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Efficient Contractor Selection and Bid Evaluation Methods for Construction Industry in India

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Abstract: ***The prequalification and bid evaluation processes requires the development of necessary and sufficient criteria. The last two decades has witnessed a huge development in project complexity and client's needs and this has led to an increasing use of alternative forms of project delivery systems. In contrast, the prequalification and bid evaluation process, quantifying and the assessment of criteria is still in its original form. Selecting a suitable contractor to execute a particular project is an important decision for the client to take. Awarding construction contracts based on the price only is not always a successful strategy for contractor selection as it could result in construction delays and cost overruns. In addition to price, factors such as quality and safety need to be taken into account when making the contractor selection decision. In this thesis the proposed methods are consisted of the development of quantitative multi-criteria decision making models for bidding. The work also involved close collaboration with construction contractors to obtain data required for the development of the models. The data required to construct the models are collected from top contractors by way of a written structured questionnaire. Finally, the Analytical Hierarchy Process (AHP) is used to assist client in the contractor selection process. The Analytical Hierarchy process provides a flexible and computer based method for contractor selection decision.***

Keywords: CPM

1. Introduction

In competitive bidding, the first decision the contractor has to make is whether to bid or not to bid for a particular project. Once the contractor has decided to bid for a particular job, the team will start by analyzing the job and preparing a cost estimate. The final price charged by the contractor is the sum of the cost estimate and a bid mark-up. The bid mark-up covers the contractor's overhead contribution and profit. Selection of the markup is therefore an essential step in determining the final bid value for a particular project. Depending on the complexity of the project, market conditions, number of competitors and the conditions of contract imposed by the client, the mark-up may also include a risk premium. The value of the risk premium may be determined either from the contractor's historical records, intuitive judgment or a quantitative analysis to take into account probabilities of occurrence of particular events and the magnitude of possible losses should the risky events materialize. Analysis of risk therefore forms an important component of the bidding process, with the overall objective of improving the decision making process.

Many studies have been conducted to assist the bid decision-making process and numerous mathematical decision models have been formulated to analyze construction risk in bidding. In previous methods have modeled the relationship between mark-up and the probability of winning a bidding competition. Several studies have also been conducted to compare the two models. Friedman's bidding model asserts that each bidder's behavior is stochastically independent of all other bidders, reviewed the features of the two models and the approach is need to more applicable to be used in conjunction with his derived general model [1] and [2].

In Recent, developed a utility theory based model for the determination of the mark-up values for construction projects. They used a firm's past mark-up values to determine a recommended bid mark-up. The advantages of a utility-based model are that the decision maker's attitude to risk is explicitly taken into account in the development of the marginal utility functions. They assert that their model could be successfully used to determine the bid mark-up for a construction project considering all types of bidding criteria for selecting of contractor but the process need to improve the sensitivity analysis [3] and [4].

Quantitative methods to determine the bid mark-up based on multiple criteria has been the subject of research by a number of investigators and developed a method for calculating a bid mark-up using the crew-day method, which relates capacity of the firm during a given time period to its particular financial goals and the method to improve the probability of winning in the competitive bidding problem by obtaining additional information concerning key competitors.

Contribute to the construction profession's understanding of risk associated with the closed and open bidding. The research also aims to improve the efficiency of the decision-making process in bidding for construction projects by quantifying the inherent uncertainity and risks. This will be achieved by using the AHP (Analytical Hierarchy Process), as a multiple criteria decision making method. The research aims to develop improved risk based quantitative models to assist contractors in formulating rational bidding decisions.

2. Background Techniques

Criteria for Prequalification Selection Process

Prequalification is a process used to investigate and assess the capabilities of the contractors to carry out a job if it is awarded to them. The process itself has been examined by many researchers. Prequalification provides a client with a list of contractors that are invited to tender on a regular basis. This is the approach most currently used by many countries and in which many and different types of criteria are considered to evaluate the overall suitability of contractors. To gain entry to an approved standing list, a contractor applies initially to the client and is then assessed on grounds of financial stability, managerial capability, organizational structure, technical expertise and the previous record of comparable construction. According to Hunt *et al* (1966), it is necessary to consider technical, managerial and financial criteria. These comprise the applicant's permanent place of business, adequacy of plant and equipment to do the work properly and expeditionary, suitability of financial capability to meet obligations required by the work, appropriateness of technical ability and experience, performance of work of the same general type and on a scale not less than 50% of the amount of the proposed contract, the frequency of previous failures to perform contracts properly or fail to complete them on time, the current position of the contractor to perform the contract well, and the contractor's relationship with subcontractors, or employees [3].

The Tendering Process

There are three distinct stages in the competitive tendering procedure leading to a final agreement between the client/promoter and contractor: Advertising the proposed project: Promoters normally advertise the proposed project in the local and trade publications to encourage qualified contractors to participate and submit an offer to undertake the work.

Q Submitting Offers: the submission of offers by interested and qualified Contractors to undertake the proposed project.

Q Bid Evaluation, consideration and acceptance of the offer: the promoter evaluating each bid and selecting the best bid leading to a contract between the promoter and one of the tenderers.

The Decision Making Process

Decision making is the process of selecting a preferred option from multiple alternatives. This option should provide the most desirable solution of the problem under consideration.

Overview of the Decision Making Process

The general steps for the decision making process is define as:

- **Define the Problem:** It is very important that the decision maker has a clear understanding of what it is he/she is trying to decide. A thorough list of objectives should be developed to make the decision makers aware of potential effects of their decisions.
- **Gather Information:** Information about the problem under consideration can be derived from many sources such as: research, results from experimentation and studies and interviews with experts and trusted bodies. In case of lack of sources, opinions and assumptions are needed.
- **Develop Alternatives:** It is important to identify all possible alternatives to give the decision makers a wide range of alternatives with different tradeoffs.
- **Weigh Alternatives:** After listing all possible alternatives, certain measurements are identified as an indication that each objective can be met. Weights express the importance of each criterion relative to other criteria.
- **Select the Best Alternative:** When the decision makers are satisfied with the alternatives and analyses they choose one alternative for implementation. The selection of the "best" alternative depends on the importance the decision maker places on various objectives.
- **Implement the Solution:** Plans for implementation of the solution need to consider the step by step process or action for solving the problem with a clear identification and allocation of resources. Moreover, the obstacles facing the implementation of this decision and how to overcome them should be included.
- **Monitor Progress and Review:** Monitoring the solution is the only way to ensure that the implementation plan is carried out successfully. As the progress is monitored, if the results are not what was expected, a review of the options and alternatives is needed [4-6].

An Overview of the AHP

The Analytical Hierarchy Process (AHP) developed by Dr. Thomas Saaty in the 1980s, is a powerful and flexible multi-criteria decision making process that helps managers to set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered. Like any good decision tool, the AHP is not designed to substitute for clear thinking by the decision-maker. It does, however, organise their thoughts and makes them more presentable to others. The real strength of AHP, though, is that it treats the decision as a system, which is difficult for many decision-makers to do due to the number of factors involved in a complex decision. The AHP model breaks down the complex structure of the decision process to a hierarchical sequence in order to determine the relative importance of each alternative through pair-wise comparisons [7-8] and [11].

3. Literature Survey

Brief Literature Review on Contractor Selection

Fong and Choi (2000) developed a contractor selection model using the Analytical Hierarchy Process. Data required for this study was collected by conducting a questionnaire survey among public organisations in Hong Kong. The eight main criteria which have been considered in this paper were: tender price, financial stability, past performance, past experience, resources, current workload, past client-contractor relationship and safety performance. The results revealed that tender price is the most important factor to contractor selection followed by the financial stability then the past performance, past experience, resources, current workload. past client/contractor relationship and finally the safety performance. The model was tested by a hypothetical scenario where three contractors were evaluated. Hatush and Skitmore (1998) presented the Utility Theory as a multi-criteria technique for contractor selection. Twenty four factors were taken into account and were categorized into six groups: the bid amount, the financial soundness, the technical ability, the management capability, the health and safety records and reputation. A hypothetical case study where five contractors are bidding for a multi-story building project was illustrated in this paper. Interviews with four leading professionals involved in contractor selection were conducted to assign utility values to different criterion in order to build the utility functions. The results showed that the bidder with the lowest price was ranked third which indicates that the other factors need to be considered when making the contractor evaluation.

Banaitiene and Banaitis analysed the issues related to the evaluation of contractors' qualification in Lithuanian companies. The required data was obtained through a questionnaire survey. Four contractor evaluation criteria were considered in this study: the bid price, legal requirements, financial criteria and technical and management criteria. The participants in the questionnaire were asked to evaluate how important each criteria for the contractor selection. The results indicated that the bid price is the most important criterion in the selection of contractor in Lithuanian and clients are selecting contractors on the basis of the tender price only.

Yawei, et al. employed an approach called the Multiple-layer Fuzzy Pattern Recognition (MFPR) to contractor selection problem. The pair-wise comparison method was used to decide relative membership degrees of qualitative criteria as well as weights of the criteria set. The feasibility of this approach was illustrated by including a case study for a channel construction project. The outcome from this paper revealed that the MFPR may assist in contractor selection decision-making process, as it can deal with different opinions in order to reach a decision.

Lee, et al (2000) examined graduate students' preferences among a set of four learning activities commonly employed in adult educational settings using the Analytical Hierarchy Process. These four activities were lectures, in-class discussion and reflections, group based projects and individual projects. A questionnaire was designed to rate the strength of their pair-wise preferences and was given to 134 students with ages ranging from 23 to 48. The result of their study showed that adult graduate students prefer to learn by discussion and reflection as opposed to lecture and prefer individual to group projects.

Inomata, A. et al (2002) employed the AHP method to recognize important parameters that would influence the effectiveness of the web-based learning system and would characterize the difference between classroom learning and web-based learning. They identified learning environment, teacher's presentation and motivation for learning as factors affecting the learning style. The learning environment factors was divided into ease of interaction between learners, ease of interaction with the teacher, space convenience, time convenience, presence and atmosphere and richness of teaching material. Teacher's presentation consisted of the following factors: talk and tone, the way to explain teaching materials and the way to summarise teaching materials. Finally, the motivation for learning included concentration, eyestrain, ear-strain and tension and sense. Several experiments were conducted and 68 students studied themselves using

web-based system. For the evaluation by the AHP, students were asked to fill in two questionnaire sheets, one was for the pair-wise comparisons between each two factors in turn and the other was to give a weight to web-based and classroom learning to each criteria. Results showed that concentration is the most important factor while ease of interaction is the least important factor.

El-Mikawi, M. et al (1996) developed an AHP model that allows decision makers to select an optimal structural material for infrastructure repairs and construction. As a case study, this model was applied to test the use of advanced composite materials in the repair of deteriorated and damaged bridge columns in Washington. Two alternative materials were considered, either the use of composites made of carbon fibers or the use of conventional steel jackets. Performance, economic analysis, environmental aspects, codes, material availability and architectural aspects were the factors included in this study. Structural performance was found to be the most important factor and of equal importance to the economic indicators while, architectural aspects was the least important factor. The resulting AHP model recommended the selection of composite materials over the steel jackets.

Dey (2001) suggested a project management model with the application of risk management principles. Both analytical hierarchy process and decision tree analysis were used in this study. A cross-country petroleum pipeline project for constructing three pump stations in India was used as a case study. Technical risk, Financial, economical and political risk and organizational risk were among the identified factors in structuring the model. The results revealed that technical risk is the major factor among other considered factors for time and cost overrun of projects. The study concluded that the AHP is an effective means for managing a complex project and that it also can improve the team spirit and motivation.

4. Proposed Methodology

Our proposed methods are consisted of the development of quantitative multi-criteria decision making models for bidding. The work also involved close collaboration with construction contractors to obtain data required for the development of the models. The data required to construct the models are collected from top contractors by way of a written structured questionnaire. Finally, the Analytical Hierarchy Process (AHP) is used to assist client in the contractor selection process. The required data is obtained from real life case study for Contractor Selection. A comparison between the points method, which has been used in the case study as a method of evaluation, and the Analytical Hierarchy Process.

Proposed Multi-Criteria Contractor Selection Model

Contractor selection is the process of choosing the most appropriate contractor to execute the project under consideration. It is a crucial part of the construction process as it affects the progress and success of any project.

Awarding construction contracts based on the bid price as the main criteria could influence the contractor's pricing. Contractors may tend to use cheaper, lower quality materials, using insufficient materials, and taking serious health and safety risks on jobs to ensure greater profits. This is why the client has to take other criteria into account when evaluating the submitted bids and not to award the contract to the lowest price only.

To consider other criteria when evaluating the submitted tenders, multi-criteria decision analysis methods can be used. This chapter compares two methods of Contractor Selection: the points method and the Analytical Hierarchy Process (AHP), which is a multi-criteria decision making method. The two methods are applied to a real life case study for Contractor Selection. The points method was recommended in the tender documents of the case study to evaluate the submitted tenders.

Tender Evaluation and Submission

Tenders were assessed on the basis of quality and price and must remain valid for 90 days. The tender must be submitted in two parts, comprising a' Quality Submission' which should be contained in Envelope A and a' Financial Submission' which should be contained in Envelope B. The envelopes are to be clearly marked 'A' or 'B' and the name(s) of the Tenderer(s) is to be clearly marked on the outside of each.

- Both envelopes should then be sealed in an outer envelope clearly marked
- Tenderers should ensure that no names, addresses, post stamps or markings indicating the identity of the Tenderer and to be marked on or affixed to the outer envelope.
- Tenders should be sent by registered post, recorded delivery by courier or hand delivery in a plain sealed envelope. The outer envelope must be clearly marked

Envelope A: Quality Submission

Envelope A shall contain statements in response to the questions contained. The questions have been separated into General Scheme Management, Design Phase and Construction Phase, under the headings listed below.

General Scheme Management

1) Overall Approach, Methodology and Programme
2) Innovation and Continuous Improvement Strategy
3) Public Relations
4) Risk
5) Target Cost and Activity Schedules
6) Open Book Accounting
7) Quality and Key Performance Indicators
8) Staff for the Project
9) Approach to Partnering

Design Phase

10) Estimate of Time Based Hours for Works in Design Phase
11) Environmental Impact Statement
12) Environmental Data Requirements
13) Design Development
14) Compulsory Purchase Orders
15) Oral Hearing
16) Construction Phase
17) Construction Issues
18) Safety and Health
19) Construction Environmental Management
20) Handover and Maintenance

Envelope A also contains the following:

1) Written undertakings stating the Tenderer's willingness, if awarded the contract, to accept the appointments and duties of Project Supervisor for Design Stage and Project Supervisor for Construction Stage (to include the nomination for Project Supervisor).
2) Summary of relevant insurance policies including certificates where appropriate.
3) Statement undertaking responsibilities for dealing with insurance claims or parts of such claims within the excess amount.
4) A list of the constituents of the Fee percentage (without any financial information)
5) The completed Contractor's Risk Register.
6) The completed staff schedules for Design Phase

Envelope B (Financial Submission)

Envelope B shall contain the following:

1) The completed Letter of Tender incorporating the anti-collusion certificate and Form of undertaking (Performance Bond) and (if a joint venture) a copy of the joint venture agreement and a statement that the parties to the JV will be jointly and severally bound for performance for the contract.
2) The completed Contract Data Part 2
3) The completed Staff Rate

Marking of the Tenders, Quality and Financial Panels

Each tender submission will be assessed by two separate panels: a Quality panel and a Financial Panel.

Quality Panel

The Quality Panel will meet prior to the Financial Panel to assess quality scores and will award marks, based on the tender criteria against the quality aspects..

Table1: Standard Marks for Quality Questions

	Criteria	Marks
A	Very high standard with no reservations at all about acceptability	10
B	High standard but falls just short of A	8-9
C	Good standard and requirements met but some reservations	5-7
D	Acceptance with significant reservations but not sufficient to warrant rejection	1-4
E	Fails to meet requirements	0

All Tenderers will be interviewed at their office by the Quality Panel to enable the panel to clarify any matters in connection with the Tenderer's quality submission. New information shall not be introduced by the Tenderer at the interview. Key members of staff proposed for the contract shall attend. The date, time and precise place of the interview and the numbers attending shall be agreed between the Tenderer and the project Manager at least 14 days in advance of the interview date. The interview will include inspection of documents relating to other ongoing projects to validate the quality and approach to the Tenderer.

Financial Panel

The Financial Panel will appraise the financial element of the tender independently of the Quality Panel and after the Quality Panel has completed the assessment outlined above. The financial score will be carried forward to the final tender assessment.

Quality Scorings

The Quality Panel will award marks against the tender score criteria. The quality threshold below which tenders will be returned to the Tenderer with Envelope B, Financial Submission, unopened is 50 marks out of the 100 available or a zero mark against any one quality section. Weightings appropriate to the importance of each aspect will be applied to the marks awarded for each question in the quality submission. After weighting, the highest scored tender will be allocated 100 marks. Other tenders will be allocated marks on the basis of two marks reduction for each mark lower than the highest marked tender. The quality score for each tender will be carried forward to the final tender assessment.

5. Financial Scorings:

The financial scoring will be split into three areas for assessment:

a) Hourly Rate by staff grade for Design Phase

The hourly rates by staff grade in the Design Phase, should be completed in accordance with the instructions given and only included in the Financial Submission, Envelope B. These rates will be inserted into a model prepared by the Employer containing his estimate of the number of hours required for the key members of staff and other supporting staff, to produce an estimate of the design fees payable in the Design Phase.

The Design Phase fees will be compared by allocating the lowest fee (of those achieving the minimum quality standard) 100 marks, and then allocating other design fee marks on the basis of a reduction of one mark for each percentage point increase in fees. The hourly rates by staff grade in the Design Phase will make 20% of the overall financial assessment.

b) The Fee % for the construction Phase entered in Contract Data.

The fee % will be compared by multiplying the scheme cost estimate by each Tenderer's fee % to calculate a notional value of the fee purely for tender assessment purposes. The upper and lower fees in the range of submissions will be disregarded and average of the remaining three will be calculated. Marks will be calculated by allocating the average fee (of those achieving the minimum quality standard) 50 marks and then allocating other tendered fees on the basis of a reduction or addition of one mark for each percentage increase or decrease in fee. The lowest fee will result in the highest mark. The constituents of the fee % entered will only form part of the quality assessment and must not be included in the Financial Submission. The fee percentage will make up 40% of the overall financial assessment.

c) Schedule of Rates

The schedule of rates for work shall be completed in accordance with the instructions given and only included in the Financial Submission, Envelope B. These rates will be inserted into a model prepared by the Employer containing his estimate of the principal quantities to produce an estimate of the cost of the works. The cost of the works will be compared by allocating the lowest cost (of those achieving the minimum quality standard) 100 marks and then allocating other costs on the basis of a reduction of one mark for each percentage point increase in cost. The schedule of rates will make up 40% of the overall financial assessment.

Final Tender Assessment:

The contract will be awarded to the Tenderer submitting the most economically advantageous tender in accordance with the award criteria. The individual award criteria which will be taken into account in making this assessment are: quality, which will account for 70% of the overall score and price which will account for 30% of the overall score. Following the calculation of the weighted overall marks, the highest overall score will be compared with any other scores that lie within 5% of this score. The tender with the best financial score of those within this range will be considered for award of this contract.

Contractor Selection Using the Analytical Hierarchy Process

This section shows how the Criterium Decision Plus can be employed to assist in the Contractor Selection decision.

Quality Assessment:

For the analysis, the Quality Assessment is divided into three main groups: the General Scheme Management, the Design Phase and the Construction Phase.

General Scheme Management:

The brainstorming session for the General Scheme Management is shown in Figure 1

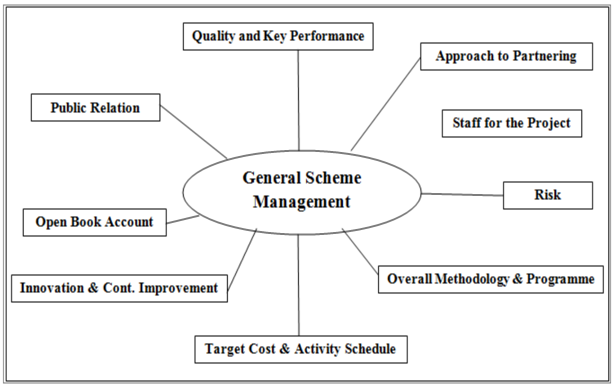


Figure 1: General Scheme Management (Quality Assessment)

The brainstorming session is followed by the generation of the General Scheme Management hierarchy. The hierarchy is built automatically based on the brainstorming session as shown in Figure 2.

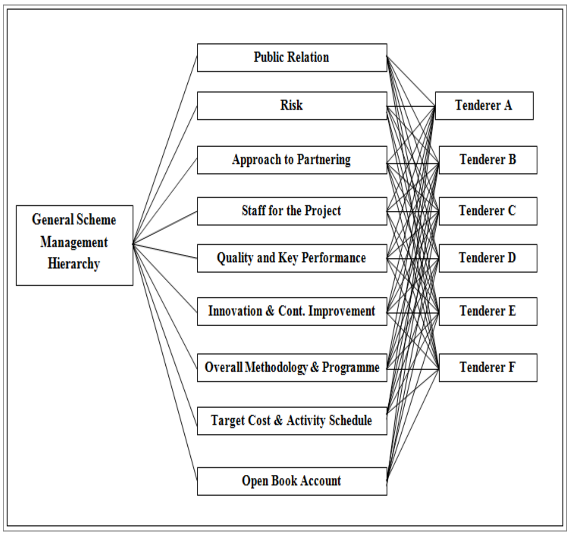


Figure 2: The General Scheme Management Hierarchy

6. Data Collection

The data needed for conducting the validation and testing of the proposed models are collected from a Contractor. Five to ten meetings are held with the contractor to gather the required data. The contractor is first asked to provide his general profile by completing the questionnaire survey. It can be seen that this contractor is a good representation of the other surveyed contractors as the company is specified for the three main types of projects and others as well. The company has been running for 5-15 years in industry which represents the 77% of the companies under study. It has between 10-20 permanent staff while 60% of the participated contractors have the same number of staff. The average job size executed in India is high for this particular contractor while (70%) of the surveyed contractors are executing the same average job size. This contractor is executing projects with an average duration of 6-12 months which represents 50% of the other contractors. The contractor is subcontracting between 51-75% of work on average job where 40 % of the contractors filled in the questionnaire are subcontracting the same percentage. The contractor is obtaining the majority of his work by competitive bidding which is the main concern in our study. The contractor is depending heavily on mathematical models in making bidding decisions. Three real life projects are selected as alternatives for the developed models. These projects are selected to represent different types of engineering work; the main activities involved in these projects are: civil, electrical, mechanical, finishing and external works.

7. Results Analysis

Analytic Hierarchy Process

Conceptually, the AHP is a three-step process that enables a decision maker to resolve the daunting task of multiple criteria optimization into an objective algorithmic approach. First, a hierarchy consisting of the possible outcomes and subordinate (intermediate) features influencing these outcomes is constructed. In the application scenario presented later in this paper, the end outcome or *goal* is to choose among competing BMP alternatives the optimal measure capable of addressing all required pollutant removal performance targets while simultaneously proving to be the most economically attractive option. The step enables priority weighting of the criteria influencing the outcome decision, as well as ranking of the *possible outcomes* in terms of performance for each criterion. Finally, matrix algebra propagates level-specific, local priorities to global priorities. Fundamentally, the AHP algorithm operates by prioritizing competing alternatives as well as the criteria used to judge the alternatives. This prioritization procedure places weights on the influential selection criteria, thus accommodating the varying scales and units exhibited by these criteria.

Construction of Pair-wise Comparison Matrices

The first step in performing the AHP is to identify all possible alternatives from which a single alternative is selected. Next, it is necessary to identify all relevant criteria influencing the selection of a single alternative from the pool of feasible alternatives. Because the numerous selection criteria exhibit varying units (or in some cases no units at all), mathematical evaluation of the criteria requires the operator to determine the *relative* scale, or weight, of the alternatives in terms of each criterion. This task is accomplished by employing Table 5.8. Table 5.8 was first proposed by Saaty for determining the dimensionless scale of relative importances. This table and others developed since Saaty's initial work, permits pairwise comparisons within the AHP. "In this approach the decision-maker has to express his opinion about the value of one single pairwise comparison at a time." (Triantaphyllou & Mann, 1995) In other words, within every hierarchal comparison matrix, the user must compare *each* competing alternative against every other competing alternative employing a scale of relative importance. This type of comparison is executed for each influential criterion, and ultimately the influential criteria are compared and ranked against themselves.

Employing the scale of relative importances, one is able to construct *judgment matrices* for *each* selection criterion. This step evaluates the performance of each possible alternative against the other alternatives in terms of the various selection criteria. These judgment matrices are of dimensions *MxM*, *"M"* being the total number of alternatives considered. The final judgment matrix is termed the *criteria judgment matrix* and evaluates and ranks the importances of each of the influential criterion when compared against the other criteria. The criteria judgment matrix is of dimension *NxN*, *"N"* being the total number of influential criteria. It is during the construction of the criteria judgment matrix that the operator is able to prioritize the criteria influencing the selection of the competing alternatives.

Table 10: Scale of Relative Importance

Intensity of Importance	Definition
1	Equal Importance
3	Weak importance of one over another
5	Essential or strong importance
7	Demonstrated importance
9	Absolute importance
2,4,6,8	Intermediate values between the two adjacent judgments

Entries into the judgment and criteria judgment matrices are expressed in terms of the importance intensities illustrated in Table 5.8. For instance, consider a judgment matrix comparing alternatives *"A," "B,"* and *"C"* in terms of criterion *"N."* "By convention, the comparison of strength is always of an activity appearing in the column on the left against an activity appearing in the row on top." An element in the matrix is equally important when compared with itself, and thus the main diagonal of all judgment matrices must be 1. Employing Table 5.8, consider the following scenario:

- In terms of criterion "*N*," *A* is demonstrably more important than *B*. In practice, such a comparison would indicate that, in terms of satisfying criterion "N," alternative *A* strongly outperforms alternative *B*.
- In terms of criterion "*N*," *C* is weakly more important than *A*. In practice, this comparison expresses that, in terms of criterion "*N*," alternative *C* is slightly superior to alternative *A*.

Data Analysis and Results on Questionnaire Survey

This section is concerned with the analysis of the results obtained through the questionnaire survey. The questionnaires were completed by top management in the organizations, mainly directors, who usually make project selection and mark-up decisions. Eight completed copies of the questionnaire were filled in English while twenty two were Arabic versions.

Section One:

The following are the results obtained by analyzing section one of the survey questionnaires.

Mainly, the characteristics of the participating contractors are given. To obtain the criteria for selection of contractor and bid evaluation which participated in the survey, company specialization details were asked for as a part of the survey questionnaire. As shown in table (11) and Figure (3),. Where percentage of priority vector are given in table 11 and figure 3.the overall result .we obtained the main factor is as Need of work.

Table 11: Criteria factor for Selection of Contractor and bid evaluation

S.No.	*Criteria factor*	*Percentage of Priority vector*
1	Payment Method(PM)	19
2	Need for Work(NW)	25
3	Company Strength(CS)	13
4	Project Type(PT)	06
5	Experience in Such projects(ER)	10
6	Owner Client and consultancy Identity(OC)	10
7	Contract Condition(CC)	08
8	Competition and Risk fluctuation in material process(CR)	05
9	Past profit in similar project(PP)	04

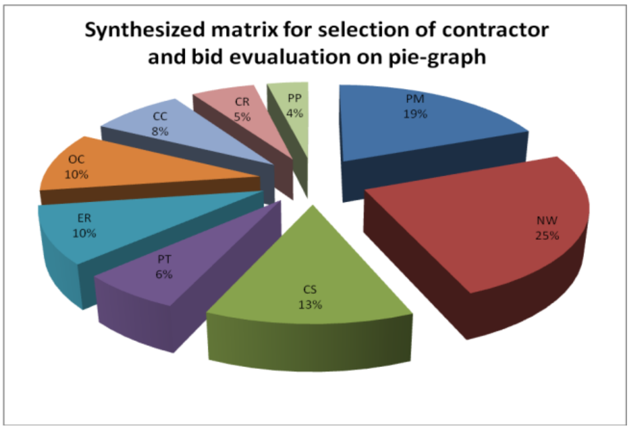
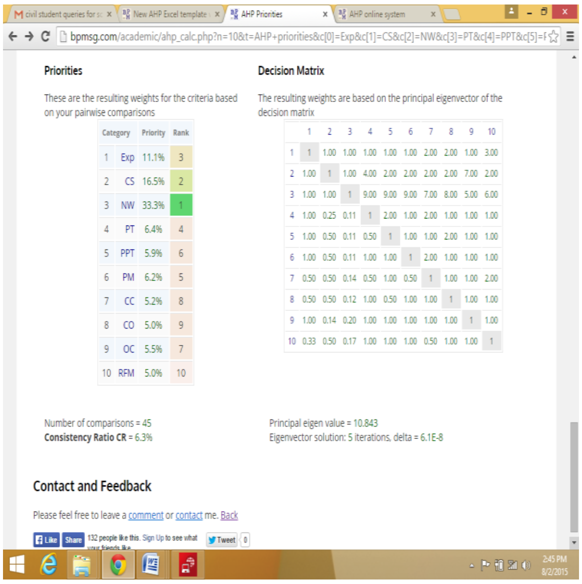


Figure 3: Criteria factor for Selection of Contractor and bid evaluation

AHP comparison table 12



	Category	Priority	Rank
1	Exp	11.1%	3
2	CS	16.5%	2
3	NW	33.3%	1
4	PT	6.4%	4
5	PPT	5.9%	6
6	PM	6.2%	5
7	CC	5.2%	8
8	CO	5.0%	9
9	OC	5.5%	7
10	RFM	5.0%	10

	1	2	3	4	5	6	7	8	9	10
1	1	1.00	1.00	1.00	1.00	1.00	2.00	2.00	1.00	3.00
2	1.00	1	1.00	4.00	2.00	2.00	2.00	2.00	7.00	2.00
3	1.00	1.00	1	9.00	9.00	9.00	7.00	8.00	5.00	6.00
4	1.00	0.25	0.11	1	2.00	1.00	2.00	1.00	1.00	1.00
5	1.00	0.50	0.11	0.50	1	1.00	1.00	2.00	1.00	1.00
6	1.00	0.50	0.11	1.00	1.00	1	2.00	1.00	1.00	1.00
7	0.50	0.50	0.14	0.50	1.00	0.50	1	1.00	1.00	2.00
8	0.50	0.50	0.12	1.00	0.50	1.00	1.00	1	1.00	1.00
9	1.00	0.14	0.20	1.00	1.00	1.00	1.00	1.00	1	1.00
10	0.33	0.50	0.17	1.00	1.00	1.00	0.50	1.00	1.00	1

8. Conclusion and Future Works

8.1 Conclusions

1) Many studies have been conducted in India to assess the efficiency of the online reverse auctions. The main conclusions drawn from these studies are that the adoption of the on-line auctions can result in cost savings for clients. While, the main drawback of auctions is that award of the contract is mainly driven by the lowest price rather than best value or quality.
2) The results of the questionnaire survey conducted in from previous studies that profit is not the most important factor when making the bid/no bid decision. It indicates that the need for work is the most important factor among all other factors examined when making the bid/no bid decision. This is followed by the company strength in the industry. Payment methods and owner/client and consultant identity also have high importance. Past profit on similar projects, project type, experience in such projects and contract conditions has moderate importance in the bid/no bid decision. Finally, competition and risk of fluctuations in material prices have low importance in the bid/no bid decision.

3) The results of the survey also support earlier findings that profit is not the most important factor when making mark-up size decisions. The results revealed that the need for work, owner/client and consultant identity, project size and project type are the most important factors to be considered when making the decision. The least important factors are the competition and the risk of fluctuations in material prices. Past profit on similar projects, experience in such projects, contract conditions, project duration and project location have moderate influence on the decision.
4) The developed multi-criteria model for mark-up decision, based on the analytical hierarchy process, can be easily used by contractors in the construction industry to determine which project will result in higher mark-up. This model takes into account various factors affecting mark-up decision.
5) Awarding contracts based on the price only is not an effective method as it affects the contractor's price. A number of factors need to be taken into account to make the contractor selection decision. When applying the AHP to a contractor selection decision presented by the Criterium Decision Plus, and the points method, both methods gave the same recommendation. The advantage of the Criterium Decision Plus over the points method is that it is a computer based model which can be modified by adding/ deleting factors or by changing the rates which then will be reflected automatically on the results.
6) There are many decision making methods and versions of these methods, all of which have the potential to improve the accuracy of a mere intuitive decision. The AHP however is an elegant decision making method that can be applied through a spectrum of decisions, from critical decisions to choosing the next destination for a family holiday. Commercial software and spreadsheet techniques have reduced the need to perform computations and calculations, making the AHP accessible to novices. For aided decision making the AHP is the recommended method. Critical and high impact decisions require insight into the problem. A sensitivity analysis as demonstrated in Section 5.4 enables the decision maker/s to obtain a deeper understanding of the problem while it simultaneously provides a check for the correctness of the numbers. To improve the confidence in the outcome it is important to perform a sensitivity analysis following the result of an important decision. Currently there is very little literature regarding this aspect of the AHP. Research into the development of more formal and structured techniques of sensitivity analysis is recommended. The sensitivity analysis has the potential to add most value to aided decision making provided it can be performed formally and structured by addressing specific issues such as judgement heuristics, rank reversal or checking the correctness of the numbers.

8.2 Expected From Government of India

The following recommendations are expected from government authorities.

1. The government must create a climate of economic stability that is sufficient to inspire investors and contractors, especially in the production of construction materials to be produced from local materials and production of enough quantity and quality of construction materials in the local market, this will curtail excessive price fluctuations associated with imported construction materials.
2. Government need to create opportunity for domestic consultants in the construction industry to work as joint venture with foreign consultancy firms for selection of contractors with modern methods.
3. For professionals on contractor selection committee for firms on the construction industry, the Government needs to take programs for institutional strengthening and man power development in the areas of construction project management.

8.3 Future Works

To further work on the on-line reverse auctions. Areas such as security issues, ways to ensure the capability of the participating contractors and the tasks that should be performed by consultants and contractors to participate in an electronic auction must be explored.

To utilize the fuzzy sets theory to quantify the uncertainty and risk involved in making bidding decisions. Then to evaluate its effectiveness in practice and furthermore compare it with the outcome from the Analytical Hierarchy Process.

To expand the work on the mark-up decision model to assist the contractor, by further introducing a mark-up percentages to the hierarchy, as alternatives. Then, apply it to real life projects and assess the results.

Linear Programming is an interesting field of study that has not been studied in depth and that should be more detailed in further works. The application of the linear programming in contractor selection needs to be explored. The difference between the linear programming, point's method and the Analytical Hierarchy Process when applied to the contractor selection is another area of study.

Another method of validation which needs to be considered in the future is to encourage contractors to apply the developed AHP models in real life situations. This can be achieved by conducting training sessions and presentations to educate the industry of how to use the models. Further work would be constructing the contractor selection model using the full version of the Criterium Decision Plus to enable the clients to handle the contractor selection model easily.

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