LOGISTICS APPROACHES IN ASSESSING THE INTENSITY OF TRAFFIC WITH THE APPLICATION TO URBAN ROADS

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Abstract

A significant and often problematic part of a local road, while solving the traffic within the city area, is the capacity of the local roads. Capacity of a local road can be defined as the maximum number of vehicles that can pass per unit of time by a pursued rust, strip or lane of local road under the favorable driving conditions. The article is aimed on analysis of the current situation of local roads with the case study in the city of Košice. The analysis will be carried out mainly in the terms of capacity of local roads. The solution may be a modification of the duration of green waves, modification of the number of traffic lanes and where appropriate adjusting the surrounding of the road, meaning a modification of organization and management of traffic in adjacent and follow-up roads.

Keywords: City logistics, urban roads, traffic flow, traffic intensity

1. INTRODUCTION

The local roads are the land roads solely of local significance. They are an integral part of the transport equipment of each residential unit. The local roads connect the places of residence with the places of jobs, the places of social amenities or with the places of entertainment and leisure complexes [1].

Development of traffic on the local roads is affected by the society. The needs of society also have an influence on traffic, the type of transport system, the method and the quality of services in the city [2].

The decisive criterion for planning the local roads is the design of its capacity. The design of capacity must be greater than its anticipated design congestion and once it is reached, the environmental capacity cannot be exceeded [3].

It is necessary to analyze whether the local roads meets the needs of current intensity of traffic. Further, it is also necessary to find out whether the parameters of roads can be modified in consideration of its surrounding buildings so as to accelerate and simplify crossing, and to increase the safety of roads.

2. METHODOLOGY

From the analysis, there are identified the values of allowed intensities. The following calculated allowable intensities are compared with the intensity measured during the National Traffic Census in 2015 [4]. The outcome of this comparative method is calculation the percentage of congestion of local roads. The classification of local roads according to congestion, which defines the levels of quality of transport mode, is determined on the basis of calculation the percentage of congestion. The traffic quality levels are determined from observations of the flow of traffic on the monitored areas and sections. The percentage of congestion is in the interface of 0-80%, while the percentage of congestion that is greater than 80% is indicated as „81 and more“. The descriptions and characteristics of individual levels of traffic are shown in the **Table 1**.

Table 1 Classification of local roads according to congestion

Levels of quality	Characteristics of quality of transport	Characteristics of transport flow	Percentage of congestion
A	very good	Road drivers are rarely mutually influenced. Transport flow is fluent.	< 30
B	good	Involved vehicles in the choice of speed and driving lane are in the small range of mutual influence. The negligible delays imply of that. Transport flow is almost fluent.	31 - 60
C	satisfactory	The presence of other road users is noticeable. There is no longer the unlimited freedom of movement given. The flow of traffic is stable. In the case of undesirable event, the area decreases on the level of quality D.	61 - 80
D	Unstable, sporadically unsatisfactory	All of the road users have to keep in mind a possible presence of barriers. A congestion or a complete stop of vehicles occurs while short-term increase in traffic intensity. The transport flow changes from stable to unstable occasionally.	81 <

The permissible (design) intensity of the traffic flow I_p of the four-way bi-directional local road shall be determined for one direction only as [5], [6]:

$$I_p = I_z . k_s \tag{1}$$

where I_z basic value of the allowable intensity [cars/hour]

k_s value of the width coefficient [-]

Determination of the estimated annual average daily intensity (RPDI) from the result of the short-term survey is performed separately for each vehicle type x [5], [7]:

$$RPDI_x = I_m . k_{m,d} . k_{d,t} . k_{t,RPDI} \tag{2}$$

where I_m the traffic intensity of the vehicle type found at the time of the survey [cars/survey period]

$k_{m,d}$ the transport intensity conversion factor at the time of the survey for the daily traffic intensity of the survey day (taking into account daily variations in traffic intensity) [-]

$k_{d,t}$ conversion factor of daily traffic intensity on day of survey converted to weekly average traffic intesity a day (taking into account weekly variations in traffic intensity) [-]

$k_{t,RPDI}$ conversion factor of weekly average daily traffic intensity to annual average daily traffic intensity (taking into account annual variations in traffic intensity) [-]

The resulting value of the annual average daily traffic intensity for vehicles is determined by the sum of the annual average daily traffic intensities for each vehicle type [8].

$$RPDI = \sum_x RPDI_x \tag{3}$$

By comparing the observed values of RPDI in extravilanes in the sections before the solved territory and in the area solved, we will determine the share of intensity of the intravilan at present. The prospective growth coefficients for intravilan are obtained as:

$$Kgrowth = \frac{O_v}{O_{ss}} \cdot \frac{PP_v}{PP_{ss}} \cdot \frac{A_v}{A_{ss}} \cdot \frac{ROV_v}{ROV_{ss}} \quad (4)$$

where O_v forecast for number of ihabitants;

O_{ss} number of inhabitants at present;

PP_v forecast for job opportunities;

PP_{ss} job opportunities at present;

ROV_v forecast of the annual circulation of the vehicle;

ROV_{ss} the annual circulation of the vehicle at present.

3. RESULTS AND DISCUSSION

3.1 Analysis of intensities on the local roads in the city of Košice

The **Table 2** shows computed values of prospective congestion during peak hours. According to the table, an increase of congested, respectively over loaded, sections is seen. This will apply to the particular entrances into the city from outlying smaller boroughs like Kavečany, Zlatá Idka, Myslava, Pereš, Krásna pri Hornáde and at present already congested section going through Košická Nová Ves.

The hardest part to drive through will be the main North - South. Roads in the city center will be congested approximately to 50%, which should be a continuous traffic except streets Rastislavova and Comenius. The best transitional sections remain the sections situated in the settlements Dargovských hrdinov and KVP. In the city centre the best transitional sections will be the streets Moyzesova, Národná trieda and Československej armády. Looking at the assessed cartogram it is clear that because of such an increase in traffic it is necessary to increase allowable intensities of the MK either by increasing the number of lanes, modification of the organization of traffic or other alternatives.

3.2 Proposals for possible measures to increase allowable intensities

In order to determine the cause of congestions of each section it is necessary to assess the main cause of the traffic congestion. The most often congested sections are the sections with two road lanes. In these sections, the main cause is a small number of road lanes. This problem can be solved by increasing the number of road lanes. It is possible (in case the surrounding region allows it) to increase the number of road lanes however it can be difficult to implement in the center of the city.

Another possible solution is to change the settings of traffic lights. This proposal is financially less challenging though the efficiency is not such high [9]. The possible solution may also be a modification of traffic organization. To solve this fact requires more time.

The analysis carried out in the previous chapter shows that the most congested section is Slanecká road that shows 261% of congestion during peak hours while during average hours it is still 121% of congestion. Along with these numbers Slanecká road is the most congested road and because of that it is important to devote increased attention. Considering the appropriate spatial conditions, it follows a proposal to increase the number of lanes in the driving lane from two-lane arrangement to the four-lane anargement MK.After recalculating the capacity calculations of a proposal communication is found a positive but also a negative side of the proposal. The positive one is that the design of proposal satisfies the current situation while after enlarging the communication, the quality of traffic will change from level D to the best level A, whose result will be a fluent transport. The negative one is the noticeable congestion of section during peak hours with the view of the year 2019. The congestion of peak hour would be identical to the current congestion of an average hour.

Table 2 A data showing forecast of traffic flow during peak hour in 2040

Road No.	Road beginning	End of the road	Road lenth [m]	Functional group	PPV [%]	$PPV_{šh}$ [%]	I_p [cars/hour]	$I_{pšh}$ [cars/hour]	I_{sph} [cars/hour]	$I_{šh}$ [cars/hour]	a_{sph} [%]	$a_{šh}$ [%]	a_{vpa} [%]	$a_{všh}$ [%]
0-2542	Slanecká-Nižné Kap.	Slanecká-Ukrajinská	3000	Z	15	16	728	721	881	1875**	121	260	247	531
0-0242	Herlian.-Sv.La.-Ortva.	Sečovská-Zdoba	1350	Z	12	11	794	801	548	1100**	69	137	141	280
0-3993	Komen.-Wats.-Hlinko.	Komen.-Hviezdoslav.	1250	Z	5	5	734	734	581	629*	79	86	161	175
0-2541	Už.t.-Alejova-Niž.Ka.	Slanecká-Južné Nábr.	750	R	23	23	2141	2141	1602	1725	75	81	153	164
0-0222	Tr.L.S.-Hlinkova	Hlinkova-Komenského	1500	Z	8	9	3694	3673	1941	3600**	53	98	107	200
0-0624	Moyze.-Štúr.-Rastisl.	Rasti.-Jantár.-Už.tr.	2250	Z	5	5	808	808	520	563*	64	70	131	142
0-2543	Slanecká-Ukrajinská	Ukraji.-smer Vyš.Hut.	3500	Z	15	13	757	830	335	750**	44	90	90	184
0-3253	Výhľ.veža-Kavečian.	Kavečian.-Kostolians.	1750	Z	8	8	334	334	122	300**	37	89	75	183
0-3251	Kosto.-Kaveč.-Vodar.	Čermeľ.-Kosto.-Kome.	200	Z	10	14	898	867	346	725**	39	83	79	171
0-3992	SNP-Popradská	Popradská-Moldavská	3600	Z	13	13	654	654	351	380*	54	58	109	119
0-0619	Moldavská-OC Opti.	E50-Lorinčík	2000	R	13	13	2350	2350	1150	1239*	49	53	100	108
0-0243	Palac.-Jantar-Pr.faš.b.	Palcekého-Južná tr.	500	Z	11	11	1814	1814	857	927*	47	51	96	104
0-0241	Sečovská-Prešovská	Prešovská-Už. Nábr.	250	Z	18	18	3880	3880	1731	1874*	45	48	91	99
0-0221	Prešovská-Hlinkova	Prešovská-Sečovská	2550	R	19	19	2225	2225	988	1064*	44	48	91	98
0-0233	Sečovská-Zdoba	Sečovská-Prešovská	1800	Z	13	17	2109	2055	804	1050**	38	51	78	104
0-0634	Štúr.-Moyzes.-Rasti.	Štúr.-Kuzma.-Žižkova	150	Z	5	5	3183	3183	1355	1466*	43	46	87	94
0-2043	Čermeľ.-smer Jahod.	Čermeľ.-Kosto.-Kome.	4000	Z	7	5	901	916	252	550**	28	60	57	122
0-0232	Prešovská-Už.Nábr.	Slanecká-Nižné Kapu.	3500	R	40	40	1786	1786	674	726*	38	41	77	83
0-3990	Mysl.-smer Bukovec	Tr. KVP-Moldavská	3000	Z	16	17	2026	1991	445	1000**	22	50	45	113
0-3252	Kostolian.-Ťahanovs.	Kost.-Voda.-Kavečia.	1500	Z	12	6	856	900	171	450**	20	50	41	102
0-2055	Jant.-Južná tr.-Rasti.	Už.t.-Alejova-Niž.Ka.	1250	Z	8	8	3694	3694	1228	1329*	33	36	68	73
0-0635	Festivalovo nám-SNP	SNP-Moldav.-Alejova	2850	Z	5	5	3687	3687	1193	1291*	32	35	66	71
0-0633	Hlinkova-Komenského	Festivalovo námestie	1350	Z	13	13	4070	4070	1289	1395*	32	34	65	70
0-0229	E68-smer Prešov	Prešovská-Hlinkova	5500	R	17	17	2268	2268	708	763*	31	34	64	69
0-2053	E50-Moldavská	E50-Alejová	2500	R	29	29	2016	2016	589	634*	29	31	60	64
0-0615	SNP-Moldav.-Alejova	Alej.-Niž.Kap.-Už.Tr.	2250	Z	5	5	3762	3762	1051	1137*	28	30	57	62
0-3254	Kostolian.-Ťahanovs.	Americ.tr.-Prešovská	2500	Z	8	8	3488	3488	930	1006*	27	29	54	59
0-0632	Palckého-Južná tr.	Štúr.-Moyzes.-Rasti.	500	Z	9	9	3848	3848	1009	1092*	26	28	53	58
0-2054	Už.t.-Alejova-Niž.Ka.	Ul.Oslobo.-smerVala.	2500	Z	18	18	3422	3422	801	867*	23	25	48	52
0-0622	Moldvská-Toryská	Toryská-SNP	750	Z	8	8	2257	2257	499	540*	22	24	45	49
0-0225	Gor.-Štef.-Mas.-Hvie.	Pr.faš.boj.-Palac.-Jan.	1250	Z	7	7	3511	3511	769	832*	22	24	45	48
0-0625	Pr.faš.boj.-Palac.-Jan.	Jant.-Južná tr.-Rasti.	2250	Z	7	7	3718	3718	801	867*	22	23	44	48
0-0621	Moldav.-Alejova-SNP	Moldavská-OC Opti.	1000	Z	7	7	3718	3718	801	866*	22	23	44	48
0-0631	Štúr.-Kuzma.-Žižkova	Moldav.-Alejova-SNP	1500	Z	6	6	3740	3740	768	831*	21	22	42	45
0-2044	Čermeľ.-Kosto.-Kome.	Komen.-Wats.-Hlinko.	250	Z	5	5	4180	4180	474	950**	11	22	23	46
0-2052	Už.tr.-Štúro.-Palack.	Už.tr.-Rasti.-Jantáro.	1500	Z	5	5	3762	3762	546	591*	15	16	30	32
0-3991	Poprads.-Trieda KVP	Trieda KVP-Myslav.	3000	Z	16	16	3834	3834	518	560*	14	15	28	30
0-0244	Tr.L.S.-Seč.-Herlian.	Tr.L.S.-Hlinkova	3500	Z	15	15	3466	3466	438	474*	13	14	26	28
0-0623	Hviezdosla.-Moyzes.	Moyzesova-Štúrová	1250	Z	7	7	3304	3304	419	453*	13	14	26	28
0-0224	Hlinkova-Národná tr.	Gor.-Štef.-Mas.-Hvie.	1500	Z	16	16	3961	3961	439	475*	11	12	23	24
0-2045	Čsl.Ar.-Hviez.-Kuzma.	Čsl.Ar.-Festivalo.nám.	750	Z	5	5	1164	1164	71	77*	6	7	12	13
0-0231	Prešovská-Už.Nábr.	Palckého-Jantárová	900	Z						***				

* peak hour was calculated according to the coefficient of peak hour
** peak hour was calculated as the maximum hour of intensity during the period of a survey CSD 2005
***in the section was not made a survey of traffic intensity during CSD becaue of the roadworks and reconstructions

Explanatory notes:

Level of quality A
Level of quality B
Level of quality C
Level of quality D

Table 3 Congestion of the current and future proposals for the section Slanecká road

	Two-way road		Four-way road	
	Road traffic load [%]	Quality level	Road traffic load [%]	Quality level
Actual average congestion per hour	121	D	26	A
Peak hour congestion	260	D	55	B
Forecast of average congestion in 2040	247	D	53	B
Forecast of peak hour congestion in 2040	531	D	112	D

From the results it is concluded that a proposal of four-lane local roads is necessary, but it does not solve all the causes of road congestions especially when considering a view of the year 2040. If this situation is not solved there will be roads overloaded about 531% during peak hour in 2040. It this case it will be necessary to devise other proposals including modification of traffic management or elimination of vehicles passing that roads. The percentage of congestion of the current and future proposals for this section Slanecká road is shown in **Table 3**. The forecast is based on the models in [10], [11], [12], [13].

4. CONCLUSION

From the results of the analysis we can conclude that the current state of the capacity of certain sections of local roads, especially during peak hours is unsustainable. Due to the traffic congestion of local roads and the constantly increasing traffic the flow of transport is greatly limited.

Currently, the transport is not the only problem. After calculating the alarming growth rate and after recalculating the prospective period in 2040, the results of the survey processed in the tables and cartograms show that extensive congestion, respectively overload of local roads, still occurs.

In the proposal of possible measures to increase the allowable intensity in the section 0-2542 Slanecká is used the method of increasing in the number of lanes. Increasing the number of lanes is recommended for areas where there is built-up area nearby. The clearly processed results show that increasing in the number of lanes in the driving lane is effective only for the current state of traffic intensity. The prospective period during peak hours is again a congestion of local roads almost identical to the current situation, which is an unsatisfactory condition.

The biggest problem is how to avoid above-mentioned situations, so that traveling comfort has not decreased and that the protection of environment has been respected. In order to prevent occurrence of this difficult situation, we have to keep in mind this clarified problem at present as well.

The conclusion of this publication indicates that the problem solving the capacity of local roads, which it deals with, is current and highly alarming. The situation needs to be solved comprehensively along the factors that directly and indirectly affect the intensity of local transport [14]. These factors do not only include the terms of the number of moving vehicles, but also, e.g. surrounding residential area, shopping centers, industrial parks, etc [15], [16].

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