SAFETY EVALUATION OF AN UNCONTROLLED INTERSECTION USING SURROGATE SAFETY MEASURES

By
S. Shekhar Babu
Research scholar (Ext) IITB
Asso Prof CME Pune

Prof. P. Vedagiri
Asst Prof Dept of civil Engg
IIT Bombay
**INTRODUCTION**

- Road traffic safety is emerging as an area of increased attention and awareness within transportation engineering professionals.

- Road traffic accidents are one of the world’s largest public health problems.

- Problem is more acute as the victims are healthy prior to accidents.
ACCIDENT PROFILE

- At least 14 people die every hour in road accidents in India.

- Total number of deaths every year due to road accidents is close to the 135,000 mark.

- India has the worst road traffic accident rate worldwide.

- About 1.25 million deaths per year, and over 30 million injuries per year globally in addition to death rate.
(Government of India, Ministry of road transport and highways transport research wing, New Delhi)

During year 2010

- Total no. of road accidents reported in India 499,628
- Total no. of persons killed in road accidents 134,513
- One fatality per 3.7 accidents.
- Motorized vehicles accounted for 93.4% of the total road accidents.
Major threat to the safety of road users is due to:

Exponential growth of vehicular population (Rising income levels)

Slow growth in road infrastructure (Rapid development rate in urban area)

<table>
<thead>
<tr>
<th></th>
<th>1951</th>
<th>2012</th>
<th>remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles</td>
<td>0.3 million</td>
<td>100 million</td>
<td>about 300 times.</td>
</tr>
<tr>
<td>Road network</td>
<td>0.4 million km</td>
<td>3.32 million km</td>
<td>8 fold increase in terms of length.</td>
</tr>
</tbody>
</table>
COUNTER MEASURES FOR SAFETY

Many countermeasures and inventions are being introduced and put into practice across the world, aimed at reducing traffic accidents.

- Development of infrastructure
- Safety features in vehicles
- Traffic strategies.

These countermeasures have advantages and disadvantages,
- To make effective decisions, reliable safety analyses of facilities is essential for before and after implementation.
SAFETY EVALUATION

- Traditional Approach: statistical accident data
- Rational method
- Measured in terms of the number of traffic accidents.
- Before-after comparisons of observed data

Limitations

- Availability and quality of accident data.
- Accident frequencies segregated by location, time and type are low
- Longer time period to statistically validate safety measures.
SAFETY EVALUATION USING SURROGATE SAFETY MEASURES (SSM)

- Conflict technique using Surrogate Safety Measures (SSM) is a proactive method of safety analysis.

- Conflicts occur more frequently than accidents.

- Research shows high correlation between accident rates and conflicts.

- Further with the technological advancements in the field of computers, it is advantageous to use micro-simulation tools for safety assessment purposes using surrogate safety indicators.
TRAFFIC CONFLICT

Conflict is defined as ‘An observable situation in which two or more road users approach each other in time and space to such an extent that there is risk of collision if their movements remain unchanged’.

Conflict can be represented as nearness to a collision in terms of either space or time proximity between interacting vehicles.

If the vehicles are closer in time or space to each other, they are nearer to a collision.
TRAFFIC CONFLICT

- All collisions are preceded by conflicts.

exposure

conflicts

Serious conflicts

accident
Many surrogate safety indicators are used which are defined as measures of crash proximity, based on the temporal and spatial measures that reflect the closeness of road-users, in relation to a projected point of collision.
SURROGATE SAFETY INDICATORS

- There are several proximal safety indicators used for this purpose.
- **Gap Time (GT)** - Time lapse between completion of encroachment by turning vehicle and the arrival time of crossing vehicle if they continue with same speed and path.
- **Encroachment Time (ET)** - Time duration during which the turning vehicle infringes upon the right-of-way of through vehicle.
- **Deceleration Rate (DR)** - Rate at which crossing vehicle must decelerate to avoid collision.
- **Proportion of Stopping Distance (PSD)** - Ratio of distance available to maneuver to the distance remaining to the projected location of collision.
- **Post-Encroachment Time (PET)** - Time lapse between end of encroachment of turning vehicle and the time that the through vehicle actually arrives at the potential point of collision.
- **Initially Attempted Post-Encroachment Time (IAPT)** - Time lapse between commencements of encroachment by turning vehicle plus the expected time for the through vehicle to reach the point of collision and the completion time of encroachment by turning vehicle.
- **Time to Collision (TTC)** - Expected time for two vehicles to collide if they remain at their present speed and on the same path.
POST-ENCROACHMENT TIME (PET).

- Post-Encroachment Time (PET) is most suitable for conflicts of crossing vehicles.

- PET - Time lapse between end of encroachment of infringing (turning) vehicle and the time that the right of way (through) vehicle actually arrives at the potential point of collision.

- It is the difference in time between the passage of the offended and conflicted road-users over a common conflict zone (i.e. area of potential collision).
PET MEASUREMENT

Start of Post-Encroachment Time Event
(No Collision Course Exists)

Priority Road

End of Post-Encroachment Time Event
(No Collision Course Exists)

Priority Road

PET = Time blue car enters Conflict Zone -
Time white car leaves Conflict Zone
**Threshold Values**

- To identify the hazardous situations in is necessary to separate the critical and non-critical conflicts based on threshold values.
- In most of the studies the threshold value is taken as reaction time of the driver.

- PET threshold ranges from 1 to 1.5 seconds (Archer, 2000)

- For the present study threshold value is taken as 2.5 s recommended by Indian Roads Congress for stopping sight distance.
PRESENT STUDY

Unsignallised intersection (Chanakya Chowk)
Palm Beach Road, Vashi, Navi Mumbai
Traffic data of the intersection is collected by video for about one hour.

Conflicts are observed using PET as surrogate safety measure.

Conflicts are mainly due to

Right turning vehicles from major road

Right turning vehicles from minor divided road
Right turning vehicles have to wait till they get acceptable gaps on all the three lanes of the major road.

Judging gaps on all the three lanes is difficult.

Each turning vehicle may have Max three conflicts.
Waiting for long duration, drivers may lose patience and may accept small gaps.

Turning vehicles may have different paths over the conflict area.
- Conflict area is divided in 15 conflict zones each measuring 3.5m x 3.5m square grids as lane width is of 3.5m.
- To track the path of turning vehicle the conflict zones are numbered.
- Time when the offending vehicle leaves the conflict zone = t1
Time when conflicting vehicle enters conflict zone 1-4 = t2
- Time at which the offending vehicle leaves the conflict zone = t1
- Time at which the conflicting vehicle enters the conflict zone = t2
- PET = t2 - t1
Video is played at the speed of **30 frames per second.**
Every **click of mouse** steps up by 0.033s.
Thus the accuracy of the PET measurement will be **0.033 s.**
PET CALCULATION EXAMPLE

- As the turning vehicle start entering the conflict area, the conflicts zones are identified.
- Table shows the turning (offending) vehicle (car) tracks zones 3-3, 2-4, and 1-4. The time at which offending vehicle leaves the conflict zone is t1 and time when conflicting vehicle enters the respective zone t2.

<table>
<thead>
<tr>
<th>Conflict zone - lane</th>
<th>Time offending veh leaves (t1)</th>
<th>Time conflicting veh enters (t2)</th>
<th>PET (t2-t1) sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-3</td>
<td>30:31.396</td>
<td>30:37.602</td>
<td>6.206</td>
</tr>
<tr>
<td>2-4</td>
<td>30:32.864</td>
<td>30:34.232</td>
<td>1.368</td>
</tr>
<tr>
<td>1-4</td>
<td>30:34.232</td>
<td>30:41.706</td>
<td>7.474</td>
</tr>
</tbody>
</table>

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Shekhar babu
**CRITICAL CONFLICTS**

Conflicts are observed by calculating PETs for all right turning vehicles.

To separate critical conflicts PET values are distributed in five categories.

- Less than 1.0 s  Severe conflicts
- 1.0 < 2.5  Critical conflicts
- 2.5 < 4.0  Nearly critical conflicts
- 4.0 < 6.0  Normal conflicts
- More than 6.0 s  Non critical conflicts (no Danger)

Conflicts are tabulated based on their PET values lane wise for Two wheelers(TW) and Cars/ Auto (CA) separately.
**Lane wise conflicts for right turning vehicles**

<table>
<thead>
<tr>
<th>For right turning</th>
<th>No of conflicts</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left lane</td>
<td>Middle lane</td>
<td>Right lane</td>
<td>Total</td>
</tr>
<tr>
<td>Two wheelers</td>
<td>32</td>
<td>53</td>
<td>45</td>
<td>130</td>
</tr>
<tr>
<td>Cars/Auto</td>
<td>46</td>
<td>68</td>
<td>63</td>
<td>177</td>
</tr>
<tr>
<td>All vehicles</td>
<td>78 (26%)</td>
<td>121 (38.4%)</td>
<td>108 (35.6%)</td>
<td>307</td>
</tr>
</tbody>
</table>
# DISTRIBUTION OF CONFLICTS BASED ON VEHICLE TYPE AND PET

<table>
<thead>
<tr>
<th>PET value in s</th>
<th>Percent of conflicts for right turning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cars/auto</td>
</tr>
<tr>
<td>&lt;1.0</td>
<td>9.039</td>
</tr>
<tr>
<td>1.0 &lt; 2.5</td>
<td>23.721</td>
</tr>
<tr>
<td>2.5 &lt; 4.0</td>
<td>16.39</td>
</tr>
<tr>
<td>4.0 &lt; 6.0</td>
<td>16.38</td>
</tr>
<tr>
<td>6.0&gt;</td>
<td>34.47</td>
</tr>
<tr>
<td>total</td>
<td>100</td>
</tr>
</tbody>
</table>
# Distribution of Conflicts Based on Lane and PET

<table>
<thead>
<tr>
<th>PET in s</th>
<th>Percent of conflicts for right turning vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left lane</td>
</tr>
<tr>
<td>&lt; 1.0</td>
<td>6.41</td>
</tr>
<tr>
<td>1.0 &lt; 2.5</td>
<td>5.12</td>
</tr>
<tr>
<td>2.5 &lt; 4.0</td>
<td>14.11</td>
</tr>
<tr>
<td>4.0 &lt; 6.0</td>
<td>21.79</td>
</tr>
<tr>
<td>6.0&gt;</td>
<td>52.57</td>
</tr>
<tr>
<td>total</td>
<td>100</td>
</tr>
</tbody>
</table>
CONCLUSIONS

- PET is the most suitable safety indicator for observing conflicts of crossing vehicles, for intersections.

- No of conflicts observed are less on left lane as some of the traffic moving on left lane turn left towards divided minor road.

- Critical and severe conflicts for cars/auto are more than for TW. This may be due to reaching of cars/auto at conflict zone slower than two wheelers, hence getting less PET values.

- Middle lane is highly trafficked and also has more percent of critical conflicts, hence cars/auto are more prone to accident at this intersection.
FUTURE WORK

• To develop a methodology to evaluate traffic safety at uncontrolled intersections using surrogate safety measures.

• To study the effect of roadway and traffic characteristics like vehicle type, number of lanes and proportion of turning traffic on SSM at uncontrolled intersection using simulation.

• Selection and modification of suitable traffic simulation model to get realistic SSM.
Any questions?
Some Questions

- This paper is based on the concept of conflict analysis, which was used by researchers in 1990s and then dropped due to many of the limitations.

- The paper is based on observations made at one intersection. Then the question is how these findings will be applicable at other intersections with different approach width, gradient, angle to next leg?

- Is it possible to collect the necessary data using the red light running cameras available at most of the junctions on a continuous basis and rate the junction with respect to safety?
THANK YOU