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SOLUTION OF TRAFFIC BY THE HELP OF THE HEURISTICS METHODS

Nikoleta Husáková[1], Eva Tomková[2]

[1]Ústav logistiky, Technická univerzita v Košiciach, Park Komenského 14, 04384 Košice, Slovakia, e-mail: nikoleta.husakova@tuke.sk

[2] Ústav logistiky, Technická univerzita v Košiciach, Park Komenského 14, 04384 Košice, Slovakia, e-mail: eva.tomkova@tuke.sk

Abstract:
Solution of traffic problems has an important role in the traffic situation of every towns and cities. One of the possible way for traffic problem solution is a detailed analysis of the traffic situation, realization of the traffic survey and by the results of this survey to propose and design the possible and workable solution for the specific towns or cities. The paper presents the output of the case study which was realized in the city Košice, and it solved the traffic problem in a frequented junction of this city. The first step of the case study was a realization of the traffic survey and then by the help of the obtained results we tried to find a suitable solution for this problem by the help of heuristics methods, namely by the help of decision-making methods.

Key words: *traffic, method, heuristics*

1 INTRODUCTION

Transport is a purposeful and organized activity, without which it is now impossible to imagine the current high-technology world. The term – transport – means activity which ensures the movement of goods and people by vehicles or transport devices [1]. Transport has an important role in logistics processes and it is one of the key factor of the global industrial development. Important part of transport and transport logistics or rather one of the important and specific tool of transport logistics [2] is the traffic engineering. Traffic engineering is a science which deals with planning, design and operation of transport device and their mutual cooperation in the urbanized areas. Development of the automotive industry and development of automobile transport have a huge influence on the traffic engineering [3]. The primary purpose of each city in terms of the traffic flow is [4]:

- construction/building up of sufficient number of traffic flows,
- construction/building up of junctions types which can assure the fluent movement of all vehicles,
- construction/building up of circular roads around the towns,
- provision of the line of urban public transport and reduction of congestions,
- provision of the sufficient number of pedestrian crossings,
- creation of a road networks for fluency of transport.

In many big cities we can find the problems of urban transport. Morning and afternoon traffic jams have become part of almost every big city. Number of passengers by urban transport constantly declining because people prefer to use their own cars. In this regard, it is not possible to expect positive change. The downward trend in public transport can be quire slow the urban transport in the future [5]. Problems of urban transport, traffic jams were solved by the case study in the city Košice. The first step of the research was a questionnaire in the selected junction and on the base of the results of this research we designed possible solutions for this city by the help of the methods of decision making, namely by the method of decision matrix method, method of quadratic graph and method of paired comparison.

2 SOLUTION OF BOTTLENECKS OF TRAFFIC FLOWS IN THE SELECTED LOCALITY

Traffic engineering can apply various methods of multi-criteria decision making by solution of bottlenecks for traffic flows. This part of the paper present application of these three methods for solution of determined bottlenecks in the analysed junction: method of DMM, method of quadratic graph and method of paired comparison. On the base of realized traffic survey and the results of the questionnaire it was determined variants which could improve the current situation by the solving junction. From the previous parts of the research it was possible to use these suitable variants: V1 – roundabout, V2 – change of traffic lights setting, V3 – building-up of several traffic lanes. For each of these methods will be used these variants. Every three methods required determination of various criteria which can affect activities by problems solution. These criteria must be set logically on the basis of the fact which factors have the greatest influence on the situation. These methods will use these criteria: K1 – safety, K2 - density of traffic, K3 – speed of traffic, K4 – cost for changes.

2.1 Method DMM (Decision Matrix Method)

1st step – Evaluation of criteria by dot scale (1-10)
K1 – safety: 9, K2 - density of traffic: 7, K3 – speed of traffic: 8, K4 – cost for changes: 4

2nd step – Evaluation of variants by the selected criteria (1-10)
By the criteria K1 (Safety): V1 roundabout: 8, V2 – change of traffic lights setting: 7, V3 – building-up of several traffic lanes: 7

By the criteria K2 (Density of traffic): V1 – roundabout: 7, V2 – change of traffic lights setting: 6, V3 – building-up of several traffic lanes: 8

By the criteria K3 (Speed of traffic): V1 – roundabout: 8, V2 – change of traffic lights setting: 6, V3 – building-up of several traffic lanes: 6

By the criteria K4 (Cost for changes): V1 – roundabout: 3, V2 – change of traffic lights setting: 9, V3 – building-up of several traffic lanes: 5

3rd step - Multiplication of numbers with the scales and notation of the results to the table (Tab.1).

Tab.1 *Decision matrix by the method DMM*

Criteria	Weights	Variants					
		V1		V2		V3	
K1	9	8	72	7	63	7	63
K2	7	7	49	6	42	8	56
K3	8	8	64	6	48	6	48
K4	4	3	12	9	36	5	20
		197		189		187	
		1.		2.		3.	

4th step – counting of the obtained values and summary of the results
V1: 72+49+64+12=197
V2: 63+42+48+36=189
V3: 63+56+48+20=187

From these results it is evident that by the method DMM the best variant for improvement of the traffic situation for the analysed locality is building-up of roundabout. The second possible solution would be the change of settings of the traffic lights and the worst option would be building-up of other traffic lanes.

2.2 Method of quadratic graph

1st step – Determination of the optimal value.
Optimal value: 10

2nd step – evaluation of variants in comparison with the optimal value

- By the criterion K1 (safety): V1 – roundabout: 8, V2 – change of traffic lights setting: 7, V3 – building-up of several traffic lanes: 7.
- By the criterion K2 (density of traffic): V1 – roundabout: 7, V2 – change of traffic lights setting: 6, V3 – building-up of several traffic lanes: 8.
- By the criterion K3 (speed of traffic): V1 – roundabout: 8, V2 – change of traffic lights setting: 6, V3 – building-up of several traffic lanes: 6.
- By the criterion K4 (cost for changes): V1 – roundabout: 3, V2 – change of traffic lights setting: 9, V3 – building-up of several traffic lanes: 5.

3rd step – Calculation by the equation

- $U_j = \sum_{i=1}^{n} \left[\frac{u_{ij} - u_{optimal}}{u_{optimal}}\right]^2$, j=1, 2, 3, ..., m
- m – number of evaluated variants, n – number of criteria, u_{ij} – utility of the j variant by the I criterion, $u_{optimal}$ – optimal value of utility of the i criterion, U_j = total utility of the variant.

4th step - Notation of the results to the table (Tab.2)

Tab. 2 *Decision matrix by the method of quadratic graph*

Criteria	Optimal value	Variants					
		V1		V2		V3	
K1	10	8	0,04	7	0,09	7	0,09
K2	10	7	0,09	6	0,16	8	0,04
K3	10	8	0,04	6	0,16	6	0,16
K4	10	3	0,49	9	0,01	5	0,25
		0,66		0,42		0,54	
		3.		1.		2.	

5th step – counting of the obtained values and summary of the results.

V1: 0,04+0,09+0,04+0,49=0,66

V2: 0,09+0,16+0,16+0,01=0,42

V3: 0,09+0,04+0,16+0,25=0,54

The suitable solution by this method is the variant with the smallest resulting number. By this method the best solution would be the change of traffic lights setting. The second best solution is building-up of several traffic lanes and the worst option according to this method is a roundabout building.

2.3 Method of paired comparison

1st step – determination of the value of normed weights of criteria by the table.

Tab. 3 *Values of the normed weights by the method of paired comparison*

	K1	K2	K3	K4	K_i	K_i+1	α_i
K1	-	K1	K1	K1	3	4	0,4
K2	-	-	K3	K2	1	2	0,2
K3	-	-	-	K3	2	3	0,3
K4	-	-	-	-	0	1	0,1
∑						10	1

2nd step – Calculation of the values for variants by the determined criteria according to the tables (4-7).

- By the criterion K1 (safety)

Tab. 4 *Values of variants by the criterion K1*

K1	V1	V2	V3		
V1	-	V1	V1	2	0,67
V2	-	-	V3	0	0
V3	-	-	-	1	0,33
∑				3	1

- By the criteria K2 (density of traffic)

Tab. 5 *Values of variants by the criterion K2*

K1	V1	V2	V3		
V1	-	V1	V1	2	0,67
V2	-	-	V3	0	0
V3	-	-	-	1	0,33
∑				3	1

- By the criteria K3 (speed of traffic)

Tab. 6 *Values of variants by the criterion K3*

K3	V1	V2	V3		
V1	-	V1	V1	2	0,67
V2	-	-	V2	1	0,33
V3	-	-	-	0	0
∑				3	1

- By the criteria K4 (cost for changes)

Tab. 7 *Values of variants by the criterion K4*

K4	V1	V2	V3		
V1	-	V2	V3	0	0
V2	-	-	V2	2	0,67
V3	-	-	-	1	0,33
∑				3	1

3rd step - Multiplication of the results with the weights, and notation of the new results to the table (Tab.8).

Tab. 8 *Decision matrix by the method of paired comparison*

Criteria	Weights	Variants					
		V1		V2		V3	
K1	0,4	0,67	0,27	0	0	0,33	0,13
K2	0,2	0,33	0,07	0	0	0,67	0,13
K3	0,3	0,67	0,2	0,33	0,1	0	0
K4	0,1	0	0	0,67	0,07	0,33	0,03
		0,54		0,17		0,29	
		1.		3.		2.	

4th step – count of the obtained values and summary of the results.
V1: 0,27+0,07+0,2+0=0,54
V2: 0+0+0,1+0,07=0,17
V3: 0,13+0,13+0+0,03=0,29

By the method of paired comparison the best solution can be building-up of roundabout. The second acceptable solution can be building-up of several traffic lanes and the worst solution by this method is change of traffic lights setting.

3 CONCLUSION

According to the realized analysis by the traffic survey and questionnaire in the selected locality of the city Košice, it is possible to state that the major problem of the selected junction is a high intensity of traffic. The solved junction creates a significant part of the transport in the analysed city. The current solution cannot manage removing vehicles through the area of this junction during the traffic peak. The worst consequence is the slow traffic in this locality. In some hours vehicles wait too long at the entrance of this junction. On the basis

of the realized questionnaire it is possible to specify that the interested passengers agree with the result of the traffic survey. In the most important questions they had similar answers (they criticized the slow traffic in this part of the city). According to the answers of the respondents the best solution can be: building-up of the roundabout and change of traffic lights setting. For the solution of this traffic problem we used selected methods of multi-criteria decision making. Before the realization of these methods we defined the basic criteria which can have the major effect on the traffic situation in this locality. We speculated with these criteria (by which were evaluated several variants) – safety, density of traffic, speed of traffic and cost for changes. By each method were used these criteria. By solution of the traffic situation of this locality we used these methods of multi-criteria decision making: method of decision matrix method, method of quadratic graph and method of paired comparison. By calculation of these methods we obtained different proposes for solution:

- By the results of the method DMM and paired comparison the best solution is the building-up of roundabout in this locality. The basic characteristics of this type of junction is a greater security. For safety reasons, so we think that the solution is more convenient than the previous solutions. The disadvantage of this solution is a cost for building up. But it is possible to state that the positive characteristics so the increased safety and speed up traffic are also important positive effect of this type of junction, that this disadvantage is negligible in comparison with the other advantages.
- By the results of the method of quadratic graph the best solution is the change of traffic lights setting. The following design could be a solution for all road users on this locality. By the design was important that the length of the periods of road signals has not changed, because the number of transport vehicles during the traffic peak. A shorter period would mean even longer interval of lost time.

It is possible to state that the results of these methods are the same as the results which were obtained by the questionnaire.

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