

SAFER ROADS IN BANGLADESH: ADDRESSING THE CHALLENGES OF ROAD INFRASTRUCTURE SAFETY AND LINEAR SETTLEMENTS

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ABSTRACT

Road traffic injuries are one of the major causes of mortality, morbidity and disability in Bangladesh. About one-fifth of injury related hospital admissions are due to road traffic accidents. According to the World Health Organization (WHO), nearly 20,000 deaths from road traffic crashes are estimated to occur annually in Bangladesh, while around 4000 deaths are officially reported. Nearly 80 percent of road traffic fatalities are attributed to Vulnerable Road Users (VRUs)-pedestrians, bicyclists, motor cyclists and users of informal and unsafe motorized and non-motorized transport. It is the poor that are most seriously affected with consequences of plunging poor households into acute poverty. Indeed the tragic premature, healthy and costly lives, permanent disabilities and property damages are exacerbating poverty reduction efforts particularly in rural areas. About 70 percent of road accident fatalities occurred in rural areas including rural sections of national and regional highways. Heavy vehicles, especially buses and trucks are mostly involved in fatal accidents. The road environmental factors are particularly prevalent with major roadway defects in design and layout, shoulders, road sides, bridge and its approaches, delineation devices and lack of access controls and others. Unregulated private/business access to inter-urban highways leads to endless linear settlements resulting in high risks for pedestrians and other vulnerable road users.

This paper presents an overview of road safety in Bangladesh and argues that road infrastructure and environmental deficiencies are particularly prevalent in accidents and casualties. It emphasizes that engineering safety on the road is clearly a priority issue which indeed emerges as a serious challenge in Bangladesh. It then outlines some promising yet most urgent actions of road safety engineering improvements under the safe system approach with particular regard to the issue of addressing linear settlements along the high speed road networks both in the context of urban and rural areas.

1. INTRODUCTION

With the tremendous global burden of the 1.3 million deaths resulting from road traffic crashes, as well as a further 50 million sustaining non-fatal injuries each year, low and middle income countries like Bangladesh are now experiencing a serious road safety crisis. The situation is predicted to worsen in the coming years unless this critical problem of epidemic nature is seriously addressed with significant improvements in the relevant sectors in a sustainable manner. According to the World Health Organization (WHO), nearly 20,000 deaths from road traffic crashes are estimated to occur annually in Bangladesh, while around 4000 deaths are officially reported. Nearly 80 percent of road traffic fatalities are attributed to Vulnerable Road Users (VRUs)- pedestrians, bicyclists, motor cyclists and users of informal and unsafe motorized and non-motorized transport. It is the poor that are most seriously affected with consequences of plunging poor households into acute poverty. Indeed the tragic premature, healthy and costly lives, permanent disabilities and property damages are exacerbating poverty reduction efforts particularly in rural areas. About 70 percent of road accident fatalities occurred in rural areas including rural sections of national and regional highways. Heavy vehicles, especially buses and trucks are mostly involved in fatal accidents. The road environmental factors are particularly prevalent with major roadway defects in design and layout, shoulders, road sides, bridge and its approaches, delineation devices and lack of access controls and others. Unregulated private/business access to inter-urban highways leads to endless linear settlements resulting in high risks for pedestrians and other vulnerable road users.

This paper presents an overview of road safety in Bangladesh and argues that road infrastructure and environmental deficiencies are particularly prevalent in accidents and casualties. It emphasizes that engineering safety on the road is clearly a priority issue which indeed emerges as a serious challenge in Bangladesh. It then outlines some promising yet most urgent actions of road safety engineering improvements under the safe system approach with particular regard to the issue of addressing linear settlements along the high speed road networks both in the context of urban and rural areas.

2. ROAD SAFETY OVERVIEW IN BANGLADESH

2.1 The Problem Characteristics

Road traffic injuries are one of the major causes of mortality, morbidity and disability in Bangladesh. About one-fifth of injury related hospital admissions are due to road traffic accidents. Children are highly vulnerable in the traffic situation compared with many other countries of the world. Road traffic crashes are the leading cause of death for children aged between 10-14 years.

There were at least 3765 reported fatalities in Bangladesh in 2008. It is estimated that the actual fatalities could well be 20,038 each year, which equates to a death

rate of 12.7 deaths per 100,000 population. In economic terms, road accidents in Bangladesh cost the community in the order of US \$ 1000 million, nearly 2% of GDP. The reported number of fatalities has been increasing from 1009 in 1982 to almost 3765 in 2008, nearly 4 times in 26 years period showing an increasing trend in recent years. In terms of vehicle ownership, the statistics revealed that Bangladesh has one of the highest fatality rates internationally in road accidents, over 100 deaths per 10,000 motor vehicles.

About 70% of road accident fatalities occurred in rural areas including rural sections of national highways. Almost 80% of fatalities are vulnerable road users e.g. pedestrians, bicyclists and motorcyclists. Pedestrian-vehicle conflicts are clearly the greatest problem with significant involvement of trucks and buses. It has been observed from the studies that up to 62% of urban road accident deaths are pedestrians alone and in Dhaka city, they represented nearly 70%. Some further more frequently occurring features of accidents are (Hoque and Mahmud 2009a):

- Of the total reported accidents nearly 50 percent occurred on national and regional highways.
- The severity of accident outcomes on highways is often devastating with a result of involving many fatalities and injuries, up to 60 deaths and 150 injuries on the spot.
- Accidents and fatalities on national highways are characterized as clustering on selected sections, identified as Hazardous Road Locations (HRLs), nearly 40 percent of accidents concentrated on around 2 percent of the highway network, demonstrating that accidents are amenable to site specific treatments.
- Accident type analysis showed 'hit pedestrian' as the dominant accident type both in urban and rural areas, 45 percent involvement in fatal accidents. Other common accident types are: rear end collision (16.5%), head on collision (13.2%) and overturning (9.3%).
- Heavy vehicles such as trucks and buses including minibuses are major contributors to road accidents (bus/minibus 33%, trucks 27%) and in fatal accidents their shares are 35 percent and 29 percent respectively.
- About 2.5 percent of reported accidents occurred on bridges and culverts

The principal contributing factors to accidents are adverse roadway and roadside environment, poor detailed design of junctions and road sections, excessive speeding, overloading, dangerous overtaking, reckless driving, carelessness of road users, failure to obey mandatory traffic regulations, variety of vehicle characteristics and defects in vehicles and conflicting use of roads. The road environmental factors are particularly prevalent. Typical road crash, road safety hazards are shown in the photographs (Figs.1-12).



Fig.1: Typical crash, roadway hazards and road environmental deficiencies for safety

2.2 Major Safety Issues of Concern

Apart from the preceding accident characteristics other road safety issues of concern are:

- **Under-reporting accidents:** This limits proper accident analysis to be carried out towards improving and monitoring road safety
- **Defective and road unworthy motor vehicles:** Presence of defective and road unworthy motor vehicles on road poses a threat to safety of road traffic.
- **Drivers incompetency:** Incompetent drivers and driving with open and widespread use of fake licenses appear to a major concern to safety on our roads. Strict licensing requirement is critically important.
- **Road engineering and environmental deficiencies:** Significant and serious road safety engineering and design deficiencies are most prevalent in many locations.
- **Inadequacy in police inspection and law enforcement:** The current level of traffic law enforcement, vehicular regulations and road users education is exceedingly low in Bangladesh and efforts in this regards require strengthening.
- **Poor road user behaviour and safety education:** Road user behaviour is much less disciplined than desirable. There is clearly a need to improve road safety education and improved road user behaviour and knowledge towards compliance of road discipline.
- **Institutional weakness:** Road safety improvement efforts in Bangladesh seriously suffer from several serious drawbacks viz. lack of strong professional safety agency with adequate executive powers and responsibilities; fragmentation of responsibilities between agencies; lack of professional capacity; lack of trained traffic police for effective enforcement and traffic regulations; absence and inadequate dissemination of road safety research, and too few resources directed towards tackling the safety problem.

3. ROAD INFRASTRUCTURE AND LINEAR SETTLEMENT FACTORS

3.1 The Context of the Problem

Road environment and roadside frictions resulting from so called linear developments are not of course the only factors contributing to accidents, nor are they the only focus of road safety programs. However, they are significant. The World Road Association PIARC has noted that unregulated linear settlements are now the worldwide disaster for road safety, particularly in developing countries like Bangladesh.

As discussed in the previous section, accidents are highly clustered at some specified locations and many major accidents also frequently occurred at those locations. Studies revealed that about 45 percent of national highway accidents occurred in only 2 to 5 percent length of its total network resulting in a total of 280 to 350 locations identified as hazardous of having varying section lengths between 0.1 - 0.5 km each location.

Selected hazardous locations were studied by conducting on site visits and in-depth investigations. The specific road and road environmental hazards and the conflicts of roadside linear developments were also identified. Studies in particular, gather roadway geometric and environmental conditions, nature and operational behavior of traffic, roadside development patterns and conflicts, traffic management practices, abutting socio-economic and land use activities and discussion with the neighborhood people. Data from these sites visits together with information from neighboring community were assembled for assessing the safety risk and needed corrective measures.

The following sections present some of the prevalent hazards relating to roadway infrastructure factors and roadside developments. Most striking features and roadway deficiencies common to all locations were briefly discussed with photographs showing the conflicts and deficiencies. More details can be in Hoque & Mahmud (2009b) and Hoque et al. 2010. Unregulated access to highways leads to endless linear settlements with high risks for pedestrian and other vulnerable road users.

3.2 Hazardous Road Locations: Case 1 On N3 Highway

Bhoradoba market is located near Bhaluka on the Dhaka -Mymensingh National Highway (N3). This market area is one of the most accident prone locations of the N-3 with a section length of 200 meter. There were 12 accidents having 17 fatalities with a total of 28 casualties in the period of 6 years. According to the local people the accident rate is very high with nearly 1 fatal accident per month. Pedestrians and Motorcyclists are the most vulnerable groups.

There are a number of shops, saw mills, hotels, tea stalls, rickshaw and tempo workshops, a police box and a local trading center which plies mainly on weekly market days (Sunday & Wednesday) around the area. On the market

days large number of people gathered from adjacent areas and make the place highly crowded. More over there are a number of schools and spinning mill adjacent to the area which also generate considerable number of pedestrians.

The striking locational features and road environmental and traffic hazards are discussed.

3.2.1 Road and Roadside Conditions:

- This is a straight road section with two staggered access roads, one of which is linked with Ghatail Cantonment and Jamuna Bridge.
- Unmarked pavement condition is considered to be good. Smooth road surface and no potholes or undulations were found. However there is no usable shoulders or edge and centre line markings on the road.
- There is no dedicated sidewalk or cross walk facilities for pedestrians and absence of regulatory/warning signs or signals.
- Most of the temporary shops and stalls are built just besides the road which obstructs the visibility when traffic from access roads merges into the main traffic stream.
- Very complex and high roadside frictions with variety of local activities and functions due to high concentration of retail/trading centers.
- Overall situation is worsen by illegally use of the roadsides for piling of wooden logs and other goods, parking and loading /unloading activities which force the pedestrians use the high-speed road carriage way.



Fig.2: Roadside temporary shops and damage roadsides



Fig.3: Stack of materials close proximity of roadsides



Fig.4: Tempos picking up passengers on roads are real danger for through



Fig.5: Uncontrolled and poorly designed access road

3.2.2 Roadside Friction and Conflicts:

- High speed, high occupancy through traffic mostly commercial vehicles very often have conflicts with local low speed operated minibuses, tempos and other non-standard vehicles, particularly NMVs from access roads. Traffic from unmarked access roads also creates hazards.
- The volume of motorcycle traffic is also high and most of the riders don't use safety helmet which makes them one of the prime vulnerable road user groups.

- Non-motorized vehicles like rickshaws, handcarts, and bicycles are also frequent on the highway and share the same carriageways in the absence of treated shoulders.

3.2.3 Pedestrian Activities and Facilities:

- The adjacent educational institutes and shopping activities generate considerable amount of pedestrian traffic.
- Pedestrian activities and volume become critical on the market days and very often encroach paved roadways.
- There are no dedicated pedestrian sidewalk or crosswalk facilities and refuges.
- No barriers or pedestrian guardrails have been provided to regulate their movements and therefore exposes them to significant danger.

3.3 Hazardous Road Location: Case 2 on N5 Highway

Polashbari Bus Stand is located on the National Highway - 5 (N-5) which is near Gaibandha district and some 270 km away from Dhaka. The location encompasses a section length of 1.7 kilometre (270.4 - 272.1 km). There were 19 accidents having 29 fatalities with a total of 32 casualties in the period of 6 years. Hit pedestrian is the most dominant type of accident (47 %), followed by 'side-swipe' (21 %), 'rear end' (15 %) and 'head on' (12 %). The peak hours of accidents are between 6.00 am and 9.00 am and 12.00 pm to 1.00 pm. Most accident victims are in the age group of 26-35 years. Buses are the most frequent vehicle type involved in accidents and fatalities accounting for about 40 percent of the total accidents. According to the local people, each day many collisions occur involving bicycle/rickshaws motorcycles and pedestrians resulting in simple/grievous injuries which are not usually reported.



Fig.6: Unregulated and conflicting use of roadway, high pedestrian & NMV movement and adjacent linear developments

It is an important growth centre. Many shops have been developed along both sides of the highway. These shops and several shop-related activities restricts pedestrians from using the shoulders along highway (see Figures 5). Furthermore, they create significant visibility problems when traffic from access roads merges into the main traffic stream. In addition to markets and shops, a cinema hall, a spinning mill and a fueling station are just beside this highway which are attracting significant number of traffic.

3.3.1 Traffic Characteristics:

- The composition of the vehicles plying on the highway shows that non-motorized vehicles (NMVs) are particularly predominant, 69 percent.
- Motorcycles accounted for nearly 15 percent of the total traffic volume. Most of the riders do not use safety helmets.
- The shares of buses, trucks, and car/jeep/tempo were 8 percent, 5 percent and 3 percent respectively.
- The conflicts between the high speed through traffic and local traffic particularly pedestrians and other NMVs are frequent. No regulatory measures were installed to control the speed of the vehicles passing through the section of the market area.
- Observed average spot speed for all motorized vehicles of 51 km/hr was found and for the buses the mean speed was around 69 km/hr which is considered to be quite high for such a busy high intensity built-up area of local activity.
- Since this location is the central place of all economic, social and cultural activities of about seven adjoining villages, massive pedestrian activities are observed and the volume of pedestrians becomes highest during the *Hat* days. The pedestrian movement is dispersed, numerous and unregulated. There are no dedicated pedestrian sidewalk or crosswalk facilities and due to encroachment of shoulders, pedestrians are forced to use the carriageway.



Fig.7: Truck loading, standing and roadside objects and roadside development

3.3.2 Observed Environmental Hazards:

Significant road environmental and traffic operation hazards were observed almost similar to that outlined in case study one. These include: uncontrolled road side land use development; road space occupation by road traders and commercial activities; high intensity NMV traffic in the absence of NMV facilities; vehicle loading/unloading, parking and damaged/broken vehicles on roadways; absence of designated off carriageway bus stops, pedestrian facilities; road shoulder defects; road side objects; obstruction and vegetations, absence of road markings and other delineation devices and frequent uncontrolled abutting access and local side road accesses.



Fig.8: Typical road users' movements and roadside objects and hazards

3.4 Hazardous Road Location: Case 3 on N5 Highway

Chowdhury Hut Bus Stand is located on the National Highway - 5 (N-5) which is near Dinajpur district and 441 km away from Dhaka. Within 0.2 km of the Bus Stand there is a high school, a girls' school, two primary schools, a girls' college, a degree college, a madrasah and a spinning mill. These educational institutes attract commuters on a daily basis and the density reaches its peak during *weekly market* days with high intensity of pedestrian activities.



3.4.1 Accident Characteristics

Among all types of accidents, 'hit pedestrian' is the major crash type. The peak time of occurring accidents is 8.00 to 9.00 am and 1.00 to 2.00 pm. This clearly indicates that school and college students (6 to 20 years age group) are mostly prone to accidents. Bus accidents and fatalities account 45 percent of the total. Motorcycle is also significant.



Fig.9: Loading of vehicles, piled logs on the roadway shoulder creating serious hazards & visibility obstructions-informative sign ('school ahead') is hardly visible due to adjacent land developments

3.4.2 Geometric Features and Unregulated Roadside Activities:

- The roadway is a two lane two-way highway having no median.
- The roadway section is straight having unauthorized accesses on to the roads.
- The shoulder of the roadway was found to be treated but in several places it was found to be occupied due to heavy vehicle loading/unloading activities.
- Standing NMVs, small motorized vehicles (e.g. van, pick-up, tempo etc.) and piled logs often substantially impede traffic flows and create severe safety hazards.
- Temporary shops during weekly market days cause serious conflict and visibility obstructions

3.4.3 Traffic Factors:

- The composition of the vehicles plying on the highway shows that non-motorized vehicles (NMVs) are predominant (almost 64 %).
- Nearly 20 percent of the total volume of traffic is motorcycle, and most of the riders do not use safety helmet.
- Buses, trucks, and car/jeep/tempo occupy 5 %, 7 % and 3 % of the total traffic volume respectively.



Fig.10: Unloading of passengers on the through lane of the high speed road and temporary shops fronting the main road create severe road safety

- The conflict between the high speed through vehicles and local low standard vehicles is significant. No regulatory measures were installed to control speeds of the through vehicles passing through the section of the built up area.
- An average of 48 km/hr spot speed was found for all vehicles and the average speed of the inter-district high standard buses were around 70 km/hr which is quite high for such a busy market place.
- Haphazard and undisciplined pedestrian movements are very marked and during weekly market days pedestrian density increases to a significant level. Illiteracy and lack of awareness of the villagers often lead them toward risky situations.
- Parking and loading/unloading of vehicles often encroach the shoulder which force pedestrians to use the carriageway. This is not only dangerous for them but also reduces the effective width of the highway.
- There is no designated space for bus stops.
- No regulatory traffic signs and edge line markings were found in the highway segment. Informative signs are poorly maintained.



Fig.11: Research team conducting the field investigations of high accident location

4. iRAP INFRASTRUCTURE RISK ASSESSMENT OF TWO HIGHWAYS

The International Road Assessment Program (iRAP) Bangladesh Pilot Project provided the first comprehensive infrastructure risk assessment of the N2 and N3 Highways. N2 National Highway connects the capital of Bangladesh, Dhaka, with Sylhet and N3 National Highway which connects Joyedpur and Mymensingh. These are two of Bangladesh's busiest highways, carrying between 10,000 motorised vehicles per day (vpd) and 85,000 vpd, as well as catering for significant numbers of pedestrians, bicyclists and other non-motorised vehicles. For much of their lengths, these two highways fit a classic linear settlement model, with the high speed roads passing through many built up areas. According to police reported data, about 180 people and 89 people were killed in traffic crashes on the N2 and N3 respectively in 2008. However, there is evidence to suggest that these numbers are understated.

The assessment showed that despite recent large-scale upgrades to the N2, road users still face a high level of risk. The N3 is also categorized as high risk for all road users. Following the inspections and coding of the road infrastructure attributes, a Road Protection Score (RPS) was calculated (see iRAP 2010). The RPS is based on a series of risk factors that relate road infrastructure with the relative likelihood of crashes and their severity, the higher the score, the greater the risk. These RPS forms the basis of the Star Ratings where by 5-star roads are the safest while 1-star the least safe. Table 1 provides a summary of the Star

Ratings of each of the roads by road user type (see also Figure 12 for Star Ratings and road attributes). Concerningly, the majority of the N2 and N3 are rated 2-stars or less (out of a possible 5-stars) for all road users- indicative of serious road infrastructure deficiencies and uncontrolled linear developments fronting the highways.

	Vehicle occupants		Motorcyclists		Bicyclists		Pedestrians	
	Length (km)	%	Length (km)	%	Length (km)	%	Length (km)	%
Highway N2								
5 Star	2	1%	1	0%	0	0%	0	0%
4 Star	14	6%	11	5%	2	1%	0	0%
3 Star	45	20%	7	3%	4	2%	4	2%
2 Star	160	70%	147	64%	213	93%	225	98%
	8	3%	63	28%	5	2%	0	0%
Not rated	0	0%	0	0%	5	2%	0	0%
Total	229	100%	229	100%	229	100%	229	100%
Highway N3								
5 Star	0	0%	0	0%	0	0%	0	0%
4 Star	6	7%	6	6%	0	0%	0	0%
3 Star	13	15%	1	1%	2	2%	2	2%
2 Star	60	67%	47	53%	49	55%	88	98%
	10	12%	36	41%	38	43%	0	0%
Not rated	0	0%	0	0%	0	0%	0	0%
Total	90	100%	90	100%	90	100%	90	100%

Table 1. Overall Star Ratings for the N2 and N3

Note: numbers might not add due to rounding (Source: iRAP, 2010).

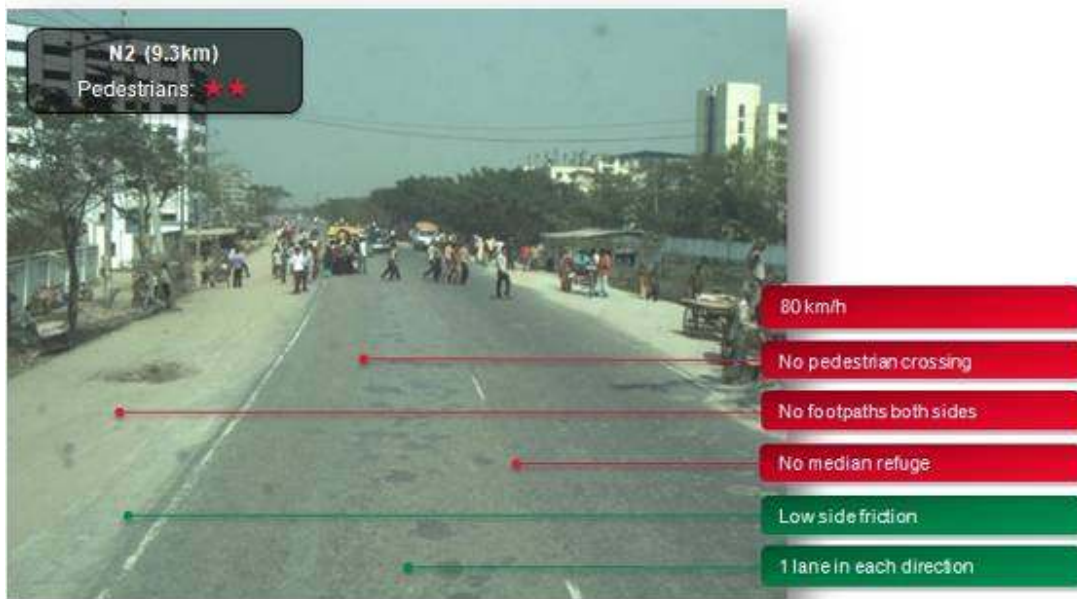


Fig.12: A section of Highway N2 rated 2-stars for pedestrians (Source: iRAP, 2010).

5. THE ROAD SAFETY CHALLENGES AND PRIORITY ACTIONS

As demonstrated in the preceding sections, many of the observed characteristics of accidents and fatalities are indicative of problems and deficiencies associated with road infrastructure and roadside environment. Observations during the iRAP road inspections also revealed the enormity of the road safety challenge. One of the key issues that emerged during the assessments is safety in built-up areas/trading centers along major highways where there is significant roadside development, high side friction, large numbers of pedestrian movements and significant intersections. These locations represent zones of increased risk, especially for vulnerable road users. The high level of activity that occurs in the commercial and trading areas along the major roads often happens because the road has been there for many years and it has been the stage for the essential 'liveability' of the area – commercial, social, functional and recreational activity. This is common for 'linear' developments which become accident blackspots as crossing pedestrians, parked/standing vehicles, slowing and accelerating vehicles come into conflict with fast moving through traffic.

It is therefore time for Bangladesh like other developing and emerging countries to quickly tighten this area of road infrastructure safety engineering practice. Indeed, in leading developed countries where great progress has already been made on driver behaviour and vehicle safety, national safety strategies show investment in safer infrastructure is expected to deliver twice the casualty saving provided by investment in either behaviour or vehicles (iRAP 2008).

The essential goal of the safe system approach is to provide a road system in which road safety engineering and design principles are geared to recognize that humans make mistakes and are highly susceptible to serious injury in impact. Therefore, safety design and engineering have now emerged as the core function of contemporary road transport safety policies in leading developed countries. Efforts on road infrastructure safety are stimulating and gaining acceptance for sustained improvement of safety and speed management on the network. The specific measures that are gaining increasing importance are road safety impact assessment, road safety audit, network management and safety inspections. Developing countries like Bangladesh however have been slower in devising and adopting such an approach and many roads still remain substandard.

These observations are especially cogent to the situation in Bangladesh where there is specific need and much scope for road environmental improvements aimed at correcting the most common deficiencies through wider application of traffic engineering approaches emphasizing on low cost engineering based improvement schemes. The following promising actions of road infrastructure safety are of prime importance for road safety improvements in Bangladesh. The treatments and approaches would help road infrastructure required to deliver safe system outcomes.

5.1 Accident Black Spot Treatments

Spot safety programs - those that seek to identify, prioritize and treat accident locations that are statistically aberrant have been very successful (Polanis 1995). There is specific need and scope for road environmental improvements aimed at correcting the most common deficiencies in hazardous road locations and accident blackspot in Bangladesh. Accident black spot treatments have demonstrated high economic benefits and therefore demand priority consideration in Bangladesh. Desirably, emphasis should be placed initially on introducing low cost improvement schemes which proved to be highly effective. Typical such safety measures are incorporation and treatments of road shoulders, pedestrian facilities (segregated footways, crossings), junction improvements, treatment of hazards, speed control devices, median barriers, access control, channelisation, traffic islands, skid resistance treatment, improved delineation devices, safety zones etc. including provision of divided roads. Observational and on-scene in-depth studies of selected hazardous locations clearly demonstrate the urgency of strengthening accident remedial works through systematic and widespread application of low-cost road and traffic engineering measures with due regard to the related issues of accident migration effects.

5.2 Road Safety Audits

Alongside accident reduction work, accident and injury prevention work must also be pursued through road safety audit as an important process in road safety engineering. An effective road safety audit process has great potential for improving road safety. Road safety audit being a systematic examination of roadway elements for safety would focus on explicit safety implications and recommend desirable changes or modifications in highway design and operational aspects appropriate to the local safety needs. Road safety auditing or checking is a very essential and systematic step that needs to be introduced to document such widespread safety deficiencies for appropriate corrections. Proactive identification and treatment of accident black spots through road safety audit is considered to be highly beneficial to Bangladesh context. Regular audit of existing roads allow road safety hazards to be identified before they results in accidents.

5.3 Road Inspections and Assessment

This approach has now emerged as a new tool for systematic analysis of road infrastructure deficiencies and provides targeted countermeasures programs to improve road safety across an entire road network. The iRAP tools particularly address the safety of vulnerable road users and asses each stretch of roads for its safety for pedestrians, bicyclists, motor cyclists and car occupants separately. The iRAP methodology offers 'vaccines for roads' are therefore demands priority consideration in Bangladesh for its application with international collaboration. It is important to note and learn that effective safety management of existing road network require infrastructure improvements at targeted locations throughout the road network apart from focusing on just a few black spots that might have high

short term accident experience (iRAP 2008). The ongoing efforts of the International Road Assessment Programme (iRAP) for low and middle income countries could well be extended to Bangladesh and is seen particularly beneficial to develop local road safety capability. The iRAP targets high-risk roads where large numbers are killed and seriously injured and inspects them to identify where affordable programs of safety engineering can reduce large number of deaths and serious injuries on the basis of strong partnership for key local stakeholders. The PIARC proactive Road Safety Inspection tool provides further opportunity for systematic analysis of infrastructure deficiencies towards recommending safety improvement options (PIARC, 2007) and therefore hoped that significant safety gains can be made from its applications in Bangladesh.

5.4 Strategic Focus and Actions

Importantly, the long term solution to road accident problems particularly in rural areas is to provide a higher quality road system with increased length of divided highways with access control, which have a better safety record than undivided highways.

The safety of the vulnerable road users must also be sufficiently catered for in the road safety strategies and principles. Potential approach to protect these users is by giving special consideration in designing vehicles and roads to ensure that they are not unnecessarily exposed to high speed traffic. It is important to provide physically separated spaces for pedestrians both in the urban and rural areas to minimize their conflicts particularly with heavy vehicles viz. trucks and buses. Innovative efforts and available tools should be applied for the reduction and control of speed through alteration of road design, revised speed limits and enforcement.

The safety challenges of encroachment and unauthorized frontage accesses on to major roads resulting from uncontrolled linear developments should be addressed with utmost priority through land use regulation and control, enforce access control, access management (e.g. provision of service roads, separation of through traffic and local traffic, minimizing intersections etc.) and strategic projects to stimulate such developments in more suitable locations. To take safety forward on a whole scale, it is also important to make efforts to implement policies and infrastructure solutions in the framework of a Safe System approach which recognizes the mutual importance of safe road users, safe vehicles and safe roads.

Importantly, therefore, the pursuit of the above road infrastructure safety improvements however would require clear understanding of the known relationships between accidents experience and various roadway and traffic engineering design features. As such it is of paramount importance to creating a competent cadre of professionals specifically trained in road safety issues and developments of new perspectives on road safety management, supported by developing programs for training and research (Tiwari et al. 2005; Breen 2008)

6. CONCLUDING REMARKS

Bangladesh is facing a considerable road safety challenge, where as many as 55 people are killed in traffic crashes daily. Like many low-income countries, vulnerable road users (including pedestrians, motorcyclists and bicyclists) account for a large proportion of road deaths. It is estimated that pedestrians account for more than half (54%) of all reported road deaths in Bangladesh. The crash study and investigations reported in the paper enabled conclusions could be drawn that road infrastructure deficiencies and linear settlements are indeed a significant safety challenge in Bangladesh. Engineering safety on roads is clearly a priority issue which needs to be pursued seriously by the road authorities and stakeholders in preventing thousands of deaths and injuries. Promising actions of road infrastructure safety improvements are discussed. It is recommended that both reactive (treatment of hazardous locations) and proactive (road safety audit, inspections and assessment) approaches be considered as a matter of urgency for rapid and sustained improvements of road safety at marginal cost.

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