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APPLICATION OF HYDRATED LIME TO RESIST MOISTURE DAMAGE AND RUTTING IN ASPHALT MIXTURE IN BANGLADESH

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ABSTRACT

In Bangladesh, road way condition is very severe. Though the number of roads are less than what is required, again utility of these roads reduces due to damages of road surface .Specially in rainy season these types of damages are occurred due to penetration of water to a depth in asphalt pavement .Every year huge amount of money is disappeared due to the repairing of these roads. So the main aim of our paper is to improve the performance of asphalt pavement by using hydrated lime and determine the improvement of it so that it can be used to reduce the economic loss of our country.

Moisture damage can manifest in the hot mix asphalt pavements in forms of stripping and/or softening of asphalt. It results in loss of stability and bearing capacity failure, and rutting of asphalt pavement. One of the common anti-stripping additives, hydrated lime, is considered to improve the properties of asphalt mixture in resisting moisture damage. The lime application process can be introduced to asphalt mixture by either adding dry hydrated lime to wet aggregates or adding lime slurry to dry aggregates. Our study evaluates the laboratory performance-based properties of asphalt mixtures using two different lime application processes as well as to compare between hydrated lime-modified and polymer- modified asphalt mixture. Results indicates that the performance of hydrated lime modified asphalt mixture in moisture damage and rutting resistance is related to the lime application processes. Adding hydrated lime to asphalt binder is a cost effective method to improve performance of asphalt mixture in moisture damage and rutting resistance in Bangladesh.

Keywords: Damaged Roadway, Economic loss, Hydrated lime, Anti-stripping , Performance.

INTRODUCTION

Moisture damage in the hot mix asphalt pavement is considered as one of major pavement deteriorations in Bangladesh, located in the tropical region with a substantial rainfall. The moisture damage causes loss of adhesion (e.g. loss of bonding between asphalt binder and aggregate), and adversely affects the strength of the asphalt mixture dramatically (Taylor and Khosla, 1983). For a high-volume road, the moisture damage can also cause the premature pavement distresses such as rutting and ravelling on the pavement surface.

The anti-stripping additives are widely employed to enhance the moisture damage resistance in asphalt mixture. Two common types of additives are the liquid anti-stripping additive and the hydrated lime. The liquid anti-stripping additive is typically applied directly to the asphalt binder, while the hydrated lime is applied to the aggregate. Lee and Nicholas (1954) indicated that the application of anti-stripping additive to the aggregate is more efficient than that to the asphalt binder. However, adding additives directly to asphalt binder is more economical (Lee and Nicholas, 1954). Because of the unpleasant odour of the liquid anti- stripping additive, and substantial amount of hydrated lime

produced, the use of hydrated lime is more desirable to resolve moisture damage problem in Bangladesh.

Several studies showed the beneficial application of hydrated lime in the asphalt mixture to improve the moisture susceptibility (Plancher *et al.*, 1977; Hicks, 1991; Little and Epps, 1953; Aschenbrener, 2002; Sebaaly, 2003; Bari and Witczak, 2005). However, most studies were conducted using the lime application process either by adding dry hydrated lime to wet aggregates or by adding lime slurry to dry aggregates (Epps *et al.*, 2003).

In this paper we evaluated the performance- based properties of the hydrated lime modified asphalt mixtures by both processes .The properties of asphalt mixture prepared by adding hydrated lime to aggregates (dry mixing process) were compared with those prepared by adding hydrated lime to asphalt binder (wet mixing process). The optimum proportion of hydrated lime used in both processes were determined and selected according to the performance of asphalt mixtures and the cost-effectiveness.

MATERIALS AND METHODS

Wet and dry mixing processes of hydrated lime application were used in the study. In the wet mixing process (as known as wet hydrated lime or WHL), the hydrated lime was applied directly to the original asphalt binder AC 60/70 at the mixing temperature of 145°C. This temperature was used to obtain a homogenous mixture of asphalt binder and hydrated lime. The properties of hydrated lime used are summarized in Table 1. The Marshall mix design method (ASTM D3515) was selected in preparation of the asphalt mixture specimens because of widely adoption in Bangladesh. The hydrated lime used in the wet process was 10% and 20% by weight of asphalt binder. The 19-mm nominal maximum limestone aggregate was used to produce the asphalt mixture specimens in accordance with ASTM D3515.

Table 1: Properties of hydrated lime

Item Analysis	Test Method	Measured Value
Available CaO	ASTM C-25	72.58 %
Purity of Ca(OH)2	ASTM C-25	95.80 %
Moisture Content	ISO 787/1	0.19 %
Residue on #170mesh	Wet sieve	0.70 %
pH	5% in DW	12.25

In the dry process (as known as dry hydrated lime or DHL), the hydrated lime was primarily added to the dry aggregate prior to mixing with the original asphalt binder. The hydrated lime used in the dry process was 0.5% and 1.5% by weight of dry aggregate. These proportions were selected because they have been used in practice in the hydrated lime application .Besides these two lime application processes, the polymer, another type of asphalt modifier, was used in the study. The original binder AC 60/70 was modified with styrene-butadiene-styrene (SBS). This modification method is thereafter called the polymer-modified asphalt or PMA in this study.

EXPERIMENTAL PROGRAM

The experimental program consists of two main parts: asphalt binder tests and asphalt mixture tests. The asphalt binder tests include the rheological property test and the creep and recovery test. The

asphalt mixture tests include the indirect tensile strength test (AASHTO T283) and the loaded wheel tracking test. The experimental program and results for each test are described as the following.

Asphalt Binder Tests

Four asphalt binders: original binder, polymer-modified binder, 10% and 20% wet hydrated lime (WHL) modified binders were tested using the Dynamic Shear Rheometer (DSR).

1)Rheological Property Test

The complex shear modulus (G*) and phase angle (δ) of asphalt binders were measured at the specified temperature and loading frequency. G* is a mechanical property that reflects the total resistance of the binder to deformation under a repetitive shearing stress. G* combines two major components: storage modulus (G′) which is an elastic or recoverable component, and loss modulus (G″) which is a viscous or non-recoverable component. The elastic component reflects the amount of energy stored in the asphalt specimen in each testing cycle. The viscous component reflects the amount of energy lost in each testing cycle through permanent flow or deformation (Roberts *et al*., 1996). The test was conducted at loading frequency of 1 Hz. Results of G*, G′, G″, and δ are summarized in Table 2.

Table 2: G*, G□, G□□, and □ of asphalt binders tested under different temperatures

Temperature (°C)	**G* (Pa)**	**G′ (Pa)**	**G″ (Pa)**	**δ (deg)**
Original Binder				
22	2530000	1290000	2180000	59.4
28	560000	157000	537500	73.7
50	7010	339	7000	87.2
Polymer-Modified Asphalt (PMA)				
22	2310000	1410000	1835100	52.6
28	6020000	2620000	542000	64.2
50	14900	5560	13800	68.1
10% WHL Binder				
22	3130000	1930000	2470000	52.0
28	716000	282000	658100	66.8
50	10400	994	10352	84.5
20% WHL Binder				
22	4580000	3000000	3460000	49.1
28	911000	374000	831000	65.8
50	12800	1180	12745	84.7

2) Creep and Recovery Test :

The resistance of asphalt binders for accumulation of permanent deformation (or strain) under a repetitive loading was measured using the creep and recovery test. The accumulated strain for each loading cycle, the rate of strain accumulation, and the viscous component of the creep stiffness (GV)

are determined to evaluate the rutting resistance of asphalt binders. Table 3 summarizes the testing results of the original binder, the polymer-modified binder, and the original binder mixed with two varied amounts of hydrated lime. The creep and recovery test on these binders were conducted at 50°C, which represents the high temperature encountered in the field.

Table 3: Effect of hydrated lime on rutting resistance of asphalt binders:

Binder	**Strain @ 50 cycles (mm/mm)**	**Rate of strain accumulation**	**GV at 1 sec. of loading (Pa)**
Original	5.33	0.923	9.56
PMA	0.55	0.094	91.20
10% WHL	3.20	0.624	15.96
20% WHL	2.7	0.523	18.88

* All tests were performed at the stress level of 100 Pa.

Asphalt Mixture Tests:

A series of asphalt mixture tests including the indirect tensile strength (IDT) and the loaded wheel tracking test (LWT) were conducted on various types of asphalt mixture specimens: the original binder (control specimen), polymer-modified binder, 10% and 20% WHL modified binders, and 0.5% and 1.5% DHL

1)Indirect Tensile Strength Test (IDT):

The IDT test was conducted in accordance with AASHTO T283, a standard test method to measure the resistance of compacted bituminous mixtures for moisture induced damage. Six Marshall standard size specimens (102-mm diameter and 64-mm high) were compacted at the optimum binder content. These specimens were statically compacted for a loading duration of two minutes to attain 7% air voids.

Six compacted specimens were divided into two groups. The first three specimens were not subjected to any conditioning. The other three specimens were inundated, which resulting in approximately 55-80% degree of saturation. Afterwards, these specimens were conditioned in a water bath at 60^0C for 24 hrs following the AASHTO T283. Both unconditioned and conditioned specimens were kept in a water bath at 25^0C for 1 hr to allow thermal equilibration prior to testing.

During the test, every specimen was subjected to a loading rate of 51 mm/min until failure. The compressive load was applied through two loading strips. The maximum indirect tensile force was recorded and the corresponding IDT strength of the asphalt mixture was determined. The tensile strength ratio (TSR), a ratio of the IDT strength of conditioned specimens to the IDT strength of unconditioned specimens, was calculated and used as a moisture susceptibility index of asphalt mixtures.

The calculated TSR of the original mixtures, polymer-modified mixtures, WHL-modified mixtures, and DHL-modified mixtures is presented in Table 4. Results indicated that the 20% WHL and 1.5% DHL modified mixtures show the highest TSR (~ 0.9). These percents of hydrated lime were added in asphalt mixture can minimize the moisture susceptibility. The polymer-modified mixture however showed less influence on moisture damage resistance.

Table 4 Tensile Strength Ratio (TSR) for modified and unmodified asphalt mixtures

% Hydrated Lime	TSR
Original Mixtures	
0	0.84
Polymer-Modified Mixtures (PMA)	
0	0.81
WHL-Modified Mixtures	
10	0.85
20	0.91
WHL-Modified Mixtures	
0.5	0.81
1.5	0.90

It should be noted that the aggregate used in this study is limestone, which is known as basic aggregate. Therefore, the original mixtures showed considerably high TSR value or less moisture sensitivity, as shown in Table 4.

2) Loaded Wheel Tracking (LWT) Test :

The LWT test was conducted to measure the resistance of asphalt mixtures against rutting under the water-exposed condition. To evaluate the effect of hydrated lime on the rutting resistance was measured by the loaded wheel tracking test, three types of asphalt mixtures were tested. They include the original, polymer-modified, 20% WHL, and 1.5% DHL asphalt mixtures. Note that the 20% WHL and 1.5% DHL were selected in the LWT test because they exhibit desirable performance in the moisture damage resistance and high stiffness in both wet and dry mixing processes.

As number of cycles increases, the rut depth or permanent deformation of specimen increases. Results indicated that the hydrated lime can improve the resistance of mixtures to rutting under the water-exposed condition. As shown in Table 5, the 1.5% DHL specimen showed higher rutting resistance than 20% WHL specimen, however, no significant difference in the rate of permanent deformation was observed. In addition, the 1.5% DHL specimen has comparable rutting resistance with the polymer modified mixture specimen.

Table 5 :Average rut depth and rate of permanent deformation measured by the LWT test (with 36 kg. loading at 50°C)

Mixtures	Average Rut Depth (mm)	Rate of Permanent Deformation (μm/cycle)
Original	8.22	0.5
PMA	4.32	0.3
20% WHL	5.11	0.2
1.5% DHL	4.41	0.3

DISCUSSIONS

Based on the analysis of data collected in this study, the summary of findings are as the following:

1. The rheological property test and the creep and recovery test conducted on the asphalt binders indicated significant changes in the performance of asphalt binder when the hydrated lime was used as asphalt modifiers.

2. Hydrated lime which was applied in asphalt binder ,increases both G*/sinδ and G*sinδ, and increases the rutting resistance by having larger viscous component of the creep stiffness (GV).
3. Polymer used in this study showed slightly decreases in both G*/sinδ and G*sinδ at intermediate temperature. Asphalt binder significantly increase G*/sinδ and G*sinδ at high temperature, and significantly increase in the rutting resistance component of the creep stiffness (GV).
4. The overall performances of asphalt mixtures modified with hydrated lime are more desirable than those of unmodified mixtures, especially for the mixtures adding 20% hydrated lime (by weight of asphalt) in binder prior to mixing with aggregate, and the mixtures prepared by applying 1.5% hydrated lime (by weight of aggregate) in dry aggregate prior to mixing with asphalt binder.
5. Although comparable overall performance, it is more economical to add 20% hydrated lime (by weight of asphalt) to binder prior to mixing with aggregate than applying 1.5% hydrated lime (by weight of aggregate) in dry aggregate prior to mixing with asphalt binder.
6. Besides the polymers, the hydrated lime can be considered as an alternative modifier to improve the properties of asphalt binders and mixtures. The hydrated lime can significantly improve both moisture damage and rutting resistance, while the polymer can significantly improve rutting resistance only.
7.The application of hydrated lime in asphalt binder is an effective and economical method to improve the performance of asphalt mixture to resist moisture damage and rutting.

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ANALYSIS OF EXTENT AND IMPACT OF VEHICLE MODIFICATION

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ABSTRACT
Roads of Bangladesh have become over numbered with the present growth of vehicle over 10%. According to the section 47 of "Motor Vehicle Ordinance, 1983", every vehicle needs to renew fitness certificate every year under proper inspection by the authority. But with the uncontrolled rapid increase of vehicle number, vehicles are found often to move on the road without having necessary registration or fitness papers for day after day. The unfitted vehicle often causes fatal accidents on highway leading to a serious damage in property and human life. Uncontrolled vehicle modification practice has become a serious issue particularly for heavy vehicles, which leads the owner not to properly follow the rules of certifying for fitness. Modification practice greatly varies with the types of vehicle. Besides owners' profit motive and compromising vehicular safety attitude, the situation has also worsen by the local body makers, who do not possess any formal training or institutional skill.

The study reveals the extent of vehicle modification of different categories of vehicle. In this regard a field survey is conducted in major three bus terminals in Dhaka (Gabtoli, Sayedabad and Mohakhali bus terminals) and three truck depots (Gabtoli, Tejgaon and kamalapur truck depot). Face to face interview survey of vehicle owners as well as the body makers and a detail vehicle condition survey are carried out. The paper would describe the findings of this research work along with appropriate remedial measures to control the unsafe modification of heavy vehicles.

Keywords: Vehicle modification, Body maker, Vehicle fitness, In-vehicle unsafe material, Bangladesh.

INTRODUCTION

In Bangladesh, presence of defective and road unworthy vehicles plying on road poses serious threat to the safety issue of road system. With the present growth rate of vehicle over 10%, number of faulty vehicles is ever increasing. Both physical and mechanical defects in vehicle, which no longer meet or conform to the rules and regulations of road traffic system can contribute to a crash or increase the likelihood of injuries to road users and depreciation of vehicle. Also in absence of proper replacement or recycling practice, number of aged vehicles is rising in road. Rapid growth of aged vehicles (20 years and older) widens the scope of harmful environmental emission; thus public safety becomes vulnerable. A research conducted in Canada shows that the proportion of fatalities, serious injuries and collisions for the occupants of aged defective vehicles (15 years and older) increases and is approximately two and a half times higher than the average for occupants of all vehicles (Lécuyer et al., 2006). Though adequate legal provisions have been made in the Motor Vehicle Ordinance, unfortunately these legal provisions are neither observed properly nor enforced strictly in Bangladesh. Taking advantage of this weak legal enforcement, uncontrolled vehicle modification is spreading as a contagious social disease. The unauthorized change of physical condition of the vehicle is done after

buying vehicle, whether it is a fresh stock or a secondary purchased vehicle. Also the extent of multiple periodic modification of vehicles is seriously noticeable while maintaining the vehicle or recovering it after any serious crash. This uncontrolled vehicle modification of heavy vehicles often prevents the owner from renewing fitness certificate which is considered as mandatory every year as per local constitution. According to MAAP5 database, among the total recorded number of vehicles causing accidents in Bangladesh during 13 years (1998-2010), 16.4% vehicles were reported to have no valid fitness certificate (ARI database, 2012). Among the heavy vehicles, no fitness certificate was found for 11.6% buses, 11.9% minibuses, 18.1% trucks (weight limits 5 tons) and 12.4% heavy trucks (weight greater than 5 tons). Such alarming situation prevails in Bangladesh as local body makers, without any academic or institutional training, perform modification where owners mainly take the role of engineers. The research aims to investigate the extent of illegal modification and its adverse impact on rapid aging of vehicle and road safety. Later necessary counter measures are recommended based on the analysis.

EFFECT OF PRESENT TRENDS OF VEHICLE MODIFICATION

Local modification of heavy vehicles is performed to give them a distinctive appearance, to improve vehicle performance, to add desired features or to modify the carriage capacity without following manufacturers' instruction or any distinctive scientific approach. Owners, compromising service quality, are stretching the parts of vehicle to last longer than their average life expectancies. This unauthorized modification trend has started from far past and emerging since the last 3-4 decades. More complex modification trends than past are found after the field survey for this research work. In previous research (Hoque, 2003), some known practiced modification were mentioned, like:

- Making of one vehicle on other types of vehicle chassis
- Projecting vehicle bodies beyond maximum dimension specified by the manufacturer
- Altering seating arrangement of bus
- Increasing the length of overhang for heavy vehicles
- Expanding width of carrier beyond headroom (front cabin) of truck
- Fixing additional features like bumpers, rooftop railing, ladder etc.

While conducting recent field survey, it was found that perception of recent modification practice and its effect is very limited among the concerned authority and general people. With the advancement of time, newer scopes of modification are invented. Some of the recent modification practices are documented here:

- Adding external metal plates in exterior and interior side of chassis of trucks
- Over-heightening of carrier of uncovered trucks; carriers are now mainly steel structure rather than wooden
- Fixing additional angle on urban vehicle, specially urban buses
- Relocating external rear view mirrors inside of the urban vehicles

Such findings of the latest survey do not come as a surprise; rather it confirms the continuity and serious deterioration in the condition of the modification procedure. The regulatory body and law enforcing authorities are also to be blamed equally as they often ignore the reverse impact of modification on road safety. As these modifications are not recommended by the vehicle manufacturers, some of the adverse effects of modification are enlisted here:

- Increasing extra material cost for owner.
- Questioning the vehicle's legal compliance
- Rising issue of safety of the vehicle
- Threatening the vehicle's reliability
- Conflicting the terms of the vehicle's warranty
- Reducing the ability to service and repair the vehicle using readily available spare parts
- Compromising public perceptions to the service quality of the public vehicle
- Reducing the expected service life of a vehicle
- Increasing maintenance frequency
- Effecting the health of local workers of garage
- Degrading the surrounding environment of local workshop, etc.

Judging the consequences, undoubtedly a conclusion can be drawn that neither modification practice has any positive effect on vehicle nor the modified vehicles can ensure road safety or economic advancement. However, in Bangladesh, owners profit earning motive has led them to modify vehicles as their own interest. The following Table 1 is furnished with the preferred dimensions of modification collected from the field. Later Fig. 1 shows the false chassis used in heavy vehicles and Fig. 2 gives a view of arbitrary use of angles in inner body of locally modified vehicle structure.

Table 1: Common measurement practiced by local body-makers for modification

Vehicle Type		Model/Parts	Model name/ Dimension
Truck	Heavy Truck	Model	Tata, Ashok Leyland, Bedford
		False chassis	Projection from chassis: 0.76 m-1.22 m
		Carrier body	Cross section of carrier: 2.44 m X 2.44 m (covered truck) Length: 5.49 m-6.1 m(authorized length: 4.88 m-5.49 m) Width: 2.44 m Width offset: 0.11 m on both side of headroom (covered truck)
		External bumper	Offset from front of headroom: 0.61 m Offset from back of the carrier: 0.1 m Bumper thickness: 5 mm Bumper height: 0.51 m- 0.76 m
	Medium Truck	Model	Tata 1615, Tata 1613
		False chassis	Offset from chassis: 0.3 m-0.91 m
		Carrier body	Cross section of carrier: 2.13 m X 2.13 m(covered truck) Length: 6.1 m(authorized length: 4.89 m) Width: 2.44 m; Width offset: 0.25 m on both side of cabin Height of side cover of the carrier: 0.76 m (uncovered truck)
		External bumper	Projection from front of headroom: 0.56 m Bumper height: 0.76 m
	Light Truck	Model	Tata 407, 709
		False chassis	Offset from chassis: 0.47 m- 0.91 m
		Carrier body	Length (Tata 407): 3.81 m (authorized length: 3.2 m) Length (Tata 709): 5.03 m Width 2.29 m
		External bumper	Offset from front of headroom: 0.61 m Bumper height: 0.15 m- 0.18 m
Bus	Large Bus	Model	Hino AK1J; Tata 1612
		False chassis	Offset from chassis: 0.61 m (Hino), 0.91 m (Tata)
		Body	Length: 10.67 m Width: 2.49 m
		Bumper	Plain sheet bumper
		Seat details	Seat number: 52,57,62 Seat area cross section: 0.46 m X 0.46 m Seat to seat distance: 0.71 m
	Minibus	Model	Hino 2002,2004 model
		False chassis	Offset from chassis: 0.76 m – 1.07 m
		Body	Inner clear height: 1.91 m; 1.83 m (if fan is attached) Length 7.62 m(authorized length: 6.4 m) Width 2.19 m
		Seat details	Seat number: 42 (authorized seat number: 31) 21 (authorized seat number: 30) Width of three seats cover area: 1.14 m – 1.22 m (authorized width: 1.37 m) Width of three seats cover area: 0.71 m – 0.76 m (authorized width 0.91 m) Seat center to center distance: 0.51 m(authorized distance: 0.66 m)
	Microbus	Leguna car	Seat number: 13 (authorized seat number: 8-9)

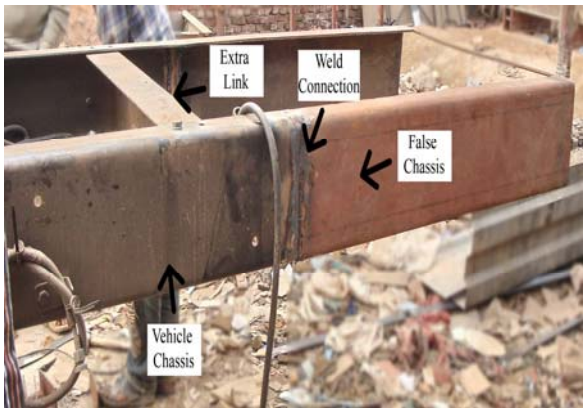

Fig. 1: False chassis in large bus

Fig. 2: Unsafe angle in inner structures (seats)

MATERIALS AND METHODS

A field survey was conducted in major three bus terminals in Dhaka (Gabtoli, Sayedabad and Mohakhali bus terminals) and three truck depots (Gabtoli, Tejgaon and kamalapur truck depot) in order to take measurements of body dimension of heavy vehicles. This survey was performed with measuring tape of millimetre accuracy on randomly taken 20 samples of buses, minibuses, covered trucks and uncovered trucks each. Vehicle condition survey was undertaken simultaneously on same vehicle samples. A detailed questionnaire was prepared to collect data with the purpose of revealing current modification practice. 15 owners and 20 local body workers were interviewed based on that.

ANALYSIS AND DISCUSSION

Analysis of Vehicle Dimension and Vehicle Condition Survey

As per local constitution, permitted dimensions of heavy vehicle body are specified as overall width should be less than 2.5 m, rear overhang can not exceed 3.2 m or 50% of the wheel base (whichever is less), front overhang should not exceed 42% of the wheel base and side overhang should not be more than 150 mm on either side (Motor Vehicle Rules, 1997). For seating room in bus, a reasonable comfortable seating space of not less than 0.38 m sq. for each passenger and a clear space of not less than 0.66 m between the backs of seats are to be provided (Motor Vehicle Rules, 1940). Field measurement was taken keeping these parameters in mind. It is evident from Table 2 that as far as heavy vehicles are concerned, violation of permitted dimension is a common practice in Bangladesh.

Table 2: Summary of measured heavy vehicle dimension

Vehicle type		External body measurement								Internal body measurement			
		Front overhangs (excludes bumper)		Rear overhangs (excludes bumper)		Side overhang (of either side)		Overall width		Seating space		Seat back distance	
		As per limit	Exceed limit	As per limit	Exceed limit	As per limit	Exceed limit	As per limit	Exceed limit	As per limit	Below limit	As per limit	Below limit
Large bus	No	2	18	0	20	20	0	7	13	20	0	20	0
	%	10	90	0	100	100	0	35	65	100	0	100	0
Mini bus	No	16	4	20	0	20	0	20	0	0	20	8	12
	%	80	20	100	0	100	0	100	0	0	100	40	60
Covered truck	No	20	0	3	17	20	0	20	0	-	-	-	-
	%	100	0	15	85	100	0	100	0	-	-	-	-
Uncovered truck	No	20	0	20	0	15	5	20	0	-	-	-	-
	%	100	0	100	0	75	25	100	0	-	-	-	-

Close observation of Table 2 reveals that 90% large buses exceeded length of front overhang while all large buses violated the limit of rear overhang. Intension of squeezing maximum number of seats is

clearly perceived with limited space for legroom between seats in 60% minibuses, even sufficient seating spaces were absent in all minibuses. For goods vehicle, 85% of the covered truck was reported to exceed allowable length of rear overhang. However safety on road is mainly threatened by side projection of carrier beyond head room and angles fixed externally of trucks, locally regarded as giant on highway. Analysing the result of condition survey enlisted in Table 3, it is found that 20% covered and 80% uncovered trucks were dangerously projected beyond headroom. Local constitution has restricted any unsafe alteration of vehicle (Motor Vehicles Rules, 1984). But presence of 95% uncovered truck with sharp edged bumper and fitting of sharp angles reflected the shocking extent of illegal modification. Extra feature like rooftop railing encourages overloading and increases potential risk of passenger falling from roof. According to a research on accident in Jamuna Multipurpose Bridge, out of total 1011 accidents, 50 passengers' fall-down incidents happened and most were recorded as fatal or severely injured (Hoque et al., 2007). Majority of large buses (80%) along with all minibuses with sharp angel rooftop railing encourages this unwanted situation of fall-down incident to be continued in near future unless earnest preventive measures against illegal modification are taken.

Table 3: Vehicle condition survey result

Vehicle type		**Offset of carrier beyond headroom**		**External bumper**			**Horizontal angle**		**Rooftop railing**		**External ladder**	
		Projected	Not projected	With sharp edge	Without sharp edge	Absent	Present	Absent	Present	Absent	Present	Absent
Large bus	No	-	-	0	0	20	0	20	16	4	15	5
	%	-	-	0	0	100	0	100	80	20	75	25
Mini bus	No	-	-	0	2	18	0	20	20	0	20	0
	%	-	-	0	10	90	0	100	100	0	100	0
Covered truck	No	4	16	2	18	0	20	0	-	-	-	-
	%	20	80	10	90	0	100	0	-	-	-	-
Uncovered truck	No	20	0	19	1	0	20	0	-	-	-	-
	%	100	0	95	5	0	100	0	-	-	-	-

Analysis of Questionnaire Survey: Characteristics of Owners and Local Body markers

Inconsistent complex modification is the consequence of fragmented ownership of heavy vehicle fleets. Commercial vehicle owners deliberately take the risk of unscientific alteration of vehicle parts. Field investigation exposed that scrap steel is used for altering chassis and vehicle body while angular bars are mainly used for rooftop railing and inner structure like seats. Use of locally made low quality glass has become widespread especially in urban vehicles. Traditionally modification is performed by a group of junior body workers, who are mainly trainees under an experienced one. With the growing number of local workshop, number of amateur workers is increasing. Simultaneously risk is also growing as no investigation is performed on the accomplished task; neither material checking nor inspection of welding. Hence quality of work solely depends on performance of body workers. Findings of the investigation on detailed characteristics of local body workers are enlisted in Table 4.

Table 4: Characteristics of local body markers

Perform with				**Required standards**								**Monotony in working overtime**				**Motivation of work standard**					
Institutional Skill		Informal Skill / Experienced body worker		Instinct/ feeling/ perception		Specification		Wild/ blindly done		Picture of renowned model		Yes		No		Quality of work		Time limit		Budget limit	
No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
3	15	17	85	15	75	3	15	1	5	1	5	20	100	0	0	2	10	7	35	11	55

It is distinctly visible from Table 4 that, major portion of body workers (85%) has no institutional skill; rather they follow the orders of senior workers. While servicing, mainly they apply their own perception (75%). Specification is mainly followed in renowned workshops, while in local workshop about 5% workers replicate from picture of popular models. Meanwhile being the only earning member in family, overtime working beside regular working hours (8 hours) was preferred by all workers. Rush of limited time (35%) and budget restraint (55%) accompanied by monotony of working overtime left a wide scope of questioning the quality of works performed by body makers.

CONCLUSIONS AND RECOMMENDATIONS

The conducted investigation, though limited in scope, shows the degree of illegal modification prevailing in Bangladesh. The grim findings of this study emphasises the need for taking instant initiatives like random roadside inspection of vehicles and rising safety awareness among owners before it becomes worse. Immediate needs of privatization and short time based fitness renewal system (like Singapore) are suggested by local law enforcing authority. Update of vehicle friendly law is needed to be prioritized. To do that, law for breaking down the tradition of fragmented ownership of vehicle fleet is to be established. Also, strict law enforcement is to be confirmed to encourage the owners to consolidate the vehicle fleet, thus import of sub-standard products can be made easier with limited number of vehicle models. Most importantly adequate academic knowledge and institutional training should be made obligatory for local body makers. No doubt exists about the upcoming challenges in near future for concerned authorities; however strong determination will help to overcome the situation in the long run.

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THE INFLUENCE OF LOCALLY AVAILABLE FILLER MATERIALS ON THE PROPERTIES OF BITUMINOUS MIXES

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ABSTRACT
The quality and durability of bituminous macadam is influenced by many factors including gradation of aggregates and type and amount of filler materials. Various materials such as cement, lime, granite powder and fine sand are normally used as filler in bituminous mixes. Cement, lime and granite powder are expensive and are used for other purposes more effectively. With this point of view the present investigation has been taken in order to study and compare the characteristics of bituminous mixes with locally available waste dust, brick dust and ash as filler. Standard Marshall mix design procedure is followed in the design and testing to determination of unit weight, stability, flow, voids in mixes as the optimum bitumen content according to AASHTO. The study reveals that the bituminous mixes with filler as waste dust is as good as of bituminous mixes with stone dust filler for use in base or surface course of bituminous pavement from the stand point of stability, deformation and voids characteristics. The Marshall stability of bituminous mixes with waste dust, brick dust and ash as filler are 8.3, 6.8 and 6.6 kN with optimum bitumen content 6.2, 7.3 and 7.4% respectively. The investigation indicates the possibility of using waste dust, brick dust and ash as filler in bituminous concrete mixes from the economic point of view.

Keywords: Bituminous mixes, Filler materials, Marshall mix design, Stability, Optimum bitumen content.

INTRODUCTION

Bituminous mix is a mixture of binder, aggregate and air in different relative proportions that determine the physical properties of the mix and ultimately how the mix will perform as a finished pavement. The performance of bituminous surfaced roads is directly affected by the proportion and quality of ingredient materials in the mixture (Mehari, 2007). Various studies has been conducted on the bituminous mix design which are revealed that certain modifications in the mixture such as, changing the type, size and gradation of aggregate, varying the filler to asphalt ratio, type and amount of filler alter the physical properties of bituminous mixes. Fillers, in particular, as one of the ingredients in bituminous mix, have only been thought to fill voids in the aggregate. Generally, the aggregate material passing through 0.075 mm standard sieve is referred to as filler. Mineral filler is defined as consisting of finely divided mineral matter, such as rock dust, slag dust, hydrated lime, hydraulic binder, fly ash, loess, or other suitable mineral matter (ASTM D242). Zulkati et al. (2012) showed that the presence of filler in an asphalt-concrete mixture affects the mixture's performance in three ways: filler influences the amount of asphalt content, filler affects the workability during mixing and compaction, and the resultant properties of asphalt-filler mastic contribute to the mixture's

performance. Hyyppa (1964) studied that the amount of filler affects the optimum bitumen content. Kim *et al.* (2003) investigated the effect of fillers and binders on the fatigue performance of asphalt mixes. They concluded that the filler type affected the fatigue behavior of asphalt binders and mastics. Fillers also stiffened the binders, and hydrated lime was more effective in stiffening binders than limestone fillers. Another conclusion was that even if the fillers stiffened the binders, they acted in such a way that they provided better resistance to micro cracking and thus an increased fatigue life. A study carried out by Shahrour and Saloukeh (1992) evaluated the effects of different types and quantity of mineral fillers on asphalt mixtures. Ahmed and Othman *et al.* (2006) investigated the effect of using waste cement dust as mineral filler on the mechanical properties of asphalt mixture, and the results indicated cement dust can totally replace limestone powder in asphalt paving mixture. Sudhakaran et al. (2012) studied that the structural characteristics of bituminous mix with added hydrated lime and phosphogvypsum. Muniandy and Aburkaba (2011) evaluate the effect of type and particle size of industrial waste as filler on stiffness and fatigue performance of Stone Mastic Asphalt (SMA) Mixtures with four types of industrial by-product wastes filler namely, limestone as reference filler, ceramic waste dust, coal fly ash, and steel slag dust. Akhter (1976) evaluated the suitability of locally available filler materials in asphaltic concrete. With the economic point of view the present investigation has been taken in order to study and compare the characteristics of bituminous mixes with locally available waste dust, brick dust and ash as filler. The objectives of this investigation are to investigate the behaviour of bituminous mixes and to determine the optimum bitumen content with different type of filler materials.

MATERIALS AND METHODS

A bituminous mix is normally composed of aggregates and bitumen. Aggregates are generally divided into coarse, fine and filler fractions according to the size of individual particles. Aggregates have to bear load stresses occurring in the roads and have to resist wear due to abrasive action of traffic. Bitumen content in mix ensure proper bond together with durable pavement under suitable compaction. Thus the properties of mineral aggregates and bitumen are of considerable significance for proper bituminous mix design.

Coarse aggregate and fine aggregate

In this investigation, black stone chips which are passing through 25 mm standard sieve and retained on 2.36 mm standard sieve were regarded as coarse aggregate (The Asphalt Institute, 1984). These coarse aggregate was originated in Panchagarh, Bangladesh. Coarse sand passing through 2.36 mm standard sieve and retained on 0.075 mm standard sieve were used as fine aggregate which was originated in Padma River, Rajshahi, Bangladesh. Both coarse and fine aggregate are collected from Transportation Engineering Lab in the department of Civil Engineering, RUET. Properties of coarse and fine aggregates were determined according to the test procedures specified by AASHTO and test results are given in Table 1.

Table 1. Properties of coarse and fine aggregate

Properties	Coarse aggregate	Fine aggregate
Dense unit wt. (kg/m^3)	1670	1570
Loose unit wt. (kg/m^3)	1535	1440
Bulk specific gravity	2.846	2.461
Apparent specific gravity	2.949	2.637
Water absorption, %	0.9	2.720
Loss angles abrasion value, %	12	…
Aggregate impact value, %	6	…
Aggregate crushing value, %	12	…

Mineral filler

In this investigation, waste dust, brick dust and ash which pass through 0.075 mm standard sieve used as filler material to study and compare the characteristics of bituminous mixes. Unit weight and specific gravity of filler materials were ascertained according to the test procedure specified by AASHTO T19 and AASHTO T133 respectively and test results are given in Table 2.

Table 1. Properties of mineral filler

Properties	Filler material		
	Waste dust	Brick dust	Ash
Dense unit wt. (kg/m^3)	1200	1320	476
Loose unit wt. (kg/m^3)	1000	1050	370
Bulk specific gravity	2.438	2.333	1.765

Bitumen binder

The bitumen was of 80/100 penetration grade bituminous cement used in this study which was purchased from local distributor. Properties of bitumen used in this investigation shown in Table 3 which were performed according to the procedures specified by the AASHTO.

Table 3. Properties binder material

Test	AASHTO designation	Test value
Penetration, ($1/10^{th}$ mm)	T49	98
Specific gravity	T229	1.002
Ductility (cm)	T51	107.5
Solubility, %	T44	99.75
Softening point, C	T53	46.5
Loss on heating, %	T47	1.8
Flash point ,C	T48	293
Fire point, C	T48	321

Mix types and aggregate gradation

The main objective of this research was to make a comparative study of the different bituminous mixes with different filler materials. Three types of mixes were studied and these were designated as mix A, B and C which contain waste dust, brick dust and ash as filler material. Coarse aggregate, fine aggregate and bitumen were remaining same for all type of mixes.

In the continuously graded bituminous macadam, the aggregate blend is designed to be evenly graded from coarse to fine so as to arrive at a dense mix with a controlled void content, hence producing a stable and durable paving. Aggregate gradation used in this study shown in [Fig. 1].

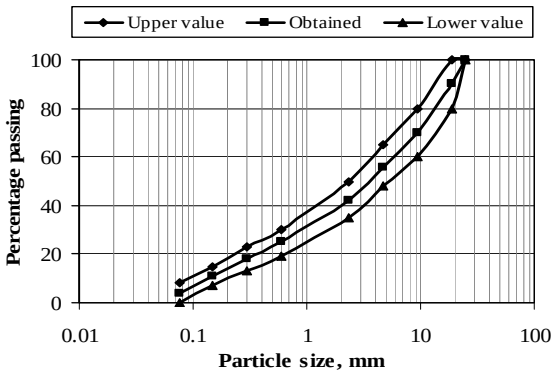

Figure 1. Gradation of aggregate

Preparation of specimen and test procedure

In order to study the effect of different filler material on compacted bituminous mixes, bituminous specimens from Mix A were prepared with 5.0%, 5.5%, 6.0%, 6.5% and 7.0% bitumen content (BC) and from both Mix B and Mix C were prepared with 6.0%, 6.5%, 7.0%, 7.5% and 8% bitumen content (BC). Marshall test specimens were prepared using Mix type A, B and C separately according to the selected aggregate grading. Marshall test specimens of 101.6mm diameter and 63.5 mm thick were prepared for medium traffic requires 50 blows per side of the specimen as per AASHTO T245-82 by varying bitumen content. The bulk specific gravities of compacted specimens were determined according to the test procedure specified by ASTM 2726. After determination of the bulk specific gravity, the specimens were then subjected to Marshall stability and flow tests as per AASHTO T245-82. The cylindrical specimens were then compressed on the lateral surface at constant rate of 2in/min. (50.8 mm/min.) until the maximum load (failure) is reached. The load resistance and the corresponding flow value were recorded. Voids analysis was made for each series of test specimens after the completion of the stability and flow tests. Then the optimum bitumen content (OBC) was determined according to the following Eq. (1).

$$\text{OBC} = \frac{\text{BC at max. unit weight} + \text{BC at max. stability} + \text{BC at 4\% air voids}}{3} \quad (1)$$

RESULTS AND DISCUSSIONS

For each mix type the variation of unit weight, Marshall stability, flow, percentage of air voids, percentage of voids in mineral aggregates and percentage of voids filled with bitumen with respect to different percentage of bitumen content were obtained from Marshall test. Six curves are graphically shown in [Fig. 2] to [Fig. 7] which representing Marshall test results for mix type A, B and C in a consolidated form for comparison.

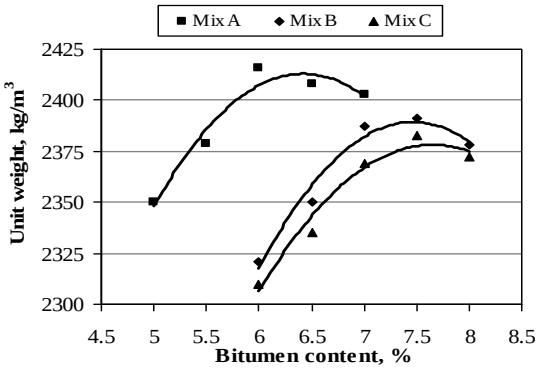

Figure 2. Relationship between unit weight and bitumen content for different mix type

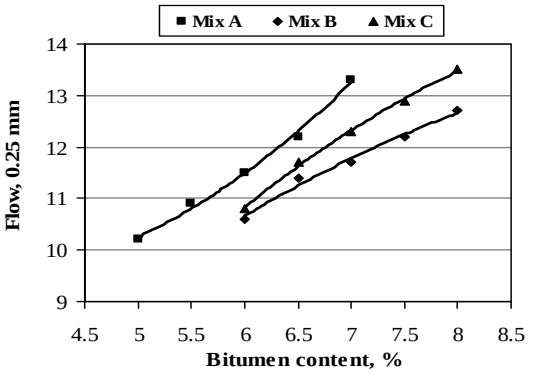

Figure 4. Relationship between flow and bitumen content for different mix type

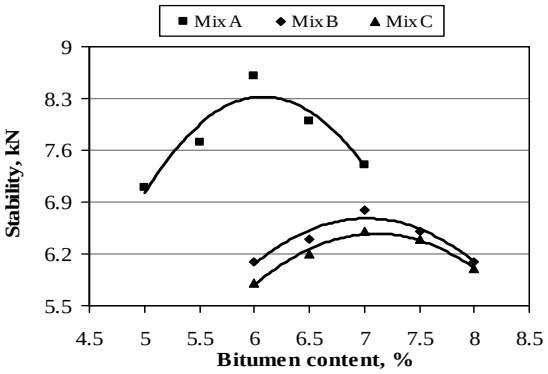

Figure 3. Relationship between stability and bitumen content for different mix type

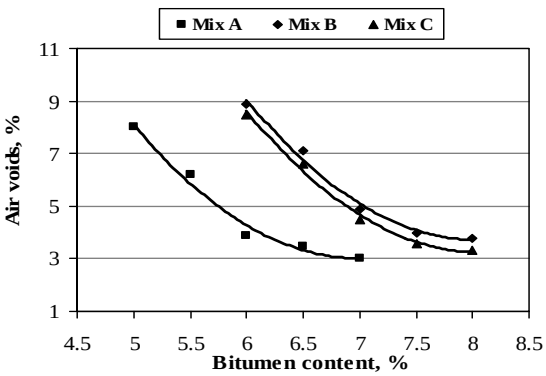

Figure 5. Relationship between air voids and bitumen content for different mix type

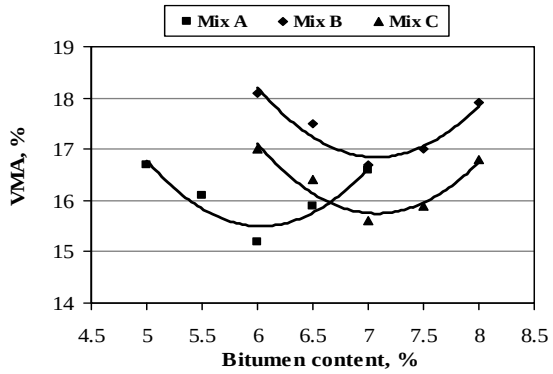

Figure 6. Relationship between VMA and bitumen content for different mix type

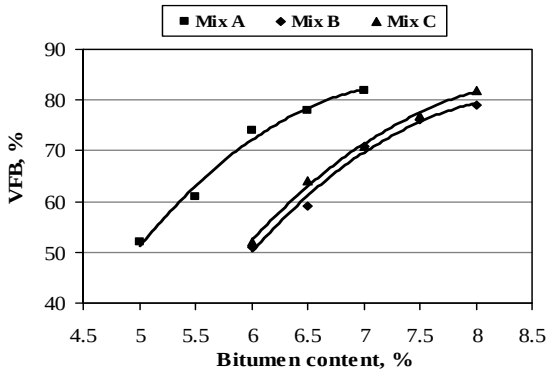

Figure 7. Relationship between VFB and bitumen content for different mix type

The bitumen content at maximum unit weight and at maximum stability are determined from [Fig. 2] and [Fig. 3] respectively. For base course, bitumen content at 4% (median of 3-5%) air voids in mix is determined from [Fig. 5]. The average of these three bitumen content is taken as optimum bitumen content which shown in Table 4.

Table 4. Optimum bitumen content of different mix types

Mix type	BC at max. unit weight (%)	BC at max. Marshall stability (%)	BC at 4% Air voids (%)	Optimum bitumen content (%)
A	6.4	6.0	6.2	6.2
B	7.5	7.1	7.4	7.3
C	7.6	7.1	7.4	7.4

At optimum bitumen content, the values of unit weight, stability, flow, percentage of air voids, percentage of voids in mineral aggregates and percentage of voids filled with bitumen for different mix type are shown in Table 5.

Table 5. Characteristics of bituminous mixes at optimum bitumen content for different mix types

Properties	Mix type			Recommended values by Asphalt Institute
	A	B	C	
OBC (%)	6.2	7.3	7.4	…
Unit weight (kg/m^3)	2410	2388	2376	…
Stability (kN)	8.3	6.8	6.6	5.338
Flow (0.25 mm)	11.8	12.6	12.2	8-16
Air voids (%)	4	4.2	3.9	3-5
VMA (%)	15.5	16.9	15.8	>12
VFB (%)	73	75	76	65-78
Marshall stiffness (kN/mm)	2.81	2.25	2.13	>2.1

Table 5 indicates that, the values of unit weight, Marshall stability, flow and voids characteristics of the bituminous mixes with different types of filler material satisfy the limiting value recommended by the Asphalt Institute. For interpretation of Marshall test results, Lees (1983) considered the stiffness (the ratio of stability to flow) of the mix which can be related to tyre pressure. In order to prevent permanent deformation of the mix under high stress, the Marshall stiffness should not be less than 2.1 kN/mm for the design tyre pressure of 100 psi. It is seen from Table 5 that, the Marshall stiffness are above required value 2.1 kN/mm for different type of mixes.

CONCLUSION

Based on the results of laboratory experiments of this investigation, the following conclusions can be drawn:

- The stability, flow value and voids characteristics of bituminous mixes with waste dust, brick dust and ash as filler satisfy the Marshall design criteria.
- From the consideration of availability, waste dust, brick dust and ash can be used as mineral filler in flexible pavement construction as compared with conventional fillers.

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ASSESSMENT OF RECYCLING AGGREGATE AS CONSTRUCTION MATERIALS

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ABSTRACT

Large volume of waste materials is produced every year. These large volumes recycled aggregates to assess further utilization for construction works. A number of laboratory tests such as specific gravity and absorptions test, aggregate crushing value test, aggregate impact value test, Loss Angeles abrasion test, compaction test, CBR test, compressive strength test, splitting test were conducted to evaluate the materials properties. The test results show that the bulk specific gravity is 1.78 both for fresh and waste aggregates, the apparent specific gravity is 2.44 both for fresh and waste aggregates, the aggregate crushing value of fresh aggregate and waste coarse aggregate is 31.01% & 34.10% respectively, the aggregate impact value of fresh aggregate and waste aggregate is 15.56 % & 17.04% respectively, the Loss Angeles abrasion value of fresh coarse aggregate is 42.20%, where as for the waste coarse aggregate the same value is 43.43 %, the maximum dry density is 1.74 for fresh aggregate and 1.71 for waste aggregate, the CBR of waste aggregate is 61.50 % for soaked condition and 68.88 % for unsoaked condition, the compressive strength of waste aggregate is 5.50Mpa for 7 days curing and 10.43 Mpa for 28 days curing, the tensile strength of waste aggregate is 1.11 Mpa for 7 days curing and 1.37Mpa for 28 days curing. The properties of fresh and recycled aggregate are compared to the standard specifications. The result of recycled aggregates confirmed that they can be used as C.C works, sub base, temporary structures.

Keywords: Recycling Materials, Materials and Aggregates as construction Materials.

INTRODUCTION

The terms' recycled aggregate, refers to aggregate that have been used previously in construction. After demolition large volume of waste materials is produced every year. These large volumes recycled aggregates to assess further utilization for construction works. To assess the further utilization of recycled concrete aggregate(RCA) , a number of laboratory test were conducted. RCA is not widely used in new concrete mixtures, however, largely because RCA concrete has been reported to be of inferior quality to concretes produced with virgin aggregates. In some countries it is a standard alternative for both construction and maintenance, particularly where there is a shortage of

construction aggregate. The construction and demolition materials create many problems. The objective of this paper to determine the technical feasibility/applicability of using the recycled aggregate in road construction as an alternative for natural aggregate.

Objective of the research

The construction and demolition materials create many problems. With a view to use them for various purposes the thesis works has done. Prior to use these materials in construction, it is essential to know its behavior and various properties that are needed in design. The investigation and experiment were performed to attain primarily the following objectives:

1. To determine and compare the physical properties of recycled aggregates and both of fresh aggregates and standard specification.
2. To compare the test results of CBR between recycled aggregates and both of fresh aggregates and standard specification.
3. To investigate the behavior of recycled aggregate and fresh aggregate with respect to i) Loss Angeles Abrasion Test results ii) Impact Value Test results iii) Crushing Value Test results iv) Compaction Test results v) CBR Test results vi) Compressive Strength Test results vii) Splitting Test results

Scope of the study

The scope of the study consists of the following application of recycled aggregate:

1. New concrete for pavements, shoulders, median barriers, sidewalks, curbs and gutters,and bridge foundations;
2. Structural grade concrete;
3. Road sub-base, base and bituminous concrete;

MATERIALS AND METHODS

General

Coarse aggregates were collected from Padma residential area. The collected samples were broken into pieces manually in 25 mm down grade. The aggregate were tested for engineering properties related to various purposes. The engineering properties of materials were determined according to the procedure specified by AASHTO, ACI, ASTM, IRC and BS standards.

Materials collection

The materials such as fresh aggregates and waste aggregates were collected from Manik Miah Road, Talaimari, Rajshahi. One of the main objectives of the work was to compare the CBR value of recycled aggregates with the fresh aggregates.

Properties of materials

The mixture of the CBR test specimen composed of coarse aggregates and 20 % sand. The following sections include the description of the coarse aggregate and fine aggregate used in this investigation.

RESULTS AND DISCUSSIONS

Table 1 Fundamental Properties of Coarse Aggregates

Properties	**Aggregate Types**	
	Fresh Aggregate	Recycled Aggregate
Unit weight, dense, (kg/m^3)	1997	1917
Unit weight, loose, (kg/m^3)	1837	1780
Bulk specific gravity	1.78	1.78
Apparent specific gravity	2.44	2.44
Absorption of water (%)	15.00	16.30

Table 2 Gradation of Recycled Aggregate

Sieve Size (mm)	Retained (%)	Passing (%)	Cumulative Retained (%)	Cumulative Passing (%)
19	0.92	99.08	0.92	99.08
12.5	39.8	60.2	40.72	59.28
9.5	29.2	70.8	69.92	30.08
6.3	19.5	80.5	89.42	10.58
4.75	5.46	94.54	94.88	5.12
			Total=295.86	

Table 3 Strength Properties of Coarse Aggregates

Properties	Aggregate Types	
	Fresh Aggregate	Recycled Aggregate
Loss Angeles Abrasion Value (%)	42.20	43.28
Aggregate Impact Value (%)	15.56	17.04
Aggregate Crushing Value (%)	31.01	34.10

Table 4 Fineness Modulus of Sand

Sieve No.	Cumulative weight retained (gm)	Cumulative (%) retained	(%)finer
No.4	0	0.00	100
No.8	0	0.00	100
No.16	0.01	0.002	99.99
No.30	3.09	0.62	99.38
No.50	197.09	39.42	60.58
No.100	461.09	92.22	7.78
	F.M = 1.32	Total=132.26	

Table 5 California Bearing Ratios

Type	CBR for 2.5 mm (%)			CBR for 5.0 mm (%)	
Fresh Aggregate	Soaked condition	Sample-1	Sample-2	Sample-1	Sample-2
		82.2	78.30	80.25	76.05
	Unsoaked condition	84.58	80.24	81.90	78.20
Recycled Aggregate	Soaked condition	60.70	59.68	62.30	60.35
	Unsoaked condition	69.45	69.97	68.31	67.45

Table 6 Compressive Strength of Fresh & Recycled Concrete

Type	Proportion	7 Days Curing(Mpa)	28 Days Curing(Mpa)
Fresh Aggregate	1:2:4	9.06	14.42
Recycled Aggregate	1:2:4	5.50	10.53

Table 7 Modulus of Elasticity of of Fresh & Recycled Concrete

Aggregate Type	Modulus of Elasticity(7 Days) (Mpa)	Modulus of Elasticity(28 Days) (Mpa)
Recycled Aggregate	11.17×10^3	15.38×10^3
Fresh Aggregate	14.34×10^3	18.13×10^3

Table 8 Tensile Strength of Fresh & Recycled Concrete

Type	Proportion	7 Days Curing(Mpa)	28 Days Curing(Mpa)
Fresh Aggregate	1:2:4	1.30	1.50
Recycled Aggregate	1:2:4	1.12	1.36

Fig 1. Physical Appearance of Fresh & Recycled Aggregate

Fig 2. Soaking of Fresh & Recycled Aggregate

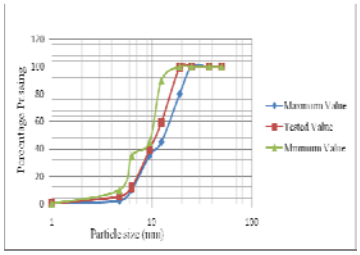

Fig 3. Particle Size Distribution Curve for Recycled Aggregate

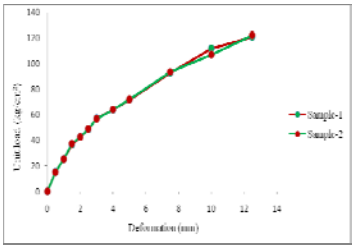

Fig 5.Deformation vs Unit Load

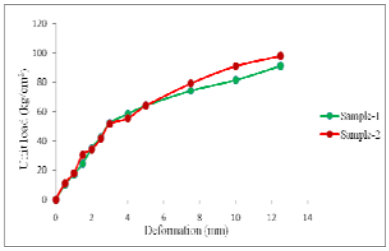

Fig 6.Deformation vs Unit Load

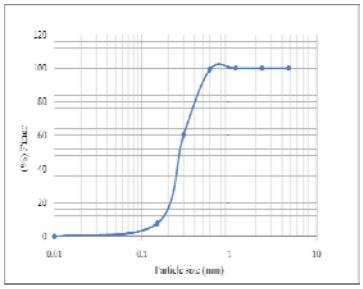

Fig: 4. Particle Size Distributions Curve for Sand

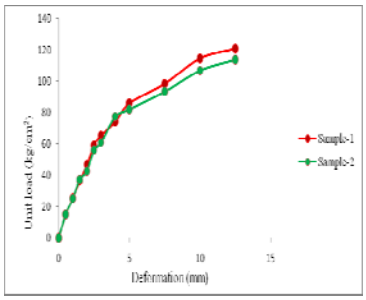

Fig 7.Deformation vs Unit Load

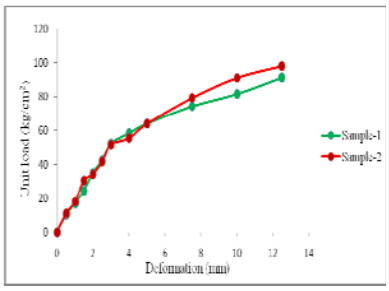

Fig 8.Deformation vs Unit Load

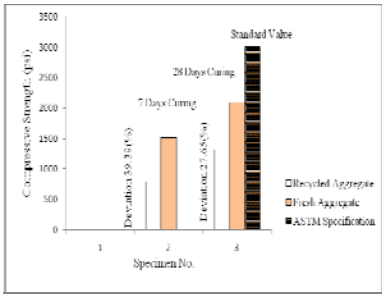

Fig 9.Compressive Strength

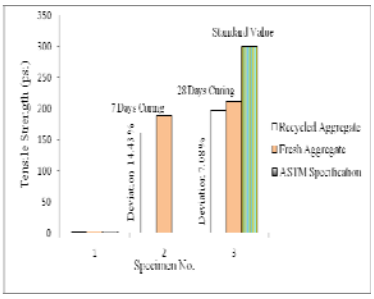

Fig 10.Tensile Strength

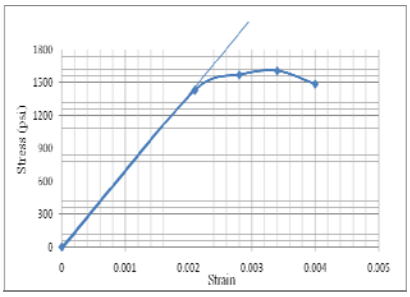

Fig 11.Stress- Strain Curve

RECOMMENDATIONS

The tests were conducted using locally available materials (recycled aggregate). Based on this study, the following recommendations can be made for future study:

1. Different proportions of fresh aggregate and recycled aggregate can be mixed to evaluate the properties of combined materials for the assessment of specific uses of these recycled aggregates.
2. Soundness of recycled coarse aggregate can be carried out to evaluate for sustainability and durability of road pavements.
3. Determination of shrinkage and creep by mixing different proportions of recycled and fresh aggregate for rigid pavements.

DISCUSSIONS AND CONCLUSIONS

The test results showed that the recycled aggregates can be used as sub base course materials. The crushing value and the impact value of recycled aggregate were within the standard specification. The Loss Angeles abrasion value of recycled aggregate was not within the standard specification. The test results concern road applications were very good and verified the adequacy of materials. However, in order to clearly outline the specification required for road application, more investigations are required to observe the field performance of these materials and their durability. On the basis of experimental results of this investigation the following conclusions can be drawn.

1. CBR of fresh aggregate were 81.22 % at soaked condition and 83.24 % at unsoaked condition & for waste aggregate the CBR were 61.50 % at soaked condition and 68.88 % at unsoaked condition.

2. Loss Angeles Abrasion value of fresh & recycled aggregate was 42.20 % & 43.43 % respectively. Impact value of fresh & recycled aggregate was 15.56 % & 17.04 % respectively. Aggregate crushing value of fresh & recycled aggregate was 31.01 % & 34.10 % respectively.
3. Compressive strength of fresh aggregate for 7 & 28 days curing was 1312.5 psi & 2091psi respectively & for recycled aggregate it was 795.5 psi & 1512.9 psi respectively.
4. Tensile strength of fresh aggregate for 7 & 28 days curing was 188 psi & 211.68 psi respectively & for recycled aggregate it was 161 psi & 196.78 psi respectively.

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PERFORMANCE EVALUATION OF LOCAL SAND AS IMPROVED SUBGRADE

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ABSTRACT

Any course of improved material between the foundation subgrade and the sub base is usually referred to as the improved subgrade. Improved subgrade (ISG) with sand of FM≥0.5 is recommended by LGED when the subgrade CBR value is less than 4%. There are large areas in Bangladesh where sand of FM≥0.5 are not available in the vicinity of road construction. Due to excessive cost on transportation of recommended sand, construction of ISG of road become expensive. This leads to search of alternative materials for construction of ISG in place of recommended sand. With this point of view this research has been carried out. The coverage area of this research is located at Gopalgonj, Jessore and upper part of Khulna of Bangladesh. The samples were collected from Modhumoti river at Gopalgonj, Underground at Jessore and Kapotakho river at Khulna. Among selected these three sources, the samples collected from Modhumoti river at Gopalgonj having FM greater than 0.5 in order to make comparison its properties with sands of FM below 0.5 collected from other two sources. Attempts were made to study and compare the properties of local sand with those of recommended sand. Test procedures specified by AASHTO standards were followed for the determination of specific gravity, FM, optimum moisture content, unit weight, CBR and shear strength parameters of local sands for this study. The test results reveal that the selected local fine sands of FM≥0.15 are suitable for the construction of ISG from the stand point of stability, permeability and swelling characteristics with saving of construction cost about 25% to 30%.

Keywords: Improved subgrade, CBR, FM, Shear strength parameters, optimum moisture content

INTRODUCTION

The road transport system is essential for the economic development of urban and rural areas of a country. Sustainable and serviceable road network system throughout the country is therefore the basic demand of the nation. The bottom layer of the road is termed as subgrade. Subgrade soil provides support to the road from below. The strength of the subgrade is the fundamental factor on determining the thickness of road pavement. Where CBR value of local soil is less than 8%, the subgrade needs to be improved or provide an additional layer called improved subgrade (ISG) with granular soil. ISG is introduced for the improvement of subgrade strength and hence reduce the thickness of pavement where the in-situ materials of subgrade have not meet specifications for suitability of pavements as per Road note 31 and BRRL. In the construction of rural roads in low land or flood prone areas, local fine sand might be considered for subgrade improvement. Mechanical or manual stabilization using thick gravel layers or granular layers is an effective method for improving roadway support over soft and wet subgrade. Chemical stabilization or stabilized by adding admixtures such as portland cement, lime, lime-cement-fly ash etc. Water proofers asphalt and geo-membranes are the alternative methods for subgrade improvement. In addition, a geo-synthetic has been used in transportation industry in

improving subgrade specified by ASTM D 35. In Bangladesh, for road construction, a thick granular layer fine sand depending on the specifications have been provided over subgrade in order to minimize the pavement thickness and cost. In Local Government Engineering Department (LGED) specification for rural roads, CBR value for subgrade material is more than 4% with compaction 95% to 100% of MDD determined in accordance with AASHTO T180-86. LGED has suggested to provide a fine sand layer of FM≥0.5 for improved subgrade in order to enhance the strength of subgrade [7]. But most of the construction agencies of coastal areas of Bangladesh, collect sand having FM below 0.5 from local tidal river bed of from underground layer and utilize them as ISG soil without any approved specification instead of LGED specified sand. Thus the importance of this research is to study the effectiveness of local sand as improved subgrade for pavement construction. The main objectives of this research are to study the uses of local sand (FM<0.5) instead of LGED scheduled sand (FM≥0.5) as ISG soil in pavement construction, to investigate the physical and strength properties of local sand and to establish a design criterion for local sand (FM<0.5) as ISG soil in pavement construction in coastal region of Bangladesh.

RESEARCH METHODOLOGY

Selection of coverage area

The coverage of this research is located at Gopalgonj, Jessore and upper part of Khulna of Bangladesh. The flexible pavements works those areas are generally not meet the specification due to the scarcity of specified sands. The three selected sources within these three districts for local sands are shown in Table 1. Among selected three sources one source was selected so as to sand of FM≥0.5 can collect in order to make comparison its properties with sands of FM below 0.5 collected from other four sources.

Table 1. List of samples with designation & name of source

Sl. No.	Sources Name	Sample Designation
1	Modhumoti River, Gopalgonj	MG-1
2	Underground at Jesssore	UJ-2
3	Kapotakho river, Khulna	KK-3

Collection of samples

After a pilot testing and all necessary checking, the samples were collected directly from the selected sources and road sections for the study. It was feasible to obtained merely undisturbed samples for cohesion less materials. In this research works, a test pit has been used to recover qualitative samples. Also a large diameter auger had been used so that batches of representative samples can be obtained for laboratory tests. Most of the samples had been collected from sources within thin plastic air proof tube, some were collected from road bed directly using split spoon. Representative samples in the sampler tube were stored in the sampler jars and returned to the laboratory for performing tests.

RESULTS AND DISCUSSIONS

Determination of physical properties

Physical properties provide the most basic description of unbound materials. These properties are also often used in correlations for more fundamental engineering properties. The principal physical properties of interest are specific gravity, grain size analysis, gradation characteristics and its classification, water content, unit weight (density) and compaction.

The specific gravity of the tested samples shown in Table 2, was determined in the laboratory and the values obtained within 2.62-2.69 but as per AASHTO and ASTM, the range of specific gravity is 2.64-2.67. It indicates that the samples are granular and which will not cause any problem in the pavement constructions.

Table 2. Specific gravity of different samples

Specific gravities	Samples		
	MG-1	UJ-2	KK-3
Apparent specific gravity	2.69	2.61	2.69
Bulk specific gravity	2.57	2.54	2.62
Bulk specific gravity SSD	2.61	2.56	2.64

The grain size distribution is commonly used for soil classification; however, there is also potential to use the grain size distribution as a basis for estimating soil behavior. Sieve analysis and hydrometer analysis of samples were conducted in the laboratory according to ASTM C 136 AASHTO T 27 test procedure. Result shows that that the selected soils are uniformly graded (poorly) fine sand and soil type is SP and A-3. [Fig. 1] shows the grain size distribution curves and grain size distribution result shows in Table 3.

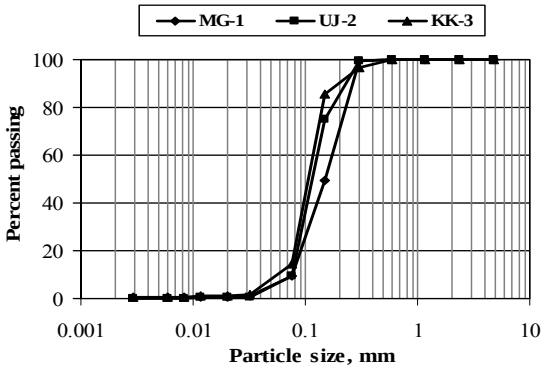

Figure 1. Grain size distribution curves

Table 3. Grain size distribution results

Sample type	FM	% of Sand	% of Finer	% of Clay	Soil type
MG-1	0.51	90.34	9.66	0.43	Uniformly graded (poorly) fine sand Type SP & A-3
UJ-2	0.26	90.40	9.60	0.09	
KK-3	0.18	85.70	14.30	0.79	

Maximum dry density (MDD) and optimum moisture content (OMC) were determined in the laboratory by the modified proctor test according to ASTM D 1557 and also field dry density (FDD) of compacted layers were determined according to ASTM D 1556 and AASHTO T 191. Test results are shown in [Fig. 2] and Table 4. Compaction needs as per LGED specification for ISG layer in pavement construction is 95%-100% based on MDD modified but the range of compaction obtained from tests is within 97%-99%, hence the selected materials go well with the LGED specification.

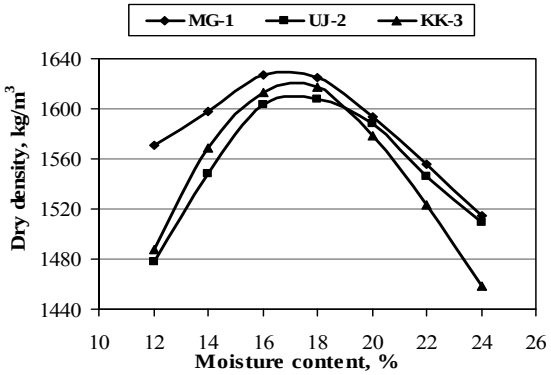

Figure 2. Relation between Maximum dry density and moisture content

Table 4. Results of density and compaction

Items	Samples		
	MG-1	UJ-2	KK-3
MDD, kg/m^3	1638	1610	1625
OMC, %	17	18	17
FDD, kg/m^3	1635	1602	1614
Compaction	99.82	99.50	99.32

The unit weight is indicates the calculation of in-situ stresses and it correlates with other behavior and properties and also control compaction. By determining dry unit wt. in the laboratory as well as in-situ dry unit weight, the relative density was then calculated based on ASTM D 4253 and test results shown in Table 5. The dense dry unit wt. obtained from the tests are within 1427-1472 kg/m3 which satisfy the value recognized by AASHTO/ASTM that is 1428-1835 kg/m3. Relative densities of the samples are within 65%- 85% indicates that the samples in the sources were in dense condition.

Table 5. Unit wt. and Relative density of different sample

Items	Samples		
	MG-1	UJ-2	KK-3
Dense dry unit wt.	1472	1427	1446
Loosen dry unit wt.	1246	1219	1218
In-situ dry unit wt.	1395	1353	1364
Relative density	69.57	67.95	67.88

Shear strength characteristics

The strength of a soil determines its ability to support the load of a structure and remain stable. The strength of a soil is often determined by its ability to withstand shearing stresses which could be determined from shear strength parameters and CBR values.

Shear strength parameters has been measured in the laboratory by the direct shear test shown in Table 6. The values of friction angle and cohesion were 22.21˚ to 30.40˚ and 0.90 kPa to 2.70 kPa respectively. According to ASTM and AASHTO, the angle of internal friction of fine sand is 27˚-35˚. But the angle of internal friction of samples is within or very near to the specification.

Table 6. Angle of internal friction and Cohesion of the samples

Items	Samples		
	MG-1	UJ-2	KK-3
Angle of Friction (º)	30.40	27.78	22.21
Cohesion (kpa)	0.90	2.25	2.70

California Bearing Ratio (CBR) is a penetration test as a method to evaluate the potential strength of subgrade soils and other pavement materials. The CBR tests were conducted in the laboratory for both soaked and un-soaked condition according to ASTM D 1883 (2007) and AASHTO T 193 (1995). As well as the field CBR was determined in the field according to Road Note 29 (2002), TRRL, UK. All of these CBR values are shown in Table 7. According to LGED specification, the soaked CBR for ISG layer should not be less than 8% at 95%-100% compaction of maximum dry density modified but we get a good result from the test materials which is greater than the specification. Also ASTM, TRRL and Road Note 29, (2002) recommended soaked CBR for sand is 7-20% which matches with the research results.

Table 7. CBR values for the different samples

Items	Samples		
	MG-1	UJ-2	KK-3
Soaked CBR (%)	12.72	12.09	11.55
Un-Soaked CBR (%)	18.93	17.09	16.65
Field CBR (%)	17.63	16.02	15.03

Cost and benefits assessment

The goal of this research is to provide local sands for road construction justifying its properties with the intention of saving money and to lessen construction time with increasing its activities. For this purpose, the cost of 1 cum scheduled sands of FM ≥ 0.5 and local sands of FM < 0.5 has been analyzed at construction site including its carrying cost. The analysis of costs diagrammatically is shown in [Fig. 3].

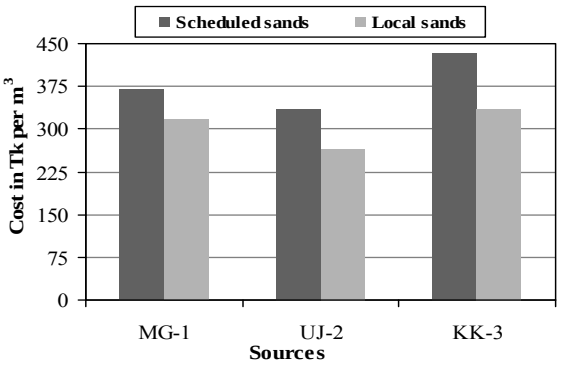

Figure 3. Comparison of cost per cum of scheduled sands and local sands

CONCLUSION

It is observed from the results of all tests for the selected materials when had been used in improved subgrade, the load carrying capacity of the model flexible pavement had significantly acceptable for all type of traffic. Based on the findings the following conclusion can be drawn:

- From the consideration of strength properties, the local sands having FM≥0.15 may be used as improved subgrade soils.
- Where scheduled sands of FM≥0.5 are not available, pavement construction with local sands of FM≥0.15 as ISG soil shall be economical and easier.
- From the outcome of this research, the following design criteria for local sands as ISG soil has been recommended in the area where Sand of FM≥0.5 is not available. The recommended design criterions are shown in Table 8.

Table 8. Recommended design criteria of local sands for improved subgrade

Description	Design Criteria	Remarks
ISG materials	Local sand	-
FM	≥ 0.15	-
Fines (pass sieve no. 200)	< 8 %	Clay < 1 %
Compaction	95% - 100 %	modified MDD
CBR (soaked)	> 8 %	modified
Internal Friction Angle	> 24 º	Optional
Cohesion	< 2 kPa	Optional

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EFFECT OF FINE AGGREGATE TYPE ON BITUMINOUS PAVING MIXES

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ABSTRACT
Properties of bituminous mixtures, not only depends upon the quality of the binder but also depends on the mineral aggregates. Fine aggregates is one of the mineral aggregate which affects the bituminous mixes by such factors as the amount, the grading and the shape of the grains. In this investigation, an attempt is made to study the effect of fine aggregate type on the characteristics of bituminous concrete mixes. Attempts are made to study and compare the characteristics of bituminous mixes with locally available fine sand, waste aggregate and brick chips as fine aggregate. In this investigation unit weight, stability, flow and voids in mixes at the optimum bitumen content for the bituminous mixes using different types of fine aggregate were determined according to AASHTO. The study reveals that the bituminous mixes with waste aggregate as fine aggregate gives the better result than the bituminous mixes with sand for use in the base or surface course of bituminous pavement from the stand point of stability, deformation and voids characteristics. The Marshall stability of bituminous mixes with sand, waste aggregate and brick chips as fine aggregates are 11.3, 11.1 and 10.6 kN at optimum bitumen content 7.2, 7.3, 7.5% respectively. This investigation indicates that the possibility of using waste aggregates and brick chips as fine aggregates in the bituminous concrete mixes with availability point of view.

Keywords: Fine aggregate, Bituminous mixes, Brick chips, Stability, Voids characteristics.

INTRODUCTION

In the construction of bituminous pavement, aggregate acts as a principal material. The properties of the aggregate have direct and significant effects on the performance of bituminous pavements. In Bangladesh, natural aggregates for the construction of conventional road are obtained by crushing of rocks. In bituminous mixes, aggregates are combined with a bituminous binding medium to form a compound material. By weight, aggregate generally accounts for between 92 and 96 percent of hot bituminous mixes (Ganapati Naidu and Adiseshu, 2011). Among the aggregates, fine aggregate in bituminous mix gives some additional stability to the mix and at the same time fine aggregate reduce in the voids in coarse aggregate through the interlocking of the particles. Research has shown that aggregate characteristics such as particle size, shape and texture influence the performance and service ability of hot bituminous pavement (Brown et al., 1989; Khandal et al., 1992; Kim et al., 1992). There is a direct correlation between the rutting potential of HMA mixtures and the shape and texture of coarse aggregate particles (Krutz and Sebaaly, 1993). Another study reveals that flat and elongated particles could be permitted in a mixture without adverse effect on its strength. Some mixes with flaky aggregates have been found to exhibit higher fatigue life than mixes with non-flaky aggregates (Li and Kett, 1967). The quality and durability of bituminous macadam is influenced by many factors

including the types of the fine aggregate. Various materials are used as a fine aggregate on bituminous mixes. But locally available fine sand, waste stone aggregate and brick chips passing through the 2.36 mm sieve and retained on the 0.075 mm sieve appear to be suitable as fine aggregate. With the above requirement, the present investigation has been taken in order to investigate the behaviour of bituminous macadam with different types of fine aggregate. The objectives of this investigation are to investigate the behaviour of bituminous mixes and to determine the optimum bitumen content with respect to different types of fine aggregate.

MATERIALS AND METHODS

One of the main objectives of this research was to make a comparative study of the bituminous mixes with different fine aggregate. Therefore, the type of coarse aggregate, type of filler and type of bitumen were same in all bituminous mixtures.

Mineral aggregate

For coarse aggregate the white stone was crushed manually and brought to the sizes of 25.0 mm or less. The aggregate were the sieved using U.S. standard sieves and separated out in different fraction. This aggregate consists of white stone chips were collected from Civil Engineering Lab, RUET which was originated in Panchagarh, Bangladesh. Domar sand, waste stone chips and brick chips were used as fine aggregate in the bituminous mixtures. These fine aggregate passing through 2.36 mm sieve and retained on 0.075 mm sieve. Mix of brick dust finer than 0.075 mm was used as filler in all mixes. The physical properties of coarse aggregate, fine aggregate and filler materials are shown in Table 1.

Table 1. Properties of mineral aggregate

Properties	Coarse aggregate	Fine aggregate			Filler
		Domar sand	Waste stone chips	Brick chips	
Loose unit wt. (kg/m^3)	1200	1400	1450	1000	1050
Dense unit wt. (kg/m^3)	1360	1570	1500	1150	1320
Apparent specific gravity	2.665	2.637	2.653	2.273	2.333
Bulk specific gravity	2.274	2.346	2.350	2.212	2.333
Water absorption, %	6.46	2.72	2.76	15.75	…
Aggregate crushing value, %	31	…	…	…	…
Aggregate impact value, %	22	…	…	…	…
Loss angles abrasion value, %	42	…	…	…	…

Mix types and aggregate gradation

Three types of mixes were studied in this investigation and these are designated as A, B and C. These mixes are given below:

Mix A: C. A. from white stone + Fine aggregate from Domar sand + Filler from non-plastic sand
Mix B: C. A. from white stone + Fine aggregate from waste stone chips + Filler from non-plastic sand
Mix C: C. A. from white stone + Fine aggregate from brick chips + Filler from non-plastic sand

To give the most satisfactory behavior for bituminous macadam base course of 6 cm to 7.5 cm thickness was selected from Roads and Highway Department (RHD) in Bangladesh. The aggregate gradation selected for this study is presented in [Fig. 1] (Sobhan et al., 2011).

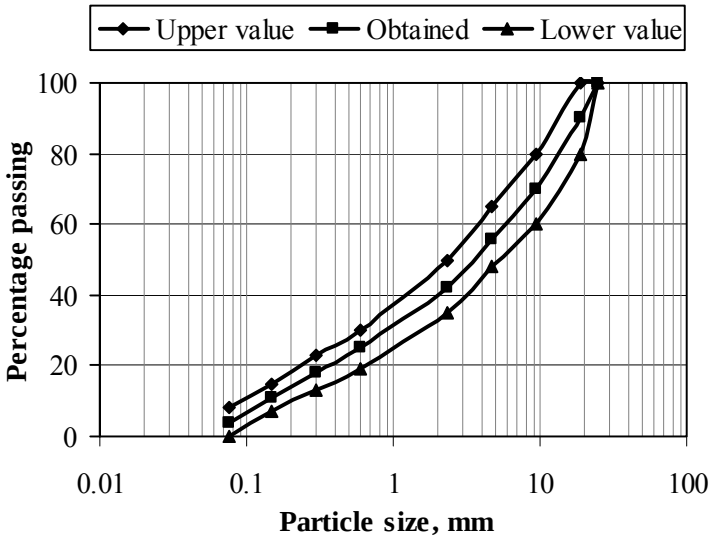

Figure 1. Gradation of aggregate

Bitumen binder

The bitumen was of 80/100 penetration grade bituminous cement collected from Eastern Refinery, Chittagong, Bangladesh. This was used for all mixes so that the type and grade of binder would be constant. Properties of bitumen used in this investigation shown in Table 2 which were performed according to the procedures specified by the AASHTO.

Table 2. Properties binder material

Test	AASHTO designation	Test value
Penetration, ($1/10^{th}$ mm)	T49	83.5
Specific gravity	T229	1.015
Ductility (cm)	T51	112.5
Solubility, %	T44	99.5
Softening point, C	T53	46.5
Loss on heating, %	T47	1.22
Flash point ,C	T48	285
Fire point, C	T48	315

Preparation of specimen and test procedure

To ascertain the optimum bitumen content for selected bituminous mixtures, Marshall test specimens of 101.6 mm diameter and 63.5 mm thick were prepared for medium traffic requires 50 blows per side of the specimen as per AASHTO T245-82 by varying bitumen content. The number of blows for the preparation of specimen was selected corresponding to 690 kN/m^2 (100 psi) tire pressure. The heavy vehicles which on the roads of Bangladesh have tire pressures in the range of 415-485 kN/m^2 (60-70 psi). So the assumption of 690 kN/m^2 tire pressure seems to be quite safe and appropriate. The bulk specific gravity of fresh compacted specimens was determined according to the test procedure specified by ASTM 2726. After determination of the bulk specific gravity, the specimens were then subjected to Marshall stability and flow tests as per AASHTO T245-82. Voids analyses were made for each series of test specimens after the completion of the stability and flow tests. The variations of bulk density, Marshall stability and air voids in total mix with bitumen contents were plotted and then the Optimum bitumen content was determined as follows: the average bitumen content of bitumen content at maximum density, bitumen content at maximum unit weight and bitumen content at 4 percent (median of 3-5 percent range) air voids in total mix.

RESULTS AND DISCUSSIONS

Effects of fine aggregate type on the behaviour of bituminous mixtures

Result shown in [Fig. 2] and [Fig. 3] indicates that, the unit weight and stabilities of the compacted specimens increase initially with the increase of bitumen reach a maximum value and then decrease for all type of mixes. With the increment of bitumen, the better compactions were done as a result the unit weight and stability increased. For further increment of bitumen, the bitumen has a tendency to segregate from the specimens as a result unit weight of the mix decreases with increase of bitumen.

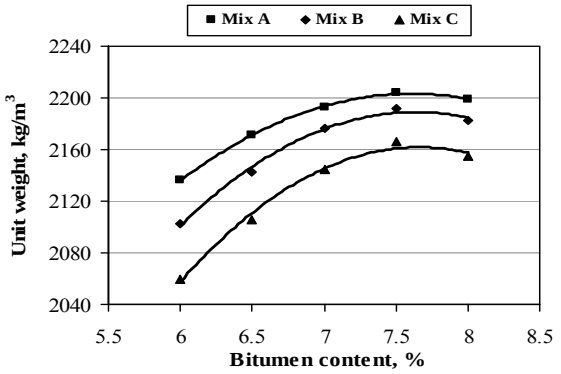

Figure 2. Relationship between unit weight and bitumen content for different types of F. A.

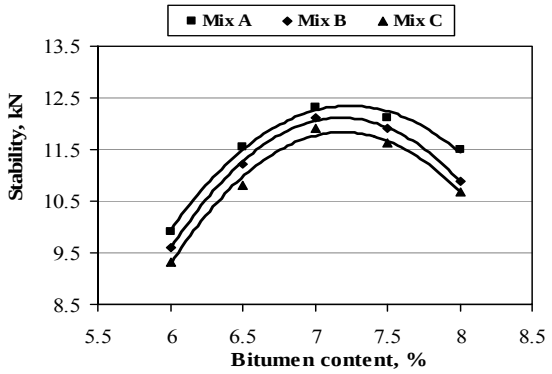

Figure 3. Relationship between stability and bitumen content for different types of F. A.

The variation of flow value with respect to bitumen content for all types of fine aggregate is shown in [Fig. 4]. Flow value increases with the increase in bitumen content due to the emulsifying action of bitumen binder. On the other hand air voids of the mix with various fine aggregate reported in [Fig. 5] shows that the percentage of air voids in the total mix decreases with the increase in percentage of bitumen content. Some values of flow and air voids are within the limiting value recommended by The Asphalt Institute, 1984.

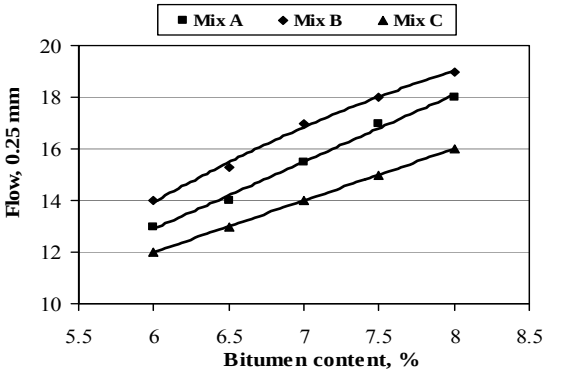

Figure 4. Relationship between flow and bitumen content for different types of F. A.

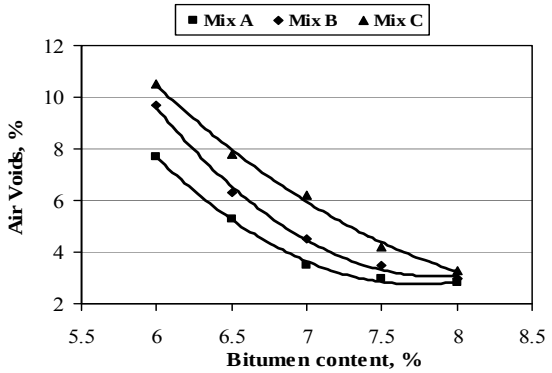

Figure 5. Relationship between air voids and bitumen content for different types of F. A.

[Fig. 6] shows that percentage of %VMA initially decreases with the increase of bitumen, reach a minimum value and then increase for all types of fine aggregates. With the increment of bitumen the void in mineral aggregate decrease but further increase in bitumen causes the segregation of bitumen from mix so that %VMA increased. On the other hand percentage of %VFB increases with increase of bitumen shown in [Fig. 7]. Some values of %VMA and %VFB are within the limiting value recommended by The Asphalt Institute, 1984.

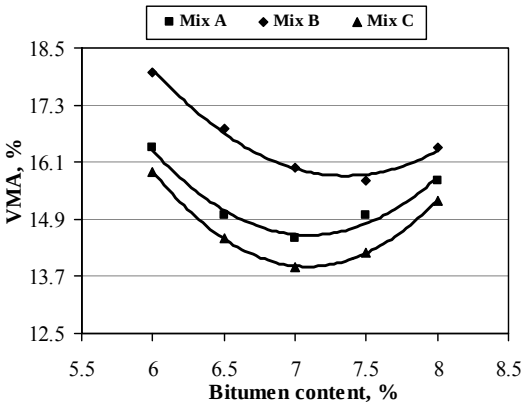

Figure 6. Relationship between VMA and bitumen content for different types of F. A.

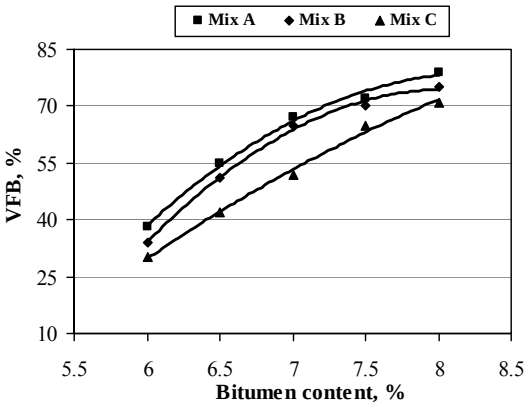

Figure 7. Relationship between VFB and bitumen content for different types of F. A.

Determination of optimum bitumen content

The bitumen content for maximum unit weight and at maximum stability is determined from [Fig. 2] and [Fig. 3]. For base course, bitumen content at 4% (median of 3-5% range) voids in total mix is determined from [Fig. 5]. The average of these three bitumen content is taken as optimum bitumen content. At optimum bitumen content, the values of unit weight, Marshall stability, flow, air voids, percentage of voids in mineral aggregate and percentage of voids filled with bitumen for different mix types are shown in Table 3.

Table 3. Characteristics of bituminous mixes at optimum bitumen content for different mix types

Mix types	OBC (%)	Unit weight (Kg/m^3)	V_a (%)	VMA (%)	VFB (%)
A	7.2	2200	3.2	14.5	70
B	7.3	2184	3.6	15.8	68
C	7.5	2160	4.2	14.1	65

Table 3 indicates that the voids in mixes for various aggregate types at optimum bitumen content are within the ranges of voids in bituminous mixes. For mix types A, B and C the percentage of voids in mineral aggregate for base course at OBC are 10.6, 11.9 and 9.8 respectively. All this values satisfy the minimum value (13%) of VMA for minimum particle size 25 mm specified by The Asphalt Institute. For mix type A, B and C the percentage of void filled with bitumen at optimum bitumen content also satisfy the limiting value (65-78%) according to The Asphalt Institute.

From the Table 4, it is shown that the Marshall stability for different mix type at optimum bitumen content satisfy the limiting value of 5.34 kN for medium traffic specified by The Asphalt Institute. For interpretation of Marshall test results, Lees (1983) considered the stiffness (the ratio of stability to flow) of the mix which can be related to tire pressure. In order to prevent permanent deformation of the mix under high stress, the Marshall stiffness should not be less than 2.1 kN/mm (120 lb/0.01″) for the design tire pressure of 100 psi (Lees, 1983). Table 4 indicates that the Marshall stiffness for all types of mixes is greater than the limiting value. The total surface covered on the pavement is dependent on volume. Table 4 shows that, to prepare one cubic meter of compacted specimen 161.5, 158.5 and 167 Kg bitumen will be required for mix type A, B and C respectively.

Table 4. Characteristics of bituminous mixes at optimum bitumen content for different mix types

Mix type	Marshall stability (kN)	Flow (0.25 mm)	Marshall stiffness (kN/mm)	Amount of bitumen per cubic meter of mix (Kg)
A	11.3	16	2.83	161.5
B	11.1	17.6	2.52	158.5
C	11.6	14.8	3.14	167.0

CONCLUSION

On the basis of experimental results of this investigation, the following conclusions can be drawn:

- The stability, flow value, percent of air voids, percentage of voids in mineral aggregates and percentage of voids filled with bitumen of bituminous mixtures with Domar sand, waste stone aggregate and brick chips as fine aggregate satisfy the Marshall design criteria.
- From the consideration of availability, brick chips can be used as fine aggregate in flexible pavement construction as compared with stone chips and coarse sand.

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PROCEDURE TO BUILD CONSENSUS FOR PUBLIC POLICY BY FUZZY AHP; CASE STUDY ON: TRAFFIC CONGESTION MANAGEMENT IN CENTRAL DHAKA

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ABSTRACT
Public policy is a matter of public importance subject to dispute and compromise or maintained by government. Generally two types of people are related to the public policy, they are-government and residence. And consensus building is known as collaborative problem solving or collaboration method. For any kind public policy when government and residences opinion is not same then it's become very important for government to build consensus. For to reduce traffic congestion Dhaka city government's consideration is to ban rickshaw from main road. But most of the residences consideration is not to ban rickshaw. So there is a conflict between government and residence opinion for transportation planning in central Dhaka. It is very important for government to build consensus for traffic congestion management in central Dhaka by considering residences opinion. To find out the procedure to build consensus for public policy this study use Fuzzy method on AHP analysis.

Keywords: Consensus building, Traffic Congestion, Rickshaw

INTRODUCTION

Now a day's to build consensus become very important for different types of public policy. The importance to build consensus also become very important for traffic congestion management in central Dhaka between government and residences.

Bangladesh is a populous country and Dhaka is the capital of Bangladesh, has to accommodate a large share of this population. The transportation system of Dhaka is predominantly road based where non-motorized transportation (mainly rickshaw) has a substantial share. So far traffic congestion has now become a very serious problem particularly in Dhaka and that congestion occurs mainly due to the mixture of motorized and non-motorized transport on the same road space, (Mannan and Karim, 2001). Under the pressure from the World Bank Dhaka City Corporation (DCC) banned rickshaw from some important roads. The reasons given for the ban were that rickshaws cause traffic congestion because they take up too much road space and move more slowly than motor vehicles, (Bhuiyan, 2007). So far Dhaka city government's consideration is to ban rickshaw from main road will be the best solution for traffic congestion management for central Dhaka. But most of the residences consideration is not to ban rickshaw. Because after rickshaw bans poor and middle class residences suffer so much because of finding no adequate replacement transport and often experiencing greater travel costs in term of time and money. So there is a conflict between government and residence opinion for transportation planning in central Dhaka. It is very important for government to build consensus for traffic congestion management in central Dhaka. For that reason this study tries to build consensus on traffic congestion

management in central Dhaka and propose generalized methodology in order that government can find out the procedure to build consensus for any kind of public policy.

STUDY AREA FOR THE CASE STUDY

Dhaka is a megacity and one of the major cities of South Asia. It is the 9th largest city in the world and also 28th among the most densely populated cities in the world. Nearly 300,000 cycle rickshaws running on its streets every day, the city is also described as the Rickshaw Capital of the World. This study applied "Motijheel" one of the most important places in central Dhaka. Here traffic congestion is the matter of every day. This study considered 9 km^2 land areas, which are shown in the Fig. 1.

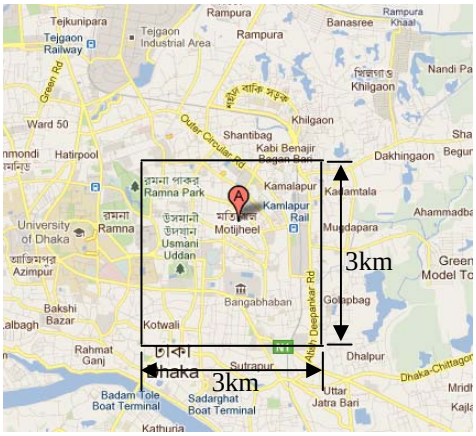


Fig. 1 Study area at the central part of Dhaka city

METHODOLOGY

Applying Fuzzy AHP for the case study

This study applied Fuzzy AHP for to build consensus for any kind of public policy and on traffic congestion management in central Dhaka. Figure 2 shows the hierarchy chart for the case study. In this study the evaluation factors are considered from the following substances, Safety: Traffic congestion sometime causes road accidents and people become injured. Therefore, traffic congestion hampered safety. Travel time: Everybody likes short travel time. However due to traffic congestion, travel time become longer. Economical impact: When the government introduces new transportation plan, social economical effect becomes important. For example people's income, travel cost (Example: fare), time value etc. Environmental impact: Due to traffic congestion, the air pollution rate in Dhaka city increase day by day. The pollution causes health hazard. Among the four evaluation factors two alternatives are considered. Those alternatives are "banned rickshaw from main road and promote efficient public transportation" which is shown in Fig. 3(a) and "only rickshaw for the central part of Dhaka city" which is shown in Fig. 3(b).

Outline of the questionnaire survey for the case study

In this study questionnaire survey was done at the central part and some other parts of Dhaka city. Total 178 questionnaires were collected from residents and 3 questionnaires from government.

Analyzing Fuzzy AHP for the case study

Degree of importance of evaluation factors:

This study analyzed the questionnaire from residences and national governments found different results. From Fig. 4 it is found that on residences consideration economical impact and safety are most important. Furthermore, the most important factor for national government is economical impact. Environmental impact is second important factor for government.

Evaluation of alternatives for the case study

Almost 1 million trips induce in 9 km^2 land area in central Dhaka every day. To move within central Dhaka residences use different types of vehicle. Table 1 shows the modal share of transportation at Dhaka for different alternatives. For analyzing the alternative "banned rickshaw from main road

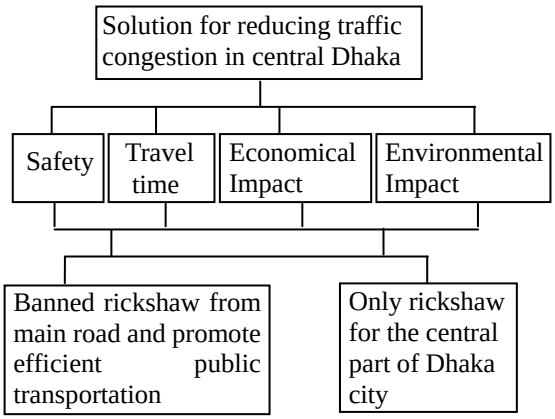


Fig. 2 Hierarchy chart

(a) Banned rickshaw from main road and promote efficient public transportation

(b) Only rickshaw for the central part of Dhaka city

Fig. 3 Alternatives

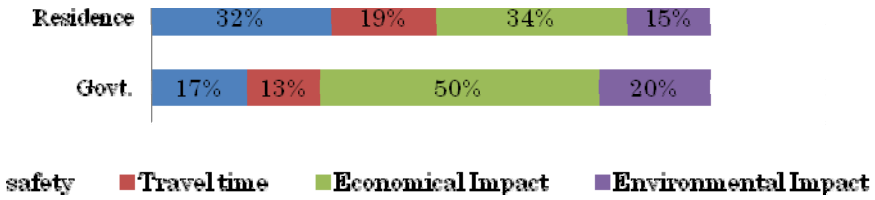


Fig. 4 Degree of Importance

Table 1 Mode of travel and modal share

Mode of Travel	Present Modal share	Banned Rickshaw	Only Rickshaw
Car	0.04	0.04	0
Bus	0.11	0.13	0
Auto-Rickshaw	0.06	0.12	0
Rickshaw	0.14	0	0.25
Pedestrian	0.65	0.71	0.75

Table 2 Evaluation factor's score of alternatives

	Safety	Travel time	Economical Impact	Environmental Impact
Banned rickshaw	0.25	0.73	0.63	0.25
Only rickshaw	0.75	0.27	0.37	0.75

Table 3 Accountable degree by residence

	Residence		Government	
	Importance degree	Accountable degree	Importance degree	Accountable degree
Safety	0.32	0.94	0.17	0.33
Travel time	0.19	0.56	0.13	0.26
Economical Impact	0.34	1.00	0.50	1
Environmental Impact	0.15	0.44	0.20	0.40

Table 4 Analysis result by Fuzzy AHP

		U-evaluation	L -evaluation
Banned Rickshaw	Residence	0.67	0.27
	Government	0.66	0.49
Only Rickshaw	Residence	0.73	0.31
	Government	0.52	0.34

and promote efficient public transportation", considered 40% of the residence travel by rickshaw before will travel by tempo, 20% by bus and 40% will move by walking. For the alternative "only rickshaw for the central part of Dhaka" considered 40% of the residence travel by bus or other public transport before will travel by rickshaw and 60% will move by walking.

This study by considered the evaluation factor safety, considered accidents rate. Rickshaws accidents rate is much lower than motor vehicle. Travel time analysis considered velocity of the vehicles. Rickshaws velocity is lower than motor vehicle. Economical impact analysis considered travel cost, income loss or gain of rickshaw driver and bus service authority, and time value etc. Environmental impact analysis considered CO_2 emission rate from vehicle. By using that information this study find out the results of evaluation factor's score of alternatives which are shown in Table 2.

Evaluation by Fuzzy AHP

This study analyzed by Fuzzy AHP uses accountable degree of the evaluation factors. Accountable degree is the degree that evaluation factor can represent upper level purpose. Table 3 shows accountable degree of the evaluation factor for the residence and government. By using Fuzzy AHP find out U & L-evaluation, (Gokitani and Kishi, 2007). U and L- evaluation of the alternatives of residences and government are analyzed by using the evaluation factor's score for alternatives and accountable degree of residences and government from Table 2 and Table 3 respectively.

U-Evaluation : Calculation by using highest evaluation factor & emphasize advantages.

$$U(A) = \sum_{i=1}^{n} \Delta_i \times \max(A_i) \qquad (1)$$

$$U(B) = \sum_{i=1}^{n} \Delta_i \times \max(B_i) \qquad (2)$$

Where, $\Delta_i = E_i - E_{i+1} (E_{n+1} = 0)$

$A_i = A_1, A_2, A_3, \ldots\ldots A_i$

$B_i = (1 - A_1), (1 - A_2), (1 - A_3), \ldots\ldots (1 - A_i)$

$A, B = Alternatives$

$i = 1,2,3, \ldots\ldots n$

E=*Accountable degree*

L-Evaluation : Calculation by using lowest evaluation facto & emphasize disadvantages.

$$L(A) = \sum_{i=1}^{n} \Delta_i \times \min(A_i) \qquad (3)$$

$$L(B) = \sum_{i=1}^{n} \Delta_i \times \min(B_i) \qquad (4)$$

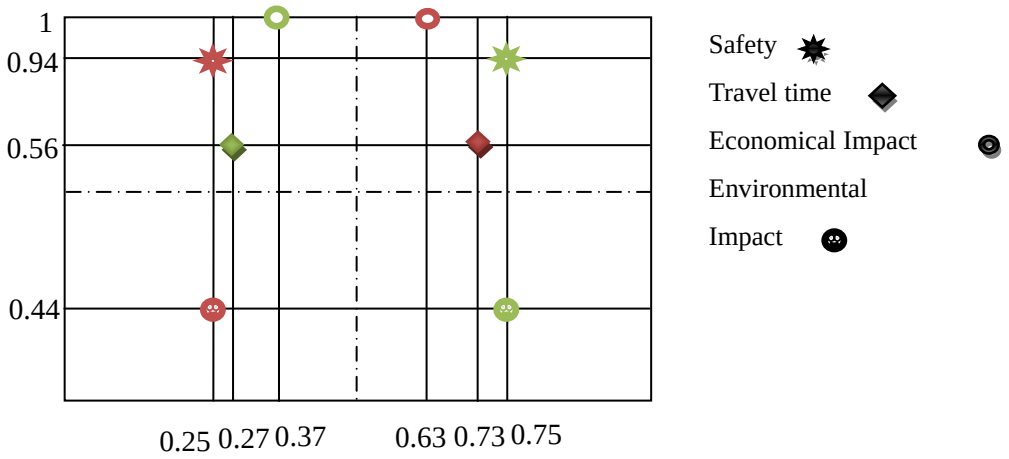
ANALYSIS RESULTS BY FUZZY AHP

This study used the Eq. (1), (2), (3) and (4); find out the results of the U and L- evaluation of the alternatives for residences and governments are shown in Table 4. By analyzing the questionnaire survey by Fuzzy AHP from residences and governments found that residences consider only rickshaw for the central part of Dhaka and governments consider banned rickshaw from main road and promote efficient public transportation will be the best solution for traffic congestion management in central Dhaka. So in this situation for Dhaka city government it's become very important to build consensus.

IMPROVED THE EVALUATION FACTORS BY CONSIDERING CASE STUDY TO BUILD CONSENSUS

In this study try to find out the situation in which condition banned rickshaw and only rickshaws evaluation will be same for residence. Consider to improve the evaluation factors has disadvantages for

banned rickshaw of residences. From Fig 5 found that safety and environmental impact of banned rickshaw has disadvantage on residences consideration. So have to improve the evaluation factors safety and environmental impact of banned rickshaw as minimum as possible.



Green for only rickshaw; Red for banned rickshaw

Fig. 5 Choquet Integral of residence for both alternatives

Table 5 Improvement score and U & L-evaluation score after improvement of evaluation factors has disadvantages

	Improvement of EF		U-evaluation	L-evaluation
Disadvantages	Safety	0.04	0.69	0.31
	Environmental Impact	0.04		

Table 6 Real condition for improvement by considering the EF has disadvantages

	Disadvantages	
	Safety (Acc. No)	Environmental Impact (CO_2 emission rate)
Improved score	0.04	0.04
Before	5570	17,812 Kg
After	3160	14,535Kg

RESULTS AND DISCUSSION

To improve the evaluation factors safety and environmental impact of banned rickshaw as minimum as possible found that when safety is improve 0.04 and environmental impact improve to 0.04 then banned rickshaw and only rickshaws U and L-evaluation score become same. Also Table 5 shows the improvement score of evaluation factor and U & L-evaluation score after improvement of evaluation factors by considering disadvantages. The real condition for improvement by considering the evaluation factor has disadvantages is shown in Table 6. So by improving safety and environmental impact Dhaka city government can build consensus easily.

GENERAL PROCEDURE TO BUILD CONSENSUS FOR PUBLIC POLICY

If the alternative choose by residence is not same with government's preferred alternative then it's very important for government to build consensus. To build consensus government have to improve his preferred alternatives evaluation factors then residence also chose government's preferred alternative. So to build consensus govt. can follow the following procedure-

Assume,
Govt. preferred alternative = A; Residence preferred alternative = B
And this study considered that consensus building will be build when on residence consideration the evaluation score of alternative “A” and alternative “B” will be equal.

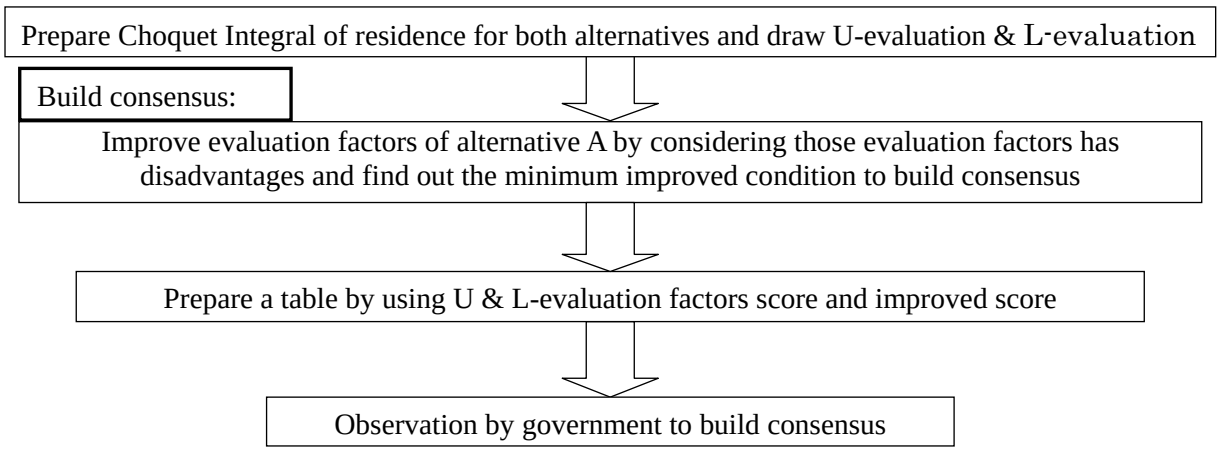


Fig. 6 General procedure to build consensus for public policy

CONCLUSIONS

This study to build consensus consider to improve the evaluation factors have disadvantages. In general to build consensus it’s better to improve the evaluation factors have disadvantages, then consensus building will be build and at the same time will improve the evaluation factors have disadvantages. By considering the case study to improve the evaluation factors have disadvantages then it will be easier for Dhaka city government to improve banned rickshaw evaluation by considering all of the evaluation factors have disadvantages as minimum as possible. Then consensus building will be build and at the same time will improve the evaluation factors have disadvantages. In the same way by observing the general procedure government can build consensus for any kind of public policy.

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EFFECTS AND FEASIBILITY OF RELOCATION OF KAMALAPUR RAILWAY STATION: AN ECONOMETRIC APPROACH

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ABSTRACT

Railways are the safest and most inexpensive land transportation system when compared to other forms of transportation. The whole railway network in Bangladesh is oriented towards Kamalapur railway station located at the heart of the capital city. It is the major railway station of Dhaka city and the railway lines connecting the station gave birth to a number of level crossings within the city. Level crossings causing significant delay at the intersections for the vehicles result in huge loss of time and resources which exacerbate the traffic volume and speed conditions as well as environmental conditions enhancing fuel emission at the intersection, noise pollution and mental sickness of passengers. It is also one of the major sources of accidents in Dhaka city. This paper demonstrates a relocation proposal of the station to outskirts of the city that in turn will result in elimination of these at-grade level crossings. Consequently, benefits can be availed in the form of reduced congestion in road network, increased road safety and enhanced reliability of rail system. On the other hand, infrastructural cost of relocation and loss of accessibility to the relocated station will add to the cons of this proposal. In this study benefits are measured quantitatively from reduction in vehicle operating costs (VOC), travel time savings using value of time (VOT) and reduced cost of road accidents. A detail econometric analysis is then performed to find out the feasibility of relocation using three different scenarios: without relocation, without relocation but with grade separated level crossings and with relocation. The study finds that the second scenario has the greatest b/c ratio and smallest payback period but as the city area expands with relocation scenario will provide more benefits due to optimal positioning of the station by lowering the cost of lack of accessibility

Keywords: Relocation, Level crossing, Delay.

INTRODUCTION

Railway System and Level Crossing

Railway is a transportation system which is termed as environment-friendly and cost-effective throughout the world. Road/rail grade intersections (Level crossings) present the only case of two

different infrastructures placed under different responsibilities and travelled by vehicles with dramatically different performances which converge and meet during their normal operation. Kamalapur Railway Station is the central railway station in Dhaka, Bangladesh. It is the largest railway station of the country and the most important terminal for communication between Dhaka and whole Bangladesh. However, the station is situated at southern part of the densely crowded city with major railway links connecting the other parts of the country entering into Dhaka from north. The major impact of the rail line passing through the city of Dhaka is the delay caused to road traffic at the level-crossings. There are 29 level crossings in Dhaka of which 9 are major ones. All these are protected with manually operating gates and provided with signaling and approach warning protection system. At present, the tracks intersect the city's road network including busy locations like Notun Bazaar, Staff Road, Old DOHS, Mohakhali, Tejgaon, Karwan Bazaar, Moghbazar, Noyatola, Wireless Gate and Malibagh Bazaar creating long traffic jams at crossings. About 72 trains arrive and depart Kamalapur Railway Station everyday and pass these level crossings (Bangladesh Railway, 2008). On an average, traffic at each crossing come to a stand still for 288 minutes every day as a train takes three to five minutes to pass by.

Moreover, level crossings on the major roads are mainly responsible for causing traffic tailbacks. The traffic situation further aggravates when motorists lock themselves in overtaking violating traffic rules. Also, rickshaws, small vehicles and pedestrians are often found crossing roads ignoring the red signal. It worsens city gridlock. The result is that these intersections constitute high-risk spots for all railways in the world. Since it is the railway which must bear the responsibility for ensuring that it is protected from the transgressions of road users (despite the fact that in many countries the law gives it priority of passage over road users), it is the railway which also has to shoulder most of the financial burden of providing this protection. Similarly, it is the railway, which has most of the responsibility for educating road users on the safe use of its level crossings (Efroymson & Rahman, 2005).

Generalized Evaluation of Level Crossing Delay

In order to overcome the problems of waiting at the level-crossings, a number of options, as suggested by STP were evaluated (Berger, 2004). An evaluation of the various options (alternatives) has been provided in the main report. The options which were examined were as follows:

1. Relocating the Railway to the eastern side of Dhaka,
2. Elevating the railway along the existing alignment,
3. Putting the Kamlapur-Tongi rail section underground,
4. Terminating the BR rail lines at appropriate northern and southern points, and establishing suitable station facilities (for both passengers and freight) and relying upon intra-urban modes to distribute and collect passengers and goods throughout the Dhaka area.

The summary recommendation is that providing grade separation in the form of road over-bridges is the responsibility of the relevant road agency. New road over-bridges have been identified at 33 locations on Roads and Highways Department (RHD) roads. These are programmed for implementation under the RHD road master plan. With regard to the existing Dhaka railway track (Kamlapur-Tongi), the analysis showed that it would be most cost effective to keep the railway at grade and build a number of over-bridges for road traffic at busy level-crossings. Most of the new passenger traffic travelling along the above mentioned tracks is expected to terminate at Kamlapur station. In case of container traffic, these will be handled by Kamlapur ICD, until Dhirasram ICD is operational. In fact, all containers coming from Chittagong and destined for northern part of Dhaka city would in the future be handled at Dhirasram. All containers coming from India, and southern District of Bangladesh could be handled by Kamlapur ICD, and subsequently by Adamji Nagar ICD to be established in southern part of Dhaka, to handle additional traffic after Kamlapur is saturated. The

above development has been planned, to keep the traffic in Kamlapur-Tongi section to accommodate upto 150 trains per day both directions. With regard to the development of Mass Rapid Transit (MRT), the Government of Bangladesh is already in the process of going for a feasibility study, in line with the recommendations of STP. Once MRT is established and operational, it would be highly important to look into the possibility of extending upto Joydebpur to Nrayanganj to serve the destinations which the commuter trains were expected to serve. In line with other country's experience, MRT extensions would be more cost effective, rather than establishing a new entity, like commuter services, having limited network to serve. Development of MRT should again be closely coordinated with the railway (BR) system in Dhaka city. Transfer points between major BR stations in Dhaka and the MRT should be effectively coordinated and designed for the convenience of passengers. Effective coordination would also be necessary between different MRT lines as well as between MRT, Bus Rapid Transit (BRT), and major bus routes, to decide about transfer points and work out proper designs for them.

In these circumstances, government decision to relocate the main Kamalapur Railway station at Joydevpur or Tongi is highly debated. Critic points out that it would hamper the business as cost of carrying cargo will increase and also traffic congestion in the city will increase rather than decrease. It would also mean relocation of the container yard/depot which will be extremely difficult, time consuming and expensive. If the station is shifted, the passengers of the main city would also find the destination difficult to reach and security of the passengers will be at risk especially at night. Huge number of commuters will have to use alternate mode of transports to enter the city while goods distribution will also depend on road-based transport modes. This step would further increase the flow of road transport inside the city intensifying the traffic congestion.

Keeping in mind of these situations, different scenarios of improvements are explored in this study to select the proper strategic solution. An econometric analysis is used to analyse this scenarios based on benefit-cost ratio and payback period.

LITERATURE REVIEW

Relocation of stations around the world

Railway relocation is an approach which is adopted all around the world to improve the existing transportation system. The Maryville, Kansas rail road relocation project is a small urban area bypass project. It was to examine rail relocation projects in the United States to determine best practices, document benefits and costs of varying types of projects, and to develop recommended policies for the Texas Department of Transportation (TxDOT) to use in assessing proposed urban rail relocation projects throughout the state. Another relocation project is Colorado Front Range Railroad Infrastructure Rationalization Project released in May 2005 changes the rail movement dynamics through the city centers along the Front Range corridor to new rail line segments (TTI, 2006). It is an analysis of a series of rail infrastructure improvements proposed by BNSF and UP entitled the *BNSF/UP Front Range Railroad Infrastructure Rationalization Project.*

Rationale behind relocation

Rail operations, as well as roadway traffic movement and efficiency, can be adversely affected by delay, increased emissions, and increased fuel use as a result of highway-rail traffic conflicts. Rail movement can also be impeded by the requirement to slow trains within urban areas in order to reduce the likelihood that accidents will occur—most often near at-grade highway-rail grade crossings. These effects could potentially be minimized by relocating through-train operations to alternative rail

corridors. The above mentioned two projects are the ideal example of such system. The Maryville, Kansas project will improve mobility and safety, reduce congestion, increase capacity, and provide economic opportunities. On the other hand Colorado Front Range facilitates front range freight movement and increase commuter options, minimize through-freight operation movement in city centers, minimize rail vehicle conflicts, make available rail corridors .

METHODOLOGY

Choosing Point of Relocation

The relocation of Kamalapur railway station to Joydevpur or grade separation without relocation will ease the traffic congestion of the city to some extent as all the level crossings will be removed and there will be no more delay at the intersection. The alternatives which can be examined are Relocating the Railway to the eastern side of Dhaka, Elevating the railway along the existing alignment, Putting the Kamalapur-Tongi rail section underground, and Terminating the BR rail lines at appropriate northern and southern points, and establishing suitable station facilities (for both passengers and freight) and relying upon intra-urban modes to distribute and collect passengers and goods throughout the Dhaka area. After careful consideration of various reasons it has been found that the ideal point of relocation is Joydevpur junction station at Tongi, Gazipur. This is because the number of Mail/Express Trains that passes Joydebpur is 14 and the number of Intercity Trains is 28. These trains go to Kamalapur Railway Station via Joydevpur. Also, the huge area that is required for relocation can be provided only at Joydevpur and it is the nearest junction station to Kamalapur railway station.

Scenarios

This study mainly analyzes three different scenarios for econometric analysis. First scenario is without the proposed relocation and no improvement of the existing road-rail junctions. Secondly, without relocation but with grade-separated level crossings at 9 major locations is analyzed. Lastly, it considers the with relocation strategy.

Calculation of delay at level crossing

The total delay incurred by roadway vehicle in queue at a railroad crossing was determined during the Access Duwamish project. A methodology was developed from the theory of traffic flow, and assumes that the railroad crossing operates similar to a signalized intersection with two phases. Since the typical blockage time caused by a train crossing is often much longer than “red time” at a signalized intersection, it is important to calculate the total delay which accounts for stopped delay as well as traffic queue-dissipation delay. An equation to determine rail delay was derived from one of the underlying equations of traffic flow theory- the Webster equation. Details about how this equation was changed are presented in a memorandum Access Duwamish Grade Delay Analysis (Heffron Transportation, 1997). The resulting equation determines the total delay in vehicle-hours for a single roadway approach during one hour. The equation is as follows:

$$D = \frac{\lambda n \mu r^2}{2(\mu - \lambda)} \qquad (1)$$

Where,

D = Total delay in vehicle-hours,

λ = Arrival rate of vehicles (Vehicles per hour),
μ = Queue dissipation rate (Vehicles per hour),
r = Average blockage time at crossing (hours),
n = Number of blockages per hour (similar in magnitude).

Most railroad crossings have traffic passing in both directions and may have multiple train blockages of varying durations. Therefore, the total delay should be calculated as the sum of total delays in both directions for each train crossing. It is important that the delay be calculated separately when multiple crossings have very different blockage durations since the delay is a function of the square of blockage duration. For example, a 2-minute passenger train blockage should not be averaged with a 7-minute freight train blockage and represented as two 4.5 minute blockages. Instead, the delay for each should be separately calculated and then summed.

Finding out Benefits

Benefits from these policy decisions may come from various sources. The primary benefit is found by alleviation of congestion. This benefit is calculated for the study as comparative reduction of delay with respect to the first scenario (IT Transport, 2005) . Then, this delay is converted into monetary terms using value of time (VOT) and vehicle operating cost (VOC) data from RHD road user cost data (RHD Road User Cost, 2005). Benefits may also ensue as reduction in pollution, reduction in accident and improved reliability of train service (Litman, 2009).

Exploring for Costs

Both the second and third scenario requires considerable infrastructural investment. So, the major costs of relocation comes from constructing new station facilities, improved terminal facilities for multimodal communication, improved goods and container terminal etc. For the second scenario cost is mainly from construction of major grade- separated facilities. Also, loss of accessibility to the new station will create an impact as loss.

DATA COLLECTION AND ANALYSIS

Collecting Delay Data

To find out delays in vehicle-hour unit we needed number of blockages per hour, average blockage time at crossings, vehicle arrival rate and queue dissipation rate at every level-crossing in Dhaka. We selected nine major level-crossings for our study and extracted these data. For Moghbazar level crossing the survey was done manually for a full day. But for the others, these values are found from pre-recorded video footages kept at Traffic Engineering Laboratory, BUET.

Calculation of Delay

Delay for each hour for each direction was found from equation (1). These values are then combined for the whole day and the total level crossing. Delay values of the studied nine crossings are summarized in table (1).

Table 1. Calculated Daily Delays at Major Level-Crossings

Level crossing	Delay per day Vehicle-hr
Staff road	4175
Old dohs	2495
Mohakhali	2712
Tejgaon	1221
Kawran Bazar	2365
Magbazar	4145
Nayatola	147
Wireless gate	1066
Malibagh	3857

Calculation of Costs

Road user costs that ensue from delay at level-crossings are calculated using value of time of passengers and vehicle operating cost data. Sample study done during this study reveals that average vehicle occupancy for a heterogeneous mix of vehicles waiting at level crossing is 7.5. The values that have been used are (RHD Road User Cost 2005), Mean value of time (VOT) per hour of people commuting in Dhaka = 55 Tk (used in column 1). Mean vehicle operation cost per hour (considering loss in opportunity cost of vehicle that would not have happened if there was no delay at level crossing) = 160 Tk (used in column 2). Mean value of Environmental Cost (only considering improved reliability and improved safety) = 6.25 Tk (used in column 3). For example, the Value of time lost is calculated annually using data from Table (1) multiplied by the value mentioned above. The calculation is summarized in table (2).

Table 2. Summary of Cost Calculation

Level crossing	Value of time lost	Loss of vehicle operation cost	Environmental cost
	1000 tk	1000 tk	1000 tk
Staff road	628598	243820	71432
Old dohs	375653	145708	42688
Mohakhali	408326	158381	46401
Tejgaon	183837	71306	20891
Kawran Bazar	356080	138116	40464
Magbazar	624082	242068	70918
Nayatola	22133	8585	2515
Wireless gate	160500	62254	18239
Malibagh	542005	225249	65991
Total	3301213	1295487	379537

Calculation of Infrastructural Expenditures and Accessibility Loss

Construction of a new railway station and ancillary facilities at Joydevpur will cost around BDT 700 crores in present condition. Each of the nine grade-separated level crossings will cost about BDT 40 crores on average. These approximations are made based on recent construction costs of similar infrastructures. To account for the loss of accessibility in the third scenario a GIS based analysis is done. The population- distance value of each ward increases from 274 million Person-Km to 1319 millon Person-Km. This loss of accessibility accounts for a staggering loss of BDT 175 crore per year.

But this loss will diminish every year as Dhaka grows Northbound and will provide us benefits after year 2024 as gain in accessibility.

Benefit Cost Ratio and Payback Period

Table 3 shows a comparative depiction of both the improvement scenarios. Here benefit-cost ratio is calculated in two different time horizons of 20 years and 50 years respectively.

Table 3. Comparative Summary of Different Scenarios

Items	Scenerio 2	Scenerio 3
Savings in Value of Time	BDT 330 crore/year	BDT 395 crore/year
Savings in Vehicle Operating Cost	BDT 129.5 crore/year	BDT 136 crore/year
Savings in Environmental Cost	BDT 36 crore/year	BDT 40 crore/year
Infrastructural Construction Cost	BDT 360 crore	BDT 700 crore
Savings in Maintenance Cost	-BDT 3 crore/year	BDT 5 crore/year
Cost of Accessibility Loss (2011)	nil	BDT 175 crore/year
Cost of Accessibility Loss (2025)	nil	-BDT 55 crore/year
Discount Rate	7%	7%
Benefit-Cost Ratio (20 years horizon)	13.4	3.0
Benefit-Cost Ratio (50 years horizon)	12.2	16.2
Payback Period	9 months	2.2 years

CONCLUSION

Relocation of a major transportation infrastructure requires coordinated approach on the part of all the stakeholders involved. This study was an effort to address all these problems incorporated with this decision and explored alternatives using basic principles of economics. According to our study, every year about BDT 500 crore (Table 2 summation of total) is lost in the form of road users' cost and environmental cost at level-crossings of Dhaka. Scenario 2 which involves providing grade-separation at 9 major level-crossings is found to be a very attractive solution to alleviate existing problems of congestion. It has a benefit cost ratio of 13.4 and payback period of 9 months. Total relocation at scenario 3 proves to be the second best solution with a benefit cost ratio of 3 and payback period of 2.2 years. With our present financial condition of our country scenario 2 is a must-go policy decision and total relocation may yield a better solution in the long run as the city scope expands towards its North-East. But the implementation agency must be careful in providing adequate facilities in terminal points to ensure coherent connectivity of multimodal services and grade-separated facilities should be designed in a way that they do not disrupt the existing movements, rather complement them. The property of railway at Kamalapur can be sold out to get new benefit-cost ratio but one would definitely want to keep the facilities at Kamalapur as it can serve as the backbone of Urban Commuter Rail Service in Dhaka and also for future expansion due to traffic demand.

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SUSTAINABLE SOLUTIONS OF DHAKA CITY TRANSPORT PROBLEMS FROM THE CONCEPT OF DELHI CITY TRANSPORT POLICIES

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ABSTRACT
The objective of a city transport system policy is to ensure safe, affordable, quick, comfortable, reliable and sustainable access for the growing number of city residents to jobs, education, recreation and such other needs within our cities. With the objective of achieving a balanced modal mix and to discourage personalized transport, it is proposed to augment mass transport by massive investments accompanied by institutional improvements. Delhi has significant reliance on its transport infrastructure. The city has developed a highly efficient public transport system with the introduction of the Delhi Metro, which is undergoing a rapid modernization and expansion. Main transport policies of Delhi are improvement of Mass Transport, Intermediate Public Transport System (IPT), Controlling vehicular pollution, Road infrastructure improvement, Integration issues, Proper financing in transport sector, Amenities for commuters, Proper parking and freight management, Integrating land use and transport planning, Equitable allocation of road space, Priority to the use of public transport, Quality and pricing of Public Transport and Priority to non-motorized transport. Dhaka is a metropolitan city and Bangladesh is a neighbouring country of India. This city is a very much congested city built-up with lack of proper development planning. Use of private car is increasing day by day and also there is lack of sufficient public transport facilities in Dhaka. As a result huge amount of congestion occurs every day. Many good sides of Delhi transportation system can be taken as solution of existing problems in Dhaka city. In this paper some sustainable steps which can be followed to solve transportation problems will be discussed.

Keywords: Public transport, Dhaka city, Delhi city, Metro, Private Car, Non-motorized transport.

INTRODUCTION

The objective of a city transport system policy is to ensure safe, affordable, quick, comfortable, reliable and sustainable access for the growing number of city residents to jobs, education, recreation and such other needs within our cities. With the objective of achieving a balanced modal mix and to discourage personalized transport, it is proposed to augment mass transport by massive investments accompanied by institutional improvements. The focus, therefore, will be on increasing mass transport options by providing adequate, accessible and affordable modes like buses, mini-buses, electric trolley buses complemented by a network of a rail based mass rapid transit systems like metro and commuter rail. Para transit modes like autos and taxis are envisaged to provide feeder services in designated areas catering to work and leisure trips. Non-motorized transport like bicycles and cycle rickshaws will be accommodated.

TRANSPORT SYSTEMS IN DELHI

Delhi has significant reliance on its transport infrastructure. The city has developed a highly efficient public transport system with the introduction of the Delhi Metro, which is undergoing a rapid

modernization and expansion. There are 5.5 million registered vehicles in the city, which is the highest in the world among all cities most of which do not follow any pollution emission norm (within municipal limits), while the Delhi metropolitan region (NCR Delhi) has 11.2 million vehicles. Delhi and NCR lose nearly 42 crore (420 million) man-hours every month while commuting between home and office through public transport, due to the traffic congestion. Therefore serious efforts, including a number of transport infrastructure projects, are under way to encourage usage of public transport in the city. Urban Delhi is predominantly dependant on road based transport systems as railways caters to only about 1% of local traffic demand (excluding the Metro). The overall capture of public transport services in the city is only 60 per cent of total trips. Of this, the metro currently accounts for 15 per cent. The widespread distribution of employment centers all over the urban space of Delhi has contained the growth in length of trips. Over 33 per cent of total trips are short trips (less than 15 minutes duration)

Road transport

Transportation depends upon roads. Railways, including rapid transit systems like Delhi Metro. Roads in Delhi are maintained by Municipal Corporation of Delhi (MCD), New Delhi Municipal Council (NDMC), Delhi Cantonment Board (DCB), Public Works Department (PWD) and Delhi Development Authority (DDA). At 1749 km of road length per 100 km², Delhi has one of the highest road densities in India. Major roadways include the Ring Road and the Outer Ring Road, which had a traffic density of 110,000 vehicles per day in 2001. Total road length of Delhi was 28,508 km including 388 km of National Highways. Major road-based public transport facilities in Delhi are provided by DTC buses, auto-rickshaws, taxis and cycle-rickshaws. Among road transport, buses, auto-rickshaws, taxies, and cycle-rickshaws are important.

Rail transport

Rail based transport in the city has started to gain-popularity with the introduction of Delhi Metro. Ring-Railway, which runs parallel to the Ring-Road system is another rail-based intra-city transport facility in Delhi.

Metro

Rapid increase of population coupled with large-scale immigration due to high economic growth has resulted in ever increasing demand for better transport, putting excessive pressure on the city's existent transport infrastructure.

Figure 1 Delhi city metro

Like many other cities in the developing world, the city faces acute transport management problems leading to air pollution, congestion and resultant loss of productivity. In order to meet the transportation demand in Delhi, the State and Union government started the construction of an ambitious Mass Rapid Transit system, known as Delhi Metro in 1998. The project started commercial operations on December 24, 2002. It has set many performance and efficiency standards ever since and is continuously expanding at a very rapid pace. As of 2010, the metro operates 5 lines with a total length of 190 km and 132 stations [citation needed] while several other lines are under construction.

MAIN TRANSPORT POLICIES

Mass Transport

In order to strike the appropriate modal balance, an extensive mass transport system including a metro, commuter rail and buses will be required. Considering this, 245 km. of a metro system network to cater to demand up-to 2021 is being planned. Of this in Phase-I, 39 km is under implementation and 21 km. is expected to be completed by 2005. In addition, Phase I of the commuter rail system called the Integrated Rail and Bus transit (IRBT) along three existing railway lines is also being taken up in partnership with neighbouring State Governments of Haryana and Uttar Pradesh and the Government of India.

Even after a fully developed rail based Mass Rapid Transit System has come into existence, the bus system will continue to play the role of the main mass transport system provider. The bus system is proposed to be augmented to 10000 CNG buses within a year on Stage Carriage to be supplemented with about 4000 CNG buses on chartered and premium services. Premium bus services will be introduced on selected routes. High Capacity Bus Systems on selected corridors for 100 km is planned. In addition, on 32 km of selected corridors, Electric Trolley Buses will also be introduced in order to reduce congestion and pollution. A Light Rail Transit for the walled city is being considered. In order to improve the bus system dedicated bus ways/lanes are being planned on designated road corridors.

Intermediate Public Transport System (IPT)

IPT modes will continue to play an important role even in the future as feeder services to the main mass transport system and providing accessible movement in pre-designated areas. Therefore, steps are being taken to strengthen this system by proper regulation and discipline.

Controlling Vehicular Pollution

A number of additional measures will be taken to reduce vehicular pollution by providing CNG buses, strengthening the Pollution Under Control (PUC) system, introduction of strict Inspection and Certification Systems and promotion of advanced technologies. Special focus will be on safety certification and stringent inspection of all transport vehicles. A Safety Council to set standards for vehicle safety and fitness is being set up shortly.

Road Infrastructure

A number of flyovers, bridges and pedestrian subways are under construction and many more are being contemplated. In addition, existing roads are being widened and new roads constructed. The peripheral expressway and NH2 bypass are being taken up to siphon off inter-city traffic passing through Delhi. Several low cost and quickly implementable transport system management (TSM) measures are being given a lot of importance in order to improve traffic flow. TSM plans are being prepared for various corridors and will be taken up for implementation.

Integration issues

Integration of all modes of transport is necessary to achieve the potential of each mode. Feeder systems to metro and commuter rail will be provided. Facilities for parking of personalised modes, autos and taxis are proposed at all stations. Time table and fare integration for metro rail and buses are also contemplated.

Financing

Plan Outlays – Tenth Five Year Plan (2002-07)

A large investment is required to finance the proposed urban transport system. For this, budgetary provisions have been enhanced in the Tenth Plan (2002-07) of the Government of NCT of Delhi. The financial outlays approved in the Tenth Plan for the transport sector are:

(A) Transport Department

S.No.	Items	(Rs in lakhs)
01.	Mass Rapid Transit System	144141
02.	Delhi Transport Corporation	61800
03.	Interstate Bus Terminals	6000
04.	Other Schemes	81950
	Sub-total (A)	293891

(B) Other Agencies

S.No.	Items	(Rs. In lakhs)
01.	Roads and Bridges (PWD)	187280
02.	Trans Yamuna Area Development Board	1500
03.	MCD	60000
04.	NDMC	2000
	Sub-total (B)	250780

Grand Total (A) + (B) 544671

Institutional Measures The financial investments are proposed to be buttressed by institutional measures to ensure effective and efficient functioning of the transport system in an integrated manner.

For this, it is proposed to set up an Integrated Metropolitan Transport Authority (IMTA) which will look after regulatory issues like fares and tariffs as well as provisioning and common functions/services for metro, rail and bus systems. Until IMTA is formed a Delhi Transport Planning Group (DTPG) may be set up under the chairmanship of the Chief Minister. To provide technical and logistic support to the DTPG and then IMTA, a Traffic Engineering and Transport planning cell will be set up which will function under the aegis of the Transport Department but will draw expertise from PWD, MCD, NDMC and the Traffic Police to ensure coordination and implementation.

Amenities for Commuters

In order to make the transport system user-friendly, many amenities for commuters are being introduced. Some of these are Help Line for bus, taxi and auto rickshaw passengers, a Unified Bus Time Table, route guide maps / folders, directory of chartered bus services, fare charts from point to point, more prepaid taxi/auto rickshaw booths and improved bus terminal designs and enhanced service standards at Inter State Bus Terminals (ISBTs) etc. Wherever feasible the needs of special groups like the physically challenged and senior citizens as well as economically weaker sections will be accommodated by encouraging user friendly technologies for access and seating as well as concessional passes on mass transport. Training programmes are also being planned for drivers of buses, mini buses and autos to make them responsive and helpful to commuters.

Parking

Multi-level parking complexes should be made a mandatory requirement in city centers that have several high rise commercial complexes. Such complexes could even be constructed underground,

including below areas declared as green belts in the master plan. Such complexes could come up through public-private partnerships in order to limit the impact on the public budget. All such parking complexes would be encouraged to go in for electronic metering so that is there is better realization of parking fees to make the investments viable and also a better recovery of the cost of using valuable urban space in the parking of personal motor vehicles. In residential areas too, appropriate changes in bye-laws would be considered to free the public carriage way from parked vehicles that impede the smooth flow of traffic. Proposals for parking complexes would also be given priority under the National Urban Renewal Mission. Provisions would also be made in the appropriate legislation to prevent the use of the right of way on road systems for parking purposes.

Figure 2 Multi-storied car parking

Freight traffic

As economic activities in cities expand and city population grows, a substantial amount of freight traffic would be generated. The timely and smooth movement of such freight is crucial to the well being of the people and the viability of the economic activities they undertake. However, with limited capacity of the transport system, it is essential that freight traffic and passenger traffic are so staggered as to make optimum use of the transport infrastructure. It is a time honored and tested practice to use off-peak passenger travel times to move freight. Many cities have earmarked late night hours for the movement of freight and restricted the entry of heavy vehicles into cities during day time. Further, several cities have by-passes that enable through traffic to go around the city and not add to city traffic. These practices are sound and would be encouraged in all cities. For this purpose, cities would be encouraged to build by-passes, through innovative and viable public – private partnerships.

OTHER POLICIES

Integrating land use and transport planning

A scheme already exists under which the Central Government provides partial financial support for traffic and transport studies in cities. This would be modified to enhance the extent of Central Government support and also make these studies more broad based to integrate transport planning with land use planning, keeping projected populations in mind.

Equitable allocation of road space

The Central Government would, therefore, encourage measures that allocate road space on a more equitable basis, with people as its focus. This can be achieved by reserving lanes and corridors exclusively for public transport and non-motorized modes of travel. Similarly lanes could be reserved for vehicles that carry more than three persons (popularly known as High Occupancy Vehicle Lanes).

Priority to the use of public transport

In order to effectively promote such investments, the Central Government provides 50% of the cost of preparing comprehensive city transport plans and detailed project reports. They also offer equity participation and/or viability gap funding to the extent of 20% of the capital cost of public transport systems offer 50% of the cost of project development whenever such projects are sought to be taken up through public-private partnerships, so that a sound basis for attracting private partners can be

established. The remaining cost of such project development would have to come from the city development authority/State government and a project developer.

Quality and pricing of Public Transport
Central Government offers support under the NURM for premium service infrastructure such as improved bus stations and terminals, improved passenger information systems, use of intelligent transport systems for monitoring and control, restructuring of State Transport Corporations, etc.

Priority to non-motorized transport
The Central Government gives priority to the construction of cycle tracks and pedestrian paths in all cities, under the National Urban Renewal Mission (NURM), to enhance safety and thereby enhance use of non-motorized modes. Cities would also be encouraged to explore the possibility of a public bicycle program, where people can rent a bicycle for use in specially designated areas.

MAIN LEARNINGS FOR DHAKA CITY

Dhaka city is a very much congested city built-up with lack of proper development planning. Dhaka is also a metropolitan city and Bangladesh is a neighboring country of India. So many good sides of Delhi transportation system can be taken as solution of existing problems in Dhaka city. Possible steps are:

Public buses
Improvement in public transport sector is very much essential now. Metro rail need to be introduced for Dhaka city to reduce the congestion that occurs now at both peak and off-peak hours. At least BRT service needs to be introduced at major routes for public transport improvement and congestion reduction. Already BRTC bus service has been provided. But no proper route or schedule is maintained yet. Segregated bus lane is needed to introduce to reduce congestion. Reversible lane, bus only street, contra-flow bus lane, bus signal priority etc are also necessary to adopt to reduce congestion and also reduce private car use which is one of the major causes of congestion in Dhaka city.

Figure 3 Bus Rapid Transit

Metro
Metro rail in a city can reduce congestion on a large scale. But in Dhaka city construction of new route for metro is costly and also difficult because during construction process a huge amount of congestion problem will occur. But after construction it will be most effective solution. Metro rail usually need a circular route. Already a step has taken to construct metro route from Mirpur with stops at Pallabi, Chandrima Udyan, Bijoy Sarani, Shahbagh, TSC, Bangla Academy, Curzon Hall, Topkhana and Bangladesh Bank, and additional routes which will be introduced in the future.

Finance:
Finance for public transport sector has to be raised. Also private sector is needed to be encouraged for raising fund and provide public transport facilities. PPP (Public Private Partnership) projects are also fruitful solution to improve existing condition of the city transport system.

Intermediate Public Transport System (IPT):
Intermediate Public Transport System (IPT) is also a better solution by providing accessible movements in pre-designated areas. Sufficient Public buses and other public transport facility have to build up and network analysis, scheduling improvement and route guidance should have to provide for our people.

Pollution control:
Introduction of strict Inspection and Certification Systems and promotion of advanced technologies will help to reduce vehicular pollution in Dhaka city. Some step is already taken by replacing 2-stroke baby taxi with 4-stroke CNG auto rickshaw.

Lane separation & time table improvement:
There must be provision for the amenities like line for bus, taxi and auto rickshaw passengers, a Unified Bus Time Table, route guide maps / folders, directory of chartered bus services, fare charts from point to point, more prepaid taxi/auto rickshaw booths and improved bus terminal designs and enhanced service standards at Inter State Bus Terminals (ISBTs) etc.

Figure 4 Separate NMT lane

Parking:
Multi-storied parking lots have to be constructed to save the spaces on street to reduce congestion. Parking restriction for important places and parking charges for excess time of parking should be introduced. Park and ride schemes are another necessary solution.

Freight management:
It is essential that freight traffic and passenger traffic are so staggered as to make optimum use of the transport infrastructure. It is a time honored and tested practice to use off-peak passenger travel times to move freight. Some steps already taken by preventing entry of freight at day hours in the city. But ware house should have to construct at several points (only one is at old Dhaka now) for loading unloading of freight and mini truck or others need to supply the goods at different point of the city, mainly at the entry points of the city so that freight vehicles could unload their goods at those ware houses and need not to enter into the city. This will help to reduce congestion.

OTHER TECHNIQUES:

1) Proper co-ordination between different planning agencies of government is urgently needed for improvement of urban transport sector of Dhaka city.

2) Have to ensure road for vehicle and footpath for pedestrians. So improvement of existing footpaths is essential. Also hawkers should have to remove from footpaths and hawker markets should construct for the hawkers.
3) Multimodal transport system and proper mode transfer facility should be provided at all stoppages.
4) Park and ride schemes are also another possible step of urban transport problem reduction.

CONCLUSIONS

Delhi is very much familiar to our Dhaka city. By following several positive side of Institutional and Management setup for Delhi transport we can improve our system and also be able to reduce the congestion in Dhaka city. Urban transport policies cannot succeed without the fullest co-operation of all the city residents. Such cooperation can be best secured if the objective of any initiative is made clearly known to them. It is, therefore, necessary to launch intensive awareness campaigns that educate people on the ill effects of the growing transport problems in urban areas - especially on their health and well-being.

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COMPRESSED NATURAL GAS (CNG): A PROBLEM OR A SOLUTION FOR TRANSPORT SECTOR IN BANGLADESH

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ABSTRACT
The use of CNG in Bangladesh is increasing day by day due to the environmental benefits as well as economic benefits. In the last decade, the importance of environment conservation has assumed great significance. Even in Bangladesh the last couple of years have witnessed a greater devotion and awakening towards the protection of the environment. Pollution due to petroleum products used in transportation is an ever-increasing problem for Bangladesh like other country. So alternative solution of energy source is trying to use, thus pressure on Compressed Natural Gas (CNG) has been increased. Thus, the environmental problem is solved but the stock of gas is simultaneously decreasing and the stress comes on the transportation sector in Bangladesh. The purpose of the study is to make coordination between the transportation sector and the use of the natural gas should be connected in such a manner to achieve the success of Bangladesh.

INTRODUCTION

Pollution has definitely been a curse on contemporary society and is a hot topic of debate at all levels. In the last decade, the importance of environment conservation has assumed great significance. People and institutions alike have been battling it out for a "cleaner, greener, world." Even in Bangladesh the last couple of years have witnessed a greater devotion and awakening towards the protection of the environment. Pollution due to petroleum products used in transportation is an ever-increasing problem for Dhaka, capital of Bangladesh and other metros. Pollution due to transportation can be divided into two main categories: air pollution and noise pollution. Some environmentalists also quote odor pollution as the third and major component.

Technical experts have suggested the use of CNG as an alternative fuel for automobiles. They have estimated that apart from being less hazardous, it is also environment friendly, can help in reducing the levels of pollutant emissions and is quite cost effective.

LITERATURE REVIEW

The suitability of CNG as vehicular fuel, environmental and economic benefits and also the commercialization of CNG as well as the growth pattern of CNG filling stations, CNG conversion workshops in Bangladesh was described by Salma et all [1]. Government has given permission to the private sector entrepreneur to install CNG refueling station and to establish of CNG conversion workshop and Government has also provided land to some private entrepreneurs for establishment of

CNG conversion workshop and CNG refueling station. [2]. However the suitability of CNG as vehicular fuel, environmental and economic benefits and also the commercialization of CNG as well as the growth pattern of CNG filling stations, CNG conversion workshops in Bangladesh was represented on these papers [3-4].

CNG – AN ALTERNATIVE FUEL

CNG is 130 octane safe and energy efficient fuel which is considerably higher than 93 octane for petrol. Higher octane rating allows higher compression ratios and improved thermal efficiency, reducing carbon dioxide emissions. CNG allows the use of catalytic converter more efficiently than diesel. Compared to petrol or diesel, CNG vehicles emit 40% less of nitrous oxide, 90% less of hydrocarbons, 80% less of carbon monoxide, and 25% less of carbon dioxide. Further, noise level of CNG engine is much lower than that of diesel. Due to some drawback, CNG sector is not growing up so well. CNG takes up more space for each gasoline gallon equivalent (GGE) compared to other gasoline power vehicle. Therefore, the tanks used to store the CNG usually take up additional space in the car. This problem is solved in factory-built CNG vehicles that install the tanks under the body of the vehicle.

CNG IN BANGLADESH

Most analysis recommends that CNG can be use as alternative fuel with the existing situation. Maintaining air quality in metropolises like Dhaka has become the nation's top most priority. Thus, CNG could cater to that need and make significant cross saving in the health sector and reduce public hazard. Estimation by World Bank showed that about Tk.117crore per year can be saved in health costs in Dhaka city alone on account of PM reduction. This does not include mortality estimates. CNG use could save Bangladesh significant amounts in foreign exchange. World Bank estimates savings of Tk. 4 crore per station per year which is twice that of the investment cost due to its cost effectiveness. Recently feed gas price for CNG both Public and Private User (From 24 th April ,2008) is Tk. 9.96 / m^3 and CNG Sales Price (From 24th April ,2008) is Tk. 16.75/ m^3. Its low cost makes it popular in Bangladesh.. But the current scenario as follows

Year	No of converted CNG Vehicle[9]	No of vehicle registered in Bangladesh [8]
2004	9308	49202
2005	10525	65878
2006	38353	80305
2007	38454	121272
2008	24042	144419
2009	26141	145243

Table1: No of converted CNG vehicle and Vehicle registered at year 2004-2009

From the figure 1, Series 1 indicates the no of converted CNG during the year of 2004 to year 2009 and series 2 indicates the number of registered vehicle at that time at the street of Bangladesh. From the graph it is clear and define that the increase of the number of Vehicle in Bangladesh, CNG conversion is a vital reason. Unfortunately, during this time the no of roads are not set up by the Government.

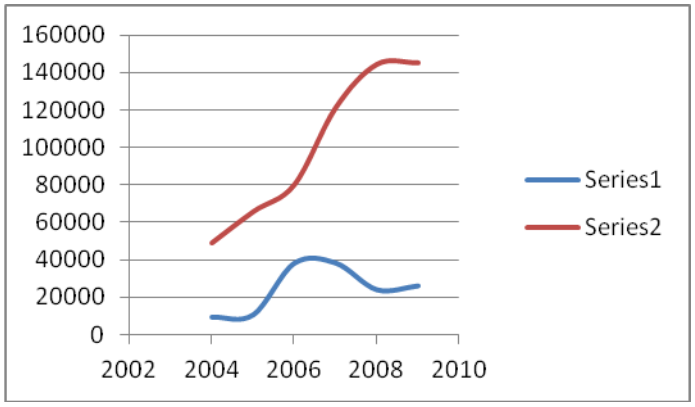

Fig1: Graphical representation of No of converted CNG vehicle and Vehicle registered during that time

STRATEGY FOR GOVERNMENT OF BANGLADESH IN THIS SECTOR

In response to government of Bangladesh, UNDP undertook a project to enhance the government's initiative to develop the infrastructure and capacity needed for CNG usage in partnership with Environment Canada. Major activities carried out under this project are as follows:

Management and technical capacity development of RPGCL to ensure efficient operations and maintenance

The Environment Canada provided expertise on clean fuel technologies, measuring emissions, and developing capacity and training. During this time the organizational structure of RPGCL was also revised to reflect changes in the CNG industry. An in-depth training program was also carried out in Canada on the role of government in the development of an alternative fuels program. The training covered CNG fuel technologies and applications, regulatory frameworks, standards and code regimes, safety protocols for conversion and refueling systems, emission standards and related enforcement needs.

Expansion of CNG use through private investment and introduction of CNG in new markets

A total of 96 CNG conversion outlets are now operational with 56 outlets in Dhaka and 40 outlets in other areas of Bangladesh. Of these, only one conversion workshop is owned by the RPGCL, while the other 95 are financed fully by the private sector. In addition, 150 CNG refueling stations have been established with 90 stations in Dhaka, and 60 outside the capital. Of these, one is directly operated by RPGCL and four are operated through a partnership between RPGCL and the private sector and the other 145 are owned and operated by private entrepreneurs.

Support through government policies and regulatory changes.

The changes include the banning of two-stroke auto-rickshaws as of January 2003 in favor of four-stroke CNG vehicles and the conversion of all government official vehicles to CNG.

To promote into the private entrepreneurs:

Government offers an attractive package for entrepreneurs to promote CNG by following ways:
Free of charge registration and enlisting; Assistance and cooperation to obtain bank loans; Necessary information; Training for manpower engaged in running the station; Assistance in site selection and taking lease of government land; Quick gas, water and electricity connections at CNG stations; Duty free import of CNG equipment and kits.

CHALLENGES FOR IMPLEMENTATION AND EXPENDING

For proper implementation

• Difficulty in retaining trained staff, as newly trained staff often used their new skills as an opportunity to move into better positions.
• Difficulty in moving to a results-oriented organizational structure based on RPGCL's priorities.
• Lack of knowledge in both public and private sectors on how an alternative fuels program can be successfully implemented and sustained.
• Lack of a long-term policy and regulatory framework, including one that promotes a user-friendly, customer-oriented and safety-based conversion protocol.
• Unavailability of CNG conversion quality kits or cylinders compatible with the different types of vehicles used in Bangladesh.
• Ongoing government support is required for the Centre of Expertise to provide continuing education and training to CNG industry stakeholders so that they can keep abreast of new technologies and best practices.
• At present, Petrobangla and its subsidiaries, like any other government organization, have become much less effective.

For proper expansion

• Gas distribution pipelines are not available to the whole country. Only 30-35 percent area is covered by the gas distribution network. It takes hours for refueling of CNG vehicles because of long queues due to in adequate number of filling stations.
• Gas stations observe a reduced gas pressure at peak hours.
• Regarding safety standards a consistent policy is not available.
• The addition of CNG fuelling equipment to the existing petrol filling stations is problematic, because a large part of them are not having disposition over enough ground space to accommodate a safe CNG compressor, dispenser and high pressure gas storage installation.
• Lack of a fixed and targeted number of trained personnel in the private sector capable of carrying out the full range of conversions.
• Paucity of trained mechanics for CNG kits has made repairs expensive.
• Unavailability of gas around the country.

FUTURE PLAN

At the same time the government department Bangladesh Road Transport Corporation (BRTC) has imported dedicated CNG passenger busses to increase the utilization of natural gas. Besides the government initiatives, private entrepreneurs are also importing CNG dedicated passenger busses as the operating cost is very attractive (70 percent less than gasoline).

RECOMMENDATION

• To get better emission control in petrol-driven vehicles, it is necessary to improve fuel quality by using catalytic convertors and ensure that fuel is not adulterated.
• In the context of Bangladesh, there is need to bring public passenger transport as early as possible on CNG.
• The government should make plans to promote all environmentally acceptable fuels along with to improve quality of other fuels with the relevant exhaust treatment devices and engine technology so that different options can compete in the market.
• RPGCL should provide an adequate and enhanced allocation of natural gas for Bangladesh's transport sector and this allocation should keep pace with the growing demand.
• Plans for future distribution infrastructure should be set into motion to ensure that it stays ahead of the growing demand and takes into account the turn around time of vehicles at the dispensing stations.
• Financial incentives should be provided to bus operators purchasing new OEM and retrofitted CNG buses in the form of sales tax and excise tax exemption and low-interest loans with the subsidies ideally recovered from enhanced road taxes on private vehicles.

• Strengthen the legal protection by enacting more laws relating to extraction of natural resources, safety and security and ensure their appropriate enforcement
• There is a need for the government to launch a vigorous campaign to attract foreign and local investment in the energy sector. Bangladesh's energy sector has every potential to attract foreign direct investment for small and medium range industries, which use natural gas as raw material.
• Searching for other new alternative source of fuel and allocate and introduce the private entrepreneur at that sector.
• It is imperative that the government considerably increase funds and provide facilities to these organizations (Petrobangla and its subsidiaries) so that they can stand as viable and effective organizations again, and take up the role of gas exploration and production of gas, eventually ending the country's dependency on foreign oil companies.
• The government should develop institutions and train more people in the energy sector, particularly in the areas of petroleum and natural gas engineering, gas processing, transmission and distribution, in mining and refining, and in geological and economic studies. Doing so would be a long-term investment requiring sustained effort, but it would reap significant rewards in the future.
• Make the natural gas networks into common carriers with predictable, independently set tariffs, allowing natural gas producers and independent power producers to negotiate directly with customers.
• At a high level, government should conduct integrated resource planning for the energy sector, including environmental and social objectives. Set a five year moratorium on natural gas exports and use this time to develop a surplus test mechanism and domestic priorities for use of gas. Create an arms-length regulatory agency responsible for natural gas.
• In the locations where a gas distribution network is available the best approach is to add fast fill CNG units to already existing petrol pump stations on the main highways and in and around the larger cities. Also new locations with dedicated fast fill CNG outlets should be foreseen in busy metropolis areas.
• Government is to improve the infrastructure quickly to eliminate the long queues for CNG refueling.
• In the coming months a further delivery capacity from one of the two gas fields in exploration will start to operate.
• Considerable policy support was provided through the ban of gasoline fuelled auto-rickshaws, the conversion of all government diesel buses and official vehicles to CNG and the availability of budgetary allocations for the development of CNG infrastructure.

CONCLUSION

This case study demonstrates that for promotion of alternative fuels for transport sector in the developing countries apart from the command and control approach i.e, a top down appraoch there are alternative market driven models that can be evolved based on contextual specificities. This requires long-term vision with business model that address concerns of all the major stakeholders evolved in a partnership approach. Such a model not only becomes financially viable but also sustainable in the long run. But it requires appropriate market conditions and deployment of marketing and communication strategies that are facilitated by the governments.

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IDENTIFICATION OF TRANSPORT ORIENTED PROBLEMS OF WOMEN IN DEVELOPING COUNTRIES

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ABSTRACT

In developing countries women have to face enormous hindrance to get a safe and comfortable ride in public transport. In the context of mobility, affordability, safety as well as privacy access to transportation is tougher for women than men. They have to face both physical and economical constraints to select any women-friendly public transport system. Therefore, existing transport systems are not adequately geared towards the needs of women. Rather, most systems are biased towards the travel needs of male breadwinners. In order to alleviate women's disproportionate transport burden in society, a variety of factors need to be addressed. Among the most important are access to modes of transport, the sitting and routing of facilities and infrastructure and the timing/frequency of services. The key issue of the paper is to evaluate the existing deficiencies in mobility, accessibility and security of the women in public transport. The investigations in this paper revealed significant difficulties that are experienced by women in many developing countries and a guideline is depicted to provide a feasible and sustainable solution of this setback.

Keywords: Mobility, Accessibility, Personal security, Reserve seat.

INTRODUCTION

Women do not have equal access to private motor vehicles. Access to motorized transport, a mode which is costly from an overall social and environmental perspective, yet convenient to the ones who can afford it, is determined not only by economic means but also by cultural roles (Peters, 2002. All over the world, car ownership is associated with success, power and social status. So it comes as no surprise that even in car-owning households, it is often only the men who get to drive, maintaining a monopoly over technical and mechanical knowledge (Little, 1994). Even in car-crazy Germany, women only make up one third of all drivers' license holders. Although motorization rates are much lower in developing countries, the overall situation is very much the same. For example, a study of Nairobi, Kenya revealed that while 24% of male heads-of-households used a car, only 9% of women heads did (Levy et al., 1992).

Using buses is a complex process requiring multiple stages such as planning the trip, moving to and from the bus stop, getting on and off the bus, and interacting with bus drivers and other passengers (Broome, Worrall et al., 2011). Significant attention has been given to researching low floor buses and other physical accessibility innovations, with relatively little consideration of other aspects of the bus

system such as information and communication needs (Ashton et al. 2008). Finding, understanding, and processing information to plan a bus journey is a hard step to using a bus system that has been relatively unexplored in the literature (Department for Transport UK 2001; Broome et al. 2009). Providing appropriate information and training has been identified as a core priority in providing a women-friendly bus system (Broome, Worrall et al. 2010). Indeed, women have specific requirements for privacy, safety and mobility that differ from the needs of men. Existing systems that may be designed without the unambiguous needs of women in mind may not be appropriate.

The overall objectives of this study are to understand the present women mobility, security and accessibility problems of overall public transport in various cities in developing countries. Also feasibility of some effective measures like increasing bus services for women, improvement of personal safety, development of boarding-alighting scenario, improved vehicle configuration etc. will be discussed in this paper.

METHODS

In order to achieve aforesaid objectives, required data and information's has collected from various government and private organization. Data has collected by using both manual and automatic method (vedio camera). Moreover, some information is collected from Strategic Transport Plan (STP, 2005) and Preparatory Survey Report on Dhaka Urban Transport Network Development Study in Bangladesh (DHUTS, 2010) .The physical surveys have been conducted at different bus stoppages as well as at other locations along the survey route on demand of various transportation modes, reserve seat for women at buses, physical and economic barriers for women etc. The field surveys also included an extensive passenger opinion surveys about the existing hazards along the selected corridor, various vehicular perimeter, comfort assessment etc. To get representative sample, data is collected from various age group, occupation group, income group, education group, travel pattern group and so forth. These data is processed by making customize data entry and decoding program and analyzed by using SPSS PC software.

RESULTS AND DISCUSSIONS

Study Area

To compare the mobility and accessibility scenario five southern cities were selected. In the comparison process secondary data is used. In Bangladesh the whole study is conducted at various busy bus stoppages and intersections along Asad gate to Motijheel Bus route corridor of Dhaka city. Video footages have been taken from the suitable vantage places like over bridges especially at Asad gate intersection, Dhaka.

Mode Choice among Male and Female in Developing Countries

In developing countries there is a common trend in the mode choice among male and female. In Lima (Peru) more than 90% male and female passengers use public transport and for Ashgabat (Urkmenistan) and Pune (India) this percentage is more than 50% (Figure 1). On the other hand for Dhaka (Bangladesh) this portion is nearly 40%. It is also revealed that for each of five countries walking percentage for women is higher than men. In Lima and Pune private transport ridership is high (20%) for men than women (10%). This clearly delineates that women have very less accessibility not only in public transport but also private vehicle. This is due to male dominating society, where male use their private vehicle most of the time. Furthermore, it is depicted from the Figure 1 that in developing country women have less access in public transport, which creates a natural penchant among them to travel by walk mode or non-motorized vehicle (NMV).

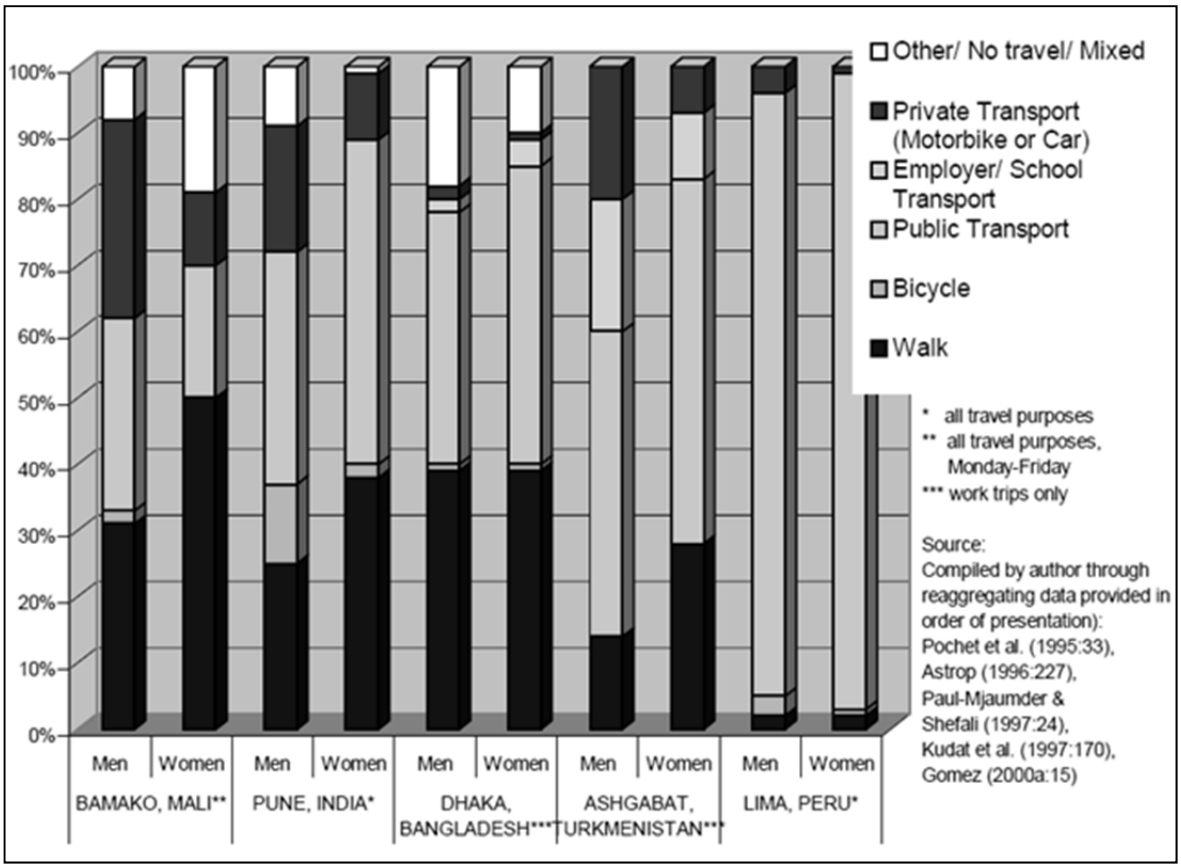

Figure 1: Gendered Mode Choice in 5 Southern Cities (Peters, 2002)

Design Problems in Bus

Physical barrier plays a vital role to reduce women accessibility in public transport. These problems were unveiled from the questionnaire survey conducted in Dhka city. A bar chart is shown in Figure 2, separating both male and female, to show the design problems in Bus. From critical observation it is seen from Figure 2 that equal percentage of male and female (35%) said that deficiency in leg room is a substantial problem for them. Moreover, due to one door, boarding-alighting is tough for women (72%) than men (43%).The matter of great apprehension is that women have some reserve seat on the hot engine. Most women (60%) find this kind of seat very much uncomfortable to them. Lack of on-board space (60%) and narrow door (25%) are also very serious design problems that discourage women to board at public transport.

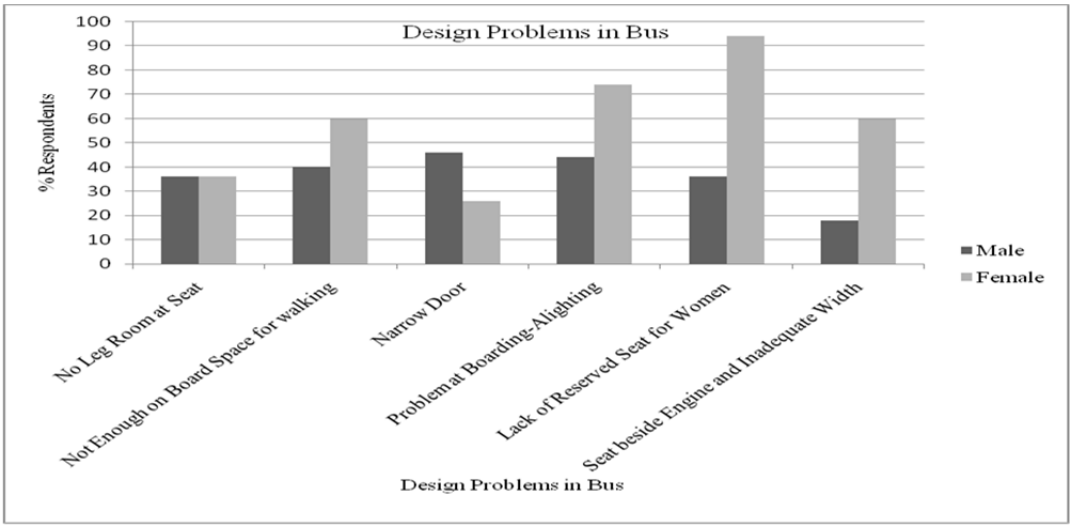

Figure 2: Design Problems in Bus (Questionnaire Survey, 2012)

Mobility Problems at Bus

One of the main objectives of this study is to disclose the on board problems of male and female in public transport in developing country. Therefore, both open ended and close ended questions were included in the questionnaire survey. The graphical illustration of their opinions is portrayed in Figure 3. Critical observation of Figure 5 discloses that 84% women passengers find smoking as hazardous to them. Besides, 68% women are concerned about their safety and security, whereas only 25% men are worried about security. Moreover, talking over mobile phone (52%), difficulties while boarding at bus (45%) and driver-helpers behavior (42%) are some major on board problems that are faced by the women group. Therefore, it is evident that these mobility problems are creating substantial impediments to make demand-oriented public transport to this vulnerable group.

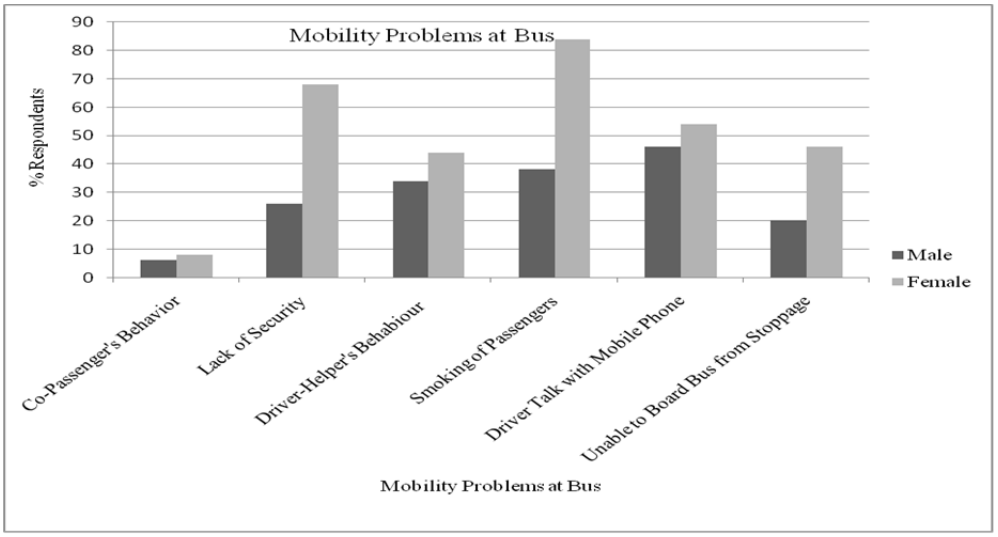

Figure 3: Mobility Problems at Bus (Questionnaire Survey, 2012)

Security at Public Transport

Crime and fear of crime stop people from using public transport, particularly at night. Night time security is always a key issue of any sustainable transport system. Apposite security itself is the advertisement for the transport provider. United Kingdom Department of Transport's analysis shows that an extra 10.5% of journeys would be generated if the public felt more secure when traveling, particularly when waiting at rail stations (Carters, 2004). In Dhaka city less than 2% women use public transport at night (after 8 pm.) in each day of the week (Figure 4). However, more than 32% male passengers ride at public transport at night time in the same circumstances. Surprisingly, more than 52% women use bus for only one day and 48% women use bus for 2 to 6 days in a week at night (Figure 4). All this data essentially suggest that there is an urgency of secured as well as women friendly night time transport system, which will indisputably increase the proportion of nighttime women ridership.

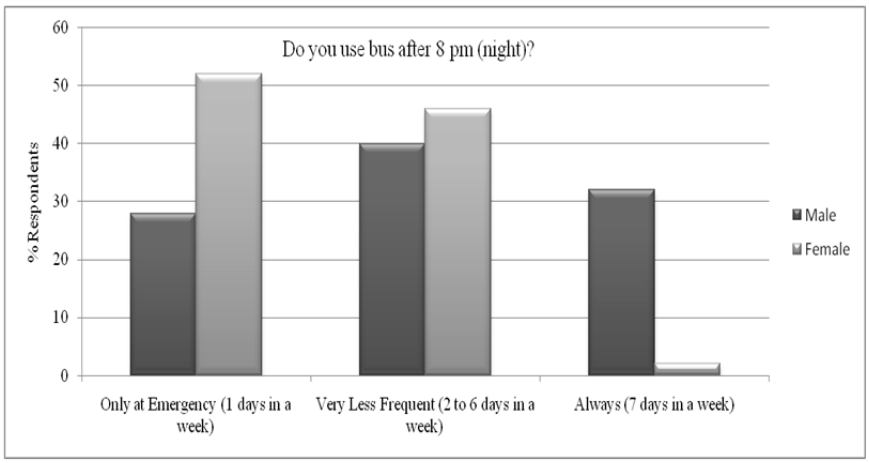

Figure 4: Night Time Security at Dhaka City (Questionnaire Survey, 2012)

Relation between MDG and Transport of Women

Table 1 illustrates the gender aspects of the Millennium Development Goals (MDGs). MDGs 2 and 3 which are the goals on universal primary education and gender equality, MDGs 4 and 5, which are the goals on child health and maternal mortality, as well as MDG 6, the HIV/AIDS, malaria and other diseases goal, all have a gender and transport dimension (Riverson et al., 2005) . Whilst transport must make important contributions to achieve most of the Goals, it has particular responsibilities to address the gender issues which are inherent to accomplishing the above five MDGs, as is shown in Table 1. Therefore, transport oriented problem solving to women directly dictate us towards the attaining path of MDGs.

Table 1: Relation between MDG, Gender and Transport

MDG	Transport and Gender Dimension
MDG 2 Universal Primary Education Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling.	Girl's lack of time for school and studying as they must help their mothers transport water, fuel and food. This leads to loss of opportunity or motivation to study. Girls face more gender related problems such as abduction and rape on their way to school. Lack of transport means for teachers and education officials affects both genders, through teacher absenteeism, lack of education quality support and monitoring.
MDG 3 Gender Equality Eliminate gender disparity in primary and secondary education, preferably by 2005, and to all levels of education no later than 2015.	Girl's lack of time for school and studying as they must help their mothers transport water, fuel and food. This leads to loss of opportunity or motivation to study. The lack of public transport inhibits opportunity for both boys and girls to go to secondary school.
MDG 4 Child Health Reduce by two thirds, between 1990 and 2015, the under-five mortality rate.	Preference for boy infant over girl infant because of parental discrimination and neglect. For example, girls may not receive adequate nutrition or be taken to the clinic as frequently as their boy siblings. Girl infants are trained to help mothers from very early age. Lack of emergency transport for children's health emergencies. Lack of transport for health equipment and medicines at the health post leading to poor quality of health service. Constraints on access of health post users due to distance, cost, difficulty of travel due to terrain and weather, path conditions.
MDG 5 Maternal Mortality Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio.	High death rate for mothers and preventable injuries partially due to delay of decision to transport and lack of transport in cases of emergency especially at childbirth.
MDG 6 HIV/AIDS, malaria and other diseases To halt and begin to reverse the spread of HIV/AIDS, Malaria and other major diseases	Transport sector workers such as long-distance drivers (mostly men), seafarers are seen to spread HIV/AIDS along road corridors and ports. Female sex workers, roadside community women with little control over reproductive health are most affected, not only by the virus but also through the extra burden of care for HIV/AIDS patients and orphans.

CONCLUSION

From the study, it was found that women safety, privacy, security, mobility and accessibility in public transport are dilapidated issues in developing countries. Though there are a huge number of women user groups, both the government and private sectors are very much reluctant to provide women friendly public transport system. It is revealed that they also face connectivity problems with bus stoppage, longer waiting time, boarding and on board privacy problems, poor intermediate accessibility, bad driver-conductor attitude and so on. It was also found that due to economic considerations majority of female passengers in Dhaka city choose local bus service. However, this study depicts that there are a wide variation in bus fares and the high fares are not affordable for women at large. Lack of adequate reserve seats, single narrow door based boarding-alighting and excessive waiting time at intermediate stoppage without any shelter facility are the major impediments of existing women unfriendly public transport system. Finally, it was seen that present public transportation sector had completely failed to ensure a women friendly, accessible and affordable, secured services to our women passengers.

As such, this is the high time to take some bold initiatives to improve the present scenario of women accessibility in public transport. Increased service during off-peak hours, better connections outside main commuting corridors, and improved low floor, multi width door vehicle design and public safety are all standard requirements which should be part of any gender-sensitive, poverty-

alleviating public transport project. There is**,** nevertheless**,** a real lack of initiatives addressing these issues, most likely because the benefits of improving women's access to public transport facilities are less immediately proven in economic terms. Therefore, believe should grow among women that accessibility is their right.

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CHILD ROAD SAFETY PROBLEMS AND THEIR PERCEPTIONS ON ROAD TRAFFIC SAFETY IN DHAKA CITY

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ABSTRACT

The overall fatality and casualty figure of children due to road accidents in Bangladesh is very alarming and accounting for about 21% in the last twelve years (1998-2009). Most the victims involved in the mishaps are of less than 16 years of age. This toll is much higher than those in other developing countries. Road safety education for children and resulting improvement of perception on road safety is a proven effective tool to minimise the child road safety hazard in all over the world. Indeed, traffic perception is a knowledge which helps to judge and take the decision practically on the road. This study focuses on some findings of the research study on road accidents involving children perception. This study critically examines perception on road accidents of the school going children and the street children including non-school going children. The study revealed that the female children perception rate (58.5%) is certainly greater than the male children perception (41.5%). On the contrary, children are more conversant with the traffic/road signs and markings (54%) than the traffic rules and regulations (46%). And lastly among the survey children, it has been seen that 83.3% children have good perception, 15.3% children have poor perception and 1.4% children have perception with confusion on traffic rules and regulations and traffic signs and markings. This study whole heartedly devotes to the children perception on road traffic safety and also suggests some suitable preventive measures to curb the magnitude of child casualties and fatalities owing to road accidents in Bangladesh. At the very outset, this paper discuss the child accident problems and analyze the child road traffic accidents and injuries characteristics in Bangladesh particularly in Dhaka city.

Keywords: Children, Accident, Perception, Road Safety, Problem

BACKGROUND OF THE STUDY

The advent of the automobile is indeed a blessing, facilitating increased mobility and aiding accelerated economic development. However, humanity pays a heavy price for this facility in terms of human lives and human sufferings resulting from road accidents, which are currently assuming epidemic proportions, especially in a developing country like Bangladesh. In the developing nations

roads being an infallible death trap utmost priority has been given to the safety of vulnerable road users particularly taking children into active consideration. According to road safety figures and national research, young people aged between 5 to 15 are at risk from road accidents and injuries. In addition, young people are more likely to take risk, which combined with a low awareness of road safety issues, increases their chances of injury and accidents when crossing the road as a pedestrian or as a bicyclist.

The national road accidents statistics in Bangladesh revealed a serious threat to the children. The incidence of overall child involvement in road accident fatalities and injuries in Bangladesh is found to be very high accounting for about 21 percent. This involvement of children under 16 years of age in road accident fatalities and injuries is much higher than those in other developing countries. It is important to note that compared to industrialized countries, the proportion of fatalities to under 16 years of age in developing countries is approximately two and a half times higher (Hoque et al., 2006). So children are the most vulnerable group in our country. Children fatality rate in rural areas (74%) is about three times higher than those of the urban areas (26%). The National highway contributing at least 37% of all children fatalities is two times higher than those Urban roads (16%) whilst children injury rates are more or less the same for both in National highways and Urban roads (32%). The total child fatalities of road accidents, nearly 82 percent involved as pedestrians with the dominant age group of 5-10 years. Indeed, about one-third of total pedestrian fatalities are children under the age of 16 years. They are the dominant age group of pedestrian fatalities. Out of the children casualties, 66 percent were boys and 34 percent were girls. On the other hand, study revealed that the female children are disproportionately higher than the male child pedestrians and the adult in road traffic injury (Hoque & Mahmud, 2007). Some studies indicate that the pedestrians walking with traffic are much more dangerous than walking against traffic (Hoque, 1992). This finding thus supports the idea that pedestrian safety specially child pedestrians safety can be enhanced by instructing them to walk facing the traffic and in this way also instructing them about the road elements, road safety issues and the road accidents.

Dhaka, the capital city is already overburdened with highest number of vehicles. In this city most of the child pedestrian accidents occurred at 8-11 am, day hour which is the school going time for the children. Out of child pedestrian casualties 68% were male and 32% were female. It was also observed that national roads are more responsible for child pedestrian casualties in Bangladesh and rural areas have been identified as more accident prone area. So this indicates that the rate of accidents and the number of fatalities and injuries of child pedestrians are high and this is a threat and a risk for a country. This rate of fatality and injury can be reduced by increasing the perception, knowledge, proper education, guidance and lastly the awareness among the child pedestrians. The parents of those child also need to be aware about the road accidents and both of them should have a perfect knowledge about perception on road accidents. However, road safety and accident perception is needed to reduce the casualties cases of child road users. This study presents some findings of the research study of perception of children on road accidents and highlights few measures for their safety improvements in Bangladesh.

OBJECTIVES OF THIS RESEARCH

The main objective of this study is to find out the present condition of the children road accidents and injuries problems and the children perception and awareness on safe road traffic system. The specific aims and possible outcomes are stated below:

1. To review the child accident problems and to analyze the child road traffic accidents and injuries characteristics in Bangladesh particularly in Dhaka city.
2. To evaluate the children's perception on safe road traffic system.
3. To recommend about the mitigating strategies of the addressed problem.

It is expected that the outcome of this research will help to understand the magnitude of the child road safety problems and the need for providing child road safety education to increase their perception for safe walking, crossing as well as for ensuring safety on road.

SCOPE OF THE STUDY

The study is mainly concerned with the investigation, survey and field observation about children road users' perception of road elements and accidents. In this study, the main focus provided on to highlight the child injuries trend on the roadway in the context of Bangladesh and their safety assurance and to identify problems related to child road users from various roadway perspectives of Bangladesh and find out possible solutions. This study will helpful to review the child accidents in Dhaka city and the total child accidents of Bangladesh and thereby understand the intensity of problem and lastly recommend about the strategies of this problem. So, it can be said that, from all directions, this study hopefully can open a new avenue for further research on the phenomena of children perception on road accidents.

The Study Area

The main aim of this study is to know the scenario of perception of school children and non school going or street children in Dhaka city of Bangladesh. Some renowned school in different location of Dhaka city like rajuk uttara model college, adamjee cantonment public school and viqarunnisa noon school for the school going children and some different locations for street children like azimpur, palashi, lalbagh and mirpur-10 etc. Are the study area of this study. Both male and female children are surveyed face to face on these locations.

The study is mainly related to school going children and non school going children or street children and their perception on road accidents. So, mainly the field of the study is some schools of Dhaka city and the students of those schools and some street children of different location in Dhaka city. An interview is taken from both male and female children. All of them were in the 8 to 16 year age range. Because the most vulnerable group for road accidents among the children is this aged group. The perception on road accidents of the school going and non school going children of Dhaka city is the main field of the study of this paper.

The study will reflect the scenario of the children perceptions and experiences which is related to the road accidents. The survey field and the number of schools are less but statistically very significant. This research did not incorporate English medium school children perceptions and behaviour. This is due to the limitation of time and manpower.

CHIDREN INVOLVEMENT IN ROAD TRAFFIC ACCIDENTS IN BANGLADESH

The incidence of risk of children in road accident is very serious in Bangladesh. To represent the extent of child safety problem in Bangladesh, the study Twelve years (1998-2009) of child casualties' data were extracted from the traffic accident database 'MAAP 5' (Microcomputer Accident Analysis Package). For the purpose of the study, accident data involving child were investigated with respect to the accident severity; nature of accident; road user movement; age of pedestrian; time and day of accident occurrence etc. Every year thousands of people are killed in road accidents in Bangladesh and 21 percent of them are children (Table 1). This involvement of children under 16 years of age in road accident fatalities is much higher than those in other developing and developed countries as reflected in Figure 1 which shows the proportion of child fatalities in different countries including Bangladesh.

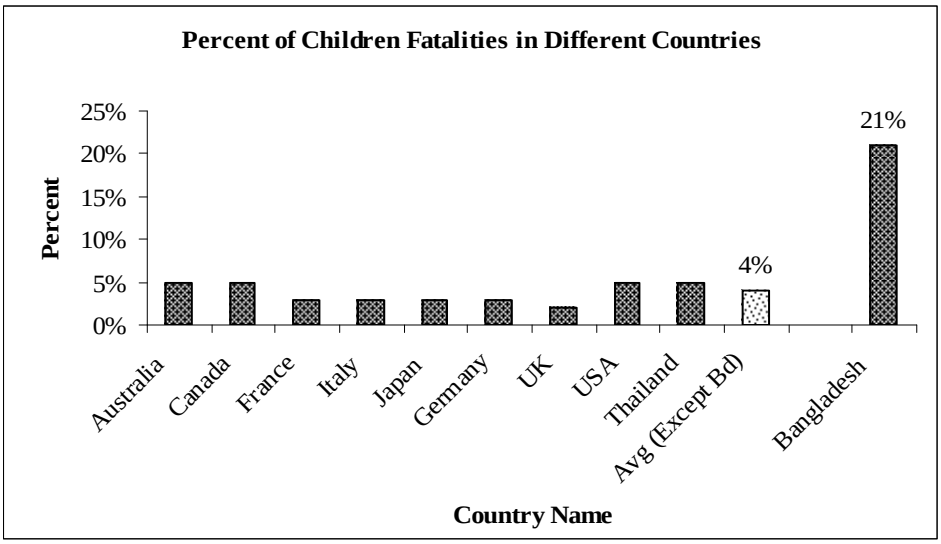

Figure 1: Percentage of Children Fatalities in Different Countries
Source: IRTAD-2005 and ESCAP-2006

Table 1: Children Fatalities and Injuries by Road Traffic Accident in Bangladesh (1998-2009)

YEAR	All Casualties (Known age)		Total Children		Percent of Child	
	Fatalities	Casualties	Fatalities	Casualties	Fatalities	Casualties
1998	1911	4309	412	652	22%	15%
1999	2266	4725	442	659	20%	14%
2000	2299	4564	474	701	21%	15%
2001	1665	3171	345	527	21%	17%
2002	1831	3277	389	526	21%	16%
2003	2040	3707	394	572	19%	15%
2004	1741	2990	363	480	21%	16%
2005	1543	2600	313	424	20%	16%
2006	2117	3350	331	461	16%	14%
2007	2291	3540	442	577	19%	16%
2008	2169	3258	372	479	17%	15%
2009	1826	2795	285	396	16%	14%
Total	23699	42286	4562	6454	21%	17%

Source: ARI MAAP Database, 2010

Children as pedestrian (79%) are most vulnerable in accidents than those of passengers (19%) or bicyclists (2%) (Table 2). Indeed, about one- third of total pedestrian fatalities are children under the age of 16 years. Therefore, great emphasis should be laid on pedestrian child safety.

SOME STRIKING CHARACTERISTICS OF CHILD INJURIES IN BANGLADESH

Children Casualties by Locations: The urban rural split of child fatalities is found to be 74.7 percent rural and 25.3 percent urban. On the other hand, the percent adult fatalities by road traffic accident in rural and urban areas are 70.6 percent and 29.4 percent respectively. This signifies that child fatalities are relatively higher in rural areas. As pedestrian, children are much more vulnerable than adult in rural areas, accounting for nearly 73.9 percent of all child pedestrian fatalities.

Child Fatalities by Types of Collision: The predominant types of collision for children are hit pedestrian, accounting for nearly 75.0 percent of all child fatalities, followed by head-on collision 7 percent, rear-end 6 percent and over turn 5 percent (Fig. 2).

Table 2: Children Fatalities and Injuries by Road Users Group in Bangladesh (1998-2009)

YEAR	Pedestrian		Passenger		Driver/Puller		Total Children	
	Fatalities	Casualties	Fatalities	Casualties	Fatalities	Casualties	Fatalities	Casualties
1998	323	447	78	189	11	16	412	652
1999	363	489	70	159	9	11	442	659
2000	376	477	89	209	9	15	474	701
2001	281	365	51	139	13	23	345	527
2002	308	378	69	131	12	17	389	526
2003	322	398	67	160	5	14	394	572
2004	276	331	81	135	6	14	363	480
2005	228	277	82	139	3	8	313	424
2006	267	330	57	124	7	7	331	461
2007	353	422	75	139	14	16	442	577
2008	294	350	70	119	8	10	372	479
2009	212	263	63	119	10	14	285	396
Total	3603	4527	852	1762	107	165	4562	6454

Source: ARI MAAP Database, 2010

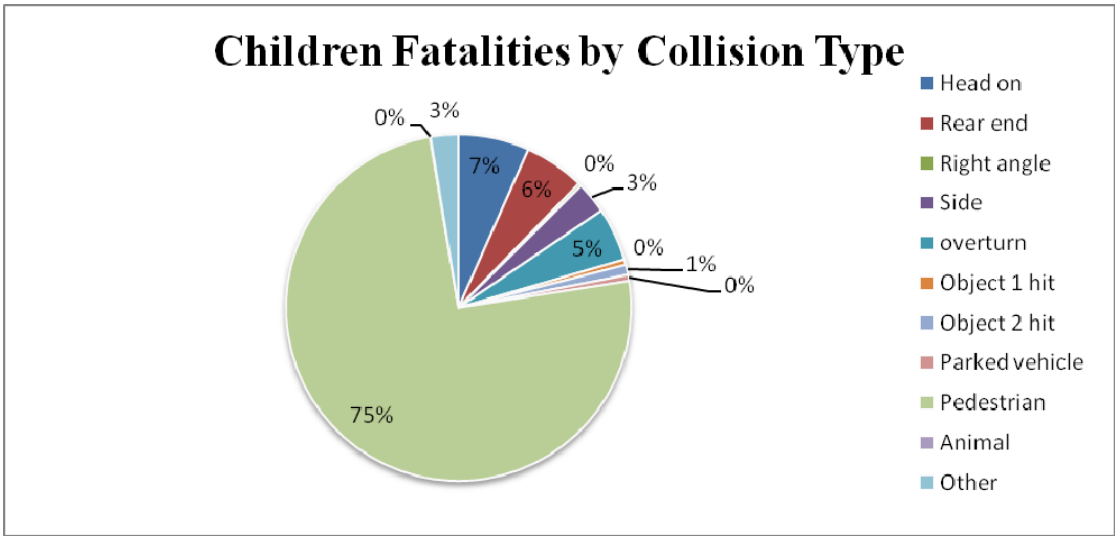

Figure 2: Children fatalities by collision type (1998-2009)

Children Fatalities by Sex: Of the total child fatalities, nearly 67 percent are male and 33 percent are female. The sex distribution of adult fatalities are 86 percent are male and 14 percent are female. This shows that children are over represented and nearly 2.5 times higher than the adult female is. The female child pedestrians are also disproportionately higher than the male child pedestrians (43% Vs 28%).

Children Fatalities by Age Group: Among the total child fatalities by road traffic accident, the over-representing age group is 6 to 11, consisting of 55 % of all child fatalities and 11 to 15 is near to this with 26 %.

Hourly Distribution of Child Fatalities: In Figure 3 the time distribution of child and fatalities are presented which shows that child fatalities peaked during 10-12 noon with high level of their involvement during the entire day period. About 57.4 percent of adult fatalities occurred within the period of 9 am to 5 pm whereas 78.8 percent of children fatalities occurred in that 8-hour period. A significant portion of fatalities of adult persons occurred at night time whereas children fatalities at night is negligible. Problem of color vision at night time is mainly for adult and not for children. The periods with the greatest involvement of children in accidents thus seem to be related with the school activities. Again, these aspects require further examination.

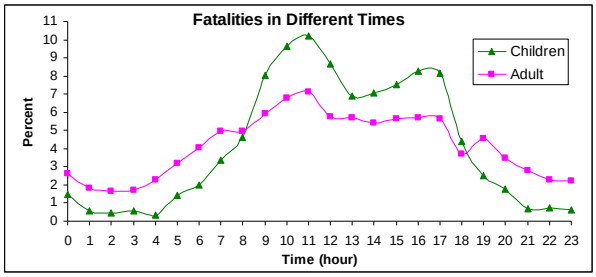

Figure 3: Hourly Distribution of Children and Adult Fatalities (1998-2009)

In rural area 80.6 percent of child pedestrian casualties occurred in the period of 9 am to 5 pm whereas, 65.9 percent casualties occurred in that period in urban area (Fig. 4). That is, in rural area child casualties are concentrated within 8 hours only. A significant number of child casualties occurred out of peak hour, that is at night time in urban area. In urban area, two extreme peaks arise at 11 to 12 am (14%) and 5 to 6 pm (11%) for the age group of 0 to 5 years, that is most of the child pedestrian casualties occurred in two-concentrated hours for that age group. In rural area, most of casualties occurred within the period of 10 to 12 am (33%) and 3 to 5 pm (24%) in all age groups of children.

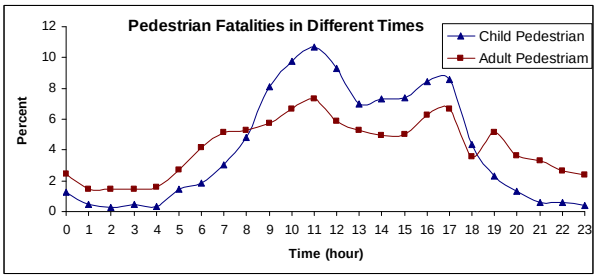

Figure 4: Hourly Distribution of Children and Adult Pedestrian Fatalities (1998-2009)

Children Casualties by Different Types of Vehicle: Studies of road accidents revealed that heavy vehicles such as trucks and buses including minibuses are major contributors to road accidents. These types of vehicles are particularly over involved in fatalities for adult and children both accounting for about 59.9 and 62.1 percent respectively**.** Particularly for children, light vehicles like jeep, car, microbus and pickup are more serious than adults from safety point of view (Fig. 5).

As regards to child pedestrian fatalities, a much higher involvement of these three vehicle types, and accounting for nearly 75.4 percent of all child pedestrian fatalities. Child fatalities as passenger of vehicles are 18 percent of all child fatalities and most of them are involved by bus/ minibus (34%), auto rickshaw/ tempo (20%), rickshaw/ rickshaw van (11%), accounting for nearly 64.0 percent of all child passenger fatalities.

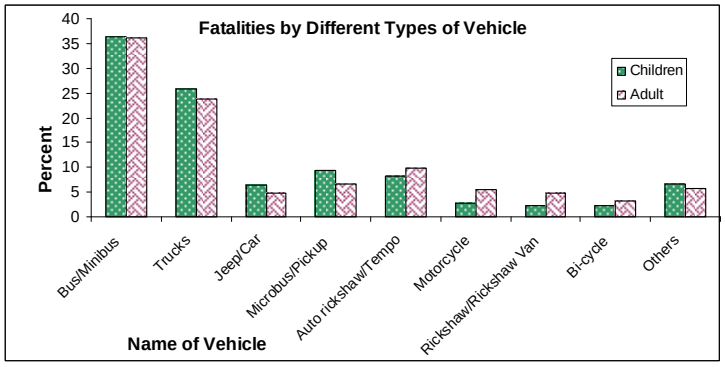

Figure 5: Fatalities by Different types of vehicle

Distribution of Child Pedestrian Fatalities in Different Locations and Actions: Most of pedestrian fatalities occur at roadsides, 47.5 percent which is followed by on road 25.7 percent and at pedestrian crossing points, 19.9 percent. As regard to child pedestrian movement, nearly 45.0 percent of fatalities

resulted from walking along the road. Crossing road was resulted for nearly 31.4 percent of child pedestrian fatalities. Playing on or besides roads has resulted are about 4.5 percent.

Children casualties by road class: The above figure shows that, the numbers of children fatalities are higher in National highway & Feeder roads. The maximum fatality rate is 37% on National highway.

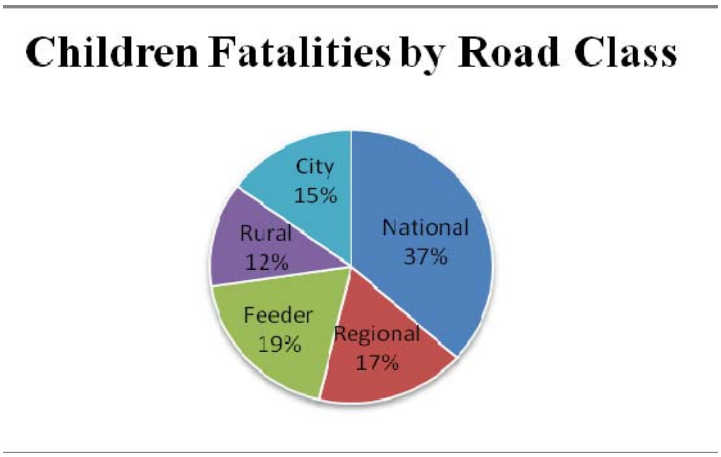

Figure 6: Children fatalities by road class (1998-2009)

SOME FEATURES OF CHILD INJURIES BY RTA IN DHAKA CITY

Total Statistics: From Table 3, it is clearly visible that, the number of accident was higher in year 1998 -2000 for fatalities and in year 2005 for casualties of children of Bangladesh in Dhaka city. The maximum rate of children fatality in year 1998-2000 is about 17% and the maximum rate of children casualty in year 2005 is 13%.

Table 3: Total percentage of children casualties of Dhaka metropolitan by year (1998-2009)

Year	All Casualties		Child Fatalities		Percent of Child	
	Fatalities	Casualties	Fatalities	Casualties	Fatalities	Casualties
1998	420	1556	70	149	17%	10%
1999	314	1079	52	102	17%	9%
2000	301	946	44	93	15%	10%
2001	259	623	34	70	13%	11%
2002	414	906	47	71	11%	8%
2003	402	923	39	74	10%	8%
2004	381	723	49	64	13%	9%
2005	271	511	37	67	14%	13%
2006	390	636	35	56	9%	9%
2007	428	739	43	66	10%	9%
2008	395	676	41	59	10%	9%
2009	339	546	28	41	8%	8%
Total	4314	9864	519	912	12%	9%

Source: ARI MAAP Database, 2010

Temporal Characteristics: The graph shows that, the pick hour of accident occurrence is from 9:00 hours to 13:00 hours and from 15:00 hours to 18:00 hours there is a common rate of children accident occurrence in Dhaka city. At the peak hour the children casualty rate is maximum.

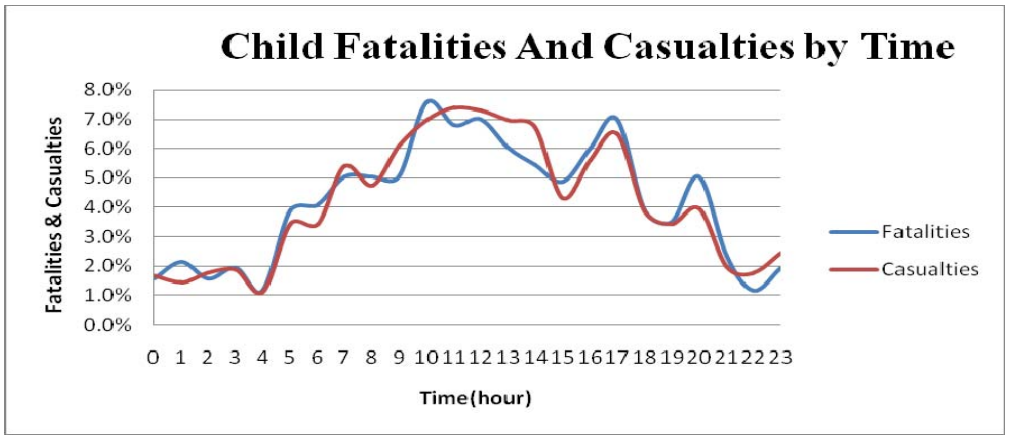

Figure 7: Children casualties by time in Dhaka metropolitan (1998-2009)

Collision by Type: Figure 8 shows that the Head-on & Rear-end collision along with the Pedestrian hit are the top ranked collision type involved in children accidents in Dhaka city. The rate of pedestrian hit is maximum (83%) among them. Other than the aforementioned three types Side collision & Over Turning are also involved collision type.

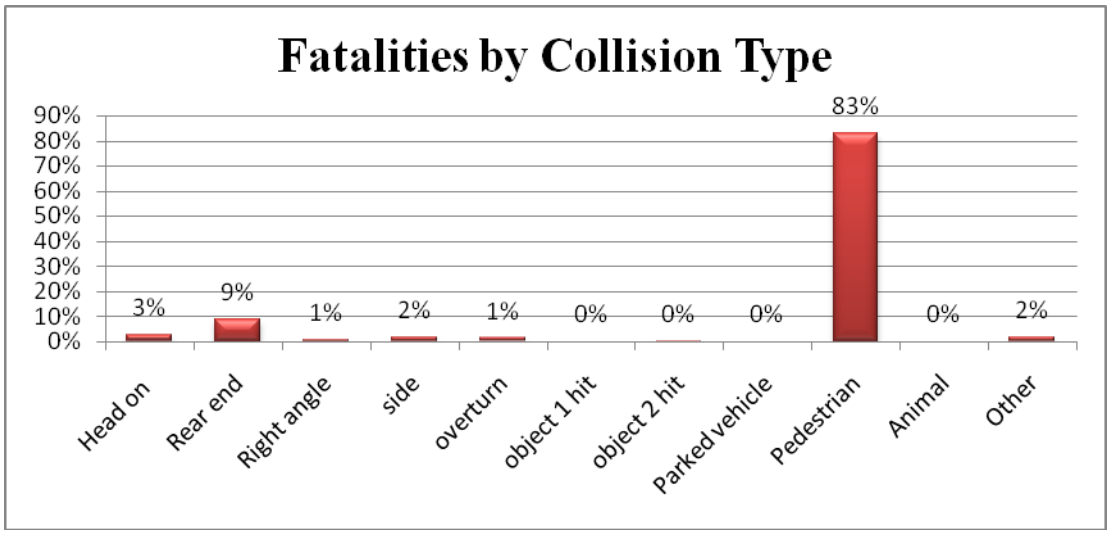

Figure 8: Children fatalities by collision type in Dhaka metropolitan (1998-2009

Vehicular Involvement: The Table 4 shows that Non-motorized vehicle, bus and motor cycle are the top ranked vehicle class involved in children fatalities in Dhaka city. The involvement of Non-motorized vehicle (33%) is maximum among them. Other than the aforementioned two types Truck and private vehicle are also involved with children fatalities.

Involvement of Girls or Boys: It is seen from the figure that, the percentage of male children fatality is higher than the female children fatality in Dhaka city. The rate of male children fatality is 70% and female children is 30%.

Table 4: Children casualties by vehicle class in Dhaka metropolitan (1998-2009)

Vehicle class	Pedestrian		Passenger		Driver/puller		Total children		Percentage	
	Fatalities	Casualties	Fatalities	Casualties	Fatalities	Casualties	Fatalities	Casualties	Fatalities	Casualties
NMV	0	0	20	63	13	21	33	84	33%	25%
M/cycle	0	0	21	62	1	6	22	68	22%	21%
3 Wheeler	0	0	2	8	0	1	2	9	2%	3%
Private Vehicle	0	0	10	51	0	1	10	52	10%	16%
Bus	0	0	18	67	0	0	18	67	18%	20%
Truck	0	0	9	28	0	0	9	28	9%	8%
Others	0	0	5	22	0	0	5	22	5%	7%
Total	0	0	85	301	14	29	99	330	100%	100%

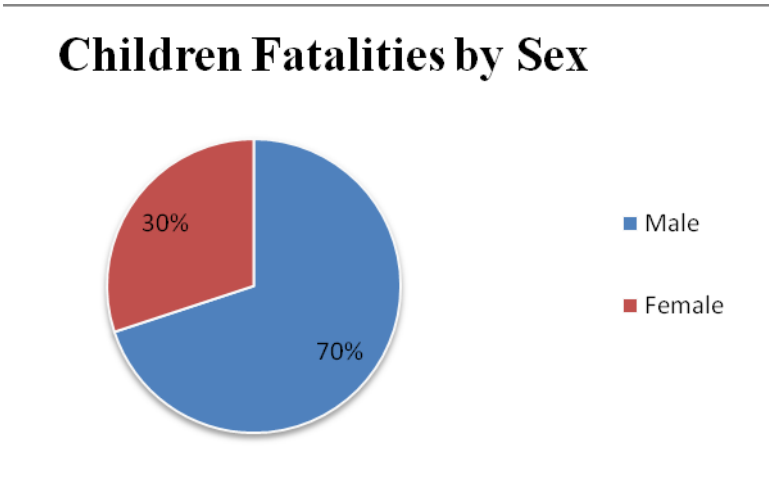

Figure 9: Children fatalities by sex in Dhaka metropolitan (1998-2009)

By age group: The data shows that the over- representing age group is 6 to 11, consisting of 51 % of all child fatalities and 11 to 15 is near to this with 35 % in Dhaka city.

Factors in Accident: Involvement of children in road accidents are attributed to many factors viz. careless and hazardous behaviour of both drivers and children, inadequate and ineffective engineering methods to safeguard children in traffic as well inadequate education and unsatisfactory law enforcement.

CHILDREN PERCEPTION ON ROAD TRAFFIC SAFETY

To evaluate the child perception on traffic safety, a face to face survey has been conducted in a prescribed questionnaire form. Some renowned schools in different locations of Dhaka city like Rajuk Uttara Model College, Adamjee Cantonment Public School and Viqarunnisa Noon School and some different locations for street children like Azimpur, Palashi, Lalbagh and Mirpur-10 etc. were the study area of this survey. The summery of the findings are pointed below:

1. The total percentage of overall perception of male children is 41.5% and the perception of female children is 58.5%.

2. The rate of perception of children on traffic signs and markings is 54% and on traffic rules and regulations is 46%.

3. The percentage of female children perception is 59.5% and the male children perception is 40.50% on traffic rules and regulations.

4. The percentage of school going female children perception is 70% and the male children perception is 30% on traffic rules and regulations.

5. The percentage of street/ non school going male children perception 51% and the female children perception is 49% on traffic rules and regulations.

6. The percentage of female children perception is 57.5% and the male children perception is 42.5% on traffic signs and markings.

7. The percentage of school going female children perception is 69% and the male children perception is 31% on traffic signs and markings.

8. The percentage of street/ non school going male children perception 54% and the female children perception is 46% on traffic signs and markings.

9. Among 120 children, those were surveyed, 83% have a good perception, 15% have poor perception and 2% have the perception with confusion.

10. Among 120 children, those were surveyed, 80% have a good perception, 18% have poor perception and 2% have the perception with confusion on traffic rules and regulations.

11. Among 120 children, those were surveyed, 86% have a good perception, 14% have poor perception and 1% has the perception with confusion on traffic rules and regulations

DISCUSSIONS AND REVIEW OF OVERALL CHILD PERCEPTION

1. The rate of perception of female children is greater than male children perception on road. The main reason behind it is the female children are more concern and aware about to take the decision and action on road practically. On the other hand male children are not so much careful on the road. So the percentage of fatalities and casualties of female children is less than the male children.

2. The children have the greater perception on Traffic signs and markings than the perception on Traffic rules and regulations. Because the traffic signs and markings has a physical existence on designated places. So by visually knowing them they can gather the knowledge easily. On the other hand perception on traffic rules and regulations is depended on the children road safety education and need the sufficient parental guidance about the road accident. But in our country these practices are very rare. So children are lack behind on the perception on traffic rules and regulations than the perception on traffic signs and markings.

3. The overall rate of female children perception on traffic rules and regulations is greater than the rate of male children perception. Because the female children are more careful and they don’t want to take risk on the road like male children do. So the percentage of fatalities and casualties of female children is less than the male children.

4. Schools going male children are less knows about the traffic rules and regulations than the school going female children.

5. Street/ non school going female children less know about the traffic rules and regulations than the street/ non school going male children.

6. The overall rate of female children perception on traffic signs and markings is greater than the rate of male children perception. Overall female children are more conscious about the traffic signs and markings and they know these all better than male children.

7. Schools going male children less know about the traffic signs and markings than school going female children.

8. Street/ non school going female children less knows about the traffic rules and regulations than the street/ non school going male children.

RECOMMENDATIONS

1. The survey and study on children perception among school children and street/ non school going children were done in separate places and different locations in Dhaka city. So, comparison between these two groups of children was not done. Scope of investigation to perform these perception surveys in same locations and areas among same category of children and compare those data precisely and intensively.

2. The face to face survey among school going children and street/ non school going children was done only. So in future traffic perception survey among other classes of people for example: teachers and parents can be done in future.

3. Proper knowledge on traffic perception is not adequately or effectively included in our national curriculum. So, steps should be taken to include them properly on national curriculum for children, which will provide them adequate and effective knowledge on road and increase their perception on road.

4. Enhance the public awareness about the need for improved road safety education and perception for child road users while promoting the health and environmental seminars or campaigns.

5. Develop, evaluate and disseminate road safety programs should be performed to educate parents and drivers about children's abilities and limitations as road users in traffic. These programs should take into account different parenting styles and abilities. It will help to encourage parents to supervise their children in traffic.

6. Develop and conduct effective safe walking programs in Bangladesh like other developing countries should be performed. Because these types of programs will help to prevent child casualties and fatalities on road in all over the country.

7. Encourage the parents, teachers, school administrators and other child care providers to identify and creatively solve the children road safety problems and to help children to acquiring the appropriate perception or knowledge on traffic.

8. To raise children awareness educational program, media coverage and audio cassette and multimedia video trainings should be performed.

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DEVELOPMENT OF TRANSPORTATION MANAGEMENT PLAN FOR A MUNICIPAL TOWN: A CASE STUDY ON NAKLA MUNICIPALITY, BANGLADESH

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ABSTRACT
In Bangladesh, the present average urban growth rate is about 4.5%. Present trend of population increase indicates that by 2020 about 40% of the total population will live in urban areas. The urban centers are going to be the focus of future employment and economic regeneration. The population and economic growth, particularly, in large urban centers is likely to boost in next few decades creating increased burden on them. In addition inefficient transport management greatly contributes to the problems in traffic and transportation system. These aspects not only influence our urban life but also arrest the national economic growth of the country. Transportation and Traffic Management Plan is an advanced document that sets out the long-term direction for transport in a particular area. It covers the movement of people by mode, for example, public transport, car, walking and cycling and freight by road, railway and waterway as appropriate to an area. This paper aims to develop and act as a guideline on the development of future transportation network and traffic management plan for Nakla municipality.

Keywords: Nakla Municipality, Transportation Network Plan, Transportation Management Plan

INTRODUCTION

Transportation and Traffic Management Plan is an advanced document that sets out the long-term direction for transport in a particular area. It covers the movement of people by mode. It is useful for defining the direction of transport-related issues in a particular area. It can recognize the links between transport and land use and urban form and set objectives and policies to address these linkages. Nakla Municipality (Pourashava) is located in the core of Nakla Upazila under Sherpur District. It is situated at the east side of Sherpur district headquarters and around 18 km off it. The Municipality is bounded by Nakla Union in the north, Kursabadagair union in the south, Urpha union in the east and Ganapaddi union in the west. Its geographical co-ordinates are 24.9833° N latitude and 90.1833° E longitude. The population of Nakla Municipality is 27,353 (BBS, 2001). Nakla Municipality connects Sherpur district headquarters, Nalitabari Municipality of Sherpur district and the Phulpur Municipality of Mymensingh district. A national highway connecting the Mymensingh district and Sherpur district divides the Municipality in East-West direction. Almost all of the offices are located in the North-East part of the

Municipality, whereas, most of the educational institutions are situated at the south part of the Municipality. All markets and shopping centers are placed along the road sides. The study area is served by 82.62 kilometers of roads. Out of the total length of roads 43.82 km are pucca, 1.22 km are semi-pucca and 54.96 km are Kutcha. Hall Patti Moor, Hospital Road, Bus Stand Moor, Sherpur Road and Nakla Road are the main and important route networks to play a vital role as a mode of transportation in the Municipality area to Sherpur and Mymensingh district and to Nakla Upazila. The river Boleshar is not being using as waterway. Not a single rail link is situated yet. Food grain such as rice is transported regularly by truck from Sherpur district headquarters and Nakla Municipality towards Dhaka through the Municipality heart. Rickshaw and Rickshaw-Van are the main mode of transport within the jurisdiction of the Municipality. *Nosimons*, locally made motorized vehicles are another mode of transport are carrying passengers into the heart of the town from long distance.

APPROACH AND METHODOLOGY

In the first step of transportation management plan, existing transport condition is identified through physical feature survey, volume survey and speed survey. In the next step, the future projection of transportation network and traffic demand is done. After that a transportation management plan is prepared based on future projection. Some strategies on transportation system management are undertaken in the plan.

EXISTING CONDITIONS OF TRANSPORTATION FACILITIES

Transport Mode

Road is the main mode of transportation in Nakla Municipality. The river Boleshar is not being used as waterway. Not a single rail link is situated yet. Food grain such as rice is transported by truck from Sherpur district headquarters and Nakla Municipality towards Dhaka through the Municipality heart regularly. Sherpur Road, Nalitabari Road, Mymensingh Road etc. are the major roads of the Municipality.

Intensity of Traffic Volume

Hall Patti intersection is the most important intersection of the Nakla Municipality. Almost all mode of traffic is found at this intersection. Bus Stand intersection is another important intersection where most of the traffic including thorough traffic is observed to play over. The peak hour and off-peak hour volume of motorized (MT) and non-motorized traffic at both intersections has been presented in **Figure-1** below.

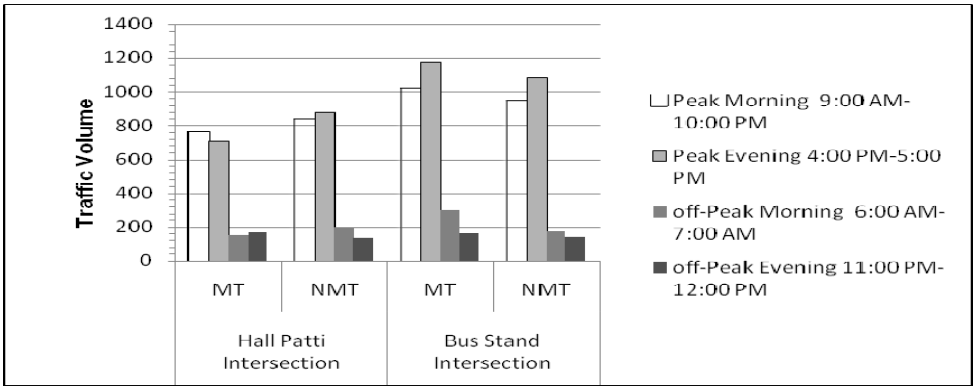


Figure-1: Composition of Peak/Off-Peak Traffic Volume at two Intersections

Level of Service (LOS): Degree of Traffic Congestion and Delay

The LOS for different roads of Nakla Municipality is demonstrated here on the basis of ratings and speed survey (Wikipedia, 2012) and it is shown in **Table 1**.

Table 1: Existing Level of Service (LOS) of major roads of Nakla Municipality

Name of Roads	Speed (mph)							LOS
	Truck	Bus	Car/ Microbus	Auto Rickshaw	Motorcycle	Others	Average	
Sherpur Road	62.14	63.25	56.21	51.25	52.84	46.1	55.30	C
Chandrakona Road	50.32	52.81	50.21	48.57	51.95	43.25	49.52	D
Mymensingh Road	58.25	57.18	55.21	54.12	53.21	46.25	54.04	C
Nalitabari Road	57.12	56.12	56	53.12	52.5	44.25	53.19	D
Ferusa-Lava Road	37.52	42.12	34.25	32.25	35.12	29.12	35.06	E

Source: Field Survey, 2011

ANALYSIS OF EXISTING DEFICIENCIES

Roadway Capacity Deficiencies

Narrow width and poor maintenance of roads have been marked as major transport problems in the town. It causes higher traffic volume exceeding roadway capacity and creates serious traffic congestion on the narrow streets. Most of roads have been constructed without maintaining the minimum standard of road width. Traffic conflict is common and frequent in towns where there is admixture of slow and fast transport vehicles in the roads. The identified reasons for traffic conflict are improper intersection design, parking of vehicles on the street, waiting of operators on the roads looking for possible passengers, absence of traffic signal, disobedience of traffic rules etc.

Operational Safety, Signal and Other Deficiencies

Like any other municipal town, which is beyond the regional and national movement directly, Nakla Municipality has no traffic management system. There is no traffic point and traffic island including road dividers and signal posts. That is why operational and road safety is not existed.

FUTURE PROJECTIONS

Traffic Volume

Traffic volume, as indicated by traffic counts at various locations on the roadway network; which reflect current travel patterns and how well the network is serving the travel demand. When planning ahead to address the needs of our transportation network, it is important to project the level of traffic that we can anticipate during our planning period and beyond (Chiaradia, A., et al, 2005). The future traffic volume of Nakla Municipality is forecasted by adopting extrapolation method. An extrapolation factor indicating the growth trends, which is derived from earlier and present year traffic volume is introduced in this method. The future traffic volume is forecasted at two intersections. The intensity of traffic movement observed in these intersections is high and traffic conflict is prevalent at these points. The forecasted traffic volume of two major intersections of Nakla Municipality is shown in **Table-2**.

Table 2: Projection of Target Year Traffic Volume up to 2026

Location	Duration	2011	2016	2021	2026
Hall Patti Intersection	09:00-10:00	1428	1632	1866	2133
	13:00-14:00	1611	1841	2105	2406
	16:00-17:00	1590	1817	2077	2375
Bus Stand Intersection	09:00-10:00	1947	2226	2544	2908
	13:00-14:00	2259	2582	2952	3374
	16:00-17:00	2259	2582	2952	3374

TRANSPORTATION PLAN

Road Network Plan

An integrated road network plan has been prepared commensurating the planning standards and considering the convenient movement of all vehicular and pedestrian traffic. Three types of road, such

as Primary Road, Secondary Road and Local Road are proposed designating a unique ID No. to each road for identifying them in map. The road network plan along with transportation management plan is presented in **Map-1** below. In the plan, 7 Primary roads (30.5m width), 7 Secondary roads (18.30m width) and 39 Local roads (6.10m width) are proposed in Nakla Municipality considering the linkage and connectivity of the different localities, as well as the trip pattern of the people.

Proposal for Improvement of the Existing Road Networks

Traffic management measures may be adopted to increase traffic capacity and safety. The improvement could be done by removing the deficiencies in the existing core road network by widening and/or strengthening of selected stretches / corridors in a phased manner and improvement of road geometrics and safety provisions. Total 22 existing roads are proposed for widening (with 6.10m to 30.5m width).

Plan for Transportation Facilities

Bus Terminal

There is no designated bus terminal in this Municipality. Considering inter-town movement of high speed vehicular traffic without interrupting safe urban living of the Municipality inhabitants, an inter-upazila Bus Terminal is proposed at the extreme east of the Municipality beside Mymensingh road. The location and outline of the proposed bus terminal is shown in **Map-1.**

Truck Terminal

The Nakugaon land port, the Indian border with Bangladesh is only 30 km off the Municipality HQ. Coal and other imported items are carried by heavy trucks and they passes by the Municipality especially during night. Therefore, a truck terminal is also proposed to the extreme east of Ward No.06 beside Mymensingh road. The location and outline of the proposed truck terminal is shown in **Map-1**.

Tempo Stand

Tempo is now a major and cheap commuter in small towns that play important role in commuter transportation. There is no formal tempo stand in the Municipality. Thus, four tempo stands along with rickshaw/van stand are proposed in Ward-2 (North of Ferusha- Bimaloy Tarakandi road), Ward-4 (At Baneshardi mor), Ward-8 (East of Chandrakona road) and at the north of Talki Road. The location and outline of the proposed tempo stand/rickshaw stand is shown in **Map-1**.

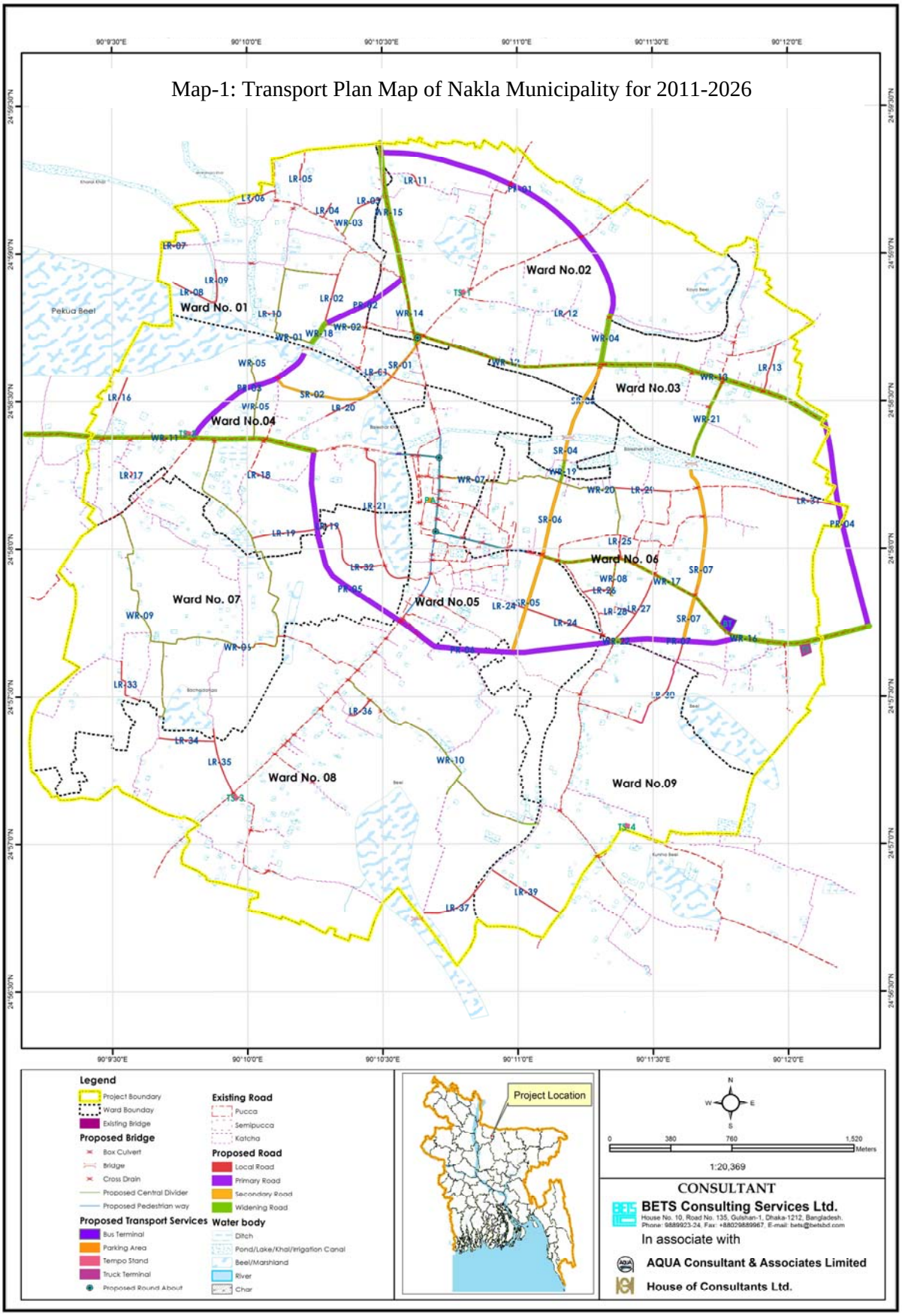
Parking Provision

There is no parking facilities provided in Nakla Municipality. People are habituated of parking beside the roads. This parking practice occupied considerable spaces reduces the effective road width. Particularly in bazaar area where a number of markets exist the parking problem become acute during weekly hat days. If it is possible to integrate parking area for tempo, rickshaw, van, etc. near to bazar area the congestion problem will be solved. In order to mitigate the traffic congestion and traffic conflict at the bazar area, a parking area is proposed (**Map-1**). On-street parking shall be prohibited on all roads within the bazar area except at places where it is specifically permitted for parking.

Development of Facilities for Pedestrians, Bicycles and Rickshaws

Footpath may refer to sidewalk, which runs along vehicular roads. It is a separate lane exclusively designed for the purpose of pedestrian movement. The footpath is quite safe and free from any accident. Unfortunately, there is no footpath besides any road of Nakla Municipality. The transportation system within residential neighborhoods should favor pedestrian movement and discourage vehicular thorough traffic in both new and existing neighborhoods. A pedestrian system that utilizes neighborhood streets and paths to link the residents with the commercial and school functions needs to be developed with beneficial considerations.

Map-1: Transport Plan Map of Nakla Municipality for 2011-2026



TRANSPORTATION MANAGEMENT PLAN

Transportation System Management Strategy (TSM)

- **Strategies for Facility Operations**

- Strict vigilance should be in force in order that no one can cut the earth from the embankment and shoulders of the road and nothing is done to cause harm to the embankment and shoulders,
- People should be encouraged not to overload the bus and they should also be informed about the hazards of trucks loaded beyond their carrying capacity to dissuade them from such practices,
- Care should be taken to dissuade people from digging irrigation canals on the shoulder or slope.

- **Strategies for Traffic Flow and Safety**

- Maximum accessibility for pedestrians and cyclists,
- Introduction of temporary signs to provide information to road users to enable safe and convenient travel,
- Provision for prescribed shoulder on either side of the road,
- The roads should be kept free from all unauthorized obstructions,
- Undesirable hump on the road, if exists, should be removed.

- **Strategies for Traffic Management**

- Enhancements to enable more effective use and management of existing physical infrastructure,
- Initiatives to improve the ability of road to adopt behavioral patterns which lead to more efficient and safer transport services,
- Improved testing and licensing procedures for all drivers and re-training for offending drivers,
- Increased level of enforcement of traffic rules to ensure a greater compliance with community desired road user behavior.

Plan Implementation Strategies

- **Regulations to Implement the Transportation Plan**

- The Motor Vehicles Ordinance, 1983 can be exercised by the respective authorities to control and scrutinize the movement pattern of motorized traffic in Nakla Municipality.
- The Motor vehicle rules, 1997 is designed to ensure the road safety, which can also be exercised by the authorities.
- The National Land Transport Policy approved in April 2004, include provision of safe and dependable transport services, and improving the regulatory and legal framework.
- On the other hand, the Municipality Authority should practice the 'Local Government (Pourashava) (Amended) Act, 2010' to ensure safe and sustainable transport service for the inhabitants.

- **Implementation, Monitoring, Evaluation and Coordination of the Plan**

- The Transportation and Traffic Management Plan should also be implemented, monitored and evaluated under the same strategy by strengthening capacity of the Municipality and forming a Monitoring and Evaluation Committee (MEC).

CONCLUSION

In order to make the plans sustainable through people's participation, it is now important to ensure involvement of the local stakeholders in the planning development process. The current plan opens up a new horizon of development opportunities and land use control through policy guidelines in broad sense and detailed development proposals unto a very micro level. It is expected that the proper implementation of plan with close monitoring will make this town livable, healthy and socioeconomically developed in future.

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IDENTIFICATION OF INEFFICIENCIES IN VEGETABLE SUPPLY CHAIN OF BANGLADESH: A CASE STUDY OF PAPAYA

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ABSTRACT

Supply chain management can play a vital role in bringing efficiency and enhancing productivity of complex vegetable supply chain. This study investigates the vegetable supply chain characteristics and analyze the flow network with focus on papaya. Market survey is conducted in wholesale market and various retail outlets of Dhaka city and those involved in the supply chain were interviewed. The details of supply chain players are analyzed and their characteristics are established. This leads to the identification of the inefficiencies and factors related to these inefficiencies. Finally, suggestions are made aiming at mitigation of bottlenecks and inefficiencies of vegetable chain, especially, the papaya supply chain.
Keywords: Supply chain, kitchen product, inefficiencies

INTRODUCTION

Transportation is an important human activity, which supports and makes possible most of the social and economic interactions among communities of the world. Freight Transportation, in particular, is one of today's most important economic activities, not only as measured by its share of nation's Gross National Product (GNP), but also by the increasing influence that the transportation and distribution of goods have on the performance of many economic sectors like wholesale & retail trade, manufacturing & production etc Bangladesh economy depends on mainly agriculture (Chanda.P.K, 2004). As a densely populated country its' growth rate of population is increasing time to time. For this reason the demand is also increasing. In order to fulfil this huge increasing demand we have to think seriously and do something better for ensuring adequate supply (Mentzer,2007). But as we are a poor country, our resource is limited and this limited resource is not yet properly distributed. So we need a much better efficient management system in order to fill the growing demand with the limited supply we have.

MATERIALS AND METHODS

Upon visit to the wholesale market in Kawran Bazaar the various components of the supply chain was found out and studied. These could be explained as the following:

FARMER:
Supply chain link starts from the activity of farmer. He produces different agricultural products. He has a little capital generally. He sells the products to beparies or local markets. Most of the time, he has no own land.

BEPARI:
The activity of bepari is very much important in supply chain link process. Generally he purchases agricultural products from local markets or farmers. He keeps the products in arothdars storage facilities as he has no ware house. He has moderate capital. Some may take loan from bank.

AROTHDAR/WHOLESELLER:
Generally the activity of arothdar is just like a media. He neither buy nor sell products but take commission. He has much capital. He provides storage facilities for the beparies. His storage facility is located near river port or bazaars. One owner may have several ware houses.
RETAILER:
The most important characteristics of supply chain link process is retailer. He sells products to consumers. Generally his tendency is make more profit as possible time. He has some capital. He usually does not own a shop. He usually rents shop in kacha bazaar. His interaction with consumers is very essential.
For knowing different type of problems existing in the supply chain link some kitchen market was visited. Here retailer, wholesalers and beparis were to be interviewed. They were to be questioned in terms of their related expenses and their profits.
The Bepari was to be interviewed in terms of:

- the transportation cost
- the kitchen product to be sold
- the mode used
- the purchasing cost from the farmers
- the reason for the aroth chosen
- the amount of product brought
- the selling cost to the retailer
- other specific problem (if any)

The Arothdar was interviewed in terms of:

- the storage costing charged
- the expenses faced by the wholesaler
- storage methodology
- the preferred mode of storage
- specific problem (if any)

The retailer was interview in terms of:

- purchasing cost from the beparis
- selling cost to the consumers
- transportation costing
- other expenses encountered
- loss of products
- specific problems (if any)

For providing improvement measures any economic model or design is always preferable. But it is very difficult to design an economic model. Any system costing much is not implemented most of the time. So our tendency is to develop any model that works properly as well as cost much lower. Here an empirical model is developed for supply chain link management system. So economic evaluation is to be carried out.

RESULTS AND DISCUSSION

At present there exist a lot of problems in the supply chain link. By observation of kitchen market many inefficiency are found. They are listed and mentioned below here:

- Little use of technology:

The retailers are not united. Unity can be achieved if the retailers use technology such as cell phones to communicate with one another. Use of technology can lead to use of mechanized/ motorized vehicles rather than non motorized vehicles.

- Tendency to get more profit:

The Bepari usually is the one who tries to make much of the profit. He usually is the one who tries to make the profits not taking into account whether farmers are getting their share.

- Increasing shop rent annually:

The retailer can be found to increase the final costing of the products due to increase in rental expenses. This expense is bore by the retailer by the so he increases price of the commodity.

- Use of hand pulled vehicle:

The traditional method of transportation of products as shown in figure below [Fig. 1] within Dhaka is the use of hand pulled vehicle as shown in {Fi such as rickshaws and vans. This takes time and is costlier as compared to transportation by mini truck. So, economic value is diminished.

Fig.1: Using hand pulled vehicles

- No effective monitoring authority:

There is no effective monitoring authority to monitor how much product is required, the costing to be maintained, where loading and unloading should take place and where parking should take place.

Of the 20 specific locations monitored in the Kawran Bazaar aroth 17 showed poor roadside parking as shown in figure below [Fig.2].

Fig. 2: Poor on street roadside parking

- Poor storage and selling conditions:

In certain locations outside and inside the aroth the kitchen products is placed, stored and sold in the open which creates a negative impression. Of the 15 locations observed outside the wholesale market 12 showed that the products were sold in the open.

Fig. 3: Selling in open spaces

- Bringing without packaging:

The kitchen freight brought to the aroth is done so without proper packaging. This can cause loss of products due to damage and so to make profit the bepais usually cover up for this bt increasing costing of the other kitchen freight.

- Increase of transport cost:

The external-internal trips are done by trucking. Due to increase in fuel costs, crew costs, vehicle maintenance cost and other expenses there is an increase in the overall transportation costs from various locations.

- Illegal allocation of the shops:

Due to presence of some powerful influence some spaces or shops in the aroth are forcefully taken by those having the influence. These can cause internal rift among the arothdars.

- Improper consumer rights:

There are certain consumer rights set by the authority but these are not maintained and no particular ones are there to observe theses. So consumer rights are violated.

- Lack of subsidy for farmers:

For greater productions to occur certain facilities are to be provided. Facilities in monitory form and subsidies can be provided by the government for development of production by the farmers.

- Insufficient facilities of loading and unloading of goods :

There are no proper locations or facilities for loading and unloading of the freight brought to the wholesale market. These can delay the loading or unloading process which decreases efficiency. Of the 15 locations surveyed as potential parking facilities 14 of them were already blocked due to poor regulation.

Development of any model that works properly as well as cost much lower is required. Here an empirical model is developed for supply chain link management system. So economic evaluation is to be carried out.

Firstly, travel costing of the mode in use i.e. hand pulled vehicle is observed.

The retailer was interviewed about the transportation costing required to bring products from wholesale market.

The data required is provided below:

Table 1: Relationship of distance with transportation costing (traditional mode):

Name of places	Distance From Kawran Bazaar (m)	Transportation Cost (Tk/kg)
Hatirpul	1.8	0.75
New Market	2.6	1.7
Polashi	3.1	2.0
Lalbagh	4.6	2.8
Kochukhet	6.2	4.0

Then observed travel costing of the mode proposed i.e. mini truck is observed.

The retailers using this mode (although few in number) were interviewed about the transportation costing required to bring products from wholesale market.
The data required is provided below:

Table 2: Relationship of distance with transportation costing (proposed mode):

Name of places	Distance From Kawran Bazaar (m)	Transportation Cost (Tk/kg)
Hatirpul	1.8	0.65
New Market	2.6	0.90
Polashi	3.1	0.90
Lalbagh	4.6	1.00
Kochukhet	6.2	1.20

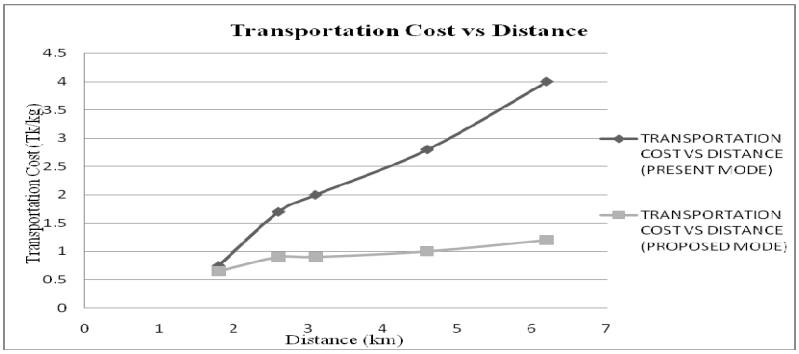

Fig. 4: Transportation costing versus distance relationship

The figure above [Fig. 4] shows that cost is saved when the proposed mode i.e. mini truck is used. So, it is better to use proposed method of transportation.

On the criterion on time consideration:
The travel time taken by the mode in use i.e. hand pulled vehicle is observed. The retailer was interviewed. Then observed travel time of the mode proposed i.e. mini truck is observed.
The retailers using this mode (although few in number) were interviewed about the transportation travel required to bring products from wholesale market.
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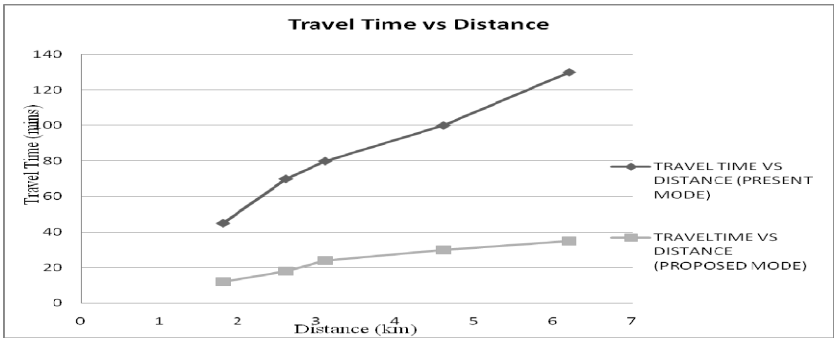

Fig. 5: Travel time versus distance relationship

The figure above [Fig. 5] shows that a lot of travel time is saved when the proposed mode i.e. mini truck is used. So, it is better to use proposed method of transportation.

CONCLUSION

According to the findings of the present research, following propositions are recommended:

- At first proper monitoring is necessary
- It is clearly seen that, trucking is the most cost effective transport in the internal trips. Use of mini trucks of 1.5 tons capacity is recommended. Therefore trucking shipment should be encouraged. Though rickshaw and van could be used in specific amount in specific routes at short haul distances. Other factors related to this study needs to be carried out in details.

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SAFE SYSTEM APPROACH FOR SAFER ROADS IN BANGLADESH

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ABSTRACT
Road transport plays an important role in catering for the ever increasing travel demand for freight and passengers in Bangladesh. The increase of number of vehicles and road mileage is adding speed and greater frequency to transportation but simultaneously the number of road accidents is also reaching a soaring height. There were at least 2646 police-reported fatalities and 1803 injuries in 2827 accidents in 2010 but the actual fatalities could well be 20,038 each year (WHO, 2009). These clearly demonstrate that road safety is a serious issue and there remains much scope for improving this sector. The introduction of 'Safe System' approach may prove to be exceptionally effective in improving the present roadway safety conditions of Bangladesh. The Safe System approach views the road transport system holistically by seeking to manage the interaction between road users, roads and roadsides, travel speeds and vehicles. This approach recognizes human error in the system is inevitable and it is probably not possible to prevent all crashes but aims to design a road system which will be more forgiving of human errors while minimizing the risk of death or serious injury. This protection is best provided by four cornerstones – safer roads, safer speeds, safer vehicles and safer road users. This paper explores the prospects and suitability of introducing the Safe System approach in Bangladesh particularly highlighting the aspects of road infrastructure and speed.

Keywords: Road Accidents, Safe System, Safer roads, Bangladesh, Road infrastructure, Speed

INTRODUCTION
Road traffic accidents are increasingly being recognized as a growing hazard for public health and economics in Bangladesh. Traffic crashes are resulting in unacceptably high socio-economic toll and are hindering poverty reduction efforts. According to the official statistics, there were at least 2646 fatalities and 1803 injuries in 2827 accidents in the year 2010. In the prevailing situation of significant underreporting of accidents, WHO estimates that, the actual fatalities could well be 20,038 each year (WHO, 2009). In economic terms, road accidents cost the community in the order of US$1000 million which is nearly 2% of the country's GDP. These clearly demonstrate that road safety is a serious issue and there remains much scope for improving this sector. For this the contributing factors of accidents should be identified and proven interventions need to be implemented with due urgency, ranging from education, engineering and enforcement. The introduction of 'Safe System' approach may prove to be exceptionally effective in improving the present roadway safety conditions of Bangladesh. The Safe System approach views the road transport system holistically by seeking to manage the interaction between road users, roads and roadsides, travel speeds and vehicles. This approach recognizes human error in the system is inevitable and it is probably not possible to prevent all crashes but aims to design a road system which will be more forgiving of human errors while minimizing the risk of death or

serious injury. This protection is best provided by four cornerstones – safer roads, safer speeds, safer vehicles and safer road users. In this paper the prospects and suitability of introducing the Safe System approach in Bangladesh is explored particularly highlighting the aspects of road infrastructure and speed in mitigating the road safety hazards.

RESEARCH METHODOLOGY

Detailed analysis was performed on accident data collected from BRTA. The results of this analysis along with information from published researches were used to define the road safety problem characteristics in Bangladesh. Then through extensive review, information regarding road safety condition in countries which have already accepted Safe System approach as the guiding principle of road safety development was gathered. Finally, the applicability and suitability of the best practices in reducing road trauma of Bangladesh were explored.

ROAD ACCIDENTS IN BANGLADESH

Road traffic injuries are one of the major reasons of mortality and disability in Bangladesh with about one-fifth of injury related hospital admissions caused by road traffic accidents. According to Police Headquarters (FIR) Report the number of fatalities has increased from 1009 in 1982 to 2646 in 2010. These figures are very alarming and urge the necessity of improving road safety sector without delay.

Road Accident Characteristics

Proper accident analysis is limited in Bangladesh by issues such as the lack of reliable and authentic data of the accidents and the inconsistency in official data of RTAs. Yet detailed analysis by various parameters performed on the accident data of the year 2010 collected from BRTA identified some characteristic features of accidents occurring in Bangladesh. These are mentioned below:

- Despite the reduction in the number of casualty accidents per 100,000 populations from 2.28 in the year 2001 to 1.56 in 2010, the total number of deaths and injuries continues to increase due to the uncontrolled rise in the country's population.
- Of the total 2319 casualty accidents which occurred in the year 2010, about 81% was fatal.
- In 2010, about 61 percent of the fatal accidents occurred in the rural road environment and based on road class, nearly 44 percent of the fatal injury occurred on the national highways.
- Among the nine national highways (N1-N9), most of the casualty accidents occurred in N1,N2 and N5 in the year 2010.
- Accident type analysis showed 'hit pedestrian' as the dominant accident type both in urban and rural areas with 50.3% involvement in fatal accidents. Other common accident types are: head on collision (16.7%), rear end collision (14%) and overturning (7.1%).
- Analysis based on type of junction revealed that about 65.5% of the casualty accidents took place in mid-blocks and the rest 34.5% occurred at intersections.
- Nearly 8% of the total 2319 accidents occurred in the 'Tee-intersections' made by local roads meeting national highways.
- Heavy vehicles such as trucks and buses including minibuses are major contributors to road accidents (bus/ minibus 31.5%, trucks 22%) though they constitute a small portion of the registered vehicles (bus/ minibus 5%, trucks 5.4%).
- People in the age group 16-45 years are the main victims of the road traffic accidents.

Road and Road Environmental Factors Contributing to Accidents

The principle contributing factors to accidents in Bangladesh have been determined in many published researches. For example, Hoque et.al. (2010 & 2011) identified the following factors contributing to accidents: adverse road 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. Several road environmental factors that are particularly prevalent in rural roads are major roadway

defects in design and layout, shoulders, roadsides, bridge and its approaches, delineation devices and lack of access control. Unregulated private/ business access to inter-urban highways led to endless linear settlement resulting in high risk for pedestrians and other vulnerable road users. BRTA in its investigation identified fifteen major causes of road trauma in Bangladesh (BRTA 2008). Reckless driving and over-speeding have been reported as the most frequent causes of accident. The prevalence of the above factors was found in some of the recent devastating crashes (See Hoque et.al. 2012).

Typical Accident Locations

About 61 percent of the fatalities occurred in the rural areasof Bangladesh and nearly 44 percent occurred on the national highways. Accidents are highly clustered at some specified 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 having section lengths varying between 0.1-0.5 km each location (Hoque et.al. 2011).Selected hazardous locations were studied and the most striking features and roadway deficiencies common to these locations were briefly discussed in Hoque et.al. (2006). One such case study is presented in the following section. More details of this study can be found in Hoque& Mahmud (2009).

Hazardous Road Location: Bhoradoba Market area 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 meters. 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.
There are a number of shops, hotels, tea stalls, rickshaw and tempo workshops, a local trading center, manyschools and mills adjacent to the area which generates considerable number of pedestrians.

Figure 1. Stacking of materials at close proximity to roadsides

Figure 2. Tempos picking up passengers on roads are real dangers for through traffic

The temporary shops and stalls built beside the road restrict pedestrians from using the shoulder and obstruct the visibility when traffic from access roads merges into the main traffic stream. Besides, illegal use of the roadsides for piling of wooden logs and other goods, parking and loading/unloading activities force the pedestrians to use the high-speed road carriageway thus increasing the complexity of roadside friction. These problems arise from road infrastructure deficiencies and linear settlements at the high risk locations which are indeed significant safety challenges in Bangladesh.

From the above discussions and the hazardous road location case study it is evident that a paradigm shift is needed in addressing the safety problem in Bangladesh. Such sustainable measures should be implemented which will aim at designing a safe and more forgiving road system. This is essentially the gist of the Safe System approach which will thus be very effective in improving road safety of Bangladesh.

THE SAFE SYSTEM

The Concept

In all regions of the world, to prevent road death and disabling injury, a traffic system better adapted to the physical vulnerabilities of its users needs to be created. The *Safe-system* approach, as exemplified

by *Vision zero* (Sweden), *Sustainable safety* (Netherlands), *Safesystem* (Australia) and *Safer Journeys*(New Zealand)should set the framework for the long-term safety management on a nation's roads. A Safe System approach to road safety represents a significant shift in thinking about road safety. By taking a total view of the combined factors involved in road safety, this approach aims to design and build a transport system that will protect responsible road users and reduce the number of deaths and serious injuries

A Safe System is one where the likelihood of a road crash is reduced, and where any crash that does occur minimizes death and serious injury. The Safe System approach identifies the shared responsibility of road system and vehicle designers, providers and users in achieving this outcome(http://www.roadsafety.vic.gov.au/about/victorias_road_safety_record/victorias_road_safety_rrecor.html).

Key Features of Safe System

Safe Systems around the world have common key features (Fildes& Langford, 2002):

- They recognize that the human body has a limited tolerance of violent forces and when crash energies exceed this tolerance, death or serious injury will be a probable outcome;
- They accept that crashes will continue to occur, prevention efforts notwithstanding, given that humans make mistakes when using the road system;
- The challenge for any Safe System in the event of a crash is to ensure that no fatalities will occur (and that serious injuries will be reduced) for road users behaving appropriately; and
- This challenge can be best met by managing the road infrastructure, vehicles and speeds to reduce crash energies to levels that can be tolerated by the human body.

Elements of a Safe System

Safe System approaches argue that for as long as mistakes are likely, all road users need to be protected – and this protection is best provided by four cornerstones – safer roads, safer speeds, safer vehicles and safer road users (Langford, 2009). So to get a Safe System we need to achieve:

- **Safe roads and roadsides** that are predictable and forgiving of mistakes – their design should encourage appropriate road user behavior and safe speeds.
- **Safe speeds** that suit the function and level of safety of the road – road users understand and comply with speed limits and drive to the conditions.
- **Safe vehicles** that help prevent crashes and protect road users from crash forces that cause death or serious injury.
- **Safe road use**, ensuring that road users are skilled and competent, alert and unimpaired, and that people comply with road rules, choose safer vehicles, take steps to improve safety and demand safety improvements.

Safe System Countermeasures

The specific countermeasures that come from a Safe System strategy differ between jurisdictions. However as a broad summary, Safe System countermeasures aim either to prevent a crash from occurring or to reduce the severity of that crash, *while minimizing the possible role of human errorin precipitating the crash*. According to Turner &Cairney (2010), the countermeasures or treatments can be broadly classified under two heads:

1. **Primary treatments** which could be expected to result in improvements in safety that prevent or minimize death or serious injury (either by preventing crashes or by dissipation of energy to such low levels that fatal and serious injury cannot occur).
2. **Supportive treatments** which deliver a safety benefit, but not necessarily Safe System outcomes. They act by reducing the likelihood and/or severity of crashes.

By careful studies of internationally recognized Safe Systems such as Vision Zero of Sweden, Sustainable Safety of the Netherlands and Safe System of Australia, some effective road infrastructure and speed related countermeasures were identified. These are listed below:

Road Related Countermeasures

- Primary treatments such as erection of guard rails, clearing away of potentially dangerous objects such as trees and boulders from roadsides, installing slip based poles and frangible poles etc are

effective in preventing or reducing the severity of **run-off road crashes** whereas separation of traffic travelling in different directions, which can be attained through duplication, or by way of center-of-road barriers and through the instigation of one-way road systems can reduce **head-on crashes**. Separation of traffic (grade separation), roundabouts, platforms at intersections, installation of traffic signals and pedestrian (and cyclist) signals are capable of providing **safer intersections**. Other Safe System countermeasures like physical separation viz. grade separation and separate facilities (footpaths, pedestrian malls etc.), Wombat crossings, proper land-use planning, signals, pedestrian fencing, provision of medians or refuge islands etc. can provide safer infrastructure for **pedestrians** while separation for cyclists through an off-road cycle path, providing motorcycle-friendly barriers etc. can promote safety of **motorcyclists and cyclists**.

- Supportive treatments like implementation of improved shoulder provisions, audio tactile edge lines and delineation, shoulder sealing, wider medians, provision of overtaking lanes, improved skid resistance, improved lighting, protected right turns (fully controlled), categorization of the road network, homogeneity of mass and direction, recognizable road design etc. can also improve the overall safety condition of the road network.

Speed Related Countermeasures

- For long-term speed management, a clear functional road hierarchyis to be established for both the rural and urban networks. For example, the Sustainable Safety recognized three functional road categories for the Netherlands: through roads, distributor roads and access roads. Generally, higher speed limits are permitted on through roads than are permitted on distributor and local roads.
- Speed management is of core importance in delivering Safe System outcomes. A report by Fildes et.al. (2005) summarizes the biomechanical tolerances of humans for different crash types.

Table 1: Biomechanical tolerances

Crash type	Tolerance
Car/pedestrian	20-30 km/h
Car/motorcyclist	20-30 km/h
Car/tree or pole	30-40 km/h
Car/car (side impact)	50 km/h
Car/car (head-on)	70 km/h

Source: Fildeset.al., 2005

Human tolerances need to be considered in the setting of speed limits to ensure that in the event ofa crash, no road users are killed or seriously injured.

- Some engineering treatments like speed humps, rumble strips, raised platforms at pedestrian crossing locations and at intersections, gateways at entrances to towns, roundabouts, pavement narrowing and treatments at curves are found to be useful in slowing down motor vehicles.
- Speed limits consistent with Safe System principles can also be adopted by the separation of VRUs, use of speed-limiting technology and intelligent speed adaptation.

THE SAFE SYSTEM FOR IMPROVING ROAD SAFETY IN BANGLADESH

The safe system approach has been adopted by some of the developed countries of the world as the guiding principle for delivering road safety outcomes. It has contributed significantlyto the reduction of road trauma and thus resulted in long-term road safety improvement. For example, the Safe System approach as adopted in the form of Vision Zero in Sweden resulted in a 34.5% reduction of fatalities within a 12 years period from 1997 to 2009. The introduction of Sustainable Safety-based measures in the Netherlands resulted in a total reduction of the number of fatalities of more than 30% in 2007 (Weijermars& Van Schagen, 2009).

As for Bangladesh, which is now experiencing a serious road safety crisis, its aim should be first to stabilize any worsening situation, and second to create road safety policies rooted in ‘good practice’ as demonstrated by better-performing countries. The Safe System framework can be adopted as a way to make substantial improvements to road safety in Bangladesh with higher priority given to

implementing infrastructure and speed related countermeasures. iRAP is also emphasizing on road infrastructure investment for improving safety because national safety strategies in leading developed countries show investment in safer infrastructure is expected to deliver twice the casualty saving provided by investment in either behavior or vehicles (iRAP 2008). Research is undergoing to prove the effectiveness of Safe System countermeasures in preventing the most dominating types of fatal accidents in Bangladesh viz. 'hit-pedestrian', 'head-on', 'overturning' and 'rear-end' collisions. Results of the ongoing research and studies will be published in the near future.

CONCLUSIONS

Bangladesh is facing a considerable road safety challenge. As many as 55 people are killed in traffic crashes daily. Road factors are particularly prevalent in such crashes. Engineering safety on roads is clearly a priority issue. A global consensus has grown around the 'Safe Systems' approach signifying the importance of safe road infrastructure. Efforts on road infrastructure safety are stimulating and gaining wider acceptance for sustained improvement of safety and speed management on the road network. Understanding and systematic application of Safe System principles are clearly important for achieving greater road safety in Bangladesh. Aspects of Safe System approach are briefly discussed in the paper.

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PEDESTRIAN SAFETY IN BANGLADESH : SOME RESEARCH FINDINGS

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ABSTRACT
Being a densely populated developing and low income country, Bangladesh has to experience many varied problems every day and amongst those road traffic injuries have emerged as a devouring giant causing deaths and injuries indiscriminately to the most vulnerable road users particularly pedestrians and children, but unfortunately they receive far less attention than vehicular traffic.According to the data from police report more than 45 percent of reported road accidents and 52 percent of fatal accidents were attributable to pedestrians of Bangladesh during the period 2000 - 2009. Around 80 percent of pedestrian accidents occurred in urban areas and rest in rural areas (20 percent). Accidents are most likely to be caused due to the careless and hazardous behaviour of both pedestrians and drivers. This situation is further augmented by inadequate and low level of education, deficiencies in law enforcement and engineering countermeasures to protect pedestrians. In this paper the current road safety conditions and trends are briefly characterized. On the basis of analysis, attributable causes and contributory factors of pedestrian accidents and injuries have been illuminated and the possible cost-effective countermeasures related to pedestrian safety are discussed.

Keywords: Pedestrians, Accident analysis, Bangladesh, Pedestrian behaviour, Countermeasures, Pedestrian safety.

INTRODUCTION

According to the latest studies road traffic injury has been suggested as a global health and development problem. Despite causing serious and enormous suffering, these life stacking injuries can drive a family into poverty as not only the person who experienced the injury but also his family has to cope with the long term consequence of the event, which may include the cost of medical care and rehabilitation and too often funeral expenses and the loss of main breadwinner of the family and these problems are particularly acute in developing countries. So road traffic injuries need a concentrated effort for effective and sustainable prevention**.**

Pedestrian form the largest single group of road user. They are the most vulnerable road user group because they do not have a protective 'shell' around them.Consequently are more at risk than those in vehicles and as a result a major portion of the people killed or seriously injured in traffic crashes are pedestrians and children. Pedestrian accidents accounted for about 45 percent of all reported road accidents and 52 percent of fatal accidents in Bangladesh. In this paper the current road safety conditions and trends in Bangladesh context are briefly characterized. On the basis of analysis,

attributable causes and contributory factors of pedestrian accidents and injuries have been identified and the possible cost-effective countermeasures related to pedestrian safety are discussed.

RESEARCH METHODOLOGY

For this paper, detailed field observational studies have been carried out to predict the behavior of both pedestrians and drivers. Pedestrians facilities provided in present roadway condition have been investigated and deficiencies of existing situation have also been identified. Pedestrian accident data has been collected using MAAP5 software cross tables of Bangladesh Road Transport Authority (BRTA). Thorough review of pedestrian behavior related research papers helped to analyze the trend of accident pattern in Bangladesh.

THE CONTEXT OF PEDESTRIAN SAFETY PROBLEMS

Global Situation

According to the 'World report on road traffic injury prevention 2004' worldwide, the number of people killed in road traffic crashes each year is estimated at almost 1.2 million, while the number injured could be as high as 50 million – the combined population of five of the world's large cities. 'Global status report on road safety 2009' says low-income and middle-income countries have higher road traffic fatality rates (21.5 and 19.5 per 100 000 population, respectively) than high-income countries (10.3 per 100 000). Over 90% of the world's fatalities on the roads occur in low-income and middle-income countries, which have only 48% of the world's registered vehicles. Almost half of those die in road traffic crashes are pedestrians, cyclists or users of motorized two-wheelers collectively known as vulnerable road user and most importantly this proportion is higher in the poorer economics of the world. For example, while in the high-income countries of the Americas Region 65% of reported road deaths are among vehicle occupants, this situation is very different in the low-income and middle-income countries of the Western Pacific Region where 70% of the reported road deaths are among vulnerable road users. Pedestrian fatality situation in some other countries can give a better review of the condition. Overall, Hong Kong, China had the highest share of pedestrian deaths (two thirds of all fatal accidents) followed by Dhaka, Bangladesh (63%), Pakistan (50%), republic of Korea (48%), Sri Lanka (45%), Fiji (43%) and Papua New Guinea (33%) (Hoque, 2000).Which reveals that pedestrians are at more risk in South Asian region.

Pedestrian Safety Problem in Bangladesh

Road traffic injury has become a major threat for a developing country like Bangladesh and is causing serious harm to the life of the pedestrian of this country. The rapid growth of population, urbanization, motorization and lacking of proper enforcement of rules and regulations are the reasons of the worsening of the pedestrian safety problems in Bangladesh. According to the data from police report more than 45 percent of all reported road accidents and 52 percent of fatal accidents were attributable to pedestrians of Bangladesh during the period 2000 - 2009. Around 80 percent of pedestrian accidents occurred in urban areas and rest in rural areas (20 percent). Pedestrian injury situation is worsening in our country day by day. From the analysis of pedestrian accident severity for the period of 2000-2009 it has been found that 83 percent of pedestrian injuries are fatal 16 percent are simple which reveals how dangerous is the impact of accidents to pedestrian.

Police report also says that around 4000 people die in Road Traffic Accidents (RTA) and it is estimated that the actual fatalities could well be 10000-12000 each year taking consideration of underreporting and definitional inconsistencies. In economic terms, road accidents in Bangladesh costing community in the order of TK 5000 crore (US $ 850 million) which is nearly 2 percent of GDP. These figures clearly demonstrate that the road safety is a serious issue as it affects each and

every one of us, whether drivers, travellers or consumers and thus demands urgent attention to improve road safety in Bangladesh (Hoque, 2008).

Walking is a transport mode that takes people unprotected through trafficwith low speeds and mass. This makes pedestrians vulnerable. By far, they suffer the most severe consequences in collisions with other road users because they cannot protect themselves against the speed and mass of the other party. In Bangladesh over 60 percent of all urban trips involved walking and 65 percent of them are short trips. From the modal shares in Metro of Dhaka from JBIC 1999 it can be said that among all kind of trips, walking is of highest percentage (62 percent) and from this it can be easily concluded that pedestrians are an important component of the roadways of Dhaka as well as in Bangladesh and hence deserves special attention.

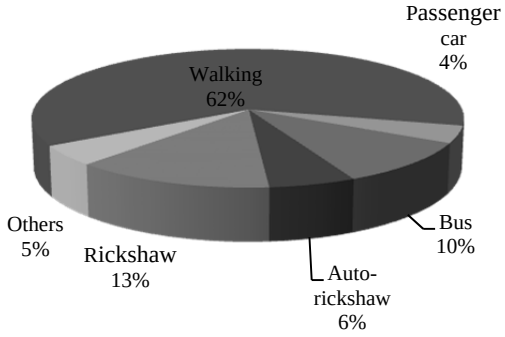


Fig.1: Modal Shares in Dhaka (source: JBIC Report, 2000)

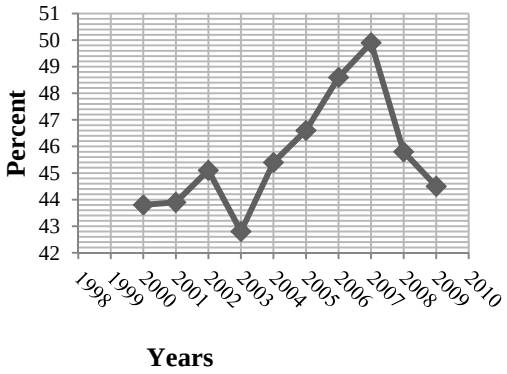


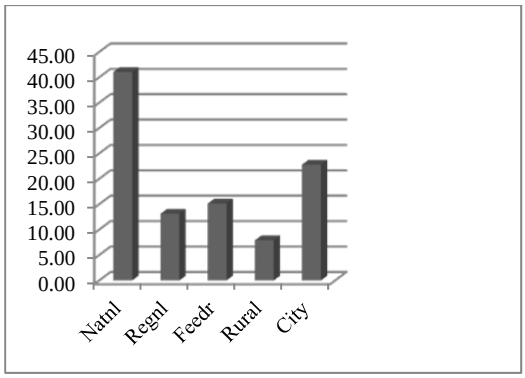
Fig.2: Trends of pedestrian accidents for 2000-2009

Pedestrian Road Accident Characteristics in Bangladesh

Pedestrian are the most vulnerable road user group and the worst sufferer from roadway accidents and injuries for a developing country like Bangladesh yet get least importance. As the number of pedestrian is huge in the roads of Bangladesh pedestrian fatality percentage is higher than any other kind of fatalities. The trend of pedestrian accidents for the year of 2000-2009 is presented in [Fig 2]. It can be seen from [Fig 2] that pedestrian accident percentage is highest in 2007 (50 percent) and the percentage varies from 43 percent to 50 percent which is undoubtedly an alarming rate. From the analysis of all accident type it has been found that the predominant type of accident is hit pedestrian having 45 percent. On the other hand head on collision 14.52 percent, rear end 14.64 percent and over turn 8.44 percent.

Pedestrian Injury by Road Class and Location

Examination of the distribution of pedestrian injuries by different road class is shown in [Fig 3]. From the fig it is evident that pedestrian injury percentage is highest in national road (41%) and second highest in city roads (22%). It can be explained in a way that in national highway most of the vehicles have high and uncontrolled speed, it is known that the more speed the more the tendency to occur accident with more severity. Again city roads are in second highest position because both the number of pedestrian and number of vehicle is high and consequently number of collision is also greater than other roadways. The number of accidents is least in rural areas (8 percent) because of less number of motorized vehicles and less number of pedestrian consequently less number of pedestrian accident.A second dimension of pedestrian injuries at different location is presented in the [Fig 4]. From the analysis roadside has been found more injurious for pedestrians (48.34%) as most of the pedestrians wait at roadside for different purposes. Other hazardous locations are center of the road (24.75%) and pedestrian crossing (21.57%).



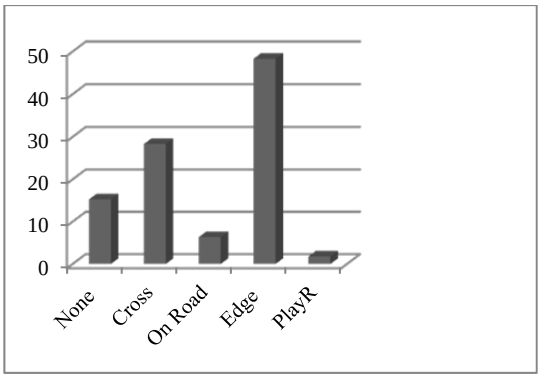


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Fig. 3: Pedestrian injury by road class

Fig 4: Pedestrian injury by location

Some Further Striking Pedestrian Accident Characteristics

From a comprehensive analysis of all reported pedestrian accidents in Bangladesh in the period 2000-2009 further more striking characteristics are

- From the reported data of pedestrian injury by roadway geometry it can be stated that nearly 94 percent road accidents occurred in straight roadway geometry followed by nearly 4 percent in curve roadway and 1.25 percent for sloped roadway geometry.
- The distribution of pedestrian injuries by action revealed that most of the injuries occurred for action on road edge (48%) and followed by crossing road (28%).
- Of the total pedestrian injuries 81.16 percent are male and 18.84 percent are female.
- Heavy vehicles such as bus and heavy truck are major contributors to pedestrian injury (bus 29.29 percent, heavy truck 23 percent). Other contributor vehicles are mini bus (11 percent), micro bus (5.37 percent) and motorcycle (4.73 percent).
- Age group of 6-10 year is the most vulnerable pedestrian to roadway injury and has a percentage of nearly 15 percent, other injury prone age group are 21-25 year (8.54 percent), 26-30 year (10.11 percent) and 31-35 year (8.51 percent).
- Nearly 96 percent of pedestrian accident occurred in fair weather and 3 percent accidents in rainy weather.
- 72.47 percent pedestrian injury had taken place in lighted condition and 11.69 percent in day condition.
- pedestrian injury probability is almost same for seven days of week and it is 14 percent.
- Nearly 78 percent of all reported pedestrian injuries occurred in Dhaka Metropolitan City. Percentage of other metropolitan cities are Khulna Metropolitan City 43.36 percent, Rajshahi Metropolitan City 4.3 percent and Comilla Metropolitan City 13.51 percent.

Factors in Pedestrian Crashes

Various kinds of factors are responsible for pedestrian crashes in Bangladesh. Factors related to pedestrian safety and morbidity according to FHWA is given in the [Fig 5]. These include factors related to such categories as pedestrians (e.g., pedestrian age, behaviour), drivers (e.g., driver distraction),vehicles (e.g., large trucks), roadway environment (e.g., vehicle speeds and volumes, roadway and intersection design), as well as demographic, social, and policy factors (e.g., land use and zoning practices). Some ofthe primary factors within each of these five categories are also given in [Fig 5].

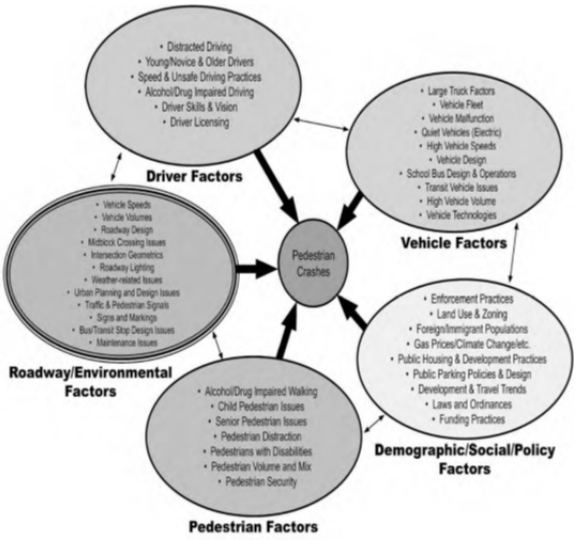

Fig 5: Factors in pedestrian crashes

Recent Pedestrian Scenario of Dhaka City

General safety problems which are faced by the pedestrian of Bangladesh particularly Dhaka city are due to high, complex and mixed traffic volume, high speeding reckless driving by drivers, multi-leg intersection with complex signal phasing, unwillingness to follow the traffic rules by pedestrians and drivers and last but not the least absence proper law enforcement. From the observation of the roads of Dhaka, the following road and traffic hazards are identified as attributable to pedestrian accidents

- Poor roadway geometry, planning, design of intersections and roadway sections as well as adverse roadside environment. Moreover absence of sidewalks or improperly designed sidewalks, absence of ramp in sidewalks for physically impaired persons.
- Dirty roadside environment due to lack of proper drainage, lack of zebra crossing in important locations and also poor maintenance of that.
- Uncontrolled behavior of pedestrians, unwillingness to use underpass or overpass, failure to make pedestrians and drivers obey the traffic rules are the major problems.

Fig 6 :Taking risk school child is crossing road

Fig 7 :Haphazard pedestrian crossing

- Lack or poorly maintenance of traffic control devices (e.g. sings markings, lightings etc) and very often they are not properly and strategically positioned in the place they should be and consequently mislead pedestrians and drivers. Absence of refuge islands.
- Encroachment of footpaths by vendors, construction materials often cause obstruction to the continuous pedestrian flow and compel pedestrians to use the carriageway, moreover loading and unloading of passengers from the bus in random places rather than bus stop also creates safety problems to pedestrians.

IMPROVING PEDESTRIAN SAFETY

From the result and analysis of accident data, continuation of dominancy of hitting pedestrian is vivid in this paper and demonstrated the sheer need of improvement road safety for pedestrians in Bangladesh. Pedestrian safety is a complex issue as several factors like unpredictable behaviour of pedestrians, attitude pattern of drivers in different challenging situation are interrelated to each other and are often being ignored during the design process. In developing countries like Bangladesh, application of low cost measures should be given considerable importance as budget is the most usual constrain in materializing and project. The engineering countermeasures considered to be effective for pedestrian safety include (Downing 1991) :

- pedestrian segregation
- improved footpath facilities
- improved crossing facilities especially on road links
- speed controlling devices e.g. humps and 'pinches'
- access controls for residential and shopping street
- improved street lighting

These are the fundamental countermeasures need to be adopted for safeguarding pedestrian. Additional requirements are mentioned below

- Road safety policy should include specific strategies for improving pedestrian safety including specific targets for casualty reduction and monitoring and reviewing the evidence base.
- Special treatments should be provided to intersections like separate signal phase (all red for pedestrian) with high visibility zebra crossing and diagonal crossing pavement marking.
- Pedestrian refuge islands should be provided in all those places where it is required.
- In order to prevent the random crossing and movement of pedestrians barriers and fencing should be provided.For ensuring safety to children, road safety education should be provided at school and drivers should also be trained so that they show more care to children than an adult.
- Increase of law enforcement for both pedestrians and drivers can improve the situation.
- Safe System : A new approach which aims at designing a safe and more forgiving road system and can be very effective in improving pedestrian safety of Bangladesh.

CONCLUSION & RECOMMENDATIONS

It can be concluded that pedestrian fatality comprise a significant portion of road traffic fatalities in Bangladesh for both rural and urban roadways. High concentration of pedestrian coupled with rapid increase of vehicular traffic is making this situation even more worse triggering the need of adopting initiatives to improve the condition immediately. Considerable studies and research are needed for addressing the issues related to pedestrian safety for providing a sustainable safe transportation system to pedestrian.

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CIRCULAR WATERWAY AROUND DHAKA: FAILURE INVESTIGATION OF 'WATERBUS' SERVICE AND REALISTIC POLICY TO ACHIEVE INTERMODAL MOVEMENT

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ABSTRACT
Dhaka is surrounded by a circular waterway system of various rivers. With a view to reducing the severe traffic pressure on roadway, Bangladesh Inland Water Transport Authority (BIWTA) planned to improve the navigability of this waterway which is being done in two phases. The western part (29.5 Kilometres) from Shadarghat to Ashulia constitutes the first phase, while the eastern part (40.5 Kilometres) from Tongi to Kanchpur constitutes the second phase. In the western part of the waterway 'Waterbus' service was launched on August 28, 2010 to serve the passenger traffic which was shut down within 2 years as it failed to attract passengers. This paper aims to figure out the principle causes responsible for the failure of 'Waterbus' service and to propose a sustainable solution to achieve interconnectedness among various modes. To achieve this, all the landing stations were visited to evaluate the operating conditions, questionnaire survey was conducted, and data obtained from Bangladesh Inland Water Transport Corporation (BIWTC) were analysed. It has been found that, faulty design, low capacity, irregular time scheduling, low frequency, absence of access road, improper location of landing station, absence of para-transit in the station, lack of advertisement- all these were responsible for failure. It is suggested that the route should be extended to Tongi to get passengers from North Dhaka and Mirpur. Necessary access roads should be constructed. And lastly, more frequent service should be introduced which will automatically ensure availability of para-tarnsit near the stations to achieve Intermodality.

Keywords: Circular Waterway, Waterbus, BIWTC, Landing station, Intermodality

INTRODUCTION

Home to some 15 million people, Dhaka is one of the fastest growing megacities of the world. Dhaka bears only 7.5% road of its land area, where minimum requirement of road is 25% for a standard city. Unlike other megacities various forms of transport are using the same roadway. More than 7 lakh registered vehicles and 10 lakh rickshaws are continually crossing the roadway capacity by making 25 million daily trips (DTCA, 2012; BRTA, 2012). Presence of 650 intersections and 25 level crossings make the condition even worse (Dhaka Metropolitan police, 2012). As a result chronic traffic congestion has become the number one urban problem for the city dwellers. Due to this traffic congestion city people are losing 1.3 man-hour per day, resulting in a total daily loss of BDT 26.54 crore within the city which contributes 63% of daily loss in whole economy (Mahmud et al., 2012). To bring a solution to this severe traffic congestion, effective and efficient integration of various transport modes should be offered to the users. Keeping this view in mind, Strategic Transport Plan (STP) was undertaken in 2005. Circular waterways around Dhaka city and improved road safety & reduction of

traffic congestion were two of the stated targets of STP. Dhaka is encircled by Buriganga, Turag, Tongi Khal, Dhaleswary, Lakhya R and Balu rivers constituting a 110.5 km circular waterway. To utilize this natural asset in the city transportation sector, BIWTA started improvement of navigability of the circular water way in July 2000. After dredging 16.48 lakhs cubic meter of earth and constructing 8 landing stations (4 major and 4 minor landing stations) from Shadarghat to Ashulia in western part of waterway, the first phase of work was completed in June 2005 at a total cost of BDT 36 crore (BIWTA, 2012). In addition to Shadarghat, landing stations were constructed in Swarighat, Kholamura, Basila, Gabtoli, Amin Bazar, Shinnirtek, Berulia and Ashulia to serve both passenger and freight vessels. The second phase of dredging on the eastern part from Tongi to Kanchpur is on progress currently. In order to divert some portion of roadway users to waterway, BIWTC launched 'Waterbus' service to ferry passengers along a 16 km route from Shadarghat to Gabtoli via Swarighat and Kholamura on August 28, 2010. Two motorised vessel namely, MV Buriganga and MV Turag were constructed for providing the service at a cost of BDT 1.115 crore. Initially after inauguration, passengers were so enthusiastic about Waterbus, but only two vessel of very low capacity could not meet up the high demand of the passengers. Waterbus service, which could be a handful mode of transport for easing the serious traffic congestion on road, eventually came to a debacle within 18 months of its inauguration. The project could earn only BDT 3,86,603 against an expenditure of BDT 35,22,095, signifying a huge loss and complete breakdown. Reluctance on the part of BIWTC authority for proper planning before launching is clearly observed. Venice Vaporetto Water bus, Chicago Water taxi, Thailand Water bus are some of the successful Water bus services for commuters and tourists. The condition in Dhaka is even more suitable than these as whole city is encircled by navigable waterway. Currently BIWTC is planning for reimplementation of the service with more vessels. Hence, before reimplementation, a study is required to sort out the reasons for which the project was not successful previously. The objectives of this study are to investigate the total 18 months' service based on BIWTC database and users opinion regarding the service, to evaluate the current condition of western part of waterway and lastly to provide some suggestions for establishment of interconnectedness of waterway with other modes.

MATERIALS AND METHODS

With a view to investigating the failure of Waterbus project, questionnaire survey was conducted in all the existing landing stations and in its nearby bus stoppages. Two sets of questions were prepared for the survey. One set of questions was asked to the people near the landing stations where Waterbus stoppages were provided (Shadarghat, Swarighat, Kholamura, Gabtoli), and the other set with different questions were asked to the people where Waterbus had no stoppage (Ashulia, Tongi, Berulia, Shinnirtek, Amin bazaar, Basila). Since the project was no more in service, survey was mainly conducted in the adjacent bus stoppages to get the view of the road users who could have used the waterway if the project had continued. Again, questionnaire survey was conducted in the morning time (8 A.M. to 9 A.M.) to get the views about pick demand. All the information so obtained helped to investigate the Waterbus project statistically. Each landing stations were visited and existing facilities were noted. GPS coordinates (latitude and longitude) of landing stations and nearby bus stoppage were taken using 'Garmin GPS 60' handheld GPS device. These coordinates were plotted in Google Maps to obtain feasible connection between landing stations and bus stoppages.

RESULTS AND DISCUSSION

Waterbus stoppage was provided in 4 stations namely, Shadarghat, Swarighat, Kholamura and Gabtoli landing stations. Shadarghat is the main river port of the country. In Swarighat and Kholamura mainly local launch service and country boats are being operated. Except serving some freight vessels, Gabtoli station is in no service currently. The following table gives a brief scenario of existing facilities for waterway users noted during survey.

Table 1: Brief description of Waterbus Landing Stations of BIWTA around the circular waterway

Name	Structure	Parking Facility	Information Booth	Waiting Room	Ticket Counter	Passenger Shed	Toilet	Pontoon	Jetty	Informatory Sign Boards	Lighting Facility
Shadarghat N23°42.429', E90°24.603'	R.C.C.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Swarighat N23°42.680', E90°23.655'	R.C.C.	No	No	Yes	Yes	Yes	Yes (poor)	Yes	Yes	No	Yes
Kholamura N23°42.834', E90°21.530'	R.C.C.	No	No	Yes	Yes	Yes	Yes (poor)	Yes	Yes	No	Yes
Gabtoli N23°46.671, E90°20.279'	R.C.C.	Yes	No	Yes	Yes	Yes	Yes (poor)	Yes	Yes	No	No

This table is prepared after conducting survey in these stations. Neither of the stations except Shadarghat was seen to be in good condition. Due to improper management these landing stations are no more passenger-friendly.

During questionnaire survey people near Shadarghat, Swarigaht, Kholamura and Gabtoli were asked regarding the failings of 'Waterbus' project. 160 people (40 people per station) were asked. 30 (19%) responded that seat capacity was low, 38 (24%) responded that frequency of waterbus was low, 14 of them (9%) told that the service was unreliable, 17 of them (10%) told that the advertisement before launching the service had been inadequate. Improper location of landing station, absence of access roads, unavailability of rickshaw, CNG auto-rickshaw in the landing stations were the other prime reasons behind the failure of the project according to the questionnaire survey. 13 (8%), 16 (10%), 7 (4%) people voted for these reasons respectively. It was quite surprising that 22 of them (14%) were absolutely unaware of Waterbus project which proves that the advertisement was inadequate. Following figure shows the result in pie chart.

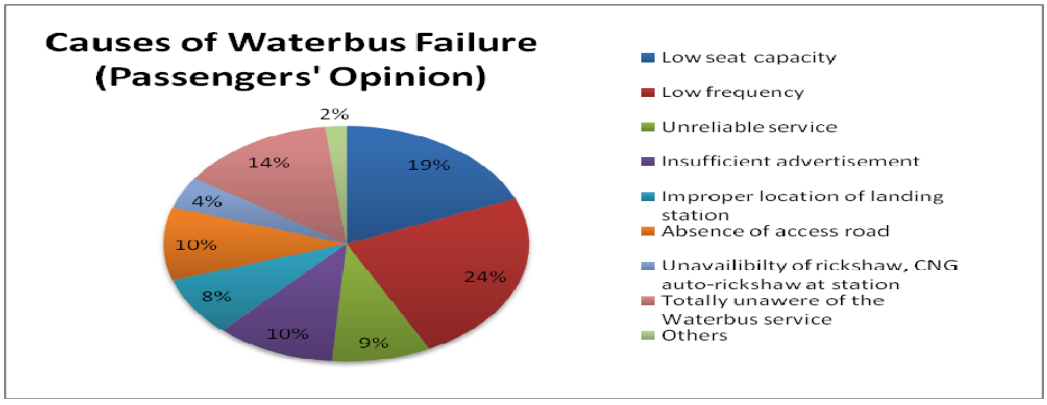

Fig. 1: Passengers' opinion behind the failure of Waterbus project

All these causes are analysed elaborately below.

Low Seat Capacity and Faulty Designed Vessel

Both MV Buriganga and MV Turag were built by Three Angle Marine Consultant for ferrying passengers. Each of the vessels was run by two 75 HP engines. 38.38 feet long, 11.48 feet wide vessels could accommodate only 35 passengers each (BIWTC, 2010). Such low capacity failed to fulfill the passengers demand. Many passengers had to leave the station as they failed to manage seats. Besides, lack of water support, life-buoy, fire-extinction facilities and toilets could not attract its passengers.

Low Frequency and Unreliable Service

At the beginning, each vessel used to provide 8 trips (one-way) per day. But the number of trips decreased gradually to 2 per day by March 2011. Although BIWTC claims the vessels could generate a speed of 22.8km/h, the actual travel time from Shadarghat to Gabtoli in a 16 Kilometers waterway was almost 90 minutes. All these resulted a very low frequency. The following graphs show how number of trips and passengers per month varied from August 2010 to February 2012.

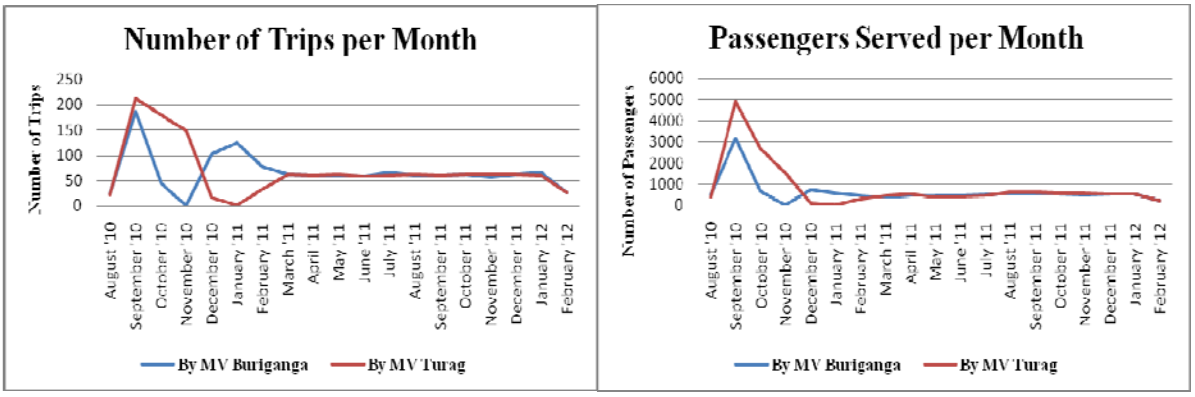

Fig. 2: Month-wise variation in trips and passengers

From [Fig. 2] we can see that, number of trips was high (212 trips for Turag, 186 for Buriganga) in September, 2010 which is the reason why number of passengers was high (4872 for Turag, 3164 for Buriganga). It is also seen that, after March, 2011 trip number per month decreased to 60 for both the vessels. It can be easily said this is responsible for subsequent decrease in passenger number. A service, providing 2 trips in a whole day can neither satisfy commuters' nor the other passengers' demand. Again from [Fig. 2] it is seen that, trip number is zero in November, 2010 and January, 2011 for Buriganga and Turag respectively as they were taken to dockyard for repair. Besides in almost every month both the vessels used to be out of service for several days due to technical failure leading to irregular and unreliable service to the passengers.

Improper Location of Landing Station and Absence of Access Road

The locations of all 4 landing stations were not suitable either. During questionnaire survey in Shadarghat people told that Badamtolighat (500 meter west to Shadarghat) would attract more users as it is near to the North South road which could directly connect the station with Gulistan, the zero point of the city. If Badamtoli was used as a landing station it would also eliminate the necessity of another landing station in Swarighat since Swarighat users also had to use North South road to reach Gulistan. Again, nearest bus stoppage from Kholamura landing station was 5 km away. Following figure shows distance of nearest bus stoppages from these landing stations (from Google Maps) and subsequent travel time (from questionnaire survey).

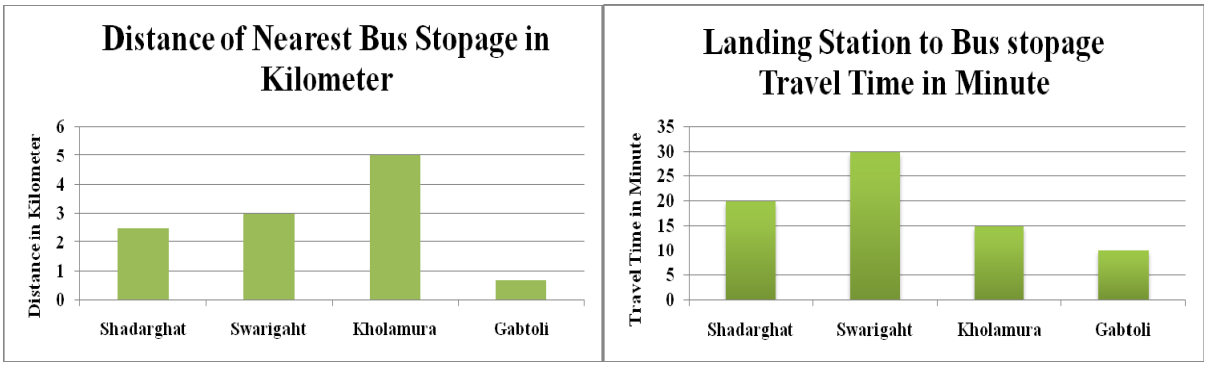

Fig. 3: Distance of nearest bus stoppages and travel time to reach them from landing station

From [Fig. 3] it is clear that, the distances between bus stoppage and landing station are quite high for Shadarghat, Swarighat and Kholamura (2.5km, 3km and 5km respectively). The travel times required

to reach bus stoppages from these landing stations are high too. All these stand against the way to achieve intermodal movement.

Unavailability of Para-transit Modes

Para-transit modes should be given importance to achieve intermodal movement. Unfortunately in all other landing stations except Shadarghat number of rickshaw, CNG auto-rickshaw, tempo was very few. Passengers could not move to their places of interest easily after landing. Following figure shows the number of CNG auto-rickshaw and rickshaw found during survey in these landing stations.

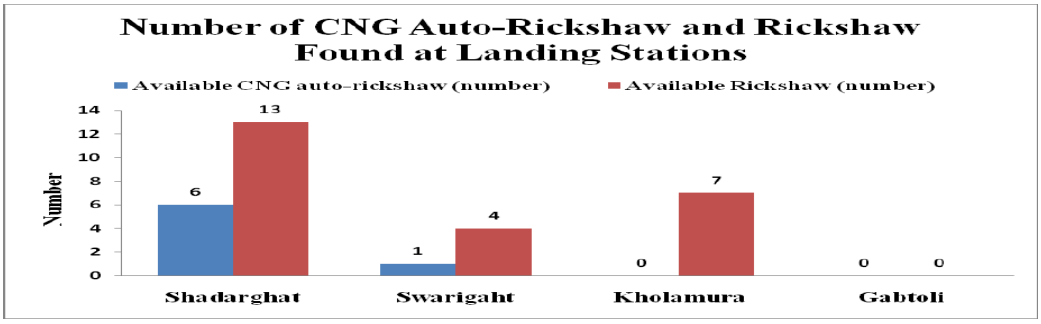

Fig. 4: Number of CNG auto-rickshaw and rickshaw available in landing stations (survey)

From [Fig. 4] it is clear that, except Shadarghat, in all other stations there is serious unavailability of CNG auto-rickshaw and rickshaw. Besides, other para-transit modes such as tempos were not seen near any stations. Especially Gabtoli landing station is placed at a completely isolated place without any availability of para-transit. So the concept of Intermodality is seriously hampered.

Shortage of manpower and mismanagement in landing stations

Since BIWTC itself had no trained driver, both MV Buriganga and MV Turag had been operated by hired drivers from BIWTA. Although there were ticket counter facilities in all the 4 stations, BIWTC had no separate employee to sell tickets. There was no supervisor for serving the passengers. Except Shadarghat, in all other stations the ticket counter, information booth, waiting room etc were found in very bad condition. Following figure shows current scenario of the landing stations.

Fig. 5: Current scenario of landing stations

[Fig. 5] shows conditions of landing stations are very poor. Sheds are totally damaged due to corrosion, waiting room is being used for storage purpose, ticket counter is permanently closed- all these show that the conditions in landing stations are not passenger friendly.

There are more reasons found while investigating, such as, insufficient advertisement, absence of traffic control measures near landing stations etc. BIWTC is currently planning for reimplementation of Waterbus service correcting all these faults. Construction of four 60-seater waterbus is almost complete by Dhaka Dockyard. Tender is going to be called for construction of another four waterbuses. Considering MV Buriganga, MV Turag there will be 10 waterbuses in total to be in service by the end of this year (BIWTC, 2012). Before launching it again, some realistic plan should

be made so that Waterbus service can play an important role in achieving Intermodality. Some suggestions are-

- In the western part of the circular waterway landing stations are already built at Ashulia (N23°53.487', E90°21.638'), Berulia (N23°50.842', E90°20.386'), Shinnirtek (N23°47.975', E90°20.623'). Since there will be 10 vessels, the route should be extended to Tongi so that large number of road users from North Dhaka can use Waterbus for commuting. Although the total waterway distance will become 28km, ten vessels will still be able to maintain good frequency.
- To achieve Intermodality necessary access roads should be constructed towards every landing station. Sonargaon Janapath of Uttara 3rd phase (N23°52.741', E90°21.632') should be extended to meet Ashulia station. If this extension is possible, then large number of passengers from new sectors of Uttara will not have to go to Tongi or Ashulia station to catch waterbus using Dhaka-Tangail highway, rather they will use Sonargaon Janapath road to reach Ashuila much more quickly and conveniently. Accordingly access road towards shinnirtek station (N23°47.975', E90°20.623') needs to be improved so that people of Mirpur can utilize Waterbus service.
- At present, there are 15 roads connecting to 9 landing stations constructed by Local Government Engineering Department and Dhaka City Corporation. These access roads are in poor operating conditions. These roads should be repaired.
- Parking facility should be ensured in every station. Separate secured bi-cycle parking space should be constructed, if possible. Rickshaw, CNG auto-rickshaw, Tempo stand should be provided near the station. DTCA should ensure public bus service near every landing stations according to the stated targets of STP.
- Trained drivers and a sound technician team should be employed by BIWTC to avoid frequent mechanical failure and to maintain a reliable frequency of service. Moreover, the passenger facilities viz. waiting room, ticket counter, shed etc should be properly managed.
- Mass advertisement should be done to familiarize waterway for achieving Intermodality. Traffic control measures such as Traffic sign directing landing station should be installed in the access roads.

CONCLUSION

Since demand has already crossed the existing capacity of each roadway of Dhaka and construction of fly-over is expensive, this extra pressure on roadway should be diverted to other modes, in an integrated manner. Hence, circular waterway around the city can be utilized to access all the major points of Dhaka. In the first phase of its implementation due to low capacity and frequency Waterbus was not accepted by the city passengers. Once large capacity vessels make their way into the circular waterway with frequent service and access roads towards each station are constructed, it is obvious that Waterbus service will be popular and intermodal movement can be achieved.

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BUS INVOLVEMENT IN ROAD TRAFFIC ACCIDENTS IN BANGLADESH

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ABSTRACT
Road traffic accidents are one of the major concerningglobal public health and economic issues, especially for developing countries like Bangladesh. In economic terms, road accidents in Bangladesh are costing the community in order of nearly 2 percent of GDP which is a huge amount that our country can ill afford to lose. Although the major mode of public transport is bus in Bangladesh, unfortunately heavy vehicles viz. trucks, buses, minibuses are involved in accidents at a large percentage.It is found that about 23.5 percent of total 61,947 involved buses and 4,203 people died. During 1998 to 2010 rural areas were more bus accident prone (68.4%) than urban areas (31.6%). Majority of the bus accidents occurred on national highways (7,393 accidents,53.1%), of which N5 is predominant(23.1%). Among accident types head-on crashes and rear-end crashes have high percentages with 17.7 and 15.3 respectively. Data analysis for 2009 and 2010 indicates that, the major collision type of bus accidents is still hit-pedestrians accounting about 38 percent. The major causes of bus accidents are found to be careless driving, over speeding and pedestrian interruption with percentages of 36.4, 32.8 and 10.5 respectively. This paper mainly focuses on the characteristics of bus accidents in Bangladesh, contributory factors associated with bus accidents, collisions of buses with other involved vehicles and pedestrian, the vulnerable locations of bus accidents on nine national highways and the urgent need of safety measures.

Keywords: Bus, Road Traffic Accident, Heavy Vehicle, MAAP5

INTRODUCTION

Road traffic fatalities and injuries are a major global public health problem. Globally, over 1.2 million people die and between 20 to 50 million people suffer non-fatal injuries every year on world's roads. Unless immediate and effective action is taken, road traffic injuries are predicted to become 5th leading cause of death in the world by 2030. Road traffic deaths are predicted to increase by 83 percent in low-income and middle-income countries (if no major action is taken) and to decrease by 27 percent in high-income counties over the next 20 years (WHO, 2009).Accident death rates in developing countries are much higher (at least 50 times) than in developed countries.Developing countries are now experiencing a serious road safety crisis and are predicted to worsen in the coming years unless this critical problem of epidemic nature is seriously addressed with significant improvement in the relevant sectors. Like many other developing countries Bangladesh is also experiencing a very severe road safety problem. This situation has been deteriorating with increasing number of road accident deaths and lack of investment in road safety.

Road transport is the major mode of transportation in Bangladesh. Over 70 percent of passengers and much of our goods movement occur through the highways. A significant growth in the road traffic sector has taken place over the past two decades in Bangladesh. Presently the length of roads is about 2,71,000 kilometres, including about 21,000 kilometres of major roads (Ahsan, 2011). There is no doubt that road transportation is vitally important to our economic and social welfare and must be so maintained and continually improved with due considerations for safety, minimizing accident hazards and risks. The fatality rate in Bangladesh in terms of number of fatalities per 10,000 on-road motor vehicles is over 60, which is very high compared to developed countries viz. 2 fatalities per 10,000 motor vehicles in the United States of America and 1.4 in the United Kingdom and Northern Ireland. In India, Pakistan, Srilanka and Nepal the number of fatalities per 10,000 vehicles per year is 25, 33, 16 and 75 respectively (Pearce, 2000). According to police reported statistics around 4,000 people die through road traffic accidents each year in Bangladesh.

Rapid rise in population along with increased and versatile land use patterns and increase in vehicle ownership have generated considerable travel demand in Bangladesh. Unfortunately in heavy vehicles viz. buses, minibuses, trucksetc have become over involved in road accidents. In a developing country travelling by bus ensures affordability, accessibility and mobility; as bus is the major mode of transportation here. The total motor vehicle population has increased from about 7,37,400 in 2003 to about 17,51,834 in 2012 in Bangladesh. Among this bus has increased from 30,617 in 2003 to 40,542 in2012 (BRTA, 2012).

This paper deals with bus involvement in road traffic accidents in Bangladesh during the period of 1998-2010. Previous studies have dealt with heavy vehicle involvement in road traffic accidents, but particular research on buses has not been done so far, which induces the need to emphasize on studies of bus accidents and the factors involved. This study attempts to focus overall bus accident scenario in Bangladesh with factors associated with bus crashes, accident types, collision types, locations, accident severity, other contributory vehicles, most vulnerable locations for bus accidents etc. The need for possible road safety counter measures related to engineering, enforcement and educational has been discussed as well.

RESEARCH METHODOLOGY

The accident data of this study are collected using Microcomputer Accident Analysis Package Five (MAAP5) software of Accident Research Institute (ARI), BUET. Different cross tabulations for different factors of bus accidents are analyzed by using this software as well. The most accident prone locations for buses on nine National Highways were also identified by location analysis using MAAP5.

DATA ANALYSIS, RESULTS AND DISCUSSIONS

Involvement of buses in road traffic accidents

During 1998-2010 a total of 45,891 accidents occurred and 38,501 people died in road traffic accidents.However, WHO estimates that the actual fatalities could well be nearly 20,000 each year (WHO, 2009).In Bangladeshtotal registered buses is 2.3% of total 17,51,834 registered vehicles. But involvement of buses in accident is about 23.5 percent of total accidents and among these accidents 4,203 people died. There were 9,787 fatal accidents, 2,800 grievous accidents, 710 simple accidents and 649 only collisions caused by buses.Trends of accidents severity in Bangladesh from 1998 to 2010 are given in Table 1.

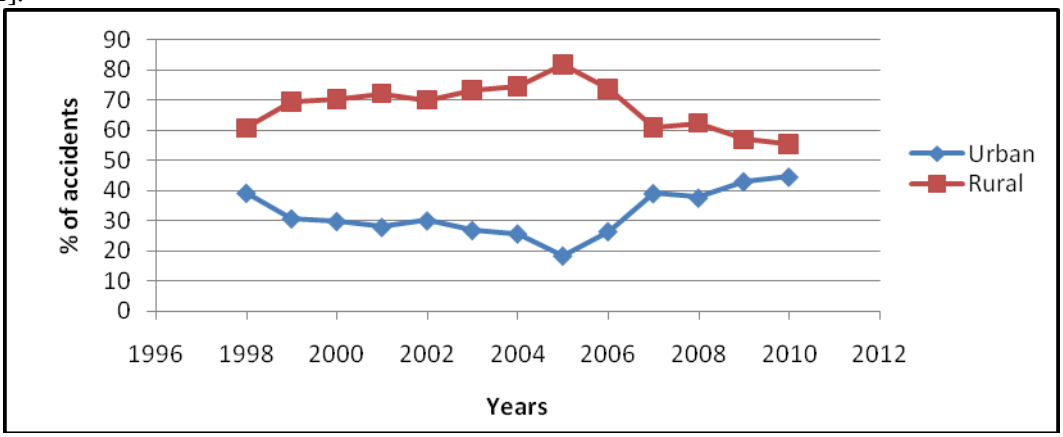
Table 1: Trend of accident severity

Year	Fatal accidents		Grievous accidents		Simple accidents		Collision type accidents		Total accidents	
	All	Bus related	All	Bus related	All	Bus related	All	Bus related	All	Bus related
1998	2000	542	1137	242	193	54	203	43	3533	881
1999	2437	735	986	254	305	94	220	42	3948	1125
2000	2523	743	1029	263	209	69	209	37	3970	1112
2001	2029	589	642	179	137	48	117	33	2925	849
2002	2599	760	904	272	200	61	238	88	3941	1181
2003	2752	895	921	264	239	68	202	64	4114	1291
2004	2509	857	683	232	216	72	158	48	3566	1209
2005	2424	761	631	178	142	46	125	46	3322	1031
2006	2695	914	602	205	124	40	145	59	3566	1218
2007	2923	947	705	236	166	64	160	68	3954	1315
2008	2842	890	676	231	154	50	128	49	3800	1220
2009	2161	625	474	139	71	24	109	40	2815	828
2010	1911	529	387	105	62	20	77	32	2437	686
Total	31805	9787	9777	2800	2218	710	2091	649	45891	13946
%	69.3	70.2	21.3	20.1	4.8	5.1	4.6	4.7	100.0	100.0

From table 1 it can be seen that from 1998 to 2003 number of all accidents increased as well as the bus accidents. After 2003 numbers of all accidents including bus accidents started to decrease, but in 2007 these numbers again increased and bus accidents were the highest in this year. But in recent years (2009-2010) it can be seen that total number of accidents has reduced significantly from 8.96% to 5.31% and bus accidents has been reduced from 9.43 percent to 4.92 percent.It is may be because of under reporting or other vehicles have become involved in larger percentages. Fatal accidents increased up to the year of 2007 and then started to drop down from 2008. Bus accidents killed almost 1i percent people; so fatality from bus accidents is a major road safety issue.

Location-wise bus accidents

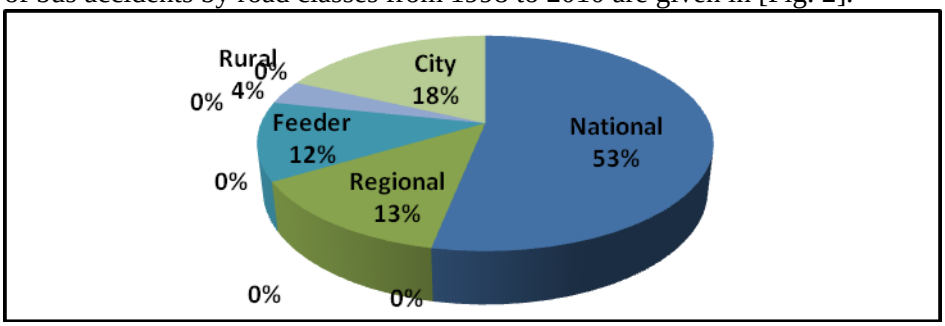
A large proportion of fatalities occur on rural sections of the main highways. Within urban areas, accident frequency is the highest on main road networks. A total of 4,368 accidents occurred in urban area which is about 31.6 percent of total accidents. Again 9,442 accidents occurred on rural areas with a higher percentage of 68.4. yearly locatione-wise bus accident trend in given in the following figure [Fig. 1].



[Fig. 1]: Yearly trends of bus accidents by location

Bus accidents by road classes

Trends of bus accidents show that about 53 percent bus accidents occur on National highways and only 18 percent bus accident occur on City roads. The percentage of bus accidents on nine National highways has increased from 42 to 54 percent over the periods. But bus accidents on city roads have come down with time from 31 to 20 percent.It may have happened because within city areas congestion has increased and speed of vehicles has decreased. But on highways drivers usually drive with high speed as there is very little side frictions and congestion. It is also found that fatal accidents are around 74 percent in all the road classes. So none of the road classes is less vulnerable. The percentage of bus accidents by road classes from 1998 to 2010 are given in [Fig. 2].



[Fig. 2]: Percentage of bus accidents by road classes

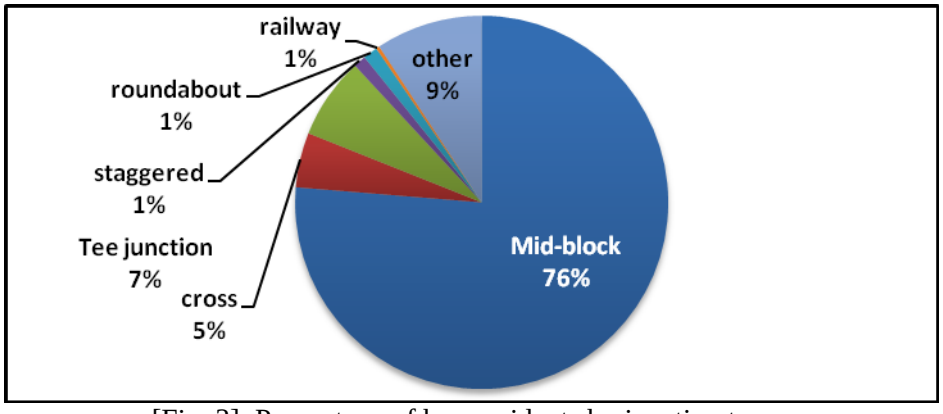
From analysis of bus accidents per kilometer on national highways it is found that national highway 9 has highest accidents with 4.1 accidents per kilometer. National highway 3 and 4 have 3.8 and 3.2 accidents per kilometer respectively. National highway 5 and 7 both have 2.4 accidents per kilometer. Route number 3 and route number 8 have got high fatal bus accidents with 77.7 percent and 78.2 percent respectively.13 percent of total bus accidents occurred on regional highways. Among 1,850 bus accidents on regional highways 74 percent accidents were fatal accidents and 18.8 perecent accidents were grievous. But in regional highways percentage of fatal accidents is increasing over the years from 70 percent in 1998 to 80 percent in 2010.From analysis it has been found that for all road classes 89 percent bus accidents occurred on two way roads because most of the highways are not provided with divider or medians in Bangladesh and only 11 percent accidents occurred on one way roads.

Bus accidents in Metropolitan areas

The major four metropolitan areas of Bangladesh are DMP, CMP, KMP, and RMP. The percentage of bus accidents in DMP is highest (79 %) and this rate is increasing with time. The second highest area is CMP (11%). But fatal accident is highest in RMP (70%) and lowest in DMP (49%).

Bus accidents by junction type and collision type

Bus accident by juction types is given in [Fig. 3], which highlights the fact that 76 percent of the total bus accidents occurred on the mid-block (not-junction) section of the roads.



[Fig. 3]: Percentage of bus accidents by junction types

Collision is one of the important considerations in the development of accidents reduction countermeasures. Bus accident by collision type analysis showed 'hit pedestrian' as the dominant accident type (40%). Other common bus accident types are rear-end collision (15%), head-on collision (18%) and overturning (10%). These four accident types account for nearly 83 percent of the total accidents.

Bus accidents trend by hour, day and month

Most bus accidents occurred at day time (06:00-18:00) with the peak at 09:00-12:00 hours of a typical day. Only 21.7 percent of the bus accidents occurred at night time. Fatal accidents are also high during day time with a peak from 9 hours to 13 hours with 12.3 percent to 15.9 percent on a typical day. Most of the bus accidents occurred on Thursday accounting about 2,100 which is 15.1 percent of total bus accidents. Fatal bus accidents are also at higher percentages on this particular day. It may be because people tend to move from city to cities/towns of the country as Thursday is the last working day after which weekend starts in our country.From the analysis of bus accidents severity by month it is found that highest number of bus accidents occurred in the month of January and number of fatal accident is also highestin this month.

Bus accidenttrendby road geometry, weather condition and light condition

Road geometry is an important factor for road accident analysis. 92 percent of the bus accidents occurred on straight roads of which 70.4 percent are fatal and 20 percent are grievous accidents. Again 5.8 percent bus accidents occurred on curved roads of which 66.6 percent are fatal accidents and 22 percent are grievous accidents.13,153 bus accidents occurred at fair weather condition of which 94.4 are fatal accidents. 3.7 percent accidents occurred in rainy weather and 1.7 percent in foggy weather. In windy weather only 0.2 percent bus accidents occurred.To determine the effect of light on bus accidents, an analysis has been done by light type. Among 13,946 bus accidents 11,941 accidents occurred in day light. Fatal accidents are also high during day time accounting nearly 75 percent.

Bus accidents trend by road surface condition, road surface type and road surface quality

It is found that 95.4 percent bus accidents occurred on dry surface, while only 4 percent occurred on wet surface. This is may be because drivers have become more careful while driving on wet surface.99.3 percent bus accidents occurred on sealed surface. Fatality is also high (99.2%) on sealed surface. Only 0.6 percent bus accidents occurred on brick surface.97.3 percent bus accidents occurred on good road surface. Only 1.7 bus accidents occurred on rough surface and 1 percent on repaired road. On rough surface drivers remain more careful and they keep the speed of buses low.

Bus accidents by traffic control system

Traffic control system is very important for reducing accidents. About 82% bus accidents occurred at places where there were no traffic control systems. So fatal and grievous accidents are also high with 83.8 percentand 80.2 percent respectively at these places.

Bus involvement with other vehicles or pedestrians in accidents

In depth analysis has been done for year 2009 and 2010 to find out which vehicle crashes mostly with buses and also to find out the impact on pedestrian. In the year of 2009 and 2010 it is found that buses had the collision mostly with pedestrians nearly 40.6 percent all together. The second highest collision was with motor cycles in both of the years with9.3 percent. It may be because of numbers of motor cycles are increasing and motor cycle riders usually ride recklessly with high speed. Bus-bus crashes were 6.4 percent in total but this percentage increased in 2010. Again collision with heavy truck was 5.3 percent and with car was 4.3 percent in total for 2009 and 2010.

Contributory factors of bus accidents

Factors contributing in bus accidents are very important to analyze to find out the reasons of bus accidents and to minimize its contribution in accidents. Over speeding and careless driving have higher percentage with 48.9 percent and 44.8 percent respectively during 1998 to 2010. Again fatal accidents were also high due to over speeding (46.1%) and careless driving (44.8%). From detail

analysis it is found that in 2009 and 2010 careless driving and over speeding had the percentages of 29.1 percent and 34.4 percent respectively in total. The overall contribution of pedestrian interruption was to be found 2.5 percent only in 13 years. But in recent years its percentages has increased to 8.5 percent in 2009 and 2010. The change of the trends of these contributory factors in recent years from overall 13years may be because, traffic polices have become more concern in highlighting the factors which were not highlighted before carefully. Also ARI has started correcting Accident Report Forms from 2006. So some more hidden reasons had been identified which were not done before.

Most vulnerable locations of bus accidents on nine National Highways

In depth analysis has been done for 2009 and 2010 to find out the most vulnerable locations for buses of our national highways. As these national highways connect most of the economic districts and buses play the major role on these highways so it is important to know where most of the bus accidents occur and why. Analysis of accident distribution of the national highways reveals thatthese accidents are highly clustered on few sections. The locations are identified with high concentration of accidents and fatalities and also the locations where fatal accidents occurred.

Alcohol and age impact on bus accidents

Fitness of drivers is a major factor for safe driving. Alcohol does not have that much effect on bus accidents in Bangladesh. The significant age group of drivers is found to be 21 to 50 years who died and suffered injuries with higher percentage during 1998 to 2010. It may be because people of this age group work for their livelihood and so drivers of this age group are most threatened to casualties.

CONCLUSION

As road traffic injuries are a major but neglected global public health hazard, so concerted efforts for effective and sustainable prevention is required. Bus is the major mode of public transport in Bangladesh. But every year so many bus related accidents have demonstrated the urgent need to act on bus accident issues right now. The analysis of available road safety data has identified various locations, environmental and behavioural factors that cause bus accidents and accident types. It is important to give priority and maintain the impetus in road safety engineering strategies by starting development measures and approaches. It is possible to significantly reduce the number of bus accidents and casualties by implementing an effective and coordinated safety policy and actions which require significant improvements in the relevant sectors viz. better enforcement, better roads, enhanced vehicle safety standards, improved and extensive public education and safety related programs. There is a need for identification of accident prevention priorities setting realistic problem specific goals and targets. The data and analysis presented the severity of bus accidents and the need to reduce the number and severity of these accidents.

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ROAD TRAFFIC ACCIDENT STATISTICS AND COUNTERMEASURESFOR NMVs IN BANGLADESH

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ABSTRACT

This paper discusses the involvement of Non-Motorized Vehicles(NMVs) in road traffic system and accidents with particular context of Bangladesh. Considering all forms of NMVs, rickshaws are the most popular mode. It appears that rickshaws are the primary travel mode for around 39 percent of all passenger trips in Dhaka.Accident records reveal that during 1998-2010 about 8 percent of the accidents involved NMVs. Almost 67 percent of these resulted in fatal accidents. The figures are almost equivalent in urban and rural areas (51 percent in rural area and 49 percent in urban area). Moreover, only about 10 percent accidents were liable to own vehicle defects. Most of the NMV (especially rickshaw) pullers are illiterate with very poor traffic knowledge and thus frequently cause or become victims of accidents. Very low level of safety features in NMV structures and significant speed difference with motorized vehicles contribute NMV accidents on both streets and highways.Accidents and road safety issues are pervasive in Bangladesh due to its vulnerable, heterogeneous and complex transport system. Thus reasonable balance between NMVs and MVs should be maintained on the basis of modal share analysis. NMVs should be given proper level of accessibility to move freely and safely on the roads. Physical separation of NMVs is a solution to this situation. Other possible safety countermeasures like engineering, enforcement and educational are also discussed in this paper.

Keywords: Accident,Safety,NMV, Bangladesh, MAAP5

INTRODUCTION

Bangladesh is a developing country with a very dense population of 152.5 million living in an area of 1,47,570 sq. km. The length of major roads in this country is about 21,269 km (BBS, 2010).Among this 3,538 km are national highways, 4,276 km are regional roads and 13,455 km are feeder roads. The transportation system of Bangladesh is complex and heterogeneous with both Motorized Vehicles (MVs) and Non-Motorized Vehicles (NMVs). Bangladesh is considered one of the least motorized countries in the world. According to BRTA there are about 17,51,834 motorized vehicles in Bangladesh. While the number of registered rickshaws in urban area is about 7,95,741 and in rural areas the number is estimated about 1,21,297. So it reveals thatabout 35% of the total vehicles are non-motorized. This huge number of NMVs plays a crucial role in the road traffic characteristics as

well asin accidents. Road traffic accidents, injuries and fatalities are major concerns for Bangladesh. Bangladesh has a very high road accident fatality rate with official figures indicating more than 60 deaths per 10,000 motor vehicles. Everyday around eight persons die in road accidents. (Maniruzzaman and Mitra, 2005) But the actual rate of fatality is likely to be even higher. According to World Bank, annual fatality rate from road accidents is nearly 85.6 fatalities per 10,000 vehicles. According to a study conducted by the Accident Research Centre (ARC) of BUET, it is estimated that road accidents claim on an average 12,000 lives annually and lead to about 35,000 injuries (Rahman, 2012). Among these the pullers and users of NMVs are considered one of the most vulnerable groups to road traffic accidents due to their light and delicate structure and significant speed difference with their motorized counterparts. About 8 percent of total accidents involved NMVs. This study focuses on NMV accidents with particular emphasis on sub categorization of accidents like accident type, severity, casualty, location, vehicle defects etc. Possible safety countermeasures are also discussed in this paper.

DATA COLLECTION AND RESEARCH METHODOLOGY

This study deals with NMV involvement in road traffic accidents in Bangladesh during the period of 1998-2010 using the Microcomputer Accident Analysis Package Five (MAAP5) software of Accident Research Institute (ARI), BUET. Primary data of these accidents were collected by police. Accident Report Forms (ARF) are then collected by ARI from range offices and district offices as hard copies and soft copies. ARI then edits both the hard and soft copies and Keeps the MAAP5 software up to date.

DATA ANALYSIS

To understand the inherent reasons behind the NMV accidents and characteristics accident data analysis is important. In this section the proportion of NMV accidents and magnitude of fatality, casualty due to accidents, trends of NMV accidents in different locations and factors contributing these accidents are examined.

Involvement of NMVs in road traffic accidents

Total 57,186 vehicles were reported to involve in the road traffic accidentsduring 1998-2010.Among these each year a significant number of NMVs are involved. Table 1 depicts this scenario.

Table 1: Proportion of NMV accidents

Year	NMV accidents	Other vehicle accidents
1998	439	4444
1999	465	4926
2000	472	4980
2001	337	3609
2002	420	4913
2003	423	5242
2004	338	4528
2005	250	4105
2006	374	4372
2007	403	4750
2008	382	4594
2009	245	3596
2010	208	3127
Total	4756	57186

From the table, it is seen that almost 8 percent of total accidents involved NMVs during these thirteen years.

Accident severity of NMVs

Though the involvement of NMVs in road traffic accident may not be so eye-catching, but the most horrified thing is the severity of NMV accident is very high. Table 2 proves the fact.

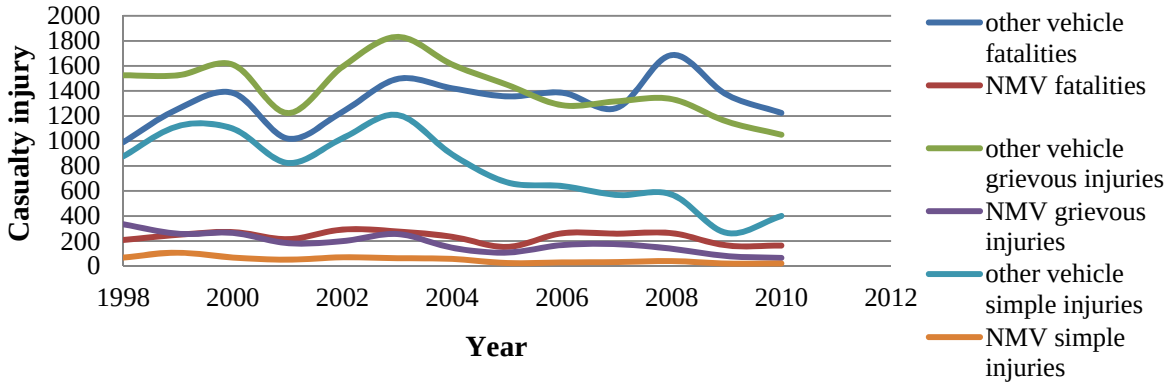
Table 2: Severity of NMV accidents comparing with other motorized vehicles

Year	Fatal		Grievous		Simple		Collision	
	All accidents	NMV accidents	All accidents	NMV accidents	All accidents	NMV accidents	All accidents	NMV accidents
1998	1784	216	945	192	176	17	201	2
1999	2187	250	824	162	272	33	213	7
2000	2240	283	872	157	192	17	199	10
2001	1808	221	546	96	126	11	115	2
2002	2317	282	789	115	183	17	233	5
2003	2486	266	796	125	213	26	199	3
2004	2272	237	615	68	193	23	155	3
2005	2252	172	567	64	133	9	123	2
2006	2421	274	533	69	107	17	142	3
2007	2632	291	621	84	154	12	158	2
2008	2567	275	597	79	135	19	124	4
2009	1972	189	435	39	60	11	109	0
2010	1745	166	357	30	56	6	77	0
Total	28683	3122	8497	1280	2000	218	2048	43

From the table, it can be found that out of the 4,663 (3,122+1,280+218+43) NMV accidents, 3,122 accidents are fatal. So, it can be inferred that amongst all the NMV accidents 67 percent of the accidents are fatal. Which is more than the fatality of car accidents (30 percent) and almost equal to the fatality of heavy vehicles (approximately70 percent for bus and truck).A significant fluctuationin accident severities is demonstrated from table 2 as well. From 1998 fatalities seem to be in an increasing trend, then a significant drop in 2001(almost 20 percent from previous year) and then peaking in 2003(2,486 fatal accidents). Then it shows a gradual drop until 2007 where it achieves a peak again. In recent years (2009 and 2010) the fatalities are seem to be in decreasing trend than the past 10 years.

Casualties of NMV accidents

While the severity of NMV accidents is huge, the casualty related to those accidents are also immense. The casualty related to NMV accidents are shown in figure 1.



[Fig.1]. Casualty injury vs. year

From the above figure, it can be showed that with some fluctuations, motorized vehicles as a whole are engaged in grievous injuries more than fatalities in most of the years. But in case of NMV fatalities suppress the other casualty injuries in most of the years. Which indicates that the casualty rate of NMV accidents is very high. During 1998-2010 among 20,103 reported fatalities 3,014 fatalities occurred due to NMV accidents, which is almost 15 percent of the total share.

Location wise NMV accidents

Since non-motorized vehicles prevails throughout the country and serves as an important para- transit for the people of Bangladesh, the accident pattern found from the data shows the accidents is not limited to a particular region but spread throughout the country.From the data analysis it can be inferred that, since most of rickshaws are in urban areas accidents occurrence is also high here. 59 percent NMV accidents occurred in urban areas compared to 41 percent in rural areas. And from the accident data during 1998-2010 it has been found that out of total 1,795 bicycle accidents, 1,189 accidents occurred in rural areas while the rest are in urban areas. Which means almost 66 percent bicycle accidents occurred in rural areas.But when NMV accidents trend is analyzed based on whole Bangladesh, the picture found is somewhat different. Considering all the mode of NMVs accident, it has been found that almost equal number of accidents occurred in both urban and rural areas (51 percent in rural areas and 49 percent in urban areas).So the density of NMV accident is uniform and spread throughout the country.

Chittagong is one of the most important cities of Bangladesh. After Dhaka most of the NMVs especially rickshaws ply in the streets of Chittagong. According to the bureau of statistics report 2010 there are approximately 94,477 registered rickshaws in Chittagong city. In rural areas there are another 12,748 rickshaws. Which is the second highest in number after Dhaka city. From the table below NMV accident state in Chittagong can be understood.

Table 3: NMV accidents in CMP and Chittagong range

Year	NMV Accidents	Motorized vehicle accident	% NMV accident
1998	41	282	14.54
1999	21	289	7.27
2000	34	211	16.11
2001	10	153	6.54
2002	15	190	7.89
2003	22	241	9.13
2004	14	187	7.49
2005	12	191	6.28
2006	18	228	7.89
2007	25	280	8.93
2008	11	208	5.29
2009	8	143	5.59
2010	18	162	11.11
TOTAL	249	2765	9.01

From the above table, it has been seen that in some years the percentage of NMV accidents is greater in Chittagong than the average percentage of Bangladesh (8%). The trend is fluctuating through 13 years with a distinct peak in 2000 and 2010. Data also reveals that as well as the whole country in Chittagong most of the NMV accidents are fatal (65%).

NMV accident by junction type

When analyzing NMV accidents based on junction type it can be found that most of the accidents occurred in a spot which is not a junction. Data shows that 71.94 percent NMV accidents occurred in not junction spots while 10.5 percent accidents occurred in a T-junction and 6.52 percent accidents

occurred in cross junctions. So NMV accidents are frequent in midblock and straight portions of the roads.

NMV accidents by collision type

Collision type is a crucial consideration in the development of accident preventive countermeasures. Data reveals that about 58.77 percent accidents caused by rear end collision and then comes the head on collision(18.25%) and side collisions (10.94%). This trend of collision is similar for all the modes of NMVs such as rickshaws, bicycles and pushcarts.

NMV accident based on traffic control system

Traffic control is another important parameter which affects accidents. Accident data demonstrated that about 80 percent NMV accidents occurred on a roadway which is not controlled by any sort of traffic control system.

NMV accidents by light and weather condition

Bad light and weather seem not to be a severe factor in case of NMV accidents. Because almost 72 percent NMV accidents occurred in daylight and about 96 percent of NMV accidents happened in fair weather condition.

Accidents due to vehicle defects

Vehicle defects are considered one of the most primary reasons of road traffic accidents. Various mechanical defects of vehicles like faulty brake, tyre and lights are responsible for accidents. But from the data of 1998-2010 reveals that in the case of NMVs only a minor portion of accidents were occurred due to defects of NMVs. It is found that, 91 percent cases the NMVs which involved in road traffic accident have no defects of their own. They involve in accidents due to other traffic, road or any other reasons.

RESULTS AND DISCUSSIONS

Off all the road traffic accidents occurred during 1998-2010, 8 percent of them are NMV accidents.67 percent of those NMV accidents are fatal, while 27 percent are grievous, 5 percent accidents are simple and rest 1 percent is collision only accident, which proves the vulnerability of these vehicles compared to other motorized vehicles.During 1998-2010 road traffic accidents caused a total 48,250 casualty injuries. Among these due to NMV accident 6,039 casualties were recorded. This is nearly 13 % of total casualties. Among these 15.86 percent are fatalities, 12.47 percent are grievous and 6.37 percent are simple injuries.Rickshaw accidents are predominant in urban areas (59%) than in rural areas (41%). On the other hand Bicycle accidents are predominant in rural areas (66%) compared to those in urban areas (34%). But as a whole they are almost equivalent in both rural and urban areas of Bangladesh (51 percent accidents in rural areas while 49 percent accidents are in urban areas). When it comes to vehicle defect as a reason of accidents, accident data shows that there are only 9 percent accidents in which some sort of defects in NMVs are identified. The rest 91 percent accidents are caused due to other factors like defects in other motorized vehicle, road or traffic factors etc. Condition of NMV accidents in Chittagong is also not so well. Among all the accidents in Chittagong metropolitan city and Chittagong range 9 percent accidents are NMV accidents and 65 percent of those accidents are fatal.

Some safety countermeasures to prevent NMV accidents

Since NMVs are one of the most popular modes of transportation in Bangladesh and is frequently used for short trips around the country, adequate safety measures must be ensured to prevent this popular mode from become victims of road traffic accidents. According toJICA (2009) study report 39 percent of all personal trips are carried out by rickshaw. So it is very much necessary to check the NMV accidents. Some safety counter measures are prescribed below.

- ✓ Provision of dedicated and exclusive NMV lane: Since the most common reason of collision of non-motorized vehicles with motorized vehicles is the significant speed difference between two vehicles, it will be wise to physically separate these two vehicles. And this can

be done by keeping provision of parallel service roads or exclusive lane only for NMVs on both sides of highway and busy streets.

- ✓ Improving the NMV design: The delicate and vulnerable structure of NMVs is a major factor to make the vehicle accident prone. So it is very important to improve the design of NMVs, especially the ancient design of rickshaws. Some potential improvements may be (i) reducing the overall weight of NMVs (ii) Providing gears to NMV (modern world pedicabs is a successful example of this) (iii) Adding reflectors for night time use.
- ✓ Training of the pullers and modernizing the licensing process: Most of the NMV pullers (especially rickshaw pullers) in our country are illiterate as they come from different villages. They have little or no knowledge about road traffic system. So they often create congestion and accidents in the road. To check this proper training should be given to each rickshaw puller prior to give them any sort of permission to ply on roads. Illegal use of rickshaw registration must be strictly prohibited by law**.**
- ✓ Separate bicycle provisions: Though bicycle is very few in number, but it is still a very reliable mode of transportation, especially in rural areas. At present there are no cycling strategy and separate regulations for bicycles in Bangladesh. These provisions should be made to check the bicycle accidents.
- ✓ Discourage overloading: Push carts and rickshaw vans are widely used for carrying goods in Bangladesh. But sometimes they carry goods and materials more than their capacity. This can be very detrimental for other road users and cause serious accidents. So strict regulations must be imposed to prevent this type of overloading.

CONCLUSION

This paper has mainly highlighted the general characteristics of NMV accidents in Bangladesh with particular emphasis on fatality of the accidents and casualty factors. Liability of defects in vehicles in causing accidents is also represented. It has been also found from the study that proportion of NMV accidents is almost same in rural and urban areas. Accidents and road safety issues are now become an alarming problem of Bangladesh. With the huge numbers of NMVs plying in the streets every day, increasing accidents and safety problems make the condition even worse. The countermeasures stated in this study might be helpful in minimizing the fatality rate of NMV accidents. It is to be ensured that NMVs get their proper places to move freely and safely in the road. A reasonable balance between NMV and MV should be maintained. This can be done by modal share analysis. NMV should be given the proper level of accessibility based on its share and need for future years. Physical separation of NMV providing adequate spaces in the major arterials and busy city streets would be a very impressive solution.NMV is one of the most popular para transit in Bangladesh. Banning the NMV will not bring any solution. So concerted effort and further research is needed to make NMV a safe mode of transportation in operational, social and environmental aspect.

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PEDESTRIANTHE MOST VULNERABLEGROUPIN ROAD TRAFFIC ACCIDENTS

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ABSTRACT
This paper is intended to highlight some characteristic features of pedestrian accidents and injuries by providing accident statistics and related safety problems, which shows the vulnerability of pedestrian in road traffic accidents with significant lacking in pedestrian facilities. Field observations were conducted to examine someexisting pedestrian facilities.It is found that about 50 percent of all accidents involve pedestrians, of which 80.5 percent are fatal. Significant accident factors are careless driving (43.05%) and over speeding (37.53%). Casualty analysis shows that most vulnerable age group is 6 to 10 years (14.6%) and the second vulnerable age group is 26 to 30 years (10.1%). So child pedestrians are a risky group in the country. Out of total pedestrian accidents nearly 62 percent occurred in rural areas and about 38 percent in urban areas. Pedestrian accident is also the highest on national highways (39.5%) of which about 85 percent are fatal. Nearly 47 percent of pedestrian casualties occurred on road side shoulders. Out of total pedestrian casualties about 80 percent are male and 20 percent are female. According to junction type, about 74 percent of pedestrian accidents occur in midblock sections. Among the vehicles bus (28.3%) and heavy truck (23.83%) are found to have high involvement in pedestrian accidents and fatalities. Some general recommendations are also discussed in this paper.

Keywords: VRU, Pedestrian,Accident, Bangladesh.

INTRODUCTION

Vulnerable Road Users (VRUs), which include pedestrians, bicyclists, and motorcyclists constitute about half of the fatalities on roads across the globe. In terms of pedestrian accidents, worldwide over 4,00,000 pedestrians die every year and over half of these deaths occur in low-income countries (Zegeer and Bushell, 2010). In particular, country like Bangladesh, which has large population as well as a growing middle class, is facing a substantial increase in road traffic injuries and fatalities as strategies are not taken yet to ensure the safety of this group. Even more distressing is the fact that children of this group are particularly at high risk. Sometimes road traffic crashes drive families into poverty and causes loss of the only family bread-earner.
Pedestrians are often called the “infantry of traffic” as they are the most vulnerable among all the road users which is also manifested in WHO, 2009report. Obviously, a typical pedestrian accident

involving a motorized vehicle and a pedestrian brings together quite unequal opponents. The seriousness of pedestrian accident problem of Bangladesh is clearly evident from the comparative data of pedestrian's involvement in fatal accidents for many countries in the developed and developing world. Pedestrians are most at risk in urban areas due to the large amount of pedestrian and vehicle activity in urban areas. In Bangladesh nearly 60% of urban trips involved walking in Dhaka city and it is particularly prevalent for short trips (Rahmanet al., 2006) primarily because of the lack of sufficient transportation facilities and poor economic condition of the people.No matter if the primary mode of transportation is the automobile, bicycle, or public transit; people must walk as a part of the trip, such as from their home to the store, place of employment, park and market or to the transit stop. In regard to safety, pedestrians are of considerable criterion for concern,in our country as they represent half of the road traffic accident manifested by the accident database of ARI. So, pedestrian accidents are a serious problem in Bangladesh. Haphazard unplanned land use, low motorization level, inadequate pedestrian facility, improper maintenance of the existing facility is the main cause of such vulnerable situation.Moreover local culture, inefficiency of present traffic regulation and disregard of pedestrian for traffic regulations make the situation even worse.

In this paper an attempt has been made to highlightsome characteristic features of pedestrian accidents and injuries in Bangladesh. Moreover, field observations were conducted to examine the pedestrian facilities presently provided on the roads of Bangladesh. Finally on the basis of observationpossible recommendations related to engineering, enforcement and education are also discussed in this paper.

RESEARCH METHODOLOGY

This study deals with the pedestrian involvement in road traffic accidents in Bangladesh. Data used for analysis are collected from ARI,BUET and analyzed using Microcomputer Accident Analysis Package Five (MAAP5) software. The study duration is 1998 to 2010. These data arecollected by ARI as hard copies and soft copies from police as police is the primary data source for all reported accidents. ARI also edits the hard and soft copies to maintain MAAP5 database up to date.

RESULTSFROM DATA ANALYSIS AND DISCUSSIONS

To analyze the pedestrian accident scenario in Bangladesh it is necessaryto know the number of pedestrian accidents, fatalities and injuries, pedestrian accident locations, contributing factors of these accidents, vehicle type most frequently involved in these accidents etc. In this section data obtained from MAAP5 regarding above stated criteria are analyzed.

Yearly trend of pedestrian accidents

It is found that out of 45,891 accidents during 1998 to 2010, 22,855 (49.8%) involved pedestrians. Fluctuation in the number of accidents show the unreliability of data due to problems of reporting and recording inconsistencies. But as a whole, percentage of pedestrian accident has been increasing from 46.8 percent in 1998 to 49.8 percent in 2010. Pedestrian accidents are distributed as fatal 80.5 percent, grievous 17.1 percent and simple 2.4 percent for the period of 1998 to 2010. This clearly exhibits the tendency of underreporting of Injury accidents by police.

It appears that there were 18,923 fatalities and 6,125 non fatal injuries in 22,855 reported pedestrian accidents during 1998-2010. In our country pedestrians are considerable cause for concern as pedestrian fatalities out of total fatalities always around 50 percent and which is 75.55 percent of all pedestrian casualties.

Table 1: Comparison of all accidents with pedestrian accidents

Year	No. of accidents			Fatal accidents			Grievous accident			Simple accident		
	Total accidents	Ped. accidents	% of Ped.	All	Ped.	% of Ped.	All	Ped.	% of Ped.	All	Ped.	% of Ped.
1998	3533	1653	46.79	2000	1160	58.00	1137	454	39.93	193	39	20.21
1999	3948	1846	46.76	2437	1386	56.87	986	385	39.05	305	75	24.59
2000	3970	1846	46.50	2523	1402	55.57	1029	395	38.39	209	49	23.44
2001	2925	1438	49.16	2029	1154	56.88	642	255	39.72	137	29	21.17
2002	3941	1927	48.90	2599	1527	58.75	904	362	40.04	200	38	19.00
2003	4114	1942	47.20	2752	1561	56.72	921	333	36.16	239	48	20.08
2004	3566	1817	50.95	2509	1495	59.59	683	271	39.68	216	51	23.61
2005	3322	1771	53.31	2424	1451	59.86	631	273	43.26	142	47	33.10
2006	3566	1891	53.03	2695	1602	59.44	602	251	41.69	124	38	30.65
2007	3954	2157	54.55	2923	1818	62.20	705	291	41.28	166	48	28.92
2008	3800	1951	51.34	2842	1620	57.00	676	279	41.27	154	52	33.77
2009	2815	1392	49.45	2161	1167	54.00	474	202	42.62	71	23	32.39
2010	2437	1224	50.23	1911	1055	55.21	387	156	40.31	62	13	20.97
Total	45891	22855	49.80	31805	18398	57.85	9777	3907	39.96	2218	550	24.80
%		100			80.5			17.1			2.4	

Location-wise pedestrian accidents

Nearly62 percent of pedestrian accidents occurred in rural areas andthe rest in urban areas.Yearly trend analysis reveals that the totalpercentage of urban pedestrian accidents decreases while for rural pedestrian accidents it increases. But the trend is somewhat different from 2006 to 2010.For this span of time as a whole urban pedestrian accidents increased while for rural pedestrian accidents decreased. So, there is a recent increasing trend of pedestrian accidents in urban areas and decreasing trend of pedestrian accidents in rural areas, though the overall share of accidents in rural areas is higher than urban areas.Casualty analysis shows that among total pedestrian casualties in rural areas, 80 percent are fatal and among total pedestrian casualties in urban areas, 69 percentare fatal.Pedestrians alone involved in 62 percent of all fatalities in urban areas and 44 percent of all fatalities in rural areas. In urban areas, 34 percent of pedestrian accidents occurred at midblock sections while in rural areas 66 percent of pedestrian accident occurred at midblock sections. Butat crossings, the share of pedestrian accidents was distributed as 65.5 percent in urban areas and 34.5 percent in rural areas. So, according to junction type share of pedestrian accidents also varies in urban and rural areas. According to road class, the highest, 39.48 percentages of pedestrian accidents occur on national highwaysand 24.61 percentages of pedestrian accidents occur on city roads. In National highways highest pedestrian accidents (21%) occur in National highway 1.

Pedestrian accidents in metropolitan areas

Among the metropolitan areas,Dhaka metropolitan represents highest pedestrian accidents (77.75%) and Chittagong metropolitan represents second highest (13.97%) pedestrian accidents. Among 9,125 police reported accidents which occurred in the metropolitan Dhaka during 1998 to 2010,4,771 involved pedestrian accidents which are52.28 percent of the total accidents. Despite some fluctuations the fatal pedestrian accidents increased from 62.66 percent in 1998 to 78.38 percent in 2010. Overall increasing trend prevailed for injury accidents.

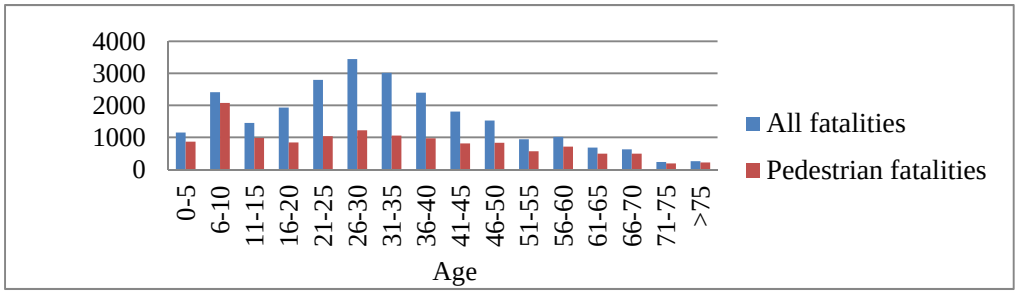
Pedestrian accidents by junction type, pedestrian position& pedestrian action

Data reveals that pedestrian is most vulnerable at midblock sections or road links (Not-Junction). Out of 22,569 pedestrian accidents, 16,762 accidents occurred at midblock sections which are 74.27

percent of the total accidents. According to pedestrian positionhighest (46.93%) pedestrian casualties occur when they are on road side or shoulder. Out of total casualties on road side shoulder 72.95 percent are fatal, which is 45.35 percent of all fatalities on different pedestrian position. According to pedestrian action highest pedestrian casualties (44.37%) occur when they are walking on the road side or shoulder. The fatality while walking on road side shoulder is 79.44 percent of total casualties due to walking on road side shoulder. 31.18 percent pedestrian casualties occurred when they were crossing road. The fatality while crossing road is 83.07 percent of total casualties due to road crossing.

Pedestriancasualties by age& sex

From data analysis it is found that, the most vulnerable age group for pedestrians is 6 to 10 years, which reflects the fact that child pedestrians are vulnerable in our country. For this age group 2,536 pedestrian casualties occurred during 1998 to 2010.



[Fig. 1].Comparison of pedestrian fatalities with all fatalities for different age groups.

Out of total pedestrian casualties 80.14 percent are male and 19.86 percent are female. This is becausein our country women's are most likely to work in household. Considering pedestrian sex, malefatality percentage is higher (79%) because of their exposure.

Temporal characteristics of pedestrian accidents

Pedestrian accidents vary considerably by hour of day. The distribution of accident was 75.27 percent during 6.00 a.m to 6.00 p.m and the remaining 24.73 percent was during 6.00 p.m to 6.00 a.m. For a typical day peak pedestrian accidents occur between 10.00 to 12.00 hours. The fatality percentage for this period is also high.

PROBLEMS OF FEW EXISTING PEDESTRIAN FACILITIES IN DHAKA

Field survey wasconducted at Panthapath to Russell square link road in order to examine the existing pedestrian facilities provided there. Various existing problemsare identified and depicted pictorially in the following.

Pedestrian refuge

[Fig. 2].Hazardous pedestrian refuge

[Fig. 3]. Obstructed and elevated pedestrian refuge

Footpaths

[Fig. 4].Stagnant water on footpaths

[Fig.5]. Parking on footpath

Zebra Crossings

[Fig. 6].Vehicle on Zebra crossing

[Fig. 7].Faded Zebra crossing

Pedestrian signals

[Fig. 8].Out of order pedestrian signals

SOME GENERAL RECOMMENDATIONS

Unplanned land use, urbanization, inadequate pedestrian facility, lack of investmentsfor pedestrian, less attentation given to pedestrians traditional transport planning are the major causes of such situation and unsafe conditions prevailing in roads and streets for pedestrians which need to be addressed urgently. Some general recommendations are given below-

- In urban areas crossing is the most dangerous action for pedestrians. So planners should incorporate safety features in the design and construction of pedestrian crossing facilities.

- With safety design,grade-separated crossings are most probably the best solution. But pedestrians often tends to cross the street in the shortest possible way. So, in some occasions it is more realistic to design at-grade crossings with proper traffic engineering measures.
- The general design guidelines for grade-separated crossings are-
    - Good level of illumination
    - Optimal width to avoid congestion on peak hours
    - Effective drainage
    - Installation of CCTV security cameras
    - Resistance roof and lateral fencing for the overpasses
- For the design of at-grade pedestrian crossings, it is important that they have sufficient width to allow for the maximum pedestrian fllow rates.
- Pedestrian flag may be used for child pedestrian.
- Attractive and user friendly pedestrian facility must be ensured.
- Illegal use of footpath should be controlled by rehabilitation of vendors to make it convenient for pedestrians and encourage them to use it.
- Due to local culture pedestrians are not willing to use the foothpath. Sidewalks with barrier can reduce the problem.
- Speed limit should be enforced strictly.
- Any pedestrian who violate traffic rules, should be charged with fines.
- Traffic rules and and regulations should be included in childrens book, so that they can learn about it from their childhood.
- Pedestrian safety campaign is very essential to make people aware, motivate and to change their disrespect for traffic rules and regulations.
- Electronic media like radio,TV can telecast programmes on pedestrian safety issues for their listeners and viewers.
- Awareness cannot be achieved only through education but need to practiced as a part of life.

CONCLUSION

Pedestrian safety is the most prior issue at hand for sustainable road safety improvement. While many countries have strategies to mitigate pedestrian accidents, it is clear that many low-income countries like ours are lacking in pedestrian safety amenities. More than half accidents involve pedestrian in our country. Situation may go worse if proper steps are not taken immediately. Improved and well planned engineering measures along with law enforcement and education can reduce the pedestrian accidents significantly.

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TRUCK ACCIDENTS ON THE ROADS OF BANGLADESH

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ABSTRACT

Heavy vehicles (bus, minibus, truck and heavy truck) contribute the highest percentagefor all road accident casualties. It is absolutely clear that with the increase of passenger and freight transport, the involvement of truck in road traffic accidents will go on increasing if factors responsible for these accidents remain ignored and uncontrolled. So comprehensive studies on truck accidents will enable us to group reveal their contribution factors. This paper emphasizes the above mentioned issues. The heavy vehicle is particularly over involved in pedestrian accidents accounting for more than 66 percent; of which, truck & heavy truck comprises around 41 percent. Other than hit pedestrian accidents, frequent involvement of trucks was found in head on collision (25%), overturning (19.5%) and side collision (25.4%). Among the 9 National Highways of Bangladesh, the highest number of truck accidents (26%) took place on N5 (Dhaka-Aricha-Panchagar). Moreover, casualty analysis involving trucks show that70 percent of truck related accidents resulted in fatal cases.Over speeding is the highest contributing factor for truck accidents, which is about 55%.Accidents caused by trucks are more severe than other vehicles due to lack of control and definite laws on truck modification, overloading and over speeding. These issues remain unseen and ignored by the law enforcing agencies. Increasing the width of carrier, extending truck bodies at rear end and use of sharp edge bumpers and angles lead this increment of fatal accidents. Also overhanging portion of goods in the carrier can cause serious injuries in simple type collisions.

Keywords: Heavy Vehicle, Truck Modification, Head on Collision, Bangladesh

INTRODUCTION

Road traffic injuries constitute a major public health and development crisis for every country in the world.Nearly 3,500 people die on the world's roads every day, mostly in low and middle-income countries. Projections indicate that these figures will increase by about 65% over the next 20 years unless there is new commitment to prevention. Nevertheless, the tragedy behind these figures attracts less mass media attention. The economic cost of road crashes and injuries is estimated to be 1-3% of gross national product (GNP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries. The global cost is estimated to be US$ 518 billion per year. Low-income and middle-income countries account for US$ 65 billion, more than they receive in development assistance (WHO, 2004).Bangladesh has about 1.75 million registered motorized vehicles (BRTA,

2012). It is estimated that accidents in Bangladesh claim on an average 12,000 lives annually and lead to about 35,000 injuries while according to 2009 World Health Organization (WHO) estimate, the count is nearly 20,000 fatalities.

In Bangladesh, the involvement of truck and heavy truck in road accidents is significant. Trucks are known as the killer giants on highways. Almost 25percentages of accidents has direct or indirect involvement of truck & heavy truck in the accidents occurred from 1998-2010 in Bangladesh. This study deals with the involvement of trucks in road accidents in Bangladesh focusing on sub categorization of accidents by location, type, severity, user group etc. These analyses will further lead to the identification of the problems involved in road traffic accidents and plan strategies and countermeasures to improve the road safety.The objective of the study is to find out the contribution of trucks and heavy trucks in overall road traffic accidents and the trend of these accidents throughout the country. Besides to find out the characteristics of truck accidents using data collected from the field observations and accident database of ARI is also our target. Determining the contribution of truck body modification and nature of loading behind the severity of accidents is a vital part of this study. The last purpose is to suggest engineering countermeasures to reduce the number and severity of truck accidents based on the analysis

STUDY METHODOLOGY

Accident data during 1998 to 2010 is collected from ARI, BUET.Moreover, field observations were conducted in different truck terminals to find out truck dimensions and loading properties.The accident data shown in the analysis part of this study is the total sum for trucks (weight limit 5 tons) and heavy trucks (weight greater than 5 tons).

To determine the main reasons behind the higher severity of truck accidents, field observations were made in two truck terminals of Dhaka city. The first one was at the Tejgaon truck terminal and the other one was at the Gabtoli truck terminal. To find out the modification of truck bodies, different parts of truck body were measured with measuring tape. Then these measurements were compared with the standards of truck according to BRTA Motor Vehicle Ordinance 1997.

ACCIDENT DATA ANALYSIS & RESULTS

The following table shows the variation of truck accident severity from 1998-2010in Bangladesh. It is seen that severity of accidents has showed significant fluctuations. Number of accidents increased by 20 per cent from 1998 to 1999 and thendropped in 2000 and 2001.It reached the peak in 2003. From 2005 to 2010, it is decreasing continuously. Number of fatal accidents increased from 1998 (52%) to 2001 (65%). After decreasing in 2002 it is continuously increasing from 2003 to 2010 except a slight decrease in 2007.

For trucks fatal accident constitutes 63 percent of total accident in 1998 and it remains almost same till 2001 which follows a sharp increase in 2001 (71%). Then it dropped in 2002. After that it is continuously increasing from 2003 to 2010 except a slight decrease in 2007.From the casualty analysis of truck accidents, it has been found that during 1998-1999, number of casualty of truck accident increased by 92 percent. Although it decreased in 2000-01, it again increased in 2002 and 2003.From 2005 it kept decreasing and in 2010, 229 of casualties in truck accidents were reported.But the number of fatalities is very high in recent years. From 1998 to 2005, it fluctuates within 61-72%. But from 2006 it kept rising except in 2007 and reached to the peak percentage in 2010 (82%).

Table 1: Accident severity of all vehicles and trucks

Year	Fatal		Grievous		Simple		Collision		Total	
	All	Truck	All	Truck	All	Truck	All	Truck	All	Truck
1998	2611	726	1737	305	312	51	368	68	5028	1150
1999	3141	875	1485	303	493	102	400	88	5519	1368
2000	3289	856	1563	329	327	77	371	105	5550	1367
2001	2591	761	960	210	216	49	217	44	3984	1064
2002	3316	878	1316	254	313	78	447	78	5392	1288
2003	3591	913	1397	248	363	82	388	62	5739	1305
2004	3270	754	1031	198	340	72	303	52	4944	1076
2005	3086	745	937	190	211	41	235	40	4469	1016
2006	3507	792	889	164	191	45	277	39	4864	1040
2007	3785	765	1043	201	252	50	289	44	5369	1060
2008	3783	758	1023	161	236	38	245	36	5287	993
2009	2937	621	716	114	115	18	208	34	3976	787
2010	2612	506	585	92	110	13	143	18	3450	629
Total	41519	9950	14682	2769	3479	716	3891	708	63571	14143

Involvement of Trucks in Road Traffic Accident

Trucks and Heavy trucks have contributed on an average to 24 percent of accidents as shown below

Table 2: Comparison between Truck and other vehicle accident

	Truck		Other vehicles	
Year	Number	%	Number	%
1998	1206	25	3677	75
1999	1457	27	3934	73
2000	1445	27	4007	73
2001	1118	28	2828	72
2002	1361	26	3972	74
2003	1396	25	4269	75
2004	1169	24	3697	76
2005	1084	25	3271	75
2006	1116	24	3630	76
2007	1134	22	4019	78
2008	1045	21	3931	79
2009	850	22	2991	78
2010	669	20	2666	80
Total	15050	24	46892	76

The contribution of truck in overall accident increased slightly from 1998 to 2001. From 2002 to 2006 it fluctuates within 24-26%. It decrased in 2007 to 22% and varies within 22-20 % till 2010.

Area wise Truck Accidents

From the analysis of truck accidents in urban and rural roads, it is found that percentage of truck accident in rural roads increased from 1998 and it reached the peak in 2004 (75.87%) except a slight decrease in 2003. In recent years this percentage has lowered to 58.41% (2010). ARI started data editing from 2006. So the variation of trends before and after 2006 may be due to this editing.Characteristics of truck accidents also vary with road classes because speed, road surface type,

ridingquality etc are not same in different classes of roads. From analysis it is found that in 1998, about 37 percent of truck accidents occurred on National highways and then this percentage kept increasing till 2004 (55%). In recent years it has been decreasing. This variation seems parallel with the variation of accidents in rural area because the national highways pass through mainly the rural areas. Contribution of city roads in truck accidents was high in 1998 (40%) but it decreased to 13 % in 2008. But in last two years it has again increased to 19%.

As discussed earlier near about 50 percent of the truck accidents took place on National highways. So truck accidents on National highways require extra attention. Among the nine national highways in our country (N1-N9), highest percentage of truck accidents occurred on N5 (Dhaka-Aricha-Panchagar) (about 20%). Number of fatal accidents in this highway increased from 1998 to 2000. From 2001 to 2007 it fluctuates within 66%-73% except a sudden decrease to 54% in 2004. But from 2008 it again increased and reached the peak in 2009 (83%). N1 (Dhaka-Chittagong-Teknaf) is the major National highway as it connects capital Dhaka and port city Chittagong. Goods from Chittagong port are carried by trucks and they are always in a rush. Hence severity of truck accident is higher on this highway. Number of fatal accidents in this route decreased within 1998-2001. After rising to 70% in 2002 it fluctuates within 60-80% from 2003 to 2006. But from2007 to now it is increasing and in 2010, 91 percent of truck accidents in this route are fatal.

Although most of the area under DMP is urban, due to heavy truck traffic from all over the country, truck accident is not a rare phenomenon in this area. Truck accidents in DMP are almost 3 times higher compared to CMP for last 13 years. But percentage of fatal accident was higher in CMP in 1998-1999. From 2002 to 2006, this percentage in CMP increased from 52% to 81% and for DMP it increased from 49% to 72%. In recent years the percentage of fatal accidents in both metropolitans decreased significantly.From the analysis of truck accidents on N1 route, number of truck accidents in thirteen years (1998-2010) is determined at 100 m interval throughout the route. These data will be helpful to determine hazardous road location (HRL) on this highway. Analysis shows that the accidents are clustered on few locations. Locations where truck accident is frequent and accidents are fatal are identified from this in depth analysis.

Trends of Truck Accidents by Collision Types

Trucks are more involved with pedestrians accounting nearly 37 percent of all truck accidents, other major collision types for truck accidents are head on collision (20%), rear end collision (17%), side swipe(8%), and overturning (7%). For truck, 90 degree collision and parked vehicle collision is rare because most of the accident occurs on highways.

Trend Analysis of Truck Accidents by Junction Types& Lighting Condition

It is found that 75 percent of truck accident took place at mid-block sections. This may be due to the fact that highways have less number of junctions than other roads. Tee junction has the second most number of accidents which is 7.6 percent of total accidents.The severity of accidents also varies with lighting condition. In day light, both the number and fatality of accidents is high. Almost 60 percent of all truck accident s occurred in day light and 71 percent of them are fatal. On the other hand the numbers of accidents is less at night time but night un-light condition has greater percent of fatalities (73%).

Major Factors Contributing to Truck Accidents

Behind an accident, there may be one or more factors which are responsible for the accident. For improvement of accident scenario, the major factors need to be identified.As per accident data from ARI, in 55 percent of the truck accidents, speed is the first contributing factor. From the analysis of recent data (2010) almost same result is found. In 2009 speed was responsible for 65 percent of truck accidents. From 1998 to 2010, other major contributing factors are careless driving (39%), pedestrian (2%) etc. When truck accidents involved passenger’s fault, pedestrian’s fault or vehicle defects then most of these resulted in fatal accidents.

TRUCK MODIFICATION

Although in ARF there is no option to enter about truck body modification data when an accident is recorded, it has serious impact on the severity of truck accidents; such outcomes are discussed in different research papers of ARI. In developed countries, truck body is made of uniform width, no extension in sides or depths or lengths are allowed. But in Bangladesh, the main reason behind higher fatality of truck accidents is illegal body modification. In Bangladesh, mainly three companies of trucks and heavy trucks are common. These are Bedford trucks of England, Tata trucks&Ashok Leylands of India.Most of the Bedford trucks are old and they have not been imported anymore in recent year whereas recently Tata and Ashok Leyland are more attractive to truck owners. Only the axle and engine of truck is imported but rest of the body of trucks is manufactured here. To increase the carrying capacity of truck, these bodies are made without maintaining any standards. Some features of truck modification aredepicted through the following figures.

Extension of Truck Width, Use of Angles & Extension of Cover

The maximum overall width of truck is 109 inch and there should be no offset of the carrier beyond the cabin. But in our country, although the widths are found within the limit, but most of truck carrier is extended 8 inch or more at each side beyond the cabin which makes the body non-uniform. Angle use for extra strengthening is prohibited. But some trucks were found with 3-4 angles to support the extended part of side. These angles act as sharp ages and during side collision, they cut through the side of the opposite vehicle and take the severity of accident to higher level. To carry extra loads, not only the width but also the height of cover is also extended by joining extra plates with the original cover.Angle use for extra strengthening is prohibited. But some trucks were found with 3-4 angles to support the extended part of side. These angles act as sharp ages and during side collision, they cut through the side of the opposite vehicle and take the severity of accident to higher level. To carry extra loads, not only the width but also the height of cover is also extended by joining extra plates with the original cover.

[Fig. 1] Extension of truck width and use of angles [Fig. 2] Extension of cover

Rear Overhang& Use of Bumper

To increase the volume of carrier the rear side is extended up to 10 feet from the rear axle. The maximum limit of this overhang is 45 percent of the front and rear axle distance. But it is more than 45% in most of the covered truck by joining extra girder with the main girder by welding as shown in the figure 3.It is traditional in our country to use bumper of excess height and it is often placed with 2 ft offset from the main body of truck. Height of bumper is found even with 4 ft&with sharp edges. This type of bumper is very dreadful and uses of these increase the severity of accident especially in case of head on collision. Bumper with no sharp edges and minimum offset should be used.

[Fig. 3] Extension of rear overhang

[Fig.4]Making of deadly bumper in truck

DISCUSSIONS

From our study, it is clear that truck accidentsare one of the most dreadful types of accidents in terms of severity. Truck modification also requires close attention for improvement severity scenario of accidents. As countermeasureto reduce truck accident and severity, it can be suggested that in highways, speed of truck has to be controlled by imposing speed limit. As pedestrian accident with truck is common, speed breakers, cautionary signs should be provided.They should also be made aware of the rules of using roads. Travel time should be such that the drivers do not rush or compete with each other. Strict enforcement of laws on truck body modification is required. Also rules should be imposed on weight and shape of goods. They should not extend beyond the body of truck.

Although these recommendations will be very helpful to keep truck accident under control but more comprehensive and detailed analysis is required to change the present condition. Like N1 highway, location of truck accident at other highways should be found out. But with the change of land use pattern and travel pattern, hazardous locations are also changing every year. To find out the change of hazardous locations with the development of lands and roads, locations of each year truck accident is to be determined. Further study is required on how exactly truck modification affects truck accidents and how fatality is increasing with body modification and overloading of truck. Rules on body modification and loading in other developed countries should be analyzed in this regard.

CONCLUSION

Accidents caused by trucks are more severe than other vehicles due to lack of control and definite laws on truck modification, overloading and over speeding. These issues remain unseen and ignored by the government. Increasing the size of carrier,overhanging portion of goods& use of sharp edge bumper and angles lead to increase the fatality of accidents. Hence laws should be enforced to control illegal modification of truck bodies. Truck should be weighted at different routes to ensure that it cannot carry goods beyond the weight limit. Truck drivers should have adequate time for rest and made aware of the traffic rules road signs, speed limit and the consequences of accidents.

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OPENSTREETMAP FOR PROMOTING TOURISM IN BANGLADESH

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ABSTRACT

OpenStreetMap (OSM) is a fast developing open source map across the world. The role of this growing map is enormous in navigation, research and in the development of location based applications. The proliferation of smart mobile phones has created the opportunity to use location based service oriented applications. These 3G mobile applications demand the digital maps which can be provided by the OSM. To meet increasing demand, developments of OSM are drastically increasing in different parts of the world. Here, details of tourist areas are mapped on OSM to attract more tourists in Bangladesh, a naturally splendid country. However, it is challenging to make this kind of voluntary efforts in third world developing countries like Bangladesh. This paper demonstrates different types of OSM maps of tourist areas in Bangladesh. Since tourists of developed countries are accustomed to utilize digital maps and location based services, so these maps are significant for boosting up the tourism industry in Bangladesh. We have also discussed about the possible scopes of the OSM where these maps can play a vital role, especially in the developing countries. Afterwards, the challenges we have faced while developing OSM in this region have also listed in this paper. Eventually, we have concluded the paper stating the future plan of developing a location based application on mobile phone to assist the tourists as a tourist guide in our country.

Keywords: OpenStreetMap, Location Based Services, Tourist Areas, Bangladesh

INTRODUCTION

OpenStreetMap (OSM) is a rapidly growing open source map of the world because of the availability of map information across the world and the advent of inexpensive portable GPS (Global Positioning System) devices. It is a collaboration project with Wikipedia to create a free editable map of the world based on user contributions [1]. OSM was founded in July 2004 by Steve Coast. The OSM Foundation (OSMF) is an international not-for-profit organization. It is dedicated to encouraging the growth, development and distribution of free geospatial data and to providing geospatial data for anyone to use and share [2]. As such, thousands of people from around the world collect geographic data in a central database under an open community. Since 2010, OSM had an agreement with Bing, a search service from Microsoft for using their aerial imagery [3]. One the other hand, since Google owns underlying data of Google map, so, anyone can not get geographic data back from Google map even though it was his contribution. Google has also begun charging its map users. In addition, the free OSM maps produced by digital mapping can be used in location based applications, GPS navigation system and scientific applications. Hence, the OSM community has carried out a number of projects in different parts of the world since its inception. Among these OSM projects, the MapKibera project and the

WikiProject Haiti drew the attention of people worldwide. In the MapKibera project, Kiberia [4], the largest slum of the Kenya was a blank spot on the map until November 2009, when young Kiberans created the first free and open digital map of their own community. The WikiProject Haiti facilitated the rescue work and helped in providing relief aid after the devastating earthquake at Haiti in 2010 [5]. So, the development of OSM across the world is very fast. However, this development of OSM is not even all over the world. The developed countries of Europe and North America have rich and detailed open maps of their countries. These informative maps are being used for various location based services. On the other hand, the pace of the growth of OSM is quite slow in Asia and Africa compared to that of OSM in Europe and North America. For the developing countries in Asia like Bangladesh, OSM shows poor condition of map. In the OSM of Bangladesh, Dhaka, the capital city and Chittagong, the port city have some details. Despite having details, the maps of these two cities are not that much developed either. Apart from these two cities, the other cities and areas of the country have nominal and scribbled details in the OSM. This huge unmapped area of Bangladesh makes it impossible to use the OSM of this country. In Bangladesh, the movement of OSM started in 2010. Five GPS trackers were donated by the OpenStreetMap Foundation. First OSM project using those trackers was done at Dhaka, capital of Bangladesh, to map the Bangladesh University of Engineering and Technology (BUET) campus and the old Dhaka. This project utilizing OSM in Bangladesh [6] is a location based application which acts as road guider for both normal and visually impaired people only in BUET campus. Using one of those GPS trackers, mapping at Chittagong, commercial capital of Bangladesh, was commenced at Chittagong University of Engineering & Technology (CUET) campus, a reputed public engineering university of Bangladesh, since March, 2011. Furthermore, an open source detailed map can be utilized in different purposes. The most striking utilization of this free map is the promotion of tourism in the beautiful country like Bangladesh. Because of resplendent natural beauty of Bangladesh, the country attracts the tourists from all around the globe especially from the developed countries. The tourists of developed countries are accustomed to use the detailed maps of the tourist areas where they want to visit. The Google Map of Bangladesh has not also been edited for this purpose. So, the community of OSM in Bangladesh can play important role to make this purposeful map of the country. Bangladesh Tourism Board can take necessary initiatives to make this mapping project a success. Our contribution of the work is to create a developed OSM of the country for promoting the tourism in Bangladesh. We have mapped the main tourist areas in Bangladesh as well as the locations of the tourist attractions, hotels, transport, restaurants, markets and shopping malls in tourist areas around Chittagong especially Cox's Bazar sea beach and Hill Tracts area. Hence, the tourists can enjoy the location based services in the tourist areas of Bangladesh which will indeed enhance economic development of the country. Also, the proliferation of smart mobile phones in Bangladesh has enabled the opportunity to use OSM in location-based applications.

UTILIZATION OF OPENSTREETMAP (OSM) FOR TOURISM IN BANGLADESH

Bangladesh, a South Asian country, is located in between the Himalayas and the ocean, on the delta of wide rivers. Though Bangladesh is known as poor and disaster-prone country throughout the world but its incredible natural beauty offers many tourist areas including archaeological sites, historical mosques and monuments, natural beach, picturesque landscapes, hill forests and wildlife, rolling tea gardens and tribal areas. So, the tourism industry in Bangladesh is flourishing with increasing flow of domestic and international tourists. The domestic tourists coming from rural and urban areas and foreign tourists travel different tourist attraction areas for diverse purposes all the year round. The purposes of their visits are tourism, business, official functions, study tours and others. Fig. 1 shows the comparative chart of the purposes of tourists for visiting the tourist areas in Bangladesh. This figure shows that travellers usually come to Bangladesh for business and tourism purposes. So, the promotion of tourism in Bangladesh becomes inevitable based on the comparative scenario of purposes. Nevertheless, boosting tourism industry makes the opportunity to earn foreign exchange. Fig. 2 demonstrates the foreign exchange earnings of Bangladesh from tourism and other travels in ten years. The remainder of this section presents different types of tourist maps of Bangladesh. These maps will facilitate the tour of tourists around Bangladesh. We have mapped the details of tourist areas

around Chittagong, Bangladesh. Cox's Bazar and Hill Tracts areas are the most prominent tourist areas around Chittagong. So, we have utilized the detail Open Street Map of these areas.

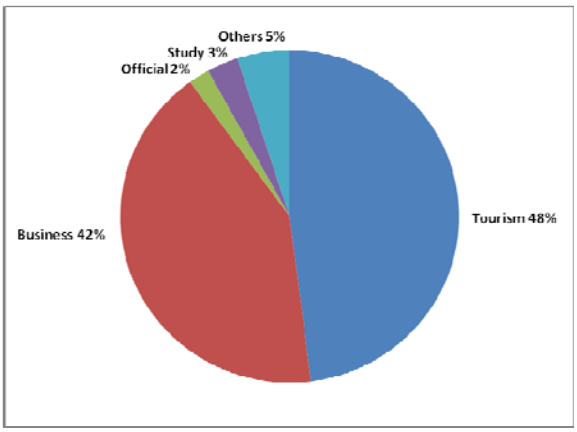

Fig. 1: Percentage of purposes of tourist visit [7]

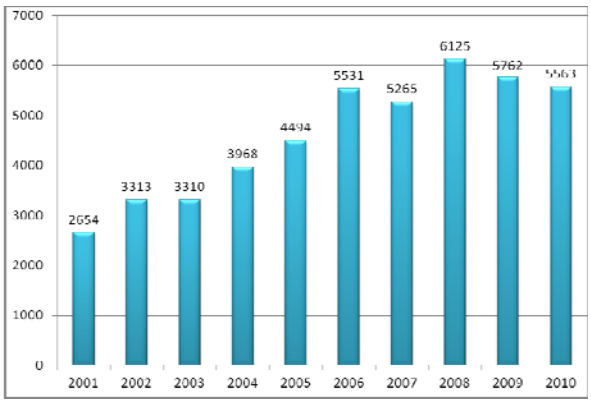

Fig. 2: Foreign Exchange Earnings (in Million Taka) of Bangladesh from Tourism and other travels during year 2001-2010 [7]

OSM of Main Scenic Spots

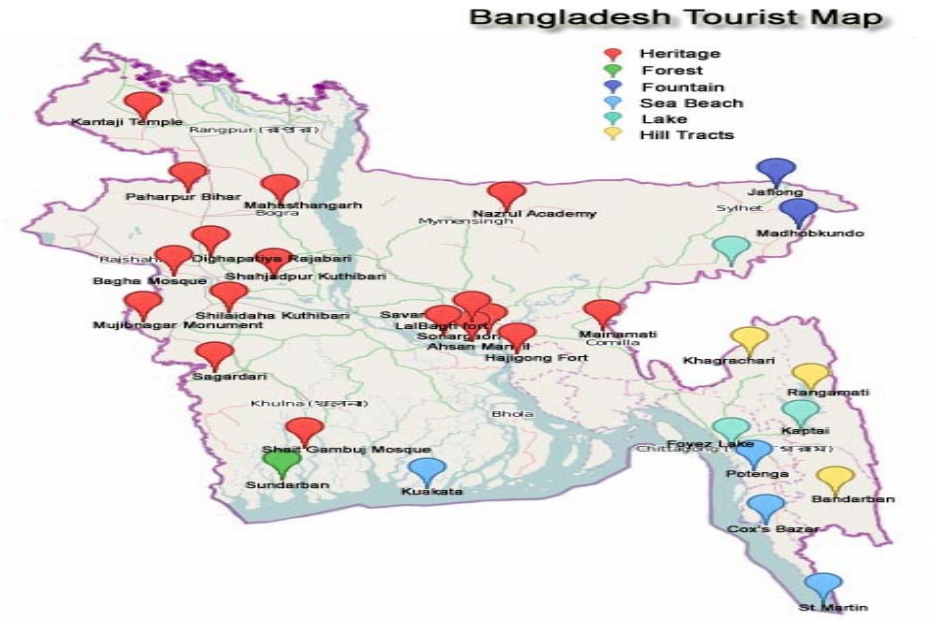

Fig. 3: OSM of Main Scenic Spots around Bangladesh [7].

OpenStreetMap (OSM) of main scenic spots of Bangladesh presents different types of tourist areas such as heritage, forest, fountain, sea beach, natural lake and hill tracts etc. around Bangladesh in Fig. 3. We have depicted different types of tourist spots by balloon markers of different colours on OSM. The details of particular tourist area can be seen clearly be zooming in that area. This OSM can assist to know all the tourist areas in Bangladesh at a glance.

Natural Beach and City OpenStreetMap

Cox's Bazar, the longest natural sea beach in the world, is the most visited tourist area in Chittagong. The hotels, restaurants, markets and other essential spots are mapped on OSM in details near to the beach area which are shown in Fig. 4. The Cox's Bazar City map is also necessary for the tourists. This City map is given in Fig. 5. Here also hotels, government and non-government offices, banks, hospitals, roads, bus counters are mapped on OSM. Tourist can get help about accommodation, foods, transport, activities, and attractions etc from OSM. It is also popular utilization of OSM to locate the hospitals and other medical services and the ways to reach them. So, tourists will also have the appropriate information about hospitals and clinics around this tourist area. They can visualize locations of the markets, supermarkets and shopping malls with a view to do the shopping. The locations of hotels and restaurants on OSM will serve the purpose of accommodation and food for them. They will also get the emergency help using OSM.

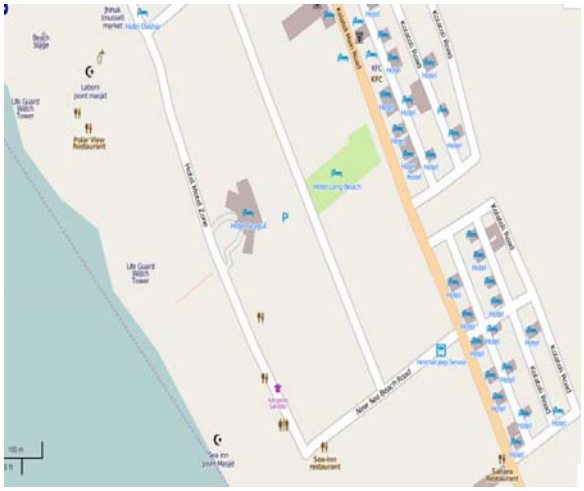

Fig. 4: Natural Beach OSM

Fig. 5: Cox's Bazar City OSM

Hill Tracts OpenStreetMap

The Chittagong Hill Tracts, the only extensive hilly area in Bangladesh which lies in south-eastern part of the country consists of three separate districts: Rangamati, Bandarban and Khagrachari and the main residence of a few tribal indigenous groups, such as the Chakma, Marma and Tripura people. Since it was completely unmapped area before, so, it was hard to move around there for a tourist.

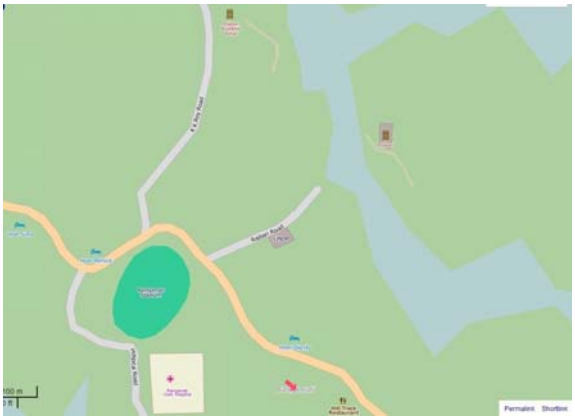

Fig. 6: Rangamati Hill Tracts OSM

We have mapped these areas with the particulars especially the Rangamati OpenStreetMap (OSM) which is shown in Fig. 6. Our Hill Tracts OSM for Rangamati also incorporates the information about hotels, tourist attractions, restaurants, shopping malls and transport.

SCOPES OF OPENSTREETMAP IN BANGLADESH

OpenStreetMap (OSM) has lots of scopes to utilize in different purposes. We have listed a few of them here.

DISASTER MANAGEMENT

Floods, cyclones and earthquakes are the most frequent disasters in Bangladesh. These disasters cause the loss of lives and belonging of the people and the damage of the civil infrastructures. OSM can help the people showing the shelter zone prior to the occurence of disasters. OSM can also be useful for rescue operation, relief distribution and medical health care after the disasters take place by showing the disaster affected area, route to the distination for relief dissemination and a particular disease affected area.

TRANSPORTATION HELP

Rickshaw is a major transport for average people in Bangladesh but it has been banned in some major streets in Dhaka. This type of traffic information may change rapidly under the direction of the traffic control authority. A road OSM showing restrictions on rickshaw as well as other information like which streets are one way would help the city dwellers.

PUBLIC HEALTH SECTOR

OSM can be utilized to develop a map showing hospitals, diagnostic centers, and pharmacies in an area. This map will help the people to get easy access of existing health care system. Apart from this, OSM can play an important role to locate the arsenic affected areas and tube-wells on the map. Governmental vaccination campaign can coordinated through OSM by distributing different teams in different areas which will be shown on the map.

SMART ADVERTISING

OSM can assist in providing smart advertisement about restaurant, super shop, etc on user's current location. These can be used in business purpose by the restaurant and super shop owner. Again it will help users to get information about the restaurant and super shop when they visit a new place.

CHALLENGES

We have faced some challenges in mapping the tourist areas of Bangladesh especially in Chittagong. There are several strong reasons behind this, some of which are discussed below.

1) There are very few GPS devices used actively in Bangladesh. Very few people own a GPS device, because of its cost.
2) There is a lack of technically skilled volunteers for OpenStreetMap contribution. The lack of volunteers is the principle reason behind the slow progress of OSM in Bangladesh.
3) Contribution in OpenStreetMap requires a moderately high speed internet connection, which is quite costly in Bangladesh. Most of the people use low-cost internet packages which suffice for browsing, but not good enough for viewing or editing OpenStreetMap quickly.
4) The concept of digital map is very new in Bangladesh and so people are not used to consult maps for their daily needs. They do not consider a map as an important gadget yet. This reluctance is also making the progress of OpenStreetMap slow.
5) 3G mobile phone technology has not been introduced to Bangladesh till June 2012. So, the location-based services are not provided by the telecom operators.
6) Software firms in Bangladesh mostly use the map services from Google and Yahoo for application development rather than making their own products. Under this situation, OpenStreetMap lags behind.
7) The Government of Bangladesh has not taken any imitative to promote open source development. All the actions on OSM have been carried out by individual small groups.

A comparison between Bangladesh and a neighboring country India can clearly indicate the situation. In the OpenStreetMap GPS traces database, there are only 28 entries from Bangladesh [8], where India

has 535 [9]. The comparison was done using the number of search results found by using the country names as search tag.

CONCLUSION AND FUTURE PLAN

In the modern world of sharing, collaboration is the key to success. The open source community is becoming more and more ameliorated. That's why, Wikipedia has become world's largest knowledgebase. OpenStreetMap (OSM) is also a wiki of maps and location data to which anyone can contribute. Today, it may be a small thing, but if its development goes on, in a few years it will become a part of people's life. OSM is also viable alternative to the constrained Google map. Bangladesh is very splendiferous country which can attract more tourists from home and abroad. Our developed OSM delineating main tourist areas of the country and details of these areas will facilitate the trip of tourists since they can use the detail map of tourist area to have the information about tourist attractions, hotels, restaurants, transports and markets etc. This can also be employed in location based applications on mobile to assist the tourists as tourist guide in our country. So, our future plan of this work is to develop a location based tourist guide application using OSM and map the unmapped tourist areas.

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PROPOSAL OF TRANSPORTATION NETWORK PLAN FOR THE SUSTAINABLE DEVELOPMENT OF LAKSHAM MUNICIPALITY OF BANGLADESH

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ABSTRACT

Transportations have continuously been fundamental components of human societies. It is an important prerequisite for the development of a developing country like Bangladesh. The movements of goods and passengers to a place describe the economic perspective of transportation. The Study area, Laksham, is in Comilla District of Chittagong Division. The Comilla-Noakhali regional highway has passed through the middle of the Municipality. There are total 158.46 km of road available, which is not sufficient to carry the traffic of Laksham Municipality. Geometric designs of the roads are no way considered to be sufficient. Though Laksham has the second largest Railway junction of Bangladesh and connected with Chittagong, Sylhet and Dhaka. But, circulation network is found only 3.85% of total land use. Several rail lines and unplanned roadside markets often hampers the free flow of traffic in the regional road, traffic jam is regular here. The history of Laksham Municipality dates back nearly 27 years. It is comparatively an old Municipality and it is an important urban center of this region. Due to its proximity to the Regional Highway and Rail connectivity, this Municipality has the potential to grow further in near future. Expected faster growth may further deteriorate existing physical and living environment of the Municipality if appropriate planning interventions are not designed and implemented now. This paper tries to propose a sustainable transport network plan for Laksham Municipality.

Keywords: Transportation Network Plan.

INTRODUCTION

Laksham Municipality (Pourashava) is situated in the Comilla district in South-East of Bangladesh. Comilla-Noakhali High Way intersects and goes through the middle of the Laksham Municipality. Laksham was declared as a class "A" Municipality on 3rd October, 1984. Therefore, it's history goes back 27 years. At present total population of the Municipality about 61335 (Laksham Municipality record, 2010) and in the year of 2031 it would be 82140 with the growth rate of 1.4%. This Municipality is comprised of 9 Wards, 26 Mouzas.

Laksham Municipality is located at the Middle part of Laksham Upazila. To cite the only national importance is the Regional Highway, Comilla-Noakhali Highway passes through the middle of the

Municipality and Laksham rail junction is one of the five biggest rail junctions in Bangladesh. Laksham upazila centre, emerged as an important Railway junction in the eastern part of the country, is expected to retain its character due to obvious reasons which connects with Chittagong, Feni, Chandpur, Sylhet, Akhaura, Dhaka etc. Rail stations. Therefore, the Laksham Municipality carries of immense national importance. The project area is one of the important centres of economic activities within the eastern region. It has long cultural and trading relation with Homna, Debidwar, Comilla Sadar, Chauddagram, Muradnagar, Matlab, Kachua and Gazaria. Moreover these areas depend on each other for various raw materials and finished products. The long established easy road and rail transportation link has brought these areas closer in terms of trade and industrial activities.

Like other fast growing Urban Towns Laksham Municipality also demonstrates similar symptoms of the ills of urbanization such as, sprawl development, housing crisis; small provisions of water supply, sanitation, drainage and also facing the problems like lack of physical infrastructure, lack of compliance to development control regulations. Taking a minimum level of planned development can be ensured particularly in the field of drainage and road infrastructure development through working out workable urban development plans and development control. This study tries to find out the current transportation problems of Laksham Municipality and provide a solution for sustainable development.

MATERIALS AND METHODS

Laksham is one of the Municipality under UTIDP (Upazila Town Infrastructure Development Project) of LGED (Local Government Engineering Department). The goal of this project is to prepare a comprehensive master plan for Laksham Municipality. All the necessary data and information for this study is collected from the Project Management Office of UTIDP.

RESULTS

Laksham Municipality is situated beside the Comilla-Noakhali Highway which is linked with the Old Highway. There are three types of road in Laksham Municipality- Pucca, Semi-Pucca and Katcha. Out of 158.46 km of roads, Pucca road is 70.30 km, Semi-pucca road is 5.68 km and Katcha Road is 82.48 km. Rail signal, haphazard parking, absence of Bus Terminal, temporary markets beside the roads, absence of pedestrian footpaths are the main causes for continuous traffic congestion in town roads. There is no public bus service available for intra-zonal movement in Laksham Municipality. Intra-zonal movement is mostly carried out through bicycle, rickshaw, rickshaw-van, motorcycle, Auto Rickshaws.

Comilla-Noakhali Highway is the main road network for communication with the other districts. Huge amount of traffics are run through this road every day. Figure 1 shows average (per hour) traffic flow of 18 hours (from 6 am to 12 am). In the Comilla-Noakhali Highway, maximum traffic (both MT & NMT) flow was found during the period of 8.00 am to 1.00pm and minimum traffic (both MT & NMT) flow was found during the period of 6.00 am to 8.00 am. Pedestrian traffic was found highest in number during the period of 8.00 am to 1.00 pm.

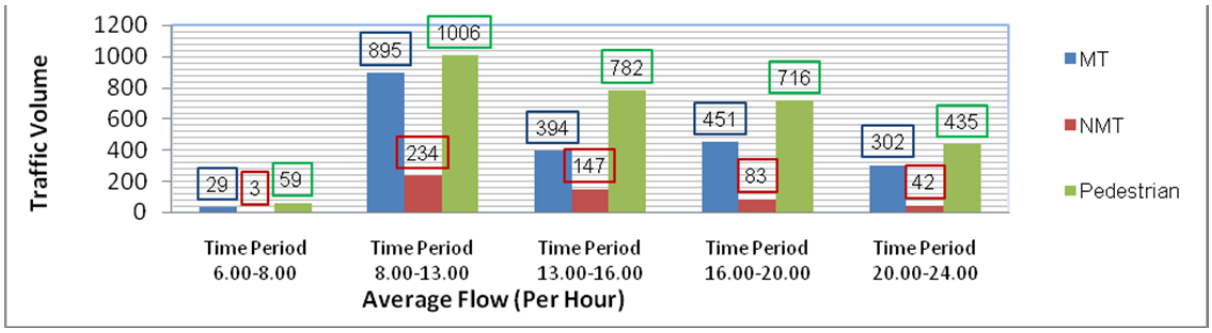

Figure 1: Average Traffic Flow at Comilla-Noakhali Highway

But, due to presence of two rail crossing and narrow road width (25 feet) of Comilla-Noakhali Highway (Figure 2), Traffic jam is regular here. Due to the absence of Bus Terminal the vehicles are using the highway intersection as Bus stoppage. The increasing commercial structures beside the highway and slow moving non-motorized vehicles causing traffic delays in the Comilla-Noakhali Highway.

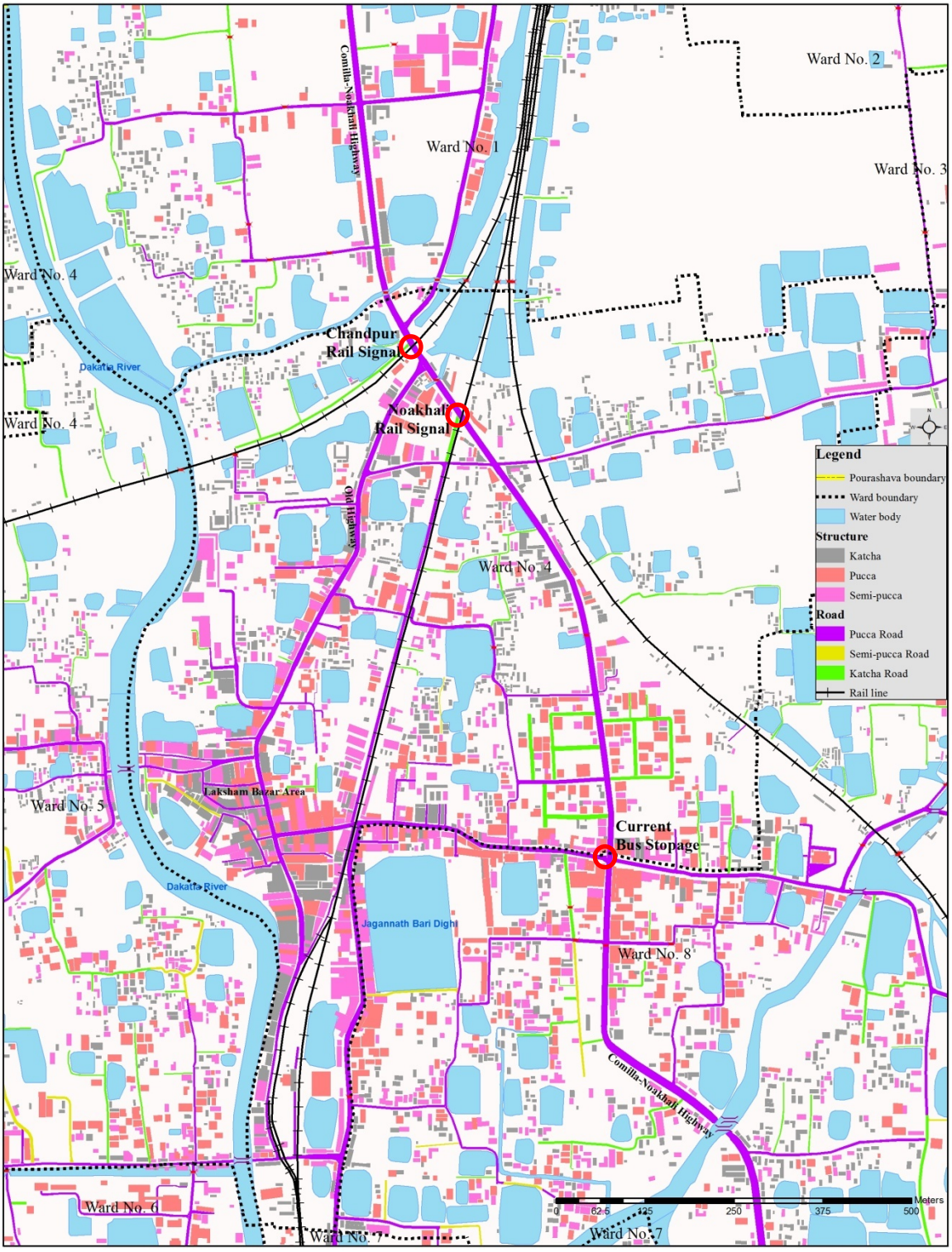

Figure 2: Locations of Traffic conflicts of Comilla-Noakhali Highway

Chandpur Rail Signal
One up and one down train is passed everyday through this signal. Chandpur 'up train' is passed through this intersection at 8am (approximately), which is the peak hour of Comilla-Noakhali Highway. Chandpur 'up train' causes nearly 20 minutes of traffic delays at Chandpur Rail signal. Chandpur 'down train' is passed through this intersection at 7pm (approximately) and it causes nearly 15 minutes of traffic delays.

Noakhali Rail Signal
Like Chandpur Rail signal, one up and one down train is also passed through this signal every day. Noakhali 'up train' is passed through this intersection at 4pm (approximately), which is the peak hour of Comilla-Noakhali Highway and causes nearly 20 minutes of traffic delays at Noakhali Rail signal. Noakhali 'down train' is passed through this intersection at 11am (approximately) and it causes nearly 20 minutes of traffic delays.

There are several up and down trains of Chittagong, but the crossings of this train line with Comilla-Noakhali Highway is outside the Municipality area and not really affect the traffic flow like the previous two signals.

Current Bus Stoppage
The current Comilla-Noakhali Highway was constructed in 1990s for bypassing the traffic from the Laksham bazar area. But due to the absence of proper planning practice the newly constructed Comilla-Noakhali Highway became congested with commercial establishment. The on-street parking of current bus stoppage (Highway intersection) and slow moving vehicles causes regular traffic congestion in peak hour. Lack of pedestrian facilities and lack of traffic signal cause accident in this intersection.

Bazar Road, Chauddagram Road, Nangalkot Road and Municipality Road also carries huge amount of traffic in the Municipality area. Lack of width, poor condition, lack of traffic signal, improperly designed intersection etc. causes transportation problems within the Municipal area.

DISCUSSIONS

The core part of the Municipality is already built up and all the pattern of the growth seems not to be changeable, which is the major problem about the transport plan. In the existing situation for the transport plan it needs to widen the all of the roads with hierarchy basis and have to propose all the standard recommendation to functionalize the road network. For this, land acquisition requires for widening the future transport sector of the Municipality.

After analyzing the current situation and estimating the future growth few proposals are listed below for efficient transportation. Those are-

Avoid dispersed and scattered development patterns
Dispersed and scattered type of development promotes 'sprawl' and increases for travel. It raises the need for more and more transport corridors inducing ever greater traffic. Therefore, avoiding and discouraging this kind of development by various policy measures would help reduce creating new trips.

Consider traffic impact of land use and occupancy of structure while giving building construction and land use permit
As transport is basically a function of land use, any proposed development should be examined with respect to the traffic impact it has on the locality. Kind of use for the any structure has to be clearly defined. 'Transportation Clearance' should be given considering the structure size and proposed use and has to be a compulsory criterion for receiving building permit.

Provide proper Bus Terminal with adequate facilities
A large amount of Bus trips are made from the Laksham Municipality towards many number of directions. A proper Bus Terminal is required for parking and stoppage with other adequate facilities.

Widening the existing important Roads
Most of the major roads are sufficiently wide enough to carry the huge volume of traffic of Laksham Municipality. So, major roads to Laksham Municipality should widen enough to carry the traffic volume.

Construction of flyover in Comilla-Noakhali Highway
Proximity of three rail lines, Dakatia river reduce the opportunity of new bypass road. Widening of existing Comilla-Noakhali Highway would be costly for congested pucca high-rise settlement s beside it. So, the only possible solution is to construct a flyover for through traffic.

Need for Control on Parking
One of the most important ways to control access to specific areas by some vehicles is to control the amount and type of parking spaces available. Clearly, if there are no parking spaces, vehicle can not stop.

Priority to pedestrians when planning infrastructure use and road-space sharing
Allocation of resources is a crucial factor in development-economy. Therefore, taking up new schemes in the transport would require careful prioritization. Focusing on the pedestrians in this respect would set the course to create vibrant, lively local communities.

Creation of Major linkage
As the Town grows and the traffic intensifies on the streets, an efficient network of roads has to be built based on major links. This would ensure direct connection between different curial nodes of the network and help reduce both travel length and time. This is a nonstop process and will be closely in interaction with the spatial development policies for the city.

Development & availability of Public Transport (PT)
This should form the major share of the motorized vehicle. PT has to be available within comfortable walking distance from any part of the Municipality. Maintenance of an efficient public transport provides a cheap and accessible solution for mass movement.

Formulate Traffic and Transport Management Committee
Designing, modeling and at last managing traffic and Transport is not an easy task. It needs important decisions of policy makers from both Public and Administrative representatives. For the Upazila Towns Mayor is the principle for taking any decisions whereas traffic and Transport related decisions require a Coordination Board where high official's opinion is very much important.

Developing an Integrated Transportation System
As there is no transport studies have conducted before for the Upazila Towns, no serious effort has been made for the functional integration of different modes of transport. However, it is well known that without effective integration of transportation systems, economic benefit, convenience and comfort from transportation services cannot be derived.

Lane-based traffic management
Determining number of lanes on every street and their individual capacity and rooting the traffic management and any future expansion on that capacity assessment. Lanes can be designated for different modes. Use of every segment of the road has to be pre-designed and clearly defined e.g. movement, parking, pedestrian crossing etc.

Promote use of Fuel Free Transport and discourage Fuel Dependent Transport

Intersection management
The intersections, especially where major roads meet or cross have to be treated with special attention. They create major points of conflict and also are at the root of creating congestion. Strong regulation is required at these places to keep the flow smooth and frictionless.

Provide equitable opportunities for short and long distance travel
Short trips dominate the transport scenario of Laksham Municipality. Moreover, access is the major function served by roads apart from the few main corridors. Therefore, road space has to be allocated in a way that caters the greater part of the road users.

CONCLUSION

There is no specific policy provided for the local urban traffic and transport management for the small town of Bangladesh though there exists National Land Transport policy for Bangladesh. For this purposes to implement the transport plan, national land transport policy can be followed. Again a traffic transport management authority must have to provide merge with Municipality urban planning sector to manage transport related development and implementation. The roles of the municipality will still be to provide essential services for the population including in the transport sector – public transport, traffic management signal systems, parking control and management and street lighting. The development of transport systems and infrastructure within the municipalities will be in accordance with proper transportation planning.

In planning the most significant role will be played by Municipality planning section. The Planning Section will carry out the entire work of project initiation and plan formulation. These works are complicated and time consuming, and require multidisciplinary professionals. As a class “A” Municipality, Laksham has a Town Planner post. But, due to lack of man power, it is not possibly by the existing Municipality personnel to undertake planning program after discharging all its regular office functions. This would necessitate strengthening of the institutional capacity of the traffic and transport Planning Section of the Municipality.

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INFORMAL TRANSPORTATION SERVICE IN DHAKA CITY: A CASE STUDY OF MIRPUR AREA, BANGLADESH

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ABSTRACT

Dhaka is one of the largest cities in the world with a population of about 15 million in its 1500 sq. km. area. By 2020, the megacity's population is expected to rise 22 - 25 million. Transport is the life of a city and choices on public transit options are fundamental decisions about a city's future growth and development. An efficient transportation system increases accessibility and improves quality of life. Although the rate of current trip is very low, the rapid growth of the city has led to massive demand for transportation. This has not been matched by sufficient development in this sector. Consequently, traffic and transportation condition in Dhaka city has been seriously deteriorated and in many respects it has already reached at crisis level. Some different transport sectors have arisen to meet up these crises, which are different with the traditional transportation, known as informal transportation. Informal transport services are those types of transport services which are used without official sanction or without concerning the owner. These provide benefits including on-demand mobility for the transit-dependent, jobs for low-skilled workers and service coverage in areas devoid of formal transit supply. They also have costs, such as increased traffic congestion, air and noise pollution, and traffic accidents. In Mirpur area a number of informal transport services are found, which are private car, micro-bus and peak-up. This article is the result of a study on informal transport services in Mirpur area of Dhaka city with an eye toward identifying the opportunities and deficiencies.

Keywords: Dhaka City, Informal Transport, Traffic Movement

INTRODUCTION AND BACKGROUND

Urban informal sector currently accounts for anywhere between 30 and 70 percent of the economically active urban population of the developing world (World Bank, 2007). By 2020, the population of megacity Dhaka is expected to rise 22 - 25 million (Rahman, 2003). In Dhaka, the level of traffic congestion and air pollution is rising at alarming rate because of rapid motorization, poor road facilities and the negligence of future transport management plan. Formal public transport services are hardly ever up to the task of fulfilling escalating demands for travel. As a result, people are being

attracted to informal transport services to execute their requirement, which also play a significant role to support the economic life of society. It also provides communal benefit either for those who need this as well as for the owner of informal transport. The benefits that receive the consumers are mostly in the form of service facilities. On the other hand, a number of vehicles used by the service providers are illegal, as to why they use these medium without owners' consent. Moreover, the significance of informal transportation is a result of the lack of management in public transport network and infrastructure. Informal transportation services are also recognized as gap filler in sense of filling the void service requirements left by formal public transport operators.

METHODOLOGY

The study is conducted through survey of 530 structured questionnaires. The interviews are performed in morning peak (7 am-10 am), evening peak (5pm-7pm) and off peak (10am-5pm) hours in different working days of a week. The route of the transport services (both the formal and informal), vehicle types, fare of the transport services, origin and destination data, purpose of trip, time duration, safety level data and public opinion are collected from this survey. Then, the cumulated data are analysed and some findings are observed.

STUDY AREA

The survey is conducted at the point of Goalchakkar in Mirpur-10. The route of these informal transport services extends towards the area of Mirpur-14, Shoinik Club (Kakoli), Gulshan -1 & 2 and a very few number of vehicles run towards the area of Airport and Uttara. The route of this informal transportation services is shown in **Map-1**.

ANALYSIS AND FINDINGS

Vehicles and Volume of Passengers in Informal Transport Service

In general, travel demand and intensity in the peak period remains high and so, informal transportation services in morning peak and evening peak are found much higher than the off-peak hours.

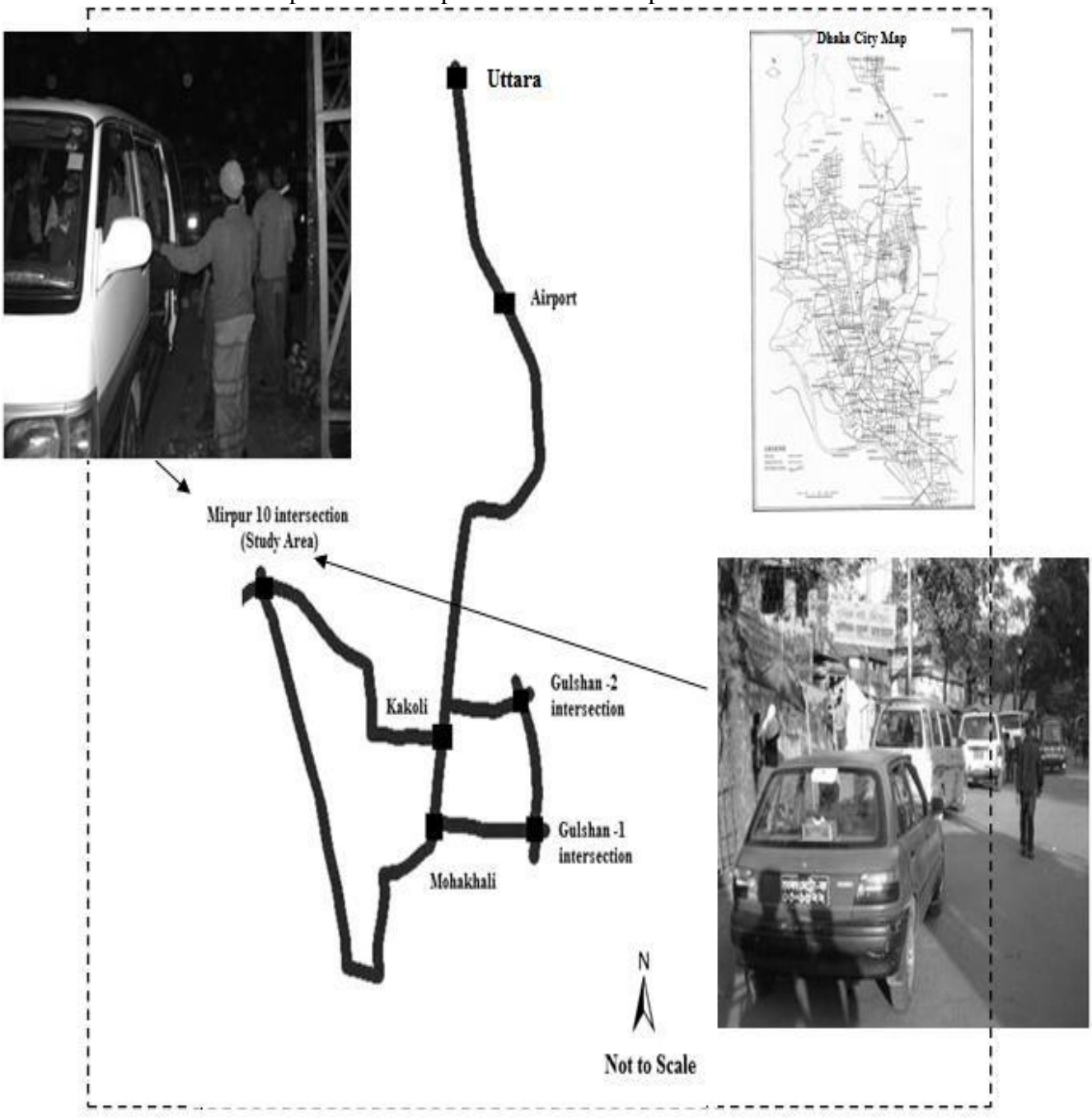
Table 1: Vehicular Movement and Volume of Passengers of Informal Service in Different Time Period

Time	Vehicle Types	Number of Vehicles		Capacity of the Vehicles (in person)		No. of Passengers (per vehicle)	
		No.	%	No.	%	No.	%
7 am – 8 am	Micro bus	20	23.53	9	12.50	156	29.43
	Private Car	8	9.41	5	6.94	32	6.04
	Pick-up	2	2.35	4	5.56	6	1.13
Sub Total		30	35.29	18	25.00	194	36.6
8 am – 10 am	Micro bus	9	10.59	9	12.50	72	13.58
	Private Car	5	5.88	5	6.94	20	3.77
	Pick-up	1	1.18	4	5.56	2	0.38
Sub Total		15	17.65	18	25.00	94	17.73
10 am – 5 pm	Micro bus	6	7.06	9	12.50	42	7.92
	Private Car	4	4.71	5	6.94	12	2.26
	Pick-up	0	0.00	4	5.56	0	0.00
Sub Total		10	11.77	18	25.00	54	10.18
5 pm – 7 pm	Micro bus	18	21.18	9	12.50	140	26.42
	Private Car	12	14.12	5	6.94	48	9.06
	Pick-up	0	0.00	4	5.56	0	0.00
Sub Total		30	35.30	18	25.00	188	35.48
Grand Total		85	100.00	72	100.00	530	100.00

Source: Field Survey, 2012

Table 1 shows that passengers of 89.81% avail informal transportation services in the peak hours, whereas they are only 10.19% in the off-peak hours. The number of vehicles under the informal transportation services in the morning peak is found 52.94% and evening peak is 35.30% are much higher than the off-peak hours of 11.77%.

Map 1: Route Map of Informal Transport Services



Distribution of Vehicles in Different Routes

Among the 85 numbers of vehicles operating in the three study routes, 42 numbers run through the Mirpur 10-Gulshan route and 32 numbers run through the Mirpur 10-Kakoli route and the rest of the vehicles run through the Mirpur 10-Uttara route. Figure 3 represents the distribution of vehicles in these routes at different time period.

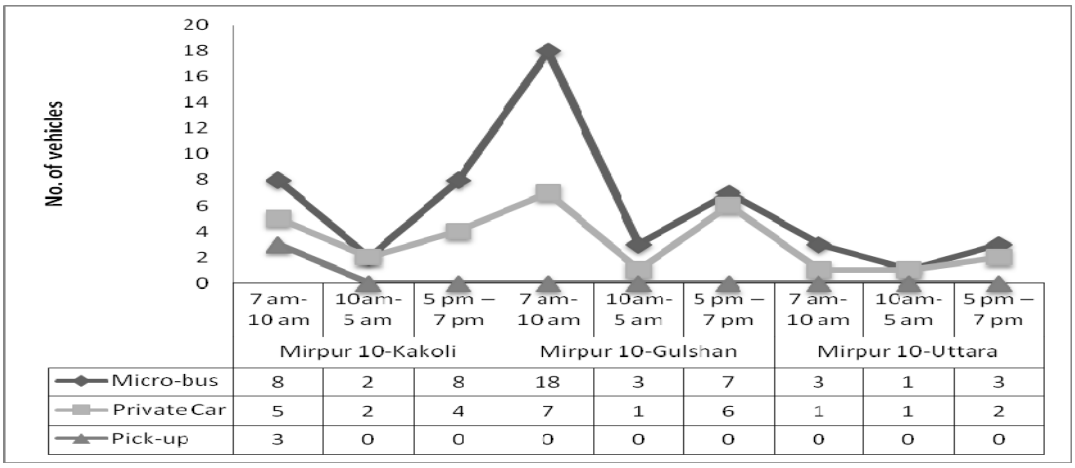


Figure 3: Distribution of Vehicles in Different Routes

Purpose of Trips of Availing Informal Transport Services

The prime reason of availing the informal services is saving the time to reach the destination. Another reason is extra comfort than any other existing formal services. Inadequate number of formal transportation services is also a major cause of choosing informal transport service.

Table 2: Purpose of Trips of Availing Informal Transport Services

Trip distribution	Purpose of trip (No. of Passengers)						Total	
	Going or coming from work	To or from school	To or from shopping	Social or residential	Business	Others	No.	%
Morning Peak	117	45	3	22	95	6	288	54.34
Evening Peak	85	8	28	12	52	3	188	45.47
Off-peak	4	8	27	5	8	2	54	10.19
Total	206	61	58	39	155	11	530	100.00

Source: Field Survey, 2012

Table 2 shows that job holders are the highest users (38.87%) of the informal transportation services, next to businessmen (29.25%) and school going people (11.51%). At the morning peak the flow of passengers is found highest, which is 288 nos. (54.34%), next to evening peak of 188 nos. (45.47%) and off peak of only 54 nos. (10.19%). In the morning peak, school going vehicles mainly create traffic congestion. People use these informal transportation services for other purposes like- shopping, social, personal business etc.

Ownership Pattern of Informal Transport Services

About 75% of the owners of informal transportation services are from private sector and the drivers using these vehicles without the consent of the owners. Only 4% of these vehicles are personally owned.

Table 3: Vehicle Ownership of the Informal Transport Services

Vehicles Type	Ownership Pattern			Total
	Govt. Office	Non-govt. Office/ School/Private	Personally Owned	
Micro-Bus	10	40	3	53
Private car	8	21	-	29
Pick-up	-	3	-	3
Total	18	64	3	85

Source: Field Survey, 2012

Existing Formal Transport Services in the Study Routes

Informal transportation service is a new term in the field of transportation. Generally these types of services are seen in the developing countries where the public transport is less than passengers' demand. Table 4 reveals that there are five (5) formal transport services in the study routes.

Table 4: Existing Formal Transport Services

Services	Destination	Routes	Fare (BDT)/Person
Alif Enterprise (Bengal)	Bonosree	Gabtoli-Mirpur 10-Mohakhali-Bonosree	30
Ekusey Paribahan Ltd	Rampura	Gabtoli – Mirpur 10 – Gulshan-Rampura	30
Grameen Service	Gulshan-2	Mirpur 12-Mirpur 10 -Mohakhali-Gulshan-2	25
Discovery	Uttara	Gabtoli-Mirpur 10-Mohakhali-Uttara	35
Konok	Uttara	Mirpur 12-Mirpur 10-Kakoli-Uttara	35

Source: Field Survey, 2012

Fare of Informal Transport Services

In comparing the fare between the formal and informal transportation services, it is found that the fare of informal transportation services is much higher than the formal services. Table 4 and table 5 show that the fare of formal services from Mirpur 10 to Gulshan is 25 BDT whereas, the fare for the informal transport services is 35 BDT per passenger. Moreover, people are using these informal services because of the term "Time Value of Money".

Table 5: Fare of Informal Transportation Services

Routes	Fare (BDT) /Person
Mirpur 10-Mirpur 14-Kochuketh-Kakoli	20
Mirpur 10—Kochuketh-Kakoli-Gulshan	35
Mirpur 10-Kakoli-Airport-Uttara	50

Source: Field Survey, 2012

The summarized findings of the study are as below:

- Inadequacy of public transport services in comparison to passengers demand.
- There is no specific parking place or terminal for the vehicles of informal transport services. As a result these vehicles are parked here and there to pick up passengers which creates traffic congestion.
- Sometimes the passengers have to pay double fare than the formal transport services.
- More often it is seen that some dishonest traffic polices are involved with the establishment of informal transportation services.
- Though these types of transport are illegal passengers find it beneficial to them because of saving time, avoid overcrowding and getting comfort.

PROBLEMS CAUSED BY INFORMAL TRANSPORT SERVICES

The informal transportation services are blamed for a long list of deficiencies that afflict cities of the developing world. Informal services would have some negative impacts which are listed below:

- Aggressive and unruly driving among drivers to fill up the empty seats often creates serious accidents.
- Unexpected competitions among drivers create excessive traffic congestion at critical intersections.
- Informal transportation services use the road space inefficiently as their capacity is less than of the conventional buses.
- The informal transportation sector is often chaotic as the vehicles are placed in a disorganized manner.
- In most cases, the informal service operators cheat the vehicle owners as the drivers use the vehicles of carrying passengers for extra earnings without the permission and consent of the owners.

- Another great problem of this service is crime. Sometimes the drivers are affiliated with criminals and they burgle their belongings.

RECOMMENDATIONS FOR SOLVING THE PROBLEMS CAUSED BY INFORMAL TRANSPORT SERVICES

Based on the findings, following recommendations are made for solving the problems caused by informal transport services:

- Sufficient number of public buses can be provided along with introduction of Bus Rapid Transit (BRT) system in the routes that have higher traffic movement and intensive demand of transport to remove the sufferings of passengers.
- Traffic laws and legislations can be strictly applied on the routes where the traffic mismanagement and chaos prevail due to informal transport services.
- Car pooling system can be introduced and promoted with the ban of the informal transportation services for better traffic distribution and reducing congestion.
- Some fixed parking places for the informal transport services can be established to reduce traffic congestion, mismanagement and chaos.
- The department of traffic and transport can often drive operation of checking the route permits of the drivers by traffic police in order to discourage informal transport services.
- All the drivers both formal and informal transport services can be made aware on the consequences of reckless driving and unexpected competitions in order to reduce the accidents and traffic congestion.
- Owners of the vehicles can be made aware on keeping control to their drivers so that they cannot use the vehicles for carrying any passenger informally for extra income. It will keep the vehicles out of accidents and frequent repair and maintenance. Longevity of vehicles will be sustained and the owners will remain free from the all sorts of hassles may be arised for operating the vehicles informally.

CONCLUSION

Many urban transport services are organized informally now a day in most of the developing cities of the world. The informal transport sector is just one part of the dual economy of such cities and countries. Inadequacy of formal transportation services force the passengers to depend mostly on the convenient informal services. Transport decision makers at all levels need to adopt strategies and approaches to integrate the informal transport services without hampering the safety of formal public transport services towards fulfilling the need of the mass people. The informal transport services should be organized and strengthened not only for promoting regional economy but also for the social economy as a whole.

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A STUDY ON EFFECTS OF UNCONTROLLED AND UNAUTHORIZED ON STREET PARKING IN DHAKA: SOME CASE STUDIES

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ABSTRACT

The problem of parking has become a burning issue of the capital city Dhaka with the growth of population and car ownership. The objectives of the study are to evaluate performance of parking facilities of some selected routes, to identify the problems associated with on street parking, and to find possible solutions to improve the situations in the study areas. Green road-Panthapath intersection and Kakrail to Malibagh corridor are selected based on previous traffic data. From field survey, photographic evidence and questionnaire survey, it is revealed that most of the basement parking facilities of shopping complexes and commercial buildings in the study areas have been developed without planning and without conducting traffic impact analysis (TIA). On street parking is a common phenomenon in most of the roads of Dhaka city due to need convenience, for short stay, free of charge and unavailability or inadequacy of off street parking facilities. To overcome the problem, on street parking charges should be restructured in such a way that it automatically discourages on street parking. Strict rules and regulations should be established and implemented to reduce and even in some cases to stop on street parking. As parking problem is related to traffic congestion, detail TIA is essential for any large establishment particularly at the vicinity of busy junctions. A coordinated policy for parking in Dhaka city should be adopted involving all the stakeholders considering parking demand & supply, parking regulations, enforcement, institutional setup and strengthening, supportive legislation etc.

Keywords: Parking control, Traffic impact analysis, Traffic Congestion, Parking demand & supply

INTRODUCTION

Dhaka, the administrative, commercial and cultural capitalcity of Bangladesh, is characterized by huge population and congested road with heavy traffic. Allocation of road space to meet the needs of both moving and stationary vehicles is an important component of traffic management strategy. The road network of Dhaka city has been developed without proper transportation planning. Almost all the roads of Dhaka city have poorly plannedto fulfilthe existing & projected demand.Office buildings, market places,residential areas, educational institutions, commercial areas all have been developed haphazardly. The road network of Dhaka city comprises of about 2000 Km of roads. Substantial portion of this network is narrow and was constructed during the period when the no. of motor

vehicles were not significant. Most of the narrow roads are located in the densely populated areas of old Dhaka where there is little scope for widening.With increasing number of vehicles plying onDhaka city roads, more and more road spaces arebeing occupied by parked vehicles. As a result,there is a gradual reduction in the road spaces for the movement of traffic. Increased traffic has nowforced to move through narrower roads. The consequences of uncontrolled and unauthorized parking make city life hazardous and interrupt the economic development (Jakle et. al., 2004). Congestion and vehicle holdups have becomea routine affair and is a major cause of concern toall stakeholders of Dhaka city roads.

OBJECTIVES

Parking management refers to the control of stationary vehicle use and non transport related use of transport facility. Parking being an integral part of roadway system should be considered at urban planning stage. Parking control is considered as the way of traffic control (Afroze, 1991). Parking control affects land use, traffic demand and traffic policy. On street parking is a common phenomenon in the most of the roads of Dhaka city due to need for short stay, convenience, free of charge and unavailable or inadequate off street parking facilities. The objectives of the study are to evaluate performance of parking facilities of some selected routes, to identify the problems associated with on street parking, and to find possible solutions to improve the situations in the study areas.

METHODOLOGY

A literature review has been made to know the parking related studies. For evaluating the effects of on-street parking on city roads, some roads have been selected to fulfil the objectives. The study areas have been surveyed to realize the present situations & explore the reasons of the on street parking.To determine the suitable locations of data collection entire routes have been thoroughly visited. Data collection is done by field survey which includes traffic volume counting through direct manual method.Practical field observations have been made for collection of necessary photographs, data and information. A questionnaire has been formulated. Formal and non formal interviews have been held with different categories of people for authentic information. Required data and information have been collected from different sources like Dhaka City Corporation (DCC), Bangladesh Road Transport Authority (BRTA) etc. Finally from data analysis and survey, conclusions and recommendations are drawn.

STUDY AREA AND DATA COLLECTION

Based on previous traffic data, some important locations of Dhaka South City Corporation (DSCC) have been selected for performing the study. The selected locations are Kakrail to Malibagh corridor (Fig. 1)and Green road - Panthapath intersection (Adjacent to Multiplaza and Liver Foundation of Bangladesh) (Fig. 2). Some surveys including traffic volume study(Robertson et. al., 1994), inventory of parking facilities, on-street parking observational survey have been carried out to collect the required data and information for the analysis of this study. Inventories of both on-street and off-street parking facilities have been carried out to determine the availability of parking spaces in commercial centres and shopping complexes in an around the study area. Reserved and marked on-street parking spaces have also

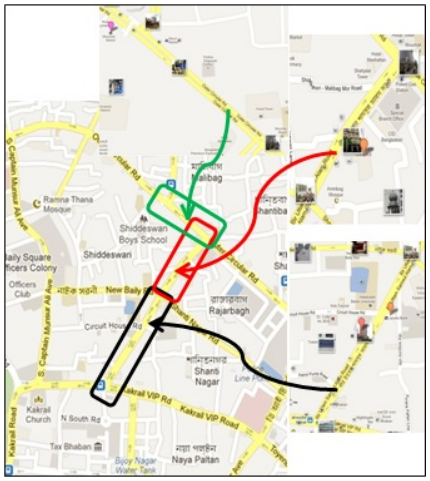

Fig. 1 Kakrail to Malibagh corridor (Google Map)

been considered in the study. The area of the parking facility,number of available car parking, status of parking facilities and demand and supply of car parking facilities at peak hours of the commercial centres and shopping complexes are also considered to justify the need of on-street parking. Finally the problems and the limitations of the parking are identified in the study sites.

Fig. 2Green road-Panthapath intersection (Google Map)

RESULTS AND DISCUSSIONS

On street parking is found to be a common phenomenon in the selected study sites of Dhaka city. The major reasons of on street parking are need for short stay, convenience, free of charge and unavailable or inadequate off street parking facilities. Though parking is an integral part of roadway system but in the selected sites it was found neglected or wrongly planned.Poor parking controlaffects land use, traffic demand and traffic policy (Kadiyali, 2004).In Malibagh to Shantinagar corridor, it is found that due to on-street parking in front of Special Branch (SB) office, Twin Tower, Chinese Restaurant, Near Intersections and T-junctions, Shantinagar Post office etc., the roadway capacity is significantly hampered which is shown in Table 1 From the on-street parking traffic volume study during peak hour it is found that in Kakrail to Malibagh Corridor contribution of car is 45%, rickshaw is 41% and bus is 3% whereas in Green road-Panthapath intersection, contribution of car is 61%, rickshaw is 27% andauto rickshaw andmotorcycle is 5% each. The Vehicle compositions in Kakrail to Malibaghcorridor and Green road-Panthapath intersection are shown in Fig. 3 and Fig. 4 respectively. The mostly observed events in the selected sites are on street unauthorized parking, interruption of free flow, passenger loading/unloading of the buses, lack of strict law implementation, lack of traffic knowledge of rickshaw pullers etc. These observations are shown in Fig. 5 to Fig. 10.

Table 1: Roadway Capacity with or without parking in Shantinagar to Malibagh corridor

Flow Direction	Flow Condition	Total PCU/Hour	Capacity Reduction (PCU/Hour)	Capacity Reduction in percentage %
Malibagh to Shantinagar Intersection	With On-street Parking (Peak Hour)	1284	1416	52.44%
	WithoutOn-street Parking (Off Peak Hour)	2700		
Shantinagar to Malibagh Intersection	With On-street Parking (Peak Hour)	1207	845	41.18%
	WithoutOn-street Parking (Off Peak Hour)	2052		

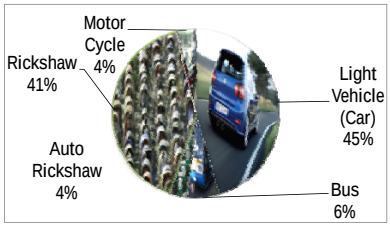

Fig. 3 Vehicle Composition in Kakrail to Malibagh Corridor

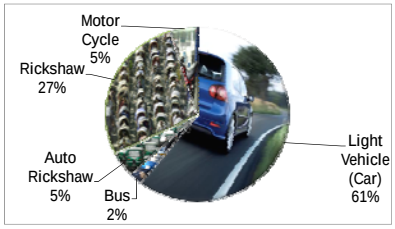

Fig. 4 Vehicle Composition in Green road - Panthapath intersection

Fig. 5: On-street parking has reduced almost half of the roadway (Site: Malibagh)

Fig. 6: On-street vendor activity and unauthorized parking (Site: In front of Hosaf shopping mall, Malibagh)

Fig. 7: On-street car parking has interrupted the free flow of bus (Site: In front of Twin tower, Shantinagar)

Fig. 8: Illegal vehicle parking at no parking zone(Site: In front of Agora, Shantinagar)

Fig. 9: Passenger loading &unloading from buses on roadhas interrupted the free flow of Vehicle (Site: Malibagh)

Fig. 10: Haphazard parking of rickshaws create congestion(Site: Malibagh)

Results of Parking Study

The shopping complexes and commercial spaces in the study routes are considered for parking studies. Questionnaire surveys have also been performed to find out the problems and limitations of the existing parking facilities and to explore possible solutions of the identified problems and limitations. Some results of the parking study is shown in Table 2

Table 2: Results of the parking study of commercial spaces/shopping complexes in the study areas

Name and Location of the commercial space/shopping complex	Photograph	Existing Parking facilities	Observed Limitations/Problems
Bank Asia Shantinagar		Basement parking: 10 to 12 (only for employees)	- No separate entry and exit way for basement parking. - Insufficient spaces for parking. - No parking space for visitors. - On street parking reduces the effective width of roadwayresulting traffic congestion - No penalty/fine for illegal parking.
Special Branch (SB) Office, Malibagh		Front side Parking: maximum 30 to 35. (for visitors) Back side	- No separate entry and exit way for parking. - Not enough parking spaces for visitors' vehicles. - Road side (Malibagh) parking creates traffic congestion. - Buses stop for passenger

		Parking: total 40.	loading & unloading near the SB office.
In front of SA Paribahan, Kakrail		No Parking Facilities	- Unauthorized double layer parking in front of the booking office. - On street loading/unloading of parcel vehicles - Frequent "stop and go" of the vehicles of the clients affect free movement on the main pavement - No penalty/fine for illegal parking
In front of Health and Hope Hospital, Greenroad-Panthapath Intersection		Limited Parking facilities for the relatives of the patients	- Unauthorized parking and mix of motorized and non motorized vehicle in front of hospital. - Rickshaw pullers temporarily park their rickshaws in haphazard manner - In peak hours, frequent traffic congestion occurs due to heavy traffic flow and on street parking.

CONCLUSIONS

The roads of Dhaka city have limited capacity for its huge traffic. With the growing population of car ownership, the problem of parking has become a serious issue-as not only volume of traffic but alsoparking demand are increasing together (Chowdhury et. al., 2007). Provision of use of valuable road spacesfor the parking of vehicles is very much inefficient use of road spaces. Field observations reveal that weak on-street parking management and low parking prices attract on street parking in the city. Traffic congestion is a common phenomenon here. The main reasons of traffic congestion are increase of the number of vehicles, poor traffic management system, mix of motorized and non motorized vehicles on road, illegal on street parking, scarcity of parking lots and tendency to break the traffic law.From the on-street traffic volume study, it is found that contribution of car varies from 45% to 61%, rickshaw varies from 27% to 41% and motorcycle varies from 3% to 5%. From photographic evidence and questionnaire survey, it is observed that most of the basement parking facilities of shopping complexesand commercial buildings in the study areas have been developed without planning and without conducting traffic impact analysis (TIA).Most of the parking lots do not meet with the parking demand generated by the establishment because of improper planning and design of these facilities.So people stop and leave their vehicles on streets without thinking the consequences of that parking.The haphazard on street parking of vehicles (both motorized and non-motorized) causes substantial loss of road capacity(Mcshane et.al., 1990). Even the parking on the running lanes obstructs visibility which makes the road unsafe for the pedestrians (Papacostas et.al., 1993). Overall, on street parking problem in Dhaka city should be a priority concern to minimize the traffic congestion and to improve traffic management system of Dhaka city.

RECOMMENDATIONS

Management of on-street parking is very much essential to minimize the unbearable traffic congestion of Dhaka city. Strict rules and regulations should be established and implemented to reduce and even in some cases to stop on street parking.(Marshall et. al., 2006)Based on the study, some possible recommendations are as follows:

- On-street parking near intersections, on narrow streets, pedestrian crossings, bridges/culverts, entrance driveways should be strictly prohibited.
- High on street parking charges compared to that of off-street parking should be imposed to discourage unnecessary trips and haphazard on-street parking.
- Bus stops should be properly designated and restriction of on street loading & unloading of public transports is necessary.
-Restricted or clearway zones, bus stops, driveways, space for fire fighting vehicles, loading/unloading spaces and parking layouts etc. should be clearly marked on the streets.
- On-street parking regulations must be transparent and widely publicized. Locations where such regulations are in force should be clearly indicated by signs and markings. Users should be made aware of the penalties that would be imposed in case of violations.
-More than single row on street parking should be prohibited on the roads of Dhaka city.
- Improvement of public transport system should get the utmost priority to reduce the need of public transport as well as need for parking facility.
- Separate parking stands for rickshaws, auto rickshaws and buses are recommended.
- Road side unauthorized activities, vendor activities on and around the footpath should be stopped to ensure free pedestrian movement.
- Appropriate guidelines should be followed in designing off-street parking facility considering attraction factors of motorists.
- No large and medium commercial establishments should be approved by RajdhaniUnnayanKartripakkha (RAJUK) without TIA.

Finally, a coordinated policy for parking in Dhaka city should be taken involving all the stakeholders considering parking demand & supply, parking regulations, enforcement, institutional setup and strengthening, supportive legislation etc.

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SITE SELECTION AND PRE-FEASIBILITY INVESTIGATION OF THE CONNECTING ROAD FROM PRATDIP TO A NEW HOTEL RESORT IN THE MOUNTAINS NORTH OF PRATDIP (MORRAL DE LA SEDA), SPAIN

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ABSTRACT
The Department of Public Works of Catalonia is proposing to make a connecting road from Pratdip to a new hotel resort in the mountains North of Pradip (Morral de la Seda). In this regard, the study aims to select the most optimal routing with possible alternative(s) for the planned road along with a detailed evaluation of all the geo-engineering works involved. Available GIS data has been used to select a two lane road (one lane each way) of 10 m width with a maximum speed of 80 km/h, which may be reduced to a maximum speed of 30 km/h along a few curved parts or more dangerous passages. The straight distance between Pratdip and Morral de la Seda is about 2000 m. But the elevation difference between the starting and final point of the route is about 603 m. Three alternative routes for the road have been proposed by a trial and error basis hand and digital sketching on the slope map and the contour map which was created based on the DEM. The best proposed road of 10.4 km length requires a total of about 153500 m^3 of cut and 249000 m^3 of fill in certain sections of the road for maintaining a smooth gradient of 10-12% in most parts and a maximum of 16% in only some critical of about 141500 m^3 excavation is required for tunneling. A numbers of culverts and ditches are also recommended to prevent the accumulation of water and washing of the base of the road.

Keywords: Site Selection, Pre-Feasibility Investigation, Connecting Road, Hotel Resort, ArcGIS 10

INTRODUCTION

The Department of Public Works of Catalonia is proposing to make a connecting road from Pratdip to a new hotel resort in the mountains North of Pradip (Morral de la Seda). In this regard, the study aims to select the most optimal routing with possible alternative(s) for the planned road along with a detailed evaluation of all the geo-engineering works involved. Available GIS data has been used to select a two lane road (one lane each way) of 10 m width with a maximum speed of 80 km/h, which may be reduced to a maximum speed of 30 km/h along a few curved parts or more dangerous passages. Heavy trucks are expected to make use of this road as well. According to AASTHO [1], In case of this local rural road in a mountainous area, a maximum of 10% gradient has been taken as allowable for a design speed of 80 km/h and a 16% of the same for 30 km/h. It has been considered the geological and geo-engineering conditions of the site, topography, environmental and climatic conditions, land-use, materials availability, cost-effective solution and aesthetical conditions to

determine the suitable site for the road. Detailed evaluation of all the geo-engineering works involved in installation of the road has been determined. For instance: road cuts, embankments, tunnels, bridges, extraction of construction materials, dump of waste material, etc. Preliminary assessment of the engineering geological conditions and hazards that will be encountered as well as estimation of quantities, i.e. volume of excavations, embankments, tunnel lengths, etc. has been done.

METHODOLOGY

For starting the work, the terrain slope map of the area was created from the available Digital Elevation Model (DEM) using ArcGIS 10 and then classified into two categories of 0-16% gradient and >16% gradient. Although the road gradient or slope is usually significantly less than the terrain slope, the terrain slope map was used for the preliminary routing with the assumption of the worst scenario in which the road gradient is equal to slope gradient. Several hand and digital sketching, using mainly the slope map and the contour map which was created based on the DEM, three alternative routes for the road were suggested. Then considering the geological and other governing factors the best road has been chosen. Engineering instalments as well as probable solutions and estimations for the road have been determined based on the elevation profile of the chosen road prepared by ArcGIS 10.

RESULTS

Characteristics of the Study Site

(i) Steep Topography: The proposed road is a connecting road from Pratdip to a new hotel resort in the mountains North of Pradip (Morral de la Seda). The straight distance between Pratdip and Morral de la Seda is about 2000 m. But, there is a high elevation difference between these two points. The elevation at Pratdip, the starting point of the rout (at 0m chainage) is about 214m from mean sea level and Morral de la Seda, the final destination of the route is at about 817m elevation. The elevation difference between the starting and final point of the route is about 603 m. It was a challenge to maintain a mild gradient for the road to climb up to the mountain.

(ii) Geology and Engineering Geology: The Catalan Coastal Ranges form a system of ridges and depressions parallel to the Catalan coast trending from the southwest to the northeast, in the south-eastern edge of the Ebro Basin [2]. The highest point is the Pratdip and Colldejou area is approximately 987 above sea level. The stratigraphy of the study area consists of a sedimentary sequence of Devonian to Quaternary age. Several igneous rocks occur, intruded into Carboniferous and Lower Muschelkalk formations and formed granodiorite bodies and aplitic dykes. This Triassic sequence is characterized by massive or very thick bedded sandstones with some conglomerate beds at the base (Buntsandstein), followed by thick bedded limestones and dolomites (Lower Muschelkalk), partly deformed sandy clayey siltstone with gypsum (Middle Muschelkalk), limestones and dolomites with marly intercalations (Upper Muschelkalk), and a series of shales and siltstones, in the lower part interbedded with limestones and dolomites (Keuper). On top of the Keuper, as the youngest formation in the Triassic, undifferentiated dolomites occur [3] (Figure-1).

(iii) Natural Hazards: Due to the steep topography, presence of swelling material (e.g. Gypsum), there are high weathering geological sub-units and annual flash floods. The region has many active and non-active but susceptible flows and slides. There are also many active talus slopes and creeping slopes present in the region [4]. Heavy flash floods resulting from short time showers should be considered in the quality and quantity of drainage installation.

(iv) Climate and Environment: The major parts of the study area are covered by pasture and forests. The climate of Pratdip is showing a mostly continental Mediterranean climate. The summers are dry and hot with sea breezes, and the maximum temperature reaches 26-31 °C. Winter is cool or slightly

cold. It occasionally snows at lower altitudes. Spring and autumn are typically the rainiest seasons, where summer is typically stormy [5].

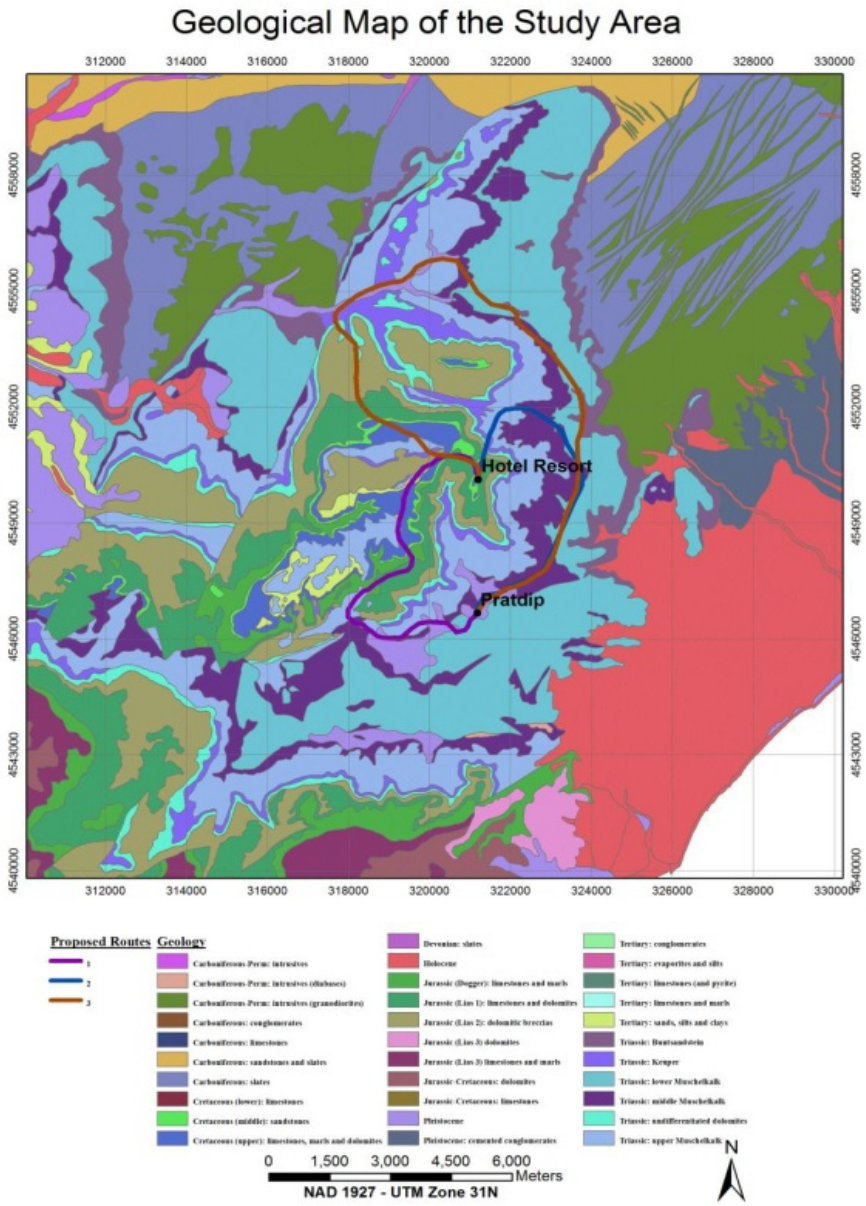

Figure.1:Geological map of study area

Site Selection and Routing:

Three alternative routes for the road have been proposed by a trial and error basis hand and digital sketching on the slope map and the contour map which was created based on the DEM (Figure 2). In order to choose the best and most feasible of the 3 proposed routings, further investigations were carried out on the geology, engineering geology, historical and susceptible natural hazards, topography and land use of the areas in the routes. The factor of the length of the road was also considered as one of the main determinants of the costs of the project. The main steps and methods used for the best choice are as follows:

a. The routes were digitized in 3D over the DEM and the 3D information such as surface distance and road average and maximum gradients were generated and added (Table-1).

Table-1: The attribute table of the three proposed routes for the road

ID	Shape Length (m)	Min Elevation (m)	Max Elevation (m)	Surface Length (m)	Min Gradient (%)	Max Gradient (%)	Average Gradient (%)
1	10471.49	224.21	821.33	10531.34	0.49	25.38	9.03
2	9387.20	232.70	821.26	9469.21	0.02	56.22	9.55
3	21155.52	230.05	829.30	21290.73	0.08	49.55	8.57

As observed in the 3D information route 1 had the least maximum gradient. It was not, however, the shortest road and was almost 1100 meters longer than the route 2. Furthermore, although its maximum gradient was the lowest, it still exceeded the standard of maximum 16% and needed to be corrected in that sense. In terms of gradient suitability and length, the route number 1 ranked 1st.

b. The proposed routes were overlaid with the geology map of the area along with the geo-engineering map of a great part of the study area which was provided by the client. A preliminary description of the major engineering geology units in the 3 routes are as follows:

Route-1:

i) Lower Muschelkalk: strong to very strong rock, slightly to moderately weathered, Calcilutite

ii) Upper Muschelkalk: strong to very strong Calcilutite, mostly with low weathering

iii) Jura-3: very strong Calcilutite, slightly to moderately weathered

iv) Jura-2: very strong Cacirudite, slightly to moderately weathered

v) Albian-1: strong rock, fine to medium grained, moderately weathered Sandstone

vi) Albian-2: strong rock, moderately weathered Limestone and Dolomite In very short distances the road might pass some Middle Muschelkalk rocks which are weak sandstones containing gypsum.

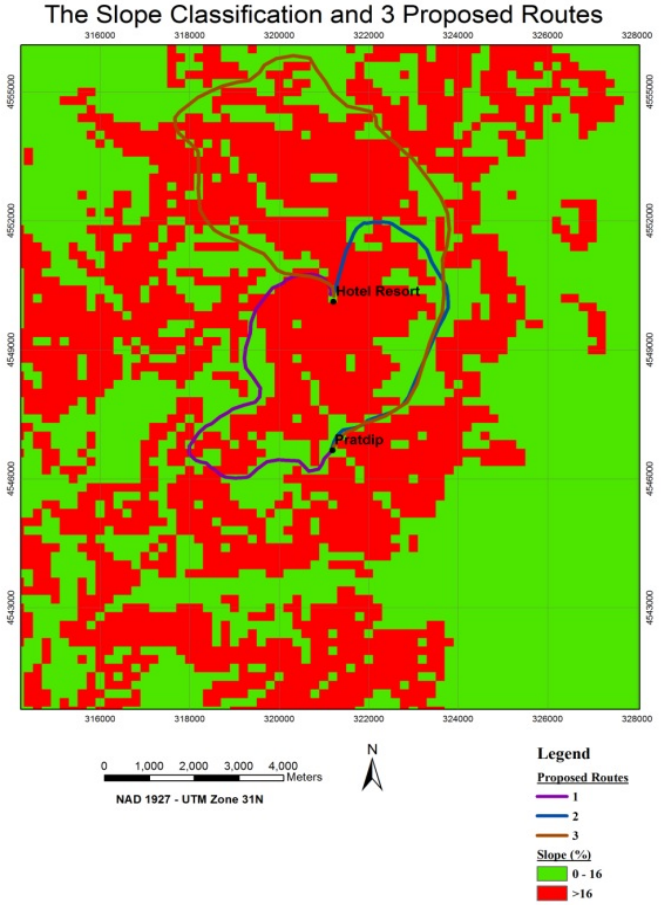

Figure 2: Three alternative routings based on the slope and contour maps

Route-2:
i) Middle Muschelkalk: weak to moderately strong, highly weathered, gypsum bearing Sandstone.
ii) Lower Muschelkalk: strong to very strong rock, slightly to moderately weathered, Calcilutite
iii) Upper Muschelkalk: strong to very strong Calcilutite, mostly with low weathering
iv) Albian-2: strong rock, moderately weathered Limestone and Dolomite

In short distances the road might pass some Keuper rocks which are very weak to weak, highly to completely weathered sandstones and gypsum.

Route-3:
i) Middle Muschelkalk: weak to moderately strong, highly weathered, gypsum bearing Sandstone.
ii) Lower Muschelkalk: strong to very strong rock, slightly to moderately weathered, Calcilutite
iii) Keuper: very weak to weak, highly to completely weathered Sandstones and gypsum
iv) Jura-1A: strong to very strong, slightly to moderately weathered Calcilutite
v) Albian-1: strong rock, fine to medium grained, moderately weathered Sandstone
vi) Albian-2: strong rock, moderately weathered Limestone and Dolomite

Considering the strength of the rocks, the suitability of cut materials for road pavement, ease of stabilizing the road cuts, the absence of problematic materials especially gypsum, etc., in overall geology and geo-engineering properties, road 1 is considered the best of the three.

c. The proposed routes were overlaid on the hazard map (slope stability) of the area. The routes can be described as follows:

Route-1: It virtually never intersects or passes over or under an area with previous record of landslide or earth flow and areas with slope or talus deposits.

Route-2: In many instances the road should pass through talus deposits and areas with records and remnants of landslide and slope instability. Changing the route is not possible due to the limitations which were imposed by gradient of the road.

Route-3: Same or worse than route2.
In overall hazard assessment, route1 was considered the safest both in the building and exploitation stages.

d. The routes were overlaid on the land use map of the area to find out the intersection of the road with places which needed the acquisition of the land before the construction work. The major intersection of each route with current land uses are as follows:

Route-1: Mostly passes shrubbery and natural forest. In small parts passes agricultural fields and bare rocks.

Route-2: Mostly passes through agricultural fields and dense forests. In small parts passes mines and bare rocks.

Route-3: Mostly passes through agricultural fields, dense forests, shrubbery. In small parts passes bare rocks and a small river.

According to very few intersections with private ownership which needed acquisition and also less intersection with dense forests which are most probably under governmental protection, it seems that route1 should be the most suitable among the possible routes. Figure-3 shows the land use map of the area and the proposed routings.

3.3 Routing Conclusion

Considering all the deterministic criteria in choosing the best route (as described above) and according to the much satisfying conditions of the route 1, it is considered as the best and most feasible among the proposed route alternatives and underwent further and detailed investigations.

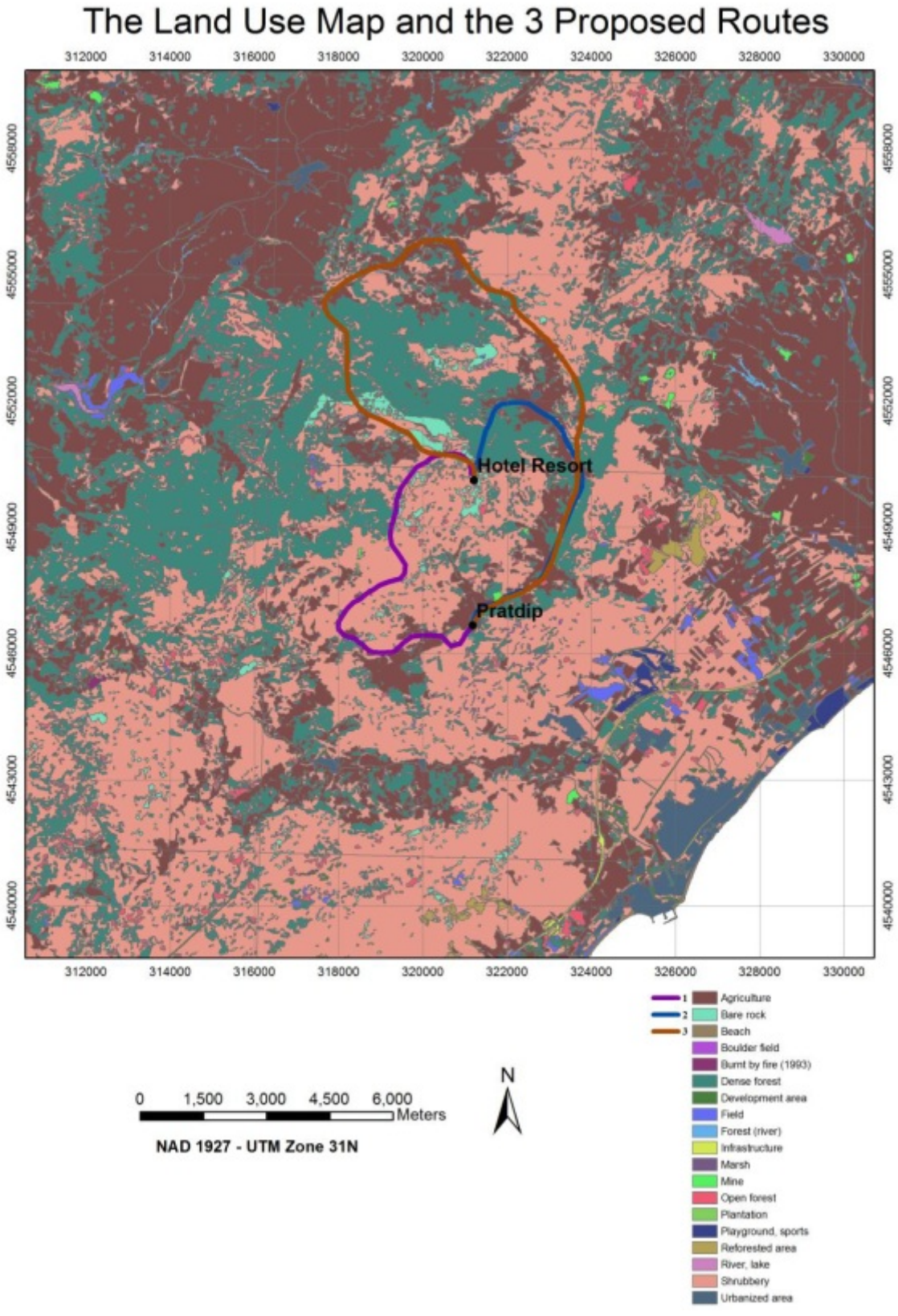

Figure 3: Land use map of the study area

3.4 Detailed Investigation of the Chosen Route

The best chosen route was divided into 11 sections based on the terrain and possible solution for maintaining the gradient of the road between 10-12% in most of the parts and a maximum of 16% in only some critical parts. It has been assumed that the interval between each side of the road will be 14m wide (10m for the road and 2 meters at each side for the shoulder). Using ArcGIS, two elevation profiles of both sides of the road was generated. It was understood that two side of the road were very much similar in terms of topography (Figure 4 and 5). Then another elevation profile of the middle of the road was generated with a 10mx50m grid (Figure-6). Cross-sectional area of the cut and fill are than calculated using grid method with the help of the elevation profile of the middle of the road. Those cross-sectional areas have multiplied by 14 to obtain the cut and fill volume. For the tunnels it was assumed that they would be semi-circular ones with a diameter of 12m for calculating the volume of excavation.

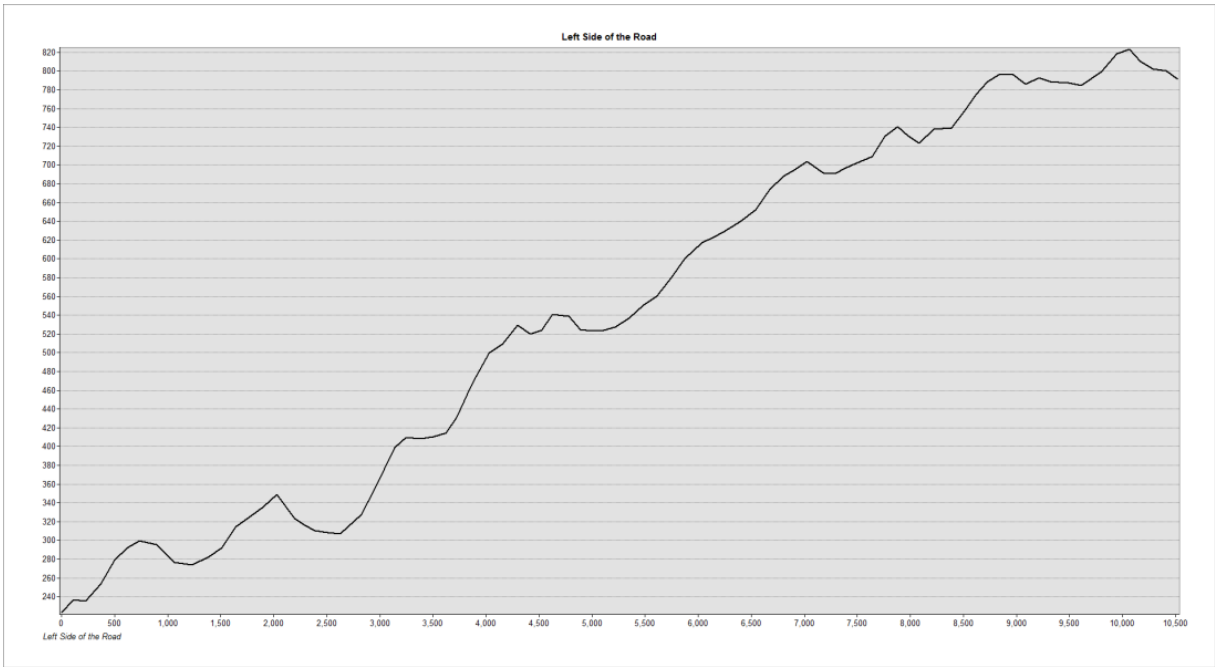

Figure 4: Existing elevation profile at the left side of the road

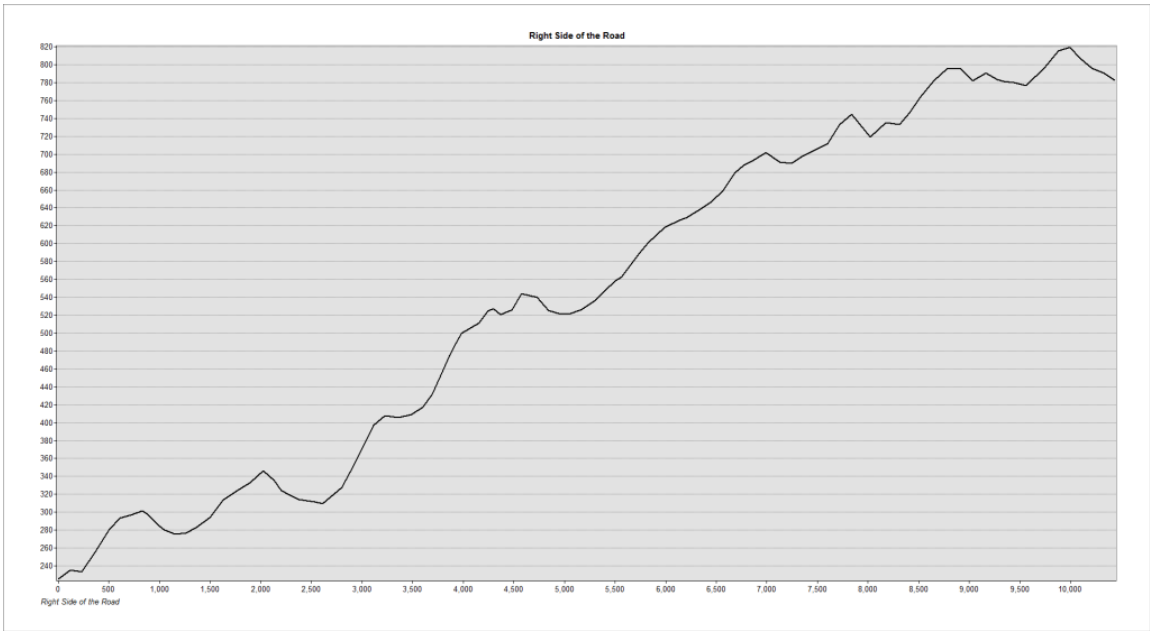

Figure 5: Existing elevation profile at the right side of the road

Figure 6: Elevation profile at the middle of the road with proposed routing

A brief description of each of these sections and the overall scenario for the road construction are summarized in the table below:

Section no.	Chainage (m)		Section Length (m)	Proposed Action	Volume to be			Maximum Gradient	
	from	to			Excavated (m^3)	Cut (m^3)	Filled (m^3)	Existing	Proposed
1	0	300	300	Cut/fill		7000	9500	10%	8.5%
2	300	1100	800	Tunnel	45300			25%	4.5%
3	1100	2100	1000	Cut/fill		35000	33500	17%	12%
4	2100	3050	950	Bridge				23%	4.2%
5	3050	3800	750	Cut/fill		35000	38000	19%	10%
6	3800	4850	1050	Tunnel	59400			22%	9.5%
7	4850	5600	750	Fill			56000	16%	10%
8	5600	6650	1050	Leveling				12%	12%
9	6650	8450	1800	Cut/fill		45000	84000	18%	11.5%
10	8450	9100	650	Tunnel	36800			18%	4%
11	9100	10400	1300	Cut/fill		31500	28000	16%	10%

Table-2: A summary of the chosen route's specifications and the required measures in different section of the road

Total Excavation = 141500 m^3
Total Cut = 153500 m^3
Total Fill = 249000 m^3
Debris = Total Excavation + Total Cut - Total Fill = 46 m^3

3.5 Sections and Solutions

The detailed description of the segments and required measures in the stages of designing and building the road are as follows:

Section-01: According to existing gradient the chainage of this section is from 0 to 300 m. The elevation at chainage 0 is about 220 m above MSL and at chainage 300 is about 240 m. The maximum existing gradient is 10%. The geology of the section can be stated as Lower Muschelkalk-B with strong rock, grey colour, fine grained, thick to very thick bedded, blocky, slightly to moderately weathered, Calcilutite. Therefore, considering the existing gradient and geological conditions the following measures are suggested for the proposed road in this section:

Measures: It is suggested to make a little earth cut followed by a little fill with help of the cut materials in some parts of the section. There will be a maximum of 7000 m^3 of earthwork for having a relatively smooth gradient of 8-10% for the proposed road. However, the fill volume is larger than the cut volume which indicates a need to import the filling materials. This can be done from the excavation materials of tunnel in the successive section, stated as section 02. Considering the geological conditions, it can be assumed that the sub-grade of the road would be composed of blocky rock materials with adequate strength. Also, where there is some weathered surface, it could be removed and replaced by fine to moderately course rock materials from available cuttings. The base materials of the road can also be extracted from the cut rock by grinding it into course aggregates of required size, shape and flakiness. The slopes will be most probably stable due to the good quality of the rock; however there might be a layer of shotcrete necessary for filling the discontinuities and prevention of the further weathering. There are also some ditches necessary along the road and at least one culvert in this 300 m section.

Section-02: This section is between 300 to 1100 chainage with an existing distance of 800 m. The elevation at 1100 chainage is about 280m while it's about 240m at 300 chainage. The section has a steep cliff with the highest elevation of 300m and that is the reason for the high maximum existing gradient of the section which is about 25%. Geologically, it is Lower Muschelkalk –B from 300 to 1020 chainage with rock materials of adequate strength while the rest of the section (almost 100m) is composed of Middle Muschelkalk of weak to moderately strong and weathered sandstone as well as gypsum. The following measures can be considered for the proposed road in this section:

Measures: It is suggested to install a tunnel in this section. However, there is a small portion of Middle Muschelkalk with weathered sandstone and gypsum in the last 100 m of the section. The tunnel should be 12 meters in diameter and 6 meters in apex so that close to the sides of the tunnel we can have the minimum 3.8m of standard height for trucks to pass. The excavation with the total volume of 45300 m^3 of is proposed to be done by blasting, however some pre-excavation measures like forepoling is required in the gypsum bearing layers. In the major parts of the tunnel in which we have lower Muschelkalk, the support could be some shotcrete and grouting and in particular places with high discontinuity some
bolting might be necessary (100 bolts, in average one in every 10 meters should be predicted, however the absolute number of the required bolts is strongly dependent on the results of lab and field tests). For the places with gypsum and sandstone there should be intensive armed concrete for the support and the concrete should be sulfate-resistant.

Section-03: It is a 1000 m long existing route from 1100m to 2100m chainage with a maximum existing gradient of 17% in a very small part of the section while the most part of the section has an average gradient of about 10%. Geologically, almost all of the section is Upper Muschelkalk-B of strong rock while in the last portion there is a small part of Middle Muschelkalk of weak and weathered rock with some gypsum.

Measures: A cut and fill of about 35000 m^3 of earthwork very much similar to section 1 is required to have a relatively smooth gradient between 10 to 12% for the road. The installation of sub-grade and base of the road can be done in a similar manner to section 01. In terms of road safety in the strong parts of the road slope only a layer of shotcrete might be enough to prevent further weathering and development of discontinuities. In the slopes with weak gypsum bearing rocks nailing with mesh and a layer of sulfate resistant shotcrete is recommended. In order to prevent further slope instability due to hydration and swelling of gypsum bearing layers an adequate array of drainages and ditches should be used. It is also necessary to have 3 (one in every 300m) culverts to prevent the accumulation of water and washing of the base of the road.

Section 04: In this section, from 2100m to 3050m, there is a valley with a maximum gradient of 23%.

Measures: It is suggested to install a truss bridge with the length of 950m and a gradient of about 3% in this section. At 2000m chainage the geology is Middle Muschelkalk with weak and weathered rock

which requires pile foundation for the abutment. For Upper Muschelkalk abutment (the other part of the bridge) it is also recommended to install a pile foundation but with the less depth due to the good quality of the rock. The number and length of the piles in both cases depends greatly on the results of the shear strength and bearing capacity tests.

Section 05: It is started from the end of the bridge and will go up to 3800 m chainage with a length of 750 m and a maximum existing gradient is of 19%. The topography has a gradual up and down with an overall mild slope. The geology is Upper Muschelkalk-B which is mostly strong rock.

Measures: It is suggested an earth cut of about 35000 m^3 from 3050m to 3400 m chainage and a fill of about 38500 m^3 from 3400m to 3800m to maintain a maximum gradient of 10% of the road. However, the fill volume is larger than the cut volume which requires an import of fill materials. This can be done by the excavation volume of the tunnel in the successive section, stated as section 06. Due to the good quality of the rock mass it seems that a layer of shotcrete will be enough for stabilizing the cut slopes. The ditches along the road plus 2 culverts (every 300 meters) for draining the flash floods are necessary.

Section 06: The section is from 3800m to 4850m with a 1050m of length and a maximum existing gradient of 22%. The rock mass is consisted of Upper Muschelkalk-B which is strong rock.

Measures: In this section, it is suggested to install a tunnel with a 9.5% gradient. It requires an excavation of 59400m^3. The excavated materials will be used as filling material for section adjacent to the beginning and ending of the tunnel, stated as section 05 and section 07 respectively. The tunnel should be 12 meters in diameter and 6 meters in apex so that close to the sides of the tunnel we can have the minimum 3.8m of standard height for trucks to pass. The excavation method is recommended to be blasting as the rock mass in most sub-units are strong and slightly weathered. For the support a layer of the shotcrete is required with some nailing and bolting in more densely fractured zones (100 bolts, in average one in every 10 meters should be predicted, however the absolute number of the required bolts is strongly dependent on the results of lab and field tests).

Section 07: It is from 4850 m to 5600m with a mild overall gradient. The maximum gradient is 16% the whole 750 m of this section is in the Upper Muschelkalk-B with strong rock.

Measures: It requires a fill of 56000 m^3 which can be imported from the excavation of section 06. Since this section requires filling, special care should be taken in draining the water in the flash flood events. The ditches should be installed along the road and at least 2 or 3 culverts (every 250 to 300 m) are recommended.

Section 08: It is from 5600 to 6650m (length of 1050m) with a mild maximum gradient of 12% and geologically has strong rocks of Upper Muschelkalk-B.

Measures: There is only a very little amount of cut and fill required for leveling of the ground and for installing the road with a smooth gradient of 10-12%. Since the amount of cutting is very small it seems that this section of the road does not require any slope stability measures, however the ditches along the road and 3 culverts (every 300m each) are still necessary.

Section 09: It starts from 6650 m and goes up to 8450 m chainage (1800m length) with a maximum existing gradient of 18%. The topography has a gradual undulation with some mild slope. The geology is Upper Muschelkalk-B of strong rock.

Measures: It is suggested an earth cut of about 24500 m3 from 6650m to 7100 m chainage and then a fill of about 49000 m^3 from 7100m to 7750m to maintain a maximum gradient of 11.5% of the road. Again from 7750m to 8000m, there will be a cut of about 21000 m3 followed by a 35000 m^3 of fill from 8000m to 8450m. However, the fill volume is larger than the cut volume which requires an import of fill materials. This can be done by the excavation volume of the tunnel in the successive

section, stated as section-10. Slope stability is required for the cut parts with shotcrete layers and in case of the sub-units with high discontinuity density and moderate weathering there might be some minor nailing and bolting required. The ditches should be installed all along the road especially in the filled areas in which the accumulation of water can impose a high risk on the safety of the road. 6 culverts (every 300m) are necessary to drain the water.

Section 10: The section is from 8450m to 9100m with a 650m of length and a maximum existing gradient of 18%. The geology is Upper Muschelkalk-B of strong rock.

Measures: In this section, it is suggested to install a tunnel with a 4% gradient. It requires an excavation of 36760m^3. The excavated materials will be used for filling in section 09. However, the tunnel can be replaced by a relatively larger amount of cut and fill of about 98000 m^3. But it will not be aesthetically feasible to have a large cut in the front of the hotel resort which may alter the landscape significantly. Moreover, the amount of debris will also be a problem because it is required about 38000 m^3 fill in section 10. So, the rest of the materials have to be removed from the site in this case. The tunnel should be 12 meters in diameter and 6 meters in apex as the previous ones. The excavation method is recommended to be blasting as the rock mass in most sub-units are strong and slightly weathered. For the support a layer of the shotcrete is required with some nailing and bolting in more densely fractured zones (65 bolts, in average one in every 10 meters should be predicted, however the absolute number of the required bolts is strongly dependent on the results of lab and field tests).

Section 11: The last section of the road extended from 9100 m to 10400m, at the site of the hotel resort. The maximum existing gradient is 16% and geologically can be defined as Upper Muschelkalk-B of strong rock.

Measures: It requires a fill of 28000 m^3 from 9100m to 10000m which can be done by the materials of cutting extracted from 10000m to 10400m. This section is in front of the Hotel Resort and in the ending parts is almost flat. The cut and fill in the ending part is used mostly for levelling the ground and thus will not have a negative effect on the scenery and view of the Resort. Small slope stability measures might be required as landscaping in steps to maintain the beauty of the view of area. The installing of the drainages should also be done with special care about the view of the Resort.

4. Discussion and Conclusion

The proposed 10.4 km road from Pratdip to the Hotel Resort at Moral de la Seda requires a total of about 153500 m^3 of cut and 249000 m^3 of fill in certain sections of the road for maintaining a smooth gradient of 10-12% in most parts and a maximum of 16% in only some critical zones. Furthermore, three tunnels and a truss bridge have to be installed in the proposed road. A total of about 141500 m^3 excavation is required for tunneling. Moreover, a pile foundation is suggested for the supports of each abutment of the bridge. A numbers of culverts and ditches are also recommended to prevent the accumulation of water and washing of the base of the road. However, this is only a site selection and pre-feasibility study. Detailed investigation with proper field and laboratory test will be required to determine the final design for the project.

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A STUDY OF MOTORCYCLE ACCIDENTS IN BANGLADESH

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ABSTRACT
This paper presents some findings of a study of motorcycle accidents and their safety improvements in Bangladesh. The number of registered motorcycles in Bangladesh has increased from 246795 in 2000 to more than 792933 in 2010, an increase of more than 460 percent with fleet growing at a faster rate than other motorized vehicles. Motorcycles are involved in more than 6 percent of road crashes claiming nearly 200 deaths annually and are much more dangerous than other vehicles at least five times the rate of rickshaw. In 2009 there were 278 fatal crashes involving motorcycles in Bangladesh. Since 1998 motorcyclist deaths have been increasing from 69 in 1998 to 189 in 2009 and nearly 70% of motorcycle crashes occurred in rural areas particularly on national highways. Male dominated in crashes, nearly 85% with the peak age group of 26-30 years. Nearly 60% of crashes are associated with the young age group of 21-35 years. Most motorcycle crashes were in day time (84%). Most frequent crash types are head-on, rear-end, hit pedestrians and lost controls. Non-use of helmet is prevalent in many instances. The safety issue of motorcycles requires urgent attention by carrying out in-depth study of motorcyclist's risk factors and intervention options.

Keywords: Motorcycle, Road safety, Accident, Transportation, Casualty.

INTRODUCTION
Motorcycles are the most common and popular mode of transportation in most Asian countries and an alternative to car travel and public transport. Despite their relative importance in traffic stream, little effort has been made to provide special facilities to cater for the need of motorcycles and consequently they are much more vulnerable. The "Global Status Report on Road Safety" reaffirms our understanding of road traffic injuries as a global health & development problem and draws our attention to the most vulnerable road user: motorcyclists, bicyclists and pedestrians. For instance Malaysia has almost half (50%) of road users registered by motorcycles. In Australia, it has found from a recent study (Safety Fact Sheet, June 2009) on motorcycle accidents that, over the last decade, the number of motorcyclist fatalities has increased more and motorcycle riders are 30 times more likely to be killed in a crash than any other vehicle driver. In India, 69% of the total numbers of motor vehicles are motorized two-wheelers and 27% of road deaths are among users of motorized two-wheelers. In Bangladesh, around 50% of registered motor vehicles are motorcycle. Motorcycles accidents are becoming a serious road safety problem and they are involved in more than 6% of road crashes claiming nearly 200 deaths annually. Motorcyclists are the most vulnerable road users, at least five times the rate of Rickshaw and require urgent attention for their safety improvements. This paper presents some characteristics of motorcycle accidents and safety improvement options and represents part of a study carried by the principal author (Bairgi, 2012) under the supervision of the second author Professor Dr. Md. Mazharul Hoque.

HIGH GROWTH RATE OF MOTORCYCLE

The trends of motorcycles growth along with total registered motor vehicles in Bangladesh are shown in Table-1 (also shown in Figure 1). It can be seen that, the number of total vehicles increase from 551938 in 1999 to 1504897 in 2010, which is more than 2.5 times over the period of 1999-2010. The number of motorcycles has increased by 3.5 times over the same period, demonstrating a rapid increase of motorcycles; increased from 42% in 1999 to 52.7% in 2010. The higher share of motorcycles in traffic stream and their indiscriminate use (Figure 2) on roads have resulted in a serious safety problem.

Table 1: Number of Total Registered Motor Vehicles and Motorcycles in Bangladesh

Years	Total Vehicles	Total Motorcycles	% of Motorcycles
1999	551938	232118	42.0
2000	580855	246795	42.5
2001	623275	271204	43.5
2002	664699	296795	44.7
2003	737400	321347	43.6
2004	786602	346288	44.0
2005	852480	389514	45.7
2006	932155	440620	47.3
2007	1054057	525751	49.9
2008	1198476	619292	51.7
2009	1344604	704434	52.4
2010	1504897	792933	52.7
Total	10831438	5187091	47.9

(Source: Bangladesh Road Transport Authority)

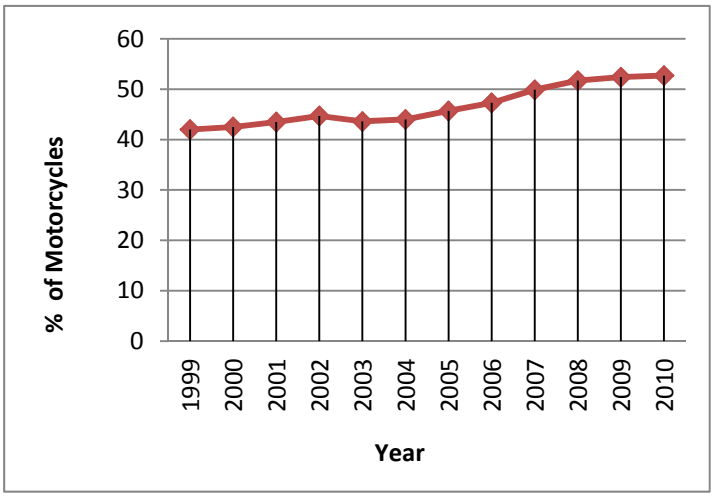

Figure 1: Percentage of Motorcycles of all vehicles (1999-2011)

Figure 2: Unsafe Motorcycle Transportation in Bangladesh

MOTORCYCLE ACCIDENTS AND CASUALTIES

Police reported accident data were gathered from the Bangladesh Road Transport Authority (BRTA) and Accident Research Institute (ARI), BUET. Some of the findings of the motorcycle accidents data analysis are presented in this section. Table 2 presents accidents and casualties of motorcycles together with other motor vehicles. Over the last twelve years motorcycle accident has increased from 5.6% in 1999 to 8.9% in 2010. Fatal motorcycle accidents are about 5.2% of all fatal accidents. Percentage of fatal motorcycle accidents has increased from 3.5% in 1999 to 7.0% in 2010 which is doubled.

Table 2: Motorcycle Accident Severity by the Year (1999-2010)

Year	All Accident	Motorcycle Accident		All Fatal Accident	Fatal Motorcycle Accident	
		No	%		No	%
1999	3948	223	5.6	2435	84	3.5
2000	3970	224	5.6	2523	97	3.8
2001	2925	230	6.9	2029	98	3.8
2002	3741	238	7.2	2599	100	5.0
2003	4114	315	7.7	2769	120	4.9
2004	3566	310	8.2	2509	125	5.0
2005	3322	315	8.3	2424	124	5.1
2006	3549	312	8.5	2668	153	5.7
2007	3910	330	8.7	2989	160	6.2
2008	3662	330	8.8	2723	187	6.9
2009	3852	341	8.9	2789	190	6.8
2010	3974	345	8.9	2860	200	7.0
Total	44723	3518	7.9	31203	1638	5.2

(Source: Accident Research Institute, BUET)

LOCATIONWISE DISTRIBUTION OF MOTORCYCLE ACCIDENTS

Of the total motorcycle accidents, nearly 40% occurred in Dhaka division, followed by Rajshahi (26%) and Chittagong (20%) (Figure 3). Accidents at rural area contributed a major portion of accidents around 70% and on the other hand urban area contributed around 30% of total motorcycle accidents. From the trends of motorcycle accidents by division (excluding city) and city areas shows that both in division and city areas, Dhaka contributed major portion of accidents. Almost 70% of all accidents in metropolitan city occurred in Dhaka city. Comparing with population density, distribution of motorcycle accidents among metropolitan cities showed, the situation of Rajshahi is the worst in compared with others because 19 accidents occurred here per 1000 population. Further analysis by road types showed that around 33% of accidents occurred in national highways, 17% in regional highways, 19% in feeder roads, 18% in city roads and 14% in rural roads (Figure 4). This figure also illustrates that motorcycle accidents are over involved in city roads and rural roads than other class of roads perhaps reflects their exposure. Accident distribution by location showed that around 64% accidents occurred in link or mid-block of carriageway, followed by T-junctions (13%), cross junctions (10%), staggered-X junctions (2%), roundabout (4%) and rest occurred at others. Motorcycle accidents are predominately a link problem indicating the incidence of speeding.

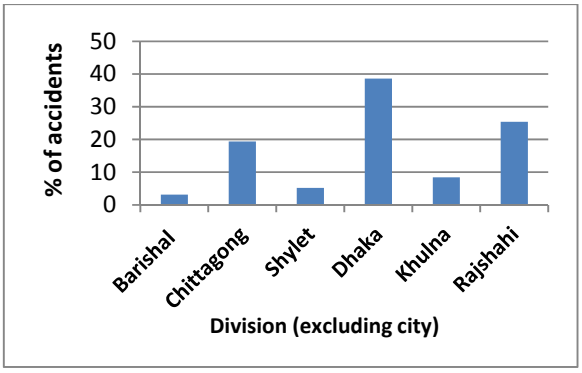

Figure 3: Motorcycle Accidents Distribution among Divisions (Excluding City)

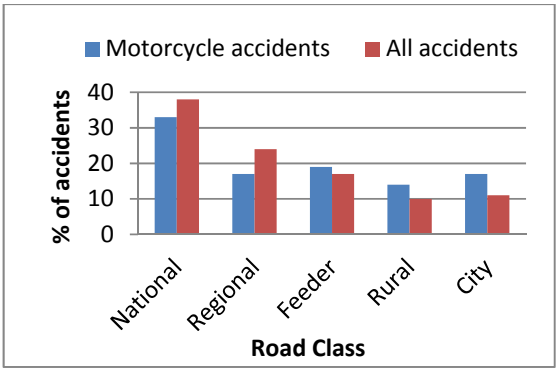

Figure 4: Motorcycle Accidents Distribution by Road Types

ACCIDENT TYPES AND VEHICLES INVOLVEMENT

Distribution of motorcycle accidents together with all accidents by different collision types over the period 1999-2010 are presented in Figure 4. The predominant type of motorcycle accidents is head-on collision (29%), followed by hit pedestrians (28%), rear-end (24%) and rest 19% are of other types- side swipe, hit parked vehicles & animals, overturn etc. Study also reveals that head-on and rear-end accidents are over involved compared with other vehicular accidents and in many cases; it results in deaths or very serious injuries (Figure 6). Further analysis of vehicle involvement in motorcycle accidents revealed that nearly 35% of accidents are involved as single vehicle and 65% are involved with other vehicles.

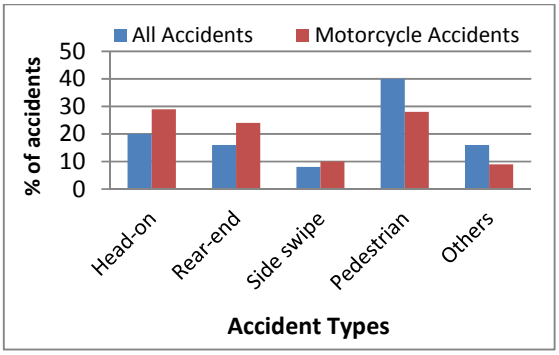

Figure 5: Motorcycle Accidents Types

Figure 6: Fatal Motorcycles Accidents

AGE AND HOURLY DISTRIBUTION OF ACCIDENTS

Motorcycle accidents distribution among the motorcyclist's age, 21-40 age groups is the most perilous group as around 70% of the motorcyclists lays in these groups (Figure 5). But the casualty percentage for young riders in the aged group 21-25 and 26-30 has maximum percentage around 22%. Figure 7 presents the daily pattern of motorcycle accidents along with all accidents by the hours of a day. Motorcycle accidents peaked during the period of 10 am to 1 pm and later at 4 pm to 5 pm in the day time coinciding

with the higher level of motorcycle flow. Accidents occur more frequently in day time (6.00 am to 6.00pm), about 84% and almost 16% at night may due to heavier traffic in day time than night time.

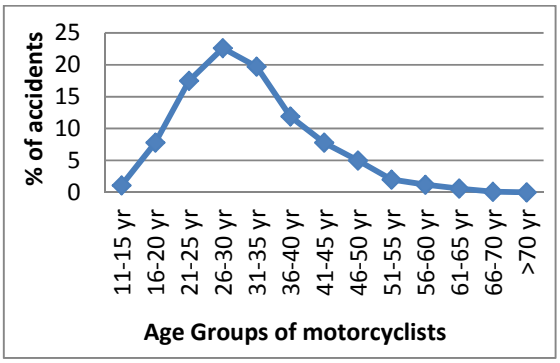

Figure 7: Age Distribution of Motorcyclists in Accidents

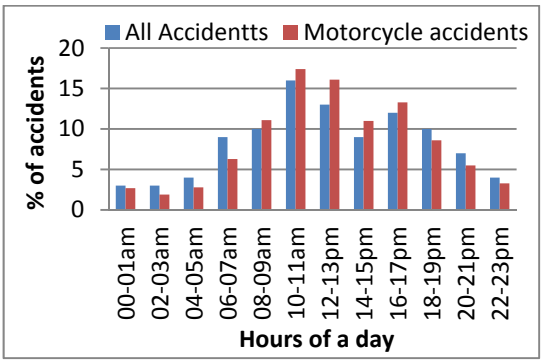

Figure 8: Hourly Distribution of Motorcycle Accidents

MOTORCYCLE ACCIDENTS RISK FACTORS AND SAFETY IMPROVEMENTS

Motorcycle Accidents Risk Factors

It appears from the literature that the determinant factors of motorcycle accidents and injury event are divided into three main following categories:

Rider's Behavioral Factors: One of the main reasons of motorcyclists being killed is because the motorcycle itself provides virtually no protection like- safety helmet, clothes etc in an accident. A study (White, 2007) reveals that the main cause of death due to motorcycle accidents is head and neck injury which occur largely for lack of protection. In addition, motorcyclists are capable to travelling at very high speed that increases their risk in the event of crash. Approximately 80% of reported motorcycle accidents result in injury or death while comparable figure for automobiles is about 20%. On the other hand, new riders who are over involved in accidents have a higher risk of being involved in crash because of their lack of experience

Vehicular Factors: Vehicular defects like tire punctures, lack of maintenance, difficulties of braking system is also dominant factors in motorcycle accidents. Vehicle involvement in accidents might be revealed from a study (Espinosa, 2002), when classified by the collision, nearly 74% cases were crashes with motor vehicles, 6% between motorcycles and 22% with fixed objects.

Roadway Factors: Of many roadway factors related to accidents, conspicuity is one of the main roadway factors that invite so many motorcycle accidents. Obstructed vision by usually stationary or mobile vehicles or by fixed objects is very common in Bangladesh. Roadway defects like poor quality and irregularity of roadway surface is directly related loss of control and most likely to cause single vehicle collision. Unconscious pedestrian action, animal involvement, fuel spills are also in account in motorcycle accidents.

In-depth studies of motorcyclist's risk factors in Bangladesh are required for greater understanding of the problem.

Safety Improvements

For motorcycle safety improvements, a series of remedial measures are needed by the combination of engineering, enforcement and behavioral measures:

- Physical Segregation of motorcycles, providing dedicated separate lane (Figure-9) or separate motorcycles path might be intended to maximize motorcyclist's safety along the road links.
- Visual Segregation of motorcycles might be provided by white line marking on the carriageway.
- The enforcement of helmet wearing, lane maintaining, speed controlling, waiting restriction in the vicinity of road etc to be ensured for through immediate integrated programs.
- Taking into account the proper licensing, training, environmental and socio-economic all factors, a rapid, safe, convenient, comfortable, and environmentally compatible road environment might be ensured.

Some of the above measures are relevant to the Bangladesh situation and require urgent attention for the safety improvements of motorcyclists.

Figure 9: Typical Figure of Physical Segregation of Motorcycles

CONCLUDING COMMENTS

Some aspects of motorcycle safety problem in Bangladesh are discussed in this paper. Motorcycle crashes are emerging as a serious road safety issue in Bangladesh claiming over 200 deaths and many more injuries annually. The increasing trends of motorcyclist casualties pose a great challenge to road engineering professionals. A series of remedial measures are needed by the combination of engineering, enforcement and behavioral measures. Understanding of the underlying factors associated with motorcyclists' risk is a critical step in developing strategies, policies and effective measures and thereby making motorcycling a more viable and safe mode of transportation in Bangladesh.

AKNOWLEDGEMENT

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