

METHODOLOGY FOR ANALYSING CAPACITY AND LEVEL OF SERVICE FOR INTERSECTION AT BLVD GOCE DELCEV AND BLVD KRSTE PETKOV MISIRKOV - SKOPJE (HCM 2000/2010)

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Abstract

The augmentation of motorization level leads us to the need for mobility and demands better infrastructure, in urban and suburban areas. The complexity of this problem is especially notable in urban areas where the space delimitations, functional characteristics and different transportation must be considered.

The intersection between boulevard Krste Petkov Misirkov and boulevard Goce Delcev, in Skopje, has been analyzed with the methodology for capacity and level of service, according to HCM. Both boulevards are with three lanes before the intersection, and two additional lanes for left and right turns in the intersection area, and this is one of the most frequent intersections in Skopje. Number of vehicles is determined by measuring the traffic, and those inputs are used to analyze three solutions: the current solution (signalized intersection), roundabout and junction (leveled roundabout). Anyway, this analysis is based on custom measurements within a week.

Keywords - intersection, analysis, roundabout, capacity, level of service, Highway Capacity Manual

INTRODUCTION

City development affects all the movements and need for transportation. In urban areas, besides the motor traffic, bicycles and pedestrians are important part of city traffic. Part of the motor traffic in cities are buses, city railways, subway and trolleybus. These vehicles must be considered in each analysis, because of their influence.

Intersection type is important and depends on many factors. For instance, if both roads are with similar traffic load, roundabout is recommendable. In case of different traffic load, signalized or unsignalized intersection is better solution. If the roads have more than 4 lanes, junction is the best solution, or intersection with required signalization.

There are six types of intersection levels with defined connections and moving regime, according to the roads that are crossing.

		ΓΑ		ΓΜ		ΓC		CΥ	
		3+3	2+2	3+3	2+2	2+2	4	4	2
ΓΑ	3+3								
	2+2		A			B		C	
ΓΜ	3+3			/	\				
	2+2								E
ΓC	2+2		B			D			
	4								
CΥ	4		C						F
	2				E				

Fig.1. Functional level of intersections

The Highway capacity manual is used for analyzing capacity and level of service for many various facilities. The analyzed flows are classified as interrupted or uninterrupted flows. Uninterrupted flows are all the flows with no fixed elements (like traffic signals). Traffic flows depends on vehicles interactions and geometric and environmental characteristics. Interrupted flows, on the other hand, have controlled and uncontrolled access points that

interrupt the flow. This includes signals, stop-signs and any type of control that interrupts or slows the traffic. City roads are classified as interrupted because of the signs, signalization and bicycle and pedestrian presence.

CAPACITY ANALYSIS OF INTERSECTION AT BLVD. KRSTE PETKOV MISIRKOV AND BLVD. GOCE DELCEV - SKOPJE

Boulevard Krste Petkov Misirkov spans in line North - South, while boulevard Goce Delcev spans in line East - West. Both boulevards have three lanes before the intersection and two additional lanes for left and right turns. In the intersection area there are five lanes in total per leg.



Fig.2.Current solution of intersection - blvd. Goce Delcev (East - West line) – Skopje



Fig.3.Current solution of intersection - blvd. Krste Petkov Misirkov (Blvd. K. P. Misirkov - North - Blvd. K. P. Misirkov - South line) – Skopje

Traffic measuring is made during a week (15.02.2016 - 21.02.2016) in the morning hours, 07:30 - 09:30 from Monday to Friday and 08:30 - 10:30 during the weekend. From these measurements for the traffic we can calculate average daily traffic (ADT) and average daily annual traffic (ADAT).

$$ADT = \frac{\check{C}O}{FNC} * 100 \quad (1)$$

$\check{C}O$ - Load per hour

FNC - n-hour factor (8-10, in this case it's 9)

$$ADAT = \frac{ADT}{Ks} \quad (2)$$

Ks - Factor of annual variability ($Ks = 1.09$ in this case)

In table 1 the Origin - Destination matrix is presented for 15 minutes traffic for the analyzed intersection.

Table 1. Origin - Destination matrix for the analyzed intersection

	Blvd. G. Delcev - Blvd. G. Delcev - East	Blvd. G. Delcev - West	Blvd. K. P. Misirkov - North	Blvd. K. P. Misirkov - South	
Blvd. G. Delcev - East	0	270	59	81	410
Blvd. G. Delcev - West	173	0	61	23	257
Blvd. K. P. Misirkov - North	167	48	0	91	306
Blvd. K. P. Misirkov - South	173	49	135	0	357
	513	367	255	195	1330

FOUR LEGGED SIGNALIZED INTERSECTION

The intersection between blvd. Krste Petkov Misirkov and blvd. Goce Delcev is four legged signalized intersection. With personal counting of vehicles, the current traffic is obtained. Considering the influence of traffic, geometric and signalization conditions, appropriate correctional factors are used in order to calculate the saturation flow rate.

First step in the calculation is grouping the lanes, so that the capacity and level of service can be calculated for each group. For this research lanes are grouped in 3 groups:

- Left turns and through
- Through
- Right turns

The left turns and through movements are actuated because they depend on the signalization, but the right turns as independent are classified as pretimed.

After grouping the lanes, volume adjustment is made by considering the % of heavy vehicles and peak hour factor. Next step is calculation of saturation flow rate, by knowing the number of lanes and appropriate adjustment factor (for lane width, HV, grade, area type, lane utilization...). Now that both, adjusted flow rate in lane group and adjusted saturation flow are familiar, the capacity analysis can be done. For each group of lanes on each leg, critical lane group or phase is determined by the biggest flow ratio (v/s). Since all of the lane groups have flow ratio smaller than 1, except for the lane for right turns in the leg of Blvd. K. P. Misirkov - South the results for level of service are acceptable. Only the leg of Blvd. K. P. Misirkov - South has level of service F, while the other three have level of service A. Another indicator of unsatisfying solution for the leg with LOS F is the delay.

In the calculations, the number of buses for some groups of lane is adjusted according to the HCM, it is given as 250 buses (max number given by the manual), even though the number is bigger than this. Also, each lane for right turns is analyzed as two lanes from 2.75m ($2 \times 2.75 = 5.50$), because by the manual is not allowed to have lane wider than 4.8m

With computation of total delay for each lane group, LOS can be determined, for each group lane and for each approach as well.

Table 2. Final results for signalized four-legged intersection

Lane group capacity, Control delay and LOS determination				
	Blvd. G. Delcev - East	Blvd. G. Delcev - West	Blvd. K. P. Misirkov - North	Blvd. K. P. Misirkov - South
LOS by approach	A	A	A	F
Approach flow rate v_A (veh/h)	3958,06	2476,77	2960,61	3450,37
Intersection delay d_i	5,07	0,27	9,45	129,00

Three of the approaches have LOS "A", while the approach of Blvd. K. P. Misirkov - South has LOS "F", because of the right turns, where the flow is bigger than the capacity.

ROUNDAABOUT - UNSIGNALIZED INTERSECTION

Roundabout analysis is divided in two parts, computation of approach flows and computation of circular flow. In order to obtain more realistic results for each lane group, methodology for unsignalized four-legged intersection is used. First step is defining circulating traffic for each entry stream. (For example, for streams 7, 8 and 9 circulating flow is 1, 2 and 10).

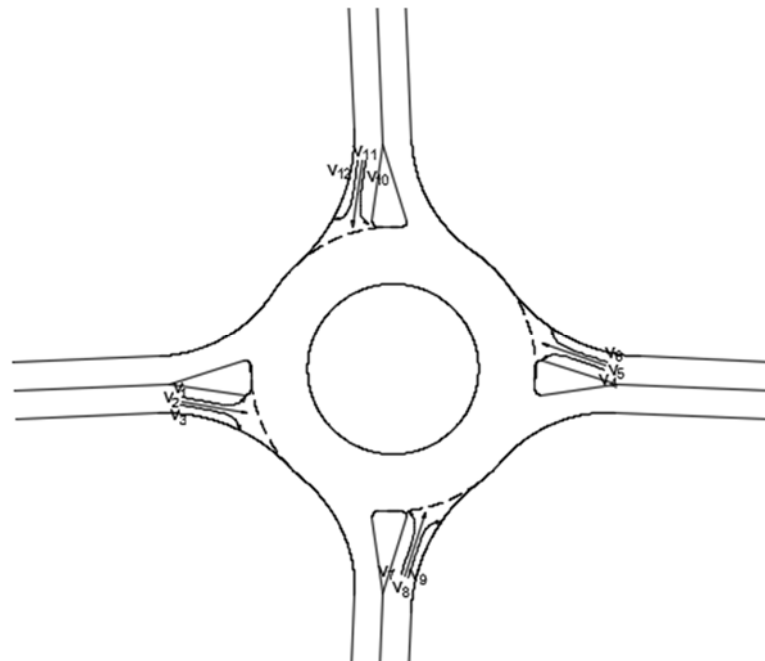


Fig.3.Flow stream definition

Because HCM 2000 only gives solution for roundabout with one circular lane, HCM 2010 methodology for two circular lanes is used in order to compute the capacity and obtain LOS. According to this methodology, the right lane is defined as dominant and the left lane as subdominant lane.

Table 3. Final results for roundabout with two circular lanes

Two - lanes roundabout				
	Blvd. G. Delcev - East	Blvd. G. Delcev - West	Blvd. K. P. Misirkov - North	Blvd. K. P. Misirkov - South
Entry lane capacity (right lane)	425	276	749	1059
Entry lane capacity (left lane)	716	561	500	515
Total capacity	1141	836	1248	1574
v/c	0,69	1,31	1,03	0,82
Control delay	14,89	164,19	52,11	16,68
LOS	B	F	F	C

Since v/c ratio is bigger than 1,0 in two approaches (Blvd. G. Delcev - West and Blvd. K. P. Misirkov - North), the delays are bigger and LOS is lower. For these approaches LOS is "F", while for the approach of Blvd. G. Delcev - East LOS is "B" and of Blvd. K. P. Misirkov - South is "C". This results are expected, considering the fact that approaches with 3 lanes before, and 5 lanes in the intersection area are reduced to two-lane approaches and two-lane circular flow. Another anomaly in this concept is the lack of adjustment factors (only factors for heavy vehicles, pedestrians and bicycles are used). Anyway, utilization of roundabout with more than two lanes is insecure solution, considering the number of conflicting points.

DELEVELED ROUNDABOUT - UNSIGNALIZED INTERSECTION

Since neither of the previously mentioned solutions is acceptable, another possibility is analyzed. By using diamond junction, delays would still remain big, and LOS would be low, so delevelled roundabout is proposed as more acceptable solution. The through movements from the main road are segregated in one level, while all the other movements are lead on another level, with circular flow. The same calculations as in two-lane roundabout is used, just the TH movements from blvd. Goce Delcev are removed.

Deleveled Two - lanes roundabout				
	Blvd. G. Delcev - East	Blvd. G. Delcev - West	Blvd. K. P. Misirkov - North	Blvd. K. P. Misirkov - South
Entry lane capacity (right lane)	425	276	1300	1510
Entry lane capacity (left lane)	716	561	903	753
Total capacity	1141	836	2203	2264
v/c	0,69	1,31	0,19	0,32
Control delay	14,89	164,19	7,02	7,35
LOS	B	F	A	A

From the table is obvious that both approaches of blvd. Krste Petkov Misirkov have acceptable delays and LOS "A", while the approach of Blvd. G. Delcev - East has LOS "B" (which is acceptable) but the approach of Blvd. G. Delcev - West has LOS "F".

This solution is proposed strictly from visual and traffic aspect, with no information for installations, possibility for developing ramps or length of ramps.

CONCLUSION

Each of the proposed solutions has advantages and disadvantages. The solution with signalized intersection has relatively small delay, except for the approach of Blvd. K. P. Misirkov - South. The results are less acceptable for two-lane roundabout, while the deleveled roundabout has similar results as signalized intersection.

If the actual solution is accepted as more favorable, some corrections must be done, so that the problem with low LOS can be solved. One way to solve this problem is by directing the traffic on other existing roads. Also, special lane for public transport vehicles would also help, because buses have big influence in capacity and LOS.

The bad results for both roundabouts can be because of the reduction of lanes in the intersection area. Anyway, this results are based on personal counting of traffic in short period, without previous information in order to obtain traffic increment, so they should be observed with backup.

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