Design of Rotary Intersection as an Alternative to Four ARM Signaled Intersection of Urban Area
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Abstract—This paper evaluates issues connected with vehicular movement moving through various urban road systems. As a consequence of the constant increment of activity in focal urban regions, movement lines and defers are knowledgeable about the region of crossing points. Fast incremental improvement, increase in urban range and development in vehicular movement has come about into issues of clog, contamination and over usage of accessible limit coming about into increase in travel time and diminishment of limit because of expanding clashes made by expanded stream of activity. Subsequently, need of this study is feel to perform similar investigation of the stream under circumstance where the clashing circumstance can be minimized. Study reveals that such minimization of conflicts and segregation of traffic is possible by proper channelization. Present signalized intersection is evaluated by traffic analysis and suitable design parameters of rotary intersection are developed to give safer, high capacity and more reliable movement at intersection.

Key words: Signalized Intersection, Safety, Conflict points, Rotary Design, Mixed Traffic Condition

I. INTRODUCTION
Blended sort of movement wins in the Indian roadways especially in the urban ranges. In blended movement condition the street width is shared by a wide range of vehicles, for example, light mechanized vehicles, substantial mechanized vehicles and non-mechanized vehicles. The quick urbanization with monetary development results in extensive volume of activity amid the top hours in the greater part of the Indian urban areas. Huge activity volume is the prime reason for movement clog at urban street organizes mostly at the crossing points. Activity clog in urban territory is a significant issue and is expanding step by step with the expansion in populace/vehicular proprietorship because of uprising monetary status of urbanizes. The movement blockage not just raises the vehicle working cost, travel time of trek creators additionally is the prime reason of poor execution at the convergence. The performance of intersection is a key issue to address the congestion problem.

Roundabouts have many advantages compared to other regular signalized intersections. The main advantages are traffic safety, operational performance, environmental factors, pedestrian safety, and aesthetics. Signalized intersection has 32 conflict points whereas roundabout with one circulating lane and one entry lane has 8 traffic conflict points. But the number of conflicts increases to 16 in the case of roundabout with two circulating and two entry lanes.

The traffic operations at a rotary are three; diverging, merging and weaving.

- Diverging: when the vehicles moving in one direction is separated into different streams according to their destinations.
- Merging: is referred to as the process of joining the traffic coming from different approaches and going to a common destination into a single stream.
- Weaving: is the combined operation of both merging and diverging movements in the same direction.

![Conflict points at Rotary and Signalized intersection](image)

Fig. 1: Conflict points at Rotary and Signalized intersection

Conflict points at signalized intersection and roundabout with one circulating and one entry lane are depicted in Fig 1. The reduced number of conflict points at a roundabout indicates the reduction of crash propensity. The increased use of roundabout as a traffic facility needs an overall assessment on potential accident rates. For the safe movement of the vehicles, it is essential to understand the operational performance of the roundabout. Capacity is one such parameter which explains the operational performance, traffic scenario and Level of Service.

II. REVIEW OF LITERATURE
George at al 2000 presented study on Effectiveness of road safety measures at junctions. The objective of this paper is the assessment of the effectiveness of road safety measures at junctions. This paper investigated the effectiveness of various junction layout treatments like conversion of junctions to roundabouts, redesigning of junctions, changes of the junction angle, staggering of junctions, reduction of gradients on approach, increase of sight triangles and channelization, or traffic control interventions aiming to reduce road accidents and fatalities. The results of the present research suggest that road safety measures implemented at junctions are among the most promising road safety measures. Harwood, at al 2002 presents study on “Safety Effectiveness of Intersection Left- and Right-Turn Lanes” This report presents the results of research that performed a well-designed before-after evaluation of the safety effects of providing left- and right-turn lanes for at-grade intersections. Geometric design, traffic control, traffic volume, and traffic accident data were gathered for some improved intersections, as well as many similar intersections that were not improved during the study period. The types of improvement projects evaluated included installation of added left-turn lanes, added right-turn lanes, and extension of the length of existing left- or right-turn lanes.
Added left-turn lanes are effective in improving safety at signalized and unsignalized intersections in both rural and urban areas.

- Added right-turn lanes are effective in improving safety at signalized and unsignalized intersections in both rural and urban areas.

- Turn-lane improvements at rural intersections resulted in larger percentage reductions in accident frequency than comparable improvements at urban intersections.

Kazunori et al. 2014 describes about Design and simulation analysis of at-grade intersection channelization of city roads. In this research with briefly introducing the intersection channelization, including the features, applicable conditions and purposes of the interaction channelization design, this paper proposed the specific flow of intersection channelization design and established a simulation model of intersection channelization design with VISSIM software in combination with a large-sized intersection in a city. It is shown by the channelization design results that the traffic capacity of the intersection has been significantly improved, so the channelization design scheme is feasible and practicable.

Vikram et al. 2014 researches on "Modelling of Speed-Flow Equations on Four-Lane National Highway-8" In this study the precise determination of relationship between speed and flow is essential for arriving at the capacity of a road. The Principal objective of the present study is to evaluate speed-flow relationships on National Highway-8 for different types of vehicles by developing separate speed-flow equations on NH-8. The composition of traffic clearly indicates the influence of city area on rural road. The highest and average speed of various types of vehicles is too high then city area because of the distance from CBD area.

To get insight of problem and to solve difficulties related to intersection in terms of right turning movement many of researchers have carried out research work on different topics and area. The research papers, manual and articles of researchers spotlight the broad area of alternative ideas of rotary intersection in urban area.

III. STUDY AREA

Particular signalized intersection located in fast developing city located in Ahmedabad, India was chosen for the present study. It is four legged isolated type, provided with pre timed signal control operating in four phases with permitted left turns. These study intersection was in such a way that they have fair geometry (level gradient on all the approaches) and there is least interference to traffic by pedestrians, bus stops and parked vehicles etc. Average driving behaviour was assumed and the condition of vehicles was assumed to be moderate. The traffic is highly heterogeneous in nature with poor observance of lane discipline. The composition of traffic consists of a large proportion of motorized two wheelers, a small percentage of auto rickshaws, cars and very smaller proportion of heavy vehicles.

A. Site Selection Criteria

Intersection consists major and minor road intersecting on arterial road of Ahmadabad city. At this intersection highly hourly traffic flow causes traffic congestion and traffic congestion causes delay.

- The selected approach provides a protected right-turn phase and an exclusive right-turn lane for right turn movement. The impact of right-turn lanes and permitted right-turn phase was not considered in this study.

- The selected sites have large right-turn traffic demand. The average queue length for right-turning vehicles at selected sites should be greater than five vehicles per cycle.

- Lane widths are at least 3.5 m.

- There are few pedestrian or cyclists.

- There is no roadside parking adjacent to a travel lane within 100 m of the stop bar.

- The approach grade is level.

IV. METHODOLOGY

A. Data Collection and Analysis

Movement review was completed at the study crossing points. As a major aspect of this, turning development study
was directed by photographic technique on run of the mill week days in the wake of posting adequate number of activity enumerators to get the grouped vehicle tally of left turning, straight going and right turning developments and to land at the morning and night top hours. Later information were gathered for the distinguished crest hours utilizing video recording procedure. The camcorder was set at an appropriate vantage indicate close to the crossing point record an unhampered perspective of all methodologies and turning developments. The video tapes were later changed over to VCD and played on extensive screen a few times to concentrate characterized volume of activity, immersion stream, normal control delay per vehicle etc.

B. Classified Volume Count Data

<table>
<thead>
<tr>
<th>Approach</th>
<th>Left Turning</th>
<th>Straight</th>
<th>Right Turning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T/W Auto Car</td>
<td>B/T LCV</td>
<td>T/W Auto Car</td>
</tr>
<tr>
<td>Thaltej</td>
<td>223 36 231 4</td>
<td>9 975 208</td>
<td>975 66 94</td>
</tr>
<tr>
<td>Ringroad</td>
<td>115 25 208 11</td>
<td>10 397 76</td>
<td>365 15 13</td>
</tr>
<tr>
<td>Iscon</td>
<td>123 39 142 6</td>
<td>9 1028 270</td>
<td>1046 53 106</td>
</tr>
<tr>
<td>Vastrapur</td>
<td>131 32 150 6</td>
<td>12 380 59</td>
<td>366 5 16</td>
</tr>
</tbody>
</table>

Table 1: Classified volume as per turning movement

<table>
<thead>
<tr>
<th>Approach</th>
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</tr>
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<td>Thaltej</td>
<td>343 2193 72</td>
<td></td>
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</tr>
<tr>
<td>Ringroad</td>
<td>390 793 406</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iscon</td>
<td>299 2341 745</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vastrapur</td>
<td>309 740 356</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Total volume on each approach

V. ANALYSIS OF LOS

<table>
<thead>
<tr>
<th>Approach</th>
<th>Carriageway width (m)</th>
<th>Saturation flow (pcu/hour)</th>
<th>Effective green (λ)</th>
<th>Capacity (pcu/hour)</th>
<th>Volume (pcu/hour)</th>
<th>X=v/c</th>
<th>Delay (sec)</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thaltej</td>
<td>14</td>
<td>7350</td>
<td>0.28</td>
<td>2082</td>
<td>3052</td>
<td>1.47</td>
<td>105</td>
<td>F</td>
</tr>
<tr>
<td>Ring road</td>
<td>10</td>
<td>5250</td>
<td>0.18</td>
<td>962</td>
<td>1561</td>
<td>1.62</td>
<td>113</td>
<td>F</td>
</tr>
<tr>
<td>Iscon</td>
<td>14</td>
<td>7350</td>
<td>0.28</td>
<td>2082</td>
<td>3473</td>
<td>1.67</td>
<td>117</td>
<td>F</td>
</tr>
<tr>
<td>Vastrapur</td>
<td>10</td>
<td>5250</td>
<td>0.18</td>
<td>962</td>
<td>1436</td>
<td>1.49</td>
<td>110</td>
<td>F</td>
</tr>
</tbody>
</table>

Table 3: Level of service of four approaches during DRT scenario at intersection

VI. DESIGN OF PROPOSED ROTARY INTERSECTION

- Maximum traffic From one Side = 3385+2908= 6293 PCU/hour

- Design speed= 30km/h
- Entry and Exit angles = 45 degree
- Radius at Entry = 20m
- Radius at Exit = 40m
- Radius at Central Island = 28m
- Width of Carriage way at entry and exit e1 = 19m
- Width of non-weaving section e2 = 10m
- Width of weaving section
  \[ W = \frac{e_1 + e_2}{2} + 3.5 = 19 + 3.5 = 22.5m \]
- W/L should be between 0.12 and 0.4, Length of weaving section L = 75m

Fig. 4: Design of Proposed Rotary Intersection

Fig. 5: Design of Proposed Rotary Intersection
A. Capacity of Proposed Roundabout

\[ C = \frac{280w \left( 1 + \frac{e}{w} \right) \left( 1 - \frac{p}{3} \right)}{1 + \frac{w}{l}} \]

\[ = \frac{280 \times 22.5 \left( 1 + \frac{19}{22.5} \right) \left( 1 - \frac{0.86}{3} \right)}{1 + \frac{22.5}{75}} \]

\[ = 6331 \text{ PCU/hour} > 6293 \text{ PCU/hour} \text{........O.K.} \]

B. Check for Acceptance:

1) \( e/w \) should be between 0.4 and 1.

\[ \frac{19}{22.5} = 0.84 \text{........O.K.} \]

2) \( w/l \) should be between 0.12 and 0.40.

\[ \frac{22.5}{75} = 0.3 \text{............O.K.} \]

3) \( p \) should be between 0.4 and 1.

\[ P = 0.86 \text{...........O.K.} \]

4) \( l \) should be between 18 and 90 m.

\[ L = 75 \text{m.........O.K.} \]

- Capacity of Roundabout is 6331 PCU/hour which is higher than traffic flow 6293 PCU/hour hence the design is acceptable.

VII. CONCLUSION

Present traffic flowing at signalized intersection is higher than its capacity which results into congestion at intersection. Analysis of delay and Level of Service results that Level F is situated at all approaches which addresses delay at intersection traffic flow. For the reduction in delay and increase in capacity of intersection there should be adopt Rotary intersection for better performance of traffic flow at all approaches. Present design of Rotary intersection’s capacity is higher than traffic flow at approaches so that shows more acceptable than conventional four legged signalized intersection.

REFERENCES