Quantifying highway safety hazards in Bangladesh

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Abstract

Traffic crashes in Bangladesh result in an unacceptably high socio-economic toll that has been growing due to inadequate attention and under-investment in safety. A combination of increasing volume of vehicles on the road, complexity of heterogeneous mix of vehicles, poor road infrastructure, unsafe vehicles, risk taking behaviour of general public, poor enforcement of traffic laws and lack of proper regulation has further aggravated the situation. More than 20,000 deaths from road traffic crashes are estimated to occur in Bangladesh, while 4,000 deaths are officially reported. Nearly 70 percent of road traffic fatalities occurred in rural areas including rural sections of national highways. The majority of the serious crashes is concentrated on a small proportion of high risk roads (e.g. 40% of the crashes took place on 2% of road network) and in many instances are attributable to adverse road environmental conditions. Roadside linear developments pose a serious problem. The safety problems especially for VRUs greatly are compounded by its serious incompatibility of the existing roadway conditions. Concerningly the majority of the highway sections are rated as 2-star or less (out of possible 5-star) as revealed from the results of the iRAP risk assessment of around 1400 kilometers of highways. Significant safety gains can be achieved by implementing affordable road infrastructure measures targeting priority crash types on such high-risk highway sections. This paper has been based on the learning from the ongoing ADB assisted iRAP road infrastructure assessment project and aims to present some of the findings of quantifying hazards associated with roadway design features that are influencing the likelihood of crashes and casualties. It identifies a range of affordable cost-effective road engineering countermeasures within the principles of the Safe System Approach towards achieving the goals and targets of the national road safety strategy for the Decade.

Introduction

The lack of road safety worldwide especially in low and middle income countries is a severe problem that needs to be tackled in a comprehensive and coordinated manner. Recent figure shows that 1.24 million people die due to road traffic accidents each year. About 92% road traffic deaths occur in low-income and middle-income countries although these countries pose only 53% of world's registered motor vehicles (WHO 2013). Death rates from road traffic crashes in low and middle income are often many times higher than the high income countries.

Bangladesh with the lowest motorization level has one of the greatest death rates and requires most cost-effective interventions for improvements. More than 20,000 deaths from road traffic crashes are estimated to occur in Bangladesh, while 4,000 deaths are officially reported. Nearly 70 percent of road traffic fatalities occurred in rural areas including rural sections of national highways. The majority of the serious crashes is concentrated on a small proportion of high risk roads (e.g. 40% of the crashes took place on 2% of road network) and in many instances are attributable to adverse road environmental conditions. Improvement of known hazardous road locations has been proved to be one of the most cost-effective methods and is indeed a priority in Bangladesh.

This paper provides information on current road safety situation in Bangladesh and describes some findings of quantifying hazards from the ongoing the ADB-iRAP Road Safety Improvement

Project. It further presents some affordable road safety countermeasures that can be effectively implemented in Bangladesh to achieve reduction in road crash fatalities.

The Context of Road Infrastructure Factor in Crashes

Road crashes are very intricate in nature, which includes many factors but lives can be saved and injuries can be prevented by building sound road infrastructure. Road infrastructure, as a third pillar of road safety, turned out to be major contributing factor in one out of three fatal accidents and managing its safety offers wide scope of improvement (EC, Impact Assessment 2004). In the United States for example, road conditions are a contributing factor in more than half (53%) of all road deaths and more than a third (38%) of injuries. In terms of crash severity, road condition is the single most lethal contributing factor, ahead of speeding, alcohol or non-use of seat belts (Miller & Zaloshnja, 2009). In Sweden, when considered a safe system-type of framework, road conditions are a contributing factor in at least 59% of fatal crashes (Stigson, Krafft, & Tingvall, 2008). In Canada's Road Safety Strategy 2015, road environment factors that may affect the likelihood of crash occurrence e. g. roadway configuration, roadway construction, road surface condition, road and roadside design, urban and rural infrastructure have been identified as one of the key issues of collisions being targeted. Polus (2005) finds that a good infrastructure (including alignment, roadside elements, sight distance, presence of guard-rails, access points, roadway consistency and additional variables for quality of highway) can reduce the crash rates on two way rural highways by 44%.

Therefore road infrastructure plays a crucial role in road safety. Well-designed roads can help people use roads safely and minimize the risk that a crash will occur. When a crash occurs, protective road infrastructure can mean the difference between life and death (Bliss, 2009). Indeed significant reduction in road accidents and casualties has been achieved by road infrastructure improvements in high-income countries essentially through application of the targeted safety engineering countermeasures. Although road infrastructure risk is of complex manner in low and middle-income countries, road infrastructure countermeasures can also be successfully implemented in low-income countries like Bangladesh. Bangladesh has been slower in devising "Safety Design and Engineering" approach due to lack of incorporation of safety design in road transport safety policies. Lack of simple low-cost measures is the reason for high risk road safety situation on a significant length of highways.

The Requirements in Bangladesh

Background and Objectives

There is growing concern that current poor road safety situation in Bangladesh constitutes an enormous crisis and therefore the apparent urgency for road infrastructure improvement signifies the need for achieving new momentum sparked by effective initiatives. Numerous studies and investigations of road infrastructure safety have been carried out in recent times in Bangladesh (Hoque and Mahmud, 2009; Hoque et. al., 2009 & 2011; Rahman, 2012).

The first pilot assessment conducted by iRAP on the Dhaka-Sylhet Highway (N2) and Joydebpur-Mymensingh Highway (N3) in 2010 have clearly indicated the severity of road infrastructure hazards in Bangladesh and which has clearly strengthened the focus on the target of Bangladesh to reduce the road crash fatalities by 50% during the Decade of Action (2011-2010). With the support from ADB, Roads and Highways Department, Bangladesh (RHD) took initiatives for further application of the iRAP inspection methodology for assessing star ratings of national and regional highways. The project particularly aimed at investing in road safety countermeasures on selected high-risk corridors; developing road safety policies; strengthening road safety management capacity; and implementing nationwide road safety improvement programs. Details could be seen in iRAP Bangladesh Technical Report, 2013.

Road Network Selection and Features

A total of 1,372.5 km of roads were included in the assessments to cover a majority of the national highway network and a small section of significant regional highway network as against the 1000 km originally planned. The Highway Network that was selected by ADB and RHD as being of strategic importance and which are known to have serious road safety problems. A map of the selected highways has been shown in Figure 1. The selected sections have varieties in AADT, roadway infrastructure and environment characteristics.

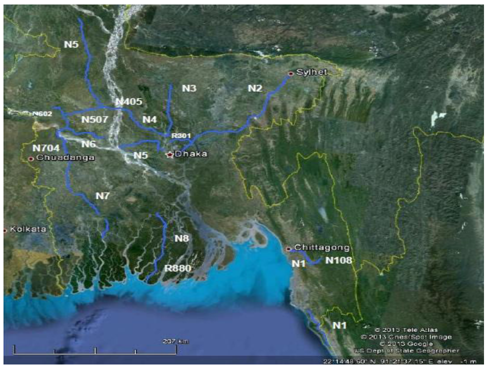
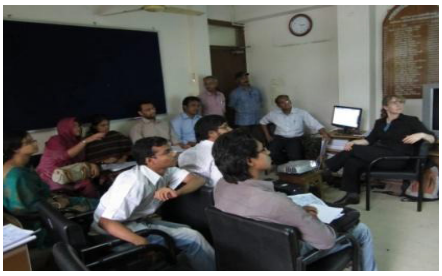


Figure 1. A map representing all the selected highways for assessment

Conducting Surveys

Training: Importantly conducting field survey required significant briefings and training about the tools and procedures. A week-long training course run by iRAP consultant was held regarding road safety inspection (survey) and recording of road related attributes (coding). RHD engineers, local engineering students and a local firm, FERBA Instrumentation Logistics which was engaged to lead the road inspections were benefitted from the training. As a preliminary step of the project, a day-long workshop on ‘iRAP Road Safety Technology Transfer’ was also held at RHD in an effort to stimulate collaborative efforts among government organizations, NGOs and stakeholders including developing future roadmaps towards achieving the project outcomes as stipulated road safety goals (Figures 2 and 3).



Figures 2 and 3. Training on Coding at RHD (left), Training on field survey (right)

Surveys: Surveys were conducted using the RAPID (Road Assessment Programme Inspection Device) equipment and software. RAPID is accredited by iRAP for use in road inspections. Details of the survey features could be seen in the iRAP-Bangladesh Technical Report, 2013. Representatives from RHD and BUET had the opportunity to participate in the surveys and use the RAPID equipment and software. In addition to the formal surveys, further site visits were undertaken separately to help ensure the analysis reflects local conditions.

Supporting Data

For the purpose of the assessment some supporting data including Traffic volume, Number of pedestrians and bicyclists, Number of deaths and injuries, Speed etc. are essential. Although the iRAP Star Ratings and Safer Roads Investment Plans use a standardized methodology, the models are calibrated with local data to ensure that, to the extent possible, the results reflect local conditions. The key data and methodology that relates specifically to the roads assessed in this project are:

Traffic Volume: Traffic volume (AADT) data and motorcycle volume data for each 100 metre segment is used in the iRAP model in parts of the risk assessment (for example, estimating overtaking demand and head-on risk) and in the generation of estimates of the number of deaths and serious injuries that could be prevented on the roads.

Pedestrians and Bicyclists*:* Data on pedestrian and bicycle flows were recorded during the road inspection and coding. It is possible to rely solely on this data for the assessment, though not usual. The pedestrian and bicyclist flows along the road were ‘smoothed’ across 500 metre lengths for pedestrians and 1 km for bicyclists by taking the highest value in that length (pedestrian crossing volumes were not smoothed).

Number of Deaths and Injuries*:* In order to estimate the life-saving potential of various countermeasures, it is necessary to begin with a baseline estimate of the numbers of deaths and serious injuries on the road network. For this assessment, data for major highways was sourced from the Bangladesh University of Engineering and Technology (BUET) Accident Research Institute (ARI) MAAP5 database where average number of deaths was estimated as 0.416 death/year. Although there is evidence that deaths are under reported by up to a factor of five, for the purposes of this assessment a conservative estimate of two times was used.

Speed*:* iRAP policy is that risk assessments are made using the ‘operating speed’ on a road, defined as being the legislated speed limit or the measured 85th percentile speed, while economic assessments are based on mean speeds. For the purposes of modeling in this project, operating speeds were set at 80km/h for rural areas and 60km/h for urban areas (except where posted speeds were higher).

Quantifying Highway Safety Hazards

During the survey, different road safety hazards are briefly outlined in this section under the headings of field observations, star ratings and illustrative examples.

Field Observations

During the survey different road safety hazard situations were observed including road infrastructure and behavioural aspects. The following is a summary of important observations along the assessed highways.

Road Infrastructure and Environment

- Roadside developments are located on either side of the highway which mainly consist of shops, commercial or residential areas and in most cases highway passes through villages and market places with informal tracks and paths being connected directly to the main carriageway. Indeed roadside linear developments pose a serious problem (Figure 4).

Figure 4. An example of a typical section passing through linear settlement

- Most of the highways passed through locations where a significant amount of pedestrians crossed the road, in particular close to schools. There are a few pedestrian crossings located on the highway including zebra crossing and foot over bridges. Sometimes the crossing is located too close to the junctions. The safety problems especially for VRUs greatly are compounded by its serious incompatibility of the existing roadway conditions (Figure 5).

Figure 5. Lack of formal pedestrian crossing is a common issue

- Markings are faded, worn even non-existent in several areas while it is well understood that road markings are considered to be the basic road furniture and play a very important role in minimizing road accidents.
- In most cases where road signs are present mingled into the background where there are significant amounts of illegal roadside advertising signs, consequently they become less conspicuous to the drivers especially driving with high speed.
- The majority of highways assessed do not have posted speed limit signs.
- Speed breakers are being used frequently at locations where efficiency is compromised. In some cases speed breakers and rumble strips are poorly marked and are not conspicuous without any advance warning signs and any markings on the speed breaker as a result they are not visible at night.
- In many cases unprotected roadside objects like trees and electric poles are situated adjacent to busy highways. End of the road side barriers especially at the entrance and exit of a bridge is unprotected.
- A number of curves are located on the highways assessed, they often take motor vehicles by surprise. Most curves have no proper delineation i.e. signs and markings to warn the drivers.
- The surface texture of the carriageway in terms of skid resistance of the surface is very poor in most cases. Potholes and uneven surfaces were also found in considerable length of the highways.

Road Users' Behaviour

- Pedestrian overpasses are often not used by pedestrians. This is a common challenge around the world, particularly in Bangladesh and requires careful planning and design to ensure that facilities match pedestrian desire lines and channel pedestrians towards the safe crossing point.
- Vehicles rarely stop for pedestrians on zebra crossings. As a result, their effectiveness in Bangladesh is likely to be compromised.
- Footpaths are often blocked by parked vehicles or shops, meaning that pedestrians need to walk on the road pavement (Figures 6 and 7).

Figures 6 and 7. Footpaths on national highways are blocked by shops

- People, very often children, travel on the roof of buses for discount fares. These travelers are highly vulnerable and there is very limited scope for road design to address the issue. A common road safety issues relates to buses stopping frequently on the main carriageway to collect and drop of passengers. A stationary bus with passengers milling around presents a significant hazard on the highway.

Star Ratings

The overall Star Ratings for the roads assessed are shown in Table 2, where 5-star is most safe and 1-star indicates least safe situation. Star ratings of highways assessed are mostly 1 or 2 star and the summary by user categories are:

- Vehicle occupants, nearly three quarters (73%) is 1 or 2-star
- Motorcyclists, 81% is 1 or 2-star
- Pedestrians, 97% is 1 or 2-star
- Bicyclists, 92% is 1 or 2-star.

Table 1. Overall star ratings of the assessed highway

Star Rating	**Vehicle occupants**		**Motorcyclists**		**Bicyclists**		**Pedestrians**	
	Length (km)	%	Length (km)	%	Length (km)	%	Length (km)	%
5 Star	1.6	0%	0	0%	49.5	4%	0	0%
4 Star	15.6	1%	2.6	0%	0.5	0%	0.1	0%
3 Star	349.3	25%	262.1	19%	59.9	4%	31.8	2%
2 Star	386.7	28%	295.2	22%	370.8	27%	348.7	25%
1 Star	617.0	45%	810.3	59%	889.5	65%	989.6	72%
Not rated	2.3	0%	2.3	0%	2.3	0%	2.3	0%
Total	1372.5	100%	1372.5	100%	1372.5	100%	1372.5	100%

Detailed results of the star ratings, its representation on the maps and star rating scores for each section of the highways are available on the website: vida.irap.org.

Typical Section

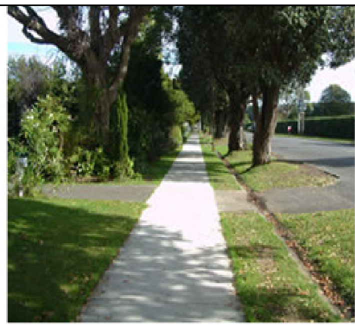
Figure 8 illustrates a typical rural highway section where there are open local markets are situated and all users have 1-star ratings. Most of the cases, there are lack of delineation which is the basic road furniture, no pedestrian facilities at all although there are a lot of pedestrians. Haphazard illegal parking increases the risk of collision of high speed vehicles and makes maneuvering difficult for slow moving vehicles like rickshaws, vans, bicycles since there are no separate facilities for them.

Figure 8: A 1-star rated section at Prembag, Jessore with associated features

Key Deficiencies and Countermeasures

Some of the key findings from iRAP analysis of Star Ratings and relative countermeasures have been represented in Table 3 as an example of contemplating infrastructure safety improvement programme.

Table 2. Key Deficiencies and Countermeasures

Deficiencies			Countermeasures
Hazardous Roadsides		Most roads have hazardous roadsides. This is especially critical on curved sections of road (20% of the network).	 **Roadside Safety Barrier**
Intersection		Almost three quarters of intersections (70%) are unsignalised with no protected turn lanes and no chanelisation.	 **Improving Intersections**
Footpath		80% of roads where pedestrians are present have no formal footpath.	 **Footpath**
No Bicycle facilities and No Shoulder		96% of roads have no formal bicycle facilities. 40% of the network has no paved shoulder.	 **Paved Shoulder**

From the 91 countermeasures proposed by iRAP, safety investment plans of different categories (Low Cost, Medium Cost, High Cost) according to different Benefit Cost Ratio (BCR) were created which provide a guideline of probable cost of different level of road infrastructure improvement.

Conclusions

This paper in brief presented the road safety problem in Bangladesh with regard to the quantification of road environmental hazards. The findings have been primarily based on the extensive field studies and observations made during the conduct of ADB assisted iRAP-RHD assessment of high risk roads. Significant road environmental and traffic operational hazards are most prevalent. Hazard characteristics include: uncontrolled roadside land use development, road space occupation by road traders and commercial activities; high intensity of pedestrians and NMV traffic in the absence of NMT 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 encroachment and local road side accesses. Concerningly the majority of the highway sections are rated as 2-star or less (out of possible 5-star) as revealed from the results of the iRAP risk assessment of around 1400 kilometers of highways. The hazard characteristics dictate priorities to be placed on corrective measures relating to road design and environmental improvements in line with the principles and strategies of Safe System Approach.

Corrections and fixing of existing road safety hazards demonstrated in the paper are indeed an enormous challenge to road engineering professionals in Bangladesh. Shortage of safety expertise, research and requisite funding are now significant constraints. It is therefore a priority for Bangladesh to address such safety issues with significant institutional improvements through sharing knowledge and experience of effective road safety programs worldwide.

Acknowledgement

The work presented in this paper is a part of the research carried out at the Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET). The paper is primarily based on the learning and experience of ADB-iRAP Road Safety Improvement Program in Bangladesh. The opinions and views expressed in this paper are those of the authors.

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