A Study on Gap-Acceptance of Unsignalized Intersection under Mixed Traffic Conditions

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Abstract:
Unsignalized intersections are the key elements in urban streets and in rural road networks. The methodology for the analysis of unsignalized intersections has been established where homogeneous traffic conditions are dominated, there are several attempts made to develop different approaches for the analysis of unsignalized intersections under mixed traffic conditions. Conflict technique is a recent development, which is based on pragmatically simplified concept, considering interaction and impact between flows at intersection. In present study, capacity of unsignalized intersection was calculated from Conflict technique. Surveys were conducted in Visakhapatnam, to measure different traffic parameters such as volume, flow $\gamma$ capacity to this method. Movements of capacity were evaluated by HCM (2000) by comparison with approach wise capacities obtained from conflict technique.

Keywords:
Unsignalized Intersection, Surveys, Traffic Parameters, Tanner’s Model, Capacity, Conflict technique.

Urban roads in India carry different types of vehicles like high speed automobiles, low speed cycles, cycle rickshaws and animal drawn carts. This will lead to complex interaction between the vehicles and study of such traffic behavior needs special attention. The traffic plying on roads in western countries is of characteristics of different vehicles with marginal variation contrary to large variation on Indian roads. This will result in increased interactions between vehicles; then they tend to move in clusters rather than one after the other. Further two or three wheelers such as scooters, cycles, and cycle rickshaws contribute to this because of their easy maneuverability. The traffic on Indian roads consists of bi-directional freedom traffic such as two or three wheeled vehicles and unidirectional vehicles such as four wheelers. While the above tend to overtake or turning or crossing or turn right even if a small gap is available.

Hence, to determine the intersection capacity traffic engineer requires a clear understanding of gaps being accepted or rejected by various modes of traffic. Besides, in these mixed traffic conditions, users do not usually follow lane discipline and can occupy any lateral position on the road. Under these conditions, capacity of an unsignalized intersection is difficult to be determined and becomes a very interesting field of highway capacity study. There are several types of capacity analysis models for unsignalized intersections. The third approach is the conflict technique which was based on the mathematical formulation of interaction and impact between flows at an intersection. Aldian et.al (2001) [1] examined the suitability of some traffic models to determine U-turn capacity at median openings.

I. INTRODUCTION:
An intersection is a node, and usually it is a block of traffic flow in highway network. Capacity of a intersection affects the total capacity of highway network due to all types of turning movements. For actions of conflicting, merging and diverging caused by traffic flow, the traffic characteristics of intersection are more complex than those of road mid block section. Traffic stream in developing countries comprises of different types of motorized and non-motorized vehicles leads to mixed traffic conditions and lane changing patterns.

1.1 Objectives
- To study the different traffic parameters for conflict technique by using HCM method.
- To identify the traffic conflicts in major & minor streams in a particular intersection/junction.
- To know the priorities an intersection/junction by using Mathematical Model.

1.2 Study Area
The major traffic conflicts occur at T-Intersections are identified in Visakhapatnam:
- Urvasi Junction
- Kancharpalem Junction
- Gnanapuram Junction

Figures 1, 6 and 11 shows the pictorial representation of three Junctions

2. DATA COLLECTION:
The study of traffic behaviour is useful for traffic engineers to design intersections, for developing traffic control warrants, traffic signal timings, to design the vehicle storage lanes.

Data is needed for analysis and understanding of the traffic conditions. The data can be collected by manual method.

2.1 Requirements:
The main objective of this study is to find the capacity of unsignalized intersection using conflict technique and to compare the results with the HCM (2000) procedure, which is based on the gap acceptance procedure. For this the following field observations are necessary:
- Travelled distance for each movement on each approach.
- Times of arrival and departure at reference lines for each vehicle from each stream.
- Approach speed of the vehicles.
- Volume at unsignalized intersection movement-wise.

Manual counts are typically used to gather data about the following:
- Vehicle classifications
- Turning movements
- Direction of travel
- Pedestrian movements
- Vehicle occupancy

The number of people need to collect data depends on the length of the count period, type of data being collected, number of lanes or cross walks being observed, and traffic volume.

2.2 Volume Count Study (Straight Road Stretch):
To determine the number, movement and classification of roadway vehicles at a given location. The number of observers needed to count the vehicles depends upon the number of lanes in the highway on which the count is to be taken and the type of information desired. The indications in table can be used as rough guides. It is perhaps more desirable to record traffic in each of travel separately and past separate observer for each direction enumerators should be literate persons with preferably middle or matriculation level for the purpose.
This survey has been conducted at Urvasi, Kanchrapalem and Gnanapuram of T-Intersections.

2.3 Volume Count Study (An Intersection):
To determine the number, movement and classification of roadway vehicles at an intersection. Traffic volume studies are conducted to determine the number of movements and classification of roadway vehicles at a given location. These data can help identifying critical flow time periods, determine the influence of large vehicles or pedestrians on vehicular traffic flow or document traffic volume trends. The length of the sampling period depends on the type of count being taken and the intended use of the data recorded. For manual count, 15min interval could be used to obtain the traffic volume data. This survey has been conducted at Urvasi, Kanchrapalem and Gnanapuram of T-Intersections.

2.4 Gap Acceptance Study:
Pedestrians preparing to cross the roadway must access the gaps in conflicting traffic determine whether sufficient length is available for crossing and decide to cross the road. Following experiments presents a method for collecting field data to identify the minimum usable gap. As if any traffic engineering analysis recognition and definition of the difference between the standard values and the observed values, the observed values increase the accuracy. This survey has been conducted at Urvasi, Kanchrapalem and Gnanapuram of T-Intersections.

2.5 Gap Acceptance Capacity Model:
The theory of gap-acceptance is the major concept for unsignalized intersection analysis. This method is based on critical gap acceptance and follow up times of vehicles from the minor road. The modified Tanner’s formula was found to be the most suitable model. Tanner proposed a theoretical model to relate the various parameters connected with the delay problem in dealing with an Intersection of a Major and Minor road and for finding capacity at unsignalized intersections and the expression is as follows:

\[ C_T = \frac{qM (1 - \lambda t_p) e^{-\lambda (t_c - t_f)}}{1 - \omega} \]

Where,
\( \lambda = qM/3600 \) (veh/s)
\( t_p = \)minimum headway in the major traffic stream
\( t_c = \)critical gap
\( qM = \)number of major stream headways
\( t_f = \)follow-up gap respectively

2.5.1 Tables and Figures:
1)Table 1 and 2 shows the maximum No. of Vehicles and maximum Capacity Time in the study area for 1st and 2nd hours at Urvasi Junction.
2)Table 3 and 4 shows the maximum No. of Vehicles and maximum Capacity Time in the study area for 1st and 2nd hour at Kanchrapalem Junction.
3)Table 5 and 6 shows the maximum No. of Vehicles and maximum Capacity Time in the study area 1st and 2nd hour at Gnanapuram Junction.
4)Figures 2,4,7,9,12,14show the graphs for maximum No. of Vehicles in the study area of 1st and 2nd hour.
5)Figures 3,5,8,10,13,15 show the graphs for maximum Capacity Time (Min) in the study area of 1st and 2nd hour.

<table>
<thead>
<tr>
<th>Conflict</th>
<th>1st Hour</th>
<th>2nd Hour</th>
<th>1st Hour</th>
<th>2nd Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towards Complex</td>
<td>184</td>
<td>190</td>
<td>41.86</td>
<td>22.28</td>
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<tr>
<td>Left side</td>
<td>176</td>
<td>182</td>
<td>32.56</td>
<td>30.6</td>
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<tr>
<td>Away from Complex</td>
<td>183</td>
<td>187</td>
<td>26.34</td>
<td>20.49</td>
</tr>
<tr>
<td>Right side</td>
<td>196</td>
<td>200</td>
<td>25.95</td>
<td>20.79</td>
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</tbody>
</table>
Table-2: Hourly Traffic in Evening Peak Hours at Urvasi Junction

<table>
<thead>
<tr>
<th>Conflict</th>
<th>No. of Vehicles</th>
<th>Maximum Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st Hour</td>
<td>2nd Hour</td>
</tr>
<tr>
<td>Towards Complex</td>
<td>189</td>
<td>178</td>
</tr>
<tr>
<td>Left side</td>
<td>191</td>
<td>190</td>
</tr>
<tr>
<td>Away from Complex</td>
<td>192</td>
<td>200</td>
</tr>
<tr>
<td>Right side</td>
<td>169</td>
<td>189</td>
</tr>
</tbody>
</table>

Fig-1: Urvasi Junction

Fig-2: No. of Vehicles in Morning Peak Hours

Fig-3: Hourly variations of Time (Min)

Fig-4: No. of Vehicles in Evening Peak Hours

Fig-5: Hourly variations of Time (Min)
Table 3: Hourly Traffic in Morning Peak Hours at Kancharpalem Junction

<table>
<thead>
<tr>
<th>Conflict</th>
<th>No. of Vehicles 1st Hour</th>
<th>No. of Vehicles 2nd Hour</th>
<th>Maximum Capacity 1st Hour</th>
<th>Maximum Capacity 2nd Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Side</td>
<td>197</td>
<td>196</td>
<td>32</td>
<td>31.53</td>
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<tr>
<td>Towards Convent</td>
<td>203</td>
<td>205</td>
<td>28.4</td>
<td>58.18</td>
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<tr>
<td>Away from Convent</td>
<td>183</td>
<td>191</td>
<td>58.07</td>
<td>52.98</td>
</tr>
<tr>
<td>Right Side</td>
<td>199</td>
<td>192</td>
<td>58.07</td>
<td>55.32</td>
</tr>
</tbody>
</table>

Fig-6: Kancharpalem Junction

Fig-7: No. of Vehicles in Peak Hours

Fig-8: Hourly variations of Time (Min)

Table 4: Hourly Traffic in Evening Peak Hours at Gnanapuram Junction

<table>
<thead>
<tr>
<th>Conflict</th>
<th>No. of Vehicles 1st Hour</th>
<th>No. of Vehicles 2nd Hour</th>
<th>Maximum Capacity 1st Hour</th>
<th>Maximum Capacity 2nd Hour</th>
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</thead>
<tbody>
<tr>
<td>Towards Convent</td>
<td>192</td>
<td>196</td>
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<td>Away from Convent</td>
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<td>209</td>
<td>46.02</td>
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<tr>
<td>Right Side</td>
<td>197</td>
<td>207</td>
<td>39.7</td>
<td>37.23</td>
</tr>
</tbody>
</table>

Fig-9: No. of Vehicles in Evening Peak Hours

Fig-10: Hourly variations of Time (Min)

Table 5: Hourly Traffic in Morning Peak Hours at Gnanapuram Junction

<table>
<thead>
<tr>
<th>Conflict</th>
<th>No. of Vehicles 1st Hour</th>
<th>No. of Vehicles 2nd Hour</th>
<th>Maximum Capacity 1st Hour</th>
<th>Maximum Capacity 2nd Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towards Dondaparthy</td>
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<td>206</td>
<td>42.45</td>
<td>45.67</td>
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<tr>
<td>Left Side</td>
<td>206</td>
<td>205</td>
<td>54.03</td>
<td>56.27</td>
</tr>
<tr>
<td>Away from Dondaparthy</td>
<td>193</td>
<td>206</td>
<td>39.02</td>
<td>29.88</td>
</tr>
<tr>
<td>Right Side</td>
<td>199</td>
<td>203</td>
<td>59.41</td>
<td>48.64</td>
</tr>
</tbody>
</table>
Fig 11: Gnanapuram Junction

Fig 12: No. of Vehicles in Morning Peak Hours

Table 6: Hourly Traffic in Evening Peak Hours at Gnanapuram Junction

<table>
<thead>
<tr>
<th>Conflict</th>
<th>No. of Vehicles</th>
<th>Maximum Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st Hour</td>
<td>2nd Hour</td>
</tr>
<tr>
<td></td>
<td>1st Hour</td>
<td>2nd Hour</td>
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<tr>
<td>Towards Dondaparthy</td>
<td>193</td>
<td>196</td>
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<tr>
<td>Left Side</td>
<td>197</td>
<td>204</td>
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<tr>
<td>Away from Dondaparthy</td>
<td>211</td>
<td>185</td>
</tr>
<tr>
<td>Right Side</td>
<td>198</td>
<td>195</td>
</tr>
</tbody>
</table>

Fig 13: Hourly variations of Time (Min)

Fig 14: No. of Vehicles in Evening Peak Hours

Fig 15: Hourly variations of Time (Min)
3. CONCLUSIONS:
1. Conflict technique is a simple method for calculating capacity of unsignalized intersections.
2. The modified Tanner’s formula was found to be the most suitable model.
3. The input data like Volume, Flow, and Capacity of each type of vehicle can be measured from the field where as for gap acceptance models the input parameters i.e., Critical gap and Follow up time (te, tf) are measured.
4. By Comparing all the 3 T-intersections are:

- The study area Kancharpalem has shown the mixed traffic conditions.
- The study area Gnanapuram has shown the Major Stream.
- The study area Urvasi has shown the Major Stream.

REFERENCES:


