PERFORMANCE EVALUATION OF A ROUNDABOUT CAPACITY, CASE STUDY TIRANA CITY, ALBANIA

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ABSTRACT

Nowadays all the developing cities are having lots of traffic problems with increasing rate of vehicles in today’s scenario. All traffic problems are due to private vehicles running in the city, increasing rates of vehicles, which usually require larger space for movement with safety, having enough capacity of roundabout. For this reason the capacity evaluation needs to be re-performed on a roundabout for easy operation of traffic. [1] The results showed that currently the analyzed roundabout is experiencing delays up to 610 seconds per vehicle during peak hour. This paper aims to give an evaluation of the performance of an existing multi-lane roundabout in Tirana city of Albania. Basing upon these controls, finally the proposals will come through the recommendations made for its improvement in performance, in terms of level of service and average delay, to suggest the alternatives or modifications, if required.

KEYWORDS: Evaluation; Traffic; Roundabout; Rate, Performance; Capacity; Safety;

INTRODUCTION

The streets represent a key component and vital artery for the city and an important timekeeper compass for the movement of population in the city. The fact that the streets have an important role in people's lives, and because the car is the most prevalent means of movement in Albania, must be taken care of and also have efficient designs taking into account the traffic problems. One of the best methods to facilitate the movement of traffic at uncontrolled intersections is roundabouts. Frequently, the presence of the roundabout is inevitable, because of its advantages such as, reduced delays, improved traffic flow and safety, less conflicts and economy. Population in Tirana city of Albania is increasing tremendously and this is leading to traffic problem as, the all people nowadays have started purchasing their own vehicles. This has led the city to be congested on roads and on intersections. The modes of transportation in the city are two wheelers and cars. Due to this much of modes, when they pass through the roundabout, need enough capacity of roundabout
for ensuring pedestrian safety.[2]

The problem of increasing traffic volume is that the absorptive capacity of the roads is not able to accommodate the traffic flow at peak hours resulting in traffic congestion. The increasing traffic volumes are posing operational difficulties for peak hour operations, which need to be addressed. This study aims to carry out an assessment of the performance of the existing roundabout during peak hours using Degree of Saturation, average delays and queue lengths and suggest solution in accordance with the engineering design and site conditions.

METHODOLOGY

After selection of a case study roundabout, first step was to collect geometric data and traffic data for peak hours. In this case study has been used the O/D (Origin/Destination) method for the four arms of the roundabout. Basing upon this matrix O/D, have been calculated the capacities (Q) in four points. This capacity comprises the circulating and incoming traffic flow. [8] In the second step, the collected data was analyzed to determine peak traffic flows and gap acceptance parameters (critical gap and follow up headway), and in third step, calculation has been done basing upon HCM (Highway Capacity Manual) to study the traffic operations at the roundabout. [5] The traffic measurements have been done in peak hours of morning at 08:00 a.m. to 09:0 a.m. and afternoon at 16:00 to 17.00 p.m., for data collection of traffic flows on roundabout lanes.

Data Collection and Analyses, Roundabout selection

“Shqiponja” roundabout in Tirana region is infested with congestion, especially at peak hours, because it connects four developing areas into entrance and exit from Tirana to Durres Cities, and two other directions inside Tirana city. Due to this, this roundabout has become a point of high traffic congestion and this problem has been observed increasing rapidly, during the last year.

It has four legs with two entries, exit and circulating lanes in each direction, entry and exit lanes separated by medians, right angled to each other. The roundabout has central island diameter of 58 m, with two circulating lanes of 4.5 m width. The average entry and exit lane width is 4.25 m and 3.8 m respectively. All approaches, except south, have a dedicated right turn lane.[7]
Extraction of Data Selection

Geometric design data contains measurements of the dimensions of the roundabout. The geometric data for roundabout includes details of circulating lanes, approach and exit lanes. The traffic data, only for peak period, was collected using video recording technique for a typical weekday, followed by manual extraction of turning movements and gap acceptance parameters from this video.[3]

The roundabout typically had two distinct peak periods, on a typical weekday; morning peak (between 8 a.m. to 9 a.m.) and evening peak (from 16 to 17 p.m.). In order to avoid the difficulties in video recording and data extraction during evening time, morning peak time was selected for recording the roundabout movements. [4] The video camera was located, such that all of the turning movements were visible from one location.

Traffic Data

The traffic data, presented in ten minutes interval, indicated peak hour from 8:00a.m to 9:00a.m with volume of 5493 vehicles/hour with a 3.4 percentage of heavy vehicles. Figure 2 shows the turning movement volumes for peak hour for each approach.[2] [4]
The flows at the Roundabout arms are as follows: Durres, Zogu i Zi, Unaza e Re, AMC with the number of vehicles in each direction 2973, 2611, 2955, and 2617 respectively.[9]

**Entrance to Tirana City**

<table>
<thead>
<tr>
<th>O/D</th>
<th>Durres</th>
<th>Zogu i Zi</th>
<th>Unaza e Re</th>
<th>AMC</th>
<th>SUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durres</td>
<td>0</td>
<td>1909</td>
<td>334</td>
<td>76</td>
<td>2319</td>
</tr>
<tr>
<td>Zogu i Zi</td>
<td>0</td>
<td>0</td>
<td>262</td>
<td>50</td>
<td>312</td>
</tr>
<tr>
<td>Unaza e Re</td>
<td>0</td>
<td>165</td>
<td>0</td>
<td>85</td>
<td>250</td>
</tr>
<tr>
<td>AMC</td>
<td>0</td>
<td>52</td>
<td>40</td>
<td>0</td>
<td>92</td>
</tr>
<tr>
<td><strong>SUM</strong></td>
<td>0</td>
<td>2126</td>
<td>636</td>
<td>211</td>
<td><strong>2973</strong></td>
</tr>
</tbody>
</table>

**Exit from Tirana City**

<table>
<thead>
<tr>
<th>O/D</th>
<th>Durres</th>
<th>Zogu i Zi</th>
<th>Unaza e Re</th>
<th>AMC</th>
<th>SUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durres</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zogu i Zi</td>
<td>1370</td>
<td>0</td>
<td>262</td>
<td>50</td>
<td>1682</td>
</tr>
<tr>
<td>Unaza e Re</td>
<td>820</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>820</td>
</tr>
<tr>
<td>AMC</td>
<td>109</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>109</td>
</tr>
<tr>
<td><strong>SUM</strong></td>
<td>0</td>
<td>0</td>
<td>262</td>
<td>50</td>
<td><strong>2611</strong></td>
</tr>
</tbody>
</table>

Table 1: Volumes in Hours from two directions (interval 08.00-09.00 am)

**Entrance to Tirana City**

<table>
<thead>
<tr>
<th>O/D</th>
<th>Durres</th>
<th>Zogu i Zi</th>
<th>Unaza e Re</th>
<th>AMC</th>
<th>SUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durres</td>
<td>0</td>
<td>1720</td>
<td>446</td>
<td>87</td>
<td>2253</td>
</tr>
<tr>
<td>Zogu i Zi</td>
<td>0</td>
<td>0</td>
<td>283</td>
<td>77</td>
<td>360</td>
</tr>
<tr>
<td>Unaza e Re</td>
<td>0</td>
<td>108</td>
<td>0</td>
<td>42</td>
<td>150</td>
</tr>
<tr>
<td>AMC</td>
<td>0</td>
<td>80</td>
<td>112</td>
<td>0</td>
<td>192</td>
</tr>
<tr>
<td><strong>SUM</strong></td>
<td>0</td>
<td>1908</td>
<td>841</td>
<td>206</td>
<td><strong>2955</strong></td>
</tr>
</tbody>
</table>

**Exit from Tirana City**

<table>
<thead>
<tr>
<th>O/D</th>
<th>Durres</th>
<th>Zogu i Zi</th>
<th>Unaza e Re</th>
<th>AMC</th>
<th>SUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durres</td>
<td>0</td>
<td>1295</td>
<td>0</td>
<td>0</td>
<td>1295</td>
</tr>
<tr>
<td>Zogu i Zi</td>
<td>1220</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1220</td>
</tr>
<tr>
<td>Unaza e Re</td>
<td>102</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>102</td>
</tr>
<tr>
<td>AMC</td>
<td>2617</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td><strong>2617</strong></td>
</tr>
</tbody>
</table>

Table 2: Volumes in Hours from two directions (interval 16.00-17.00 pm)

In the study are calculated the capacities in four sections of conflicts for every arm of roundabout, for two intervals, 08.00-09.00 a.m and 16.00-17.00 p.m (entrance and exit movements).
Figure 2. Entrance and exit flows: 08.00-09.00

Figure 3. Linear dependence of roundabout conflict points: 08.00-09.00

Figure 4. Entrance and exit flows: 16.00-17.00
Figure 5. Linear dependence of roundabout conflict points: 16.00-17.00

In the tables below are summarized the traffic volumes in the four conflict points of each roundabout branch, for two intervals; 08.00-09.00 a.m and 16.00-17.00 p.m.

<table>
<thead>
<tr>
<th>Hours 08.00 - 09.00</th>
<th>Hours 16.00 - 17.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point 1</td>
<td>2578</td>
</tr>
<tr>
<td>Point 2</td>
<td>2653</td>
</tr>
<tr>
<td>Point 3</td>
<td>2673</td>
</tr>
<tr>
<td>Point 4</td>
<td>3107</td>
</tr>
<tr>
<td>Point 1</td>
<td>3044</td>
</tr>
<tr>
<td>Point 2</td>
<td>3092</td>
</tr>
<tr>
<td>Point 3</td>
<td>2728</td>
</tr>
<tr>
<td>Point 4</td>
<td>3257</td>
</tr>
</tbody>
</table>

Table 3: Summary of Volumes in Hours from two directions (in two intervals)

Estimation of capacity

The value of entry angles and exit angles on the analyzed roundabout are verified, thus there is no need of correction to the practical capacity. [4] The capacity of the roundabout for different weaving sections is calculated with the formula for the estimation of the capacity, as follows:

\[
Q = \frac{280w \left(1+\frac{e}{w}\right)(1-\frac{e}{w})}{1+\frac{w}{l}}
\]

Where:

- \( Q \) = practical capacity of the weaving section of the roundabout in passenger car unit per hour;
- \( w \) = width of weaving section in meter (within a range of 6 to 18 m);
- \( e \) = average entry width in meters, \( e/w \) to be within a range of (0.4 to 1);
- \( l \) = length in meters of the weaving section between the end of channelizing island (\( w/l \) to be within a range of 0.12 to 0.4);
p = proportion of weaving traffic, i.e. ratio of sum of crossing stream to the total traffic on the weaving section, range of p being 0.4 to 1;

[Figure 5. Dimensions of weaving section and proportion of weaving traffic for use incapacity formula for roundabout]

Basing upon the waves of the flows, and the values of p coefficients, it has been done the calculation of capacities with the mentioned above formula:[6]

\[
p = \frac{b + c}{a + b + c + d}
\]

The coefficient p is calculated for two intervals: 08-09.00 and 16.00-17.00 as follows:

For the interval 08.00-09.00:

\[
p_1 = \frac{1970 + 262 + 76 + 38}{2578} = 0.69
\]

\[
p_2 = \frac{(57 + 45 + 26)}{3669} = 0.09
\]

\[
p_3 = \frac{(193 + 237)}{2636} = 0.08
\]

\[
p_4 = \frac{(57 + 45 + 26 + 112 + 112)}{3107} = 0.95
\]

For the interval 16.00-17.00:

\[
p_1 = \frac{(1030 + 1250 + 1370 + 112 + 47)}{3804} = 0.97
\]

\[
p_2 = \frac{(300 + 105 + 1250 + 1403)}{3592} = 0.96
\]

\[
p_3 = \frac{(112 + 253) + (1720 + 87 + 68)}{2728} = 0.83
\]

\[
p_4 = \frac{(112 + 253 + 1720 + 87 + 68)}{3257} = 0.94
\]

The calculated capacities with the formula, basing upon the values of: w = 14m, l/w = 0.7 and w/e = 0, are as follows:

For the interval 8.00-09.00:

Q 1 = 3947 vehicles
Q 2 = 3503 vehicles

For the interval 8.00-09.00:

Q 1 = 3469 vehicles
Q 2 = 3486 vehicles
RESULTS

Considering the evaluation capacities data, at the conflict points 1, 2, 3, 4 at peak hours, we might see that at hours from 8 to 9 o’clock, the point 1 was the most loaded and exceed the maximum capacity norm. Meanwhile, at peak hour for interval 16-17, the point 3 is the most loaded. From the comparison of 1 and 3 points, we might conclude that the conflict point 1 has a capacity around 4% higher, than the capacity at point 3 and 31.5% higher, than the maximum value $Q_{\text{max}}$. [6] Nevertheless these differences, it is evident that all the conflict points exceeds $Q_{\text{max}}$, thus we are constrained to propose an urgent intervention for the solution of these congestion traffic problems.

CONCLUSIONS AND RECOMMENDATIONS

This paper shows clearly the performance of a busy roundabout operating in Tirana City of Albania. The current yield control at roundabout seemed to observe delays and queues daily during peak hour. The capacity analysis indicated inscribed diameter as most important factor affecting the roundabout performance. However, it was not considered as an option to improve the performance.

Total vehicles entering into each of weaving section are more than 3000 vehicles/hour; hence roundabout cannot accommodate the traffic safely. This leads to traffic congestion, increasing the travelling cost and risk on road safety. In this situation, the intercession to resolve such a problem becomes more than indispensable. We need to adopt other alternatives to accommodate the actual traffic.

*There are two suggested alternatives of solution in this paper:*

- The intercession with short term smooth measures, with the improve of traffic management (until 2 years), applying the prevention of vehicles circulation over 3.5 ton, from 7.00 a.m to 22.00 p.m.;
- The intercession with medium term measures, predicting the disposal of traffic signals to arrange the vehicle circulation; However, when the roundabout shall be upgraded to a fully signal controlled intersection, significant improvement for current, as well as future years, should be observed, hoping that a signalized intersection normally shall expected to provide more safety to drivers reducing the collisions.[9]
Acknowledgments

This paper represents a revision of the project that was undertaken by the Municipality of Tirana, for the reevaluation of the most important problematic intersections of the city. We were joined to the initiative of the Institute of Transport, of the Transport and Infrastructure Ministry of Albania, to reevaluate the congested intersection, “Shqiponja” Roundabout, as the most important and crucial link junction between Tirana and Durres cities of Albania.[11] For this reason, we have appreciated the information received from this institution, which gave us the incentive to go further in our case study, having then our technical contribute, as useful and indispensable in such an initiative.

REFERENCES