ABSTRACT

Pedestrian accidents are a serious and growing problem in the cities of developing countries, especially in Dhaka, the capital of Bangladesh. Poor planning of road networks, poor traffic control and management at intersections, inadequate pedestrian facilities and the severe lack of priority and attention given to the pedestrians are the main causes of such dangerous situation. Particular concern is the urban intersections, specifically the signalized ones that have been identified as among the most hazardous locations on the roads which account for a substantial portion of traffic accidents (Helai, Chor & Haque, 2008). Study shows that out of more than thirty six hundred accidents in Dhaka city nearly 63% occurred at non-intersection areas whereas 37% at intersections from 2007-2014 in Dhaka metropolitan city (ARI, 2014). Pedestrian accidents (58%) dominated total accidents occurred during this period. The heterogeneity of traffic, inadequate crossing facilities, plying of modes with varying speed and maneuvering time make the intersections even more complex. Field study also indicates that nearly 65% of total intersections in Dhaka city have Pedestrian Traffic Signal (PTS) whereas nearly 15% have no pedestrian control devices. Due to the Ineffective PTS and faded crossing marking, pedestrian’s risk at intersections is increasing.

This paper aims to provide a broad overview of pedestrian safety facilities at intersections in Dhaka city. Analyzing the survey data, it has attempted to shed some light on the major causes and factors of pedestrian accidents and also suggested appropriate safety measures to reduce the accidents and enhance crossing facilities at the intersections.
1. INTRODUCTION

Dhaka, gateway of Bangladesh is the cultural, economic, educational and recreational center of the country. It is a metropolis of 2,161.17 square kilometers (Bangladesh Bureau of Statistics, BBS report, 2011). Population density in Dhaka is over 7,936.4 per square kilometer in the city area. As the population is increasing, number of vehicles is also increasing in this city. As a result congestion level is also increasing which increases competition among the drivers to pass the intersections quickly. This competition increases degree of risk of pedestrian accidents during crossing the intersections. The reported pedestrian accident and casualty statistics over the past five years for Dhaka city have significant fluctuation. Almost 37% of total accidents occurred at intersections in Dhaka city (2007-2014). Analysis in Microcomputer Accident Analysis Package (MAAP5) shows that during 8 years from 2007 to 2014, pedestrians are making up about 77 percent of fatal road accident and are involved in more than 62 percent of all reported accidents in Dhaka Metropolitan city (Figure 1). However, any significant improvement of the crossing facilities did not notice for the last decade.

Table 1: Yearly Pedestrian Accidents in DMP Area (2007-2014)

<table>
<thead>
<tr>
<th>Year</th>
<th>Fatal Accident</th>
<th>Fatal Pedestrian Accident</th>
<th>% of Fatal Pedestrian Accident</th>
<th>All Accident</th>
<th>All Pedestrian Accident</th>
<th>% of All Pedestrian Accident</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>330</td>
<td>262</td>
<td>79.4</td>
<td>565</td>
<td>329</td>
<td>58.2</td>
</tr>
<tr>
<td>2008</td>
<td>391</td>
<td>299</td>
<td>76.5</td>
<td>642</td>
<td>387</td>
<td>60.3</td>
</tr>
<tr>
<td>2009</td>
<td>318</td>
<td>251</td>
<td>78.9</td>
<td>525</td>
<td>328</td>
<td>62.5</td>
</tr>
<tr>
<td>2010</td>
<td>296</td>
<td>232</td>
<td>78.4</td>
<td>458</td>
<td>287</td>
<td>62.7</td>
</tr>
<tr>
<td>2011</td>
<td>271</td>
<td>200</td>
<td>73.8</td>
<td>400</td>
<td>245</td>
<td>61.3</td>
</tr>
<tr>
<td>2012</td>
<td>279</td>
<td>209</td>
<td>74.9</td>
<td>372</td>
<td>241</td>
<td>64.8</td>
</tr>
<tr>
<td>2013</td>
<td>252</td>
<td>196</td>
<td>77.8</td>
<td>341</td>
<td>231</td>
<td>67.7</td>
</tr>
<tr>
<td>2014</td>
<td>226</td>
<td>173</td>
<td>76.5</td>
<td>323</td>
<td>215</td>
<td>66.6</td>
</tr>
<tr>
<td>Total</td>
<td>2363</td>
<td>1822</td>
<td>77.1</td>
<td>3626</td>
<td>2263</td>
<td>62.4</td>
</tr>
</tbody>
</table>

An ambitious attempt has been made in this paper in order to bring out existing problems, causes of pedestrian accidents and effectiveness of pedestrian crossing facilities at the intersections in Dhaka city and propose standard safety measures to enhance pedestrian safety.

2. PEDESTRIAN TRAFFIC GENERATION IN DHAKA METROPOLITAN (DMP) AREA

Pedestrians are the largest single user group in Bangladesh. Nearly 60 percent of urban trips involved walking alone in Dhaka city and it is particularly prevalent for short trips. In terms of road usage, at some locations, nearly 62 percent of the total user groups in Dhaka are pedestrian (Rahman, Hoque, Mahmud & Ahmed, 2006). The primary reasons behind this situation are insufficient transportation facilities and poor economic condition of the people. Following reasons are also responsible for large pedestrian traffic in DMP area:

- Generation of floating people coming from other districts in order to seek job
- Lack of adequate public transportation services increase the tendency of walking
• Inadequacy of female-friendly public transport system is pushing many women workers and commuters to walk
• Increasing of traffic congestion is also pushing passengers to walk

3. GLOBAL SCENARIO OF PEDESTRIAN ACCIDENTS AT INTERSECTIONS
Pedestrian safety at intersection is a serious matter of concern for the traffic and road safety engineers, researchers and organizations. Enormous statistics and literatures are available related to this region. After studying several literatures, some significant points have been acknowledged that are cited here concisely.

• U.S. national statistics of FHWA has shown that about 79% of total fatalities occurred in non-intersection points and 21% at intersections, where about half of all injury crashes occurred at intersections in 2007. Among the intersection fatalities 39% occurred in rural intersections and 61% in urban intersections.

• On average a pedestrian is killed in a traffic crash every 111 minutes in U.S. (NHTSA 2000)

• Studies have shown that children under the age of 10 are not yet capable of crossing a roadway intersection alone. Young children have not fully developed an awareness of the direction of sound (e.g., an approaching car), peripheral vision, focus and concentration levels, or proper judgment of a car’s speed and distance until after the age of 10 (FHWA & ITE 2000).

• Pedestrians are at risk even at simple stop sign or yield sign intersections because of the common disregard of traffic control devices by motorists.

• Pedestrians have not been accorded equal status with vehicles at intersections. Roadways have been designed and constructed primarily to accommodate vehicular traffic rather than pedestrians.

• About one-third of fatal collisions with pedestrians are the result of pedestrians disobeying intersection traffic control or making dangerous judgments in attempting to cross a street (FARS 2000).

• Collisions with pedestrians occur far more often with turning vehicles than with straight-through traffic. Left-turning vehicles are more often involved in pedestrian accidents than right-turning vehicles, partly because drivers are not able to see pedestrians to the left as well (Insurance Institute for Highway Safety, 2000).

• Pedestrians involved in crashes are more likely to be killed as vehicle speed increases. The fatality rate for a pedestrian hit by a car at 20 mph is five per-cent. The fatality rate rises to 80 percent when vehicle speed is increased to 40 mph (Ibid.).

4. ACCIDENTS SCENARIO IN DHAKA METROPOLITAN (DMP) AREA
High accident rate makes Dhaka metropolitan city as one the vulnerable cities of the world. Table 1 shows that, a total number of 3626 traffic accidents occurred during 2007 to 2014 in this city. Bayes (2012) found that excessive speed of the vehicles, negative attitude of drivers, road users’
unconsciousness, mechanical failure of the vehicles and poor traffic control and intersection management have been identified as the reasons behind these accidents. In terms of collision type, hit pedestrian is the most dominant 2088, (58%), rear end collision is in second position 834, (23%) and head on collision is in the third position 225, (6%) in DMP area. Figure 1 demonstrates the collision type in percentage from 2007 to 2014 occurred in DMP area.

![Collision Type (%) in Dhaka City (2007-2014)](image)

**Figure 1: Collisions Type in Dhaka City**

5. **PEDESTRIAN ACCIDENTS IN DMP AREA**

From 2007 to 2014, total 1822 pedestrian fatal accidents occurred in DMP area with 1865 fatalities and 585 injuries (Grievous plus Simple). Table 2 shows the pedestrian casualty scenario in Dhaka metropolitan city during 2007-2014.

<table>
<thead>
<tr>
<th>Year</th>
<th>Fatality</th>
<th>Grievous Injury</th>
<th>Simple Injury</th>
<th>Total Casualty</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>267</td>
<td>85</td>
<td>6</td>
<td>358</td>
</tr>
<tr>
<td>2008</td>
<td>299</td>
<td>81</td>
<td>19</td>
<td>399</td>
</tr>
<tr>
<td>2009</td>
<td>253</td>
<td>75</td>
<td>11</td>
<td>339</td>
</tr>
<tr>
<td>2010</td>
<td>238</td>
<td>66</td>
<td>6</td>
<td>310</td>
</tr>
<tr>
<td>2011</td>
<td>202</td>
<td>52</td>
<td>10</td>
<td>264</td>
</tr>
<tr>
<td>2012</td>
<td>213</td>
<td>30</td>
<td>11</td>
<td>254</td>
</tr>
<tr>
<td>2013</td>
<td>203</td>
<td>41</td>
<td>8</td>
<td>252</td>
</tr>
<tr>
<td>2014</td>
<td>190</td>
<td>44</td>
<td>13</td>
<td>247</td>
</tr>
<tr>
<td>Total</td>
<td>1865</td>
<td>474</td>
<td>84</td>
<td>2423</td>
</tr>
</tbody>
</table>

From Table 1 and Table 2 it is obvious that, a significant number of pedestrian accidents occurs in Dhaka city every year with a large number of resulting casualties. Though percentage of pedestrian accident in Dhaka city shows an increasing trend according to Table 1, the number of all accident as
well as pedestrian accident and pedestrian casualty maintains a decreasing trend. Figure 2 demonstrate this declining trend.

![Pedestrian Accidents and Casualties in DMP Area (2007-2014)](image)

**Figure 2: Pedestrian Accidents and Casualties in Dhaka Metropolitan Area**

### 6. TRAFFIC ACCIDENTS AT INTERSECTIONS IN DMP AREA

Out of total 3624 accidents, about 63% occurred at non-intersection areas and 37% at intersections in Dhaka metropolitan city. Again 15% of total accidents occurred at “Tee” intersection and 12% at “Cross” intersection during 2007 to 2014. Figure 3 demonstrates the traffic accidents at intersections in Dhaka city during 2007-2014.

![Traffic Accidents at Intersections in DMP Area (2007-2014)](image)

**Figure 3: Traffic Accidents at Intersections in Dhaka City**

From the figure, it is clear that, significant portion of the traffic accidents occurred at Cross intersection and Tee intersection in DMP area in the period of 2007-2014.
7. PEDESTRIAN ACCIDENTS AT INTERSECTIONS IN DMP AREA

Heterogeneity of vehicles, turning and maneuvering, inadequate crossing facilities and random road crossing phenomena make intersections in Dhaka city a more complex point. In Dhaka city, 54 intersections have been identified by Accident Research Institute (ARI) as hazardous where at least one accident occurred during 2009-2014. Among them, Table 3 shows 17 most accident prone intersections in Dhaka city where at least 5 accident occurred.

Table 3: Hazardous Intersections in Dhaka City

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Name of Intersection</th>
<th>Type</th>
<th>Total Accident</th>
<th>Pedestrian Accident</th>
<th>% of Pedestrian Accident</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Farmgate</td>
<td>Multiple</td>
<td>19</td>
<td>9</td>
<td>47.4</td>
</tr>
<tr>
<td>2</td>
<td>Jatrabari</td>
<td>Roundabout</td>
<td>16</td>
<td>11</td>
<td>68.8</td>
</tr>
<tr>
<td>3</td>
<td>Saidabad</td>
<td>Tee</td>
<td>16</td>
<td>14</td>
<td>87.5</td>
</tr>
<tr>
<td>4</td>
<td>Bijoy Sarani</td>
<td>Cross</td>
<td>10</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>Joar Shahara</td>
<td>Tee</td>
<td>10</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>Progoti Sarani (Badda)</td>
<td>Tee</td>
<td>9</td>
<td>1</td>
<td>11.1</td>
</tr>
<tr>
<td>7</td>
<td>Topkhana-Purana Paltan</td>
<td>Cross</td>
<td>8</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>Shahbag</td>
<td>Roundabout</td>
<td>8</td>
<td>3</td>
<td>37.5</td>
</tr>
<tr>
<td>9</td>
<td>Shapla Chattar</td>
<td>Roundabout</td>
<td>7</td>
<td>5</td>
<td>71.4</td>
</tr>
<tr>
<td>10</td>
<td>Postagola (Railway crossing+ Madrasha Rd crossing)</td>
<td>Cross</td>
<td>7</td>
<td>2</td>
<td>28.6</td>
</tr>
<tr>
<td>11</td>
<td>Kakrail Traffic Signal</td>
<td>Stag-X</td>
<td>7</td>
<td>2</td>
<td>28.6</td>
</tr>
<tr>
<td>12</td>
<td>Moghbazar</td>
<td>Cross</td>
<td>6</td>
<td>2</td>
<td>33.3</td>
</tr>
<tr>
<td>13</td>
<td>GPO (Abdul Gani Rd.)</td>
<td>Multiple</td>
<td>6</td>
<td>2</td>
<td>33.3</td>
</tr>
<tr>
<td>14</td>
<td>Motijheel</td>
<td>Cross</td>
<td>5</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>15</td>
<td>Green Road (in front of Science Lab)</td>
<td>Tee</td>
<td>5</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>16</td>
<td>Shatrasta Round Circle</td>
<td>Roundabout</td>
<td>5</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>17</td>
<td>Mahakhali Crossing</td>
<td>Tee</td>
<td>5</td>
<td>3</td>
<td>60</td>
</tr>
</tbody>
</table>

Figure 4 illustrates the most hazardous intersections in terms of pedestrian accident. Analyzing Table 3 and Figure 4 it can be said that Farmgate, Jatrabari and Saidabad are the worst intersection in Dhaka city in terms of both total accident as well as pedestrian accident.
8. PEDESTRIAN CROSSING FACILITIES AT INTERSECTION IN DMP AREA

An extensive field survey has been carried out in order to find out pedestrian crossing facilities at intersection in Dhaka city. Survey has been conducted at 20 intersections. During the survey availability of pedestrian crossing signs, pedestrian traffic signals and conditions of crosswalk markings and their effectiveness have been observed. Following figure shows the survey results.

Figure 5 shows that, 50% intersections have Crosswalk signs, 65% have Pedestrian Traffic Signals, 30% have Crosswalks Markings and 15% intersections have no pedestrian crossing facilities in Dhaka city.

9. MAJOR PROBLEMS IDENTIFIED FROM FIELD SURVEY

A number of problems have been identified from the field investigation in study area regarding the pedestrians’ convenience. Some of them are:
9.1. **Ineffective Pedestrian Crossing Control Devices**
Field investigation has shown that, 61% of the signalized intersections have pedestrian traffic signal (at least at one approach of the intersections) in DMP area. But they are not in effective use. Therefore pedestrian passes intersection randomly. Again nearly 28% of the signalized intersections have crosswalk markings. But they do not have advance crossing signs. Most of the crosswalks are zebra crossing type with faded markings. Therefore drivers cannot detect the crossing marks at a distance.

9.2. **Vehicles Occupied Crosswalks**
Field investigation also shows that, the vehicles do not stop beyond the stop line at intersections. They attempt to go as far as possible in the leg of the intersections and occupy the crosswalks. This situation creates hindrance to the pedestrian to cross the roads.

9.3. **Manual Operation of Intersections**
Most of the signal controlled intersections are operate manually by traffic police in Dhaka city. Therefore late coming drivers often disobey police and try to pass intersection quickly. This attitude increases pedestrian fatality risk at intersections.

9.4. **Raised Crosswalks at Exits**
Although raised crosswalks should be installed at the approaches of the intersections, they are found to be installed at exits of some intersections (like Shahbag). As a result they have failed to fulfill installation purposes and are not working effectively.

9.5. **Lack of Authorized Bus Stops**
Due to the lack of adequate authorized bus stops, most of the buses stop near intersection in Dhaka city. Therefore, competition among the drivers for pedestrian loading and unloading makes the intersections more hazardous for pedestrians.

9.6. **Competition among Drivers**
Rushing and competition among pedestrians to catch bus cause haphazard crossing of intersection and increase probability of accidents.

9.7. **Teenager’s Unconsciousness**
Pedestrian, especially teenagers are found to cross roads with headphone in ears in Dhaka city. Sometimes they fail to hear vehicular horn and accidents occur.

9.8. **Illegally Occupied Footpath**
Hawkers, mini tea stall etc. occupied the footpath or sidewalks illegally near the intersection that forces pedestrians to walk through the carriage way of the roads and exposes them to the vehicles. Therefore probability of accidents increase.

9.9. **Lack of Uses of Overpass**
In Dhaka city few intersections have Overpass facility (like Science laboratory intersection). But most of the cases they are not attracted to pedestrians and occupied by the hawkers. Therefore pedestrians cross the road creating serious safety hazards.
9.10. Illegal On-street Parking
Illegal vehicle parking on footpaths and on-street parking near the intersections create obstruction to the pedestrian to watch the vehicles during road crossing. They also push the pedestrian to walk through the road which exposes them to the vehicles.

9.11. Garbage Stock
Thrown out of garbage or open dustbin near the intersections also forces pedestrians to walk through the carriage way of the roads which increases pedestrian’s risk.

9.12. Poor Construction Materials
Using of poor construction materials often creates water logging and muddy situation on the sidewalks during the rainy season (monsoon) causing people not to use the sidewalks rather using the carriage way of the roads.

9.13. Absent of Footpath Barrier
Footpath barriers are mainly found near the intersections and at some high pedestrian activities areas (like Farmgate intersection). But large portion of the footpath does not have this facility. For this reason, the effectiveness of the footpaths near the intersections is greatly reduced.

9.14. Drivers’ Perceptions
Survey result shows that, most of the drivers do not want to take responsibilities for pedestrian casualties. They blame poor traffic control system, poor traffic management and random pedestrian crossing from any section of the roads at the intersections. Lack of using crosswalks is also acknowledged as a reason for these casualties by drivers. But they hardly confess, over speed is one of the main reasons for the accidents.

9.15. Pedestrians’ Perceptions
In contrast, pedestrians specify, over speed of the vehicles is the main reason for the accidents. Again illegal hawkers on footpath and on-street parking compel them to use carriages that increase the probability of accidents. Poor management of pedestrian traffic signals, lack of overpass facility and faded crosswalk markings are also acknowledged as the reasons for the accidents.

10. CONCLUSIONS AND RECOMMENDATIONS
Condition of pedestrian crossing control devices in 20 intersections of DMP area were observed in this study. The goal was to bring out accidents characteristics and effectiveness of available pedestrian safety facilities along with perceptions of intersection users (pedestrians and drivers). Field observation shows that removal of garbage stock near the intersections, prohibition of illegal parking and hawkers and uses of foot over bridge can make the intersections pedestrian friendly. Again proper education of the drivers, obeying signs and signals and positive attitude can reduce accidents effectively.

In order to eradicate pedestrian’s risk and make intersections safe some recommendations are:

10.1. Improvement of Geometric Features
- Sidewalks should be liberated to ensure safer pedestrian movements. On-street parking near the intersections should be prohibited in order to ensure eye contact among the pedestrians and drivers during crossing. Enhanced enforcement by police can focus on intersections with high numbers of pedestrian collisions.
• Traffic calming measures (raised crosswalks, raised intersections, traffic circles etc.) that increase pedestrian safety should be installed at the intersections of residential areas.

• A roadway edge treatment such as curb extensions also called “neckdowns” can be used at the location of a pedestrian crosswalk to minimize the distance and time that a crossing pedestrian must be in the roadway.

• Textured, brick, and/or colored pavement treatments are effective in reducing speed of the vehicles as well as increase pedestrian safety. These treatments are feasible for the intersections of residential areas.

• Crosswalks should be marked at all intersections where there is substantial conflict between vehicular and pedestrian movements. Crosswalk lines should not be used indiscriminately. Retro-reflective pavement markings are feasible at any location serving as a marked crosswalk.

10.2. Modern Crossing Facilities

• To provide crossing assistance to pedestrians with vision impairment at signalized intersections Audible Pedestrian Traffic Signals may be used. They are feasible to provide crossing information to people with disabilities at the area of high pedestrian generators, midblock intersections, “Tee” Intersections and multi-phase traffic signal intersections. They should be activated by a pedestrian signal push button with at least a one second-delay to activate the sound (ITE, 2009).

• The intersections where there is combination of both lower traffic volumes and lower pedestrian volumes, pedestrian actuated Rectangular Rapid Flash Beacons (RRFBs) can be used.

• Research provided by the FHWA (2000) recommends that adequate night time lighting should be provided at marked crosswalks to enhance the safety of pedestrians crossing at night. Crosswalk lighting will be provided at all crosswalks utilizing traffic signals, HAWK beacons and RRFBs. Crosswalk lighting will be provided at all other marked crosswalks, unless engineering judgment suggests crosswalk lighting is not needed.

10.3. Increasing of Pedestrian Awareness

• While crossing, a pedestrian should use all senses and not use cell phone and head phone for calls, texting and listening songs.

• As pedestrians are not always clear about the meaning of pedestrian signal indicators mainly children, guidance for pedestrians at crossing may serve to alleviate situations that could reduce the conflicts or incidents with motor vehicles.

• Course related to road safety, pedestrian behavior and accidents should be included at primary curriculum for the students.

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North Central Section Institute of Transportation Engineers (NCITE), 2009. Guidance for the Installation of Pedestrian Crossing Facilities, section C, page no. C-14