Facilitating Building Owners Through Developing of Strategies for Selection of Maintenance Contractor

By

Osama Farid

(Registration No: 00000363807)

Department of Construction Engineering & Management

NUST Institute of Civil Engineering

School of Civil and Environmental Engineering

National University of Sciences and Technology (NUST)

Islamabad, Pakistan

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Osama Farid

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NUST Institute of Civil Engineering

School of Civil and Environmental Engineering

National University of Sciences & Technology (NUST)
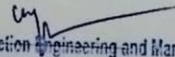
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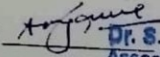
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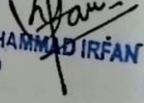
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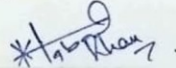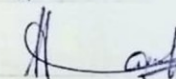SCEE, NUST

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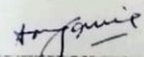
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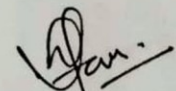
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HoD Construction Engineering and Management
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National University of Sciences and Technology

(Associate Dean)
Dr. S. Muhammad Jamil
Associate Dean
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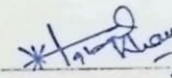
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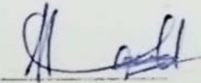
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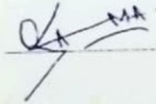Assistant Professor
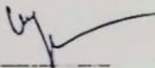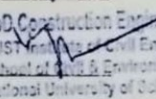
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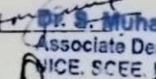
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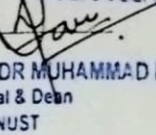
Name of HOD: Dr. Muhammad Usman Hasssan   Signature: _____
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NUST
School of Civil & Environmental Engineering
National University of Sciences and Technology

Name of Associate Dean: Dr. Syed Muhammad Jamil   Signature: _____
Dr. S. Muhammad Jamil
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ABSTRACT

It has been observed that since last few decades maintenance activities are solely more than 50% of total construction activities. It has been reported in last few decades maintenance work ratio is increasing yearly. Hence it also shows that maintenance is clearly an important and big issue as efficient maintenance work holds the key to better operation facility, for this maintenance strategies and selection of appropriate maintenance contractor plays an important role. Traditionally contractor is selection is a process purely based on low price contract. Best value procurement is other method of procurement arises due to increase the complexity of projects & increasing awareness of maintenance. But a limited work is carried out for maintenance contractor selection process also these best values approaches come with lack of substantiation knowledge for the factors include in the best value approach, which make the model difficult to adopt and there is no strategies of evaluating criteria are mentioned, hence this research aims to provide best value selection criteria through introducing of Analytical Hierarchy Process (AHP) analysis for maintenance contractor selection process along with the substantiation knowledge of factors to enhance owner ability in selection process of maintenance contractor. For this goal 17 factors are divided into 5 criteria and pairwise comparison of among criteria and attributes has been done from consultants. The attributes have been given local and global weights through AHP procedure. Our result shows that past performance of contractor has the most weightage criteria among all. The strategies for substantiation of the factors are also discussed, which is primarily achieved through interviews with industry consultants. Final best value framework has been made which shows the weightages of criteria and attributes along with strategies through which those attributes can be evaluated.

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CHAPTER 1: INTRODUCTION

1.1 Background:

Like human building components also have life cycle which starts from the point its start operating, however its end is difficult to predict because it highly depends on its maintenance facilities time to time, without which it can be endure until collapse (Silva, de Brito et al. 2022). Now a days along with basic living space people also focuses on quality of services provided, whenever affordable people the value-added facilities provided in an area, these facilities include security, power supply, fire services & elevators etc , Nevertheless, all these services and facilities require maintenance to upkeep their conditions in acceptable level (Au-Yong, Ali et al. 2019). Building owners worldwide envisage an optimum, conducive, and safe indoor environment for the tenants. Subsequently, several previous studies have determined the factors affecting the end-user satisfaction (Mohammadpour, Karan et al. 2015).

For ensuring end user satisfaction, it is necessary that the services and facilities are available seamlessly without any disruption Without proper maintenance, the facilities provided unable to support the intended function and retain its value. These services primarily constitute the mechanical, electrical, and plumbing facilities, such air conditioning, sewerage, lighting, elevators, etc. The performance of facilities is highly dependent on their effective maintenance (Swanson 2001). The longevity and use of building components and facilities are heavily reliant on their care and the commitment of the maintenance contractor. To maintain the efficiency, dependability, and safety of their assets, organizations in a range of industries must carefully select

their maintenance contractors (Tsang 2002). Similarly, other building components life and usage is highly dependent of its maintenance.

1.2 Maintenance Work:

It has been observed that since 2002 maintenance activities are solely more than 50% of total construction activities (Lam, Chan et al. 2010). It has been reported in last 10 years the maintenance activities increases by 66% and it increases by 43% in between early 90's and 2000 compare to only 28% maintenance work of total construction (El-Haram, Marenjak et al. 2002, Wood 2005). Hence it also shows that now maintenance is clearly an important and big issue (Wood 2005).

1.3 Maintenance Contractor:

Efficient maintenance work holds the key to better operation facility, for this maintenance strategies and selection of appropriate maintenance contractor plays an important role. Traditionally contractor is selection is a process purely based on low price contract (Waara and Bröchner 2006). Best value procurement is other method of procurement arises due to increase the complexity of projects & increasing awareness of maintenance(Bruno, Gelderman et al. 2018). Best value procurement method removes a weakness in selection criteria purely based on price with dissatisfaction of contractor, Best value criteria increases the competition in a construction industry leads to innovation (Ying, Zhao et al. 2022).

A critical component in best value process is to determine the correct evaluation criteria for specific work (Perrenoud, Lines et al. 2017). Hence, it is imperative that the

building owners have some benchmarks to select Maintenance Contractors. Subsequently, they can identify the areas of weakness and suggest necessary changes to promote end user satisfaction.

The Problem at hand is the lack of substantiated knowledge and understanding regarding the factors that contribute to the selection of maintenance contractors based on based value. Best value refers to a holistic approach so without comprehensive knowledge of these factors' substantiation organizations may struggle to make informed decisions when choosing a maintenance contractor, potentially leads to subpar performance and increase costs.

Therefore, this research aims to facilitate the building owners in two different ways by providing a substantiated framework that organizations can utilize to make well informed decisions when selecting maintenance contractor through best value approach.

(1) To develop a framework for the best value selection criteria Maintenance Contractors

(2) To devise strategies to enhance owner ability to evaluate/Substantiate maintenance contractor Performance indicators.

1.4 Research Gap:

The current best value selection procedure for maintenance contractor comes with attribute weightages but without any strategies on how to evaluate these criteria while selecting maintenance contractor, this also leads to include those attributes in selection models which are practically impossible to substantiate at time of procurement

of maintenance contractor, which make it practically impossible to adopt the best value practices in selection procedure of maintenance contractor.

1.5 Problem Statement:

Inefficient maintenance contractor selection practices with lack of substantiation strategies inhibit in selection of competent maintenance contractor & effect project success. This research explores strategies for substantiated best value attribute assessment in maintenance contractor selection.

1.6 Research Objectives:

- To identify the factors influencing the selecting criteria of maintenance contractors.

- To develop a framework for employing of maintenance contractor.

- To devise strategies to facilitate owner in substantiation of factors in best value process.

1.7 Research Significance:

By addressing these research objectives, this study will provide a substantiated framework that organizations can utilize in to make well informed decisions while selection maintenance contractor which will lead to enhanced maintenance outcomes and cost saving.

CHAPTER 2:   LITERATURE REVIEW

2.1 Traditional Selection Method:

Contractor selection is one of the most crucial tasks undertaken by the project owner to ensure the successful execution of the work, it is an all-around, challenging, and exhaustive process requiring consideration of numerous interrelated factors and uncertainties simultaneous in order to produce a knowledgeable decision (Le, Jeong et al. 2020). Incompetency in selection process can affect future decision process (Singh and Tiong 2005). Most of the time, selection of contractor takes place purely on basis of lowest bid instead of practices of best value criteria (Lines, Nguyen et al. 2021). However, the choice of the lowest bidder does not guarantee the lowest cost at the completion due to the possibility of claims and litigation during the construction phase and also, incompetent contractor causes project delays results in additional cost along with poor quality of work (Le, Jeong et al. 2020).

2.2 Best Value Selection Approach:

To increase the likelihood of project success Best value Criteria is used at pre-qualification stages as well as contractor selection stage to remove the incompetent contractors from the list (Afshar, Alipouri et al. 2017, Shalwani, Lines et al. 2019). Best value criteria evaluates the contractor based on technical, financial, experience and past performance criteria for evaluation rather than focusing on bid price only, In short BV criteria focuses on quality and value of work rather than focusing only on price (Cheng and Li 2004, Perrenoud, Lines et al. 2017). Best value process theoretically balances

the cost and quality-based selection criteria by considering both in selection process, previous research shows that contractors who selection are based on qualification tend to achieve better performance in project quality, professionalism and customer satisfaction, best value criteria also cause reduction in cost, disputes and claims(Nguyen, Lines et al. 2018). Best value criteria make sure to identify the right person for right job, it has been observed from previous research that 98% of projects avoid cost & time overruns due to adoption of best value criteria for selecting of contractor (Sullivan 2011).

2.3 Adoption of Best value selection:

BV criteria has been adopted in many developed countries like USA and others, but it also faces barriers sometimes due to liability claims of illegally favoring someone by other contractors because usually BV contractor bid price is high compare to some other bidders (Yu and Wang 2012). On the other hand a study carried out for design bid build contractors in USA to focus more in a best value selection process, they collect the data based on 167 DBB contracts based on best value selection, the study shows that best value contractors select the qualified contractors almost 52% of time, and lowest bid 48%, this study also shows that 67% of time the qualified contractors ranked also as top 2 lowest bid contractor showing that qualified contractor doesn't come on premium but rather they have efficiency in implementation of their work(Nguyen, Lines et al. 2018).

BV criteria is not limited to contractor selection only but also has been applied in other critical employment in construction industry, A study for best value construction manager has been done in which study focus on RFPs, RFQs of different

projects, In this study total of 29 transportation projects & 25 non transportation projects documents are analyzed, mainly these documents include RFPs and RFQs, A formal content analysis of these documents has been which concludes that non price factors are considered 73% compare to 23% of price factors in selection of general contractor by these firms (Gransberg and Shane 2015).

In another study best value selection criteria is used for risk management purposes and it includes risk maturity as a factor in selection of contractor which shows that risk maturity is directly link with project success (Perrenoud, Lines et al. 2017). Hence above discussion shows that best value practices increase the probability of success, and such practice should also be incorporated in maintenance contractor selection process.

2.4 Analytical Hierarchy process:

One of the technique most commonly used in BV criteria as multi criteria decision making is AHP, which is gaining more attention because of available literature make it easy to apply the procedure for finding solution to a problem. AHP is used for many constructions management problem solutions, one of the major portion is using AHP in used for finding solution to problems related to risk management, other than AHP is used in sustainable construction, bidding problems, contractor prequalification and many more (Darko, Chan et al. 2019).

2.5 Contractor Selection Practices:

Various procedures for contractor selection are applied in the field as well proposed by different researchers. For example in Denmark contract selection procedure removes the two lowest and two highest bids and consider the average ones, Similarly in Italy and South Korea only lowest and highest bids are excluded and the one close to average is selected, In France the bid having abnormally low cost has been not considered, Also in Australia contractor selection process occur in two stages in first experience is evaluated and then in second step price negotiation occur (Zavadskas and Vilutienė 2006). It can be stated that the process of contractor selection is a not limited to bid price only but a multi-criteria problem (Huang 2011). Now people have been investigating contractor selection & evaluation criteria more because now governments in developed world also focuses and encourages use of multi-criteria evaluation in contractor selection process compare to low price contracts (Waara and Bröchner 2006).

As traditional low price contract award is also in practice in Turkey, but the main aim to select contractor for work is not to select low bidder but to select the bests bidder among them, A study carried out in turkey for public sector contractor selection process observes that if pre-qualification stage exists also then at 2nd stage contractor selection process was based purely on low bid means if a contractor gets a high score in pre-qualification still it won't get a contractor if someone with low score and low bid exists, which also contradicts the best bidder selection process for this purpose they study literature and gets an expert opinion finds out that quality and time are two factors which should be taken into consideration, they proposes a multicriteria model for contractor selection process considering quality and time factors in the contractor selection process. The study divides contractor selection into two stages i)

Prequalification stage & ii) choice of contractor, at 1st stage quality and time are considered as prequalification criteria. After successful qualification in the 2nd stage along with bid price quality and time are also incorporated to make selection not purely based on lowest bid at 2nd stage also (Topcu 2004).

A study in Hong Kong in 2003 has been done for improving the framework of multi criteria decision making in contractor selection process, the study uses analytical network(ANP) process for which 8 factors which includes Tender price, financial Capability, Past performance, Past experience, Resources, Current workload, Past relationship & Safety management in which 4 factors have further divided into sub-factors like financial capability is divided into Financial statement & Financial references, Past performance is sub factorized as failed contracts, cost overruns, delays & quality achieved, resources are divided into human & physical resources & past experience is divided into scale of project, work in local area & Type of project completed. These all are selected to be consider in contractor selection process taken from literature. They compare their result with previous work which considers AHP for contractor selection, They took a case study by considering 3 contractors and run both AHP & ANP model both shows different results due to consideration of interdependent relation by ANP which shows contractor A is more efficient for work considering above factors, Due to consideration of interdependent relations among all factors and sub factors ANP is terms as more efficient method in contractor selection. (Cheng and Li 2004).

In China for the problem of contractor selection has been proposed a solution of Multiple-layer Fuzzy Pattern Recognition (MFPR) approach to solve contractor selection problem, in this technique the factors are divided into specified categories and decision making are based on considering these categories as base for each layer in

decision making process, for contractor selection the factors are divided into 2 layers of financial and technical aspects only. Financial group includes bid, routine maintenance, lump-sum item price, financial stability & financial status while technical group includes experience, equipment, personal & past performance, safety record, management ability, environmental protection, construction planning and quality guarantee ability. The result shows the weightages of considered factors helps in decision making of final contractor selection (Singh and Tiong 2005).

Same as contractor selection a study has been done for selection of sub-contractor, in this study a web based sub-contractor evaluation system has been develop based on multi-criteria. The model has been based on cost, quality, time & adequacy parameters. Further the parameters have been divided into sub-factors. The parameter has been set in a web form and each having scores 1 to 10 where 1 represents unsatisfactory, the contractors scored based on his resources and gives a suitable sub-contractor at end (Arslan, Kivrak et al. 2008).

In 2013 a study carried out for selection of design build contractors which uses the methodology of text analysis of request of proposals. For this study the RFPs sample contains RFPs of residential, commercial, heavy civil work, institutional, industrial & renovation work. The study identifies 23 factors which are considered in these RFPs and place them in 10 different categories. According to this study Price holds the most frequency of 91% followed by experience 83% other categories like technical approach, management approach, qualification & schedule holds 72%, 68%, 62% & 60% respectively, while past performance, financial capability, responsive to RFP & legal status holds 54%, 37%, 37% & 14% respectively (Xia, Chan et al. 2013).

In 2017 a study carried out for knowing the procurement methods and their focus on factors consider in those literature, detailed literature has been studied in which total of 676 papers are observed, from filtering out the irrelevant one 119 papers remained has been analyzed through text analysis which shows that many methods have been suggested in research which include best value criteria, fuzzy set technique, multi criteria-based methods, structured framework etc. This research also points out that in this literature the quality factor is comes out to be most imported which have 9.2% of total followed by cost 8.2%, other factors include staff features, financial, company management, experience & time which are 7.9%, 7.9%, 7.6%, 6.5% & 6% respectively (de Araújo, Alencar et al. 2017).

Another study shows that contractor selection process should have fair competition among for that purpose the study considers technical aspect, Health, Safety, and environment factor (HSE), bid price & bidder competence in developing a framework through generalized comparative linguistic ELECTRE III. The research incorporated the quantitative and qualitative factor in selection criteria (Chen, Zhang et al. 2021).

2.6 Maintenance Contractor Selection Practices:

A study is carried out (Zavadskas, Turskis et al. 2005) is done to find out solution of maintenance contractor selection problem, for this purpose simulation of 15 maintenance contractor data has been used to find out the best alternative practices to be apply in maintenance contractor selection procedure which is user satisfactory.

In another Study multi criteria evaluation of maintenance contractor has been done through a case study in which 16 maintenance firms & 11 client data has been

used hence this model linking client satisfaction and maintenance performance through a statistical calculation of obtain data. The study shows that client ranks cost as the highest priority followed by maintenance level, quality standard of service, reliability of firm, employee qualification & Implementation of needs, On other hand the maintenance firm employee qualification is most important followed by number of project, reputation, reliability of firm and range up-to which services are provided (Zavadskas and Vilutienė 2006).

To find out the criteria prioritize by parties involve in selection of maintenance contractor and maintenance work a study is carried out for evaluating of maintenance contractor my ranking the attributes for maintenance contractor which is acceptable to all parties in selection as well as maintenance work (Zavadskas, Kaklauskas et al. 2009).

Another study based on Saudi Arabia industry problem in selection of maintenance contractor concludes that maintenance contractor should be procure based on his past performance, expertise, technical plan along with health and safety plans as well (Hadidi and Khater 2015)

In a study for developing a framework for elevator maintenance contractor has been done through text analysis of RFPs, in this study total of 70 RFPs has been analyzed which are based on best value procurement. In this study the total of 29 factors attained from RFPs has been categorized into 9 groups, Price, experience and qualification, past performance, responsive to RFPs, maintenance strategies, financial capability, diversity, contractor resources & legal status. Through manual content analysis of all these RFPs it has been found out that Price has been included in 100% in these RFPS followed by experience and qualification which holds 92% other factors

are included in as 77% responsive to RFPs, 54% maintenance strategies, financial capability is included in 51%, diversity in 26%, contractor resources in 25% & legal status in 11%. Among the average weightages given it has been observed that price holds the highest weightage of 35.71%, followed by experience and qualification 25.39%, Past performance has been given 18.47%, maintenance strategies 21.99%, responsive to RFPs are 18.50%, financial capability has been given 10.68% average weightage, diversity, contractor resources & legal status received the lowest weightages which are 8.08%, 11.61%, 88.33% respectively (Zubair and Zhang 2022).

The current frameworks for selecting contractors are markedly lacking in substantiation knowledge. These frameworks don't have any strategies to evaluate the attributes of maintenance contractor hence lacking the guidelines in evaluating maintenance contractor based on their past performances. Due to lack of strategies for substantiation of attributes of maintenance contractor, the current practices may not find be very helpful by owners.

In conclusion, current maintenance contractor selection frameworks emphasize a multi-criteria approach, however there is lack of robust strategies for evaluating these criteria. It is important to incorporate current best practices, proven business considerations, and well-researched industry insights into this process to address this problem. The selection of an informed and efficient maintenance contractor will be handled back from this iterative analysis, reducing risk and improving overall project success. The framework should be in such a way that it provides methods for specific quality assessments to ensure industry adoption. Therefore, this research aims to facilitate the building owners by providing a substantiated framework that organizations can utilize to make well informed decisions when selecting maintenance contractor through best value approach. Multi criteria–decision-making approaches,

such the AHP, have been adopted in the search to achieve a balance between cost-effectiveness and service quality when choosing the best maintenance contractor.

2.7 Attributes for selection of maintenance contractor:

Based on literature review regarding selection of maintenance contractor total of 21 factors has been identified which compromises both on approach towards project and contractor record in previous projects. The identified attributes are given in following table 2.1 along with its references.

Table 2.1 Identified factors with references

S.No	Factors	References
(1)	Proposed maintenance approach and plans	(Singh and Tiong 2005, Zavadskas and Vilutienė 2006, Araújo, Alencar et al. 2018)
(2)	Approach to manage subcontractors.	(Al-Hammad and Assaf 1996, Arslan, Kivrak et al. 2008, Araújo, Alencar et al. 2018, Tayeh, Al Hallaq et al. 2018, Naji, Gunduz et al. 2022)
(3)	Understanding insight of clients and project needs.	(Al-Hammad and Assaf 1996, Arslan, Kivrak et al. 2008, Assaf, Hassanain et al. 2011, Enshassi, Mohamed et al. 2013, Hasnain, Thaheem et al. 2018, Tayeh, Al Hallaq et al. 2018, Zubair and Zhang 2022)
(4)	General work Experience	(Cheng and Li 2004, Egemen and Mohamed 2006, Zavadskas and Vilutienė 2006, Arslan, Kivrak et al. 2008, de Araújo, Alencar et al.

		2017, Araújo, Alencar et al. 2018, Tayeh, Al Hallaq et al. 2018, Naji, Gunduz et al. 2022)
(5)	Experience of similar works	(Egemen and Mohamed 2006, Zavadskas and Vilutienė 2006, Arslan, Kivrak et al. 2008, Tan, Shen et al. 2014, Naji, Gunduz et al. 2022, Zubair and Zhang 2022)
(6)	Employee qualification	(Tan, Shen et al. 2014, Bintoro and Malani 2017, Araújo, Alencar et al. 2018, Naji, Gunduz et al. 2022, Zubair and Zhang 2022)
(7)	Availability of technical skilled/Trained staff	(Al-Hammad and Assaf 1996, Egemen and Mohamed 2006, Zavadskas and Vilutienė 2006, Arslan, Kivrak et al. 2008, Watt, Kayis et al. 2009, Enshassi, Mohamed et al. 2013, Hosny, Nassar et al. 2013, Tan, Shen et al. 2014, de Araújo, Alencar et al. 2017, Araújo, Alencar et al. 2018, Hasnain, Thaheem et al. 2018)
(8)	Past performance	(Cheng and Li 2004, Singh and Tiong 2005, Watt, Kayis et al. 2009, Enshassi, Mohamed et al. 2013, Hosny, Nassar et al. 2013)
(9)	Performance In similar project	(Enshassi, Mohamed et al. 2013, Hosny, Nassar et al. 2013, Hasnain, Thaheem et al. 2018, Zubair and Zhang 2022)
(10)	Previous Client satisfaction /Reputation earned.	(Singh and Tiong 2005, Wireman 2005, Egemen and Mohamed 2006, Zavadskas and Vilutienė 2006, Watt, Kayis et al. 2009, Enshassi, Mohamed et al. 2013, Hosny, Nassar et al. 2013, Tan, Shen et al. 2014, Araújo, Alencar et al. 2018, Hasnain, Thaheem et al.

		2018, Tayeh, Al Hallaq et al. 2018, Zubair and Zhang 2022)
(11)	Safety of work/Accidents Record	(Al-Hammad and Assaf 1996, Cheng and Li 2004, Singh and Tiong 2005, Egemen and Mohamed 2006, Arslan, Kivrak et al. 2008, Watt, Kayis et al. 2009, Puri and Tiwari 2014, de Araújo, Alencar et al. 2017, Araújo, Alencar et al. 2018, Hasnain, Thaheem et al. 2018, Naji, Gunduz et al. 2022)
(12)	Previous work Quality	(Ahmed and Kangari 1995, Topcu 2004, Wireman 2005, Banaitiene and Banaitis 2006, Egemen and Mohamed 2006, Arslan, Kivrak et al. 2008, Enshassi, Mohamed et al. 2013, Hosny, Nassar et al. 2013, Puri and Tiwari 2014, Tan, Shen et al. 2014, de Araújo, Alencar et al. 2017, Araújo, Alencar et al. 2018, Hasnain, Thaheem et al. 2018, Tayeh, Al Hallaq et al. 2018, Naji, Gunduz et al. 2022)
(13)	Documentation of works	(Al-Hammad and Assaf 1996, Love, Holt et al. 2002, East 2007, Tayeh, Al Hallaq et al. 2018)
(14)	Current workload	(Cheng and Li 2004, Singh and Tiong 2005, Egemen and Mohamed 2006, Zavadskas and Vilutienė 2006, Watt, Kayis et al. 2009, de Araújo, Alencar et al. 2017, Naji, Gunduz et al. 2022)
(15)	Failed contracts	(Cheng and Li 2004, Singh and Tiong 2005, Banaitiene and Banaitis 2006, Hosny, Nassar et al. 2013, Puri and Tiwari 2014, Naji, Gunduz et al. 2022)

(16)	Inventory in stock /Resources	(Al-Hammad and Assaf 1996, Cheng and Li 2004, Singh and Tiong 2005, Zavadskas and Vilutienė 2006, Assaf, Hassanain et al. 2011, Enshassi, Mohamed et al. 2013, Au-Yong, Azmi et al. 2018, Tayeh, Al Hallaq et al. 2018, Zubair and Zhang 2022)
(17)	Financial Capability/stability	(Cheng and Li 2004, Singh and Tiong 2005, Banaitiene and Banaitis 2006, Egemen and Mohamed 2006, Arslan, Kivrak et al. 2008, Watt, Kayis et al. 2009, Enshassi, Mohamed et al. 2013, Puri and Tiwari 2014, de Araújo, Alencar et al. 2017, Araújo, Alencar et al. 2018, Hasnain, Thaheem et al. 2018, Naji, Gunduz et al. 2022, Zubair and Zhang 2022)
(18)	Proposed Price	(Cheng and Li 2004, Singh and Tiong 2005, Banaitiene and Banaitis 2006, Egemen and Mohamed 2006, Zavadskas and Vilutienė 2006, Enshassi, Mohamed et al. 2013, Hasnain, Thaheem et al. 2018, Naji, Gunduz et al. 2022)
(19)	Availability of required licenses to perform maintenance.	(Tan, Shen et al. 2014, Tayeh, Al Hallaq et al. 2018)
(20)	Litigation & Claim History	(Banaitiene and Banaitis 2006, Egemen and Mohamed 2006, Hassaan, Fors et al. 2013, Hosny, Nassar et al. 2013, Tayeh, Al Hallaq et al. 2018)
(21)	Minority and special organizations	(Witherspoon and Wohlert 1996, Steele and Sodhi 2004, Zubair and Zhang 2022)

2.8 Grouping of identified factors:

The above 21 factors are divided into 6 categories of main criteria, the grouping of these factors is based on their connectivity to each other, the grouping of these factors has been given in table 2.2,

Table 2.2 Categorizing of Factors

S.No	Main Criteria	Factors
1.	Work Approach	Proposed maintenance approach and plans
		Approach to manage subcontractors.
		Understanding insight of clients and project needs.
2.	Experience	General work Experience
		Experience of similar works
		Employee qualification
		Availability of technical skilled/Trained staff
3.	Past Performance	Past performance
		Performance In similar project
		Previous Client satisfaction /Reputation earned.
		Safety of work/Accidents Record

		Previous work Quality
		Documentation of works
4.	Personal Record & Resources	Current workload
		Failed contracts
		Inventory in stock /Resources
5.	Financial & Legal Status	Financial Capability/stability
		Proposed Price
		Availability of required licenses to perform maintenance.
		Litigation & Claim History
6.	Diversity	Minority & Special Organization

CHAPTER 3: METHODOLOGY

3.1 Introduction:

The research technique being used to achieve the specified objectives is analyzed and presented in this chapter. The research methodology shows how research is going to carry out step by step to achieve their research objectives.

There are several techniques which will be used to carry out this research to fulfill certain objectives. This research includes detailed literature review, preliminary survey & detail questionnaire survey, by use of Analytical hierarchy process as a multi criteria decision making technique, for development of a model for selection of maintenance contractor.

Along with weightages of attributes substantiation of these factors has been carried out by face to face interviews from concern experts of related field, the substantiation for each factor is linked with attribute weightages and criteria weightages in the final framework for selection of maintenance contractor. The steps adopted in methodology of this research is shown in figure 3.1,

Step 1: Identification of Factors consider in maintenance contractor selection

Literature Review

Identification & Categorizing of factors

Step 2: Validation of identified factors

Questionnaire development

Pilot assessment

Data Source

Interviews

LinkedIn

Data Analysis

Frequency Analysis

Step 3: Application on Analytical Hierarchy Process (AHP) & Substantiation Strategies

Classifying goal, criteria & identified attributes

Questionnaire Survey for pairwise comparison

Survey questionnaire for strategies to substantiate attributes

Development of pairwise comparison matrix for criteria and attributes

Development of Normalized matrix for criteria and attributes

Calculate priority weights and determine local & Global weights of attributes

No

CR<0.1

Yes

Final Ranking of attribute

Final framework having attribute weightages and substantiation strategies

Figure 3.1 Methodology Framework

3.2 Identification of factors for selection of maintenance contractor:

In the first step of this research is to identify a key attribute which are important in the selection of maintenance contractor. For this phase a detailed literature review has been carried out to point out the related factors which are important for owner or consultants to be consider at the time of procurement of maintenance contractor. A total of 21 factors has been identified at first through detailed literature review which are divided in 6 different categories.

3.3 Preliminary survey:

After shortlisting of factors from literature, A questionnaire survey was developed to take expert opinion on the priority of these factors for selection of maintenance contractor. Questionnaire survey was distributed to industrial professionals mainly consultants. The survey was based to validate the identified factors and either they are substantiable or no. As a result of this survey 4 of identified factors which are rated low by industry experts and also may face substantiation issue further has been removed and final 17 factors are consider for future progress.

3.4 Main survey Questionnaire:

After short listing 17 factors which are distributed in 5 categories a questionnaire is developed with the main objective of the study which is weightages of attributes and their substantiation techniques in decision making process of selection of maintenance contractor. For weightages of attributes a multi criteria decision making technique is employed due to its significance in solving complex problems. For this

purpose, Analytical Hierarchy Process (AHP) is used which is a mathematical decision-making technique used to solve problems that are complex. This technique which helps in disintegrating problems into a hierarchy of criteria and sub-criteria with the help on comparative analysis.

3.5 AHP methodology:

Analytical hierarchy process is a technique which is used to structure and analyze a complex decision problem by establishing a step wise decision model in order to achieve the goal. This process includes qualitative and quantitative components. AHP assumes that the relationship between clusters is unidirectional along different decision levels of the hierarchy and uncorrelated between clusters & elements within each cluster or sub cluster.

The AHP process works as shown in figure 3.2, involves identifying criteria and their corresponding sub criteria. This helps in breaking down the decision into specific factors for consideration. Following this, pairwise comparisons are made between the components, providing a relative scale of their importance. Experts in their respective fields are asked to compare the importance of each pair of elements at every level of the hierarchy. This involves assessing the relative significance of each criterion compared to others at the second level. Similarly, experts compare the importance of each pair of sub-criteria under the same criterion at the second level and continue this process throughout the hierarchy. Since AHP uses subjective judgments from decision makers, there is no automatic assurance of consistency in these judgments. Hence, it becomes essential to conduct consistency checks to ensure an optimized outcome. Results from these comparisons are normalized, a process where values are adjusted

for accurate weight calculations. Subsequently, weights are determined for the decision components(criteria/sub-criteria) and in the end, the weights assigned to decision components are combined, aggregating all the factors to a final decision effectively.

Figure 3.2 AHP Methodology

3.6 Data Analysis:

After main Survey the data will be analyzed through AHP process getting local & global weights for criteria & factors by developing decision matrixes to get the required best value framework, on the other hand the substantiation of all the factors is collected into qualitative form of survey and represented along with best value framework.

3.7 Substantiation of attributes:

Along with AHP pair-wise comparison the strategies to substantiate those attributes is identified through conducting interviews from consultants having industrial experience of 5 to 25 years. The strategies have been identified to evaluate the certain attribute in shape of either meeting or specified documents through which certain criteria can be substantiated.

CHAPTER 4: RESULTS & ANALYSIS

4.1 Introduction:

This section explains the findings of the initial interviews and final questionnaire surveys and then provides a thorough analysis of the results. The AHP model is offered for choosing a maintenance contractor, along with strategies for evaluating the attributes that have been identified.

4.2 Preliminary Interview:

A preliminary interview was conducted to obtain feedback from the construction sector regarding the identified attributes and their substantiation possibilities. Interviews from 5 construction consultants having more than 5 years' experience had been taken.

As a result of preliminary interviews shown in table 4.1, 4 factors from the identified 21 factors has been removed because of the majority of consultants vote out due to its substantiation issue at the time of procurement of contractor as well as having less importance compare to others.

Table 4.1 Preliminary Interview

S.No	Main Criteria	Factors	Vote out by consultants
1.	Work Approach	Proposed maintenance approach and plans	-
		Approach to manage subcontractors.	4
		Understanding insight of clients and project needs.	-
2.	Experience	General work Experience	-
		Experience of similar works	-
		Employee qualification	-
		Availability of technical skilled/Trained staff	-
3.	Past Performance	Past performance	-
		Performance In similar project	-
		Previous Client satisfaction /Reputation earned.	-
		Safety of work/Accidents Record	2
		Previous work Quality	-
		Documentation of works	3
4.	Personal Record & Resources	Current workload	4
		Failed contracts	2
		Inventory in stock /Resources	1
5.	Financial & Legal Status	Financial Capability/stability	2
		Proposed Price	-
		Availability of required licenses to perform maintenance.	-

		Litigation & Claim History	2
6.	Diversity	Minority & Special Organization	4

As it has been observed that majority of consultants had voted out 4 factors namely,

1. Approach to manage subcontractor

2. Documentation of work

3. Current work load

4. Minority & Special organization

The above mention factors have been not considered in further process.

4.3 Shortlisted attributes:

After analysis of interviews 17 attributes are shortlisted which are further categorized according to same nature in 5 different criteria. AHP procedure has been selected for the final survey.

The shortlisted attribute placed in 5 criteria are shown in table 4.2,

Table 4.2 Shortlisted Factors

S.No	Main Criteria	Factors
1.	Work Approach	Proposed maintenance approach and plans
		Understanding insight of clients and project needs.
2.	Experience	General work Experience
		Experience of similar works
		Employee qualification
		Availability of technical skilled/Trained staff
3.	Past Performance	Past performance
		Performance In similar project
		Previous Client satisfaction /Reputation earned.
		Safety of work/Accidents Record
		Previous work Quality
4.	Personal Record & Resources	Failed contracts
		Inventory in stock /Resources
5.	Financial & Legal Status	Financial Capability/stability
		Proposed Price
		Availability of required licenses to perform maintenance.
		Litigation & Claim History

4.4 Prioritizing attributes for selection of maintenance contractor:

The first stage is to create a hierarchy structure for the issue, starting with the study's objective and moving on to the relevant criteria and sub-criteria. Depending on the nature of the problem and the managerial choice, a hierarchy may have numerous levels. a system of hierarchy of the issue can be developed by original thought, memory, and utilization of people's perception, to achieve the objective of the study for which the AHP technique will be employed. Figure 4.1 shows the hierarchy structure for AHP containing goal followed by categories and sub-factors.
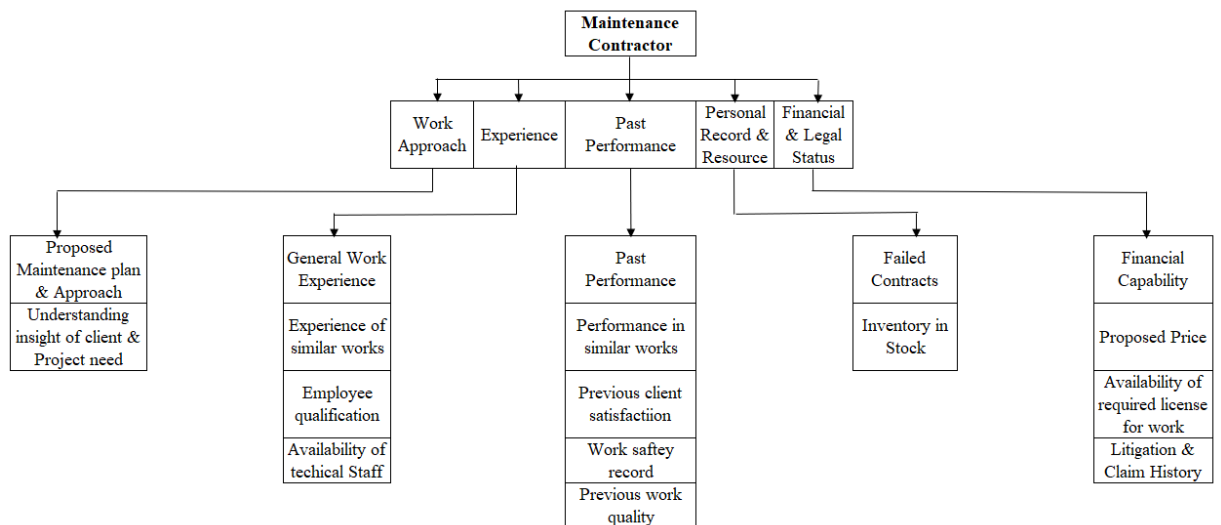
Figure 4.1 AHP based hierarchy model for selection of maintenance contractor

4.4.1 Approach of assigning weightages:

According to AHP the categories will be pairwise compared to each other as well as attributes of each category will be compared to each other pairwise to get relative importance of each attribute and category. A comparison matrix is created after the responder assigns relative weights to the factors, showing the components' relative importance. In order to assign values to factors and demonstrate their relative importance in relation to one another while keeping the goal in mind (Satty, Blakeley et al. 1988) presented a nine-point scale. In figure 4.2, the relative scale is displayed. Through pairwise comparison, a matrix is created where the diagonal values are equal to 1 and the other factors have a reciprocal value. For instance, factor j is "1/q times" as important as factor i if factor i is "q times" as essential as component j.

Explanation	Numeric Values
If Option A and Option B are equally important: Mark	1
If one option is moderately more important than the other: Mark	3
If one option is strongly more important than the other: Mark	5
If one option is very strongly more important than the other: Mark	7
If one option is extremely more important than the other: Mark	9
Use even numbers for intermediate judgements	2, 4, 6, 8

Figure 4.2 Relative scale of comparison

4.4.2 Aggregation of responses:

People generally respond differently from one another since their opinions are formed from their experiences. In group decision-making, individual decision-makers may rank certain aspects differently from one another depending on how essential they believe they are. Consequently, it's critical to come to a decision based on a methodology (Dong, Zhang et al. 2010). Among several techniques for aggregation of responses, one of the most popular techniques is the weighted geometric mean method, to reach consensus, weighted geometric mean of the responses was calculated for criteria and sub criteria pairwise comparisons. The qualification and experience of participants are shown in figure 4.3.
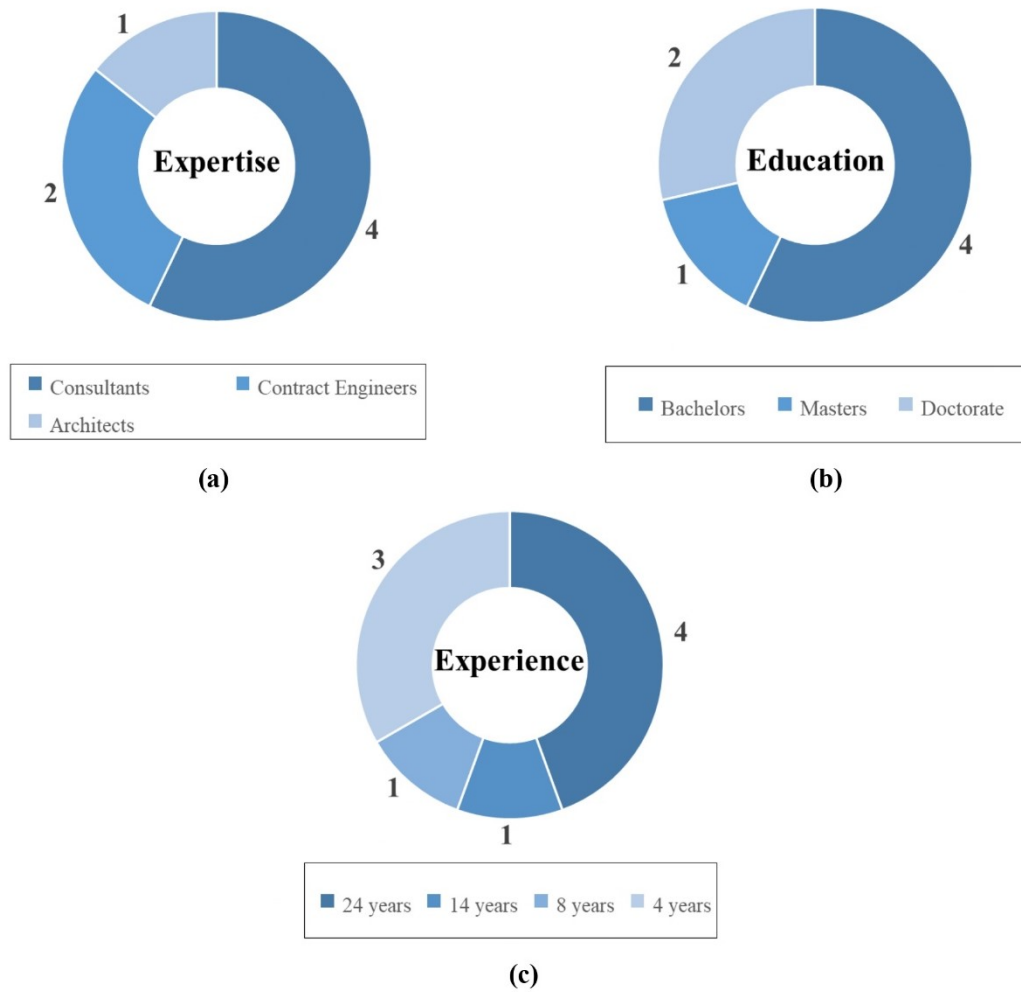
Figure 4.3 . Details of the experts a) Expertise b) Education c) Experience

4.4.3 Pair-wise Comparison of Criteria:

To determine the weightages of criteria for selection of maintenance contractor, the five criteria are compared with each other and their priorities are calculated. The matrix formed as a result of pairwise comparison is shown in table 4.3. The shown matrix is formed in a result of taking geometric mean of experts rating for criteria during pair-wise comparison.

Table 4.3 Pair-wise comparison of criteria

Criteria					
	Work Approach	Experience	Past Performance	Personal Record & Resource	Financial & Legal Status
Work Approach	1.000	1.146	0.820	0.517	2.246
Experience	0.873	1.000	0.882	1.647	1.566
Past Performance	1.219	1.134	1.000	1.723	1.216
Personal Record & Resource	1.933	0.607	0.581	1.000	0.739
Financial & Legal Status	0.445	0.638	0.822	1.353	1.000

4.4.4 Pair-wise Comparison of Attributes:

To determine the weightages of attributes of each category for selection of maintenance contractor, all attributes of specific category are compared with each other and their priorities are calculated. The matrix formed as a result of pairwise comparison of under each category is shown in table 4.4, 4.5, 4.6, 4.7 & 4.8 respectively according to categories.

Table 4.4 Pair-wise comparison of work Approach Attributes

Work Approach		
	Proposed Maintenance plan & Approach	Understanding insight of client & Project need
Proposed Maintenance plan & Approach	1.000	0.640
Understanding insight of client & Project need	1.563	1.000

Table 4.5 Pair-wise comparison of Experience Attributes

Experience				
	General Work Experience	Experience of similar works	Employee qualification	Availability of technical Staff
General Work Experience	1.000	0.353	1.933	0.381
Experience of similar works	2.831	1.000	1.811	0.529
Employee qualification	0.517	0.552	1.000	0.345
Availability of technical Staff	2.627	1.891	2.901	1.000

Table 4.6 Pair-wise comparison of Past performance Attributes

Past Performance					
	Past Performance	Performance in similar works	Previous client satisfaction	Work safety record	Previous work quality
Past Performance	1.000	0.223	0.259	0.981	0.266
Performance in similar works	4.481	1.000	1.199	2.034	0.711
Previous client satisfaction	3.861	0.834	1.000	0.654	1.148
Work safety record	1.019	0.492	1.530	1.000	1.448
Previous work quality	3.758	1.407	0.871	0.691	1.000

Table 4.7 Pair-wise comparison of Personal record & resources Attributes

Personal Record & Resource		
	Failed Contracts	Inventory in Stock
Failed Contracts	1.000	0.645
Inventory in Stock	1.551	1.000

Table 4.8 Pair-wise comparison of financial & legal status Attributes

Financial & Legal Status				
	Financial Capability	Proposed Price	Availability of required license for work	Litigation & Claim History
Financial Capability	1.000	1.632	0.459	1.919
Proposed Price	0.613	1.000	0.339	1.739
Availability of required license for work	2.180	2.950	1.000	2.420
Litigation & Claim History	0.521	0.575	0.413	1.000

4.4.5 Normalized Matrix:

The numbers in the matrix are normalized to take into consideration the overall values in order to calculate the weightages of criterion and attributes & bring it into common scale. To create a normalized matrix, the columns of the matrix are added together, and then each element of the matrix for a given column is divided by the sum of that column. Equation 1 shows the process for normalization for 1st entry of table 4.3 pairwise matrix.

$$X_{1,1} = \frac{1}{1+0.873+1.219+1.933+0.445} = 0.183 \qquad (1)$$

The normalized matrix of comparisons for the criteria, work approach, experience, past performance, personal record and resources, & financial and legal status factors are shown in table 4.9, 4.10, 4.11, 4.12, 4.13 & 4.14.

Table 4.9 Normalized matrix for criteria

Criteria					
	Work Approach	Experience	Past Performance	Personal Record & Resource	Financial & Legal Status
Work Approach	0.183	0.253	0.200	0.083	0.332
Experience	0.160	0.221	0.215	0.264	0.231
Past Performance	0.223	0.251	0.244	0.276	0.180
Personal Record & Resource	0.353	0.134	0.141	0.160	0.109
Financial & Legal Status	0.081	0.141	0.200	0.217	0.148

Table 4.10 Normalized matrix for work Approach Attributes

Work Approach		
	Proposed Maintenance plan & Approach	Understanding insight of client & Project need
Proposed Maintenance plan & Approach	0.390	0.390
Understanding insight of client & Project need	0.610	0.610

Table 4.11 Normalized Matrix for Experience Attributes

Experience				
	General Work Experience	Experience of similar works	Employee qualification	Availability of technical Staff
General Work Experience	0.143	0.093	0.253	0.169
Experience of similar works	0.406	0.263	0.237	0.235
Employee qualification	0.074	0.145	0.131	0.153
Availability of technical Staff	0.377	0.498	0.379	0.444

Table 4.12 Normalized matrix for Past performance Attributes

Past Performance					
	Past Performance	Performance in similar works	Previous client satisfaction	Work safety record	Previous work quality
Past Performance	0.071	0.056	0.053	0.183	0.058
Performance in similar works	0.317	0.253	0.247	0.380	0.155
Previous client satisfaction	0.273	0.211	0.206	0.122	0.251
Work safety record	0.072	0.124	0.315	0.187	0.317
Previous work quality	0.266	0.356	0.179	0.129	0.219

Table 4.13 Normalized matrix for Personal record & resources Attributes

Personal Record & Resources		
	Failed Contracts	Inventory in Stock
Failed Contracts	0.392	0.392
Inventory in Stock	0.608	0.608

Table 4.14 Normalized matrix for financial & legal status Attributes

Financial & Legal Status				
	Financial Capability	Proposed Price	Availability of required license for work	Litigation & Claim History
Financial Capability	0.232	0.265	0.207	0.271
Proposed Price	0.142	0.162	0.153	0.246
Availability of required license for work	0.505	0.479	0.452	0.342
Litigation & Claim History	0.121	0.093	0.187	0.141

4.4.6 Local & Global weights:

When the matrices are normalized, the weights of attributes are calculated with respect to their criteria and with respect to the goal of the study which are known as local weights and global weights respectively. The local weight of an attribute is its weight or priority with respect to its node placed one level above the hierarchy also known as criteria. In this case, local weight of an attribute termed as sub criteria is with respect to its particular criteria. After local weights are calculated, the next step is to calculate the weight of the attribute with respect to the main goal. These values of weights are called global weights. Global weights for any element in the hierarchy are calculated by weighing local priority by global priority assigned to the element at the preceding level. For example, the weightage for work approach has been shown below in equation 2 & 3,

$$Score\ or\ Local\ weight = \frac{\sum Row_{attribute}}{n} \qquad (2)$$

$$Score_{work\ appraoch} = \frac{0.183+0.253+0.2+0.083+0.332}{5} = 0.210 \qquad (3)$$

4.4.7 Ranking the criteria & attributes:

The next step after calculating local and global weights is to rank the criteria and attributes in descending order. This technique is helpful for the identifying the most important criteria and attributes which will affect the decision more in selection of maintenance contractor process. The priority weights of criteria and attributes in descending order are shown in table 4.15.

Table 4.15 Priority weights of criteria and attributes

Category	Score	Factors	Local Score	Global Score
Past Performance	0.235	Performance in similar works	0.270	0.063
		Previous work quality	0.230	0.054
		Previous client satisfaction	0.213	0.050
		Work safety record	0.203	0.048
		Past Performance	0.084	0.020
Experience	0.218	Availability of technical Staff	0.424	0.093
		Experience of similar works	0.285	0.062
		General Work Experience	0.165	0.036
		Employee qualification	0.126	0.027
Work Approach	0.210	Understanding insight of client & Project need	0.610	0.128
		Proposed Maintenance plan & Approach	0.390	0.082
Personal Record & Resources	0.180	Inventory in Stock	0.608	0.109
		Failed Contracts	0.392	0.070
Financial & Legal Status	0.157	Availability of required license for work	0.445	0.070
		Financial Capability	0.244	0.038
		Proposed Price	0.176	0.028
		Litigation & Claim History	0.136	0.021

This study provides a technique for ranking of attributes for selection of maintenance contractor that affects the decision making significantly and hence award contract, to do this, an analytical hierarchy approach is applied, which weighs attributes by comparing them pairwise and figuring out how important they are to one another. Based on the evaluation of regional industry experts, this strategy has produced outcomes. Expert evaluation led to the ranking of attributes according to priority, as indicated in figure 4.4.
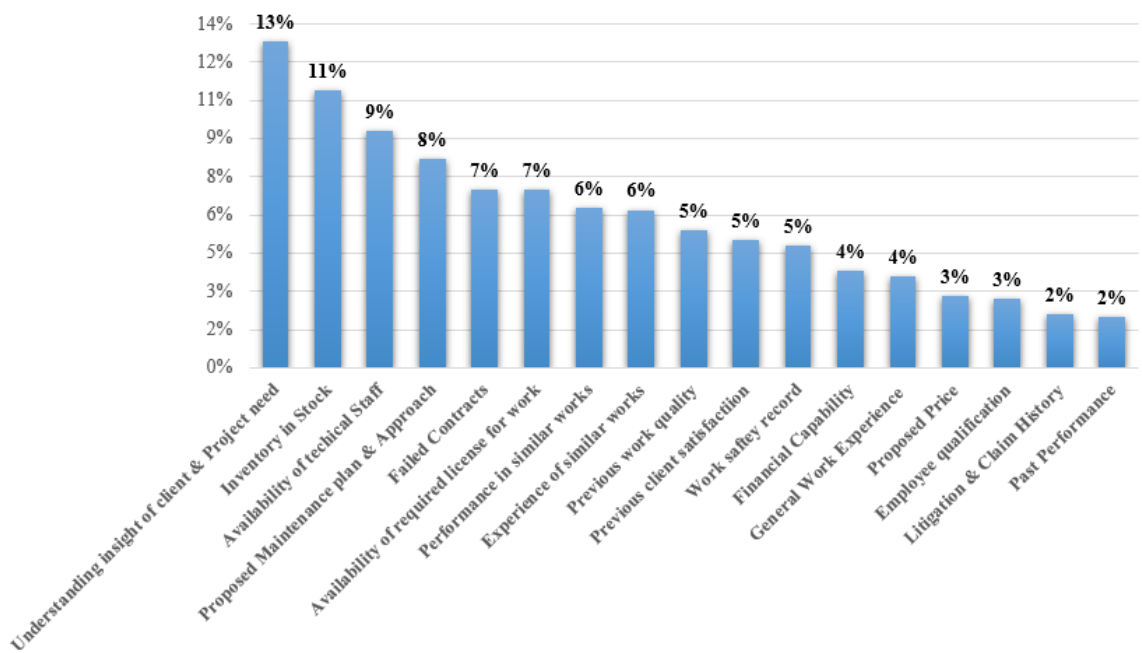
Figure 4.4 Global weights of attributes in descending order

The above figure shows the global weights of attributes shown in table 4.15 in descending order, the column two of same table represents the weightages of criteria. It has been observed that criteria "Past Performance" is the come out as most important

criteria having 23.5% of overall weightage. It shows that in selecting of maintenance contractor his past performance matters a lot & it can be a decisive factor among others. The contractor while submitting bid can show his past performance on projects more clearly in order to get edge on other in competitive bidding. The attributes of past performance include performance in similar projects, general performance, safety of work, quality of previous work & previous client satisfaction. In these attributes "performance in similar projects" holds the most importance followed by quality of work in previous projects showing that contractor work in similar projects is the important factor to be consider while selecting the maintenance contractor.

After past performance the 2nd most important criteria in selection of maintenance contractor is "experience" of contractor which holds the 21.8% of total weightage. The attributes include in these criteria are general work experience, experience in similar work, employee qualifications & availability of technical staff. This shows that experience of not only the projects work on but also the current availability of staff and employee also counts. Among the above attributes the availability of technical staff holds the most importance showing that importance of technical skilled labor and employee is most important factor considering for maintenance work. The other attribute importance is in order experience in similar project, general work experience & employee qualification respectively.

After Experience the other important criteria is contractor's "Work Approach" which holds the 21% of total weightage. Having attributes like proposed maintenance plan & understanding client and projects need it shows that how important it is to understand the work and proposed a specific work plan accordingly.

The other two criteria Personal record and resources & financial & legal status holds 18% and 15.7% respectively, which shows their significance as well in selecting of maintenance contractor. The attributes in these criteria are inventory in stock, failed contracts, price, financial capability, litigation and claim history & proper required licenses. All attributes are important factors to be consider in process of selecting maintenance contractor.

According to global weights of attributes, understanding of client & projects needs holds the most importance with 13& of total weightage shows that the most important factor performing maintenance work is to first understand the project needs and client requirement and proceed further accordingly. After understanding another important factor is inventory in stock require to perform maintenance work. Having the required machinery, equipment and other needful items is one of important factor in selection of maintenance contractor, the presence of self-inventory could not only save cost but also reduce time to perform maintenance work. The 3rd important attribute is availability of technical staff which has global weightage of 11% showing the importance of skilled staff with contractor to perform the work efficiently in safe manner according to requirement.

4.4.8 Equation for selection of maintenance contractor using AHP:

Using the AHP method, priority weights of all criteria and factors have been calculated which highlights the importance of factors in decision making for selection of maintenance contractor. The equation for maintenance contractor selection has been proposed as follow in equation 4,

$$Maintenance\ contractor\ score\ =\ \sum Bi * Xi \qquad (4)$$

Where 'Bi' is the priority weight of the factor which has been calculated in the previous section and 'Xi' are the variables with values ranging from 1 to 9. The decision maker will decide the value of the variable based of the capability of the subcontractor against each factor separately.

4.4.9 Consistency Ratio:

The consistency checks on pairwise data are required to apply on every matrix having order 3*3 or above, for consistency checks first finding λmax value with help of pair-wise comparison data and final score of criteria & attributes. With help of λmax consistency index is find out and furthermore the consistency index is compared to the random index to see whether a decision maker made irrational pairwise comparisons. The requirement is that consistency ratio should not be more than 10% or 0.1 (Karapetrovic and Rosenbloom 1999). Equation 5,6 & 7 are the equations to find max eigen value, Consistency Index & Consistency ration respectively.

$$\lambda max = \sum (weighted\ sum/final\ weightage)/no\ of\ factor\ in\ matrix(n) \qquad (5)$$

$$Consistency\ index\ (CI) = (\lambda max - n)/(n-1) \qquad (6)$$

$$Consistency\ ratio\ (CR) = Consistency\ Index/Random\ index \qquad (7)$$

From equation 5,6 & 7 the consistency ratio of criteria matrix and attributes matrix of pairwise comparison are derived and are given in table 4.16, 4.17, 4.18 & 4.19 respectively.

Table 4.16 Consistency ratio of criteria matrix

	Work Approach	Experience	Past Performance	Personal Record & Resource	Financial & Legal Status	Weighted score	weighted sum	Ratio
Criteria								
Work Approach	1.000	1.146	0.820	0.517	2.246	0.21	1.1	5.2
Experience	0.873	1.000	0.882	1.647	1.566	0.218	1.2	5.3
Past Performance	1.219	1.134	1.000	1.723	1.216	0.235	1.2	5.3
Personal Record & Resource	1.933	0.607	0.581	1.000	0.739	0.18	1.0	5.4
Financial & Legal Status	0.445	0.638	0.822	1.353	1.000	0.157	0.8	5.3

λmax	5.288
C.I	0.072
Consistency Ratio	0.064

Table 4.17 Consistency ratio of experience attribute

Experience							
	General Work Experience	Experience of similar works	Employee qualification	Availability of technical Staff	Weighted score	weighted sum	Ratio
General Work Experience	1.000	0.353	1.933	0.381	0.165	0.7	4.1
Experience of similar works	2.831	1.000	1.811	0.529	0.285	1.2	4.2
Employee qualification	0.517	0.552	1.000	0.345	0.126	0.5	4.1
Availability of technical Staff	2.627	1.891	2.901	1.000	0.424	1.8	4.2
					λmax		4.1
					C.I		0.044
					Consistency Ratio		0.049

Table 4.18 Consistency ratio of attribute Past performance

Past Performance								
	Past Performance	Performance in similar works	Previous client satisfaction	Work safety record	Previous work quality	Weighted score	weighted sum	Ratio
Past Performance	1.000	0.223	0.259	0.981	0.266	0.084	0.5	5.5
Performance in similar works	4.481	1.000	1.199	2.034	0.711	0.27	1.5	5.5
Previous client satisfaction	3.861	0.834	1.000	0.654	1.148	0.213	1.2	5.4
Work safety record	1.019	0.492	1.530	1.000	1.448	0.203	1.1	5.3
Previous work quality	3.758	1.407	0.871	0.691	1.000	0.23	1.3	5.4

λmax	5.430
C.I	0.108
Consistency Ratio	0.096

Table 4.19 Consistency ratio of attribute financial & legal status

Financial & Legal Status							
	Financial Capability	Proposed Price	Availability of required license for work	Litigation & Claim History	Weighted score	weighted sum	Ratio
Financial Capability	1.000	1.632	0.459	1.919	0.244	1.0	4.1
Proposed Price	0.613	1.000	0.339	1.739	0.176	0.7	4.0
Availability of required license for work	2.180	2.950	1.000	2.420	0.445	1.8	4.1
Litigation & Claim History	0.521	0.575	0.413	1.000	0.136	0.5	4.0
					λmax		4.1
					C.I		0.022
					Consistency Ratio		0.025

As consistency ratio value of all the matrix are within the specified range which is less than 0.1 hence, the result of pair-wise comparison and AHP is acceptable.

4.5 Substantiation of attributes:

To help in the evaluation of attributes, the study also gives substantiation guidelines for the above attributes. The evaluation strategies have been identified through interviewing face to face questionnaire from 7 consultants having more than 4 years' experience. The evaluation strategies will help the decision makers to assign score to attributes easily and make the selection process more reliable and time saving. The evaluation strategies of all 17 attributes are given in table 4.20.

Table 4.20 Substantiation strategies of attributes

S. No	Factors	Ways to Substantiate
	Approach to Work / Work Approach	
1.	Proposed maintenance approach and plans	Bid documents, approach to fulfill codal requirement, proposed methodology, evaluation of technical bid
2.	Understanding insight of clients and project needs	Proper understanding, Subsequent meetings, tender documents, method statement, proposed methodology
	Experience	
3.	General work Experience	List of projects, contractor profile, list of projects having similar cost, completion certificates

4.	Experience of similar works	List of similar projects done, portfolio of contractor, completion certificates of same nature projects
5.	Employee qualification	Employee CVs, Employee resume, contractor profile, experience certificates
6.	Availability of technical skilled/Trained staff	Certificates, experience of staff, list of engineers, supervisors, technicians, labor etc
Past Performance		
7.	Past performance	Quality assurance reports of previous projects, project completion reports, physical inspection of project, previous approvals & awards
8.	Performance In similar project	Quality assurance reports of previous of similar projects, project completion reports, physical inspection of project, previous approvals & awards
9.	Previous Client satisfaction /Reputation earned.	Client satisfactory report, Quality assurance report, previous approvals & awards.
10.	Safety of work/Accidents Record	Contractor HSE plan, level of safety in previous projects, accidents & nature of accident report.
11.	Previous work Quality	Performance certificates from client, client satisfactory report, project completion report
Personal Record & Resources		
12.	Failed contracts	List of failed contracts with reasons, documents provided by contractor, checking blacklisting of company
13.	Inventory in stock /Resources	Contractor profile, list of equipment and resources available.

	Financial & Legal status	
14.	Financial Capability/stability	Bank statement, audit reports, bank guarantee, enlistment slips with client
15.	Proposed Price	Bid price, tender amount, financial proposal of contractor
16.	Availability of required licenses to perform maintenance.	Copy of required licenses from PEC, work department etc
17.	Litigation and claims history	Non litigation certificate

The above table shows the documents which will help in substantiation of attribute in-front of them, e.g., for attribute "understanding client need" the documents require to evaluate is "tender documents/ technical proposal" along with subsequent meeting the understanding of contractor on project need can be assessed. Similarly, "experience" of contractor can be assessed through list of projects done, completed projects etc. for all attributes the mentioned record in table will help the owner/consultant to make him able to access the previous performance of contractor and can give score accordingly in AHP selection model. The substantiation strategies will help in using best value criteria model more easily and adoption of best value selection for maintenance contractor can be adopted in practical.

4.6 Final Best value substantiated framework:

The final model represents the criteria along with attributes and their percentages weightages along substantiation strategies, which is shown in Figure 4.5,
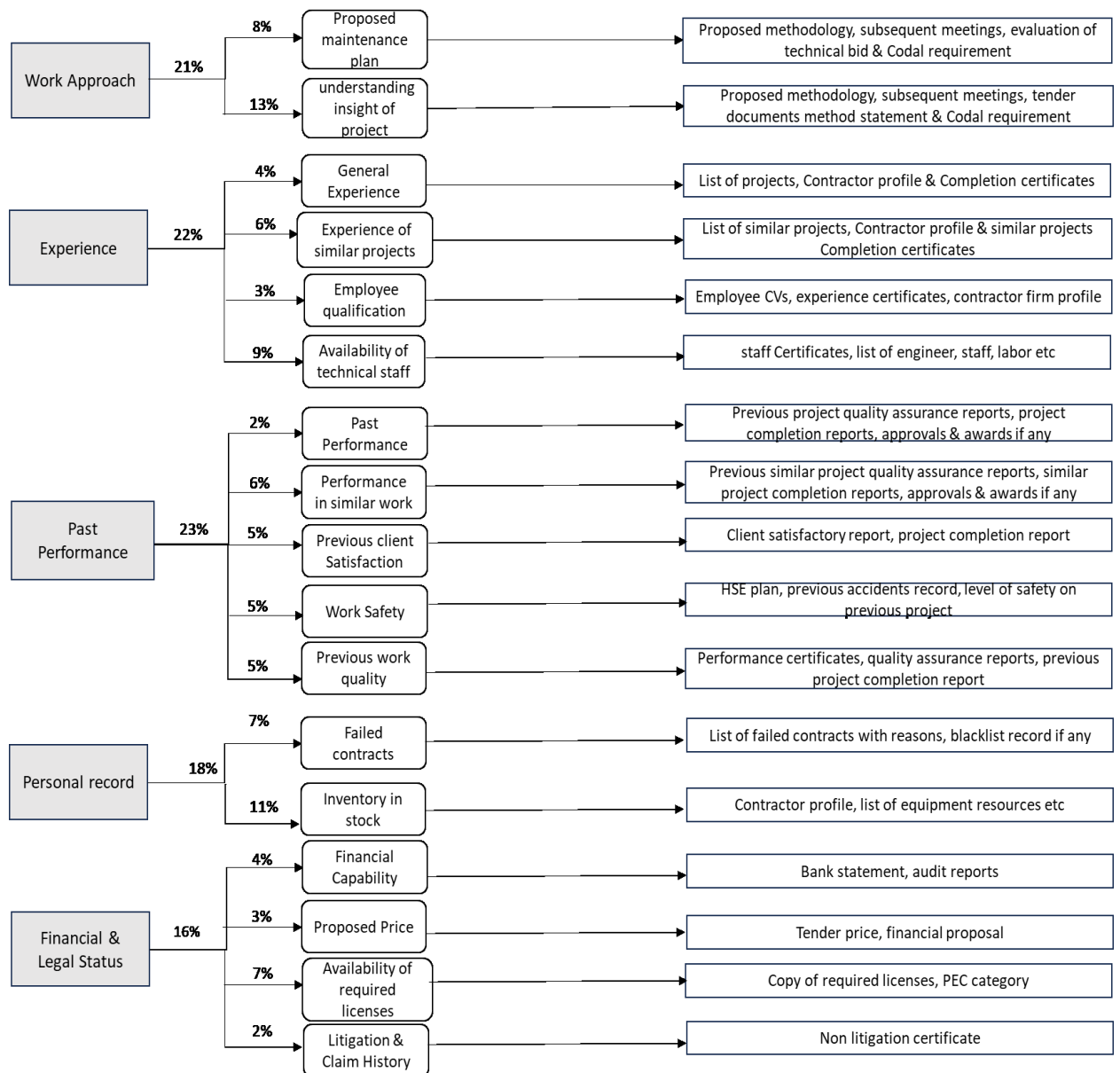
Figure 4.5 Final Best Value Framework

SUMMARY OF RESEARCH WORK

Maintenance is clearly big issues with growing field and people importance in provided facilities certain attention is required, for efficient maintenance work the key is to hire an efficient maintenance contractor through a fair process. For address that issue this study is carried out for proposing a framework for selection of maintenance contractor.

In the initial stages the detail literature has been studied to find out the research gap in current best value models, it has been observed that models proposed are just weightages of attributes with no strategies for evaluation moreover those models are basically impractical in use because of consideration of those factors which are unable to substantiate at time of procurement. After that a detailed literature study is carried out for identifying the attributes considering in selection of maintenance contractor. This results in finding the 21 attributes which are divided into 6 categories initially. These attributes are validated from industry through interviews from consultants having experience more than 4 years in the construction industry, the opinion of those experts results in removing 4 out of 21 attributes because of their less importance in maintenance work and also have a substantiation issue at time of procurement of maintenance contractor. The remaining 17 attributes are divided into 5 categories/criteria and are shortlisted for final AHP analysis.

The pair-wise comparison has been done for all 5 criteria and attributes within criteria from 7 consultancies and form pair-wise matrix through geometric mean of experts data, matrices are than normalized to get one unit analysis and hence normalized matrices are formed, after which arithmetic mean of rows of normalized matrices are

taken to get local and global weightages of attributes. The data has been than checked for its consistency, by applying the consistency checks on pair wise matrices, which shows that consistency ratio of each matric of order 3 or above are less than 10% and the data collected is consist.

In 2nd step of research strategies to evaluate the attributes of best value criteria are obtained through face to face interviews, interviews are conducted from consultants having vast experience in field of construction in these interviews consultants give their opinion how a certain attribute can be evaluated, and through which documents certain attributes can be evaluate at time of hiring a maintenance contractor.

After evaluation/substantiation strategies are identified final framework along with weightages and strategies to substantiate has been made which can be used at time of procurement of maintenance contractor.

CONCLUSION

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The research addresses the major gap in the selection process of maintenance contractor which is the non-existence of strategies for evaluation of attributes for maintenance contractors. This research concluded in giving a framework for strategic selection of maintenance contractor having specific attributes weightages and most importantly the strategies to substantiate those attributes.

Using multi criteria decision modelling technique AHP it has been observed that past performance of contractor is the criteria having the most weightage among all followed by experience and work approach of contractor. The attribute understanding need of project holds the high weightage among the 17 attributes.

The research result in giving a strategic framework having each attribute weightage is assigned along with the substantiation strategy is identified from experts which make the selection process for maintenance contractor more adoptable for industry.

FURTURE RESEARCH RECOMMENDATION

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This work has been for general maintenance contractor and the attributes identified are general in nature. For more specific approach the work can be done for specific maintenance work like maintenance of HVAC, elevators, escalators, cracks etc which may have additional few attributes considering the complexity of maintenance work and parts of specified maintenance required. Other multi decision making methods can also be applied like ANP, Fizzy AHP etc.

REFERENCES:

[1]   Afshar, M. R., et al. (2017). "A type-2 fuzzy set model for contractor prequalification." Automation in Construction **84**: 356-366.

[2]   PAhmed, S. M. and R. Kangari (1995). "Analysis of client-satisfaction factors in construction industry." Journal of Management in Engineering **11**(2): 36-44.

[3]   Al-Hammad, A.-m. and S. Assaf (1996). "Assessment of work performance of maintenance contractors in Saudi Arabia." Journal of Management in Engineering **12**(2): 44-49.

[4]   Araújo, M., et al. (2018). Decision criteria for contractor selection in construction industry: A literature review. 2018 IEEE international conference on industrial engineering and engineering management (IEEM), IEEE.

[5]   Arslan, G., et al. (2008). "Improving sub-contractor selection process in construction projects: Web-based sub-contractor evaluation system (WEBSES)." Automation in Construction **17**(4): 480-488.

[6]   Assaf, S., et al. (2011). "Factors affecting outsourcing decisions of maintenance services in Saudi Arabian universities." Property management **29**(2): 195-212.

[7]   Au-Yong, C. P., et al. (2019). "A literature review of routine maintenance in high-rise residential buildings: a theoretical framework and directions for future research." Journal of Facilities Management **17**(1): 2-17.

[8]   Au-Yong, C. P., et al. (2018). "Maintenance of lift systems affecting resident satisfaction in low-cost high-rise residential buildings." Journal of Facilities Management.

[9]   Banaitiene, N. and A. Banaitis (2006). "Analysis of criteria for contractors' qualification evaluation." Technological and Economic Development of Economy **12**(4): 276-282.

[10]   Bintoro, I. and R. Malani (2017). <u>Modelling of contractor selection using fuzzy-TOPSIS</u>. 2017 5Th International Conference On Electrical, Electronics And Information Engineering (ICEEIE), IEEE.

[11]   Bruno, T., et al. (2018). "The promise of Best Value Procurement: Governance and (in) stability of specifications within an innovative biogas project." <u>Journal of Cleaner Production</u> **172**: 1465-1475.

[12]   Chen, Z.-S., et al. (2021). "Expertise-based bid evaluation for construction-contractor selection with generalized comparative linguistic ELECTRE III." <u>Automation in Construction</u> **125**: 103578.

[13]   Cheng, E. W. and H. Li (2004). "Contractor selection using the analytic network process." <u>Construction management and Economics</u> **22**(10): 1021-1032.

[14]   Darko, A., et al. (2019). "Review of application of analytic hierarchy process (AHP) in construction." <u>International Journal of Construction Management</u> **19**(5): 436-452.

[15]   de Araújo, M. C. B., et al. (2017). "Project procurement management: A structured literature review." <u>International journal of project management</u> **35**(3): 353-377.

[16]   Dong, Y., et al. (2010). "Consensus models for AHP group decision making under row geometric mean prioritization method." <u>Decision Support Systems</u> **49**(3): 281-289.

[17]   East, E. W. (2007). Construction operations building information exchange (COBie), ENGINEER RESEARCH AND DEVELOPMENT CENTER CHAMPAIGN IL CONSTRUCTION ….

[18]   Egemen, M. and A. N. Mohamed (2006). "Clients' needs, wants and expectations from contractors and approach to the concept of repetitive works in the Northern Cyprus construction market." <u>Building and environment</u> **41**(5): 602-614.

[19] El-Haram, M. A., et al. (2002). "Development of a generic framework for collecting whole life cost data for the building industry." Journal of Quality in Maintenance Engineering **8**(2): 144-151.

[20] Enshassi, A., et al. (2013). "Contractors' selection criteria: opinions of Palestinian construction professionals." International Journal of Construction Management **13**(1): 19-37.

[21] Gransberg, D. D. and J. S. Shane (2015). "Defining best value for construction manager/general contractor projects: The CMGC learning curve." Journal of Management in Engineering **31**(4): 04014060.

[22] Hadidi, L. A. and M. A. Khater (2015). "Loss prevention in turnaround maintenance projects by selecting contractors based on safety criteria using the analytic hierarchy process (AHP)." Journal of loss prevention in the process industries **34**: 115-126.

[23] Hasnain, M., et al. (2018). "Best value contractor selection in road construction projects: ANP-based decision support system." International Journal of Civil Engineering **16**(6): 695-714.

[24] Hassaan, H., et al. (2013). Fuzzy decision model for construction contractor's selection in Egypt: Tender phase. 2013 IEEE International Conference on Industrial Engineering and Engineering Management, IEEE.

[25] Hosny, O., et al. (2013). "Prequalification of Egyptian construction contractors using fuzzy-AHP models." Engineering, Construction and Architectural Management.

[26] Huang, X. (2011). "An analysis of the selection of project contractor in the construction management process." International journal of business and management **6**(3): 184.

[27]   Karapetrovic, S. and E. Rosenbloom (1999). "A quality control approach to consistency paradoxes in AHP." <u>European Journal of Operational Research</u> **119**(3): 704-718.

[28]   Lam, E. W., et al. (2010). "Benchmarking success of building maintenance projects." <u>Facilities</u> **28**(5/6): 290-305.

[29]   Le, C., et al. (2020). "Evaluating contractors' production performance in highway projects using historical daily work report data." <u>Journal of Management in Engineering</u> **36**(3): 04020015.

[30]   Lines, B. C., et al. (2021). "An empirical analysis of project performance outcomes for best-value procurement in design–bid–build projects." <u>Journal of Management in Engineering</u> **37**(3): 04021005.

[31]   Love, P. E., et al. (2002). "Using systems dynamics to better understand change and rework in construction project management systems." <u>International journal of project management</u> **20**(6): 425-436.

[32]   Mohammadpour, A., et al. (2015). "Measuring end-user satisfaction in the design of building projects using eye-tracking technology." <u>Computing in Civil Engineering 2015</u>: 564-571.

[33]   Naji, K. K., et al. (2022). "Assessment of Construction Project Contractor Selection Success Factors considering Their Interconnections." <u>KSCE Journal of Civil Engineering</u> **26**(9): 3677-3690.

[34]   Nguyen, P. H., et al. (2018). "Best-value procurement in design-bid-build construction projects: Empirical analysis of selection outcomes." <u>Journal of Construction Engineering and Management</u> **144**(10): 04018093.

[35]   Perrenoud, A., et al. (2017). "Using Best-Value Procurement to Measure the Impact of Initial Risk-Management Capability on Qualitative Construction Performance." <u>J. Manage. Eng</u> **33**(5): 1-1.

[36] Puri, D. and S. Tiwari (2014). "Evaluating the criteria for contractors' selection and bid evaluation." <u>International journal of engineering science invention</u> **3**(7): 44-48.

[37] Satty, G., et al. (1988). <u>Computing and Logic, Mathematics and Language</u>, Philosophia Verlag.

[38] Shalwani, A., et al. (2019). "Differentiation of evaluation criteria in design-build and construction manager at risk procurements." <u>Journal of Management in Engineering</u> **35**(5): 04019017.

[39] Silva, A., et al. (2022). "Causal effects between criteria that establish the end of service life of buildings and components." <u>Buildings</u> **12**(2): 88.

[40] Singh, D. and R. L. Tiong (2005). "A fuzzy decision framework for contractor selection." <u>Journal of construction engineering and management</u> **131**(1): 62-70.

[41] Steele, A. and D. Sodhi (2004). "Black and minority ethnic contractors and consultants and UK housing associations' contracting power." <u>Construction Management and Economics</u> **22**(2): 151-157.

[42] Sullivan, K. T. (2011). "Quality management programs in the construction industry: Best value compared with other methodologies." <u>Journal of Management in Engineering</u> **27**(4): 210-219.

[43] Swanson, L. (2001). "Linking maintenance strategies to performance." <u>International journal of production economics</u> **70**(3): 237-244.

[44] Tan, Y., et al. (2014). "Critical success factors for building maintenance business: a Hong Kong case study." <u>Facilities</u> **32**(5/6): 208-225.

[45] Tayeh, B. A., et al. (2018). "Factors affecting the success of construction projects in Gaza Strip." <u>The Open Civil Engineering Journal</u> **12**(1).

[46]   Topcu, Y. I. (2004). "A decision model proposal for construction contractor selection in Turkey." Building and environment **39**(4): 469-481.

[47]   Tsang, A. H. (2002). "Strategic dimensions of maintenance management." Journal of Quality in Maintenance Engineering **8**(1): 7-39.

[48]   Waara, F. and J. Bröchner (2006). "Price and nonprice criteria for contractor selection." Journal of Construction Engineering and Management **132**(8): 797-804.

[49]   Watt, D., et al. (2009). "Identifying key factors in the evaluation of tenders for projects and services." International journal of project management **27**(3): 250-260.

[50]   Wireman, T. (2005). Developing performance indicators for managing maintenance, Industrial Press Inc.

[51]   Witherspoon, P. D. and K. L. Wohlert (1996). "An approach to developing communication strategies for enhancing organizational diversity." The Journal of Business Communication (1973) **33**(4): 375-399.

[52]   Wood, B. (2005). "Towards innovative building maintenance." Structural Survey **23**(4): 291-297.

[53]   Xia, B., et al. (2013). "Analysis of selection criteria for design-builders through the analysis of requests for proposal." Journal of Management in Engineering **29**(1): 19-24.

[54]   Ying, F. J., et al. (2022). "Achieving construction innovation in best value procurement projects: New Zealand mega projects study." Construction Innovation **22**(2): 388-403.

[55]   Yu, W.-d. and K.-W. Wang (2012). "Best value or lowest bid? A quantitative perspective." Journal of Construction Engineering and Management **138**(1): 128-134.

[56]   Zavadskas, E., et al. (2005). "Simulation of multi-criteria selection of buildings' maintenance contractor using the game theory." Computer Modelling and New Technologies **9**(2): 7-16.

[57]   Zavadskas, E. K., et al. (2009). "Multicriteria evaluation of apartment blocks maintenance contractors: Lithuanian case study." International Journal of Strategic Property Management **13**(4): 319-338.

[58]   Zavadskas, E. K. and T. Vilutienė (2006). "A multiple criteria evaluation of multi-family apartment block's maintenance contractors: I—Model for maintenance contractor evaluation and the determination of its selection criteria." Building and environment **41**(5): 621-632.

[59]   Zubair, M. U. and X. Zhang (2022). "Investigation and Improvements of the Existing Best-Value Selection Criteria for Elevator Maintenance Contractors." Journal of Management in Engineering **38**(1): 04021083.

APPENDIX:

The survey form for prioritizing criteria and attributes are as follow,

Prioritizing Criteria & Factors consider in Selection of maintenance Contractor

In this survey the participants are asked to rate the criteria and factors according to relative importance to each other considering its importance in maintenance contractor selection process.

The Scale of comparison has been shown in following table:

Explanation	Numeric Values
If Option A and Option B are equally important: Mark	1
If one option is moderately more important than the other: Mark	3
If one option is strongly more important than the other: Mark	5
If one option is very strongly more important than the other: Mark	7
If one option is extremely more important than the other: Mark	9
Use even numbers for intermediate judgements	2, 4, 6, 8

Using the scale from 1 to 9 where 9 shows extreme importance of one to other and 1 shows equally important, please indicate the relative importance of option A to option B.

Introduction:

Participant's Name: _____

Name of Organization: _____

Participant Field of Expertise: _____

Experience of Participant (if any): _____

1.Relative Importance of Criteria/Categories																		
IF "*OPTION A*" IS RELATIVELY IMPORTANT										IF "*OPTION B*" IS RELATIVELY IMPORTANT								
Option A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Option B
Work Approach																		Experience
Work Approach																		Past Performance
Work Approach																		Personal Record & Resources
Work Approach																		Financial & Legal Status
Experience																		Past Performance
Experience																		Personal Record & Resources
Experience																		Financial & Legal Status
Past Performance																		Personal Record & Resources
Past Performance																		Financial & Legal Status
Personal Record & Resources																		Financial & Legal Status

2.Relative Importance of Work Approach Factors																		
IF "*OPTION A*" IS RELATIVELY IMPORTANT										IF "*OPTION B*" IS RELATIVELY IMPORTANT								
Option A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Option B
Proposed Maintenance plan & Approach																		Understanding insight of client & Project need

	3.Relative Importance of Experience Factors																		
IF "*OPTION A*" IS RELATIVELY IMPORTANT										IF "*OPTION B*" IS RELATIVELY IMPORTANT									
Option A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Option B**
General Work Experience																			Experience of Similar works
General Work Experience																			Employee Qualification
General Work Experience																			Availability of Technical Staff
Experience of Similar works																			Employee Qualification
Experience of Similar works																			Availability of Technical Staff
Employee Qualification																			Availability of Technical Staff

4.Relative Importance of Past Performance Factors																		
IF "*OPTION A*" IS RELATIVELY IMPORTANT										IF "*OPTION B*" IS RELATIVELY IMPORTANT								
Option A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Option B
Past Performance																		Performance in Similar work
Past Performance																		Previous Client Satisfaction
Past Performance																		Work Safety/Accidents record
Past Performance																		Previous work quality
Performance in similar works																		Previous Client Satisfaction
Performance in similar works																		Work Safety/Accidents record
Performance in similar works																		Previous work quality
Previous Client Satisfaction																		Work Safety/Accidents record
Previous Client Satisfaction																		Previous work quality
Work Safety/Accidents Record																		Previous work quality

5.Relative Importance of Personal Record & Resources Factors																		
IF "*OPTION A*" IS RELATIVELY IMPORTANT										IF "*OPTION B*" IS RELATIVELY IMPORTANT								
Option A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Option B
Failed Contracts																		Inventory In Stock

6.Relative Importance of Financial & Legal status Factors																		
IF "*OPTION A*" IS RELATIVELY IMPORTANT										IF "*OPTION B*" IS RELATIVELY IMPORTANT								
Option A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Option B
Financial Capability/ Stability																		Proposed Price
Financial Capability/ Stability																		Availability of require licenses to perform maintenance work
Financial Capability/ Stability																		Litigation & Claim History
Proposed Price																		Availability of require licenses to perform maintenance work
Proposed Price																		Litigation & Claim History
Availability of require licenses to perform maintenance work																		Litigation & Claim History

Part-B: Substantiation of Factors:

Following are the factors consider for best value selection process of maintenance contractor, kindly answer according to your knowledge how these factors can be substantiated for a specific contractor in procurement process, which documents can help in evaluating these factors for a contractor.

S. No	Factors	Ways to Substantiate
Approach to Work / Work Approach		
1.	Understanding insight of clients and project needs.	
2.	Proposed maintenance approach and plans	
Experience		
3.	General work Experience	
4.	Experience of similar works	
5.	Employee qualification	
6.	Availability of technical skilled/Trained staff	
Past Performance		
7.	Past performance	
8.	Performance In similar project	
9.	Previous Client satisfaction /Reputation earned.	
10.	Safety of work/Accidents Record	
11.	Previous work Quality	

	Personal Record & Resources	
12.	Failed contracts	
13.	Inventory in stock /Resources	
	Financial & Legal status	
14.	Financial Capability/stability	
15.	Proposed Price	
16.	Availability of required licenses to perform maintenance.	
17.	Litigation and claims history	