Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 13 Issue 1, January - 2026

Decision Making with Analytic Hierarchy Process (AHP) for Concrete Selection

Kadir Güçlüer
Adıyaman University, Vocational School of Technical Science, Department of Construction
Adıyaman, Türkiye
corresponding author: kgucluer@adiyaman.edu.tr

Berkant Dulkadir
Adıyaman University, Gölbaşı Vocational School, Department of Management and Organization
Adıyaman, Türkiye
bdulkadir44@hotmail.com

***Abstract*— Concrete, as the basic component of the load-bearing systems of structures, has critical importance in terms of safety, sustainability and economy. However, not only the technical properties of concrete but also factors such as the service quality offered by the supplier, production infrastructure and delivery processes can directly affect the quality and safety of the structure. In this study, the selection of the concrete company was considered as a multi-criteria decision problem and systematically analyzed with the Analytical Hierarchy Process (AHP) method. In the model based on 11 criteria shaped in line with the opinions of 15 field professionals, a rational preference scale was created to determine the most suitable alternatives by calculating the weights of the criteria with the pairwise comparison method. As a result of the AHP analysis, the criteria of "having qualified technical personnel" (25.82%) and "membership in the Turkish Ready-Mixed Concrete Association (THBB)" (18.28%) were determined to be the most important factors.**

Keywords—AHP; concrete selection; multi-criteria decision making

I. INTRODUCTION

The construction industry is not only a field of building production but also a complex and high-risk sector in which systematic supply chains are present and managed. In this context, the material supply process stands out as a strategic factor that plays a key role in the successful completion of construction projects (Gunasekaran et al., 2001). In the case of structural materials like concrete, which forms the backbone of the load-bearing system, not only the technical characteristics of the material but also factors such as which company provides the concrete, and how it is produced and delivered, significantly affect structural safety and cost-effectiveness (Topcu, 2004; Ho et al., 2010). Thus, choosing a concrete supplier should not merely be regarded as a procurement decision; it must be treated as a decision-making problem that involves comprehensive evaluation of economic, ecological, and safety-related criteria. Differences among concrete producers in terms of production methods and technology, quality control practices, certifications, delivery reliability, and sustainability approaches result in highly variable outcomes (Buyukozkan & Ciftci, 2011). Currently, many supplier selections are based on experience or intuition, which often leads to faulty decisions, resulting in issues related to quality, cost and structural safety. In such complex decision environments, methods that offer rational and systematic decision support are essential. Developed by Thomas L. Saaty (1980), the Analytic Hierarchy Process (AHP) is a decision-making method that enables the hierarchical evaluation of multi-criteria problems. AHP incorporates both qualitative and quantitative criteria in a single model, allowing subjective judgments of decision-makers to be quantified through comparison matrices and to calculate priorities systematically (Saaty, 2008; Vaidya &Kumar,2006).
Through AHP, criteria such as cost, quality assurance, production capabilities, delivery processes, ecological considerations, and technical support can be compared for evaluating concrete supplier alternatives (Kahraman et al., 2003; Cheng & Li, 2005). In the literature, AHP has been applied in the construction sector to assess suppliers, evaluate material selection, and manage risks in location selection and project prioritization, providing valuable insights (Ho et al., 2010; Ashby, 2005; Önüt & Soner, 2008; Cheng & Heng, 2004). However, there remains a gap in applying AHP specifically to concrete supply decision processes.

To address this gap, the present study models the decision-making process of concrete supplier selection using AHP from a multi-criteria decision-making perspective. The goal is to provide both a theoretical and practical model that offers rational and reliable guidance to field professionals and decision-makers.

II. MATERILAS AND METHODS

A. AHP

AHP is a decision-making tool used for solving complex, multidimensional, and unstructured problems (Razmi et al., 2002). It is also considered a multi-criteria decision-making method that facilitates the comprehensibility of the decision-making process (Chen, 2006). As illustrated in the Figure 1. hierarchical structure of AHP, the goal is to make the best decision and select the most suitable alternative. The lower levels of the hierarchy consist of sub-criteria that contribute to achieving this goal. These sub-criteria can be further detailed. The bottom level includes the decision alternatives (Zahedi, 1986).

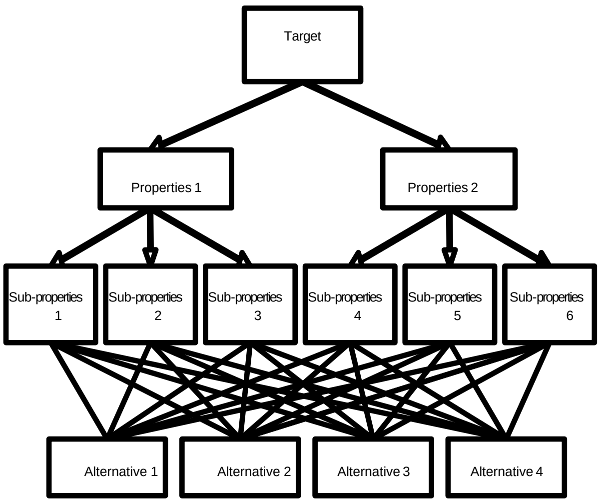

Figure 1. Hierarchical structure of AHP (Razmi et al., 2002)

The AHP-based decision-making process involves four stages. The first stage entails decomposing the problem hierarchically into sub-problems. The second stage involves conducting pairwise comparisons using matrices developed by Saaty. The third stage is synthesis, where priority vectors are calculated for each criterion. The fourth stage involves computing consistency ratios to finalize the decision.

$$A = \left(a_{ij} \right)_{nxn} = \begin{bmatrix} a11 & a12 & . & a12 \\ a21 & a22 & . & a2n \\ . & . & . & . \\ an1 & an2 & . & ann \end{bmatrix} \quad (1)$$

B. Measurement Tools

In the study, firstly, all the criteria that could be the subject of the study were determined with the literature review and the opinions of 15 experts in the field. Some similar expressions were combined and turned into a single criterion. The 11 criteria and criterion codes obtained with the opinions of 15 experts in the field are listed alphabetically as follows:

- Having a strong vehicle fleet (K1)
- Using river aggregate (K2)
- Producing low-cost concrete (K3)
- Having its own aggregate facility (K4)
- Having its own cement production facility (K5)
- Being a member of THBB (K6)
- Using crushed stone aggregate (K7)
- Being a well-established company (K8)
- Producing concrete at reasonable prices (K9)
- Having qualified technical personnel (K10)
- Being a new company (K11)

In the next stage, 11 criteria were adapted to a nine-point scale and made suitable for the AHP method, and a sample group of 15 people was asked to make a pairwise comparison of a total of 55 items. An example for pairwise comparison is given in Table 1.

Table 1. Example of a binary comparison

1. Criteria	**Point**									**2. Criteria**
Having a strong vehicle fleet	9	7	5	3	1	3	5	7	9	Using river aggregate

In the comparison, the samples were asked to indicate what kind of relationship there was between two concrete criteria. The comparisons were made using the scale in Table 2, which is suitable for data analysis with AHP. For example, if the “Strong vehicle fleet” criterion was at the same level as the “Using stream aggregate” criterion, 1 was asked to be marked, if the “Strong vehicle fleet” criterion was extremely important compared to the “Using stream aggregate” criterion, 9 was asked to be marked on the left, and if the opposite was the case, 9 was asked to be marked on the right.

Table 2. Importance Scale (Saaty, T., L., 1980).

Importance Level	**Definition**
1	Equally important
3	One is of little importance compared to the other
5	Strongly important
7	Very strongly important
9	Extremely important
2, 4, 6, 8	Intermediate values

C. Data Analysis

The data obtained through the surveys were analyzed using the AHP method. The consistency of the data obtained using the AHP method can be checked at the end of the analysis. As a result of the calculations, since the consistency ratio was less than 0.1, it was concluded that the data was consistent. Since the study data were consistent, conclusions were drawn regarding the data and suggestions were made.

III. Findings and Discussion

In this section, the analysis of the data obtained through the surveys using the AHP method is discussed in detail and information is provided about the findings of the study. In the AHP method, firstly, a paired comparison table is created using the data obtained as a result of the comparative evaluation of the concrete criteria. While filling the table, the dominant value is written in the cell where the row of the dominant criterion and the column of the weak criterion intersect. In the opposite cell, that is, the cell where the row of the weak criterion and the column of the dominant criterion intersect, the inverse of this value according to multiplication is written. In case of equality, the value 1 is entered in both cells (Saaty, 1980). The comparison matrix created by entering the study data is given in Table 3.

Table 3. Comparison Matrix of Concrete Criteria

Criteria	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11
K1	1,00	4,87	3,40	0,48	1,13	0,35	1,93	0,65	2,73	0,23	5,67
K2	0,21	1,00	0,71	0,15	0,26	0,14	0,28	0,16	0,40	0,13	1,67
K3	0,29	1,40	1,00	0,17	0,35	0,15	0,40	0,19	0,60	0,14	2,47
K4	2,07	6,60	5,80	1,00	2,60	0,71	0,28	1,40	4,60	0,43	7,13
K5	0,88	3,80	2,87	0,38	1,00	0,26	1,27	0,40	2,20	0,23	4,33
K6	2,87	7,40	6,73	1,40	3,80	1,00	4,73	2,07	5,40	0,56	7,80
K7	0,52	3,53	2,47	3,53	0,79	0,21	1,00	0,35	1,53	0,16	3,93
K8	1,53	6,07	5,27	0,71	2,47	0,48	2,87	1,00	3,67	0,26	6,47
K9	0,37	2,47	1,67	0,22	0,45	0,19	0,65	0,27	1,00	0,14	3,40
K10	4,33	7,93	7,13	2,33	4,33	1,80	6,20	3,80	7,13	1,00	8,33
K11	0,18	0,60	0,40	0,14	0,23	0,13	0,25	0,15	0,29	0,12	1,00

For example, the “strong vehicle fleet (K1)” criterion is dominant over the “use of stream aggregate (K2)” criterion with a value of 4.87 in the survey results. For this reason, 4.87 was written in the cell where the “strong vehicle fleet (K1)” row and the “use of stream aggregate (K2)” column intersect. The opposite of this, the multiplicative inverse of the value 5.87, 0.21, was entered in the point where the “use of stream aggregate (K2)” row and the “strong vehicle fleet (K1)” column intersect. The normalization process was performed in the next stage. In this process, first the total of each column was determined and then all cells were divided by the total of the column they were in (Saaty, 1980). The normalization data obtained by applying this process to the data in Table 3 are given in Table 4.

Table 4. Matrix Resulting from Normalization

Criteria	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11
K1	0,0702	0,1066	0,0908	0,0459	0,0649	0,0643	0,0971	0,0625	0,0924	0,0680	0,1086
K2	0,0144	0,0219	0,0191	0,0144	0,0151	0,0249	0,0143	0,0158	0,0137	0,0371	0,0320
K3	0,0206	0,0307	0,0267	0,0164	0,0200	0,0274	0,0204	0,0181	0,0203	0,0413	0,0473
K4	0,1453	0,1445	0,1548	0,0950	0,1493	0,1318	0,0143	0,1339	0,1556	0,1263	0,1366
K5	0,0621	0,0832	0,0766	0,0365	0,0574	0,0486	0,0639	0,0387	0,0744	0,0680	0,0830
K6	0,2015	0,1620	0,1797	0,1330	0,2182	0,1846	0,2379	0,1979	0,1827	0,1635	0,1494
K7	0,0364	0,0773	0,0659	0,3354	0,0452	0,0390	0,0503	0,0333	0,0518	0,0475	0,0753
K8	0,1074	0,1329	0,1407	0,0679	0,1418	0,0892	0,1444	0,0956	0,1242	0,0775	0,1239
K9	0,0257	0,0541	0,0446	0,0207	0,0261	0,0342	0,0329	0,0261	0,0338	0,0413	0,0651
K10	0,3040	0,1736	0,1903	0,2214	0,2486	0,3323	0,3119	0,3633	0,2412	0,2943	0,1596
K11	0,0124	0,0131	0,0108	0,0133	0,0133	0,0237	0,0128	0,0148	0,0100	0,0353	0,0192

In the third stage of the method, the values in each row of the normalized matrix are collected and divided by the number of criteria used in the study, that is, 11. As a result of this process, the eigenvector is obtained. The eigenvector also represents the percentage rates for each criterion. The percentage weights of each criterion are determined by writing the eigenvector values as percentages (Saaty, 1980). The eigenvector values and percentage rates of the criteria in the study are given in Table 5.

Table 5. Eigenvectors and Weight Percentages

Criteria Code	Concrete Criteria	Eigenvector	Weight (%)
K1	Having a strong vehicle fleet	0,0792	7,92
K2	Using river aggregate	0,0202	2,02
K3	Producing low-cost concrete	0,0263	2,63
K4	Having its own aggregate facility	0,1261	12,61
K5	Having its own cement production facility	0,0629	6,29
K6	Being a member of THBB	0,1828	18,28
K7	Using crushed stone aggregate	0,0779	7,79
K8	Being a well-established company	0,1132	11,32
K9	Producing concrete at reasonable prices	0,0368	3,68
K10	Having qualified technical personnel	0,2582	25,82
K11	Being a new company	0,0162	1,62

The final criteria ranking and percentage weights of the study are made more understandable by sorting the data obtained from high to low in Table 5. The ranking of the criteria and their weights are given in Table 6.

Table 6. Importance Order and Percentage Weights of Concrete Criteria

Criteria Code	Concrete Criteria	Weight (%)
K10	Having qualified technical personnel	25,82
K6	Being a member of THBB	18,28
K4	Having its own aggregate facility	12,61
K8	Being a well-established company	11,32
K1	Having a strong vehicle fleet	7,92
K7	Using crushed stone aggregate	7,79
K5	Having its own cement production facility	6,29
K9	Producing concrete at reasonable prices	3,68
K3	Producing low-cost concrete	2,63
K2	Using river aggregate	2,02
K11	Being a new company	1,62

In the AHP method, the validity and reliability of the data are determined by the consistency ratio formula applied to the data at the end of the study. The purpose of this process is to check whether the A criterion is dominant over the C criterion if A>B and B>C in the data obtained from the samples. If it is dominant, the study is considered consistent, and if the opposite is the case, the study is considered inconsistent. The process is considered holistically in the study. When this process is performed, the eigenvalue table is first created. This process is obtained by multiplying the matrix in Table 3 with the eigenvector matrix in Table 5. The process is performed separately for each row and the eigenvalue matrix given in Table 7 is obtained (Saaty, 2002).

Table 7. Eigenvalue Matrix

Criteria Code	Concrete Criteria	Eigenvalue
K1	Having a strong vehicle fleet	0,9394
K2	Using river aggregate	0,2310
K3	Producing low-cost concrete	0,3001
K4	Having its own aggregate facility	1,4467
K5	Having its own cement production facility	0,7377
K6	Being a member of THBB	2,2243
K7	Using crushed stone aggregate	0,9900
K8	Being a well-established company	1,3613
K9	Producing concrete at reasonable prices	0,4228
K10	Having qualified technical personnel	3,1555
K11	Being a new company	0,1878

Each row of the eigenvector matrix is multiplied by the row of the eigenvalue matrix in the same row, the obtained values are summed and divided by the number of criteria used in the study. Thus, the largest eigenvalue (λmax) to be used in the consistency index formula is determined (Saaty, 2002). The largest eigenvalue (λmax) obtained by applying the specified process to the study data was found to be 11.823. By applying the data to the consistency index formula given in formula (2), the consistency index of the study was determined to be 0.0823.

$$\text{Consistency Index} = x = \frac{\lambda\text{max}-\text{n}}{\text{n}-1} = \frac{11{,}823-11}{11-1} = 0{,}0823$$
(2)

In the next stage, the randomness index is determined according to the number of criteria used in the study (Saaty, 2002). Since 10 criteria were used in the study, the randomness index was determined as 1.51.

Table 8. Randomness Indicators (Saaty, 2002)

N	1	2	3	4	5	6	7	8	9	10	11	12
RI	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,48

The final step in determining the consistency ratio is to apply formula (2) to the data. In order for the study data to be considered consistent, the result must be less than 0.1 (Saaty, 2002).

$$\text{Consistency Ratio} = \frac{\text{Consistency Index}}{\text{Randomness Index}} = \frac{0{,}0823}{1{,}51} = 0{,}0545.$$
(3)

Since the consistency ratio value obtained by applying formula (3) to the study data was less than 0.1, the study data were accepted as consistent.

IV. Conclusion

This study has revealed that concrete company selection is not only a price-oriented procurement decision, but also a multi-criteria decision problem in which many technical, economic and organizational factors must be evaluated together. The effect of 11 different criteria on concrete company selection was systematically analyzed through the model developed with the Analytical Hierarchy Process (AHP) method.

As a result of the analysis, it was determined that the criteria of "having qualified technical personnel" and "THBB membership" were of the highest importance. This finding shows how effective technical expertise and institutional quality assurance are in sectoral decision-making processes.

The consistency ratio obtained at the end of the study was found to be 0.0545, which shows that the decision makers' evaluations are consistent and reliable. This supports that the model is valid and sustainable in terms of application. In future studies, more holistic models can be developed by making comparative analyses with alternative multi-criteria decision-making methods such as fuzzy AHP (F-AHP), ANP or TOPSIS

References

Ashby, M. F. (2005). Materials Selection in Mechanical Design (3rd ed.). Elsevier.

Buyukozkan, G., & Ciftci, G. (2011). A novel fuzzy multi-criteria decision framework for sustainable supplier selection with incomplete information. Computers in Industry, 62(2), 164–174.

Cheng, E. W. L., & Heng, L. (2004). Analytic network process applied to project selection. Journal of Construction Engineering and Management, 130(2), 200–208.

Cheng, E. W. L., & Li, H. (2005). Analytic hierarchy process: An approach to determine measures for business performance. Measuring Business Excellence, 9(2), 25–33.

Chen, C-F. (2006), “Applying the Analytical Hierarchy Process (AHP) Approach to Convention Site Selection”, Journal of Travel Research, 45(2): 167-174.

Dulmin, R., & Mininno, V. (2003). Supplier selection using a multi-criteria decision aid method. Journal of Purchasing and Supply Management, 9(4), 177–187.

Gunasekaran, A., Patel, C., & McGaughey, R. E. (2001). A framework for supply chain performance measurement. International Journal of Production Economics, 87(3), 333–347.

Ho, W., Xu, X., & Dey, P. K. (2010). Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. European Journal of Operational Research, 202(1), 16–24.

Kahraman, C., Cebeci, U., & Ulukan, Z. (2003). Multi-criteria supplier selection using fuzzy AHP. Logistics Information Management, 16(6), 382–394.

Önüt, S., & Soner, S. (2008). Transshipment site selection using the AHP and TOPSIS approaches under fuzzy environment. Waste Management, 28(9), 1552–1559.

Saaty, T. L. (1980). The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. McGraw-Hill.

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. International Journal of Services Sciences, 1(1), 83–98.

Topcu, Y. I. (2004). A decision model proposal for construction contractor selection in Turkey. Building and Environment, 39(4), 469–481.

Vaidya, O. S., & Kumar, S. (2006). Analytic hierarchy process: An overview of applications. European Journal of Operational Research, 169(1), 1–29.

Saaty, T. L. (2002). Decision making with the analytic hierarchy process. Scientia Iranica, 9(3), 215-229.

Razmi, J., Rahnejat, H. ve Khan, M. K. (2002), “The New Concept of Manufacturing “DNA” within an Analytic Hierarchy Process-Driven Expert System”, European Journal of Innovation Management, 3(4): 199-211.

Zahedi, F. M. (1986), “The Analytic Hierarchy Process A Survey of the Method and its Application”, Interfeces, 16 (July-August): 96-108.