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A new technique in optimizing urban highway bypasses

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ABSTRACT

In this paper, by reviewing the previous studies and literature on the highway bypasses selection, the criteria and variables associated with the bypasses planning are investigated. Then, the needed statistics and information for the top model of the identified bypass selection are collected. Using the Delphi technique, a model is developed for the bypasses optimization. The model is constructed based on the collected data analysis and finally verified. In each decision, the decision making space is continuous or discrete and the decision making in discrete or continuous spaces are functions of variables which affect decision making product (optimum option). Regarding the variables or criteria of decision making space, the importance and relevance value of criteria with each other are of high importance further to the determination of the effective value of the decision making title. This study clarifies how such a unique method is implemented for the highway bypasses planning problem solution. The result shows this introduced method in this study for planning and prioritizing bypasses has many advantages over traditional methods which have been used up to now and can be a good alternative to the traditional methods by creating a comprehensive vision of the national road network.

1. Introduction

The rural road networks are the vital arteries of country's road transportation and their function plays a basic role in the economy and different activities in a country. In our country, the organization responsible for the suburban ways is apart the one which is responsible for urban streets affairs and each has its own duties. The suburban ways are maintained and constructed by the ministry of roads and urban development, while, urban roads are governed by municipalities. As a result, the first problem in managing the rural roads network is the determination of the proper response for the parts of rural roads which pass through or near the cities. However, one of the challenges with which the road transportation network is faced is the interruption in urban areas. Hence, the transition of vehicles including both passengers and cargo from these areas has always faced with problems such as human and financial damages due to the accidents, wasting time and increasing traffic congestion in urban areas especially in the entrance and exit of the cities. A glance at the released statistics by country's ministry of transportation illustrates that 70 percent of the road accidents occur at the entrance and exit of the cities and this further points out to the importance of the bypasses.

The performed researches on the road accidents of Iran confirm the relationship between the value of road accidents and closeness to the residential sections (Ayati, 1992), so that, the vast majority of road accidents happen at the distance of 30 kilometers from the cities. From one side, the road accidents increase due to the presence of the local traffic and pedestrians in the vicinity of the cities and from the other side, transit corridors and highway bypasses passing through urban areas have always been associated with numerous problems such as land ownership, neighborhood distinctions and geographical and local limitations. The main impetus of the present research is to achieve an optimal solution by which one could eliminate or reduce the above mentioned issues.

2. Literature review

One of the most commonly used solutions in the new era is the crossing of roads in the vicinity of cities instead of their crossing through the cities or creation of urban bypasses. Nowadays, roads are not crossed through the cities, but, it is attempted to

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maintain the connectivity of the ways by passing the road at a distance from the city and link the cities to the global routes by means of specific connecting ways. The part of the global road crossing over the vicinity of the cities whether specifically constructed after a long time of the global road construction or it is a part of newly founded road, is named as highway bypass. Bypasses have different influences on urban activities and also on the modality and value of exploitation and productivity of the main road. The closeness of these roads to cities from one side may harm the environment, uncontrolled urban expansion towards them, safety decrease and uncoordinated and unplanned changes in land use. However, it can facilitate access and reduce the transportation costs in the road network. Their distance from the cities is of high importance in terms of the path length and other factors which directly affect the initial repair and maintenance expenses and the productivity during the exploitation period. Reaching to an optimal interval for this distance is of high prominence. The problem of bypasses has been available in other countries. In European countries where most of the cities have emerged before the creation of motor vehicles, the problem of bypasses has been under consideration since a long time ago. The idea of separating the heavy traffic from light urban traffic was first came to the power in 1960 in Europe and led to the bypasses foundation. In 1970, Pate proposed the idea of separating urban roads from passing traffic and also traffic relaxation in Denmark and named them as silent roads regarding to the above mentioned idea and their performance. Denmark's bureau of ways (DRD) published a booklet indicating that how the traffic could be relaxed in urban areas. Also in 1990, DRD organized the traffic planning in the vicinity of cities in order to separate passing fast cars from slow urban traffic. In 1960 and 1970 decades in Finland, special locations were predicted for pedestrians and cyclists reducing the number and severity of the accidents. Also in 1980, roads passing through small towns were designed considering the environmental status of these cities and safety prediction to increase the safety of citizens. In 1990s in Finland, several studies were carried out on the performance of the ways which had been constructed decades ago and an instruction titled as passing roads status improvement through small towns was spread out in 1993 by the bureau responsible for the ways' management of this country. Therefore, 6 cities were selected as samples and new traffic regulations were applied in their passages (Pates, 1998).

In 1990s in Norway, the bureau of ways (NPRA) designed flow passages for 6 typical cities with minimal environmental impacts. Also in the villages, sections and small towns of other countries, solutions were made for improving the main passages of these places and bypasses were made in greater residential centers.

This set of actions and attitudes with passing traffic through residential sections are divided into the four following groups:

- Case 1 (constructing a new way as a bypass): This includes constructing bypass and banning the traffic pass through the city. This method creates the negative economic consequences for those residential areas which economically depend on passing ways.
- Case 2 (The main road passing through the city): Here, the proposed policy is the priority of crossing traffic protected by islands and fences which limits the access to the different parts of the city.
- Case 3 (The main road passing through residential centers): This action is performed upon the thought that the traffic must be adapted with the traffic situation of the city. This leads to the slowness of the crossing traffic but has less effect on the biological status of citizens. However, the city pollutions are not to be decreased in this case.
- A combination of cases 1 and 3: This means the simultaneous existence of bypass and main road but with the policy of putting intercity crossing limitative regulations for heavy vehicles.

The aforementioned classification and thinking about methods other than bypass construction was taken with the viewpoint that the bypasses are basically needed for locations with high passing traffic volume and bigger cities. However, in smaller town and sections, with the proper management of the crossing traffic through the city one can avoid the problems associated with the land ownership and high expenses of bypass construction. During the 1960 and 1970s in US, studies were carried out on the constructed bypasses effects in order to evaluate the economic and environmental influences and their effects on the land use changes, land value, etc. (Vockrodt, 1968).

The common as well as important point that can be seen in all the studies performed on the bypasses during the last 30 years is the proper design and planning to reduce their possible negative consequences and optimize their usage. Although, bypasses fall in the category of the ways but further to the public duties of the ways, their task is to avoid the crossing traffic and help providing a relaxed and healthy city environment. The bypass impacts on the adjacent community (city) depends on the amount, source and destination of the passing traffic, city's local geography, how to link bypass to the city and also city's size.

The more closeness to the cities, the more possibility of bypasses usage by the city's local traffic. The farther the distance between the bypass and the city is the possibility becomes less. It is clear that the amount of constructions adjacent to the bypass lands, connectivity to the city and other negative impacts on them, have inverse proportion with the distance between the city and bypass. The amount of local traffic usage from the bypass depends on the local geography, farness or closeness to the city and the connective intersections conditions. However, from one viewpoint, the bypass must be placed nearer to the city in such a way that the local traffic could use from and be farther enough not to ban the city's development in the future.

Although the proximity of bypass to the city may lead to its smaller length and reduce its construction expenses, but it is important to note that the land value is higher near the cities and this can nullify the possible savings in terms of the reduced length. However, it should be said that the bypass construction in the farther distance could cause added value of the lands between the bypass and city.

In small cities, bypasses are constructed far beyond the city adjacent areas in order to be far from city's future development area. This matter causes the relative reclusiveness of the streets, distance reduction through the city and attraction for those vehicles passing from one side to the other side of the city, as a consequence. Furthermore, it causes the local traffic and a portion of passing traffic not to use from the bypass. Whereas, due to the long distances, crowded streets and closer bypass route feeling in big cities, much higher percentage of local traffic use the bypasses.

3. Methodology

Till now, selecting an option among several available options for the bypasses have been performed by experienced engineers and further to several consecutive working days, expert opinions without weighing to any criteria have been involved. Now, the question to ask is how to involve the effective parameters with proper weight in bypasses selection. In other hand, how one can choose and introduce the best option among two or more available options considering the influence of effective factors and criteria. To reach to this aim and ask the above question, a special algorithm must be prepared.

3.1. The decision support system of bypass selection

Since the aim of the research is selecting the best option among the available bypasses which deals with different and multiple variables and criteria, a multi-criteria decision support system must be necessarily used in the model. According to (Forman, 1985), a multi-criteria decision support system must have the following specifications:

- Be based on a strong theory
- Involve both qualitative and quantitative criteria in decision making
- Capable of considering the different options
- Capable of combining judgments and different weights in order to determine the final option weight.

As investigated by this study, analytical hierarchy process (AHP) is one of the most inclusive support algorithms for the multi-criteria based decision making. Fig. 1 depicts the hierarchical structure of the best bypass selection among several options. As would be observed, the variables used in this frame are the most important design variables for the bypasses selection which have been obtained upon investigations carried out by the author.

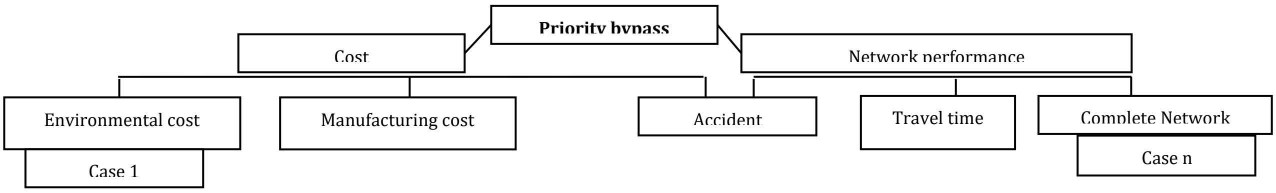

Fig. 1: The hierarchical graph of bypass priority

At the level of a hierarchical structure of matter, the aim is exhibited which is the bypass selection. Bypass selection is related to the criteria or second level variables (variables placed in the second row of hierarchical structure). Also, these criteria are used for the options evaluation (the relations are also shown in the graph as well). As can be seen in this chart, the best option selection of bypasses has a hierarchical structure and must be dealt with using the AHP. To analyze the above mentioned designed support system, the relations among the various criteria must be defined and simulated.

3.2. Bypass priority model pillars in the network

The construction planning of bypasses which are accounted as important elements of ways network must be codified regarding to the priorities as budget and each bypass's construction impact in the network. The question to ask here is that which bypasses meet the investment and construction priorities in a suburban roads network. In other words, which cities (locations) must be placed in the bypasses construction priority in a country ways network? The criteria which may be considered here are those related to the effects of bypass building in the network and also the previous mentioned criteria regarding to the bypass selection. Therefore, the classification of these criteria must be performed so that equipotential and univalent criteria could be placed in one group. Using the integer planning and by implementing the network design problem (NDP), Eldessouki et al. (1998) considered only the travel and network completion times and the cost required for constructing each piece of network in the way construction prioritization of a network (Eldessouki et al., 1998). However in the present research, more criteria can be considered using the AHP method.

3.3. Hierarchical criteria of bypass priority

All of the constituent criteria of the model's structure have been considered by examining the previous studies on the bypasses or ways. In the following, they are introduced and the place of each in the hierarchical structure complex will be illustrated. Since the components related to the current cost criterion are mostly dependent on the path length and travel time and also the travel time is to be considered as a separate criterion, one can ignore the current cost from the main criteria list (Litman, 1999).

3.3.1. Travel time

The Travel time depends on factors such as velocity, traffic volume and length and other path specifications. According to the conducted surveys, several models have been prepared and proposed for this parameter. In this research, different methods can be implemented for estimating the travel time change before and after a bypass construction. The kind of model and calculation method is selected according to the conducted surveys. Here, the capability of MINUTP software is used for estimating this parameter. One can state the results of this measurement which are obtained in terms of vehicle-elapsed time by having the average vehicle passenger and determining time value in Rial. To obtain the travel time in a bypass, Eq. 1 can be used as following:

$$T_i = \frac{L_{iflat}}{90} + \frac{L_{ihill}}{80} + \frac{L_{imont}}{65} \quad (1)$$

Here, T_i stands for the travel time in the ith bypass in hours, L_{imont}, L_{ihill} and L_{iflat} define the ith bypass length in kilometers which are mountainous, hills and flat, respectively.

3.3.2. Construction cost

The construction cost in the hierarchical structure is related to the geometry characteristics, accidents, environmental effects and soil status of the location. This cost is divided into several sub-costs such as earthworks, building, infrastructure, and asphalt and path ownership costs. Having the length, width and longitudinal profile of the path, the aforementioned costs can be calculated in Rial. In this calculation, mathematical formulas for area, volume, etc., are used and avoided mentioning here. The bridges costs are estimated in terms of square meters of the bridge's area regarding to its span and the tunnels construction costs are calculated in terms of cubic meters of their volumes with the regard of the covering wall's material and earth status. All of the above costs which are of the same kind will be gathered together and stated as the construction cost.

3.3.3. Environmental effects

The most important environmental effects of the bypasses building are the air pollution reduction and traffic elimination crossing through the cities. But this factor cannot be used for selecting the optimum option as all the options provide the city with this possibility (Peltola, 2000). However, the effects made by the bypass construction on the environment may be considered as the assessment parameter. For example, if we are forced with cutting trees or passing through a river coast in a portion of path, the effects of bypass construction on the environment should be considered. Since, no information or data is available on this topic in our country, these effects are determined using the Delphi method and according to the specialist's comments (Harris et al., 2001).

3.3.4. Accordance with the comprehensive plan

Since bypasses should be designed in such a way that not to be placed in the city with the city development and its surface increase, they must be in accordance with the city comprehensive plan. This variable may be determined by expert opinion and acquire a value between 0 and 20. This criterion is also assessed by asking from specialists and using the Delphi method.

3.3.5. Network effectiveness

The network effectiveness is considered upon the two assumed criteria as (Eldessouki et al., 1998):

- Network completion percentage: The network completion percentage is defined as the ratio of each bypass's length to the final predicted length of the entire rural roads network, in terms of percentage. This criterion indicates that by constructing a bypass what portion of the total road network length will be provided.
- Travel time: It is defined as the number of vehicles-hour passing through the network with each bypass construction. In other words, it shows the total travel time in the roads network. This parameter can be estimated by entering the general specifications of the road network and by using MINUTP software.

3.4. Model verification

In order to be sure about the accuracy of the results of the designed model, they must be first verified (Saaty, 1980). The validation of the models made up of the AHP method are stated by the incompatibility rate calculation whose value should not be greater than 0.1. The only difference between the verification method of AHP based models and the other ones is that the verification process should be performed for each problem solving stage (HCM, 2016). This work is done here for a case study.

4. Discussion

The aim of this section is to determine the bypasses construction priorities in the rural roads network using the hierarchical chart. That is, it is assumed that 10 bypasses with the specifications given in Table 1 are identified for constructing in the rural roads network. Hence, one must know that which bypass should be a priority. Meanwhile, due to the short length of the bypasses, it is assumed that the time period required for building each is one year at most. Table 2 lists the effectiveness value of each bypass in Iran's entire roads network.

Table 1: Specifications of various options

Bypass number	Earthwork (Rial)	Construction costs (Rial)	Ownership (Rial)	Total (Rial)
1	284713053	9679000000	1702000000	11665713050
2	270651290	9153000000	1243000000	10666651290
3	105423111	6242000000	1487000000	7834423111
4	320946667	11950000000	1760000000	14030946670
5	341452881	12140000000	1133000000	13614452880
6	300130245	11535000000	1643400000	13478530250
7	290264429	9732000000	1839000000	11861264430

Table 2: The effectiveness of each option

Criteria	Bypass number									
	1	2	3	4	5	6	7	8	9	10
Network complete	0.10%	0.08%	%0.07	%0.06	%0.11	0.09%	.10 %	%.075	0.10%	0.08%
Travel time	13559620	13543071	13451250	13536369	12596942	11312543	13438952	99876430	13111263	12125713

In order to examine the environmental effects of each bypass using the Delphi method, the average weight based on 7 and the final rank of each bypass are illustrated by Table 3.

Also, the average weight based on 10 is specified for each bypass. To predict the number of accidents based on the passing traffic volume, the bypass capacity, the number of accidents due to the traffic condition and accidents due to the geometry status are listed in Table 4.

Table 3: Criteria weights

bypass	The mean weight taken on the basis of 7	Final ranking	Weighted average based on 10
1	5.2	4	7.43
2	5.1	5	7.29
3	4.9	7	7
4	5	6	50/7
5	5.3	3	7.57
6	5.5	2	7.86
7	5.6	1	8
8	4.8	8	6.86
9	4.9	7	7
10	5	6	50/7

Table 4: Accidents number prediction

Bypass	Volume of traffic	capacity	Accident number	Accident for geometry	total	Intersection number	Difference
1	3700	1400	1.45= 2	18	20	30	10
2	5100	1350	2.033=2	26	28	35	7
3	4000	1300	1.7=2	15	17	31	14
4	4000	1200	2	23	25	40	15
5	4900	1400	1.9=2	12	14	21	7
6	13900	1300	5.56=6	15	21	30	9
7	13600	1500	4.035=5	20	25	35	10
8	14200	1300	5.67=6	25	31	47	16
9	30000	2600	8.13=8	14	22	30	8
10	12700	1500	4.7=5	17	22	32	10

In order to accurately identify the various options, they are compared with different parameters such as network completion percentage, travel time and construction cost. Figs. 2-4 show the comparative matrix of options relative to various variables such as: the network completion percentage, travel time and construction cost.

Table 5 shows the experts' evaluation from the environmental effects of the options including two columns of scores based on 7 and 10. Also, as pointed out by the methodology section, the various criteria weights are obtained using Delphi method and specialists' investigations and given in Table 6. Then, the relative weights associated with each criterion are calculated by obtaining the eigenvector of each comparative matrix. Table 7 gives the relative weights associated with each criterion.

In order to estimate the total weight of each option, the data given in Table 6 must be multiplied by the criteria weights of Table 7 to specify the priority of each bypass. The final priorities and weights corresponding to each bypass are given by Table 8. According to this table, the bypass number 5 meets the first priority and bypass number 4 is the last one for the present study.

By using the integer planning and the assumption that each bypass's construction operation only lasts a year, the optimum maximum number of them can be calculated using Eq. 2 to be put into the one-year work program. The mentioned condition (second term) in this relation indicates the budget constraints and W_i stand for the weights of the hierarchy.

$$\max z = \sum_{i=1}^{10} W_i X_i$$
$$\text{S.T.}$$
$$\sum W_i X_i \leq 5x10\text{^}10 \qquad (2)$$
$$\forall X_i \geq 0$$

Table 5: The environmental effects assessment

Case number	Score based on 7	Score based on 10
1	2.8	4
2	2.1	3
3	4.2	6
4	3.5	5
5	3.5	8
6	3.5	5
7	5	7
8	4.2	6
9	5	7
10	2.8	4

$$\begin{bmatrix}
1 & \frac{.1}{.07} & \frac{.1}{.06} & \frac{.1}{.06} & \frac{.1}{.11} & \frac{.1}{.091} & \frac{.1}{.103} & \frac{.1}{.075} & \frac{.1}{1} & \frac{.1}{.08} \\
\frac{.08}{.1} & 1 & \frac{.08}{.07} & \frac{.08}{.06} & \frac{.08}{.11} & \frac{.08}{.091} & \frac{.08}{.103} & \frac{.08}{.075} & \frac{.08}{.1} & 1 \\
\frac{.07}{.1} & \frac{.07}{.08} & 1 & \frac{.07}{.06} & \frac{.07}{.11} & \frac{.07}{.091} & \frac{.07}{.103} & \frac{.07}{.075} & \frac{.07}{.1} & \frac{.07}{.08} \\
\frac{.06}{.1} & \frac{.06}{.08} & \frac{.06}{.07} & 1 & \frac{.06}{.11} & \frac{.06}{.091} & \frac{.06}{.103} & \frac{.06}{.075} & \frac{.06}{.1} & \frac{.06}{.08} \\
\frac{.11}{.1} & \frac{.11}{.08} & \frac{.11}{.07} & \frac{.11}{.06} & 1 & \frac{.11}{.091} & \frac{.11}{.103} & \frac{.11}{.075} & \frac{.11}{.1} & \frac{.11}{.08} \\
\frac{.091}{.1} & \frac{.091}{.08} & \frac{.091}{.07} & \frac{.091}{.06} & \frac{.091}{.11} & 1 & \frac{.091}{.103} & \frac{.091}{.075} & \frac{.091}{.1} & \frac{.091}{.08} \\
\frac{.103}{.1} & \frac{.103}{.08} & \frac{.103}{.07} & \frac{.103}{.06} & \frac{.103}{.11} & \frac{.103}{.091} & 1 & \frac{.103}{.075} & \frac{.103}{.1} & \frac{.103}{.08} \\
\frac{.075}{.1} & \frac{.075}{.08} & \frac{.075}{.07} & \frac{.075}{.06} & \frac{.075}{.11} & \frac{.075}{.091} & \frac{.075}{.103} & 1 & \frac{.075}{.1} & \frac{.075}{.08} \\
1 & \frac{.1}{.08} & \frac{.1}{.07} & \frac{.1}{.06} & \frac{.1}{.11} & \frac{.1}{.091} & \frac{.1}{.103} & \frac{.1}{.075} & 1 & \frac{.1}{.08} \\
\frac{.08}{.1} & 1 & \frac{.08}{.07} & \frac{.08}{.06} & \frac{.08}{.11} & \frac{.08}{.091} & \frac{.08}{.103} & \frac{.08}{.075} & \frac{.08}{.1} & 1
\end{bmatrix}$$

Fig. 2: The comparative matrix of options relative to the network completion percentage

$$\begin{bmatrix}
1 & .9888 & .992 & .9983 & .929 & .8343 & .9911 & .7366 & .9669 & .8943 \\
1.0012 & 1 & .9932 & .9995 & .9301 & .8353 & .9923 & .7325 & .9669 & .8953 \\
1.0081 & 1.0068 & 1 & 1.0063 & .9365 & .841 & .9991 & .7425 & .9747 & .9015 \\
1.0017 & 1.0005 & .9937 & 1 & .9306 & .8357 & .9928 & .7378 & .9686 & .8958 \\
1.0764 & 1.0751 & 1.0678 & 1.0746 & 1 & .898 & 1.0668 & .7929 & 1.041 & .9626 \\
1.1986 & 1.1972 & 1.1891 & 1.1966 & 1.1135 & 1 & 1.1879 & .8829 & 1.159 & 1.072 \\
1.009 & 1.0077 & 1.0009 & 1.0072 & .9373 & .8418 & 1 & .7432 & .9756 & .9023 \\
1.3576 & 1.356 & 1.347 & 1.3553 & 1.2613 & 1.1327 & 1.3456 & 1 & 1.3127 & 1.2141 \\
1.0342 & 1.0329 & 1.259 & 1.324 & .9608 & .8628 & 1.025 & .7618 & 1 & .9248 \\
1.1183 & 1.1169 & 1.1093 & 1.1163 & 1.0389 & .9329 & 1.1083 & .8237 & 1.0813 & 1
\end{bmatrix}$$

Fig. 3: The comparative matrix of options relative to the travel time in the network

$$\begin{bmatrix}
1 & .9144 & .6716 & 1.2028 & 1.167 & 1.554 & 1.0168 & .8788 & .5714 & 1 \\
1.0937 & 1 & .7345 & 1.3154 & 1.2764 & 1.2636 & 1.112 & .9612 & 1.015 & .9276 \\
1.489 & 1.3615 & 1 & 1.7909 & 1.7378 & 1.7204 & 1.514 & 1.3086 & 1.3819 & 1.2629 \\
.8314 & .7602 & .5584 & 1 & .9703 & 09606 & .8454 & .7307 & .7716 & .7051 \\
.8569 & .7835 & .5754 & 1.0306 & 1 & .99 & .8712 & .753 & .7952 & .7267 \\
.8655 & .7914 & .5813 & 1.041 & 1.0101 & 1 & .88 & .7606 & .8032 & .734 \\
.9835 & .8993 & .6605 & 1.1829 & 1.1478 & 1.1363 & 1 & .8643 & .9128 & .8341 \\
1.1379 & 1.0404 & .7642 & 1.3686 & 1.3279 & 1.3147 & 1.1569 & 1 & 1.056 & .965 \\
1.0775 & .9852 & .7236 & 1.296 & 1.2575 & 1.245 & 1.0956 & .947 & 1 & .9139 \\
1.1791 & 1.0781 & .7918 & 1.4181 & 1.376 & 1.3623 & 1.1988 & 1.0362 & 1.0943 & 1
\end{bmatrix}$$

Fig. 4: The comparative matrix of options relative to the construction cost

Table 6: Criteria weights

Environmental	Travel time	Network providing	Accident	Construction costs
0.186	0.147	0.147	0.26	0.26

There are many advantages over traditional methods of prioritizing selection options and bypass construction in the introduced method in this research. Table 9 shows this comparison.

Table 7: The relative weights of each criterion

Case number	Construction costs	Accident	Environmental	Travel time	Network providing
1	0.0951	0.0978	0.0727	0.0925	0.1151
2	0.104	0.1397	0.0545	0.0927	0.0921
3	0.1416	0.0699	0.1091	0.0934	0.0805
4	0.0791	0.0652	0.0909	0.0927	0.069
5	0.0815	0.1397	0.1456	0.0996	0.1266
6	0.0823	0.1087	0.0909	0.1109	0.1047
7	0.0935	0.0978	0.1273	0.0934	0.1185
8	0.1082	0.0611	0.1091	0.1256	0.0863
9	0.1025	0.1233	0.1273	0.0957	0.1151
10	0.1121	0.0978	0.0727	0.1035	0.0921

Table 8: Final ranking of the options

Case	1	2	3	4	5	6	7	8	9	10
priority	9	5	4	10	1	6	3	8	2	7
The final rank	0.0942	0.1007	0.1008	0.0782	0.1178	0.0983	0.1046	0.0955	0.1131	0.968

Table 9: Comparison table of bypass construction with introduced method and traditional method for prioritizing the bypasses

Criterion	Traditional Method	The introduced method considering network approach
Use of multi-criteria decision making system	-	✓
Considering the effect of bypass in completing the roads network	-	✓
Considering the effect of travel time in selecting options	Individually between several options of city bypass	Network form between all scenarios of city bypasses
Considering the bypass construction cost	Comparison between several individual bypasses	Comparison between bypasses in the road network
Considering the predicted accidents costs after constructing of bypass	-	✓
Considering the adaptation with comprehensive plan	Sometimes yes, sometimes no	Network form between all options
Considering environment effect of bypass construction costs	It may be considered individually as an option for city bypass	Network form for all studied city bypasses in the road network

5. Conclusion

Using the Delphi technique, a model is developed for the bypasses optimization. In this regard, prioritizing the predicted bypasses construction has been performed for various cities in the rural roads network. Since the involved criteria and variables in the design of a decision making support system of the bypasses are the combination of the qualitative and quantitative variables, the hierarchical decision making support system capable of separately considering these two classes of variables will be the most appropriate system. Road accidents are considered as the most important involved criterion in designing a decision making support system for the bypasses optimization. For this reason, it is attempted here to focus on developing a model as a major issue of decision about the bypasses.

As it is investigated, the introduced method in this study for planning and prioritizing bypasses has many advantages over traditional methods which have been used up to now and can be a good alternative to the traditional methods by creating a comprehensive vision of the national road network.

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