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SELECTION OF HEAVY EQUIPMENT WITH MULTI-CRITERIA GROUP DECISION MAKING METHOD FOR THE PURCHASE OPERATION IN THE CONSTRUCTION INDUSTRY

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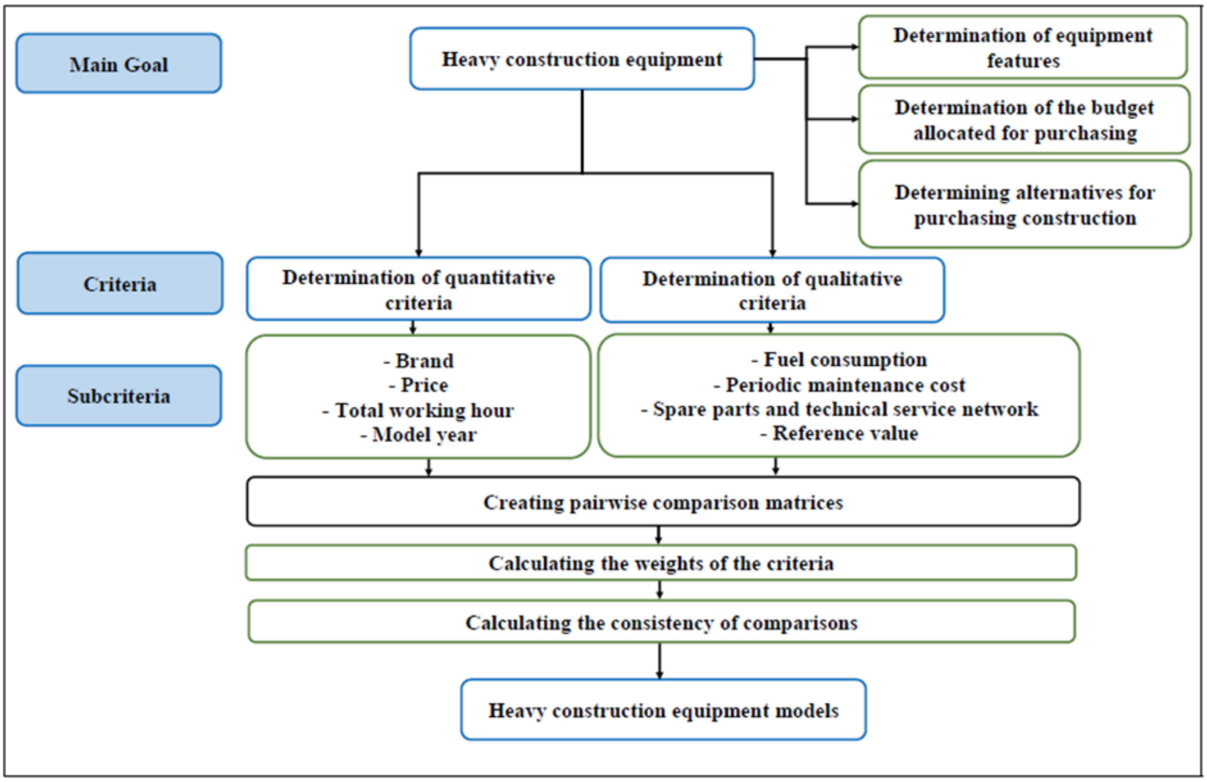
Highlights

- Correctly managing the heavy equipment to be purchased is an important decision.
- MCDM is widely used method to determine the right alternative in complex situations.
- AHP leads to capture both subjective and objective aspects of a decision.

Graphical Abstract



Flowchart of the proposed method

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ABSTRACT: In the construction industry, especially in infrastructure construction, the purchase of construction equipment is an important investment decision in terms of operational efficiency. In this process, many factors such as purchase cost, total working hour, model year, fuel consumption, service network, operation and maintenance cost, should be considered. Increasing the number of factors to be considered can make the decision-making process complex. In such cases, the use of decision support techniques will help decision makers to make the most accurate decision. The purpose of this study is to investigate the effectiveness of the AHP technique in the purchase of heavy construction equipment in the construction sector. In the evaluation of the alternatives determined by the purchasing unit, eight criteria were used, four quantitative and four qualitative. Data regarding quantitative criteria were obtained through market research conducted by the purchasing department, and data regarding qualitative criteria were obtained through face-to-face surveys with four experts. For the analysis, the Analytic Hierarchy Process (AHP) technique, which is widely used for decision support purposes, was used, and the criterion with the highest importance weight was determined as the periodic maintenance cost. The results obtained from the study show that multi-criteria decision making (MCDM) methods are effective to help decision makers in the purchase of heavy equipment in the construction industry.

Keywords: *Analytical Hierarchy Process (AHP), Heavy Construction Equipment Purchasing, Multi-criteria Group Decision Making*

1. INTRODUCTION

Heavy equipment has a very important structure in today's industry and construction sector. Heavy equipment used in the construction industry are the direct execution of work. The employment of heavy construction equipment has been demonstrated to have a number of beneficial effects on construction projects. Firstly, it has been shown to reduce the need for manual labour, thus reducing the time taken to complete the project. Secondly, it has been demonstrated to increase work efficiency. However, the financial outlay required for the procurement of heavy construction equipment is substantial, given the equipment's high cost. It is necessary to consider not only the purchase cost of the heavy equipment, but also the long-term operating and maintenance costs. Many factors such as fuel consumption, service network, maintenance and spare parts costs, user recommendations and brand reliability of a construction heavy equipment directly affect the purchasing cost. When purchasing a second-hand heavy equipment, the model year of the equipment and its total working hours are also added to these factors. In addition, the compliance of a heavy equipment with sectoral ranges is also an important factor from a technical perspective. Therefore, the decision to purchase a heavy construction equipment often requires analysis of numerous technical and commercial criteria.

Decision making is the key to any outcome, especially the establishment of a job or project in the construction industry, especially in capturing the multitude of information and possibilities it can contain. MCDM is an important tool in solving decision problems because more than one criterion and goal is not taken into account at the same time. For solving real comprehensive design analyses, different MCDM methods are constantly being developed and increasingly adopted [1]. Equipment selection is a very

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important decision problem in terms of production program activities. Since many criteria such as production planning, costs, capacity and payments must be taken into consideration in the selection process of the appropriate machine, an effective decision-making tool is needed for the equipment selection problem. MCDM techniques, which stand out with their applicability in many fields, can be used as an effective solution tool in this regard [2]. Equipment selection for construction projects is an important decision in the success of the solution and is part of the complexity [3]. Selecting the right equipment for the project is a multifaceted process of evaluating the costs and benefits of its components [4]. Making wrong choices when purchasing a heavy construction equipment will result in increased costs and replacement. Therefore, correctly managing the heavy construction equipment to be purchased is a critically important decision. In order to properly protect your purchase, many alternatives and factors must be evaluated together. This situation can make the decision-making process extremely complex and you can expand the appropriate decision support system units to make the right choice. This is where MCDM protocols come into play. By taking into account multiple factors, MCDM supports decision makers in making appropriate choices by ensuring that multiple alternatives are accurately cut out. MCDM is a widely used method to determine the right alternative in complex situations with many variables. MCDM techniques are used successfully in different sectors and application areas. Many factors usually need to be taken into account when making important and costly decisions, such as purchasing a heavy equipment. For this reason, MCDM techniques provide important guidance to decision makers in the selection of heavy equipment. MCDM research has developed rapidly and has become a major area of research to address complex decision problems [5]. In the modern economy, choosing the most suitable machine is very important to increase the level of production and generate income. In addition, machine selection becomes difficult with the increase in the number of alternative machines and conflicting criteria [6]. Decision making in project management in construction has always been complex, especially when multiple criteria are considered. MCDM has been frequently used for complex decisions in the construction industry where many criteria are involved [7].

A thorough analysis of extant literature reveals that the predominant research themes within the domain of MCDM encompass the selection of machinery and equipment, the selection of site and area, and the selection of suppliers and contractors.

A plethora of studies have been conducted on the utilisation of MCDM in the selection of machinery and equipment. Chamzini and Yakhchali [8] developed a decision making model. The developed model based on fuzzy AHP and fuzzy TOPSIS to evaluate the potential of tunnel boring machines (TBMs) and select the best one from the pool of alternative TBMs with using MCDM methods. Fuzzy AHP based on pairwise comparison was used to obtain the weights of the evaluation criteria, while fuzzy TOPSIS was used to prioritize suitable alternatives. The weights obtained from fuzzy AHP were used in fuzzy TOPSIS calculations and included in the TBM selection problem, and the ranking order was assigned according to the weights. In the end, the alternative TBM with the highest number of points was selected. In addition, a sensitivity analysis was carried out to determine the effect of the weighting of the criteria on the TBM selection problem. The proposed model has shown that the evaluation and ranking of alternatives under the lack of partial or quantitative information can be done. In the study conducted by Kurtay et al. [9], 5 main criteria and 19 sub-criteria were determined, taking into account expert opinions, to determine the hierarchical structure commonly used in the literature in order to evaluate alternative suppliers for the supply of plastic pipe welding machines. The importance levels of the criteria were calculated using the AHP method. The evaluation and ranking of the 5 alternative suppliers, which were taken into account in the weights obtained as a result of AHP, were made with the Gray Relational Analysis Method. Tolun and Tümtürk [10] aimed to find a solution to the equipment selection problem of a business that needs to purchase an equipment, taking into account many criteria. Due to the difference in priorities of the manager, the criteria taken into account when purchasing machinery are weighted with AHP. In order to choose among the different alternatives determined by the business, the most suitable one was selected with the help of Gray Relational Analysis. Gürgen and Altın [11] made a comprehensive evaluation of ship main engine selection criteria using the Fuzzy AHP. This method provides a systematic framework for evaluating criteria that include qualitative and quantitative data based on their relative importance. Three main criteria were identified for the selection of main machinery: economic, technical and company-related, and each major criterion was detailed with four sub-criteria. The results showed that when the relative importance of each sub-criterion was evaluated together, fuel consumption emerged as the highest priority, constituting the overall importance. The findings of the study conducted by Stirbanovic et al. [12] demonstrate the applicability of MCDM methods such as TOPSIS and VIKOR in the selection of flotation machines. The evaluation of five flotation machines was conducted by three experts using ten criteria divided into three groups: constructional, economical and technical. The findings of this evaluation constituted the basis for application of VIKOR and TOPSIS methods. The results of the evaluation process demonstrated that the machine A4 exhibited the optimal performance inboth methods.

A considerable number of studies have been conducted on the utilisation of MCDM in the context of site and area selection. Biluca et al [13] studied to create a methodology for mapping suitable areas for the receipt of inert waste from medium and small sized cities. They used AHP and ELECTRE TRI methods for this purpose. The proposed methodology based on geographic information system (GIS) has been shown to facilitate the decision-making by allowing analysis of the entire region in regional management models. Wang et al. [14], developed a decision making model, based on improved TOPSIS and GIS, for the site selection planning of integrated power plants. First, GIS was used to identify suitable areas for construction. Secondly, with the integration of GIS function, a comprehensive evaluation index system for society, nature and economy was established by using the AHP method to calculate the weight of each index to obtain the final optimal location. Finally, the TOPSIS model was used for the ranking of the alternative locations and the ranking results were as follows. The analysis result effectively confirms that the improved TOPSIS technique can improve the accuracy of the location selection decision for integrated power plants. Karabıçak et al. [15] aimed to determine the most suitable construction site location among the alternatives determined on the route for a highway construction. Fuzzy AHP and TOPSIS methods, which are MCDM techniques, were applied together to evaluate the alternatives. Among these methods, the criteria were weighted with Fuzzy AHP, and the alternative locations were ranked according to their suitability with TOPSIS. As a result of the evaluation, the most important criteria were revealed and a preference ranking was made among alternative construction sites. Dinç et al. [16] aimed to determine station areas, which is an important step in planning of transportation on high-speed train lines. Determining and optimizing station locations is very important for increasing the preferability of the line and in the line efficiency. First, the importance weights of possible station locations on the Ankara-Sivas high-speed train line were determined using the AHP, in this study. Then, a target programming model was established with the aim of achieving the targets of importance weight, proximity to the center and maximum population, and special constraints. According to the results obtained, station locations on the line were determined. In the study conducted by Çetin et al. [17], it is shown that quantitative decision-making methods can be used as decision support systems in making investment decisions and in situations that require choosing among available alternatives, and it is recommended to benefit from these methods. In the study, the problem of land selection for residential construction was discussed as a decision-making practice in the construction industry. An evaluation was made by taking into account the fuzzy AHP as a method that can assist the decision maker in the land selection decision. It has been shown that the fuzzy AHP method can be used as a solution offering tool while solving a multi-objective decision problem, taking into account uncertainties. Taşkaya and Ulutaş [18] aimed to identify the most suitable points for investment in order to establish a restaurant by using GIS, AHP and TOPSIS techniques. The determined alternatives were evaluated with AHP and TOPSIS techniques. The results obtained show that it is easier to determine suitable areas for restaurants, business centers, shopping malls, commercial, residential and commercial buildings. Gümüşay et al. [19] defined areas suitable for building a marina using topographic and demographic data on an existing coastline by applying the AHP MCDM method. The AHP method was used to weight to each data set in this study. A methodology was proposed for the integration of multiple data sets that were of different scales and types. Using the proposed methodology, it has been shown that it is possible to create a decision support system for upper-scale plans that will enable authorities to conduct analyzes accurately, cost- and time-effectively. In the study conducted by Çolak [20], examines wind energy. The objective of this study was to enhance efficiency by identifying the optimal location for the construction of a wind power plant. Following consultation with experts in the field and reviewing literature, 16 criteria were identified for site selection. The present study utilized the fuzzy AHP and DEMATEL methods. The analyses indicated that Balıkesir province is the best location for the construction of a wind power plant. Shao et al. [21] present an integrated methodology that combines GIS, MCDM and ANN techniques for optimal site selection. In this regard, they have developed a comprehensive set of criteria encompassing environmental, technical, economic, and social dimensions. This research contributes to theoretical understanding in site selection and wave forecasting while providing a practical and adaptable framework for stakeholders involved in renewable energy projects. The objective of the study conducted by Xuan et al. [22] was to ascertain the most suitable location for solar-powered hydrogen production in 13 provinces of Uzbekistan. This study is employes the Stepwise Weight Assessment Ratio Analysis (SWARA) for criteria weighting and using the Weighted Aggregated Sum Product Assessment (WASPAS), the COmplex PRoportional Assessment of alternatives (COPRAS), the Evaluation Based on Distance from Average Solution (EDAS), and the Weight Sum Model (WSM) for ranking locations. All ranking methods identify Bukhara province as the most suitable location for solar-powered hydrogen production in Uzbekistan.

Another area in which numerous studies have been conducted on the use of MCDM is the selection of suppliers and contractors. Aydın and Eren [23] focused on a hybrid method based on AHP and TOPSIS that determines the best supplier up to the selected criteria, in order to select the best supplier for a critical sub-part of the defense industry. For this; AHP and TOPSIS algorithms were used to make a selection in line with the criteria of cost, quality, machinery, delivery, technical competence and qualified workmanship. It is considered as a suitable approach for supplier selection problems. The results obtained show that the model works correctly. Daulay and Dinariyana [24], were used MCDM method for shipyard selection. The method used for selection is a combination of the AHP and the TOPSIS. While AHP is used to determine the weights of the criteria and sub criteria used in the selection, TOPSIS is used to determine the shipyard selection priorities based on the weights of the criteria and sub criteria created from the AHP process. According to the analysis results of six different shipyards in the region, the priority order of the shipyards recommended by the company for shipbuilding was obtained. And sensitivity analysis showed that the results produced on shipyard selection were quite robust. Jabbarzadeh [25] presents a MCDM method for contractor selection. Six criteria are used in the proposed study; financial stability, experience, manpower resources, quality performance, current workload and equipment resources to evaluate various contractors. The study ranks the criteria and finds their relative importance using the AHP. The Ranking of TOPSIS technique is then used to rank alternative contractors based on these criteria. The results obtained show that the ranking is important in terms of support to decision makers. Cheng and Li [26] suggested that MCDM is a suitable method for contractor selection. AHP and analytical network process (ANP), which are MCDM techniques, were used to select the most suitable contractor. Seth et al. [27] focused on the supply chain of a large-scale residential project to demonstrate the role of competitiveness and supplier profile and its impact on supplier evaluation based on current market conditions. Different scenarios have been investigated to reveal the impact of competition on supplier evaluation. MCDM has been used to evaluate various situations. The results obtained show that the evaluation method presented in the study can be applied to project-based situations such as oil refinery and shipbuilding where many suppliers are involved. In their study Ma and Li [28] developed a decision support system for supplier quality assessment. The system is presented as a conceptual framework consisting of three modules: the decision matrix and criteria initialization module, the MCDM method selection and implementation module, and the aggregation module. The system has been developed for the purpose of enabling the dynamic monitoring and evaluation of the supplier and product quality performance. The results of this study demonstrate that the decision support system provides more robust and reliable evaluation results in comparison to traditional individual MCDM method.

Apart from these, researchers have also investigated issues related to MCDM, such as construction cost and time [29], construction waste management [30, 31], construction method [32], selection of private partners in housing sector [33], research and development activities [34], stock management [35], facility planning [36], and sales of a company that builds low-rise buildings/villas [37].

The aim of this study is to examine the applicability of the AHP technique, a widely utilised method in purchasing processes, in the acquisition of heavy construction equipment. The utilisation of MCDM methodologies in the context of equipment selection is predominantly employed in the operation of industrial facilities. In the field of construction, MCDM methods are predominantly employed in the domains of site selection and contractor selection. The originality of this study is that it provides a framework for how AHP technique can be used in heavy construction equipment selection in the construction industry. In the study, first of all, the factors and alternatives that should be taken into consideration in the heavy construction equipment purchasing process were determined. Then, based on these factors, the score ranking of the alternatives was determined as a result of the evaluation using the AHP method. It is evaluated that the results obtained from this study will contribute to the studies carried out in the coming years on purchasing problems in the construction sector.

2. MATERIAL AND METHODS

In this study, the use of MCDM techniques was investigated in purchasing a heavy construction equipment to be included in the heavy equipment pool of a construction company operating in infrastructure construction. For this purpose, considering the required features of a 30 ton operating weight crawler excavator as the heavy construction equipment to be purchased and the budget of 75,000.00 USD allocated for the purchase, 7 alternatives were notified to the purchasing department by the requesting construction site management. The AHP often uses seven elements and puts them in clusters if there are more [38]. The purchasing department determined the values of four quantitative criteria, namely brand, purchasing cost, total working hours and model year of each of the alternatives, through market research. Four qualitative criteria were discussed: fuel consumption, spare parts and technical service network, periodic maintenance cost and references. Data regarding qualitative criteria were obtained through face-to-face surveys with the founding partners of the company in question, the equipment pool manager and the heavy construction equipment chief operator. Regarding the heavy construction equipment, the company partners have over 30 years of experience, the pool manager has 25 years, and the chief operator has 20 years of experience.

AHP, one of the MCDM methods, was developed by Thomas L. Saaty [38]. The AHP method helps to capture both objective and subjective aspects of a decision. It reduces complex decisions and synthesizes the results [39]. AHP provides a MCDM platform that allows decision-makers to assign weights to each element in a decision model, which is necessary for index calculation. AHP can capture the subjective judgments of decision-makers and then transform them into numerical values [40]. In MCDM problems, after the problem is identified, criteria and alternatives for the solution are determined. A hierarchical structure is built for decision making, and as a result, the most suitable alternative is selected.

The AHP method is used to determine the priorities or weights of different criteria and alternatives and to determine the most suitable alternative. In this process, the steps are building the hierarchical structure of the problem, creating a pairwise comparison matrix, calculating the weights using the matrix, and evaluating the consistency of the existing data. If the data is consistent, the most appropriate alternative is selected. In the process steps, the values showing the importance levels given in Table 1 are used in pairwise comparisons for the criteria.

Table 1. The Fundamental Scale by Saaty [38]

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgement strongly favor one activity over another
7	Very strong or demonstrated importance	An activity is favored very strongly over another, its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	For compromise between the above values	When compromise is needed

AHP process steps are given below.

Step 1: The decision hierarchy is built. Criteria, sub-criteria and alternatives are determined.

Step 2: In comparing the criteria according to the purpose, pairwise comparison matrices are created according to the values suggested by Saaty (1990) given in Table 1.

Step 3: The eigenvector of the matrix is calculated and priorities are determined.

Step 4: The consistency of the comparisons is calculated. A consistency ratio of 0.10 or less is positive evidence for informed judgment [38].

In recent years, AHP, one of the MCDM methods, has attracted great attention from researchers and experts in many disciplines. There are many scientific studies and publications prepared using the AHP method [41].

The issue of purchasing heavy construction equipment was resolved with the "Group Decision Making" approach. The methodology applied in the study is given as a flow chart in Figure 1.

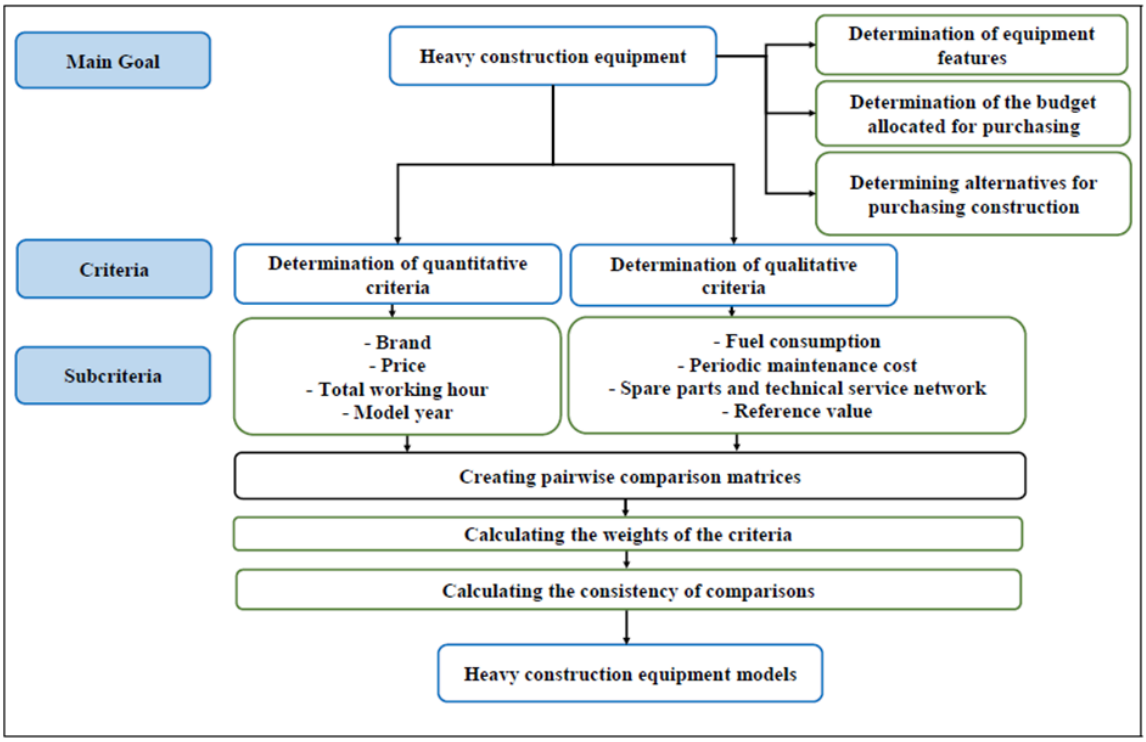

Figure 1. Purpose and Criteria of the Study

3. RESULTS AND DISCUSSION

The surveys used in this study consist of two stages. In the first step, participants were given grades out of 10 for the qualitative evaluation score, with 1 being the worst and 10 being the best. Evaluation of quantitative and qualitative criteria is given in Table 2.

Table 2. Scores of evaluation of quantitative and qualitative criteria

	Quantitative Measures				Qualitative Measures															
					Co-Founder-1				Co-Founder-2				Equipment Pool Manager				Heavy Construction Equipment Chief Operator			
Alternative No.	Brand of Heavy Equipment	Purchase Cost (USD)	Total Working Hour	Model Year of Heavy Equipment	Fuel Consumption	Spare Parts and Technical Service Network	Periodic Maintenance Cost	Reference Value	Fuel Consumption	Spare Parts and Technical Service Network	Periodic Maintenance Cost	Reference Value	Fuel Consumption	Spare Parts and Technical Service Network	Periodic Maintenance Cost	Reference Value	Fuel Consumption	Spare Parts and Technical Service Network	Periodic Maintenance Cost	Reference Value
1	A	66000	17.500	2007	8	10	3	9	7	8	3	9	8	10	1	9	8	6	3	9
2	B	64500	26.000	2008	8	10	3	9	7	6	6	7	8	10	1	7	8	8	3	9
3	C	67000	16.700	2010	8	8	8	8	7	8	5	10	8	10	1	9	8	9	8	9
4	D	70500	14.800	2011	8	9	7	8	7	8	5	8	8	7	3	5	8	8	7	8
5	E	73500	32.000	2007	8	6	9	6	7	8	7	8	8	7	3	5	8	7	7	7
6	F	63000	17.000	2008	8	7	5	10	7	10	5	10	8	10	1	10	8	10	10	10
7	F	70300	14.750	2013	8	7	5	10	7	10	5	10	8	10	1	10	8	10	10	10

In the second step, each of the quantitative and qualitative criteria was scored by comparing them with all other criteria separately. According to the first stage survey results, since all participants scored the "fuel consumption" criterion at the same value for all alternatives, the "fuel consumption" criterion was not included in the second stage of the survey.

The comparison of the criteria in the second step is given in Tables 3, 4, 5 and 6, respectively.

Table 3. Comparison of criteria by Co-Founder-1

	Purchase Cost	Total Working Hour	Model Year of Heavy Equipment	Spare Parts and Technical Service Network	Periodic Maintenance Cost	Reference Value
Purchase Cost	1	3	2	5	1/5	5
Total Working Hour	1/3	1	1/5	1/5	1/5	1/5
Model Year of Heavy Equipment	1/2	5	1	4	1/3	1/3
Spare Parts and Technical Service Network	1/5	5	1/4	1	1/5	1/3
Periodic Maintenance Cost	5	5	3	5	1	3
Reference Value	1/5	5	3	3	1/3	1

Table 4. Comparison of criteria by Co-Founder-2

	Purchase Cost	Total Working Hour	Model Year of Heavy Equipment	Spare Parts and Technical Service Network	Periodic Maintenance Cost	Reference Value
Purchase Cost	1	5	2	5	3	3
Total Working Hour	1/5	1	1/5	2	2	2
Model Year of Heavy Equipment	1/2	5	1	3	3	3
Spare Parts and Technical Service Network	1/5	1/2	1/3	1	2	3
Periodic Maintenance Cost	1/3	1/2	1/3	1/2	1	3
Reference Value	1/3	1/2	1/3	1/3	1/3	1

Table 5. Comparison of criteria by Heavy Equipment Pool Manager

	Purchase Cost	Total Working Hour	Model Year of Heavy Equipment	Spare Parts and Technical Service Network	Periodic Maintenance Cost	Reference Value
Purchase Cost	1	2	1	3	1/5	5
Total Working Hour	1/2	1	1/5	1	1/7	1/7
Model Year of Heavy Equipment	1	5	1	1/5	1/3	1/5
Spare Parts and Technical Service Network	1/3	1	5	1	1/5	1/5
Periodic Maintenance Cost	5	7	3	5	1	3
Reference Value	1/5	7	5	5	1/3	1

Table 6. Comparison of criteria by Heavy Construction Equipment Chief Operator

	Purchase Cost	Total Working Hour	Model Year of Heavy Equipment	Spare Parts and Technical Service Network	Periodic Maintenance Cost	Reference Value
Purchase Cost	1	5	2	1/2	1/3	1/2
Total Working Hour	1/5	1	1/5	1	1/3	1/5
Model Year of Heavy Equipment	1/2	5	1	1	1/3	1/3
Spare Parts and Technical Service Network	2	1	1	1	1	1/3
Periodic Maintenance Cost	3	3	3	1	1	1/2
Reference Value	2	5	3	3	2	1

The evaluations of co-founder-1, co-founder-2, equipment pool manager and heavy construction equipment chief operator are given in Tables 3, 4, 5 and 6, respectively, with pairwise comparisons.

The concept of pairwise comparisons is based on the evaluation of pairs of options. In the next step, the values representing the group decision for each criterion were calculated by taking the geometric mean. The eigenvector corresponding to the largest eigenvalue of the pairwise comparison matrix is calculated. Following the determination of the eigenvector, it is imperative that the consistency arising from the evaluations of the decision makers is tested. The calculation of rates is an essential step in the process.

In Analytical Hierarchy process (AHP) methodology, the consistency ratio is defined as CR, where CR is calculated as CI/RI. In accordance with Saaty (2012), the consistency ratio (CR) of 0.10 or lower has been demonstrated to be acceptable in terms of the continuation of AHP analysis [42]. In instances where the result exceeds 0.10, it is imperative that a thorough review of the decision is conducted to ascertain the root cause of the discrepancy and implement necessary corrections.

As a result of the calculations, the consistency index was found to be CI=0.094623 and the consistency ratio CR=CI/RI was found to be 0.076309. The results were considered consistent because the CR value was less than 0.10.

In the next step, the weights of the qualitative and quantitative criteria were calculated (Table 7). In the next step, scores and rankings were determined in the calculations made using these matrices (Table 8).

Table 7. Weight of criteria

Criteria	**Weight**
Purchase Cost	0.231143
Total Working Hour	0.063863
Age / Model Year of Heavy Equipment	0.154254
Spare Parts and Technical Service Network	0.104846
Periodic Maintenance Cost	0.272596
Reference Value	0.173297

Table 8. Ranking of alternatives

Alternatives	Score	Rank
Alternative-1	0.731433	7
Alternative-2	0.739328	6
Alternative-3	0.876421	3
Alternative-4	0.8477	4
Alternative-5	0.791953	5
Alternative-6	0.890921	2
Alternative-7	0.923576	1

As a result of this study, according to the findings obtained in the application made with the group decision-making approach in the heavy construction equipment purchasing problem, when the importance weights are ranked from highest to lowest as a result of the AHP method, the highest criterion weight is periodic maintenance cost with a value of 0.272596, and the second is the purchase cost with a criterion weight of 0.231143. The fact that the highest criterion weight is the periodic maintenance cost has been interpreted as being due to the very hard working conditions of heavy construction equipment operating in the construction sector, unlike other sectors. The lowest criteria weights are attributed to total working hours, with a criteria weight of 0.0633863, and spare parts and technical service network, with a criteria weight of 0.104846. This phenomenon is interpreted as a shift in which the provision of good technical service is no longer a determining factor, due to the enhancement of service quality across all brands and the facilitation of access to spare parts through logistics services in the globalised world. The enhancement in technical service has the effect of reducing the importance of total working hours, as equipment repair and maintenance is carried out correctly and in a timely manner. Therefore, in the evaluation of alternatives, the importance of any criterion is important, as well as whether there is a difference between the alternatives with respect to that criterion. In the study conducted using the AHP method, it was found that the most suitable construction machine model was Alternative-7.

In AHP method the weights of alternatives are dependent on the priorities of attributes and sensitivity analysis, concept can be studied under variations in the weights of attribute and based on the following procedure changes in attribute priorities that obtain from the behavior of decision makers can cause changes in the alternative weights [39]. At the stage of evaluating the consistency of the evaluations of decision makers; The eigenvalue matrix was found by multiplying the comparison matrix and the weight matrix. After calculating the largest eigenvalue, the consistency index and consistency ratio were calculated. As a result of the calculations, the consistency ratio was found to be 0.076. Since the calculated consistency ratio value is less than 0.1, it is concluded that the evaluations of the decision makers are consistent.

4. CONCLUSIONS

In the construction industry, especially in infrastructure construction, the purchase of construction equipment is an important investment decision in terms of operational efficiency. In this process, many factors such as purchase cost, total working hour, model year, fuel consumption, service network, operation and maintenance cost, should be considered. Increasing the number of factors to be considered can make the decision-making process complex. In such cases, the use of decision support systems will help decision makers to make the most accurate decision. Heavy construction equipment purchasing decisions are complex processes that generally require the evaluation of many alternatives and criteria. The objective of this study is to examine the potential of the AHP technique, a prevalent method in purchasing processes, to facilitate acquisition of heavy construction equipment. For this purpose, it is shown how multi-criteria group decision-making techniques can be used in the purchase of construction equipment. For the analysis, the Analytic Hierarchy Process (AHP) technique, which is widely used for decision support purposes, was used. According to the results obtained from spesifically this study, the criterion with the highest criterion weight with the AHP method is the periodic maintenance cost and the second criterion is the purchasing cost. Data regarding qualitative criteria were obtained through personal evaluation of experts and may vary depending on expert opinions. The results reveal that multi-criteria group decision-making techniques provide decision makers with a systematic approach based on the evaluators' scoring, and make the decision process more efficient and effective. The results obtained from the study are important for equipment purchase, especially in the construction sector, where every other project has different characteristics.

In the future, wider application of such decision support systems will allow more optimal choices to be made, especially in large-scale projects. Integration of MCDM techniques also offers decision makers greater transparency and comparability between alternatives.

Declaration of Ethical Standards

The paper is carried out in accordance with ethical standards.

Credit Authorship Contribution Statement

Conceptualization, Methodology, Validation, Analysis, Investigation, Writing – review and editing.

Declaration of Competing Interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data Availability

All data generated or analyzed during this study are included in this published article.

REFERENCES

[1] X. Zhu, X. Meng, and M. Zhang, "Applıcatıon of multıple crıterıa decısıon makıng methods ın constructıon: a systematıc lıterature revıew," *Journal of Civil Engineering and Management,* vol. 27, no. 6, pp. 372–403, 2021.

[2] A. C. G. Kısa and S. Perçin, "Application of integrated fuzzy DEMATEL-fuzzy VIKOR approach to machine selection problem," *Journal of Yasar University,* vol. 12, no. 48, pp. 249-256, 2017.

[3] A. Shapira and M. Goldenberg, "AHP-based equipment selection model for construction," *J. Constr. Eng. Manage.,* vol. 131, no. 12, pp. 1263-1273, 2005.

[4] M. Goldenberg and A. Shapira, "Systematic evaluation of construction equipment alternatives: case study," *J. Constr. Eng. Manage.,* vol. 133, no. 1, pp. 72-85, 2007.

[5] C. C. Sun, "A performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods," *Expert Systems with Applications,* vol. 37, pp. 7745–7754, 2010.

[6] R. Karim and C. L. Karmaker, "Machine selection by AHP and TOPSIS methods," *American Journal of Industrial Engineering,* vol. 4, no. 1, pp. 7-13, 2016.

[7] J. Antuchevičienė, E. K. Zavadskas, and A. Zakarevičius, "Multiple criteria construction management decisions considering relations between criteria," *Technological and Economic Development of Economy,* vol. 16, no. 1, pp. 109–125, 2010.

[8] A. Y. Chamzini and S. H.Yakhchali, "Tunnel boring machine (TBM) selection using fuzzy multicriteria decision making methods," *Tunnelling and Underground Space Technology*, vol. 30, pp. 194–204, 2012.

[9] K. B. Kurtay, H. A. Dağıstanlı, and S. Erol, "Integration of analytical hierarchy process and gray relational analysis methods for plastic pipe and welding machine selection problem," *The Journal of Defense Sciences,* vol. 20, no. 2, pp. 267-291, 2021.

[10] B. G. Tolun and A. Tümtürk, "Machine selection using integration of AHP and grey relational analysis: application in agricultural machinery production enterprise," *Yönetim ve Ekonomi,* vol:27, no. 1, pp. 21-34, 2020.

[11] S. Gürgen and İ. Altın, "Assessıng key factors ın marıne maın engıne selectıon usıng fuzzy AHP method," *Mersin Üniversitesi Denizcilik ve Lojistik Araştırmaları Dergisi,* vol:5, no. 1, pp. 57-79, 2023.

[12] Z. Stirbanovic, D. Stanujkic, I. Miljanovic, D. Milanovic, "Application of MCDM methods for flotation machine selection", *Minerals Engineering,* 137, p.140-146, 2019.

[13] J. Biluca, C. R. Aguiar, and F. Trojan, "Sorting of suitable areas for disposal of construction and demolition waste using GIS and ELECTRE TRI," *Waste Management,* vol. 114, pp. 307–320, 2020.

[14] Y. Wang, S. Tao, X. Chen, F. Huang, X. Xu, X. Liu, and Y. Liu, "Method multi-criteria decision-making method for site selection analysis and evaluation of urban integrated energy stations based on geographic information system," *Renewable Energy*, vol. 194, pp. 273-292, 2022.

[15] Ç. Karabıçak, A. İ. Boyacı, M. K. Akay, and B. Özcan, "Multi criteria decision making methods and an application for selectıon highway construction site," *Kastamonu Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi,* no.13, pp. 107-121, 2016.

[16] S. Dinç, M. Hamurcu, and T. Eren, "Multicriteria decision making aided 0-1 goal programming model for selection of station location in the Ankara-Sivas high speed rail line," *Demiryolu Mühendisliği Dergisi, vol.* 9, pp. 1-16, 2019.

[17] E. İ. Çetin, Y. Akil, and A. I. Güler, "Decision making with fuzzy analytic hierarchy process in construction projects," *International Journal of Management Economics and Business,* vol. 10, no. 23, pp. 173-190, 2014.

[18] S. Taşkaya and N. Ulutaş "Determining the most suitable restaurant areas for investment by GIS, the case of Tunceli," *OKU Journal of Natural and Applied Sciences*, vol. 4, no. 2, pp. 134-141, 2021.

[19] M. U. Gumusay, G. Koseoglu, and T. Bakirman, "An assessment of site suitability for marina construction in Istanbul, Turkey, using GIS and AHP multicriteria decision analysis," *Environ Monit Assess,* vol. 188, no. 677, pp.1-15, 2016.

[20] Z. Çolak, "A hybrid MCDM method for enhancing site selection for wind power plants in Turkey" *Energy for Sustainable Development*, vol. 82, pp.1-14, 2024.

[21] M. Shao, Z. Han, J. Sun, H. Gao, S. Zhang, Y. Zhao, "A novel framework for wave power plant site selection and wave forecasting based on GIS, MCDM, and ANN methods: A case study in Hainan Island, Southern China", *Energy Conversion and Management,* vol. 299, pp.1-20, 2024

[22] H. A. Xuan, V. V. Trinh, K. Techato, K. Phoungthong, "Use of hybrid MCDM methods for site location of solar-powered hydrogen production plants in Uzbekistan", *Sustainable Energy Technologies and Assessments*, vol. 52, pp.1-12, 2022.

[23] Y. Aydın and T. Eren, "Supplier selectıon with multi criteria desicion making methods for strategic products in defense indusrty," *Omer Halisdemir University Journal of Engineering Sciences,* vol. 7, no.1, pp. 129-148, 2018.

[24] I. T. Daulay and A. A. B.Dinariyana, "Application of a combination of AHP and TOPSIS methods in shipyard selection," *International Journal of Marine Engineering Innovation and Research,* vol. 8, no. 4, pp. 658-666, 2023.

[25] A. Jabbarzadeh, "Application of the AHP and TOPSIS in project management," *Journal of Project Management*, vol. 3, pp. 125–130, 2018.

[26] E. W. L. Cheng and H. Li, "Contractor selection using the analytic network process," *Construction Management and Economics,* vol. 22, no. 10, pp. 1021-1032, 2004.

[27] D. Seth, K. Nemani, S. Pokharel, and A. Y. A. Sayed, "Impact of competitive conditions on supplier evaluation: a construction supply chain case study," *Production Planning & Control,* vol. 29, no.3, pp. 217-235, 2018.

[28] Q. Ma and H. Li, "A decision support system for supplier quality evaluation based on MCDM-aggregation and machine learning", *Expert Systems With Applications*, vol. 242, pp.1-17, 2024.
[29] C. C. Lin, W. C. Wang, and W. D. Yu, "Improving AHP for construction with an adaptive AHP approach (A^3)," *Automation in Construction*, vol. 17, pp. 180–187, 2008.
[30] Y. Yi, X. Fei, A. Fedele, M. C. Lavagnolo, A. Manzardo, "Decision support model for selecting construction and demolition waste management alternatives: A life cycle-based approach", *Science of the Total Environment*, vol. 951, p.1-16, 2024.
[31] A. Sobotka, J. Sagan, "Decision support system in management of concrete demolition waste", *Automation in Construction*, vol. 128, p.1-13, 2021.
[32] S. S. Lin, A. Zhou, S. L. Shen, "Optimal construction method evaluation for underground infrastructure construction", *Automation in Construction*, vol. 152, pp.1-17, 2023.
[33] A. K. Abdullah and A. Alshibani, "Multi-criteria decision-making framework for selecting sustainable private partners for housing projects," *Journal of Financial Management of Property and Construction,* vol. 27, no. 1, pp. 112-140, 2022.
[34] K. Ateş and C. Şahin, "A hybrid fuzzy model to the ranking problem of companies operating R&D activities in technology innovation centers," *OKU Journal of The Institute of Science and Technology,* vol. 6, no. 2, pp. 1452-1468, 2023.
[35] M. Kokoç and S. Ersöz, "Comparison of AHP-TOPSIS and AHP-VIKOR methods in product selection in terms of inventory management," *International Journal of Engineering Research and Development,* vol. 11, no. 1, pp. 163-172, 2019.
[36] İ. Düzdar and S. Kolçak, "Lights-out manufacturing factors evaluation in terms of facility planning," *OKU Journal of The Institute of Science and Technology,* vol. 7, no. 3, pp. 994-1009, 2024.
[37] K. Baynal, Y. Şahin, and S. Taphasanoğlu, "Selectıon of white goods for luxury housing project with multi-criteria decision making techniques," *MANAS Journal of Social Studies,* vol. 8, no. 2, pp. 1871-1888, 2019.
[38] T. L. Saaty, "How to make a decision: The analytical hierarchy process," *European Journal of Operational Research*, vol. 48, pp. 9-26, 1990.
[39] B. F. Dehaghi and A. Khoshfetrat, "AHP-GP approach by considering the Leopold Matrix for sustainable water reuse allocation: Najafabad case study, Iran," *Periodica Polytechnica Civil Engineering,* vol. 64, no. 2, pp. 485–499, 2020.
[40] L. A. Ocampo, "A hierarchical framework for index computation in sustainable manufacturing," *Advances in Production Engineering & Management,* vol. 10, no. 1, pp. 40–50, 2015.
[41] R. Russo and R. Camanho, "Criteria in AHP: a systematic review of literature," *Procedia Computer Science*, vol. 55, pp. 1123-1132, 2015.
[42] T. L. Saaty, *Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World*, Third Revised Edition, Pittsburgh, RWS Publications, 2012.