A MULTICRITERIA DECISION-MAKING FOR MONORAIL ROUTE SELECTION IN ANKARA

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Abstract—An increase of the population in Ankara has become a lot of problem. It comes to traffic problems at the beginning of this problems. For this reason, transportation costs, time and demand for public transport have increased. A monorail is an alternative transport vehicle for solving this problem in urban areas. Monorail is one of the urban public transport systems. A monorail is a railway in which the track made up of a single rail, urban rapid transit system. The most important step of establishing a new transportation system is to determine the route. There are many factors to affect the determination of the route. For example: population, working population, public spaces, traffic density, other transport systems, etc. At this point, multi-criteria evaluation is needed. In this study, it has been tried to be determined route using Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods for monorail in Ankara. A case study in Ankara, in which the best monorail routes select, was applied.

Keywords—AHP, Monorail, MCDM, Route selection, TOPSIS

I. INTRODUCTION

The monorail (Fig.1) has spread out recently as a popular mode for transit use in the world. Monorails are urban rail transport systems. They are elevated light rail systems from ground. A monorail is a very attractive transit system. Because monorails are cost effective, safe. And accidents with surface traffic are impossible for monorails. Because monorails have belong to them ways and routes. Monorails have got many characteristics as environmentally friendly, low construction and maintenance cost etc.

With the increase in the urban density, monorail can reduce the use of private vehicles in narrow and busy road and will provide comfort to the passengers because of its suitability in the congested areas. Marathe and Hajiani[2], the author in his paper the characteristics of monorail systems; a great separated, cost effective, safely, low energy consumption, low noise and adaptable. In paper, monorails provide height air quality, traffic safety and solution for traffic congestion. Kennedy[3], defined as the characteristics of monorail technology safety and evacuation, rubber traction and guidance, energy consumption, acceleration and breaking, gradient, weather, noise it also is defined power, speed, ride, switching and maintenance for Operational characteristics. Hamurcu and Eren[4, 5], have done two studies on this issue. They proposed monorail for urban transport of Turkey in one of the studies. In other studies were made for route selection for monorail in Ankara. Jwalant et al. [6], looked at new transit technology and they had been discussed some of the important aspects regarding conditions favoring monorail rapid transit. Peter [7] has mentioned that of the monorail system provides a great solution for traffic at metropolitan in the work. Xi et al. [8] described the development of vehicle monorail transit system and the application of monorail vehicles has been studied. They had discussed the development and application of monorail for urban transit.

Many countries around the World today have established monorail systems. For example: Particularly Japan, Malaysia, Europe, Russia, Korea, China, Brazil, UAE, Saudi Arabia, Singapore, Iran and a few in the United States. Several more are either under construction or in advanced planning.

Sections of this study are as follows: In section 2, the route selection problem has been explained. In section 3, we have presented our plan of methodology. In section 4, multicriteria decision making methods have been described. In section 5, criteria for route selection have been mentioned. In section 6, a case study has been done for Ankara. Finally, it was shown to ranking of the best route selection.

II. THE ROUTE SELECTION PROBLEM

The issue of traffic congestion is one of the most problems that have to be solved in developing and growing cities. So, the public transport is an effective
A Multicriteria Decision-Making For Monorail Route Selection in Ankara

Due to the increase in urban population, transportation time increased in cities. Therefore, there is a need for new transportation projects in urban areas. Monorail public transportation is a sound investment in this regard. But the system should be well-defined route. Otherwise it would not be effective in urban areas. Instead of costly projects that will be temporary solutions, such as monorail transit systems must be constructed to overcome the rapidly increasing travel demand and congestion of traffic. Selecting the mode of monorail transportation is not enough to solve the traffic problem. Also the best route to be determined for the monorail. It should be seen as multidimensional.

Route select is an important decision made for urban area. The goal in a route selection study is to find the best place or corridor. These choices are really complex problems that depend on multiple considerations. Route selection goal is to prevent traffic congestion, meet the demand for transportation and to reduce the travel time. Thus, it will be providing improvements in urban areas. Otherwise established new routes will further increase the traffic load.

The route selection process, based on multi criteria decision making and applied in AHP and TOPSIS for monorail route selection, is showed in this study.

III. METHODOLOGY

The methodology for route selection problem, composed of AHP and TOPSIS methods, consists of three steps. These are:

1. Identify the criteria to be used in the model. In the first step of application, we determined the criteria for route selection.
2. The criteria of route selection were weighted by using AHP.
3. Evaluation of alternatives with TOPSIS and determination of the final rank. Finally, it was selected the best alternative a route.
IV. MULTICRITERIA DECISION MAKING (MCDM)

This technique that performs the selection from among many alternatives analyzes comparing by specific criteria. This method compares the different alternatives for routes of monorail. To be able to decide, alternatives of route were selected by using AHP and TOPSIS methods which are multiple criteria decision making methods.

4.1. Analytic Hierarchy Process (AHP)

It is a multi-criteria decision analysis (MCDA) to evaluate alternatives. A problem is basic structured as a hierarchy in the AHP. The AHP is aggregating the solutions of all the sub problems in a conclusion, by making binary comparisons [9]. The AHP’s steps (Fig.3):

Step 1: List the overall goal, criteria and decision alternatives.
Step 2: Develop a pair wise comparison matrix.
Step 3: Develop a normalized matrix.
Step 4: Develop the priority vector.
Step 5: Rank the preferred criteria.

Fig. 3: AHP’s steps

4.2. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

Yoon and Hwang [10] introduced TOPSIS method for the first time. TOPSIS technique is one of the decision making methods. It is a target based approach. Aimed to finding the alternative that is closest to the ideal solution goal. General TOPSIS process with 6 steps:

Step 1: Establish a decision matrix (Aij)

\[
A_{ij} = \begin{bmatrix}
    a_{11} & a_{12} & \ldots & a_{1n} \\
    a_{21} & a_{22} & \ldots & a_{2n} \\
    \vdots & \vdots & \ddots & \vdots \\
    a_{m1} & a_{m2} & \ldots & a_{mn} 
\end{bmatrix}
\]

Step 2: Calculate the normalized decision matrix (rij).

\[
rij = \frac{a_{ij}}{\sqrt{\sum_{j=1}^{n} a_{ij}^2}}
\]

Step 3: Calculate the weighted normalized decision matrix (Vij).

\[
V_j = \begin{bmatrix}
    w_1r_{j1} & w_2r_{j2} & \ldots & w_nr_{jn} \\
    \vdots & \vdots & \ddots & \vdots \\
    w_mr_{m1} & w_mr_{m2} & \ldots & w_mr_{mn} 
\end{bmatrix}
\]

Step 4: Finding the positive-ideal (A+) and negative-ideal (A-) solutions.

\[
A^+ = \left\{ (\max_i v_{ij} | j \in J), (\min_i v_{ij} | j \in J) \right\}
\]

\[
A^- = \left\{ (\min_i v_{ij} | j \in J), (\max_i v_{ij} | j \in J) \right\}
\]

Step 5: Calculate the separation measures (Sij* and Sij+)

\[
S_j^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_{ij}^+)^2}
\]

\[
S_j^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_{ij}^-)^2}
\]

Step 6: Calculate the relative closeness to the ideal solution (Ci) and rank the performance order.

\[
C_i^* = \frac{S_j^-}{S_j^- + S_j^+}
\]

The Ci* index value lies between 0 and 1. The larger the index value means the better the performance of the alternatives.
V. LITERATURE REVIEW

Route selection involves the determination of path in urban area for traffic problems, based on design objectives, such as minimum construction cost, maximum travel speed, and accessibility, the integration of transport and minimum environmental influences.

There are studies in the literature about the route choice. Studies of as the train route [10, 11], light rail transit route [12, 20], bike route [13], the route of the tramway [14], highway route [15], bus route [16], high-speed rail route [18, 21] and monorail route [3, 22] selection are available in literature.

VI. A CASE STUDY

We received the opinion of experts. A literature search was performed. As a result it was identified of route selection criteria. These criteria had been used previously by Hamurcu and Eren [3].

1. Construction cost (a)
2. Expropriation (b)
3. The integration of transport (c)
4. Accessibility (d)
5. The total travel time (d)
6. Aesthetic and visual impact (e)
7. Access to employment and education (f)
8. Access to shopping and residential areas (g)
9. Ability to develop and to improve (h)
10. Land structure (s)
11. Population density (i)
12. Traffic capacity (j)
13. Public mobility (k)
14. Demand level (s)
15. Environmental influences (m)

It was evaluated eight alternative routes (Fig. 5) around the 15 criteria. A multi criteria decision-making (MCDM) method was applied to decide the best alternative.

Table 1: Characteristics of routes

<table>
<thead>
<tr>
<th>Route</th>
<th>Distance (m)</th>
<th>Number of Stations</th>
<th>Number of vehicles</th>
<th>Number of series</th>
<th>Total Number of Vehicles</th>
<th>Approximate Total Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route 1</td>
<td>1100</td>
<td>11</td>
<td>4</td>
<td>20</td>
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<td>412,100,000</td>
</tr>
<tr>
<td>Route 2</td>
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<td>15</td>
<td>60</td>
<td>153,700,000</td>
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<tr>
<td>Route 3</td>
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<td>10</td>
<td>80</td>
<td>60</td>
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<tr>
<td>Route 4</td>
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<td>15</td>
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<td>4</td>
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<td>140</td>
<td>709,210,000</td>
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Table 2: The weighted matrix for criteria

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<tr>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
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Table 3: AHP weights of the criteria for TOPSIS

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<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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Table 4: Weighted evaluation for the alternative weapons

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<tbody>
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<td>0.01</td>
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Table 5: Ideal and negative ideal solution

<table>
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A Multicriteria Decision-Making For Monorail Route Selection in Ankara
CONCLUSION
The goal of the paper is to present solutions to decision makers at route selection process with multi criteria decision methods. Based on MCDM application in route selection, AHP is used in weighting of different criteria, TOPSIS is applied in the best suitable route.

Route_7 were selected in the study results. The system will be installed on the selected route is proposed to improve the urban traffic.

Table 6: Results of route selection and ranking

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>A+</th>
<th>A-</th>
<th>U=(A+ - A-)</th>
<th>%</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route_1</td>
<td>0.87</td>
<td>0.04</td>
<td>0.832</td>
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<tr>
<td>Route_2</td>
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<td>0.06</td>
<td>0.79</td>
<td>7</td>
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<tr>
<td>Route_3</td>
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<td>0.08</td>
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<tr>
<td>Route_4</td>
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<tr>
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<td>-0.2</td>
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</tr>
</tbody>
</table>

For cities that have a population of like Ankara and Istanbul, monorail is the ideal mode of transport. Monorail is well suitable for the urban transportation in Ankara. Monorail, urban rail systems can meet the transportation demand. When the best route selection is made, the monorail will be meeting the passenger demand in urban areas.

REFERENCES