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CHOOSING CONCRETE PRODUCTION FACILITY LOCATION USING AHP AND TOPSIS METHODOLOGIES

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ABSTRACT
In construction industry, the used concrete is one of the most important factors. The quality of the concrete depends on the location of concrete production facility. Deciding on the wrong facility location causes big economic and prestige loss both for customers and producers.
Although selecting the best production facility is very important, most firms use traditional methods to select the production facility.
In this paper, we used multi criteria decision making techniques to determine the best location for a concrete facility. There are two alternative locations. We used Analytic Hierarchy Process (AHP) and TOPSIS methodologies to select the best location.
Firstly, we determined main and sub-criteria. Then we applied the decision making techniques on our problem. Finally we compared two techniques and decided on the best location
Keywords: Concrete production facility, AHP, TOPSIS

1. INTRODUCTION
When compared to another construction materials, concrete has more strength, ease of product and ease of maintenance. With these characteristics, concrete is the most common construction material in the world as well as in Turkey. In industrial countries the number of constructions is growing as a result of urbanization and industrial investment. And concrete is preferred as a construction material increasingly.
In recent years, to meet the construction needs concrete production facilities have been built in many areas. The problem of facility location is common to all businesses. The strategic planning of facility location is critical to a company’s eventual success. A suitable location can provide favorable contributions to a company’s market competitiveness. More and more firms are clearly dispersing parts of their production process to locations around the world to take advantage of national differences in the cost and quality of labor, talent, energy, facilities and capital [1]. But there are many constraints for the facility location like the ease of reach to raw material and offering service to the market. For that reason investors have to deal with a big problem: to determine on the best concrete facility location.
Traditional decision making techniques are not enough to select the best location because of the complicated structure of the constraints. Wrong preferences cause firms money and prestige loss. For that reason to determine on the best location, using analytical methods is a great need for companies.
We have two alternative locations A and B. In this paper we use Analytic Hierarchy Process (AHP) and TOPSIS methodologies to select the best concrete production facility location.

2. APPLICATION
There are 4 main criteria and 14 sub-criteria to select the best location. The main criteria and their sub-criteria are listed below:

- Market (M)
    - House (H)

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  - Underwork (U)
  - Industrial plant (IP)
- Raw Material and Labour (RL)
  - Agrega potential (AP)
  - Cement potential (CP)
  - Water potential (WP)
  - Labour potential (LP)
- Transport (T)
  - Motorway (M)
  - Alternative transport ways (ATW)
  - Reachable area size (RAS)
- Cost (C)
  - Investment cost (IC)
  - Raw material transport cost (RC)
  - Labour transport cost (LTC)
  - Product transport cost (PTC)

2.1. AHP Methodology

The Analytic Hierarchy Process (AHP) was developed by Saaty. It is a multi-criteria decision-making method which permits the relative assessment and prioritization of alternatives.[2]. The hierarchy is constructed in such a way that the overall decision goal is at the top level, decision factors (and sub-factors if any) are in the middle level(s), and competitive companies at the bottom. [3]. The steps of AHP are listed below [3,4]:

Firstly a hierarchical structure is created. The hierarchy is constructed in such a way that the overall decision goal is at the top level, decision factors (and sub-factors if any) are in the middle level(s), and alternatives at the bottom. Then the pairwise comparisons are made. . We used Saaty's 1-9 pairwise comparison scale. The weights of main criteria and sub criteria are found. Then consistency rates are calculated. It should be less than 0.1 Then the weights of alternatives with respect to each factor are obtained by using pairwise comparisons. Finally the overall results are obtained.

Figure 1 shows the hierarchical structure of the concrete production facility location problem. Table 1 shows the weights of the main and sub-criteria. And Table 2 shows the weights of alternatives according to sub-criteria.

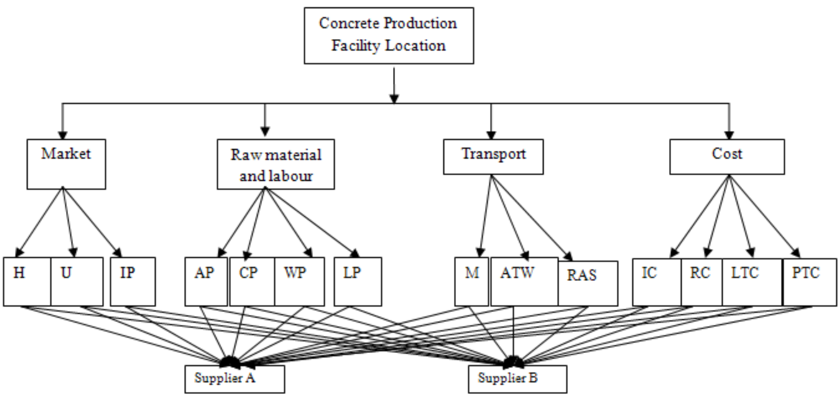

Figure 1. Hierarchical structure

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Table 1. The weights of main and sub-criteria

Main Criteria	Main Criteria Weights	Sub-Criteria	Local Weights	Global Weights
Market	0.31	House	0.62	0.192
		Underwork	0.14	0.043
		Industrial Plant	0.24	0.074
Raw material and labour	0.45	Agrega potential	0.56	0.252
		Cement potential	0.28	0.126
		Water potential	0.09	0.041
		Labour potential	0.07	0.032
Transport	0.05	Motorway	0.32	0.016
		Alternative transport ways	0.08	0.04
		Reachable area size	0.6	0.03
Cost	0.19	Investment cost	0.1	0.019
		Raw material transport cost	0.54	0.103
		Labour transport cost	0.09	0.017
		Product transport cost	0.27	0.051

Table 2. The weights of alternatives

Sub-criteria	Global Weight (GW)	Alternative A		Alternative B	
		Priority Vector(PV)	PVxGW	Priority Vector(PV)	PVxGW
House	0.192	0.6	0.115	0.4	0.077
Underwork	0.043	0.5	0.022	0.5	0.022
Industrial plant	0.074	0.33	0.024	0.67	0.05
Agrega potential	0.252	0.5	0.126	0.5	0.126
Cement potential	0.126	0.67	0.084	0.33	0.042
Water potential	0.042	0.25	0.011	0.75	0.032
Labour potential	0.032	0.75	0.024	0.25	0.008
Motorway	0.016	0.67	0.011	0.33	0.005
Alternative transport ways	0.004	0.25	0.001	0.75	0.003
Reachable area size	0.030	0.4	0.012	0.6	0.018
Investment cost	0.019	0.67	0.013	0.33	0.006
Raw material transport cost	0.103	0.75	0.077	0.25	0.026
Labour transport cost	0.017	0.75	0.013	0.5	0.009
Product transport cost	0.051	0.4	0.02	0.6	0.031
		Alternative A= 0.553		**Alternative B= 0.455**	

2.2. TOPSIS Methodology

Our second method is TOPSIS(Technique for Order Preference by Similarity to Ideal Solution). In this methodology, we use the main criteria weights that we found from the AHP methodology. Table 3 shows the decision matrix of the problem. The steps of TOPSIS are listed below [5,6]:

- The decision matrix is established.
- Decision matrix is normalized.

$$r_{ij} = \frac{w_{ij}}{\sqrt{\sum_{j=1}^{J} w_{ij}^2}}, \quad j = 1,2,3,\ldots,J, \quad i = 1,2,3,\ldots,n \tag{1}$$

- Weighted normalized decision matrix is constructed.

$$v_{ij} = w_i * r_{ij}, \quad j = 1,2,3,\ldots,J, \ \ i = 1,2,3,\ldots,n \tag{2}$$

- Positive and negative ideal solutions are determined.

$$A^* = \{v_1^*, v_2^*, \ldots, v_n^*\} \quad \text{maximum values} \tag{3}$$

$$A^- = \{v_1^-, v_2^-, \ldots, v_n^-\} \quad \text{minimum values} \tag{4}$$

- The distance of each alternative determined.

$$d_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2}, \quad j = 1, 2, \ldots, J \tag{5}$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, \quad i = 1, 2, \ldots, J \tag{6}$$

- The relative closeness to ideal reference point is calculated.

$$C_i = \frac{d_i^-}{d_i^+ + d_i^-}, \qquad i = 1, 2, \ldots, J \tag{7}$$

- The ranking of alternative is determined.

Table 3. Decision matrix of TOPSIS

	CRİTERİA			
	Market	**Raw material and labour**	**Transport**	**Cost**
Weights	31.00%	45.00%	5.00%	19.00%
Alternative A	2	2	1	2
Alternative B	1	1	2	1
	2.24	2.24	2.24	2.24

And Table 4 shows the final points of the alternatives according to TOPSIS methodology.

Table 4. Final points according to TOPSIS

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Alternative A	**0.920**
Alternative B	**0.080**

3. CONCLUSION

In this paper we decided on the best location for the concrete production facility. We used two different multi criteria decision making techniques, AHP and TOPSIS. Alternative A is the best location according to both techniques. But in TOPSIS the difference between two alternatives is higher. Alternative A is by far the best alternative.

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