansion, there has been a rise in the usage of alternate project delivery systems. Qualification and bid evaluation processes, on the other hand, which include the quantification and evaluation of criteria, have remained intact. Selecting a qualified and capable contractor to complete any project increases the likelihood of timely delivery of results that are within the allocated budget and of acceptable quality. Using a decision-making tool such as the AHP to complete contractor selection and qualification can be particularly useful to ensure that a project is successful.

Damjan Maletič et, al.,[1] proposed (i) a framework for maintenance policy selection based on the AHP methodology and (ii) a framework to determine the importance of sustainability factors for employee suggestion schemes. Marc J. Schniederjans et, al.,[4] presented an improved information system (IS) project selection methodology that combines the recently applied IS project selection methodologies of the analytic hierarchy process (AHP) within a goal programming (GP) model framework. Kamal M.A, et, al.,[2] presents group decision-making using the AHP for project management.

Data collected from senior construction engineers, construction managers, contract advisers, and project controllers were among the persons interviewed and met with as part of the contract procurement process and project management.

3. DATA OF THE PROBLEM

3.1 ANALYTIC HIERARCHY PROCESS(AHP)

The stages of the AHP process are described. Each project has a purpose and a set of objectives. They reflect the demands and desires of customers. There are generally numerous options for meeting these needs and desires. As a result, we create a number of situations in the form of projects. We need criteria to choose the best qualified contractor to perform the job. The best criteria for evaluating projects are determined by the project client and the project team.

The technique begins with the creation of a hierarchy of criteria. The decision-making objective or construction goal is at the highest level. Building a hierarchy of criteria and its sub criteria is what structuring project criteria entails. Setting priorities among projects is easier when criteria are broken down into sub-criteria. The hierarchy of criteria represents the structure of the organization's strategy and key performance metrics while also allowing for the selection of constructors based on their alignment with business objectives. Setting suitable and unambiguous criteria is the first issue when choosing among several strategically essential initiatives for our business. When we choose criteria it is almost immediately clear that they are not equally important and that they are interrelated.

The next step is to assign weights to the previously selected criteria and, if required, split the overall criterion weight across sub criteria. Mian and Dai [16] advocate for a pairwise comparison approach to weighing, in which each criterion is compared to each other. Every hierarchic level (comparison of two components belonging to the same group within a hierarchy) and every level of the entire hierarchy is subjected to this pairwise comparison. As a result of this comparison, we can always focus on only two of the criteria at a time. This allows us to determine which criteria are more essential and which are less important for each combination, as well as the difference in importance between them.

When we prioritization the criteria, what technique is used to apply weights to criteria? We normally evaluate two criteria simultaneously and utilize a point framework going from 1 to 9. The pertinence of understanding that the human brain can precisely recognize and consider a couple of things at once is the scale's limitation. Table 1 contains the most dependable guidelines for assessing the pairings. We give the degree of dominance of one element over another in each pair. The exceptional predominance of one criterion over another is given a score of 9, while equality is given a rating of one. Record the reciprocal value if the second criterion is more significant than the first. As a result, we get values in the range of 1/9 to 9. This proportion appraisal approach has been exactly shown to be precise enough for vast majority of issues. A decrease in the balance of assessments would result from a more prominent variety of judgment. Utilize the weighted typical strategy to show up at the last decision. This might be determined by increasing the meaning of the model by the vulnerability level.

The specific steps of the AHP process. Each project has its purpose and its goals. They represent customers' needs and wants. There are usually several possibilities to fulfil these needs and wants. Therefore, we prepare several scenarios in the form of projects. To select most eligible contractor to complete the project we need criteria. The project customer together with project team decides what the best criteria to evaluate projects are.

The fore most step in the process is to develop a norms hierarchy. Decision making goal is the higher level in the process. Structuring project norms defines constructing order of norms and its sub norms. Changing Structuring norms to sub norms benefits manager to set priorities among projects. Norms hierarchy reproduces the structure of organizational strategy and significant performance indicators and provides an opportunity to choose a constructor with respect to its arrangement with business aims. The primary task when an important project selected for our organization is to establish proper and clear norms. When we select a norm, it clearly shows that they are not equally significant and are interrelated.

The second step involves assigning weights to earlier selected norms and, wherever is required dividing total criterion weight among sub norms. Mian and Dai [16] suggested pair wise comparison method to weighting, wherein every criterion is compared with every other criterion. This process of comparison is carried out at each level of hierarchy and for every level of the whole hierarchy. Such comparison permits that one constantly focuses on two of the norms at the time. This way one can found that each combination, which norms are more significant and which norms are less significant and also significant difference between them.

The AHP approach is used in this study to identify the most qualified contractor (Constructor) to finish the project work. In this section, we reviewed the six criteria that were picked from the hierarchy technique for each Constructor. I) Financial situation, ii) Work History, iii) Work Experience, iv) Resources, v) Current Workload, vi) Safety Performance All of the aforementioned factors were evaluated with the primary goal of selecting the most qualified and skilled contractor for the project in mind. The goal of this research was to improve an effective decision-making approach and apply it to contractor qualifying and final selection utilizing different criteria.

Table-1: Scale rating of AHP pair wise comparison between the two parameters.

Scale Rating	Preferences agree (Meaning)	Reciprocal
1	Equally Important	1
2	Equally Moderately Important	1/2
3	Moderately Important	1/3
4	Very Important	1/4
5	Strongly very important	1/5
6	Highly Important	1/6
7	Strongly Important	1/7
8	Very Strongly Important	1/8
9	Excessively important	1/9

3.2 PAIR WISE AND CONSISTENCY

AHP assists with assessment measures by providing a useful approach for examining evaluation consistency and minimizing any arguments in decision-making. This structure is separated into suitable levels of detail, knowing that the more criteria that are provided, the less significant each particular criterion becomes. It also aids to establish decision problem relevant qualities such as objectives and selection criteria between the top and bottom levels. The relative weights of each item are then determined at the appropriate level. The total of all criteria should be one.

According to experience with the Analytical Hierarchy Process, Table -2 describes the procedures for the function Object prequalification problem for the assumption construction project. It depicts an illustrative case for which contractors A, B, C, and D would want to be prequalified. The hierarchy problem might be seen and analyzed using the AHP techniques that were provided.

Table-2: Contractor (constructor) details

Factor	Financial Capability	Past Performance	Past Experience	Resources	Current Workload	Safety Performance
A	8 crore assets	Good	10 years	Manpower -70, 2JCB, 4 Mixer Machines, 6 others	3 big Projects	Good
B	180 crore assets	Average	8 years	Manpower -85, 2JCB,3 Mixer Machines, 8 others	2 big Projects	Good
C	165 crore assets	Good	12 years	Manpower -120, 4JCB, 4 Mixer Machines, 10 others	Two large project nearing completion, 1 major project	Good
D	200 crore assets	Good	15 years	Manpower -90, 1JCB, 2 Mixer Machines, 5 others	3 projects	Good

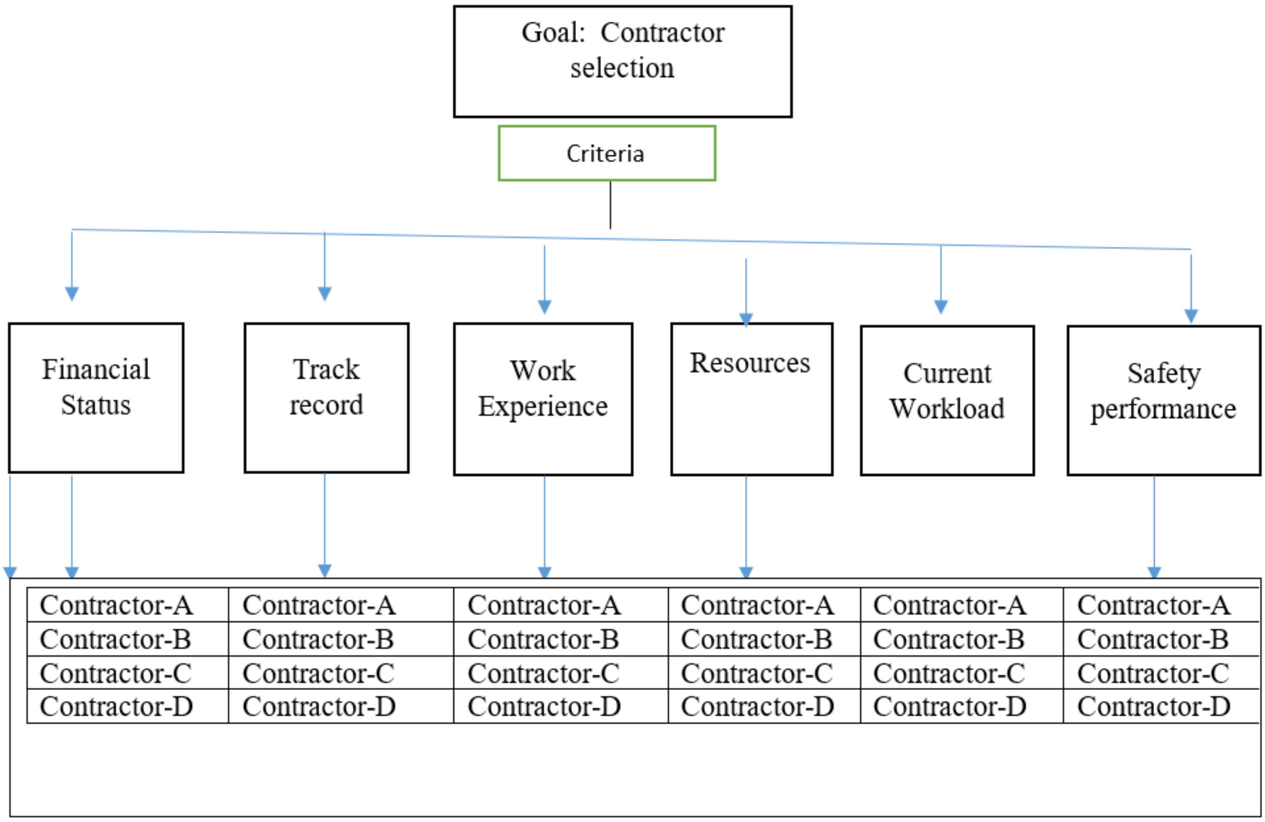

Table-3:- General Analytical Hierarchy Process Model

	Financial Status	Track Record	Work Experience	Resources	Current Workload	Safety Performance
Financial status	1	0.33	0.2	0.11	0.14	3
Track Record	3	1	0.33	0.14	0.33	3
Work Experience	5	3	1	0.2	0.2	3
Resources	9	7	5	1	3	7
Current Workload	7	3	5	0.33	1	9
Safety Performance	0.33	0.33	0.33	0.14	0.11	1
SUM	25.33	14.66	11.86	1.92	4.78	26

Table 5. Normalized Pair-Wise Matrix. Normalizing the matrix means to divide each element in every column by the sum of that column

	Financial Status	Track Record	Work Experience	Resources	Current Workload	Safety Performance	Criteria Weights (AVG)
Financial status	0.039	0.023	0.017	0.057	0.029	0.115	0.047
Track Record	0.118	0.068	0.028	0.073	0.069	0.115	0.079
Work Experience	0.197	0.205	0.084	0.104	0.042	0.115	0.125
Resources	0.355	0.477	0.422	0.521	0.628	0.269	0.445
Current Workload	0.276	0.205	0.422	0.172	0.209	0.346	0.272
Safety Performance	0.013	0.023	0.028	0.073	0.023	0.038	0.033

Table 6. Each criterion Pairwise Comparison Matrix and Normalization Matrix (constructor or contractor), A:- Constructor-1; B:- Constructor-2; C:- Constructor-3; D:- Constructor-4

Pairwise Comparison Matrix					Normalization Matrix					AVG
Financial status	A	B	C	D	Financial status	A	B	C	D	
A	1	2	0.125	0.166	A	0.065	0.143	0.086	0.023	0.079
B	0.5	1	0.166	0.2	B	0.032	0.071	0.114	0.027	0.061
C	8	6	1	6	C	0.516	0.429	0.686	0.815	0.611
D	6	5	0.166	1	D	0.387	0.357	0.114	0.136	0.248
sum	15.5	14	1.457	7.366	E					

$\lambda_{max} = 4.0048$, Consistency Index $CI = 0.0016$, $RI = 0.9$, Consistency Ratio$(CR) = 0.0017 < 0.1$, the degree of consistency is satisfactory (the judgments are acceptable)

Pairwise Comparison Matrix					Normalization Matrix					AVG
Work-Load	A	B	C	D	Work-Load	A	B	C	D	
A	1	0.166	5	0.125	A	0.066	0.023	0.412	0.013	0.129
B	6	1	6	0.166	B	0.395	0.136	0.495	0.018	0.261
C	0.200	0.167	1	8	C	0.013	0.023	0.082	0.861	0.245
D	8	6	0.125	1	D	0.526	0.818	0.010	0.108	0.366
SUM	15.200	7.333	12.125	9.291						

$\lambda_{max} = 3.951$, Consistency Index $CI = 0.016$, $RI = 0.9$, Consistency Ratio$(CR) = 0.018 < 0.1$, the degree of consistency is satisfactory (the judgments are acceptable)

Pairwise Comparison Matrix					Normalization Matrix					AVG
Track Record	A	B	C	D	Track Record	A	B	C	D	Weights
A	1	0.330	0.166	3	A	0.163	0.031	0.013	0.322	0.133
B	3	1	6	0.111	B	0.490	0.095	0.480	0.012	0.269
C	6	0.167	1	5	C	0.980	0.016	0.080	0.537	0.403

D	0.333	9	0.200	1	D	0.054	0.857	0.016	0.107	0.259
sum	10.333	10.497	7.366	9.111						

$\lambda_{max} = 3.951$, Consistency Index $CI = 0.061$, $RI = 0.9$, Consistency Ratio$(CR) = 0.068 < 0.1$, the degree of consistency is satisfactory (the judgments are acceptable)

Pairwise Comparison Matrix					Normalization Matrix					AVG
Safety Performance	A	B	C	D	Safety Performance	A	B	C	D	Weights
A	1	0.166	0.5	5	A	0.137	0.016	0.029	0.381	0.141
B	6	1	0.111	7	B	0.819	0.097	0.006	0.533	0.364
C	2	9	1	0.125	C	0.273	0.873	0.058	0.010	0.304
D	0.200	0.142	8	1	D	0.027	0.014	0.468	0.076	0.146
sum	9.200	10.308	9.611	13.125						

$\lambda_{max} = 4.385$, Consistency Index $CI = 0.0161$, $RI = 0.9$, Consistency Ratio$(CR) = 0.017 < 0.1$, the degree of consistency is satisfactory (the judgments are acceptable)

Pairwise Comparison Matrix					Normalization Matrix					AVG
Work Experience	A	B	C	D	work Experience	A	B	C	D	Weights
A	1	0.33	0.2	1	A	0.100	0.032	0.032	0.098	0.065
B	3	1	0.111	8	B	0.300	0.096	0.018	0.784	0.299
C	5	9	1	0.2	C	0.500	0.861	0.158	0.020	0.385
D	1.000	0.125	5	1	D	0.100	0.012	0.792	0.098	0.251
sum	10.000	10.455	6.311	10.2						

$\lambda_{max} = 4.004$, Consistency Index $CI = 0.0012$, $RI = 0.9$, Consistency Ratio$(CR) = 0.0014 < 0.1$, the degree of consistency is satisfactory (the judgments are acceptable)

Pairwise Comparison Matrix					Normalization Matrix					AVG
Resources	A	B	C	D	Resources	A	B	C	D	Weights
A	1	3	0.2	6	A	0.100	0.287	0.032	0.588	0.252
B	0.33	1	0.111	0.125	B	0.033	0.096	0.018	0.012	0.040
C	5	8	1	5	C	0.500	0.765	0.158	0.490	0.478
D	0.166	0.111	5	1	D	0.017	0.011	0.792	0.098	0.229
sum	6.496	12.111	6.311	12.125						

$\lambda_{max} = 3.968$, Consistency Index $CI = 0.0106$, $RI = 0.9$, Consistency Ratio$(CR) = 0.0117 < 0.1$, the degree of consistency is satisfactory (the judgments are acceptable)

Table 7. Pair wise comparison matrix.

	Financial Status	Track Record	Work Experience	Resources	Current Workload	Safety Performance
Financial status	1	0.33	0.2	0.11	0.14	3
Track Record	3	1	0.33	0.14	0.33	3
Work Experience	5	3	1	0.2	0.2	3

Resources	9	7	5	1	3	7
Current Workload	7	3	5	0.33	1	9
Safety Performance	0.33	0.33	0.33	0.14	0.11	1
SUM	25.33	14.66	11.86	1.92	4.78	26

Table 8. Normalized Pair-Wise and average values of the matrix priority vector.

	Financial Status	Track Record	Work Experience	Resources	Current Workload	Safety Performance	AVG
Financial status	1	0.33	0.2	0.11	0.14	3	0.046
Track Record	3	1	0.33	0.14	0.33	3	0.078
Work Experience	5	3	1	0.2	0.2	3	0.124
Resources	9	7	5	1	3	7	0.444
Current Workload	7	3	5	0.33	1	9	0.271
Safety Performance	0.33	0.33	0.33	0.14	0.11	1	0.032

Table 9. Consistency ratio calculation

	Financial Status	Track Record	Work Experience	Resources	Current Workload	Safety Performance	SUM
Financial status	0.039	0.023	0.017	0.057	0.029	0.115	0.281
Track Record	0.118	0.068	0.028	0.073	0.069	0.115	0.472
Work Experience	0.197	0.205	0.084	0.104	0.042	0.115	0.748
Resources	0.355	0.477	0.422	0.521	0.628	0.269	2.672
Current Workload	0.276	0.205	0.422	0.172	0.209	0.346	1.630
Safety Performance	0.013	0.023	0.028	0.073	0.023	0.038	0.198

Table 10. Ratio of weighted sum value and criteria weights

	SUM	AVG	SUM /AVG
Financial status	0.281	0.046	6.105
Track Record	0.472	0.078	6.049
Work Experience	0.748	0.124	6.030
Resources	2.672	0.444	6.018
Current Workload	1.630	0.271	6.014
Safety Performance	0.198	0.032	6.180
AVG			6.066

4. CONSISTENCY RATIO

- Compute the consistency index (CI) as follows: $(CI) = \frac{(\lambda_{max}-n)}{(n-1)}$ The smaller the CI, the smaller the deviation from the consistency is. If CI is sufficiently small, the decision-maker's comparisons are probably consistent enough to give useful estimates of the weights for their objective
- Compare the consistency index with the random index for the appropriate value of n used in decision making. If $\left(\frac{CI}{RI}\right) < 0.10$, the degree of consistency is satisfactory, but if $\left(\frac{CI}{RI}\right) > 0.10$, serious inconsistencies may exist and the AHP may not yield meaningful results.

The consistency ratio for each criterion at the same level was calculated as follows:

Determine the Consistency Index$(CI) = \frac{(\lambda_{max} - n)}{(n-1)}$
Where λ_{max} is the average of Sum / Weights Column.
n is the number of Criteria,
Random Consistency index table:

Size of Matrix	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Average of Sum / Weights Column
$\lambda_{max} = \frac{(6.105+6.049+6.030+6.018+6.014+6.180)}{6}$
$\lambda_{max} = 6.066$
Consistency Index$(CI) = \frac{(6.066 - 6)}{(6-1)}$
Consistency Index$(CI) = 0.0132$
Consistency Ratio $(CR) = \frac{CI}{RI} = \frac{0.0132}{1.24} = 0.0106$
Consistency Ratio $(CR) = 0.0106$
The result is within the acceptable range because the value of the consistency ratio is less than 0.10.

4.1. COMPLETE PRIORITY VECTOR

The complete priorities were determined by multiplying the priority vectors of the criteria by the priorities for each alternative decision for each objective.

Table 11. Total priority vector with critical weights

Financial Status	Track Record	Work Experience	Resources	Current Workload	Safety Performance
0.046	0.078	0.124	0.444	0.271	0.032

Table 12. Alternatives priority vector (A- Contractor; B- Contractor; C- Contractor; D- Contractor)

	Financial Status	Track Record	Work Experience	Resources	Current Workload	Safety Performance
A	0.079	0.133	0.065	0.252	0.129	0.141
B	0.061	0.269	0.299	0.040	0.261	0.364
C	0.611	0.403	0.385	0.478	0.245	0.304
D	0.248	0.259	0.251	0.229	0.366	0.146

Priority vector for Contractor -A:
$0.079 + 0.133 + 0.065 + 0.252 + 0.129 + 0.141 = 0.133$
Priority vector for Contractor -B:
$0.061 + 0.269 + 0.299 + 0.040 + 0.261 + 0.364 = 0.216$
Priority vector for Contractor -C:
$0.611 + 0.403 + 0.385 + 0.478 + 0.245 + 0.304 = 0.404$
Priority vector for Contractor -D:
$0.248 + 0.259 + 0.251 + 0.229 + 0.366 + 0.146 = 0.250$

RESULTS:

The contractors are now ranked according to their overall priorities, based on the table of values to achieve the project objectives. The best contractor was C (Contractor-C)
A, B, C and D specifying that C is the best eligible contractor (constructor) to complete the project facilities for performing sensitivity analysis, the decision-maker can check the accepting of this decision on the overall priorities of contractors by demanding altered values for his comparison decisions.
Hence we can observe that AHP takes into account individual aspects of all the criteria as well as alternatives and combines them to give the final score.

CONCLUSION:

The AHP procedure is utilized in a variety of decision-making situations. We have chosen to show you how AHP evaluates and selects the best contractor. AHP is capable of expediting the development of construction project tenders. The major strength of AHP is its methodical approach in multiple phases, as well as its capacity to reduce function object subjectivity when deciding between project options. AHP also has a number of flaws when it comes to contractor selection. The first flaw is that it overlooks the fact that certain decisions might have negative consequences. The second constraint is that all criteria must be fully disclosed and accounted for at the start of the selection process, as per AHP. It also permits the organization's more influential members to cheer for their own initiatives while obstructing the open selection process. The procedure is not only difficult to comprehend, but it also necessitates some mathematical work. As a result, we created a simple software tool to assist managers in assessing function Object offers. Simultaneously, this tool allows for easy simulation.
The goal of this paper is to use AHP as a decision-making approach that allows for the consideration of multiple criteria to select the most qualified and capable contractor for project management. A study of contractor requalification was formed to demonstrate AHP application.

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