ANALYSIS OF SIGNALISED INTERSECTIONS ACCORDING TO THE HIGHWAY CAPACITY MANUAL FROM THE POINT OF VIEW OF THE PROCESSES APPLIED IN HUNGARY

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SUMMARY

The method described in the presentation discusses the capacity and level of service of the road section entering into the intersection as well es the level of service of the intersection as a whole. The capacity is evaluated based on the ratio of the traffic volume and the capacity (v/c), the level of service is determined based on the delay come from the average stop time of vehicles. Delay is a complex feature, depends on many variables including the progress, cycle time, green time and v/c ratio of the examined lane group. There are more analysis level according to HCM'94 among which ones the primarily applied and for the wanted results indispensable is the traffic analysis. The method described in the presentation gives formulas and tables for all applied factors. The boundaries between ones the methods is valid are given in every case.

Keywords: signalised intersections, traffic operation, HCM

1. INTRODUCTION

During the last years the motorization has been increased significantly and continuously. The developing vehicle technologies have promoted the change of the traffic characteristics and the easier, faster movement, controllablity of vehicles. These effects modify the methodology of geometrical and traffic analysis of intersections as well. For example the gaps and because of it the delays are decreasing. For accurate results the supplementary factors should be taken into account precisely. The traffic operation could be influenced most significantly by signalization. This process leads to the modification of the behavior of the participants of the motorized traffic stream. In this way the headways, the critical gaps of movements, the reaction time are decreasing. To the realization of the advantages of signalized intersections such as decreasing of number of accidents, of the delays of the minor movements and of the harmful environmental effects, more detailed traffic and geometrical data, new analysis processes could be necessary.

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2. METHODOLOGY

The presentation compares two methodologies. One of them is the process of Highway Capacity Manual '95 (HCM) for signalized intersections. The second one is the issue of the Road Technological Regulation used in Hungary with the title 'Design of signalized intersections).

The method of HCM has two analysis levels. This presentation examines the first level, which is the traffic analysis.

2.1 Traffic analysis according to HCM

The purpose of traffic analysis is the determination of capacity and level of services of lane groups or of the intersection as a whole. Detailed data of geometry, traffic condition and signalization of the intersection are recquired. These should be known regarding an existing or a planned intersection. Because the traffic analysiis of signalized intersections are very complex, it is worth to divide it into the following units:

1. *Input unit*: All data necessary to the calculation should be given here. This unit includes the necessary data regarding geometry, traffic volumes, traffic conditions and signalization. These data are the base of the calculations of the following units.

2. *Volume adjustment unit*: The traffic volume is generally determined for the peak hour in vph. This unit converts hourly traffic volumes to 15 minutes flow rates, and takes into account the effect of the lane configuration. Determination of lane groups is made in this unit as well.

3. *Saturation flow unit*: The saturated flow rate is calculated for every lane group. The ideal saturated flow is adjusted by the specific conditions of the intersection.

4. *Capacity analysis unit*: Based on the flow rates and saturated flow rates the capacity and the volume-capacity ratio (v/c) are calculated for the lane groups. The critical v/c is also calculated regarding the intersection as a whole.

5. *Level of service unit*: The delays are estimated regarding each lane groups. The average delays of directions and the intersection as a whole are also calculated. The levels of services are determined based on the delays.

Evaluation of results: The results of traffic analysis determine two key values. The first one is the v/c ratio of each lane groups and of the intersection, the second one the delays and level of services of the lane groups and of the intersection.

Figure 1 shos the diagram of units and the analysis process:

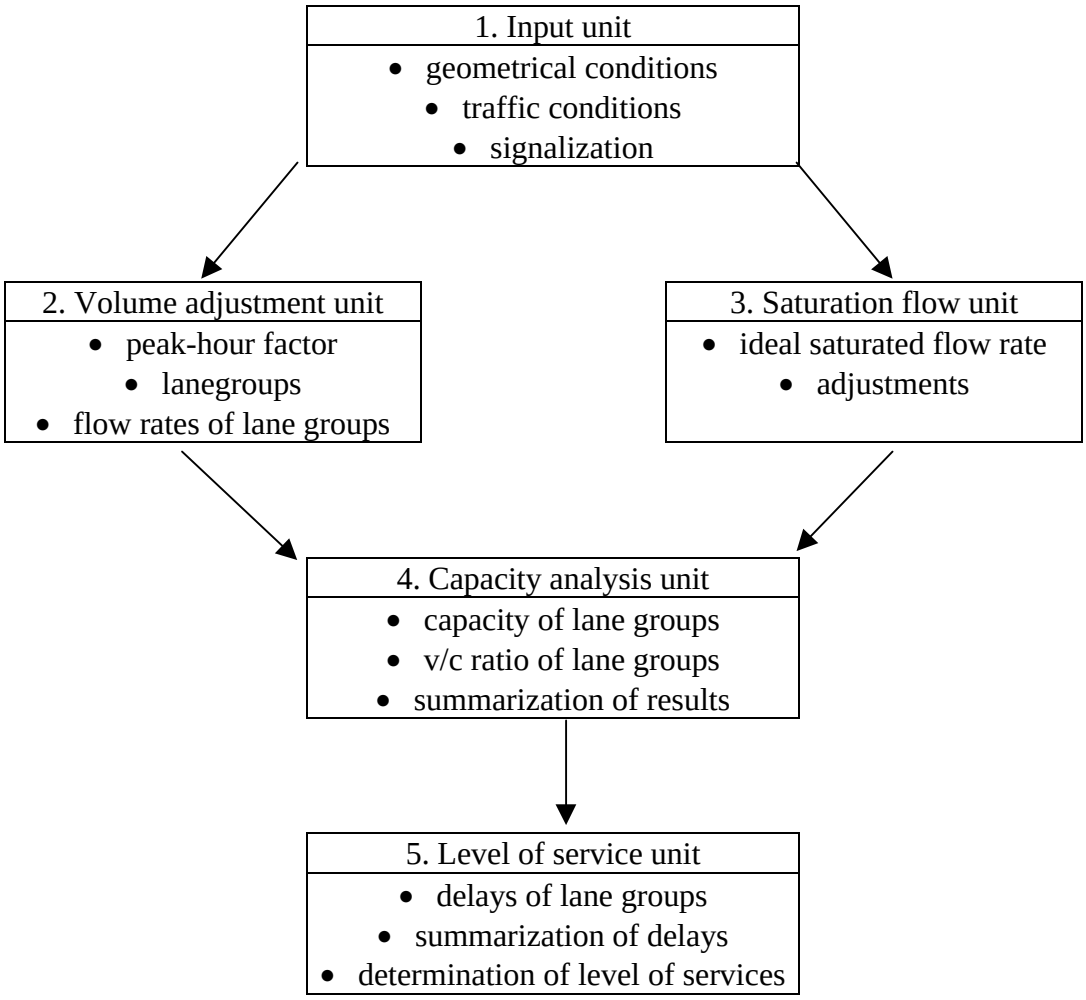


Figure 1. Process diagram of traffic analysis.

2.2 Traffic analysis according to the Hungarian Road Technological Regulation

The purpose of the traffic analysis is the determination of the number and type of recquired lanes as well as the signalization, based on the relevant traffic demands, maintaining optimal quality of traffic operation. The goal is the most effective usage of the available road surface and time, assuring as few phases for the necessary connection as possible.

Process of traffic analysis:

1. Observing traffic streams, determination of traffic volumes.

2. Determination of number of lanes, lane configuration, number of phases and the approximate cycle length.

3. Calculation of lost times, determination of cycle length.

4. Determination of green time of each phase based on the dominant traffic flows.

5. Verifing capacity calculation. The fact if the dominant traffic flow can cross the intersection in each phase, and also the capacity reserve should be checked.

3. COMPARIZATION OF THE TWO METHODS

The intersection showed in Figure 2. is examined. The traffic and geometrical conditions are general. The East-West direction has significant traffic flow, the North-South direction is a one way road northbound. Because one of the directions is one way, that is why there is only one left turning from the two way road.

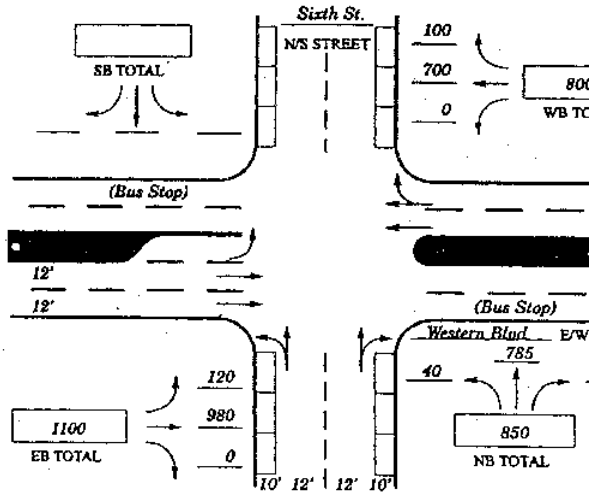
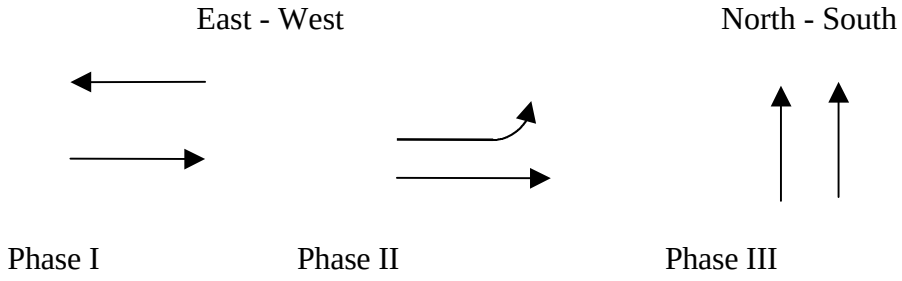


Figure 2. The examined intersection

The calculation and analysis were made paralel with the two methods. In this way conclusions could be made during the processes not only based on the results. In case of the method of HCM the detailed input data such as parking movements, number of buses, lane width, grade, percentage of trucks, location of the intersection, left turning and traffic volumes, influence the analysis. The adjustment factors are taken into account in the Volume adjustment unit. The Hungarian method takes into account less initial data but the values of these data are between wider limits. In these example the percentage of trucks is 5% in the North-South direction, 10% in the East-West direction. The lane width 12 feet (3.65 m), there is no parking movement in the East-West direction, and there is 20 parking movement in an hour northbound. In the East-West direction there is 20 local bus stopping in the area of the intersection in an hour. The grade is 0% eastbound and westbound, 2% northbound. The pedestrian flow crossing right turning movements is 50 pph.

Analysis of HCM emphasizes the left turning movements, distinguishes protected and permitted and its combinations. It has importance at the determination of phase plan. We can choose among six phase orders. In the example only the eastbound vehicles has

separated left turning lane, the northbound vehicles use a shared lane. The applied phase plan could be seen on Figure 3. The non-existing movements have zero traffic volume (3rd phase).



3.Figure. Phase plan

The HCM and the Hungarian method have similar phase plans, although it differs from the basic phase orders used in Hungary. Because the westbound stream belongs to two phases, its volume is divided between the phases, it is not dominant, so during the calculation the volumes of the two other streams should be used.

And there are differencies in the process of calculation as well. The Hungarian method determines the v/c ratio of relevant movements, the lost times based on the intersection geometry, which lost time could be calculated from the entering and leaving time and from the change interval (3 s vagy 5 s). From this data the minimal and the applied cycle length and the green time of the phases could be calculated. The cycle length is 75 s. The length of green times are shown in Table 1.

Phase	Green time of Phases (sec)	
	HCM	MSZ
I..	24.7 s	25 s
II.	7.6 s	8 s
III.	28.7 s	25 s

Table 1. Green time of phases according to the two methods.

The method of HCM determines the critical v/c ratio after calculating the critical traffic demands and gives the lost times of phases based on the chosen phase order, which lost times could be 0 or 3 s. The cycle length will be 70 s (because the v/c ratio is low). In other cases the process of determination of cycle length follows the same principles in both methods. The green times of phases are almost the same in the two methods, only the green time of the northbound traffic stream differs with 4 s. Its reason is the difference in the determination of lost times. The Hungarian method recquires more detailed calculation for the determination of lost times, which calculation results higher values. It could be explained by the motorization of vehicles and safety reasons. The cycle length is increased together with the lost times, which means 5 s in this example. The adjustment of left turning movements is important part of the HCM method. There

is a separate unit for this adjustment. It should be taken into account at the calculation of saturated traffic flow, its maximal value could be 1.00.

The following part is the capacity analysis, which is involved by both methods, and the determination of the level of services, which is included only by HCM. These units give result regarding v/c ratio of lane groups, delays and level of service of the intersection. In the capacity analysis unit the data from the previous units are summarized for calculating the capacityand v/c ratio of lane groups and for determining the critical lane groups. In this case the calculation of delays is simple, every critical lane groups adds 3 s to the delay, which means 9 s. The critical v/c ratio of the intersection as a whole is 0.733.

Movement / lane group	Adjusted traffic volume (vph)	Capacity of lane group (vph)	v/c ratio of lane group
Nbound / LTR	939	1331	0.706
Sbound	-	-	-
Ebound / L	126	178	0.707
/ T	1084	1672	0.648
Wbound / TR	884	1145	0.772

Table 2. Capacity of lane groups according to the HCM.

The v/c ratio is acceptable in each lane groups. The low v/c ratio of the eastbound left turning laneshows that the joint application of the permitted and protected phase is not necessary. The low value of the critical v/c ratio shows that shorter cycle length would be adequate as well, however the minimal green times should be taken into account. The Hungarian method gives similar results. The reserve capacity is high, the delay is 17 s, the total green time is 58 s. The v/c ratio of the left turning movement of westbound direction is low, 0.719.

Number of phases	volume of one lane (pcph)		v/c	Reserve capacity (%)
	actual	maximal		
I.	460	600	0.766	23
II.	138	192	0.719	28
III.	457	600	0.762	24

Table 3. Capacity of phases according to the Hungarian method.

Only the HCM determines the level of services. The method estimates the average stopping delay of vehicles, and calculates the average value for the legs and for the intersection as a whole. During the calculation the delays of the legs determine the delay of the intersection, which is 26.5 s. The level of service criteria based ont he delays, according to Table 4.

Level of service	Stopping delay per vehicle (sec)
A	≤ 5,0
B	5,0 < ≤15,0
C	15,0 < ≤ 25,0
D	25,0 < ≤ 40,0
E	40,0 < ≤ 60,0
F	60,0 <

Table 4. Level of service criteria of signalized intersections.

The level of service of the intersection is D. Disturbances in the traffic stream could occur but these remains in the acceptable level.

The main differences of the method have appeared in the results. The following table summarizes the characteristic results of the calculations.

	HCM-94	MSZ
Total green time	61 s	58 s
Cycle length	70 s	75 s
Lost time	9 s	17 s
Delay of intersection	26.5 s	

Table 5. Comparization of results.

4. CONCLUSIONS

The change of characteristics and features of the Hungarian traffic operation, the disappearance of old fashioned vehicles and the high percentage of trucks make necessary the development of traffic analysis methods taking into account the local conditions. The application of process of other countries can not made without analysis. But it is useful and necessary to pay attention to the processes applied in different countries.

5. REFERENCES

Road Technological Regulation, ÚT 1-1.204, 1. Chapter (1995), "Design, implementation and operation of signalized intersections".
Washington DC (1994), *Highway Capacity Manual*, Special Report 209.