SAFETY AUDIT OF ROADS FOR PEDESTRIANS

By
Dr. Nishi Mittal
Head, Traffic Engineering & Safety
Central Road Research Institute,
New Delhi
nishisafe@gmail.com
More than 1,27,000 persons die on Indian roads annually (which was 95,000 in 2005)
India has now dubious distinction of having highest fatalities amongst countries in transitions
India accounts for 10% of world road deaths
Indian Scenario

- It loses around 3% of its GDP on road traffic accidents.
- Majority of the accident victims fall in the age group 15-39 year (around 50-65 %) followed by 40-59 years (around 20 to 30 %)
- Road safety is now a public health issue and needs immediate attention
Percent Share of Persons Killed in Road Accidents by type of Motor Vehicle (Primarily Responsible) during 2009
Percent Share of Persons Killed in Road Accidents by Type of Road User Category during 2009
Road Accidents and Road Length as per Classification of Roads

- No. of Road Accidents 2009:
  - Other Roads: 46.85%
  - SH: 23.85%
  - NH: 29.3%

- Road Length 2008:
  - Other Roads: 94.62%
  - SH: 3.72%
Most Productive Age-Group Persons are Killed in Road Accidents (2009)
Highway Development Programme and Road Safety in India

- Massive development and improvement of road network.
- Highway network upgraded to 4/6 lane roads
- Provided golden chance for highway engineers and planners to plan and build road safety features
- However, initial experience indicates, it is not so...
Highway Development increased mobility for high speed traffic.

But made life more miserable for VRU’s as they were not experienced to cope with such road environment.

No adequate pedestrian footways provided or proposed.

Required underpasses or pedestrian crossings not provided.
Road Safety Audit Studies carried-out by CRRI

- Road Safety Audit of Engineering Design for Construction Packages on NH-2, 900 km (15 packages)
- Road Safety Audit of Mumbai-Pune Expressway (2004)
- Road Safety Audit of Indore-Dewas bypass (2001)
- Road Safety Audit of Noida Toll Bridge (2003)
- Road Safety Audit of Delhi-Gurgaon Expressway (2006)
- Road Safety Audit of NHAI sponsored 12 packages at Design and Construction Stages 1200 km (ongoing)
Road Safety Audit Studies

- Road Safety Audit of ODR’s and MDR’s in Punjab, 408 km (ongoing)
- Road Safety Audit of Mumbra Bypass on NH-4 (2009)
- Road Safety Audit on NH-4 and NH-7 (2005)
Research Studies for Vulnerable Road Users

- Safety Issues in Non-Motorized Transport in India (1999)
- Design Norms and Standards for Pedestrian Safety in India: Theory and Practice (2001)
- Non-Transport Usage of Limited Pedestrian Facilities (2001)
- Adequacy of Signal Timing for Pedestrians (2011)
- Pedestrian Safety Practices in India (2001)
Research Studies for Vulnerable Road Users


• Mobility and Accessibility Problems of The Transport Disabled (2004)

• Pedestrian Facilities in and Around Metro Stations in Delhi (2009)

• Impact of Motorists not sharing the Road with Pedestrian (2010)
In India pedestrian fatalities constitute around 40-50% of the total fatalities.

In India the pedestrians face quite unsafe situations.

Some of the RSA studies for pedestrians are presented.
Design Stage Audits for Pedestrians
Non provision of Service Road

- Non provision of service road at start of project road can promote lawless movement in hazardous manner because of built up areas.

Recommendations

- Provide service road for safe management of traffic in built up areas from Zeerakpur intersection to start point of project road.
Location of Bus bays too close to Intersections

- It overlaps and conflicts with the Intersection influence area.

Recommendations

- Provide bus bays away from Intersections influence area preferably after the Intersections.
Location of access from service road too close to Intersections

- It conflicts with the Intersection influence area.

Recommendations
- Provide access away from Intersections influence area.
Pedestrian crossing Facilities at Intersections

• Stop line and Pedestrian Zebra crossing not provided properly
• Pedestrian desire line of crossing across the approach roads is not followed appropriately and is not integrated with stop line and zebra crossing markings etc. leading to a situation where pedestrians will try to cross at unauthorized places and put themselves to risk.

Recommendations

• Straight movement along the slip roads can be integrated with that along the main road and extra conflicts may be avoided. Proper pedestrian management / circulation plan with signal phasing be provided.
Facilities for Pedestrians and NMT across Project- Road

- Proposed PUP at km 58.704 is narrow (1x1.6x2.5) and steep as it will be also used by NMT and 2-wheelers.

Recommendations

- Provide wider facility with proper slope to accommodate the expected crossing traffic
Facilities for Pedestrians and NMT across Project- Road

• Non Provision of Pedestrians Facility at km 60.100 at Bitna High School across Project Highway.

Recommendations

• Pedestrian Under Pass may be Provided as the Project Road is at embankments.
Wrong Signage for “School Ahead”

A school sign is provided at location 54+900 has been shown. It is shown only in direction towards Parwanoo but not in the reverse direction.

Recommendation: Signs for school ahead should be provided on both directions. Also there should be advisory speed limits and “Go Slow” plate advising motorists to slow down while approaching school area.
ADEQUACY OF TRAFFIC SIGNAL TIMINGS FOR PEDESTRIANS AT INTERSECTIONS
Sites Selected

- Ashram Intersection
- Sarai Kalekhan Intersection
- Burari Intersection
- Dhaulakuan Intersection
- Shastri Park Intersection
Accidents at Burari Intersection

<table>
<thead>
<tr>
<th>S.No</th>
<th>Year</th>
<th>Persons Killed</th>
<th>Persons Injured</th>
<th>Total No of Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2008</td>
<td>18</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>2009</td>
<td>13</td>
<td>14</td>
<td>27</td>
</tr>
</tbody>
</table>

- Pedestrians formed 56% of the total victims.
- 37% of the total accidents occurred between the time slot 22:00 hrs to 01:00 hrs, and 11% of the total accidents occurred between the time slot 01:00 hrs-05:00 hrs and 8% of the total accidents occurred between the time slot 18:00 hrs-20:00 hrs.
Two wheelers formed around 47% followed by Small Cars 14%, Auto rickshaws around 6%, Big Car around 15%. Light commercial vehicles 12%, bus around 4%, Heavy vehicles like Trucks around 2%.
Pedestrian hourly volume is maximum (176) from Buradi to ISBT followed by from Karnal to Buradi (166).
# Pedestrian Volume Count Survey at Burari

Pedestrian volumes across approaches and PV² values Sidewalks

<table>
<thead>
<tr>
<th>Approach</th>
<th>Direction</th>
<th>Hourly Traffic Volume (V)</th>
<th>Pedestrian hourly Volume (P)</th>
<th>PV² Index Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISBT</td>
<td>UP</td>
<td>3012</td>
<td>626</td>
<td>2.47 x 10¹⁰</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td>3270</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modal Town</td>
<td>UP</td>
<td>1022</td>
<td>86</td>
<td>5.16 x 8¹⁰</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td>1428</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Karnal</td>
<td>UP</td>
<td>3182</td>
<td>196</td>
<td>7.75 x 9¹⁰</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td>3108</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buradi</td>
<td>UP</td>
<td>2054</td>
<td>150</td>
<td>1.86 x 9¹⁰</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td>1464</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- At all the four approach roads PV² index values are more than threshold value (2 X 10⁸)
The walking speeds required on some approaches are as high as 11.7 Kmph. These speeds are difficult even for the able bodied young people not to speak of the handicapped persons, old age people, woman and Children.

### Pedestrian Signal timings and wastages due to violation

<table>
<thead>
<tr>
<th>Approach</th>
<th>Direction</th>
<th>Time available for Pedestrian Crossings (Sec)</th>
<th>Time Wasted due to traffic violation (sec)</th>
<th>Effective Time available for crossing (sec)</th>
<th>Width of road to Cross (m)</th>
<th>Required Pedestrian walking speed (Kmph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISBT</td>
<td>UP</td>
<td>90</td>
<td>10</td>
<td>80</td>
<td>37.8</td>
<td>1.701</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modal Town</td>
<td>UP</td>
<td>70</td>
<td>13</td>
<td>57</td>
<td>25.2</td>
<td>1.59</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Karnal</td>
<td>UP</td>
<td>25</td>
<td>13</td>
<td>12</td>
<td>39</td>
<td>11.70</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buradi</td>
<td>UP</td>
<td>65</td>
<td>12</td>
<td>53</td>
<td>33.9</td>
<td>2.30</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


**Recommendations at Burari**

- The pedestrian speed required on Karnal approach as high as 11.7 Kmph. This speed cannot be achieved even by any healthy person. Hence, it is recommended to provide pedestrian signal for 45 sec to keep the normal speed below 3.5 kmph.

- Considering providing zebra markings wherever absent and maintain at worn out places.

- There is absence of sidewalks partly on some approaches and the width is also not as per standards. Hence, it is recommended to provide pedestrian friendly sidewalks.

- All the four left turns at the intersection are free left turns and pedestrians have to cross at their own risk. In order to avoid this, it is recommended to provide signalised left turn in co-ordination with other movements.
<table>
<thead>
<tr>
<th>Name of Intersection</th>
<th>Name of Approach</th>
<th>Time Wasted due to Traffic Violations (%)</th>
<th>Free Left Turns Provided</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashram</td>
<td>South Ex</td>
<td>12.5</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bhogal</td>
<td>5.9</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kale khan</td>
<td>11.1</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Apollo</td>
<td>5.7</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Burari</td>
<td>ISBT</td>
<td>11.1</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modal Town</td>
<td>18.6</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Karnal</td>
<td>52</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Burari</td>
<td>18.5</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Dhaula Kuan</td>
<td>Gurgaon (Airport)</td>
<td>48.8</td>
<td>Yes</td>
<td>Extreme Two lanes</td>
</tr>
<tr>
<td></td>
<td>Dhaula Kuan (AIIMS)</td>
<td>17.5</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delhi Cant (Janakpuri)</td>
<td>0</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Shastri Park</td>
<td>ISBT</td>
<td>6.8</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Khajuri</td>
<td>13.2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shastri Park</td>
<td>10.5</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shadara</td>
<td>6.3</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>
Pedestrian opinion survey

Frequency of Road Crossing

Percentage Difficulty of Road Crossing
Pedestrian opinion survey

Types of Conflicts Pedestrians Faced while Road Crossing

Visibility of Traffic Signals while Road Crossing
Feelings of Anxiety & Physical Pain while Road Crossing

Problems faced by the pedestrians while Road Crossing
Causes of Conflict

Preferred Time for Road Crossing
Pedestrian opinion survey

Perception of Beggars related to Hazards

Safety while road crossing
Pedestrian opinion survey

Causes of Vulnerability of Pedestrians

Fig 12: Causation of Vulnerability of Pedestrians

- Allotted time is less: 50
- Speed of vehicles is too high: 24
- Motorists don’t stop and give way to pedestrians: 15
- None of these: 11

Total: 101
Conclusions

- \( PV^2 \) index values are more than \( 2 \times 10^8 \) at most of the intersections which is a standard value decided to provide grade separated facility and indicates the requirement of grade separated pedestrian facilities. However, grade separated facilities are not provided in the above selected intersections.

- In spite of the absence of grade separated facilities provided at these locations and heavy pedestrian and vehicle volume observed at no arm of any junction studied, pedestrian phase signal is provided to cater to the needs of the pedestrians.
Conclusions (Contd....)

- At these junctions in the absence of grade separated facilities and exclusive pedestrian phase signal, pedestrians cross when there is red signal for the vehicles. It was observed that 8-40% allotted time is washed due to traffic violations i.e. motorists especially two-wheeler riders and cyclists do not stop even when it is red light. So effective time left for pedestrians to cross is not sufficient.

- At many locations required walking speed to cross was as high as 11 km. Per hour which is impossible even for the able bodied pedestrians not to speak of the elderly, women and disabled population.
Conclusions (Contd....)

- At many locations, free left turns and U-turns are provided and so the pedestrians do not find any exclusive and safe time and are forced to cross in between the moving traffic. This makes the crossing activity very hazardous for the pedestrians especially to elderly, women and disabled pedestrians.
Survey of Pedestrian Crossing Facilities in Delhi by CRRI (2007)

- CRRI carried out following surveys in year 2007 at 5 four-arm intersections and six T-intersections and 150-200 metre approach roads to these intersections
- Physical and environmental parameters of pedestrian facilities
- Opinion survey of pedestrians
- Opinion survey of motorists
- Observed behaviour of pedestrians and motorists
Pedestrian Facilities Available

- Zebra crossing was available only at 38% surveyed Four-arm intersections and 45% T-Intersections.
- Pedestrian signal was available only at 5% surveyed four arm intersections at and 2% T-intersections.
Available Pedestrian Facilities

- At 30% surveyed four arm intersections and 40% T-intersections, encroachment was there.
- Only at 10% four arm intersections and 21% T-intersections, pedestrian Refuge Islands were available.
- So very few pedestrian crossing facilities are available.
## Availability and Width of Side Walks

<table>
<thead>
<tr>
<th>Intersection Type</th>
<th>Side Walk Availability (%age)</th>
<th>Side Walk width (%age)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 0.9m</td>
<td>0.9 to 1.8m</td>
</tr>
<tr>
<td>Four-Arms</td>
<td>86</td>
<td>11</td>
</tr>
<tr>
<td>T-Intersections</td>
<td>67</td>
<td>8</td>
</tr>
</tbody>
</table>
## Side Walk Height

<table>
<thead>
<tr>
<th>Intersection Type</th>
<th>Side Walk Height (%age)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 15 cm</td>
</tr>
<tr>
<td>1. Four Arm Arm Intersection</td>
<td>0</td>
</tr>
<tr>
<td>2. T-Intersections</td>
<td>0</td>
</tr>
</tbody>
</table>
Problem Faced by Pedestrians
Environmental Aspects of Footpaths

- On 20% surveyed four arm intersections and 64% T-intersections, potholes were observed.
- 25% surveyed four arm intersections were not found comfortable to walk upon.
- 15% surveyed four arm intersections were observed to be aesthetically displeasing
Results of the Survey

At 38% four-arm intersections and 83% surveyed T-intersections, Pedestrian Refuge Islands were not available.

Road Signs Markings and Signals were not adequately provided.
Opinion of Pedestrians

- Two third surveyed pedestrians said that it is unsafe to cross the road.
- Around 65% pedestrians were of the view that allotted time given to cross is inadequate.
- 76% pedestrians felt that beggars and sellers create problem at intersections.
Opinion of Pedestrians

- Around 75% interviewed pedestrians were of the view that condition of footpaths at intersections is not proper.
- 73% people felt that the width of footpaths is inadequate
- 77% were of the view that height is more
- 64% felt that walking on footpaths is not comfortable.
90% pedestrians felt that the situation has become more unsafe during last 5 years because of complex intersections (65%) width of footpath has been reduced (70%) speed of vehicles has increased (60%).
More females (76%) felt that allotted time for crossing is inadequate – Males 51%

82% females felt that beggars create problems at intersections (82%) versus males (67%)

More males take risk to cross the road (36%) in comparison to 15% females.

64% females thought footpath height more in comparison of 34% males.
People of older age group (45-60 years) stated more difficulty in crossing the roads (70%) in comparison to 49% for 15-30 years age group.

Older people stated that they wait for red light to cross the road (68%) in comparison to 45% younger people.

Older people asked for more time to cross 68% in comparison to 45% younger people.
Opinion of Motorists

- Motorists felt that pedestrians create problems when on green light they just raise their hands and cross the road. (50%) jump the railing to cross the road (50%).
- 90% motorists felt that pedestrians should also be challaned for violating traffic rules.
- 60% drivers felt that pedestrians are not visible during night.
The most important reason for pedestrian unsafe situations is apathy towards pedestrians.

In our transport plans, the highest priority is accorded to uninterrupted flow of motor vehicles.

The most important element of our transport plans – pedestrian has disappeared.
IN RURAL AND SEMI-URBAN AREAS, IT IS MOSTLY NON-MOTORISED TRANSPORT ROAD USERS (60%-65% ROAD TRAFFIC FATALITIES)
CHARACTERISTICS OF NMT FATALITIES ON NATIONAL HIGHWAYS

- Severity
- Type
- Temporal
- Vehicles Involved
- Location
- Age of Victims
- Socio-Economic Background
• **Severity**

  72% pedestrian accidents were fatal,
  24% grievous injury and only
  6% were minor injury accidents (Reason: High Speed)

• **Type**

  35% were side swipe
  23% head on,
  11% rear end and
  8% were right angled (Reason: Narrow & Undivided carriage way – Lack of Pedestrian Facilities)
• **Temporal**

  Evening Hours From 4 P.M. To 8 P.M. 29%
  
  (Reason: Heavy Pedestrian Flows, Lighting And Conspicuity)

• **Vehicles Involved**

  Trucks 33%, Buses 20%, (Heavy Vehicles 53%),
  
  Car/Jeep/Van 18% (Reason: Heavy Volume & High Speeds)
• **Location**
  
  Junctions 28%, Inhabitated 23%
  
  Bus-Stands 15%, Two Third at these locations
  
  (Reason: More pedestrians with lack of pedestrian facilities)

• **Age of victims**
  
  More productive age group people are involved in road traffic accidents
  
  (reason: more exposure)
Socio-Economic background

Labourers are the most accident prone in rural areas.

More females as they perform more walking trips

Elderly, disabled, women, children, etc. don't dare to walk on present day footways
Provision For NMT vehicles
Till now provision of facilities for non motorized vehicles seems to be a residual and not the prime consideration

In situations of space constraints, compromise is always made by cutting pedestrian facilities and not by reducing the carriageway
WALKWAYS

For footways, only width is mentioned and that too not varying according to pedestrian flows.

This proposed width is the minimum of just 1.5 m for any footway (as per IRC guidelines), sometimes even below this – just 1.0 m

Contd.
Contd.

Pedestrian footways are suggested on drainage facilities which will raise the height of footways thus making them non-usable for elderly, women and the infirm.

Footways on drainage will have other safety implications also as drain cover next to a well used carriageway or service road is likely to be broken within weeks by truck parking.
SERVICE ROADS

At many locations width of service roads provided is inadequate (3.5m)

Service roads in the absence of adequate parking facilities will be blocked by parked vehicles

Adequate lighting at built up areas is not suggested

The width of the walkways has to be designed according to pedestrian flows

Contd.
Nothing is mentioned about how the speeds would be reduced at critical locations like built up areas, at curves, educational institutes etc.

The bypasses/underpasses at required heavily built up areas like Handia, Baraut, Gopiganj etc. are not suggested thus may create more pedestrian – vehicular conflicts at high speed locations.
RECOMMENDATIONS SUGGESTED FOR PROVISION OF NON-MOTORIZED VEHICLES

WALKWAYS

Reconsider the cross-section to ensure an adequate provision of footways specifically in the built up areas.

The walkways height, surface, type, continuity are to be specified.

Construct drains in urban areas at critical pedestrian locations by using buried pipes and manholes and thus allowing concrete or paved footways to be installed.
SERVICE ROADS

Provide Width of the Service Roads According to Pedestrian and Non-Motorised Traffic Flows

Provide Adequate Parking Spaces to Avoid Parking on Service Roads and Shoulders

Ensure Service Roads Remain Service Roads

Traffic Calming Techniques are to be suggested at Built-up Areas
Provide Crossing Facilities At Bus Stops

Provide pedestrian refuge Islands of minimum 1.8 width as well as pedestrian friendly

At bus intersections, include a pedestrian only phase
BUS BAYS

Ensure that all required bus bays are constructed, not just those shown on drawings

Show bus bay lengths, depths, tapers and footway widths as minimum dimensions

Add a note stating bus bays and footpath areas need to be increased at busy locations depending on available space
Because of public apathy towards pedestrians, the type of roads constructed now-a-days do not fulfill the needs of pedestrians.

- Inadequate pedestrian facilities
- Inadequate and uncomfortable footpaths
- Inadequate Light
- Inadequate Road crossing facilities
Problems Faced by Pedestrians

contd...
Problems Faced by Pedestrians

- Problem in crossing wide and multi-lane roads
- High speed of vehicles
- Complex intersections
- Long waiting time at Intersections
- Less countermeasures for pedestrian safety
- Lack of continuous walking
- Adverse Road Design for Pedestrians
Adverse Road Design for Pedestrians
Reasons for Road Accidents at Intersections

- Improper Design of Intersections
- Inadequate Traffic Engineering
- Driver Education and Licensing
- Drivers Disregard Traffic Control at Intersections.
Strategies for Making Safer Cross Walks

- Pedestrian Refuge Islands
- Curb Extensions (or bull-outs)
- Median
- Zebra crossings
- Traffic Signal controlled pedestrian crossings
- Grade separated pedestrian crossings
- F.O.B. and subways
Thank You