

# **Evaluation of Sanliurfa Concrete Technology with GIS Supported AHP Method as a Useful Tool in Technical Measurement**

## **Teknik Ölçmede Yararlı Bir Araç Olarak CBS Destekli AHP Yöntemiyle Şanlıurfa Beton Teknolojisinin Değerlendirilmesi**

**Veysel ASLAN<sup>(1)</sup>, Mehmet Yaşar SEPETÇİOĞLU<sup>(2)</sup>, Abdurrahman Oktay YAŞAR<sup>(3)</sup>**

<sup>(1,2)</sup>Harran Üniversitesi, Hilvan Meslek Yüksek Okulu, İnşaat Teknolojileri Bölümü, 63900, Şanlıurfa, Türkiye.

<sup>(3)</sup>Harran Üniversitesi, Şanlıurfa Meslek Yüksek Okulu, İnşaat Teknolojileri Bölümü, 63100, Şanlıurfa, Türkiye.

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\*İlgili yazar e-mail: [vaslan0209@outlook.com](mailto:vaslan0209@outlook.com)

**Abstract:** Concrete is one of the most important building materials of strategies that reduce the environmental impact of buildings. Building materials, which undertake many tasks in the building, affect the environment of the buildings in a multifaceted way with their ecological feature. Therefore, it is also important to take the right decisions considering the environmental characteristics in the selection of building materials while designing. Since concrete is the most widely used building material globally and regionally today, the fact that it reflects its properties to the majority of the buildings in which it is used also determines the total environmental impact level. Especially since it is a widely used building material, it becomes very important to increase the environmental properties of concrete. An environmental analysis is made by evaluating the life time levels of concrete in terms of building material criteria. Therefore, this is to consider solutions that will reduce the negativities seen in the ecological life cycle. However, in this study, application was made by assigning weights to five criteria such as Customer, Competitor, Location, Transportation and Price selection problem for concrete with the GIS supported AHP (Analytic Hierarchy Process) method. It is thought that the results obtained will contribute to the concrete plant site selection evaluation in the context of the determined criteria.

**Keywords:** GIS, MCDM, AHP Method, Sanliurfa, Concrete Plant Site Selection

**Özet:** Yapıların çevresel etkilerini azaltan stratejilerin en önemli yapı malzemelerinden biri betondur. Yapıda bir çok görevi üstlenen yapı malzemeleri, ekolojik özelliğiyle de çok yönlü bir şekilde yapıların çevresini etkilemektedir. Dolayısıyla tasarım yapılırken yapı malzemesi seçiminde çevresel özellikleri göz önüne alan doğru kararların alınması da önemlidir. Betonun günümüzde küresel ve bölgesel olarak en çok kullanılan yapı malzemesi olması münasebetiyle kendisinde var olan özellikleri kullandıkları yapıların büyük çoğunluğuna yansıtması, toplam çevresel etki seviyesini de belirlemektedir. Özellikle yaygın kullanılan bir yapı malzemesi olmasından dolayı, betonun çevresel özelliklerinin artırılması oldukça önemli hale gelmektedir. Betonun, ömür süresi mertebeleri yapı malzemesi kriterleri açısından değerlendirilerek çevresel bir analizi yapılmaktadır. Dolayısıyla bu ekolojik yaşam döngüsü içerisinde görülen olumsuzlukları azaltacak çözümleri göz önüne sermektir. Bununla beraber bu çalışmada, CBS destekli çok kriterli karar verme yöntemlerinden biri olan AHP (Analytic Hierarchy Process) yöntemi ile betonun; Müşteri, Rakip, Bulunduğu Konum, Ulaşım ve Fiyat seçimi problemi gibi beş kritere ağırlıklar atanarak uygulama yapılmıştır. Elde edilen sonuçların belirlenen kriterler bağlamında beton santrali yer seçimi değerlendirmesine katkı sağlayacağı düşünülmektedir.

**Anahtar Kelimeler:** CBS, ÇKKV (Çok Kriterli Karar Verme), AHP Metodu, Şanlıurfa, Beton Santrali Yer Seçimi

## 1. INTRODUCTION

Construction activities have an important role in the formation of environmental problems experienced today. However, it is possible to minimize this share by reducing the environmental impacts of buildings. For this, it is necessary to know and implement strategies to reduce environmental impact. Perhaps the most important of these strategies is the location selection of production facilities. The environmental effects of building materials, especially concrete, which undertake many tasks in the building, make it important to consider these effects during the production phase of concrete and to make the right decisions in site selection.

Concrete is the most widely used building material globally and regionally today. For this reason, the production conditions of concrete, which is a widely used building material, necessitates taking into account the effects of concrete on the environment and it must be produced accordingly.

Since real world events are very complex, it is not possible to keep these events under control by defining them with clear equations. As a natural consequence of this, the researcher always prefers to apply to methods that are approximate but with solubility, even if they are not exact. Mathematical equations cannot accurately describe all natural phenomena. Therefore, the solutions in all studies are approximate to some extent.

In engineering, all theories and equations describe the real world in approximate terms. Although many real systems are nonlinear, every effort is made to include the assumption of linearity in their classical study. For example, in the strength calculations, it has been confirmed by Hooke's law that the material will cause linear deformations under stress. However, the material cannot be expected to behave this way all the time, and some deviations, albeit small, are expected. As a natural consequence of this, a size such as the factor of safety was imported into the calculations in strength dimensioning, and the possible uncertainties were again clearly taken into account.

For these reasons, the researcher can use fuzzy systems to solve the problem. In the fuzzy system, the event and mechanism examined by the researcher can be modeled by considering the relevant verbal and rather vague information available as a complement to the events, instead of only equations with definite rules and assumptions and assumptions in their inferences. Verbal data is increasing its importance day by day. It

is necessary to formulate these verbal human data in a system and to consider in engineering systems together with the numerical information given by the devices. The main issue of fuzzy systems is how to think about going for analysis if such information is found.

Decision making problem in the most general sense; It can be defined as the selection of the most appropriate option from a set of options according to at least one purpose or criterion. Research shows that while it is sufficient to make many everyday decisions intuitively, this path alone is not enough for complex and vital decisions. Multi-Criteria Decision-Making Methods started to be developed in the 1960s, when some tools were deemed necessary to assist decision-making [14], [1]. In a decision-making problem, where many parameters determine the goal to be achieved and each of the alternatives to be evaluated for selection has its own advantages, the decision-making task will be very difficult. In such cases, the person who will make the decision, in order to get rid of all this indecision problem, regardless of whether he is healthy or not, either come to a decision; or he will arrive at a decision in doubt after long and irrational analyzes. The purpose of using Multi-Criteria Decision-Making Methods is to keep the decision-making mechanism under control in cases where the number of alternatives and criteria is high and to obtain the decision result as easily and quickly as possible.

Companies that use modern decision support methods can have a competitive advantage in leading globalized business relations and managing this network of relations.

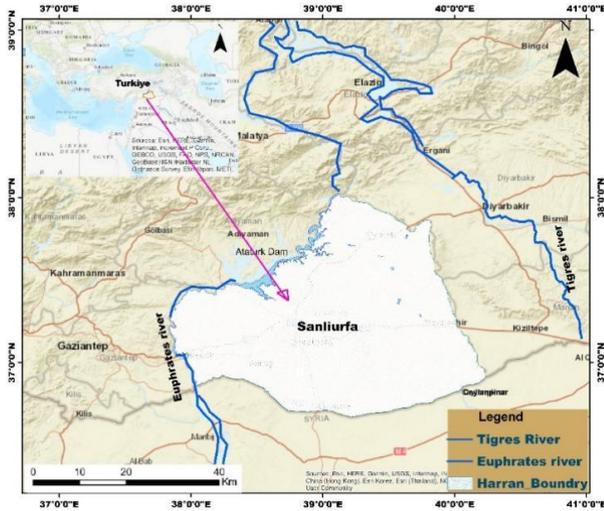
In this study; Site selection analysis was made with multi-criteria decision-making methods by evaluating the criteria that are important in site selection and the life cycle stages from obtaining the raw material of the concrete from nature to the recovery phase.

## 2. LOCATION OF THE STUDY AREA AND ITS GEOMORPHOLOGICAL FEATURES

Sanliurfa is the center of the GAP (Southeast Anatolia Project), which is the most important regional development project of Turkey. Sanliurfa is on the southern skirts of the central part of the Southeast Taurus Mountains. The mountains and high hills in the north of the province generally decrease towards the south. Great plains are located in the south of Sanliurfa. Rows of hills are quite common, among which are the Suruc, Harran and Viransehir plains, which are ordered from west to east. The area of Sanliurfa is 18,584 km

[6]. Although Sanliurfa has the characteristics of the continental climate of the Southeastern Anatolia Region, the effects of the Mediterranean climate are also seen in the province. Summers in the region are hot and dry, and winters are cold and rainy.

Sanliurfa province has a very plain appearance in terms of morphology and includes mountains, plateaus and plains from the main land forms. The only mass that we can call a mountain in the geographical sense is the Karacadag volcanic mass [16].



**Figure 1.** Location of The Study Area and Its Geomorphological Features

### 2.1 Geological Structure of the Study Area

Only sedimentary and volcanic rocks are found in the study area. Sedimentary rocks constitute both the site itself and the base of the site. The oldest rocks in the region are Silicic limestones and red gray clays, which are likely to be Paleocene or Lower Eocene. Eocene aged limestones occupy a large area at the top. Over the lime stones there are also non-fossilized but somewhat looser limestones that can be included in the Eocene or Miocene. These lime stones are included in the Eocene, since no age distinction is made. At the top are Upper Miocene or Pliocene loose clayey lime stones and red clay and sands, which are widely spread only in the plain. Volcanic rocks consist of basalts that cover some heights in the plain. The study area is located in the 3rd and 4th earthquake zones [4].

## 3. MATERIAL AND METHOD

### 3.1 Material

In the evaluation of the concrete features of the Sanliurfa basin, hydrological, anthropogenic and

geological conditions were discussed based on expert opinions, field observations and literature reviews; Factors such as geology and geomorphology were considered as geological elements. Data such as fault density and soil class were considered as anthropogenic features [7]. Elements such as precipitation, meteorological, earthquake and active fault are considered natural disasters. The geology, earthquake, precipitation and soil class, geomorphology, fault parameters data related to the concrete plant location selection were obtained from the relevant institutions, satellite system and private institutions. These data were first corrected in the excel program and then digitized in the Arc map 10.2 program.

### 3.2 Method

Multi-Criteria Decision Making (MCDM) methods are expressed as giving values to alternatives by bringing together different criteria [9]. Spatial multi-criteria analyzes clearly differ from traditional MCDM in terms of content [5]. Because spatial analyzes contain geographical data, location analyzes etc. It brings together many qualitative and quantitative arguments with features and also requires the participation of visual materials in the research.

Spatial decision making methods basically consist of three stages. These are data collection and mental processes, design and selection phases. The first of these phases focuses on the existence of a problem and whether there are opportunities for change. In the second stage, the design stage, what the alternatives are, and in the last stage, the choice stage, the best alternative is selected [10].

#### 3.2.1 Data Usage, Display and Models in GIS

Geographic information includes a reference system such as latitude, longitude, or coordinate system to clearly and precisely indicate the location of a geographic feature. GIS uses a system called geocoding to do this. Thus, the locations of geographical events that require analysis such as business centers, forest areas, earthquake zones, fault lines are determined. Geo-coding is done by several different methods. Depending on the type of features desired, one or both of these methods are often used. These are vector and raster models. In addition, if necessary, data reclassification, Weighted Overlay or Weighted Sum methods are also used. Geographic features represented by point, line and polygon symbols in the vector model are encoded and stored with the x and y coordinate system. An oil well represented by the dot symbol, a

stream basin represented by the polygon symbol, and a transportation network vector model represented by the line symbol. Although the vector model is suitable for clearly separated geographical features, it is incomplete for continuously changing geographic features such as soil types and population density. Here, a raster model has been developed to be used in this case. The features to be displayed in the raster are structured by grouping the cells. The scale used determines the dimensions of the cells, and the dimensions of the cells determine the resolution, thus the quality of the map. In vector, the basic structure is the point. Features that require points are shown with a single point, while features that require lines and areas are shown by connecting points. Depending on the nature of the study, there are situations where the use of both models is advantageous or incomplete. Therefore, the features in the study are modeled by selecting the appropriate model and they are recorded in separate layers in accordance with the GIS working principle [8].

Thematic maps of some parameters affecting the characteristics of concrete technology are as follows;

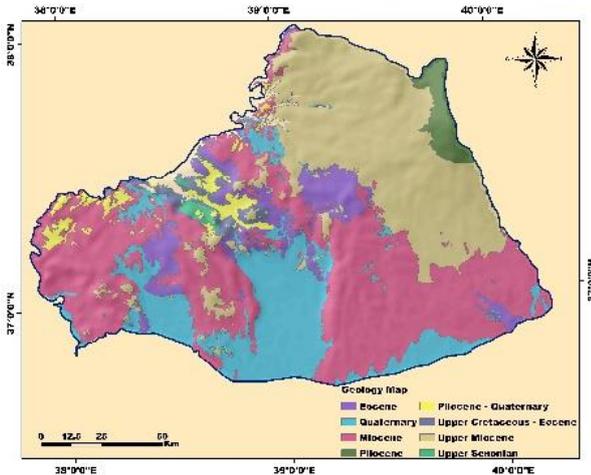


Figure 2a. Sanliurfa Geology Map

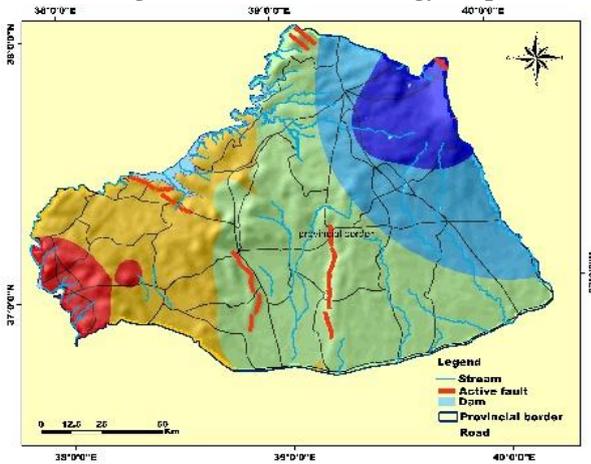


Figure 2b. Sanliurfa Earthquake Map

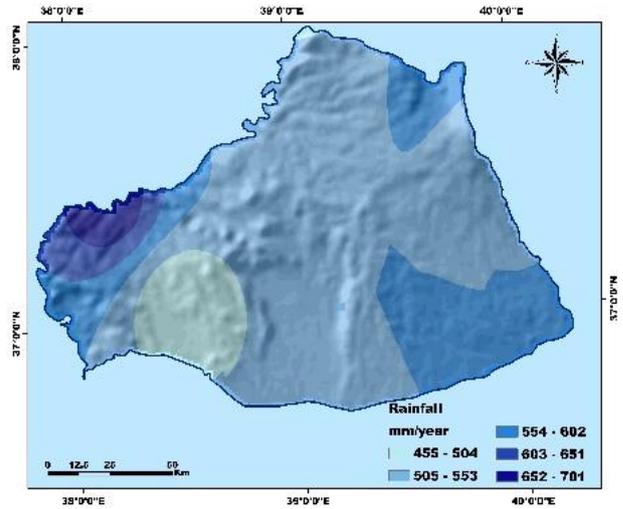


Figure 2c. Sanliurfa Rainfall Map

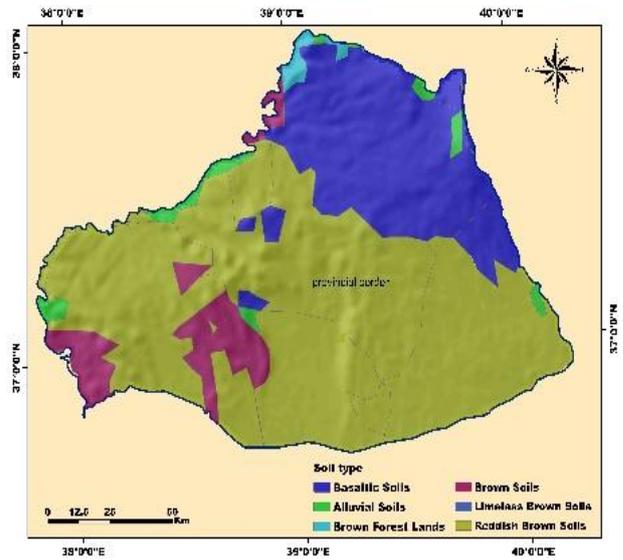


Figure 2d. Sanliurfa Soil Map

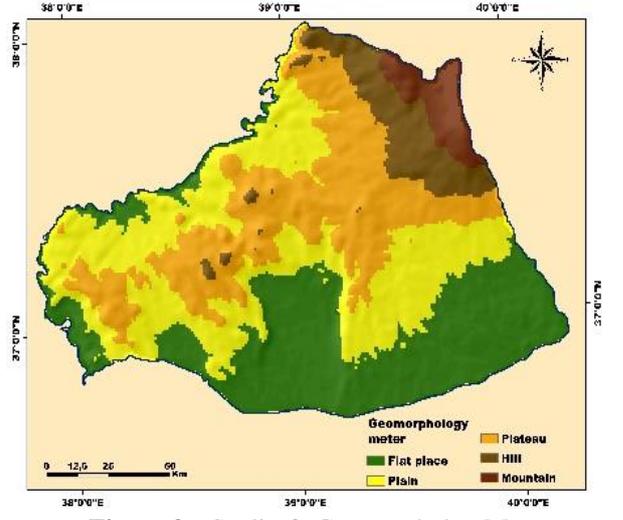


Figure 2e. Sanliurfa Geomorphology Map

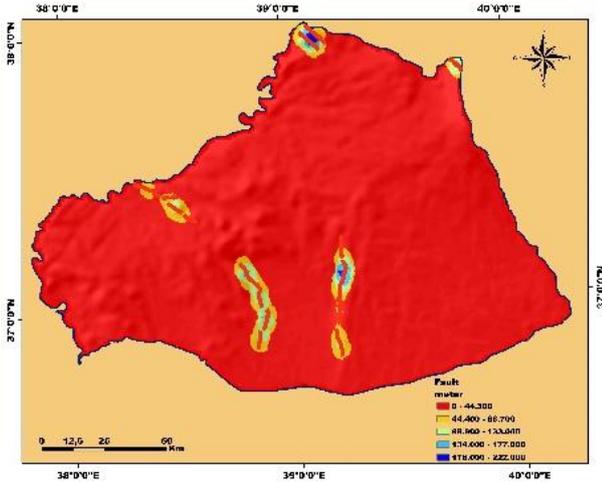


Figure 2f. Sanliurfa Active Fault Map

### 3.2.2 AHP (Analytic Hierarchy Process)

AHP method developed by Thomas L. Saaty in the 1970s; It is a technique used to convert individual assignments for relative importance into a set of weights. The application of AHP is shaped by four basic principles: decomposition, pairwise comparison, hierarchical composition or synthesis of priorities, and making the final decision according to mixed composition [12], [13]. These basic principles also form the steps of AHP.

The most important aspect of AHP is that it allows the decision maker to see the "multi-criteria decision making problem" visually in the form of a hierarchy of criteria. A hierarchy constructed in this way consists of at least three levels: at the top is the top objective of the problem, in the middle is the criteria that define the alternatives, and at the bottom are the alternatives to choose from. When a criterion is very abstract or comprehensive, such as being good, lower criteria are derived and placed in a multi-level hierarchy [15], [17].

Table 3. AHP Evaluation Scale [13]

Num.Values	Definition
1	Elements are equally important or indifferent between them
3	The first item is slightly more important or preferable than the second item.
5	The first item is overrated or over preferred over the second item.
7	The first item is too important or highly preferred over the second item
9	The first item is extremely important or highly preferred over the second item
2, 4, 6, 8	Intermediate values

After the hierarchy is established, pairwise comparisons are made between the criteria. To assist the decision maker in these pairwise comparisons, Saaty developed a

Aslan, V., Sepetçioğlu, M.Y., Yaşar, A.O., ORCID: 0000-0002-0288-073X, ORCID: 0000-0001-9138-0691, ORCID: 0000-0002-2237-1254, Turkish Journal of Hydraulics: Evaluation of Sanliurfa Concrete Technology with GIS Supported AHP Method as a Useful Tool in Technical Measurement, Vol :6 , Number : 2, Page : 14-21 (2022)

nine-point scale to determine the importance between the two elements. The numbers that will determine the preference ratio between the two elements and their verbal equivalents are shown in Table 1. Values in between (2, 4, 6 and 8) can be used for decisions falling between the two expressions.

In this way, after comparing the criteria at each level and ultimately the alternatives according to each criterion, comparison matrices are created. In these matrices, rows and columns form the criteria or alternatives that are compared, and each element of the matrix is the ratio obtained by comparing the element in the row to the element in the column [7], [21]. It is obvious that the matrix formed in this way will be symmetrical. The matrix created for three criteria such as  $C_1, C_2, C_3$  is in Figure 3; The matrix created for three alternatives such as  $A_1, A_2,$  and  $A_3$  is shown in Figure 4.

$$\begin{matrix} & C_1 & C_2 & C_3 \\ \begin{matrix} C_1 \\ A_2 \\ A_3 \end{matrix} & \begin{bmatrix} 1 & C_1/C_2 & C_1/C_3 \\ A_2/A_1 & 1 & A_2/A_3 \\ A_3/A_1 & A_2/A_3 & 1 \end{bmatrix} & & 
 \end{matrix}$$

Figure 3. Comparison of  $C_1, C_2, C_3$  Criteria

$$\begin{matrix} \text{For } C_i & A_1 & A_2 & A_3 \\ \begin{matrix} A_1 \\ A_2 \\ A_3 \end{matrix} & \begin{bmatrix} 1 & A/A_2 & A_1/A_3 \\ A_2/A_1 & 1 & A_2/A_3 \\ A_3/A_1 & A_2/A_3 & 1 \end{bmatrix} & & 
 \end{matrix}$$

Figure 4. Comparison matrix for the criterion  $C_i$  of  $A_1, A_2, A_3$  Alternatives Criteria

The next step after constructing the pairwise comparisons matrix is; is to obtain the weights of the elements in the matrix. To get close results in most cases, Saaty recommends calculating the geometric mean of the rows:

- Multiply n elements in each row, n. its root is taken and a new column is created for the obtained values,
- The new column is normalized (each value divided by the sum of the values). In this way, the importance weight of each criterion over one and the score of each alternative from each criterion are obtained over one. In order to obtain the final values of the alternatives, the scores of the alternatives from each criterion and the product of that criterion are added. The alternative with the highest sum indicates the most appropriate choice.

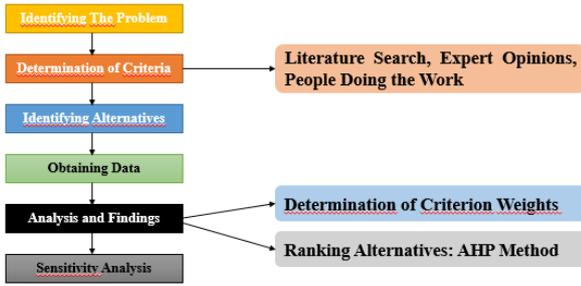


Figure 5. Hierarchical Template Of AHP Method

3.2.2.1 Application of AHP method in Ready-Mixed Concrete Plant Land Selection

The application of the AHP method to the land and region selection problem for the ready mixed concrete plant investment is exemplified below.

A ready-mixed concrete company wants to choose the most suitable one from A, B, C regions for its new concrete plant investment. It is assumed that the company in question pays attention to four main criteria and two sub-criteria during the selection:

1. Customer: The situation of the region in terms of potential customers
- 2 Opponents: Amount of opponents in the area
3. Location: The region's transportation status to customers and distance to raw materials
  - 3.1. Transportation: The transportation situation of the region to the customers
  - 3.2. Distance to Material: The distance of the region to the material resources (cement factories etc.)
4. Price: Average unit (m<sup>2</sup>) price of the lands in the region

After decomposing the problem and determining its criteria, a decision hierarchy is created. Selection of the best region, which is the main goal, is at the top of the hierarchy. At the second level, four criteria that contribute to the purpose; At the third level, there are sub-criteria, and at the last level, there are options to be evaluated in terms of these criteria (Figure 5).

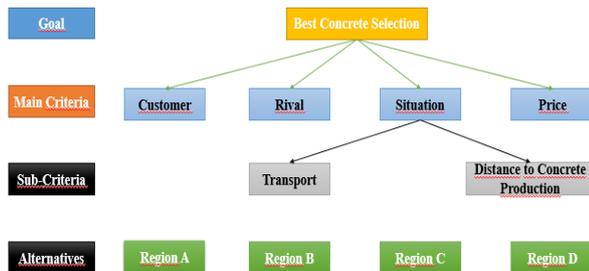


Figure 6. Hierarchical Model in Establishment of Region Selection in Concrete Production

After the selection hierarchy has been established, the relative importance of the items must be determined. Firstly; The relative importance of four criteria is determined for the firm in achieving the main goal of choosing the best region. For this, pairwise comparisons are applied to the criteria and the Decision Maker is asked using the scale in Table 1. Questions such as which of the two compared criteria is more important for the region where the facility will be established will be asked. When the preference values of the Decision Maker are determined by answering this question for pairwise comparisons of all criteria, the pairwise comparison matrix in Table 2 is obtained. For example, the criterion of the average m<sup>2</sup> unit cost of the lands in the region by purpose is five times more important for the decision maker than the criterion of the number of competitors in the region. Transportation and the number of potential customers are equally important [2].

Table 4. Pairwise Comparison Method for Concrete

Goal	Assigned Weight	Customer	Rival	Situation	Price
Customer	8	1.000	1.143	1.600	1.333
Rival	7	0.875	1.000	1.400	1.167
Situation	5	0.625	0.714	1.000	0.833
Price	6	0.750	0.857	1.200	1.000
Total		3.250	3.714	5.200	4.333

Table 5. Normalization and geometric mean of selected layers for concrete

Goal	Customer	Rival	Situation	Price	Geometric Mean	Normalized weight
Customer	0.3077	0.3078	0.3077	0.3076	0.31525	1.2610
Rival	0.1769	0.2693	0.2692	0.2693	0.24925	0.9970
Situation	0.1923	0.1922	0.1923	0.1922	0.19250	0.7900
Price	0.2308	0.2307	0.2308	0.2308	0.23853	0.9541

$$Ave. \lambda_{max} = \frac{\sum(\text{Normalized weight}) / (\text{Geometric mean})}{8} = 4.0021$$

In the last step, the CR value is calculated as follows. The fact that the value of CR is less than 0.1 in AHP applications shows that the application is consistent, otherwise the process should be reviewed again [11].

$$\text{Consistency Index (CI)} = \frac{4.0021 - 4}{3} = 0.0007$$

$$CR = \frac{CI(\text{Consistency Indicator})}{\text{Randomness Indicator}} = \frac{0.0007}{1} = 0.0007 < 0.1$$

Since the result is <0.1, it is within the limits of agreement.

Using the matrix in question, determining the relative importance of the criteria in achieving the main objective is the second step. For this calculation, the largest eigenvector of the pairwise comparisons matrix should be found and normalized as explained earlier. Normalization-based method can be used for this process [3], [17].

#### 4.CONCLUSION AND DISCUSSION

The geology of an area, earthquake conditions, precipitation, climate, soil type, geomorphological structure, whether there are fault lines or not, affect many human and economic activities in that region. If the geological and tectonic structure are considered together, the building material, construction technique, number of floors, etc. of the dwellings to be built in a region are made by taking into account the geological structure. In addition, the geological structure, with its features such as determining the soil type and containing various minerals, affects the structure and properties of the materials used in concrete. For example, as observed in the researches, the storage and stacking of cement in a closed and humid area for three months causes the property to be lost. The suitability of the structure of concrete components is also a factor affecting the strength of concrete technology. The production and pouring of concrete in very hot or very cold climate conditions is also an important factor.

Concrete technology is a building material that affects the development of urban and rural areas, the formation of zoning and urbanism. In order for this structure to be completed with objective criteria, it is very important in terms of quality, strength, cleanliness, compatibility of its components and determining the criteria that affect the value of the concrete. In this study, the information obtained from engineers and technical experts during the determination of these criteria is compatible with the literature at the stage of obtaining opinions with its application. In addition, the study is compatible with the literature by using AHP, which is one of the multi-criteria decision analysis methods, as a method to eliminate criteria with high correlation with each other.

In this study, the concrete properties process of Sanliurfa province was examined from an objective point of view. For this purpose, the criteria affecting the concrete technology value of a determined development area were weighted with the AHP method. Structural features of the samples were scored for the weights of the criteria that were considered statistically significant among the obtained criteria. In addition, the location features of the sampled buildings were evaluated and scored with the help of GIS.

As a result, the sum of the structural and spatial scores for the concrete values determined with the help of AHP and GIS was normalized and compared with the previously studied values. It has been determined that the values obtained with the help of AHP and GIS are compatible with Saaty's suggestion and previously studied values.

In the process of working on the application of concrete technology; It has contributed to the literature in terms of preventing negative market conditions, realizing

objective valuation, and realizing valuation that balances market values with the help of GIS and AHP. In addition, this study will guide studies on a neighborhood or regional scale in order to carry out the concrete technology process objectively and prevent speculative effects for future studies.

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