Volume-to-Capacity Estimation of Signalized Road Networks for Metropolitan Transportation Planning

Hao Xu (Corresponding Author)
Research Associate
Department of Civil & Environmental Engineering
Texas Tech University
Lubbock, TX 79409-1023
Phone: (806) 786-0934
E-mail: hao.xu@ttu.edu

Hongchao Liu
Associate Professor
Department of Civil & Environmental Engineering
Texas Tech University
Lubbock, TX 79409-1023
Phone: (806) 742-3523 Ext. 229
E-mail: Hongchao.Liu@ttu.edu

Hiron Fernando
Research Assistant
Department of Civil & Environmental Engineering
Texas Tech University
Lubbock, TX 79409-1023
Phone: (817) 681-4330
E-mail: hiron.fernando@ttu.edu

Sanjaya Senadheera
Associate Professor and Director, TechMRT
Department of Civil & Environmental Engineering
Texas Tech University
Lubbock, TX 79409-1023
Phone: (806) 742-3037 Ext. 227
E-mail: sanjaya.senadheera@ttu.edu

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ABSTRACT

Transportation planning has been playing a critical role in shaping the economic health and quality of life. It not only provides insight into the mobility of people and goods, but also influences patterns of growth and economic activity. Metropolitan transportation planning is a challenging transportation topic due to the lack of future traffic information, such as evaluation of the capacity sufficiency on large metropolitan road networks with signalized intersections. The Highway Capacity Manual provides methods for analysis of signalized intersections and urban streets for planning; however, these methods need detailed traffic volume inputs and lane configurations at signalized intersections, which are normally not readily available in metropolitan transportation planning. The conventional four step planning process is widely used to forecast directional traffic volumes on road segments, but the projected volumes are not enough for analyzing capacity sufficiency of future road networks by existing methods. This paper discusses the proposed method developed by integration of available transportation planning data and characteristics of signalized intersections. It links traffic assignment results of the conventional transportation planning procedure to capacity sufficiency estimation. By using the proposed method, transportation planners can estimate capacity sufficiency of future metropolitan road networks through use of readily available data in transportation planning. This method will dramatically decrease the effort required for capacity evaluation of large signalized metropolitan road networks.

Keywords: volume-to-capacity ratio, metropolitan transportation planning, signalized intersection, signalized road network
1. INTRODUCTION

Metropolitan transportation planning (1) is defined by FHWA as the process of examining travel and transportation issues and needs in the metropolitan areas. Government officials, transportation planners, transportation engineers and researchers are increasingly putting more effort to metropolitan transportation planning, which not only provides insight into the mobility of people and goods, but also influences patterns of growth and economic activity.(2) Metropolitan transportation planning is important to the development of all metropolitan areas; however, it is an especially challenging area due to the lack of future traffic information, such as evaluating the capacity sufficiency on large metropolitan road networks.

Throughout this paper, the use of the Highway Capacity Manual (HCM) is discussed, all references to this book is from HCM 2000.

FHWA suggested a cooperative transportation planning process for the Metropolitan Planning Organization (MPO), state Department of Transportation (state DOT) and transit operators (2). The suggested process includes a number of steps:

1. Monitoring existing conditions
2. Forecasting future population and employment growth, including assessing projected land uses in the region and identifying major growth corridors
3. Identifying current and projected transportation problems and needs, and various transportation improvement strategies to address those needs, through detailed planning studies
4. Developing long-range plans and short-range programs of alternative capital improvement and operational strategies for moving people and goods
5. Estimating the impact of recommended future improvements to the transportation system on environmental features, including air quality
6. Developing a financial plan for securing sufficient revenue to cover the costs of implementation of these strategies

Both steps 3 and 4 require comprehensive analysis of transportation capacity sufficiency of metropolitan road networks, for which volume-to-capacity ratio (v/c ratio) is often the efficient description. (3) When there is no detailed traffic information of the future transportation system, v/c ratio can also be used to estimate Level of Service (LOS) of a road network. The widely used four-step planning procedure (4) (5), including trip generation, trip distribution, model selection and traffic assignment, estimates future directional traffic volumes on each road segment of a network. Projected future traffic volumes or traffic growth rates on roads can give a very basic understanding of how the future traffic will be changed, but not enough for evaluating the future capacity sufficiency of a road network or determining the possible bottle-necks and problem points.

v/c ratio estimation for freeways is an intuitive and simple process. v/c ratios can be calculated by dividing current or projected future traffic volumes by freeway saturation flows, which are considered as capacity of freeways. Freeway saturation flows can be estimated by using freeway geometric designs (lane number, lane width, etc.) and other parameters (3). However, a metropolitan road network includes a lot of signalized intersections, where road v/c ratios cannot be estimated by the approach for freeways. Capacities of road segments connected to signalized intersections are decided by not only road geometric designs, but also intersection signal timing. Chapter 10 of HCM (3) introduces a methodology for analyzing signalized
intersections, which is based on known or projected signalization plans at intersections. The method is used to estimate the critical v/c ratio, control delay and LOS of an intersection. A general signal timing estimation method is included for estimating a feasible signal timing plan of an intersection. It is noted that the estimated signal timing plan is not necessarily the optimal timing plan, but the method is widely used by traffic engineers and signal timing software.

The timing plan estimation procedure includes five major steps:

1. Phasing plan development
2. Computation of critical sum
3. Estimation of total lost time
4. Cycle length estimation
5. Effective green time estimation

The intersection critical v/c ratio is calculated with outputs of the above process. The critical v/c ratio is an approximate indicator of the overall adequacy of the intersection geometry. It is often used to evaluate the intersection for quick estimation purposes during planning. For signalized intersection planning, Exhibit A10-9 of HCM expresses the intersection status as over, at, near, or under capacity. With the input of traffic volumes, saturation flows and signal timing cycle length, the v/c ratios of roads connected to the intersection can also be estimated by using the signal timing estimation process. However, one problem with the method is that the required input parameters are often lacking in transportation planning, especially for large metropolitan road networks. The v/c ratio analysis method for signalized intersections is detailed. It is efficient for analysis of intersections when knowing traffic volumes of all movements and lane configurations. However, the method is not appropriate for capacity sufficiency analysis in metropolitan transportation planning if large signalized road networks are involved. The required detailed inputs are often not readily available.

A method for urban street analysis is documented in Chapter 15 of HCM. The objective of an urban street analysis at a planning level is to estimate the operating conditions of the facility. The urban street analysis method is based on the signal timing estimation procedure in Chapter 10 of HCM. A major difference between the planning analysis of signalized intersections and that of urban streets is the treatment of turning vehicles. Since the analysis of an urban street emphasizes through movement, the simplifying assumption is that left turns are accommodated by left-turn bays at major intersections and by controls of a properly timed separate phase. As a result, many of the inputs and complexities of intersection analyses can be simplified by using default values. However, Chapter 15 of HCM does not provide any detailed description on how to simplify the signal timing estimation procedure by only considering the through movement. It does not introduce the possible impact of left-turn traffic on the accuracy of the analysis results either.

In this study, a simplified v/c ratio estimation procedure was developed for evaluating capacity sufficiency of signalized road networks with available information in metropolitan transportation planning. The v/c ratio estimation procedure considers characteristics of signalized intersections and availability of planning data. A few assumptions on signal time phasing were proposed and used. The basic idea of the method is to estimate signal timing of signalized intersections, using viable assumptions and readily available data in transportation planning. Then, estimation of the capacity of each road segment using green-to-cycle ratios (g/C ratio) and saturation traffic flows is computed, which finally yields the v/c ratio of each road segment by
calculating the projected future traffic flow and the estimated capacity. The proposed method was validated by analysis of selected intersections and roads.

2. AVAILABILITY OF TRANSPORTATION PLANNING DATA AND ASSUMPTIONS FOR V/C RATIO ESTIMATION

The proposed v/c ratio estimation procedure considers signal timing principles and the data available in transportation planning. The required inputs only include directional road saturation flow, which can be estimated with roadway geometric designs (lane number, lane width, etc.), and projected directional traffic flow on each road segment, which is normally a result of the traditional transportation planning process. The HCM method needs traffic volumes of all movements and lane configurations at intersections. Transportation planners’ estimation of appropriate phasing plans at each intersection is also required. The phasing plan estimation for each intersection of a large road network is impractical for transportation planners. The required inputs of the proposed method are far less, and are readily available to transportation planners.

To generalize the road v/c ratio estimation procedure for common metropolitan transportation planning, the normally available traffic and road network data are listed below:

1. Directional traffic flow volumes of road segments, without detailed turning movement volumes at intersections
2. Lane numbers of each road segment, without lane configurations at intersections
3. Area type of each road segment
4. Facility type of each road segment

The following assumptions are sequentially given for the signal phasing of each signalized intersection:

Assumption 1: Protective left turn movements are assumed to be leading, as shown in the Assumption 1 of Figure 1.

In signal timing design, the order of phases does not impact the green time designated to a movement. The leading or lagging position of a protective left turn does not change the estimated green time, so the leading protective left turn movement can be assumed without impact on the calculated g/C ratio and v/c ratio. This assumption turns the signal timing plan of each signalized intersection to the general NEMA phase sequence (6).

Assumption 2: A pair of left turn movements in opposite directions are assumed to be only in the same phase, which means the two left turn movements are assumed to have the same green time, as shown in the Assumption 2 of Figure 1.

Since turning movements, traffic volumes and intersection lane configuration details at intersections may be lacking in metropolitan transportation planning, green time of protective left turn movements cannot be accurately calculated. Based on Assumption 1, the Assumption 2 can simplify the signal timing estimation for planning. This assumption may cause the estimated green time for through movements be shorter and bring higher estimated v/c ratios for through movements. However, after applying the assumption 3, the total green time assigned to this road direction, including green for through movement and green for left movement, will be fairly decided by the v/s ratio of this road direction.

Assumption 3: The left turn phases are assumed to be combined with through movement phases in two opposite directions, as Assumption 3 in Figure 1.
This assumption is for the v/c ratio estimation when there are no left-turn traffic volumes. The assumption is based on the fact that both the left-turn and through phases are used for discharging the traffic on upstream road segments. Since the left turn movement flow rate is normally lower than through movement, this assumption may overestimate capacities of related road segments when the saturation flow of through movement is used. However, when there is no detailed information of the left-turn movement traffic, it is still a reasonable assumption to give an approximate estimation of the v/c ratios.

Based on the three signal phasing assumptions listed above, the signal phasing of an intersection is approximately estimated as a two-phase plan (Assumption 3 of Figure 1).

3. METHODOLOGY OF THE V/C RATIO ESTIMATION PROCEDURE

Signal timing is normally determined by two major elements of traffic movements: the traffic demand (flow rate) and the saturation traffic flow. To estimate v/c ratios of a signalized road network, planners first need to estimate signal timing of each signalized intersection, and then determine road capacities by using g/C ratios and the saturation traffic flows. Finally, the v/c ratios with directional traffic flows and estimated capacities are calculated. The signal timing estimation method used in the proposed procedure is based on the equalizing v/s ratio method, as documented in Chapter 10 of HCM.

The v/c ratio estimation procedure includes the following steps:
1. Determine the critical movement of the two phases (Assumption 3 Figure 1)
2. Determine the cycle length
3. Calculate the green time estimation for each phase
4. Calculate the capacity for each movement
5. Estimate the v/c ratios for each movement

The detailed description of each step is as follows:

Step 1: Determine critical movement of each phase
With the three sequential signal phasing design assumptions, movements of each phase are known (through movements of two opposite directions); v/s ratio of each movement is calculated by using the projected directional traffic volume and also the estimated saturation flow of road segments. The movement with higher v/s ratio in a phase is the critical movement.

Step 2: Determine the cycle length
The proposed procedure uses the method in Chapter 10 of HCM for determining the cycle length of the two-phase signal timing, shown as Equation (1) in this document. If a fixed cycle length is required for signal coordination in a metropolitan area, that value should be used.

\[
C = \frac{L}{1 - \frac{\min(CS, RS)}{RS}}
\]

where
\[
C = \text{cycle length (s)}
\]
\[
L = \text{total lost time (s)}
\]
\[
RS = \text{reference sum flow rate 1530*PHF*fa (veh/h)}
\]
\[
CS = \text{critical sum (veh/h)}
\]
The default values of 3 seconds yellow time and 1-second all-red time from HCM are used for each phase. Thus the L of the two-phase signal timing is 8 seconds.

Figure 1: Phase design assumptions for road v/c ratio estimation
RS is the reference sum of phase flow rates representing the theoretical maximum that the intersection could accommodate at an infinite cycle length. The recommended value for the reference sum, RS, is computed as an adjusted saturation flow rate. The value of 1530 is about 90 percent of the base saturation flow rate of 1700/pc/h/ln. The objective is to produce a 90 percent v/c ratio for all critical movements. Finally, the CS volume is the sum of the critical phase volume for each street. (3)

The cycle length determined by this equation should be checked against reasonable minimum (long enough to serve pedestrians, use 60s if local data are not available) and maximum (such as 150s) values, which could be set by transportation planners.

**Step 3: Green time estimation**

The method for estimating effective green time can also be found in Chapter 10 of HCM. The total cycle time is divided among the conflicting phases in the phase plan on the basis of the principle of equalizing the degree of saturation for the critical movements. The lost time per cycle is subtracted from the total cycle time to determine the effective green time per cycle. This is based on the proportion of the critical phase flow rate sum for each phase determined in a previous step.

The effective green time for each phase can be computed using Equation (2).

\[
g = \left[ (C - L) \left( \frac{CV}{CS} \right) \right]
\]

where

\( g \) = effective green time (s)
\( C \) = cycle length (s)
\( L \) = total lost time (s)
\( CV \) = critical phase flow rate (veh/h)
\( CS \) = critical sum (veh/h)

This method of estimating green time will not necessarily minimize the overall delay at the intersection, but is a commonly used by traffic engineers.

**Step 4: Calculate capacity of each road direction**

The practical capacity of each road direction to the intersection can then be estimated by its saturation flow, effective green time and cycle length, as Equation (3). For a two-way road segment, its directional capacity is decided by the downstream intersection.

\[
c_i = \frac{S_l g_i}{C}
\]

where

\( c_i \) = practical capacity of the direction to the intersection of the \( l \)th road segment (veh/h),
\( S_l \) = saturation traffic flow of the direction to the intersection of the \( l \)th road segment (veh/h),
\( g_i \) = effective green time of the direction to the intersection of the \( l \)th road segment (s),
\( C \) = cycle length (s).
Step 5: Estimate v/c ratios for each road direction

The directional v/c ratios of roads are estimated with projected traffic flows and directional road capacities by equation (4).

\[
\left( \frac{v}{c} \right)_l = \frac{v_l}{c_l} 
\]  

(4)

where

\[
\left( \frac{v}{c} \right)_l = \text{v/c ratio of the direction to the intersection of the } l\text{th road segment (veh/h)}, 
\]

\[
v_l = \text{projected future traffic flow of the direction to the intersection of the } l\text{th road segment (veh/h)}, 
\]

\[
c_l = \text{practical capacity of the direction to the intersection of the } l\text{th road segment (veh/h)}. 
\]

The traffic volume data from transportation planning are normally directional Annual Average Daily Traffic Volume (AADT). The peak hour traffic flow, \(v_l\), can be estimated by equation (5).

\[
K \cdot AADT = \frac{v_l}{c_l} 
\]  

(5)

where

\[
K = \text{proportion of daily traffic occurring in peak hour (decimal).} 
\]

\(K\) is between 0.07 and 0.12 for urban areas, when 0.1 is normally used as the default value (7).

The whole procedure for estimating road v/c ratios of signalized road networks is demonstrated by the flow chart in Figure 2.

4. TEST OF THE PROPOSED METHOD

To validate the effect of the proposed method, estimation of v/c ratios of 16 directional road segments connected to four signalized intersections were conducted. The results were then compared to the v/c ratios calculated by the signalized intersection analysis method of HCM.

Four actual intersections in the city of Lubbock, Texas were selected for validating the proposed method. Two of them were operated by signal timing plans with protected left-turn movement (as shown by Figure 3-a), and the other two were operated with only permitted left turn movements (as shown by Figure 3-b).

The four intersections’ v/c ratios were estimated by both the signalized intersection analysis method of HCM and also the newly developed procedure.

During the calculation, some default parameters were obtained from HCM and applied for both methods, as listed below:

- Minimum Green Time - 60 seconds
- Maximum Green Time - 150 seconds
- Lost Time per Phase - 4 seconds (3s yellow time plus 1s all red time)
- Saturation flow rate – 1530 veh/h/ln
Step 1 - Decide critical movement of each phase

Step 2 - Decide cycle lengths
\[
C = \frac{L}{1 - \frac{\min(CS, RS)}{RS}}
\]

Step 3 - Green time estimation
\[
g = \left(1 - \frac{L}{C}ight) \frac{CV}{CS}
\]

Step 4 - Calculate capacity of each movement
\[
c_i = S_i \frac{g_i}{C}
\]

Step 5 - Estimate v/c ratios for each movement
\[
\frac{v}{c_i} = \frac{v_i}{c_i}
\]
\[
v_i = AADT \cdot K
\]

Figure 2: Flow chart of the proposed procedure for estimating road v/c ratio
Figure 3: Selected intersections and road segments for validating the proposed procedure
Input parameters for the two methods are listed and compared in Table 1.

<table>
<thead>
<tr>
<th>Table 1: Required Inputs for the HCM Method and the Proposed Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Parameters</td>
</tr>
<tr>
<td>HCM Method</td>
</tr>
<tr>
<td>Proposed Method</td>
</tr>
</tbody>
</table>

The calculated results when using the HCM method are listed in Table 2. When using the HCM method, transportation planners first need to analyze the left-turn traffic volumes and estimate the phasing plan according to EXHIBIT A10-8 (PHASE PLAN SUMMARY FOR QUICK ESTIMATION METHOD) of HCM. The estimated phase sequence of the intersection of Indiana Ave. and 50th street was the phase plan 3b in EXHIBIT A10-8, (as shown in Table 2). Then the detailed traffic volumes and lane configurations were used to calculate the cycle length (maximum length was used at the intersections of Indiana Ave. & 50th Street and Memphis Avenue & 50th Street) and green time for each phase. Finally the v/c ratio of each movement was calculated. The directional traffic volumes were then compared with the total capacity of the left-turn movement and through movement to calculate v/c ratios of the directional road segment.

The calculated results when using the proposed method are listed in Table 3. The calculation procedure using the proposed method was very similar to the procedure using the HCM method. The major difference is that the proposed method does not need transportation planners to estimate an appropriate phasing plan, but directly use the two phase design based on the assumptions introduced in the second part of this paper. The traffic volumes used by the proposed method were the directional traffic flows on road segments.

To validate the proposed method under different traffic demands, different groups of traffic volumes were used for selected intersections and road segments. The traffic volumes in Table 2 were the basic volumes, which were counted in the field. A group of growth rates were applied to the basic volumes to generate volumes for different traffic demands. For critical approaches, the results by the proposed method were lower than the results by the HCM method. It is caused by the assumption we used for the estimation, as documented in the second part of the paper.

To test the impact of extreme traffic demands to the accuracy of the proposed method, the authors tested the method by using different percentages of left turn traffic volume when the total volumes of left-turn and through were the same. The northbound approach of the intersection of Indiana Avenue and 50th Street was selected for the test.

The v/c ratios under different traffic demands were estimated by the HCM method and the proposed method. Results were demonstrated and compared graphically and numerically in Figures 4 – 7. It can be found that the v/c ratios, especially ratios of critical approaches (the one with the highest v/c ratio in the four approaches to an intersection), calculated by the proposed method are close to the ratios calculated by the HCM method, while the proposed method requires less inputs than the HCM method. The difference of non-critical approaches may be higher, but these non-critical approaches are not as important as the critical approaches to capacity evaluation in transportation planning.

As discussed in the second section of this paper, the left-turn traffic may impact the accuracy of the proposed method. The estimation results and related left-turn percentages are shown in Figure 8, in which there is much variation in the data. Figure 9 shows the difference of
the proposed method from HCM method by percentages. When the northbound left-turn percentage is lower than 30%, the southbound left-turn and northbound through are critical movements. With the northbound left-turn traffic percentage increasing, the northbound through traffic volume decreases and the green time of the northbound through traffic is consequently reduced. Therefore the northbound v/c ratio calculated by the HCM method gets larger, but the v/c ratio calculated by the proposed method keeps fixed. The other directions get more green time, so their v/c ratios by the HCM method turn to be lower. When the northbound left-turn percentage is higher than 30%, the northbound left-turn and northbound through are critical movements. As the northbound left-turn traffic increasing, more green time is allocated to the northbound left-turn movement from other directions, so the northbound v/c ratio becomes lower and v/c ratios of other directions turn to be higher.

Table 2: The Calculated Results When Using the HCM Method

<table>
<thead>
<tr>
<th>Phase</th>
<th>No.</th>
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<th>No.</th>
<th>2 Phase</th>
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<td>46</td>
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<td>Saturation Flow, s (veh/h)       0.1496732</td>
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<td>Volume, V (veh/h)</td>
<td>253</td>
<td>1442</td>
<td>135</td>
<td>1095</td>
</tr>
<tr>
<td>Green time, g (s)</td>
<td>13.1880187</td>
<td>50.111</td>
<td>16.41965351</td>
<td>33.342834</td>
</tr>
<tr>
<td>Lane number, n</td>
<td>3060</td>
<td>3060</td>
<td>4590</td>
<td>3060</td>
</tr>
<tr>
<td>Saturation flow, s (veh/h)</td>
<td>0.08267974</td>
<td>0.31416122</td>
<td>0.1496732</td>
<td>0.020261438</td>
</tr>
<tr>
<td>g/C</td>
<td>0.840087146</td>
<td>0.102941176</td>
<td>0.238562099</td>
<td>0.31416122</td>
</tr>
<tr>
<td>Capacity, c (veh/h)</td>
<td>269.035881</td>
<td>1533.396</td>
<td>334.965249</td>
<td>1632.291</td>
</tr>
<tr>
<td>v/c</td>
<td>0.940396059</td>
<td>0.940396059</td>
<td>0.940396059</td>
<td>0.940396059</td>
</tr>
</tbody>
</table>
Table 3: The Calculated Results When Using The Proposed Method

| Phase No. | EBWB | Critical phase volume, CV (veh/h) | 2015 | Lost time/phase, t. (s) | 4 | Lane Number, n | 3 | Saturation Flow, s (veh/h) | 4590 | v/s | 0.42895782 |
|---|---|---|---|---|---|---|---|---|---|---|
| North-South Phasing Plan | | | | | | | | | | |
| Selected plan (Exhibit A 10-8) | Phase No. 1 | | | | | | | | | |
| Movement codes | NBSB | | | | | | | | | |
| Critical phase volume, CV (veh/h) | 1906 | | | | | | | | | |
| Lost time/phase, t. (s) | | | | | | | | | | |
| Lane Number, n | 3 | | | | | | | | | |
| Saturation Flow, s (veh/h) | 4590 | | | | | | | | | |
| v/s | 0.41525054 | | | | | | | | | |

Green Time Calculation

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<tr>
<th>Cycle length</th>
<th>Minimum, Cmin</th>
<th>60</th>
<th>Maximum, Cmax</th>
<th>150</th>
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<td>East-West Phasing</td>
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<td>Phase No. 1</td>
<td>Phase No. 2</td>
<td>Phase No. 3</td>
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<td></td>
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<tr>
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<td>72.9737312</td>
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<td>0</td>
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<tr>
<td>North-South Phasing</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Phase No. 1</td>
<td>Phase No. 2</td>
<td>Phase No. 3</td>
<td></td>
<td></td>
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<tr>
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<td>69.0262688</td>
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</table>

Volume and Signal Input

<table>
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<th>Volume, V (veh/h)</th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
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<tbody>
<tr>
<td>2015</td>
<td>1638</td>
<td>1902</td>
<td>1902</td>
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<tr>
<td>Green time, g (s)</td>
<td>72.97373119</td>
<td>72.97373119</td>
<td>69.02626881</td>
<td>69.02626881</td>
</tr>
<tr>
<td>Lane number, n</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Saturation Flow, s (veh/h)</td>
<td>4590</td>
<td>4590</td>
<td>4590</td>
<td>4590</td>
</tr>
<tr>
<td>v/s</td>
<td>0.43899782</td>
<td>0.35686274</td>
<td>0.41002175</td>
<td>0.41525054</td>
</tr>
<tr>
<td>g/C</td>
<td>0.486491541</td>
<td>0.486491541</td>
<td>0.486491541</td>
<td>0.486491541</td>
</tr>
<tr>
<td>Capacity, c (veh/h)</td>
<td>2232.996174</td>
<td>2232.996174</td>
<td>2112.203826</td>
<td>2112.203826</td>
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<tr>
<td>v/c</td>
<td>0.907275039</td>
<td>0.713543576</td>
<td>0.891012495</td>
<td>0.902775039</td>
</tr>
</tbody>
</table>
Figure 4: v/c ratio estimation results at the intersection of Indiana Avenue and 50th Street

Figure 5: v/c ratio estimation results at the intersection of Memphis Avenue and 50th Street
Figure 6: v/c ratio estimation results at the intersection of Avenue Q and 10th Street

Figure 7: v/c ratio estimation results at the intersection of Avenue Q and Main Street
Figure 8: Difference of estimated v/c ratios with different left-turn traffic percentages

Figure 8: Difference percentage of estimated v/c ratios with different left-turn traffic percentages
5. CONCLUSION

In this study, a v/c ratio estimation procedure for signalized road networks was developed to evaluate road network capacity with only available information in transportation planning procedure. The proposed procedure considers characteristics of signalized intersections and availability of planning data.

Through the analysis it was found that the proposed model works ideally at intersections with left-turn traffic percentage lower than 60%. The main reason for the difference in HCM to proposed v/c ratios is the use of the simple two–phase assumption and the left turn ratio. The fact of the matter is that the HCM method uses more inputs and the exact signal phasing information; therefore inherently yielding a greater accuracy. The experimental results proved that the proposed method could provide reasonable v/c estimation for evaluating capacity sufficiency of signalized road networks with available data of transportation planning.

By using the proposed method, transportation planners can estimate capacity sufficiency of future metropolitan road networks with the basic geometric design information in planning and the forecasted traffic volumes from the traditional transportation planning procedure. When the estimated future v/c ratio results show some road segments have high v/c ratios (larger than 1), detailed signalized intersection analysis can be applied to them for more accurate analysis. Transportation planners only need detailed traffic volumes, lane configurations and signal phasing estimation at very limited intersections and road segments. Therefore, the proposed method will dramatically decrease the required effort for capacity evaluation of a large metropolitan road network.

The proposed method can be considered when a quick capacity analysis is needed on a signalized road network, especially when very detailed data does not exist for the roadway segment.

In future research, the proposed procedure will be considered for being used in the traffic assignment procedure of the traditional four-step transportation planning to improve the traffic assignment accuracy on a signalized road network.

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REFERENCES


