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DECIDING THE BEST VEHICLE ALTERNATIVE BY USING A MULTI CRITERIA DECISION MAKING METHODOLOGY

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Abstract:

Multi-Criteria Decision Making is one of the most important issues, especially when there are numerous competing criteria and alternatives to consider. There are a variety of approaches for dealing with such issues. The Analytic Hierarchy Process (AHP) is one of the most popular problem solvers for this type of problem, and it's especially useful for determining the weights of the criteria. Using decision-makers' evaluation tables, this method compares each of the criteria to each other. Furthermore, this method employs a consistency ratio to assess the consistency of decision-makers' choices. The decision maker's experience and knowledge are critical in this process. Selection of a construction vehicle (truck) alternative is discussed in this study. Four different vehicles are selected based on five criteria. The AHP approach is used to choose the best option. The results are interpreted at the end of the process.

Keywords: *Decision Making; AHP; Vehicle Selection.*

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1. Introduction

Many judgments are made in our day-to-day lives based on a variety of factors. Therefore, decisions can be made by assigning weights to various criteria with all weights obtained from expert groups. There are not only very complicated difficulties requiring multiple criteria, and certain criteria may have an effect on some problems, but all alternatives must have common criteria that clearly lead to more informed and better selections in order to have an optimal solution [1]. Multi-Criteria Decision Making (MCDM) has seen a tremendous amount of use over the last years. Its importance in several application fields has grown dramatically, particularly when new approaches emerge and existing ones improve [2].

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When there are a number of criteria (variables) in a decision-making problem, MCDM procedures are applied. Every day, the number of MCDM procedures grows. The Analytic Hierarchy Process (AHP) is better suited to solving real-world decision problems since it does not reflect human thinking styles, despite the fact that the AHP's goal is to make judgments by acquiring expert information. AHP method is used in many problems in the literature such as an analysis in construction industry [3], engineering education [4], retail site selection [5], reverse logistics [6], assessment of flood hazard [7], renewable energy selection [8], solar farm site selection [9]. In this study an application is made for the selection of a new construction truck is considered.

The remainder of the work is organized as follows. In the second part, the AHP method is briefly mentioned. In the third chapter, the definition of the problem is mentioned. In the last section, the results are evaluated.

2. AHP Methodology

AHP methodology is proposed by Saaty [10] to evaluation of the criteria weight and to decide best alternative. The method steps are provided as below.
Step 1: Define the objective
Step 2: Create binary comparison matrices
Step 3: Normalization
Step 4: Weight vector is calculated
Step 5: Calculate the consistency index
Step 6: Evaluation of alternatives

3. Truck selection problem

This study considers a construction truck selection problem. This problem has different types of criteria and alternatives. A construction company decided to purchase a truck and wants to decide the best one that satisfy company needs at the most appropriate level. The decision-maker of the company is decided criteria as follows:

- Load carrying capacity
- Maintenance period
- Fuel performance
- Service period
- Cost of spare parts

After deciding the criteria decision-makers is decided the alternative trucks. The alternatives are provided as follows:

- Truck-1
- Truck-2
- Truck-3
- Truck-4

Application of the AHP methodology
Step 1. The objective is defined as vehicle selection.
Step 2. Binary comparison matric is given in Table 1. This matric is created using Saaty [10] scale.
Step 4. Weight vector is calculated and the findings are given in Table 3.

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Table 1: Binary comparison matric

Criteria	**Load carrying capacity**	**Maintenance period**	**Fuel performance**	**Service period**	**Cost of spare parts**
Load carrying capacity	1	4	1	3	1
Maintenance period	0,25	1	0,2	0,333	0,25
Fuel performance	1	5	1	3	3
Service period	0,333	3	0	1	0,333
Cost of spare parts	1	4	0,333	3	1

Table 2: Normalized matric

Criteria	**Load carrying capacity**	**Maintenance period**	**Fuel performance**	**Service period**	**Cost of spare parts**
Load carrying capacity	0,2791	0,23529	0,34892	0,29033	0,17912
Maintenance period	0,06977	0,05882	0,06978	0,03223	0,04478
Fuel performance	0,2791	0,29412	0,34892	0,29033	0,53735
Service period	0,09294	0,17647	0,11619	0,09678	0,05965
Cost of spare parts	0,2791	0,23529	0,11619	0,29033	0,17912

Table 3: Weight vector calculation

Weight	**W_i**	**D vector**	**E values**
Load carrying capacity	0,26655	1,38204	5,184901
Maintenance period	0,05508	0,28281	5,134733
Fuel performance	0,34996	1,87713	5,36381
Service period	0,1084	0,5522	5,093862
Cost of spare parts	0,22001	1,14862	5,220856

After the normalization processes, the weight (Wi) of each criterion is found. This process is applied as follows. The values in each row in the normalized matrix are summed and averaged. In this way, the weight of the criteria is found. The D column vector is found by multiplying the criterion comparison matrix and the W matrix. By dividing the reciprocal elements of the D column vector and the W column vector; the base value (E) for each evaluation factor is obtained.

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Step 5: The consistency rate for this study was 0.044. Since this value is less than 1, the matrix is consistent.

Step 6: The alternatives are evaluated with respect to each criteria. The evaluation matrices are provided as below tables.

Table 4: Load carrying capacity matric

Alternative	Truck - 1	Truck - 2	Truck - 3	Truck - 4
Truck - 1	1	2	0,5	2
Truck - 2	0,5	1	0,33333	0,5
Truck - 3	2	3	1	3
Truck - 4	0,5	2	0,33333	1

Table 5: The obtained values for load carrying capacity criteria

Alternative	Truck - 1	Truck - 2	Truck - 3	Truck - 4	W	D	E
Truck - 1	0,25	0,25	0,23077	0,30769231	0,25962	1,06611	4,10648
Truck - 2	0,125	0,125	0,15385	0,07692308	0,12019	0,48518	4,03667
Truck - 3	0,5	0,375	0,46154	0,46153846	0,44952	1,84135	4,09626
Truck - 4	0,125	0,25	0,15385	0,15384615	0,17067	0,69071	4,04695

Table 6: Maintenance period matric

Alternative	Truck - 1	Truck - 2	Truck - 3	Truck - 4
Truck - 1	1	4	3	5
Truck - 2	0,25	1	2	3
Truck - 3	0,33	0,5	1	2
Truck - 4	0,2	0,333	0,5	1

Table 7: The obtained values for maintenance period criteria

Alternative	Truck - 1	Truck - 2	Truck - 3	Truck - 4	W	D	E
Truck - 1	0,56179775	0,685753	0,46154	0,45454546	0,54091	2,3099	4,27041
Truck - 2	0,14044944	0,171438	0,30769	0,27272727	0,22308	0,91465	4,10017
Truck - 3	0,18539326	0,085719	0,15385	0,18181818	0,15169	0,61037	4,02371
Truck - 4	0,11235955	0,057089	0,07692	0,09090909	0,08432	0,34263	4,06348

Table 8: Fuel performance matric

Alternative	Truck - 1	Truck - 2	Truck - 3	Truck - 4
Truck - 1	1	0,2	3	4
Truck - 2	5	1	7	6
Truck - 3	0,333	0,111	1	2
Truck - 4	0,25	0,166667	0,5	1

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Table 9: The obtained values for fuel performance capacity criteria

Alternative	Truck - 1	Truck - 2	Truck - 3	Truck - 4	W	D	E
Truck - 1	0,15190643	0,135338	0,26087	0,30769231	0,21395	0,88537	4,13816
Truck - 2	0,75953213	0,676692	0,6087	0,46153846	0,62661	2,74462	4,38008
Truck - 3	0,05058484	0,075188	0,08696	0,15384615	0,09164	0,36809	4,01657
Truck - 4	0,03797661	0,112782	0,04348	0,07692308	0,06779	0,27154	4,00554

Table 10: Service period matric

Alternative	Truck - 1	Truck - 2	Truck - 3	Truck - 4
Truck - 1	1	3	1	2
Truck - 2	0,333	1	0,5	3
Truck - 3	1	2	1	3
Truck - 4	0,5	0,333	0,33	1

Table 11: The obtained values for service period criteria

Alternative	Truck - 1	Truck - 2	Truck - 3	Truck - 4	W	D	E
Truck - 1	0,3529827	0,473709	0,35298	0,22222222	0,35047	1,50707	4,30008
Truck - 2	0,11754324	0,157903	0,17649	0,33333333	0,19632	0,82571	4,20598
Truck - 3	0,3529827	0,315806	0,35298	0,33333333	0,33878	1,42518	4,20685
Truck - 4	0,17649135	0,052582	0,11754	0,11111111	0,11443	0,46786	4,08851

The consistency ratio for:
Load capacity: 0,0238
Maintenance period: 0,0423
Fuel performance: 0,05
Service period: 0,07

Table 12: Cost of spare parts matric

Alternative	Truck - 1	Truck - 2	Truck - 3	Truck - 4
Truck - 1	1	0,333	0,5	0,5
Truck - 2	3	1	2	2
Truck - 3	2	0,5	1	3
Truck - 4	2	0,5	0,333	1

Table 13: The obtained values for cost of spare parts criteria

Alternative	Truck - 1	Truck - 2	Truck - 3	Truck - 4	W	D	E
Truck - 1	0,125	0,142735	0,13045	0,07692308	0,11878	0,49121	4,13556
Truck - 2	0,375	0,428633	0,52178	0,30769231	0,40828	1,7105	4,18955
Truck - 3	0,25	0,214316	0,26089	0,46153846	0,29669	1,26716	4,27103
Truck - 4	0,25	0,214316	0,08688	0,15384615	0,17626	0,71675	4,06642

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The consistency ratio for "cost of spare parts" is 0,063. The criteria weights are combined at final stage and provided in Table 14. Wi values that calculated at initial stage is multiplied with combined weights and this table provided in Table 15.

Table 14: Combined criteria weights

Criteria	**Load carrying capacity**	**Maintenance period**	**Fuel performance**	**Service period**	**Cost of spare parts**
Truck - 1	0,25962	0,54091	0,213952	0,350474	0,118776
Truck - 2	0,12019	0,22308	0,626614	0,196318	0,408277
Truck - 3	0,44952	0,15169	0,091644	0,338776	0,296687
Truck - 4	0,17067	0,08432	0,06779	0,114432	0,17626

Table 15: Multiplied criteria weights

Criteria	**Load carrying capacity**	**Maintenance period**	**Fuel performance**	**Service period**	**Cost of spare parts**
Truck - 1	0,0692	0,02979	0,07487507	0,037992783	0,02613131
Truck - 2	0,03204	0,01229	0,21929109	0,021281656	0,08982298
Truck - 3	0,11982	0,00835	0,03207192	0,036724674	0,06527262
Truck - 4	0,04549	0,00464	0,02372392	0,012404887	0,03877808

Table 16: Combined criteria weights

Criteria	**Load carrying capacity**	**Maintenance period**	**Fuel performance**	**Service period**	**Cost of spare parts**	**Total**
Truck - 1	0,0692	0,02979	0,07487507	0,037992783	0,02613131	0,23799144
Truck - 2	0,03204	0,01229	0,21929109	0,021281656	0,08982298	0,37471944
Truck - 3	0,11982	0,00835	0,03207192	0,036724674	0,06527262	0,2622438
Truck - 4	0,04549	0,00464	0,02372392	0,012404887	0,03877808	0,12504404

As shown in Table 16 the total performance of the Truck-2 is the best alternative to purchase. Secondly, Truck-3 has the highest score. Truck-1 and Truck-4 is the other alternative to be considered.

4. Results and Discussions

Selection problems are one of the difficult types of problems encountered at every stage of life. Many methods have been developed before to solve these problems. Although each method is different from each other, some of the developed methods are used more frequently.

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In this study, a construction truck selection problem is discussed. The AHP method was used to solve the problem in question. This method also considers the interaction between the criteria while evaluating the alternatives. In the study, four different alternative trucks were determined by the decision maker. Five different criteria were taken into consideration to decide the most suitable one of these alternatives. As a result of the calculations, it was seen that the second alternative was the most appropriate. This problem is important as the study is a guiding study in terms of vehicle selection problems in the construction sector. The limited number of alternatives and criteria in the study can be shown as a limitation of the study.

The expressions used in the study are valid for certain situations. Modeling under uncertainty may be among the studies that can be done in the future. However, the results can also be analyzed in cases where the number of decision makers increases.

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