COST EFFECTIVE DESIGN OF CONCRETE PAVEMENT USING USED FOUNDRY SAND

B. Ahmed*, M. T. Hossen, M. M. Rana & M. R. Islam

Department of Civil Engineering, Rajshahi University of Engineering & Technology, Rajshahi-6204, Bangladesh
**Corresponding Author: bulbulruet@gmail.com*

ABSTRACT
Concrete is the most undisputable material being used in infrastructure development throughout the world. The reduction in the cost of concrete production has resulted in the increased need to find new alternative materials. The aim of the study is to minimize the cost of concrete pavement. The alternative material, Used Foundry Sand which is generated by metal casting industry is partially replaced by natural sand. The fine aggregate has been replaced by used foundry sand accordingly in the range of 10%, 20%, 30%, 40% & 50% by weight for M-20 grade concrete. Compressive and flexural strength tests are conducted for 7, 14, 28 days curing period, and compared with the conventional concrete. Maximum compressive and flexural strength are found for 20% replacement of used foundry sand (FA_2) with respect to the conventional concrete (A_0). The pavement slab thickness and construction cost reduced to 6 cm and 22% respectively in case of concrete FA_2.

Keywords: Pavement; used foundry sand; compressive and flexural Strength; cost effective

INTRODUCTION

The maintenance cost of flexible pavement is more than concrete pavement but it is more stable, durable than flexible pavement. Sand is a major material used for preparation of concrete and plays an important role in mix design. In general consumption of natural sand is high, due to the large use of concrete and mortar. Hence the demand of natural sand is very high in developing countries to satisfy the rapid infrastructure growth. The developing country like Bangladesh facing shortage of good quality natural sand and particularly in Bangladesh, natural sand deposits are being used up and causing serious threat to environment as well as the society. Rapid extraction of sand from river bed causing so many problems like losing water retaining soil strata, deepening of the river beds and causing bank slides, loss of vegetation on the bank of rivers, disturbs the aquatic life as well as disturbs agriculture due to lowering the water table in the well etc. are some of the examples. For the reduction in the sources of natural sand and in the cost of concrete production has resulted in the increased need to find new alternative materials to replace river sand, so that excess river erosion is prevented and high strength concrete is obtained at lower cost. Used foundry sand can be the good replacement of river sand.

Metal foundries use large amounts of sand in the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry and the remaining sand that is termed as foundry sand is removed from foundry. To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them and use of foundry sand in various engineering applications can solve the problem of disposal of foundry sand and other purposes. This study presents the information about the civil engineering applications of foundry sand which is technically sound, cost effective and is environmentally safe. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry sand can be used as a partial replacement of fine aggregates to achieve characteristic properties of concrete.

This study presents the information about the civil engineering applications of foundry sand, which are technically sound, cost effective and is environmentally safe.

METHODOLOGY

Foundry sand

Metal foundries use large amounts of sand in the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry and the remaining sand that is termed as foundry sand is removed from foundry. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry Sand can be used as a partial replacement of fine aggregates to achieve characteristic properties of concrete. The Physical appearance of used foundry sand and chemical compositions of used foundry sand is represented in Fig. 1 and Table 1 respectively.

Fig. 1: Physical appearance of used foundry sand

Table 1: Chemical compositions of used foundry sand

Constituents	Value (%)
SiO_2	87.91
Al_2O_3	4.70
Fe_2O_3	0.94
Cao	0.14
MgO	0.30
SO_3	0.09
Na_2O_3	0.19
K_2O	0.25
TiO_2	0.15
SrO	0.03
LOI	5.15

Design Mix

A mix of M-20 grade is designed as per IS: 10262-1982 and the same is used to prepare the test samples. The design mix proportion is 1:1.50:3.20 and w/c ratio is 0.50. The evaluation of Used Foundry Sand to use as a replacement of fine aggregate begins with the concrete testing. The fine aggregate has been replaced by Used Foundry Sand accordingly in the range of 10% (FA_1), 20% (FA_2), 30% (FA_3), 40% (FA_4) & 50% (FA_5) by weight for M-20 grade concrete. The (6 in × 6 in × 6 in) cube for compressive strength test and (4 in × 4 in × 20 in) beam for flexural strength test are made, tested and compared in terms of compressive and flexural strength with the conventional concrete. Samples are tested after 7, 14 and 28 days for compressive strength and 28 days for flexural strength tests.

Compressive Strength and Flexural Strength

Compressive strength tests are performed on compression testing machine using cube samples. Three samples per batch are tested with the average strength values reported in this paper. The loading rate on the cube is 35 N/mm^2 per min. The comparative studies are made on their characteristics for concrete mix with partial replacement of fine aggregate by used foundry sand as 10%, 20%, 30%, 40% and 50% respectively.

The flexural strength is determined by the central point method. Standard metallic beam molds (4 in × 4 in × 20 in) are cast for the preparation of concrete specimens for flexural strength. A table vibrator is used for compaction of hand filled concrete beams. The specimens are de molded after 24 hours and subsequently immersed in water for different age of testing. For each age three specimens are used for the determination of average flexural strength. The test is performed on Universal Testing Machine (UTM) having capacity of 50 BT.

The variation of compressive strength and flexural strength at 28 days curing period is represented in Fig. 2 and Fig. 3.

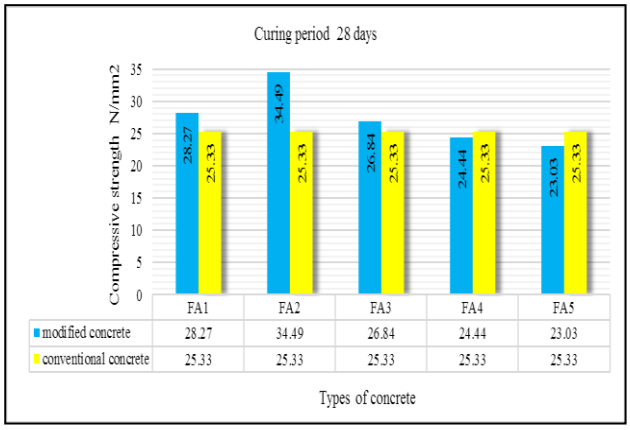


Fig. 2: Compressive strength at 28 days curing period

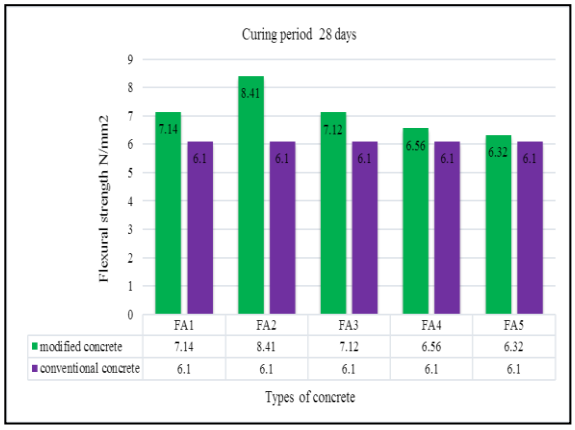
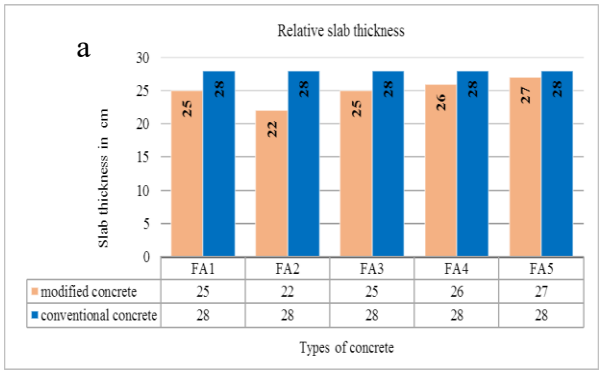


Fig. 3: Flexural strength at 28 days curing period

RESULTS AND DISCUSSIONS

Economic feasibility

A cement concrete pavement has been designed for a four-lane two-way National Highway in Rajshahi city from Talaimari MOR to Kalpona Cinema Hall. The total two-way traffic is 4500 commercial vehicles per day at the end of the construction period. (Source: Rajshahi City Corporation). The relative thickness and cost for different types of concrete modified by Used Foundry Sand is represented in Fig. 4 (a & b).



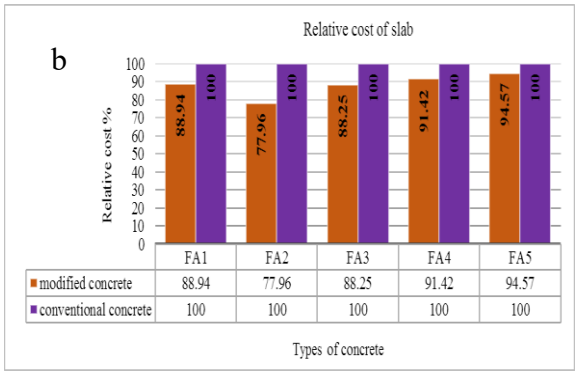


Fig. 4: The relative slab thickness (a) and relative cost of slab (b) for different types of concrete

CONCLUSIONS

After conducting compressive and flexural strength test of specimen made by partially replacing the river sand with Used Foundry Sand for different percentages, then a concrete pavement has been designed. The thickness of pavement slab is reduced and the relative cost of pavement construction is reduced almost 22% for concrete FA_2.

DETERMINATION OF WALKWAY USAGE INDEX IN MARKET AREA OF DHAKA CITY

N. K. Zinia*, A. A. Mamun & F. Sultana

Department of Civil Engineering, Ahsanullah University of Science and Technology, Dhaka, Bangladesh
**Corresponding Author: ziniaaust@yahoo.com*

ABSTRACT
The study is focused on determining the walkway usage index in market area of Dhaka city. Two prominent market areas like New Market & Bashundhara City Shopping Mall were selected to perceive the overall condition of pedestrian walkway of Dhaka city. Historical research shows that a very few researches were conducted on pedestrian friendly walkway. The study reveals that walkway usage index in market places of Dhaka City is almost half of the total pedestrians in both peak and off peak hours which indicate approximately half of the total pedestrian is unable to use walkway of market area. The reasons behind this problem are unavailable walkway width, presence of hawker along the road, poor surface condition of walkway, insufficient road crossing facilities etc. There is a proportional relationship between the usable area and walkway usage index. The overall quality of walkway is found average in our observation. The aim of this research work was to identify overall condition of pedestrian walkway and their usage which would facilitate the authority to take proper steps to provide remedy to the problems of walkway in the market places of the City.

Keywords: Market place; pedestrian; walkway usage index

INTRODUCTION
Walking is a commonly used mode of transport for people in Dhaka City. The proportion of trips made by walking is substantial, and for some people walking is not only a matter of choice and convenience, but also a matter of economic necessity.It is also a way to get rid of traffic jam. According to some estimates, nearly 40% of the pedestrian walkways are being occupied illegally. As a consequence, pedestrians are often forced to walk in the street instead of on the footpaths that results pedestrian injuries and traffic congestion (The Strategic Transport Plan Final Report, December 2005). Walkway usage index is a new term introduced here. The term is 'Walkway Usage Index' which may be defined as the percentage of pedestrians among the total users who are willing to/capable of using an existing walkway on that travelling route. It also lightens up about the condition of the walkway in the selected areas and the reasons behind the reluctance of using walkway in the market area.
A previous DevCon (2009) report noted that there are only about 400 kilometres of walkways within the DCC area, compared to a road network of 1,293 km. The ideal condition is walkways should exist on both sides of a street; this suggests that Dhaka should have almost 2,600 km of walkway. However, only 37% of observed roads had walkways on both sides, and almost half had none at all [2].Moreover, in Dhaka City most of the walkways do not meet the ideal quality. Due to that reason majority of the pedestrians in Dhaka City are compelled to walk on the road instead of walkway. About 40% of the total trips are made on foot in Dhaka but the pedestrians are facing many problems while using the walkways.
According to BRT (Bus Rapid Transit) report a major factor in pedestrian injury is the lack of good quality walkways, as people are forced to walk on the road. A recent analysis of total 5836 reported road accidents which occurred in metropolitan Dhaka during the period January 1998 to December 2004 has provided some characteristics of the pedestrian accidents. There were 2726 pedestrian accidents in metropolitan Dhaka in seven years which is 48% percent of total accidents (Dhaka Metropolitan Police Database, 2004).Current statistics revealed a deteriorating situation in Metropolitan Dhaka. Pedestrians are now making up approximately 72% of road fatalities, 45% of casualties and are involved in about 48% of all reported accidents. Over all Bhutan and Nepal had the highest share of pedestrian deaths

whereas industrialized countries like Denmark, France, Germany, USA has much lower deaths(Rahman et al., 2006).

Dhaka is situated in the economic heartland of Bangladesh. This city is one of the fastest growing startup hubs in the world. There are many market areas around Dhaka city. The major market areas of the city are New Market, Bashundhara City, Bango Bazar, Jamuna Future Park. Historical research shows that there are few analyses had taken place before about pedestrian friendly walkway. Therefore, the quality of pedestrian walkways in Dhaka City and the overall condition of its walkway have not improved enough to provide pedestrians a friendly and safe walkway. However, this research will try to portray the picture of existing walkway conditions around market area of Dhaka City from a set of traffic, geometric and choice rating data collected from the study site. This study will determine the percentage of users who refrain themselves from using walkways for walking and also find out the reasons that affecting the people to walk on the roadway instead of walkway. This research may help to gain some insights about the policies and options for pedestrian friendly walkway in Dhaka city.

STUDY METHODOLOGY AND DATA COLLECTION

Choice of Location (Market Place)

In this study, walkways of two different market areas of Dhaka city Bashundhara City and New Market were selected to perceive the pedestrian behaviour of market area because of land use diversity, different groups of consumers and highly attracted zones for different income people. New Market area is composed of some institutional land use and with some shopping centers. Well known Dhaka University campus is very close to this area and some other institutions are at a walking distance too. Bashundhara City is one of the largest markets of Bangladesh has constantly been named as one of the most visited attractions in Bangladesh. It is nearer to Karwan Bazar which is designated as a business district and commercial zone of Dhaka City.

In every location, a 500m long walkway was selected for the study. Then each walkway was divided into 5 segments. It means each segment was 100m long, total 10 segments of 1 km long walkway were considered to be surveyed.

(a) (b)

Fig. 1: (a) The selected 500m walkway in front of New Market; (b) The selected 500m walkway in front of Bashundhara City Shopping Mall.

Data Collection

The whole data collection procedure was conducted from October to December of 2014.For survey and data collection, working days were chosen rather than holidays to get the actual walkway using rates by the pedestrian. Besides the day and time, the weather condition was also taken into consideration. Some typical issues were found on these walkways which are attached here to give a clear view about the walkway of those selected areas.

Walkway Occupied by Hawkers (New Market area)

Obstruction on Walkway (New Market area)

Poor Quality of Walkway (New Market area)

Presence of Hawkers (Bashundhara City area)

Portion of Over Bridge on Walkway and Construction Material on Walkway (near Bashundhara City market area)

Collection of Geometric and Pedestrian Data in Study Areas

The geometric data was collected with the help of pedometer (An Android App using on a cell phone) and endomondo (tracker type Android App).The length and profile of walkways, length of obstruction which was long enough to measure with a tape was measured with pedometer. The regular and effective width of walkway, width of buffers and shoulders, width of obstruction were measured with the measuring tape. Manual counting like tally sheet method had been adopted for pedestrian counting. Detail video recording of pedestrian flows in this study walkway was recorded.

Table 1: The collected geometric data of the walkway of New Market

Sl No.	Collected Data	0-100m	100-200m	200-300m	300-400m	400-500m
1	Average width of walkway(m)	2.03	2.03	2.46	1.32	2.03
2	Average height of walkway(m)	0.254	0.152	0.152	0.152	0.229
3	No of barrier	24	0	0	0	0
4	No of driveway	0	0	0	1	0
5	No of sideway	0	0	1	0	1
6	Pedestrian volume(male) for 15 minutes counting(off peak) on walkway	122	168	175	209	226
7	Pedestrian volume(female) for 15 minutes counting(off peak) on walkway	93	96	62	45	70
8	Pedestrian volume(male) for 15 minutes counting(off peak) out of walkway	177	223	218	193	193

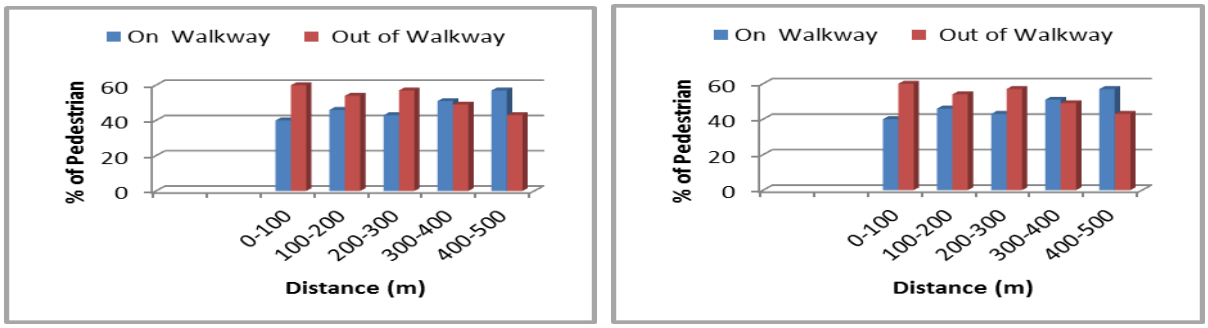
9	Pedestrian volume(female) for 15 minutes counting(off peak) out of walkway	143	90	95	48	34
10	Pedestrian volume(male) for 15 minutes counting(peak) on walkway	137	183	197	173	297
11	Pedestrian volume(female) for 15 minutes counting(peak) on walkway	82	93	85	48	75
12	Pedestrian volume(male) for 15 minutes counting(peak) out of walkway	192	247	187	212	203
13	Pedestrian volume (female) for 15 minutes counting out of walkway	111	117	103	77	90

Table 2: The collected geometric data of the walkway of Bashundhara City

Sl No.	Collected Data	0-100m	100-200m	200-300m	300-400m	400-500m
1	Average width of walkway(m)	1.75	2.10	2.29	3.10	2.73
2	Average height of walkway(m)	0.235	0.235	0.305	0.305	0.419
3	No of barrier	0	0	0	0	0
4	No of driveway	6	2	0	4	1
5	No of sideway	0	0	0	0	0
6	Pedestrian volume(male) for 15 minutes counting(off peak) on walkway	395	373	361	105	96
7	Pedestrian volume(female) for 15 minutes counting(off peak) on walkway	35	32	39	12	17
8	Pedestrian volume(male) for 15 minutes counting(off peak) out of walkway	97	101	88	152	117
9	Pedestrian volume(female) for 15 minutes counting(off peak) out of walkway	26	21	36	33	22
10	Pedestrian volume(male) for 15 minutes counting(peak) on walkway	515	541	437	122	132
11	Pedestrian volume(female) for 15 minutes counting(peak) on walkway	45	53	78	13	17
12	Pedestrian volume(male) for 15 minutes counting(peak) out of walkway	122	152	117	252	185
13	Pedestrian volume(female) for 15 minutes counting(peak) out of walkway	17	37	34	41	31

DATA ANALYSIS AND RESULTS

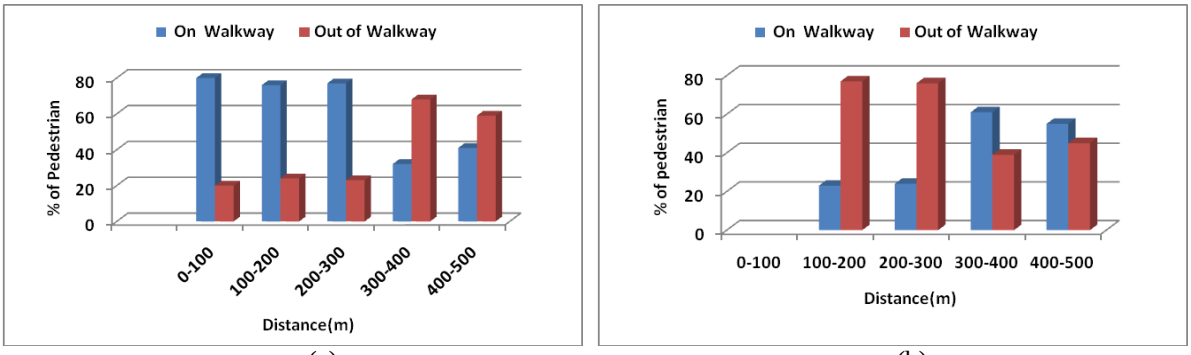
Walkway Uses Index for Total participants



(a) (b)

Fig. 2: (a) Comparative view on percentage of pedestrians moving on & out of walkway on peak hour in New Market area; (b) Comparative view on percentage of pedestrians moving on & out of walkway on off peak hour in New Market area

Data represents that in New Market Area both in peak and off peak hour the percentage of the pedestrian on the walkway is approximately more than 45% whereas the percentages of the pedestrian walking out of the walkway is approximately more than 50%. That indicates more than half of the total users could not use the walkway for the presence of hawker, crowd of pedestrian, various obstruction & other different reasons.
The observation found that the percentage of female pedestrians were comparatively more or same than male on the outside of walkway in most of the segments both in peak and off- peak hour which indicates female pedestrians face more problems than male in New Market areas which compelled them to share the road with vehicle.



(a) (b)

Fig. 3: (a) Comparative view on percentage of pedestrian moving on & out of walkway on peak hour in Bashundhara City area; (b) Comparative view on percentage of pedestrians moving on & out of walkway on off peak hour in Bashundhara City area

Here, data depicts that in Bashundhara City both in peak hour and off peak hour percentage of pedestrian walks above the walkway more than 60% & pedestrian walks outside the walkway is more than 35%.That means almost one third of total users could not use the walkway for different reasons.
In New Market area, pedestrian were compelled to walk outside the walkway more than Bashundhara City area. Both in these Market area of Dhaka City female pedestrian were compelled more than male to share the road with vehicle rather than walking on the walkway.

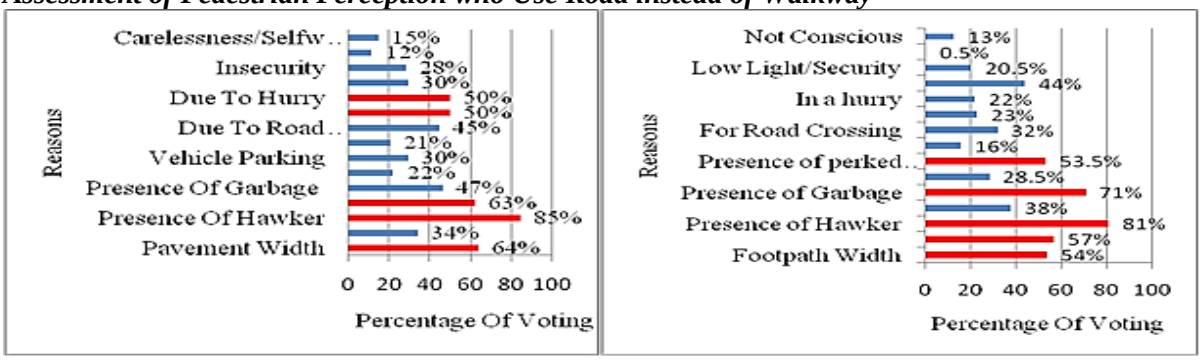
Walkway Uses Index with respect to Useable Walkway Area

Table 3: Comparison between the occupied area by obstruction and volume of pedestrian walking outside walkway

Study Location	Distance	Walkway Area(m^2)	Occupied Area(m^2)	Available Area(m^2)	% of occupied area	% of pedestrian outside walkway (off peak)	% of pedestrian outside walkway (peak)
New Market	0m-100m	203	121.03	81.97	59.6	60	58
	100m-200m	203	114.69	88.31	56.5	54	56
	200m-300m	246	81.8	164.2	33.3	52	54
	300m-400m	132	17.36	114.64	13.2	49	57
	400m-500m	203	20.87	182.13	10.3	43	44
Bashundhara City	0m-100m	175	12.65	162.35	7.2	22	20
	100m-200m	210	1.71	208.29	0.8	23	24
	200m-300m	229	0.63	228.37	0.3	24	23
	300m-400m	310	55.03	254.97	17.8	61	68
	400m-500m	273	52.50	220.50	19.2	55	59

From this table, it can be concluded that with the decreasing usable area the percentages of the pedestrians walking on the roads increases in both the market place areas.

Assessment of Pedestrian Perception who Use Road instead of Walkway



(a) (b)

Fig. 4: (a) Graphical presentation of questionnaire survey (New Market: out of walkway); (b) Graphical presentation of questionnaire survey (Bashundhara City shopping mall: out of walkway)

The graphical presentation in Fig 4(a) shows in the New Market Area the presence of the hawkers on the walkway is the major reason that 85% pedestrian has chosen as their choice of the factors to walk on road. 64% pedestrians thought pavement width is the reason behind their walking on the walkway. In Bashundhara City area in Fig 4(b), 81% pedestrian has also chosen road to walk due to presence of the hawkers and 71% pedestrians avoid walkway to get rid of the presence of garbage. Therefore, it can be concluded that to dispel the hawkers on the walkway is one of the prior steps that should be taken in order to foster a huge number of pedestrians to walk on walkway.

Assessment of Pedestrian Perception on Quality of Walkway

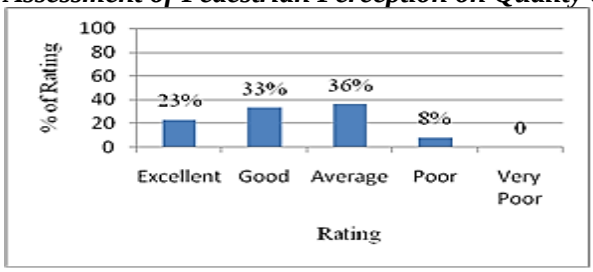


Fig. 5: Perception of Rating of New Market

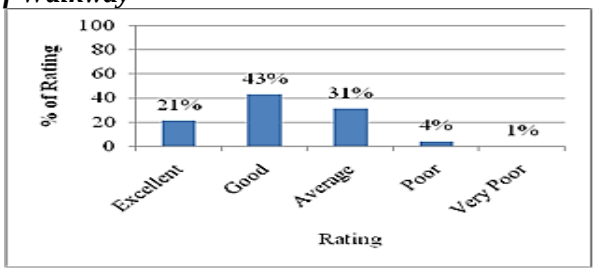


Fig. 6: Perception of Rating of Bashundhara City

In New Market Area analysis shows that 56% of the pedestrian's observation was within excellent to good but 44% of the pedestrians rated the walkway to be average and poor. Thus it can be stated the walkway as an average service providing walkway which has rooms for improvement. In the Bashudhara City area, analysis shows that 64% pedestrians thinks the walkway to be good and excellent whereas 36% deemed the walkway to be average or below average in service quality.

CONCLUSION

This study shows a significant number of people cannot use walkway. So, it can be said that the condition of pedestrian walkway in Dhaka City is not satisfactory. The aim of this study was to find out the walkway usage index of pedestrian perception about the existing walkway of market area in Dhaka City. The study was limited for only one type of area of Dhaka City. The detail study about this index can be performed to improve it as a new quality measure of walkway. Therefore, the further study should be required.

REFERENCES

Bangladesh Road Transport Authority, *Using a BRT Workability Strategy to Make Dhaka's Transportation Infrastructure Pedestrian-Friendly*.

Rahman, R; Mahmud, SMS; Hoque, MM and Ahmed, SN. 2006. Pedestrian Accident Characteristics in Dhaka: A Comparative Investigation. *International Conference Proceedings on Road Safety in Developing Countries*, BUET, Dhaka, 22-24 August, 84-90, P. N. – 15.

The Strategic Transport Plan Final Report (December 2005), *THE LOUIS BERGER GROUP INC BANGLADES CONSULTANTS LTD.*

STUDY ON NON-CONVENTIONAL MOTORIZED VEHICLE

M. N. Bari*, A. A. Mahmud, A. A. Masum & M. N. Rahman

Department of Civil Engineering, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh
**Corresponding Author: niamulbari@yahoo.com*

ABSTRACT
Within the last few years a massive revolution has been taken place in rural transportation system in Bangladesh by introducing locally manufactured non-conventional motorized vehicles that is gradually coming in international as well as national notice. These transport revolution is able to draw attention of the policy makers and researchers. These vehicles are modified form for transportation used normally in rural areas of Bangladesh. The aim of this study is to identify the existing conditions of the non-conventional motorized vehicle and focus on the critical issues that should be overcome to reach up to the standard mark. The field investigations were carried out on non-conventional vehicles considering the types, technical features, impact on socio-economy, environment, public health, etc. The results of the field investigation depicts that four types of vehicles are commonly available and are not safe for riding as well as environment friendly. However, they have a great positive contribution to rural socio-economy and transportation facilities and cannot be avoided from rural life. Therefore, further research need to be conducted for necessary improvement to overcome the short comings.

Keywords: NCMVs; rural transport; safety and risk; environmental impact; socio-economy

INTRODUCTION

By the turn of civilization and over the years, numbers of vehicle has been introduced in the transportation system for the human hauling and goods carrying. These are usually conventional motorized vehicles such as bus, truck, trailer, tractor, private car, jeep, etc. that are serving all over the world. The development of these conventional motorized vehicles has been made by the result of long time research. The comfort, safety, breaking system, noise level, sustainability, stability in static and dynamic state, etc. of these conventional motorized vehicles have been studied to maintain up to a certain standard level. These conventional motorized vehicles are also used in transportation system of Bangladesh. Besides these conventional vehicles, another transportation technology which is known as non-conventional motorized vehicle (NCMV) has been introduced in the urban and rural transportation in Bangladesh very recently (Scott Justice, 2004).

So far our knowledge goes, a little formal studies have been carried out on the widespread use of such non-conventional motorized vehicles which are locally called as “Nosimon”, “Korimon”, “Botboti”, “Fighter” (Scott Justice, 2004; Bari and Haque, 2011). The names are given by the rural people by matching with their rural culture and for the distinctive sound makes by the single cylinder diesel engines of these vehicles. These NCMVs have made their space in rural and even in some cases in urban transportation system stealthy due to the inadequacy of conventional transportation facilities, availability of locally manufacturing facilities with very inexpensive Chinese diesel engines (1000taka per HP; Scott Justice, 2004). The designs of these non-conventional vehicles are simple due to the fact that the rural workshops, with a stick welder, a drill press and in some cases a very old lathe, are presently not able to fabricate more complicated machinery. These vehicles are mostly used in rural areas of Bangladesh and their number is increasing day by day. This study focuses on – categorizing of the vehicles, capacity of hauling, purposes of use, engine specification, driving mechanism, overall engine performance, safety measures, environmental effect and socio-economic feasibility of the operation.

METHODOLOGY

A comprehensive field investigation was carried out at various places around Rajshahi City on non-conventional motorized vehicle to collect the detail information about the various types of NCMV used in rural and peri-urban areas. The investigation was conducted on types of vehicles based on the purposes of use, engine types, capacity of vehicle, specification of various engines used in particular purposes, physical dimension of vehicle, wheel size, breaking system, etc. Some opinion regarding the various subjects of NCMV from users were also collected by talking with the users. Finally, a summary was made based on the collected information and conclusion was drawn.

RESULTS AND DISCUSSIONS

Description of Non-Conventional Motorized Vehicles

Non-Conventional Motorized Vehicles are made in local workshops. The dimension of the vehicle depends on purposes and capacity of the engine. However, the size of these vehicles is made without any engineering design consideration. Components of these vehicles are same but most of the cases safety measures are not provided properly. The NCMVs are designed and fabricated as three wheeler rickshaw and tempo. There are four kinds of vehicles are observed around Rajshahi City those can be classified as (i) Motorized flatbed light rickshaw (MFBLR), (ii) Motorized flatbed heavy rickshaw (MFBHR), (iii) Motorized medium size tempo (MMST) and (iv) Motorized heavy duty tempo (MHDT). The characteristics of these NCMVs are summarized in Table 1.

Table 1: Characteristics of various types of non-conventional motorized vehicles

Items	MFBLR	MFBHR	MMST	MHDT
Local name	Nosimon /Fighter/ Botboti	Korimon/ Botboti	Noshimon/ tempo	Noshimon/ Botboti mini truck
Body	Length: 6 ft Width: 4 ft Height: 4 ft	Length: 9 ft Width: 4 ft-6 in Height: 4 ft	Length: 10 ft Width: 4 ft Height: 6 ft	
Engine	CHANG FA (China)		EME (China)	CHANGCHAI ZS1115 (China)
HP	2.5 ~ 4	4 ~ 8	8~12	25
Output	1h rating output- 4.47 KW 12h rating output-3.88 KW	1h rating output- 6.47 KW 12h rating output – 5.88 KW		
Wheel	Normal vangari are used.	Diameter of wheel is 18 in.	Diameter of wheel is 18 in.	Diameter of wheel is 26 in. and 30 in.
Stirring	Rickshaw handle	Rickshaw handle	Rickshaw handle	Wheel stirring
Brakes	Belt type brake is provided		Indian auto-rickshaw's axle's rear brakes	Conventional brake
Axel rotation	By rubber belt			By differential
Axel	Axel of normal rickshaw	Axel of Indian auto rickshaw		Axel of Indian truck
Speed	30~35 kmph	35~40 kmph	40~45 kmph	45~55 kmph
Skid	About 6 ft	About 5 ft	About 4 ft	About 2 ft
Light	No light	No light	Single light	Double light
Mirror	No mirror	Two mirrors	Two mirrors	Two mirrors
Speed Meter	No meter	No meter	No meter	With meter
Fuel	Diesel			
Mileage	Approximately 15 km per hour	Approximately 15 km per hour	Approximately 20 km per hour	Approximately 15 km per hour
Mobil consumption	2 Liter of lubricant is used for about 2.5 months for about 2500 km.			
Capacity	4 ~ 6 Passengers	6 ~ 8 Passengers	8 ~ 10 Passengers	Goods carrier (cows/ buffalos)

Motorized flatbed light rickshaw (MFBLR)

The smaller motorized rickshaw vehicles have a 2.5 - 4 HP engines and feature a very simple "single speed" V-belt clutch/transmission where a foot peddle/lever with idler pulley slowly tightens or engages the belt to begin moving forward. There is no reverse gear provision. The frame surrounding and supporting the engine are made in local workshops. Many times the front forks are also manufactured locally as the factory rickshaw forks are not strong enough for increased speed and poor road condition. The remaining frame, axle, tires, etc. are the commercially available rickshaw frames and parts. The rear brake is a piece of 4 inch flat belt (normally to power threshers and mills) wrapped around a 5 inch hub fixed on the rear axle around the hub and connected and tightened by yet another foot peddle to provide friction for stopping. Many times the commercial rickshaw front-wheel brake is also provided. They normally can carry 250 - 400 kgs of cargo/passengers. Costs are reportedly under 400USD. This type of vehicle is usually used for both man and goods carrying in rural areas of Bangladesh. Fig. 1 shows the typical motorized flatbed light rickshaw.

Fig. 1: Motorized rickshaw flatbed with 3 HP Chinese engine

This motorized flatbed rickshaw has become obsolete very recently. The place of this motorized flatbed rickshaw has been taken by rechargeable battery (electric power) driven flatbed rickshaw van after coming the electric rickshaw in market. This newly imported electric power driven rickshaw van has gained popularity because of lighter weight, noise free, smoke free, low initial and maintenance cost and easy operation.

Motorized flatbed heavy rickshaw (MFBHR)

Fig. 2 shows the typical motorized flatbed heavy rickshaw and other features are presented in Table 1.

Fig. 2: Motorized flatbed heavy rickshaw or 'vangari'

The MFBHR is heavier than that of MFBLR structurally and engine capacity. The body frame is made in local engineering workshop with MS angle, flat bar, rod, etc. Diesel engine manufactured in China of 4 to 8 HP is mounted on bed under the driver sit. Tempo wheels of 18 inch are used. Similar "Single speed" V-belt clutch/transmission as well as braking system is used in this vehicle as MFBLR. They normally can carry 400 - 500 kgs of cargo/passengers. Costs are reportedly under 500USD. This is also used for both man and goods carrying in rural areas of Bangladesh.

Motorized medium size tempo (MMST)

The medium size 3-wheeled vehicles are based on auto-rickshaw designs but whose frames and bodies are locally manufactured (Fig. 3). The engines are varying from 8-12 HP and have a similar belt transmission system but with heavier sometimes multiple V-belts. Many times these medium size vehicles may have two clutch levers with two sizes of drive pulley/drive belts on the engine that provide the machine a first and second gear. The rear axles are of various sizes can be from old Indian auto-rickshaws supplied from scrap yards, but with the planetary gears removed and a double chain or double belt pulley inserted in its place with a single drive axle/wheel. Tires and hubs are also purchased from scrap yards. These vehicles will sometimes have leaf spring suspension but coil springs seem to be the main suspension system and very few may have shock absorbers. The size and capacity varies greatly in this category. The brake system utilizes the Indian auto-rickshaw's axle's rear brakes and rarely features a front brake. They generally have a small simple belt driven dynamo attached for headlamp/night time driving. This category or vehicles are the most numerous and author estimates there could be upwards of 10,000 or more on the roads around Bangladesh. Their cost ranges from 500-1000 USD.

Fig. 3: Motorized medium size tempo (MMST)

Motorized heavy duty tempo (MHDT)

Though in the beginning found in much fewer in numbers but in recent years the heavy duty 3-wheel vehicles are gaining popularity. They range from 12-25 HP engine capacity. The one shown below is a top-of-the-line model that uses a 25 HP Chinese diesel engine that is connected by three heavy V-belts to a heavy duty Japanese van's 5 speed clutch and transmission and duel wheel rear axle (Fig. 4). An automobile battery/alternator charging system is belt driven from the engine and the vehicle has two front headlights and rear running lights and brake lights. It substantial main frame and front tire suspension is locally manufactured. The rear brakes are the Toyota's and there is no front brake. The steering assembly is also cobbled together from the Toyota's steering wheel and gear. Admittedly, this featured vehicle is one of the most sophisticated that the author has seen but illustrates what is possible in many of these less sophisticated but highly motivated workshops. Cost range over 1000 USD.

Short Comings of Non-Conventional Motorized Vehicles

The vehicles are manufactured without following proper design considerations by any automobile engineer such as dynamic stability, braking efficiency, vibration, sock absorption, noise control, comfort, etc. Even though, most of the components fabricated locally are not designed following any

engineering analysis for choosing the section and size. Therefore, safety factors are not properly provided to the components of these vehicles.

Fig. 4: Motorized heavy duty tempo (MHD)

The short comings of the non-conventional motorized vehicles can be summarized as:

i. Brakes are not sufficient in case of emergency.
ii. Rubber belt and rotating shaft are used for braking which are not checked regularly.
iii. As break system is not good it has skidding and slipping tendency.
iv. Lighting arrangement of these vehicles is not sufficient but drivers don't hesitate to drive vehicle at night time. Passengers often take this risk to reach at home quickly.
v. In most cases mirror is not used. So driver cannot get rear view and thus has risk of accident while vehicle from back tends to overtake.
vi. The limit of speed often goes beyond the control of driver due to the absence of meter.
vii. The capacity of these vehicles is not too much but drivers have a tendency to carry more people or goods at a time to earn more money. They are not aware and do not care about capacity of the vehicle.
viii. Drivers are mostly of age about 14 to 25 years old. They do not have proper training or driving license.
ix. Drivers have the competitive tendency for driving.
x. There is no safety measure for passengers and even for drivers.
xi. Sitting arrangement for driver is at very high level in most cases and uncomfortable.
xii. The vehicles are not registered to road transport authority.
xiii. There is no route permit and certification system for running.
xiv. There is no information about number of vehicles, owner, address of owner, capacity, purpose of use, etc. to road transport authority.
xv. The traffic management division is not able to take necessary action against them for disobeying the traffic rules.

Impact of Non-Conventional Motorized Vehicles on Socio-economy

Nobody can deny the contribution, importance, necessity of non-conventional motorized vehicles in rural transportation system in our country though it has many negative impacts. The non-conventional motorized vehicles are mostly used in rural areas where transportation system is not improved and conventional motorized vehicles are rare or not sufficient. It has developed easy transportation system for carrying the goods as well as people in rural life which has also mobilized the social and economic development. The rural people easily can carry their products for selling in urban market at higher price. On the other hand, they also can run their business comfortably by buying necessary goods from urban market for selling in rural area. Therefore, this transportation system has made comfortable rural life with easily available urban advantages.

Furthermore, it has opened an opportunity for earning money from rural transportation business. Most of the cases the drivers are owner of their vehicle they drive. Many cases it is observed that this transportation business is the major earning source of the family. In this case mostly 3 to 6 people are

dependant on this income. A questioner survey was conducted among 143 drivers of non-conventional motorized vehicles around the Rajshahi City. The results are summarized in Table 2.

Table 2: Socio-economic survey of non-conventional motorized vehicles drivers

Items		MFBLR	MFBHR	MMST	MHDT
Surveyed vehicle (Nos.)		36	28	62	17
Driver age	12-15	12%	9%	16%	2%
	16-20	29%	19%	26%	16%
	21-25	43%	54%	47%	58%
	>26	16%	18%	11%	24%
Ownership	Self	100%	100%	94%	70%
	Other	0%	0%	6%	30%
Dependent	0	11%	9%	4%	0%
	1-2	13%	27%	11%	12%
	3-4	34%	23%	47%	47%
	5-6	42%	41%	38%	41%
Daily income	Tk.	500-700	500-800	600-800	800-1200

On the other hand, many engineering workshops have been developed in the rural areas. All the engineering workshops are very busy for manufacturing, repairing and maintenance of these non-conventional motorized vehicles. A good numbers of people are working in these workshops though in many cases children are found as worker. Mostly they are learners and not working as employee. It is also found that some children workers are to be paid though the amount is small. In some cases, it is observed that the children workers are earning person for their family. Therefore, these non-conventional motorized vehicles have great contribution to the socio-economy of rural life and many cases that is the only way to living for the low income rural people.

Impact of Non-Conventional Motorized Vehicles on Environment and Public Health

Like as conventional motorized vehicles, non-conventional motorized vehicles have also effect on environment and public health as well. These are affecting the environment and public health directly, indirectly and cumulatively by their discharge, emission, partially burnt fuel exhaust and noise. Some times the noise exceeds 100 db based on engine types and conditions which is excessive comparing to the conventional vehicles and allowable limits. Bari and Haque (2011) has also measured the noise level at different distance from source which varying from 84 to 76 db.

Accident of Non-Conventional Motorized Vehicles

The drivers have no institutional training and driving license. Moreover, vehicles are with least safety measures. Furthermore, as drivers are of young aged, they do not care about safety and drive recklessly. Therefore, they often fall on accident. The usual nature of accidents are overturning, falling in nearby ditch, head to head collision, pushing and knocking from back. As a result, numbers of people become injured and even died every year by accident.

CONCLUSIONS

These vehicles are best choice for rural transportation now days and their numbers are increasing day by day. It has become an essential part for rural transportation system and absence of these vehicles will cause great problem for rural people. A number of people earn their lives by driving this vehicle. However, these vehicles are not environment friendly as well as safe for riding. The drivers have lack of awareness and proper training on driving. Therefore, the automobile engineers have to take the necessary initiatives to conduct research for the improvement of these non-conventional motorized vehicles to overcome the shortcomings. On the other hand, road transport authority and traffic management division should take proper step to make them aware and trained for safe driving and following traffic rules.

REFERENCES

Scott Justice (2004). A Not So Quiet Transport Revolution in Bangladesh: A case study on rural motorized three-wheelers in Bangladesh, NAEF 2004. http://www/naef-nepal.org

Bari, QH and Haque, KW. 2011. Is It an Issue to Think About the Spreading of Shallow Engine Vehicles? A Case Study In & Around Khulna City. *Proceedings of the International Conference on Environmental Technology & Construction Engineering for Sustainable Development*, ICETCESD-2011, March 10-12, SUST, Sylhet, Bangladesh.

A STUDY ON VALUE OF DELAY AT RAILROAD INTERSECTION DUE TO CONGESTION: A CASE STUDY OF DHAKA CITY CORPORATION (DCC) AREA

M. H. Hasan[1*], S. B. Kadir[2], M. Sen[1] & S. K. Mitra[3]

[1]*Norwegian University of Science and Technology (NTNU), Trondheim, Norway*
[2]*Hochschule für Technik Stuttgart, Stuttgart, Germany*
[3]*Department of Urban and Regional Planning, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh*
**Corresponding Author: nabin.urp@gmail.com*

ABSTRACT
Traffic congestion is a global issue for which certain communities are inevitably suffering from the constant waste of precious resource of time. It's also a crucial problem in Dhaka, the capital city of Bangladesh. One of the major reasons for this congestion is at grade railroad intersections which causes wastage of time. The main focus of this paper is to determine the value of delay time at major railroad intersections during the crossing of trains. The valuation of delay time is calculated on the basis of average wage rate of vehicle users. The average delay takes place in each major intersections during the working period of the day is 85 minutes and annual value of delay in major railroad intersections of Dhaka city is approximately 0.92 Billion BDT (Bangladeshi Taka-The currency of Bangladesh).

Keywords: Average wage rate; traffic congestion; railroad intersection; value of delay

INTRODUCTION
Congestion is a relative phenomenon which reflects the difference between expectation of users on the roadway system performance and actual road system performance (OECD, 2007). In general, this congestion as well as delay may be fixed in nature and caused due to a traffic signal or rail crossing. On the other hand, it may also be caused due to the interference of other traffic, inadequate capacity of road and poor road condition (Kadiyali, 2003).

However, Dhaka city is facing a huge loss every year due to traffic congestion. From a study of Roads and Highway Department (RHD), the estimated yearly congestion cost for Dhaka city is nearly $3 billion (The Daily Star, 2010). Railway level crossing signals are playing a significant contribution to this congested condition by generating a fixed delay every day.

Railroads play a vital role in the transportation system of Dhaka city by providing access to transportation for industrial or personal uses. Several roads including major arterial roads within the Dhaka City Corporation (DCC) area, intersects with these rail roads. When a rail line is at the same level with road, a variety of problems including congestion, safety incidents, and higher pollution occurs. With the increasing train traffic and vehicle levels, more vehicles are being delayed from their destinations due to the impedance at grade crossings. This wastage of time has an adverse effect on individual's income as well as national income which ultimately results in loss of productivity.

The benefit of saving time could have been received by taking an alternative action. In general, grade separations, such as overpasses and underpasses between rail lines and surface streets, are used to reduce the problems related to grade crossings. The construction of these overpasses and underpasses can effectively eliminate the delays associated with grade crossings. But for a developing country like Bangladesh, grade separations can be very expensive solution and less feasible. Due to these financial constraints, a feasibility study will be required before taking any decisions and value of delay in railroad intersection has to be determined.

OBJECTIVE

The main purpose of this study is to determine the cost of delay time due to congestion at railroad intersections on major arterial roads of DCC area.

ASSUMPTIONS

- Four categories of vehicle: cars, bus, truck and Non- Motorized Vehicle (NMV) are considered.
- Car includes only private car, taxi and Compressed Natural Gas (CNG) driven auto rickshaw.
- It has been assumed that, all the vehicles that are counted in vehicle count survey had been waiting from the beginning of the level crossing signal.
- Any human being below the age of 18 years has been considered to be a child (Young, 2007).

METHODOLOGY

The whole research is based on extensive survey, such as – delay time survey and vehicle count survey. Average wage rate method is mainly used to determine the value of delay. A detailed schematic diagram is given below.

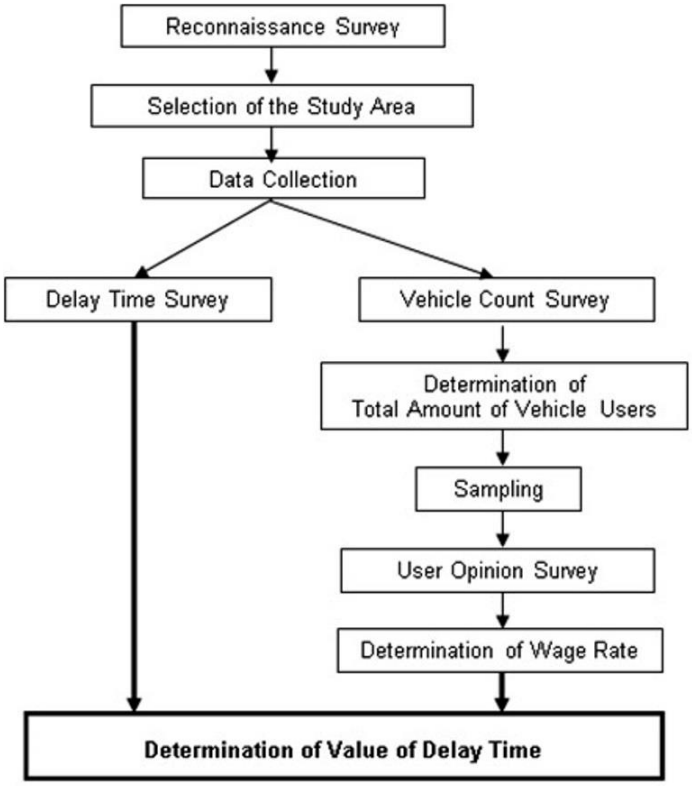


Fig. 1: Methodology

Selection of Study Area

A development plan for Dhaka metropolitan area, titled as Dhaka Metropolitan Development Plan (DMDP) was accumulated by capital development authority of Bangladesh. It covers 1528 sq. km of land including the area of DCC. There are fifty railroad intersections in the DMDP area and among them forty are in the DCC area. Some of them are intersecting the roads which have high volume of traffic flow. Among these rail crossings across the DCC area, twenty-eight are authorized by Bangladesh Railway and twelve are unauthorized (Shuboktagin, 2011). Moreover, nine authorized rail crossing gates are in the same grade with the major arterial roads and are divided into two categories. Six intersections have accessibility both for motorized and non-motorized vehicles whereas only three intersections are only for motorized vehicles. All of these nine intersections have been considered as the study area for this research.

DETERMINATION OF VALUE OF DELAY

A detail reconnaissance survey was conducted to assess the present condition of the study area which has provided a guideline for necessary surveys required for this research. Other surveys named vehicle count survey, delay time survey and user opinion survey have also been conducted.

According to Road Master Plan 2009, the motorized vehicles are classified into three categories such as car, bus and truck (Roads and Highway Department, 2009). In this research, the vehicle count survey has been conducted for these three categories of motorized vehicles and non-motorized vehicles. Also a delay time survey was conducted. Delay time and vehicle count survey were conducted on a working day for each intersection. For a specific day (7:00am – 7:00pm), every moment when a train passes through the intersection point, time counting has started and vehicles were counted during that time.

From vehicle count survey it has been seen that, the volume of vehicles is high in Malibag, Senakunja and Khilgaon area. The lowest volume is at Saidabad.

Table 1: Composition of Vehicles at Different Intersections

Intersection	Car			Bus	Truck	NMV	Total
	Passenger car	CNG Auto	Taxi				
Saidabad	67	456	10	698	17	763	2011
Khilgaon	739	1610	103	211	35	13201	15899
Malibag	6714	2782	463	2092	504	18516	31071
Maghbazar	2887	1543	103	458	100	257	5348
FDC	2234	1227	201	94	97	487	4340
Mahakhali	4998	3414	305	1738	2	0	10457
Banani	2282	1205	201	112	5	348	4153
Senakunja	13161	3686	1214	2597	844	231	21733
Kuril	5754	1936	564	3854	495	0	12603

Source: Field Survey (2011)

Amount of vehicles have been converted to amount of users by multiplying with respective occupancy rate of vehicles. According to Road User Cost Annual Report (2010) of Bangladesh, the occupancy rate of car, bus and NMV are respectively 3, 36.4 and 2. The calculated amount of car, bus and NMV users are respectively 179577, 431486 and 67606. So, total population passing through these intersections using different types of vehicles (except truck) in a day is 678669.

After that, sample size of total population has been determined by using 95% confidence level and confidence interval of 5. The formula for sample size is-

$$Sample\ Size = \frac{P \times (1 - P) \times Z^2}{C^2}$$

Where, Z = Z value (e.g. 1.96 for 95% confidence level); P = Percentage picking a choice; C= Confidence interval

The total sample size for questionnaire survey is 384. Likewise, the sample sizes of car user, bus user and NMV user have also been determined and they are respectively 102, 245 and 39. After that, the ratio of car in each intersection has been determined. The obtained sample size for car has been distributed to these intersections according to this ratio. Same procedure has been followed for bus and NMV. Questionnaire survey was conducted by picking each type of vehicle users randomly at each intersection according to stratified sample size. The questions were asked about the age of vehicle user, their purposes for trip, individual income or household income and working hour. From the questionnaire survey, various types of information about 382 vehicle users were found. It has been found that, about 66.5% of vehicle users were wage earners and 41.2% of the trips were non-working

trip. Working trips were mostly made by buses and cars. On the other hand, most of the non-working trips were made by NMVs.
Afterward, each type of vehicle users has been categorized into several types on the basis of wage earning, age, trip purpose. Following chart represents various categories of user-

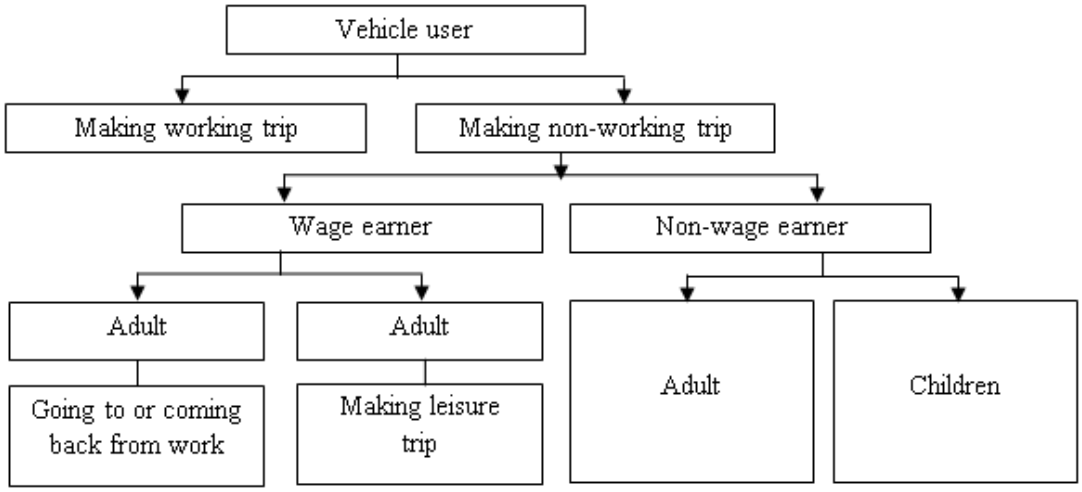


Fig. 2: Categories of Vehicle User

Finally, five categories have been arrived and average income per minute has been derived for each of the categories.

Wage earner user making working trip (F1)
Hourly income of this type of user was adjusted by multiplying by 1.33 to reflect additional employee related costs. This would include paid holidays, employment taxes, other compulsory contributions (e.g. employer pension contributions) and an allowance for overhead required to keep someone employed (Gwilliam 1997). So, the equations to determine the average income of this type of user are-

$$Average\ Hourly\ Income = \frac{\sum\left(\frac{\text{Monthly Income} \times 1.33}{\text{Working Hour}}\right)}{\text{Total Number of F1}}$$

$$Average\ Income\ per\ Minute = \frac{\text{Average Hourly Income}}{60}$$

Non-wage earner and adult user making non-working Trip (F2):
The income of this type of vehicle users has been taken as 30% of per head monthly household income (Gwilliam 1997). Hence the equations are-

$$Average\ Monthly\ Income = \frac{\sum\left(\frac{\text{Monthly Household Income} \times 0.3}{\text{Household Number}}\right)}{Total\ Number\ of\ F2}$$

$$Average\ Income\ per\ Minute = \frac{\text{Average Monthly Income}}{30 \times 24 \times 60}$$

Non-wage earner children user making non-working trip (F3):
Income of a children non-wage earner has been determined by considering it as 15% of total household income (Gwilliam 1997) and the obtained equations for this type of user are-

$$Average\ Monthly\ Income = \frac{\sum(\text{Monthly Household Income} \times 0.15)}{Total\ Number\ of\ F3}$$

$$Average\ Income\ per\ Minute\ = \frac{\text{Average Monthly Income}}{30 \times 24 \times 60}$$

Wage earner user, making non-working Trip for going to or coming back from work (F4)
Value of time saved of wage earner while making journey to the home or office in non-working hour has been assumed as 25% of hourly income (Kadiyali 2003). Additional employee related cost also was considered.

$$Average\ Hourly\ Income\ = \frac{\sum\left(\frac{\text{Monthly Income} \times 1.33 \times 0.25}{\text{Working Hour}}\right)}{Total\ Number\ of\ F4}$$

$$Average\ Income\ per\ Minute\ = \frac{\text{Average Hourly Income}}{60}$$

Wage earner user, making non-working trip for leisure purposes (F5)
Value of time saved of wage earner while making journey for leisure purposes has been assumed as 25% of hourly income (Kadiyali 2003).

$$Average\ Hourly\ Income\ = \frac{\sum\left(\frac{\text{Monthly Income} \times 1.33 \times 0.25}{\text{Working Hour}}\right)}{Total\ Number\ of\ F5}$$

$$Average\ Income\ per\ Minute\ = \frac{\text{Average Hourly Income}}{60}$$

After that, weighted average of all categories was calculated. Sample size of each user pattern has been considered as a weight factor. Weighted average income of car user, bus user and NMV user are respectively 2.23, 1.01 and 0.68 BDT per minute.

Table 2: Weighted Average Income

User pattern	Sample size			Average income (BDT/min)			Weighted average income (BDT/min)		
	Car	Bus	NMV	Car	Bus	NMV	Car	Bus	NMV
F1	59	93	12	3.61	2.23	2.07	2.23	1.01	0.68
F2	12	27	7	1.41	0.40	0.50			
F3	1	51	3	0.65	0.55	0.01			
F4	20	63	13	0.13	0.04	0.04			
F5	14	14	9	0.22	0.10	0.09			
Total	106	248	44						

From the delay time survey, it has been observed that, the extent of delay depends on this frequency of signals. As the frequency increases, the length of total delay also increases. Table 2 shows that, frequency of level crossing signal is the highest in FDC Rail Gate and it causes 64.63 minutes of delay. In contrast, the length of delay at the Saidabad intersection is only 45.5 minutes in a day, as the number of train passing through this intersection is lowest. Width of the road is another factor that influences the length of delay. If the width of the road, intersected by the rail track increases then the length of delay will also increase. For example, at Senakunja, the length of delay is 128.22 minutes, but the number of level crossing signal is not the highest. Finally, value of delay has been determined every time a train has approached in each intersection. Value of delay time for truck has been calculated separately using the standards from "Project Appraisal Framework, Road Sector Manual, 2005". Value of delay per truck is 2.77 BDT per minute (Planning Commission, 2005). Following equations have been used for the calculation.

$$VOT = VOT\ (bus) + VOT(car) + VOT(NMV) + VOT(truck)$$
$$VOT(bus) = Delay \times Number\ of\ bus \times Occupancy\ Rate\ of\ bus \times weighted\ average\ income\ of\ bus\ user$$
$$VOT(car) = Delay \times Number\ of\ car \times Occupancy\ Rate\ of\ car \times weighted\ average\ income\ of\ car\ user$$
$$VOT(NMV) = Delay \times Number\ of\ NMV \times Occupancy\ Rate\ of\ NMV \times weighted\ average\ income\ of\ NMV\ user$$
$$VOT(truck) = Delay \times Number\ of\ truck \times Value\ of\ delay\ per\ truck$$

Where, VOT= Value of Delay Time

Intersection wise calculation of delay time is given below:

Table 3: Value of Delay at Different Intersections

Intersection	No of approach	Total delay (min)	VOT (BDT) - Daily	VOT (BDT) – Annual
Saidabad	14	45.5	102385	37370525
Khilgaon	32	124.45	191324	69833260
Malibag	34	77.38	392327	143199355
Maghbazar	36	63.33	85068	31049820
FDC	37	64.63	62443	22791695
Mahakhali	33	60.1	220880	80621200
Banani	37	90.72	71822	26215030
Senakunja	35	128.22	875777	319658605
Kuril	36	96.97	540658	197340170
Total	280	705.8	2542684	928079660

Source: Field Survey (2011)

CONCLUSION

The output of this research reflects the adverse effect of congestion at railroad intersections. From this case study of Dhaka, it is seen that daily average loss of time is 84 minutes and its annual monetary worth value is approximately 0.92 billion BDT which is very alarming.

REFERENCES

Gwilliam, KM. "The Value of Time In Economic Evaluation of Transport Projects Lessons from Recent Research." *World Bank Web site.* January 1997. http://www4.worldbank.org/afr/ssatp/Resources/HTML/Models/RED_3.2/RED_Additional_Reference_Materials/InfrastructureNote_Value_of_Time.pdf (accessed January 1, 2011).

Kadiyali, LR. 2003. *Traffic Engineering and Transport Planning.* 6th Edition. New Delhi: Khanna Publishers.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT. "Managing Urban Traffic Congestion." *EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT.* Paris: ECMT, 2007.

Planning Commission. *Project Appraisal Framework, Road Sector Manual 2005.* Appraisal Report, Dhaka: Government of the People's Republic of Bangladesh, 2005.

Rajdhani Unnayan Kartripakkha. . *Metropolitan Development Plan Vol-I: Dhaka Structure Plan (1995-2015).* Dhaka: Hoque Printing Press, 1995.

Roads and Highway Department. *Road Master Plan.* Dhaka: Ministry of Communications, Government of Bangladesh, 2009.

Roads and Highway Department. *RHD Road User Cost Annual Report for 2004 – 2005.* Annual Report, Dhaka: Government of the People's Republic of Bangladesh , Ministry of Communications, 2005.

Shuboktagin, M. 2011. Interview by Mohammed Hamidul Hasan. *Number of railroad intersection in Dhaka city*.

The Daily Star. "Traffic congestion causes Tk 19,555cr loss a year: study." *The Daily Star*, July 22, 2010.

Young, A. 2007. Preventing, Demobilizing, Rehabilitating, and Reintegrating Child Soldiers in African Conflicts. *The Journal of International Policy Solutions*, VII: 19-24.

GEOMETRIC DESIGN OF T-INTERSECTION IN AN URBAN AREA

M. Jibon[1*], S. K. Palit[2] , M. M. Alam[2] & M. Robel[2]

[1]*Departmen of Civil Engineering, Southern University Bangladesh, Chittagong, Bangladesh*
[2]*Department of Civil Engineering, Chittagong University of Engineering & Technology, Chittagong, Bangladesh*
[*]*Corresponding Author: jibonce@gmail.com*

ABSTRACT
Geometric design of T-intersection is one of the essential parts for the development of city to reduce traffic congestion. Safe, efficient and economic operation of a highway relies on how assiduously geometric design of intersection has been worked out. That is possible only if the design elements have been meticulously considered. Chittagong city, the commercial capital of Bangladesh is considered as the heart of national economy. An efficient road network is badly needed here to boost up the economy of the country. There are many T-intersections in this city which are the cardinal points influencing the city roads and traffic conditions. Using the selected data and prescribed formula, the practical capacity have been evaluated and compared with the total traffic for the particular T-intersection. It has been found that the practical capacities are larger than the existing traffic volume. So geometric elements of the intersections can be treated as quite satisfactorily. But due to illegal parking and traffic mismanagements, traffic congestion is frequently observed at the T-intersection. For solving it, some suggestions are enclosed regarding traffic congestion and given remedial measures for T-intersection.
Keywords: geometric elements, T-intersection, practical capacities & traffic congestion.

INTRODUCTION
Transportation system is one of the infrastructures of a city. Most of the economic status depends upon the transportation systems. The efficiency, safety, speed, cost of operation and capacity of road systems very much depend on the intersection design. Some of the factors to be considered in intersection design. In roadway, intersection is the most critical part. Intersection is defined as the area where three or more roads intersect with is other. At the intersection turning and crossing depends on the types of intersection. The growth of traffic in road network of large cities is serious concern from traffic Engineers point of view. Improper intersection creates traffic congestion which affects the performance of intersection and overall road network. Intersection directly influences socio-economic development of the city as well as the country. So the intersection should be properly designed and managed. Chittagong City, the commercial capital of Bangladesh and the area experiencing rapid population growth and boom in vehicle number with traffic congestion has been examined in this thesis work.. The development of commercial area, residential area and industrial area are depends on intersection. Proper intersection design reduces jamming concentration which save the time and attract the foreigners for investment. Intersection is a compulsory part of traffic management system in the city area, must function properly to be success in achieving goals of regional development. From the above discussion the following objectives have been selected for the present study.

1. Investigation of some T-intersection at present condition and its problem identification.
2. To study the traffic volume of the present condition at the selected intersection.
3. To compare obtained result with standard values.
4. To propose a new channelization as a remedy for traffic congestion.

METHODOLOGY (SECTIONS)

The entire procedure is composed of some continuous functions following reaching point of finishing threshold. The work done under this project is shown with a flow diagram in Fig. 4.1.

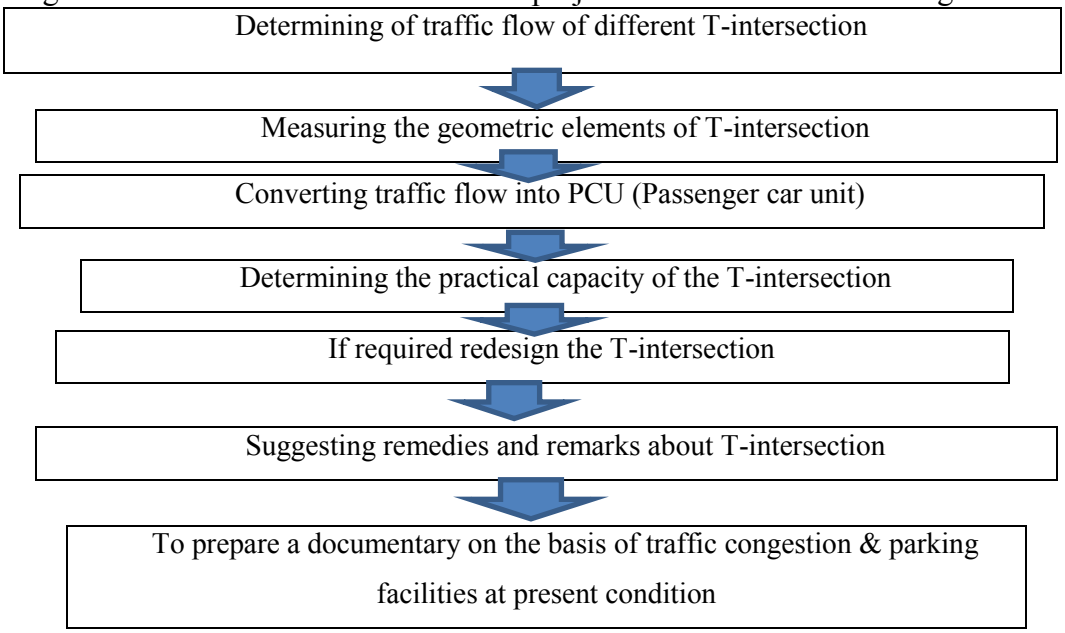


Fig 1: Work flow diagram showing the performed steps

Among many other intersection in Chittagong City two T-intersection sites(Kaptai Raster Matha and CNB intersection) under inspection and study have been selected as vulnerable ones those remaining in need of proper treatment. The performance of observing as well as auditing, the existing geometries at the selected intersection are successfully done. Tapes have been used to measure the present geometries. The weaving length, weaving width, entry width, radius and diameter of central island have been measured. The other geometries such as entry angle, exit angle, internal angle to weaving section are calculated. The traffic flow is counted manually at the selected intersection per hourly with left turning, right turning, straight and u-turning with carefully. The traffic survey is done at peak period. 7 hours traffic volume data were recorded for getting peak hour and also the maximum number of vehicles. The different types of vehicles are counted separately and converted into passenger car units [4] to get the generalized idea about the traffic flow. The geometric elements which govern practical capacity are measured and calculated. A generalised formula [5] recommended by The Transport and Road Research Laboratory (U.K) used to determine the practical capacity is mentioned in equation (1)

$$Qp = \frac{[280w(1+e/w)(1-p/3)]}{(1+w/l)} \quad (1)$$

A channelization in existing T-intersection with defined parking facilities is proposed for minimizing confliction between right turning and u-turning traffic. A channelization intersection is one in which traffic is directional into definite paths by islands and markings.

INVESTIGATION

Causes of traffic jam

Chittagong city is the busiest city in Bangladesh due to port of Karnophuli. Most of the goods transfer from this city to another city. So intersection is to be designed very carefully. Otherwise due to improper designed jamming concentration increases are various causes of traffic jam at the intersection. Some of the causes investigated at the T intersection. This types of congestion occurred due to traffic mismanagement, illegal parking and improper design of the intersection. Some of the causes of traffic jam at the intersection have been shown below:

1. Mismanagement of the traffic rules at the intersection.
2. Illegal CNG, Rickshaw parking.
3. Illegal loading and unloading buses at intersection.
4. Composition of traffic at the same road.

Determination of existing geometric dimension:

The existing geometric dimension of Kaptai rastar matha and CNB have been shown in Fig.2 and Fig. 3.

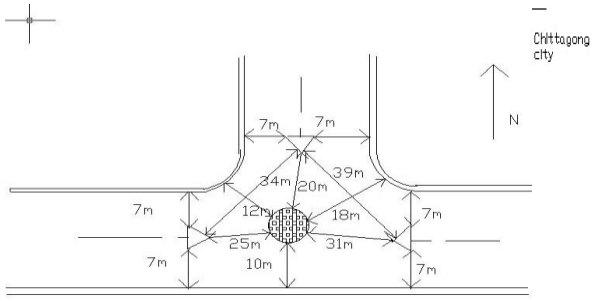


Fig. 2: Existing Geometric dimension at Kaptai rastar matha CNB

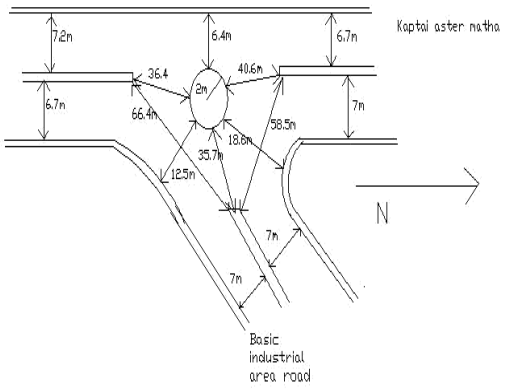


Fig. 3: Existing dimension at T-intersection

The existing geometric dimension is measured at Kaptai rastar matha and at CNB and compared with standard values. The standard dimension of geometric elements according to AASHTO are shown in Table 1.

Table 1: The standard dimension of geometric elements according to AASHTO

Name of the geometric element	1.Entry width (e_1)	2.Non-weaving width (e_2)	3.Weaving width (w)	4. Weaving length (L)
Standard value (m) (AASHTO)	7 (For 2 way road)	7 (For 2 way road)	10.5	30 (For urban area)

Traffic volume study

In the intersection at every legs, traffic volume have been collected. There are various types of traffic on the intersection so traffic flow counted separately. At the leg of the intersection all of the straight, left turning, right turning traffic have been collected separately. Generally tally methods are used for

determining traffic flow. Various types of traffic converted in a single unit in PCU (passenger car unit). The collecting traffic volume converted into PCU , sample calculation of which have been shown in Table 2.

Table 2: Daily Traffic flow Chart for the face Kaptai to Chittagong City at
Kaptai Rasta Matha (Date: 25/3/2015)

Time limit (HR)	CNG/ Car (1.0)	Ricksha w/two Wheels (2.0)	Mini Bus/ Mini Truck (1.75)	Bus/ Truck (2.8)	Heavy Truck (3.50)	Tempo /Micro (1.50)	Hand Drawn Vehicle (5.0)	Total (PCU)
7.40-8.40 AM	210	69	15	11	3	34	1	472
8.40-9:40 AM	212	62	15	8	2	24	0	490
9.40-10.40 AM	275	77	12	7	1	29	1	522
10.40-11:40 AM	245	70	9	9	2	19	1	467
4.30- 5:30 AM	267	72	21	16	6	41	0	575
5.30-6:30 AM	245	82	17	21	6	48	0	684
6.30-7:30 AM	238	75	14	19	11	42	0	568

Geometric design of Kaptai raster matha

Kaptai raster matha is one of the most important intersection in Chittagong city. Most important tourist area Kaptai lake is connected by Kaptai raster matha intersection. CUET is also connected by this intersection. Some of heavy vehicle is gone Kalurghat industrial area by using this intersection. More flow than Kaptai road is generated in here every day. Tourist vehicles are found at the vacation. This intersection influences the traffic volume at a great extent. The peak hour value has been shown in Table 3.

Table 3:Traffiic flow data in PCU at Kaptai raster maatha(peak hour)

Approach	Left turning	Right turning	Straight ahead	U-turning
Chitagong City to Kaptai rastar matha intersection	587	0	970	74
Kaptai to Kaptai rastar matha intersection	311	684	0	146
Karnopuli to kaptai rastar matha intersection	0	331	1037	68

The collected traffic flow data have been shown in Fig 4.

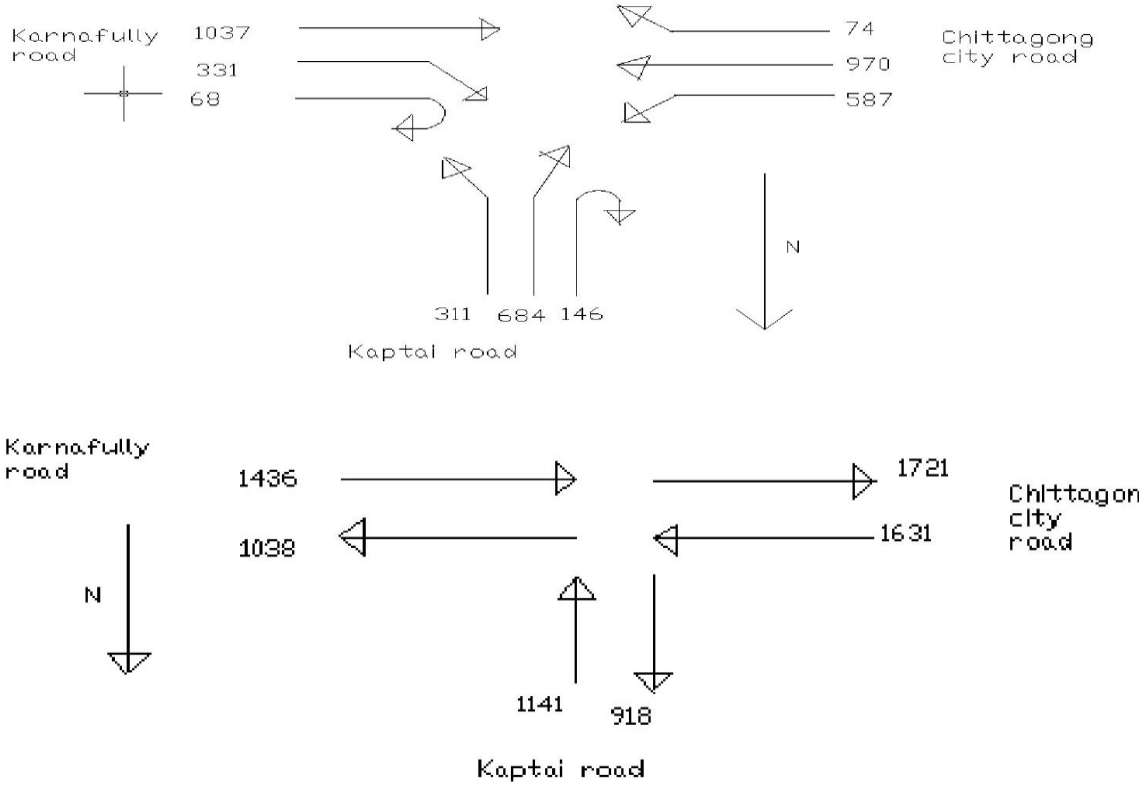


Fig 4:Traffic flow diagram at Kaptai raster matha (peak hour)

T-intersection design for Kaptai rastar matha from Chittagong city to Kaptai:

Width of entry, e_1= 7m Width at exit e_2 = 24 m

Non weaving width, e= $(e_1+e_2)/2$ = 15.5m Weaving width,w= 11.9m
a=587pcu,b=74+970pcu,c=331pcu
Weaving length, L= 34m, The maximum weaving occurs in the junction,
From the above data practical capacity found Q=4352 >1962 pcu/hour. So the T-intersection is satisfied. Similarly in other three direction, it was found that T-intersection is satisfied.

Geometric design of T-intersection at C&B

Most of the heavy vehicles in Chittagong city used this intersection for going to Kalurghat heavy industrial area. The peak hour value at CNB have been shown in Table 4.

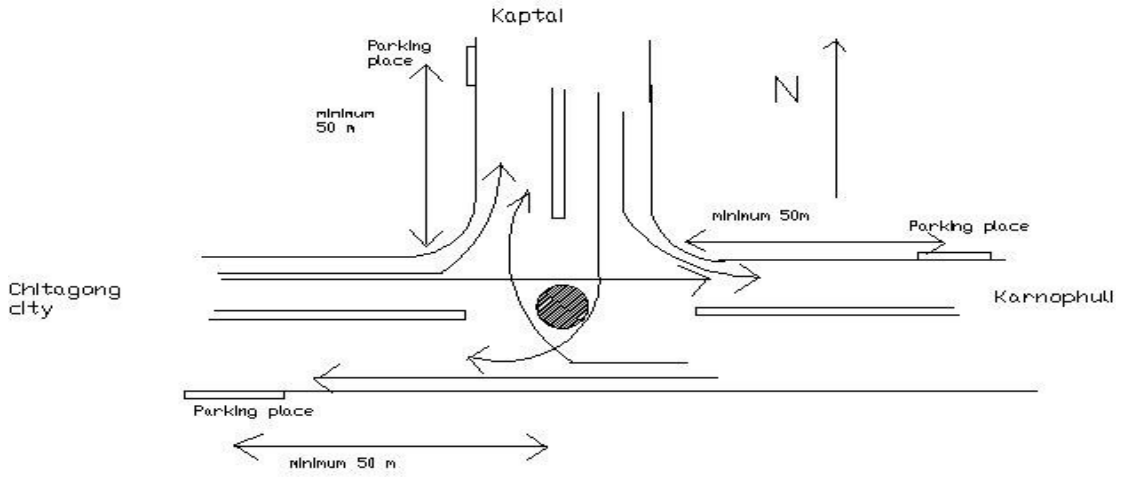
From similar calculation it was found that this T intersection satisfies the practical capacity in all four directions.

Remedial measure

It has been found that the geometric dimension of the intersection are ok. But in T-intersection at the peak period traffic congestion are created. It is normally occurred due to lackage of parking facilities, illegal loading and unloading of vehicles and mismanagement of traffic rules. For this flowing measures can be taken.

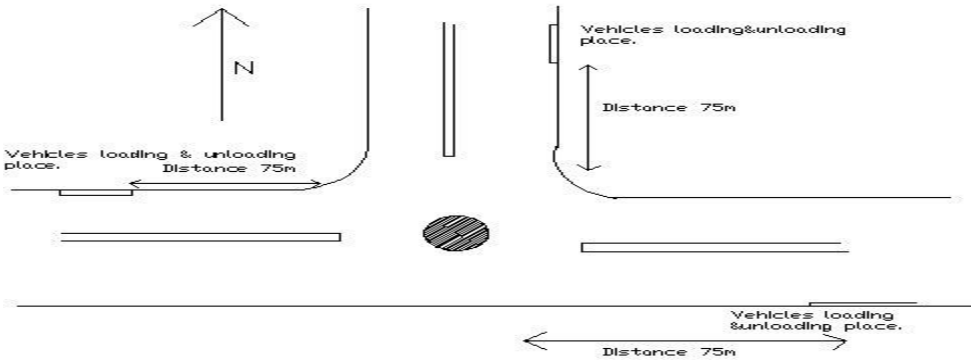
Parking facilities

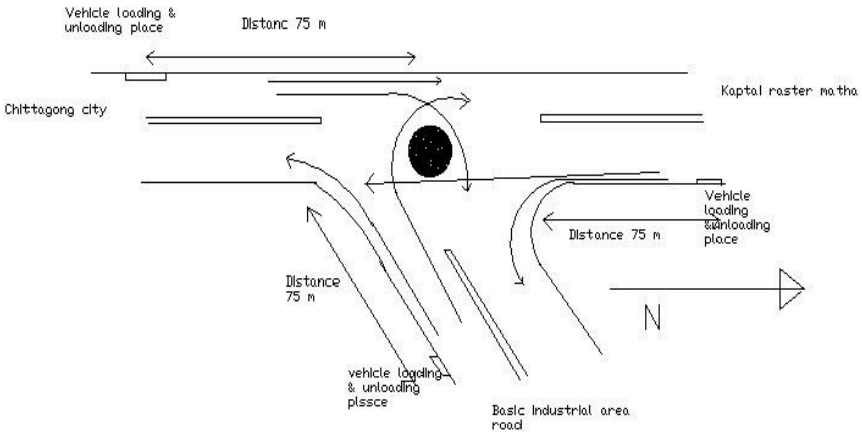
Due to illegal CNG and Rickshaw parking in T-intersection traffic congestion occurred. For removing traffic congestion in T-intersection can be reduced by providing parking facilities. Parking facility should be provided certain distance from the intersection. Illegal bus stoppage should be also removed from intersection. So bus stoppage may be identified certain distance from the intersection. The parking facilities have been shown in Fig 6.



Defining loading and unloading place

Normally the vehicles loading and unloading have done in T-intersection at peak period and passing long time. For this reason, the effective width are reduced and practical capacity reduced. As a result, traffic congestion occurred in T-intersection. For reducing traffic congestion the loading and unloading should be done before intersection. The loading and unloading place have been shown in Fig 7. and Fig 8 below:





Channelization

The direction of traffic flow at intersections to definite paths, by means of traffic markings, islands or other means is known as channelization. A channelization intersection is one in which traffic is directional into definite paths by islands and markings. An unchannelised intersection, on the other hand, is one without islands for directing traffic into definite paths. An unchannelised intersection is the most simple type but is the most dangerous and inefficient. All important junction should, therefore, provide for channelization. The proposed channelization have been shown in Fig. 9. at Kaptai Rastar Matha and Fig. 10. at C&B

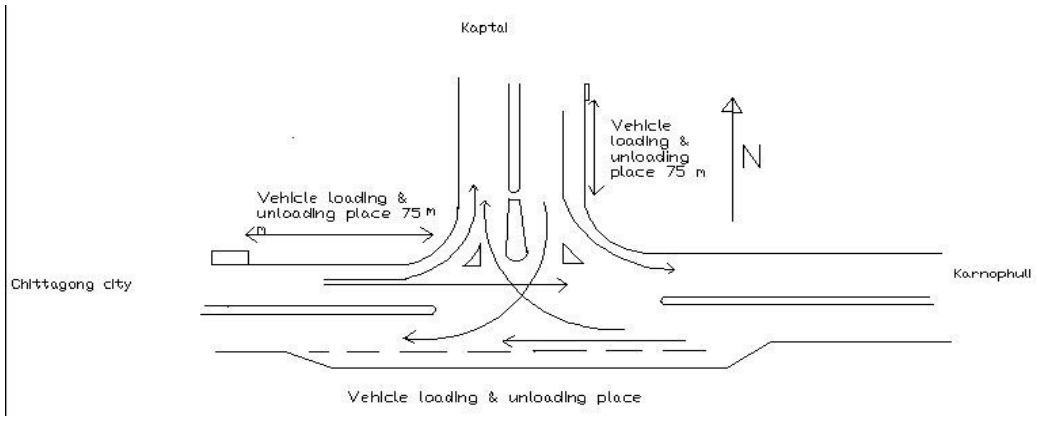


Fig. 9: Channelized T-intersection with a divisional island & two turning roadways (Kaptai Raster Matha)

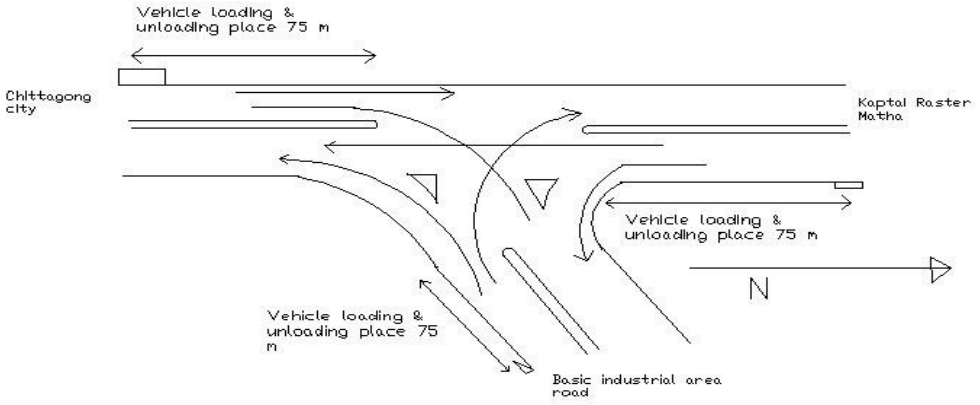


Fig. 10: Channelized T-intersection with a divisional islands & two turning roadways (C&B)

RESULTS AND CONCLUSION

The existing dimension were checked at present condition and compared with standard values and determination of practical capacity of the intersection and compared with survey value. From the investigation, it has been found that the geometric dimension of the intersections is ok. It is normally occurred due to lackage of parking facilities, illegal loading and unloading of vehicles and mismanagement of traffic rules. By providing parking facilities at certain distance from the intersection, traffic congestion can be minimized. Illegal bus stoppage should be also removed from intersection. Traffic loading and unloading have done in T-intersection at peak period which reduces the practical capacity of intersection by reducing the effective width of the roads. So loading and unloading facilities are proposed in two study area Kaptai Raster Matha and CNB intersection.

CONCLUSIONS

Cities are the heart of economic growth for any country. According to Burtone Et.al.(1994), around eighty percent of GDP (Gross Domestic Product) growth in developing countries is expected to come from cities. For the purpose of economic activities to provide movement facilities. Transportation system is the best way for movement and medium for reaching destination. In proper transportation system hamper economic activities and overall development of any country. In most of the developing countries which are overburden with extreme and huge population, increasing economic activities and opportunities in the cities in rapid increase in urban population and consequent need for transportation facilities. Authorities in this country often fail due to pressure of increasing population growth and economic activities in the cities, due to unplanned expansion of the cities traffic congestion. The urban transportation network is the backbone of the urban cities. So the transportation network should be design with carefully with growing population and diversified land activities. Some land should be kept around transportation network system for future readjusted of updated of the intersection. Any lacking between growing transportation demand and network capacities result in traffic congestion at the intersection. If any traffic congestion there occurred there by economic loss from above the investigation in T-intersection some conclusion have drawn which following below:

1. Every intersection for rural, urban and suburban contains individual capacities for traffic content. The practical capacity of the T-intersection depends on the effective width of the network system. Prescribed capacities are available in various international text books. Determining traffic capacities compared with prescribed capacities and then decision specified.
2. If the practical capacity is more than the total traffic at the max weaving section at the intersection then geometric dimension is not treated. But if the practical capacity is less than the total traffic then the geometric dimension of the intersection should be revised.
3. The suggestion attached with this thesis paper contain the solution to the present traffic congestion and other existing road user problem. It may be stated here that the disbenefits of poor traffic management system prevailing in the Chittagong came badly during inspection performance.
4. If the geometric dimension is ok but for mismanagement traffic congestion is created at peak hour time then some recommendation should be implemented for traffic movement at the T-intersection.

Whatever this points summarize, it may be exclaimed with bold voice that the thesis contains solution to the question following listening the intersection related problems and parking facilities provided and traffic flow pattern to be set up roles.

REFERENCES

[1] Khanna, S.K. & Justo, C.E.G. 2001, *Highway Enginerring*. Roorkee(U.S): Eight edition, Nem Chand & Bros.

[2] Kadyali, L.R. & Lal, N.B. 2006, Principle and Practice of Highway Engineering: Fourth edition, Khanna publishers, Delhi.

[3] Kadyali, L.R. 1987, Traffic Engineering & Transportation Planning, Khanna Publishers, Delhi.

[4] Recommended practice for Traffic Rotaries, IRC; 65-1976, Indian Road Congress, New Delhi,1976

[5] Layout 0f Roads in Rural areas, Department of Environment (U.K), H.M.S.O., London, 1968.

[6] Auditing geometric elements of the intersections at the northern sites of the Chittagong Metropolitan City (September, 2011) by Tanjir Saif Ahmed & Imtiaz Ahmed.

PERFORMANCE EVALUATION OF MOHAKHALI FLYOVER BY USING VISSIM SIMULATION SOFTWARE

M. S. Mamun*, S. Mohammad, M. A. Haque & M. Y. A. Riyad

Department of Civil Engineering, Ahsanullah University of Science & Technology, Dhaka, Bangladesh
**Corresponding Author: smamun93@hotmail.com*

ABSTRACT
Mohakhali rail crossing intersection is one of the most congested places within Dhaka city. In order to alleviate traffic congestion at this area, Mohakhali flyover was constructed and opened to traffic in 2004. But, unfortunately, it is observed that traffic congestion still exists at Mohakhali flyover and its surrounding areas. In this research, the performance of Mohakhali flyover is evaluated. The whole analysis is performed in VISSIM simulation software. First, existing condition (with flyover) is simulated to obtain the density, flow, speed and delay. The performance measures are then obtained for the network without flyover using the same traffic load. From the result comparison it is found that with the flyover the flow and speed at major links has increased, although the improvements are not significant. In order to increase the capacity of the intersection, it is proposed to extend the flyover by constructing additional links to and from the Gulshan Mohakhali connecting road. The extended version of the flyover is also simulated in VISSIM. Remarkable improvements are noticed. At every major link flow and speed has increased and delay has decreased significantly.

Keywords: Flyover; interchange; simulation software; traffic congestion; VISSIM

INTRODUCTION
The congested situation prevails all the day in most of the streets and intersections in Dhaka city. A recent study reveals that the average speed at Mirpur road (a major arterial road) is 15 to 17 kilometer per hour during peak period (Monayem, 2001). Many government and public transport agencies are trying to solve these problems by drafting policies, undertaking projects and implementing programs. The Dhaka Integrated Transport Studies (DITS, 1994), Strategic Transport Plan (STP, 2005) and Dhaka Urban Transport Network Development Study (DHUTS, 2009) are the major transport related studies conducted to alleviate traffic congestion in Dhaka city. Among many recommendations from those studies, building flyover and interchanges at major intersections gained major attention from Bangladesh government and policymakers. As a consequence, Mohakhali flyover was built to reduce the congestion at Jahangir gate, Mohakhali, Gulshan and Banani area.

The construction of flyover started in December 2001 and opened to traffic in November 2004. The flyover was expected to ease the traffic congestion at Mohakhali railway crossing. Before the construction of Mohakhali flyover, the total area at Mohakhali, Gulshan and Jahangir gate were full of traffic jam because of the Mohakhali intersection and the rail crossing. After the construction of Mohakhali flyover, the situation has been improved but which is not enough to reduce the congestion at those areas. In this research, attempt has been taken to evaluate the performance of Mohakhali flyover and make recommendations to increase the performance. Average delay and speed of the vehicles at the study area for two scenarios are compared: one with the flyover and the other without the flyover. The network is built in VISSIM simulation software and simulated to get the performance measures for both the scenarios. Moreover, the flyover is proposed to be connected to Gulshan-Mohakhali link road to reduce the congestion and increase the effectiveness of the flyover, which is also modelled and tested in VISSIM.

TRAFFIC SIMULATION
Traffic simulation is "Microscopic simulation", also called micro simulation, which means each entity (car, train, and person) that is to be simulated is simulated individually. The widely used micro

simulation software packages are VISSIM, TSIS-CORSIM, TransModeler, PARAMICS, AIMSUN, INTEGRATION, etc.

Simulation software is frequently used to simulate freeways, surface networks, intersections, roundabouts, public transport, etc. Prevedouros and Wang (1998) simulated a large integrated (street and freeway) network to compare three state-of-the-art software programs (INTEGRATION, CORSIM and WATSim). Mystkowski and Khan (2000) examined queue length as measure of effectiveness at signalized intersection by using CORSIM, TRANSYT-7F, and SIGNAL94, PASSER II-90 and SYNCHRO3. Kim and Benekohal (2005) compared control delays obtained from CORSIM simulation to the Highway Capacity Manual (HCM, 2000). Rilett et al. (2000) compared low-fidelity TRANSIMS and high-fidelity CORSIM highway models with ITS data.

Simulation software is also used with signal controlling system. Adaptive signal control systems proposed by Perrin et al. (2001) was connected to Federal Highway's CORSIM model. Park et al. (2000) presented a stochastic signal optimization method based on a genetic algorithm (GA-SOM) that interfaces with the CORSIM microscopic simulation program.

Many researchers used simulation software in access management, operation of roundabouts, operation of public transport, etc. Yang and Zhou (2004) proposed Right turn plus U-turn at median openings as an alternative to direct left turn for access management, which was tested in CORSIM. Trueblood and Dale (2003) simulated roundabouts with VISSIM. Vandebona and Richardson (1985) developed TRAMS (Transit Route Animation and Modeling by Simulation) for simulating light rail transit operations. Chien et al. (2000) developed a CORSIM-based microscopic simulation model, which provides transit planners and operators with the ability to simulate bus operations on transit routes.

Simulation software is now a widely used tool in the field of transportation engineering. The advantage of using simulation is that it offers the users the opportunity to evaluate alternative strategies which could be very helpful in the field of transportation engineering. In this research the strength of VISSIM simulation software is used to evaluate the performance of Mohakhali flyover.

STUDY AREA AND DATA COLLECTION

Mohakhali flyover is located at Mohakhali connecting Bir Uttam Ziaur Rahman Sarak and New Airport raod. The portion of the network used in this study is shown in Figure 1. The network consists of two intersections (Rail crossing intersection and Gulshan-Mohakhlai link road intersection) which are controlled manually by the traffic police very poorly. The passengers and travellers need to wait for a long time at the signals.

For this study, data was collected during 9:30 to 10:30 am on Sunday (16th and 23rd June, 2013) and during 5:00 to 6:00 pm on Thursday (20th and 27th June, 2013). Traffic volume was counted for four consecutive 15-minutes at four data collection points and converted to Passenger Car Unit (PCU/hr). A sample data is provided in Table 1.

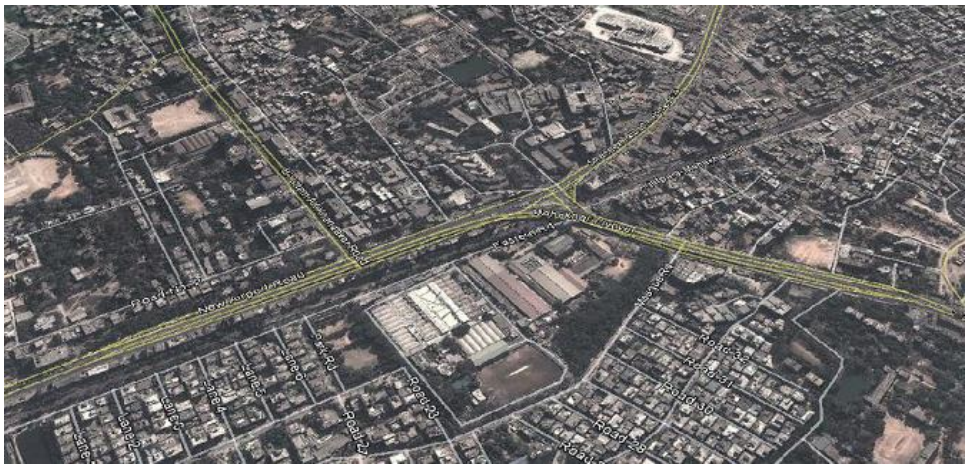


Fig. 1: Satellite View of the Network

Table 1: Traffic Flow at Different Locations

Locations	VPH	PCU/Hr
Banani Shoinik Club to Mohakhali	4156	3665
Mohakhali ICDDRB to Mohakhali	1440	1596
BAF Shaheen College to Mohakhali	3256	2705
Gulshan wireless more to Mohakhali	1468	1308

NETWORK DEVELOPMENT AND SIMULATION

The network is built by using link, lane, connector, signal, etc. First, background is set and scale is adjusted. Then gradually links are added. Links are then connected by link connectors. The entire network is presented in Figure 2. Total road width is divided into number of lanes. Simulation parameters, speed profiles, vehicle type characteristics, traffic composition are adjusted according to modeling needs. Entering traffic volumes, routing decision, speed changes, conflict area, etc. are inputted/set according to data obtained from field survey. Although, at Mohakhali, traffics are controlled manually by traffic police, signal timings are set arbitrarily that provides the best traffic operations in the network.

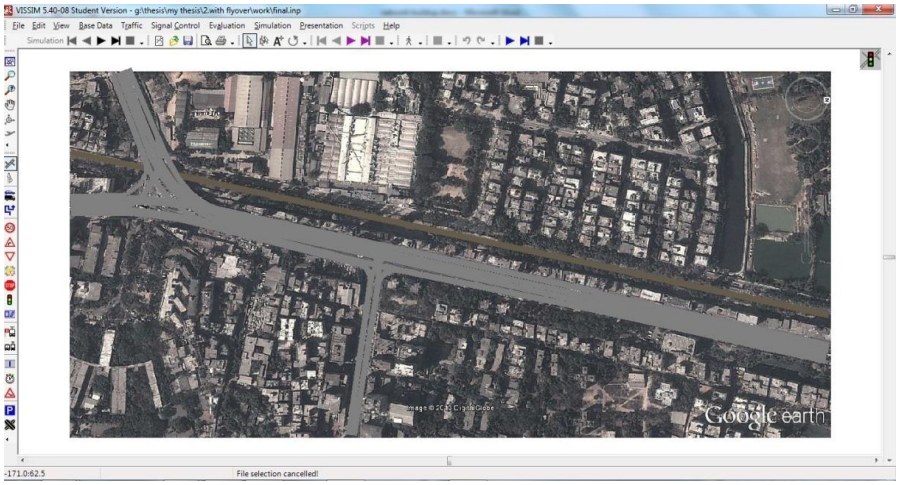


Fig. 2: Screen Shot of the Entire Network in VISSIM

Present Condition Simulation (with flyover)

In order to get the current performance of the flyover, the calibrated network is simulated in VISSIM (Figure 3). Performance measures (density, flow, speed and delay) obtained from the simulation runs are provided in the result section.

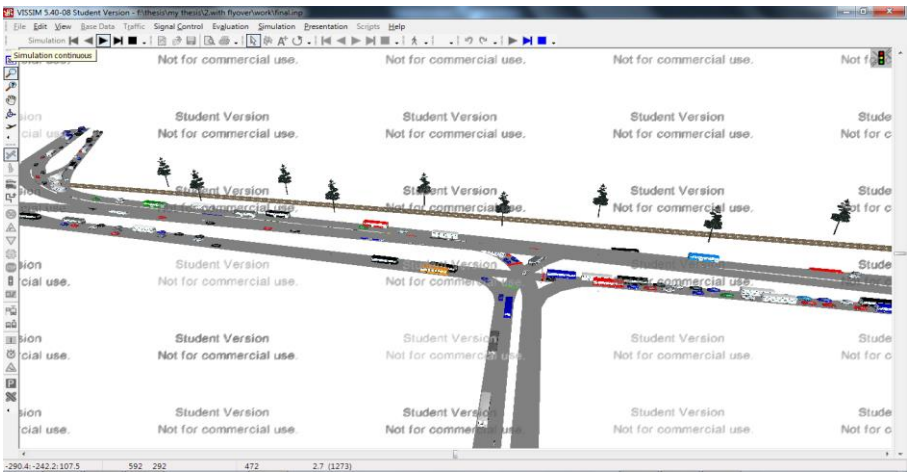


Fig. 3: Present Condition Simulation

Previous Condition Simulation (without flyover)

In order to get the performance of the previous condition, the same network is simulated in VISSIM without the flyover (Figure 4). Performance measures (density, flow, speed and delay) obtained from the simulation runs are provided in the result section.

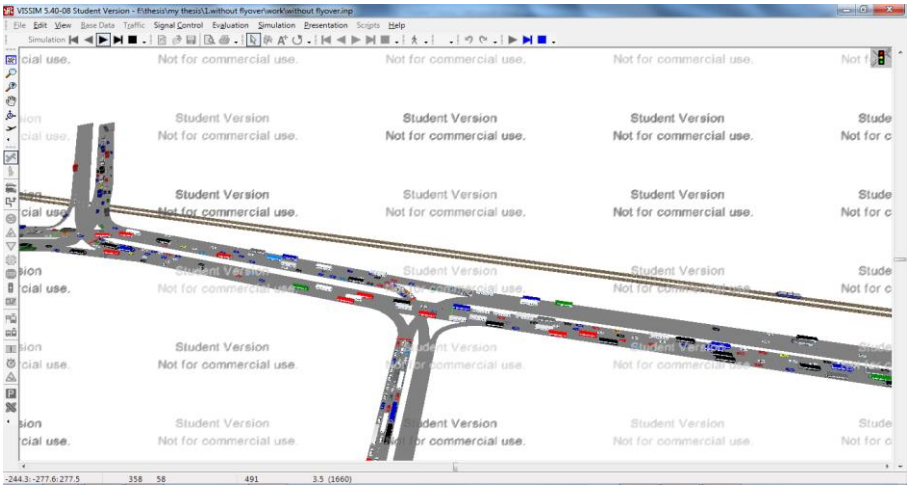


Fig. 4: Previous Condition Simulation

Extension of Mohakhali Flyover

There are two intersections having 3 legs present in Mohakhali. These are the main reasons for congestion in the network. Especially the intersection at the head of the Gulshan Mohakhali connecting road causes the main problem. Therefore, in order to solve the congestion problem in the network it is required to improve the capacity of this intersection. After taking some physical measures (i.e., parking control, vehicle movement control, and pedestrian movement control) additional links can be constructed to/from the flyover. One link can be added from Gulshan wireless to Mohakhali flyover towards Banani, one can be added to the Mohakhali flyover towards Shaheen College from the same position and one can be added from Mohakhali flyover towards Gulshan wireless. The new trumpet interchange created in VISSIM is shown in Figure 5. Three new routes will be generated by the additional construction. Therefore, huge numbers of right-turns will be eliminated at both of the intersection within our study area. Performance measures (density, flow, speed and delay) obtained from the simulation runs are provided in the result section.

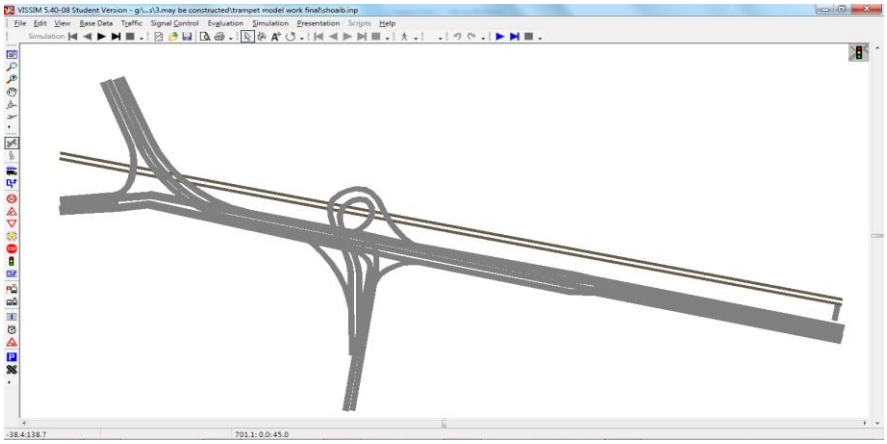


Fig. 5: New Trumpet Interchange

RESULTS

The density, flow and speed of the important links under three conditions are provided in Figures 6 to 8. From the Figures we can observe that density has decreased significantly, and the flow and speed have increased significantly for the extended flyover scenario. The comparisons of average speed and delay

of the whole network are provided in Figure 9. From the figure it can be seen that without flyover average speed of traffic is very low (13.05 km/h) and delay time per vehicle is very high (135.22 sec/veh). After the flyover construction, the average speed increases to 17.73 km/h and delay time per vehicle also decreases to 109.65 sec/veh, although the changes are not significant. Still there exists congestion. With the extension of the flyover, the average speed of traffic has increases remarkably and the delay time per vehicle has become very low. The average speed of the vehicle is now 53.61 km/h and average delay is now 21.86 sec/veh.

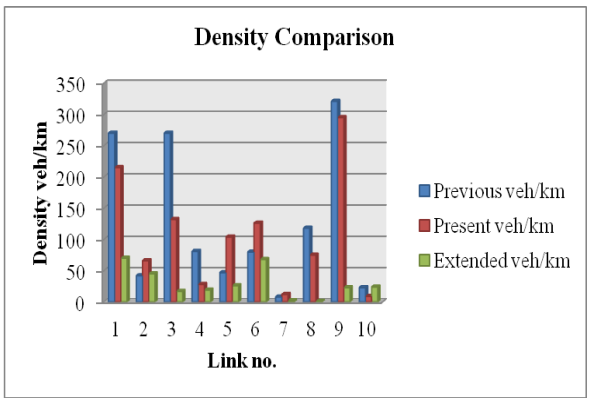


Figure 6: Density Comparison

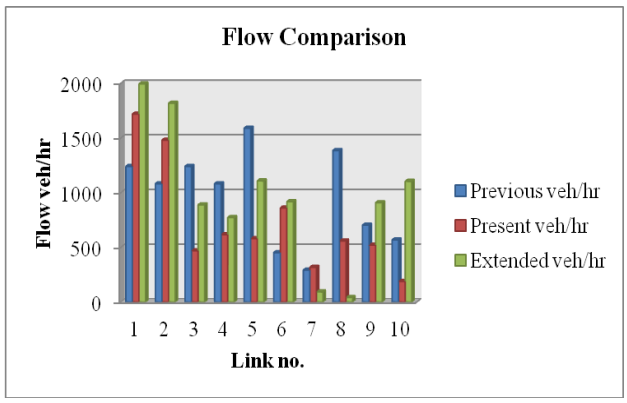


Figure 7: Flow Comparison

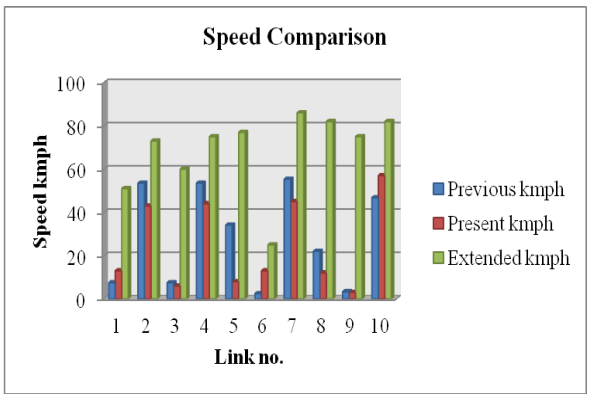


Figure 8: Speed Comparison

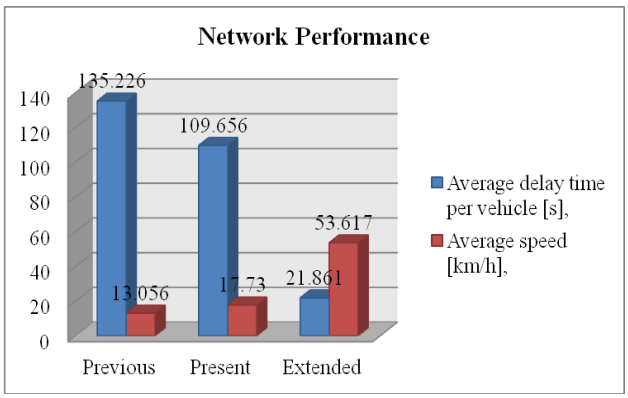


Figure 9: Avg. Speed and Delay of the Whole Network

CONCLUSIONS

The existing flyover is not very effective in reducing traffic congestion at Mohakhali area. And we cannot go back to the previous condition where there was no flyover. Moreover, we have spent Tk 113,52,72,000 for the construction of this flyover. Therefore, at this point we need to do something that can increase the capacity of this area and increase the effectiveness of the flyover. Extension of the flyover is one such solution. If we spend some extra money and construct few additional links as mentioned in this research, the flyover will be converted to interchange and it will be able to handle traffic congestion more efficiently at the study area.

REFERENCES

Chien, SI; Chowdhury, SM; Mouskos, KC and Ding, Y. 2000. Enhancement of CORSIM Model in Simulating Transit Operations. *Journal of Transportation Engineering.*

DITS. 1994. *Dhaka Integrated Transport Study*, Dhaka.

DHUTS. 2010. *Dhaka Urban Transport Study*, Dhaka.

Kim, S and Benehohal, RF. 2005. Comparison of Control Delays from CORSIM and the Highway Capacity Manual for Oversaturated Signalized Intersections. *Journal of Transportation Engineering*, ASCE.

Monayem, MA. 2001. *Evaluation of Traffic Operation Conditions on Two Urban Arterials in Metropolitan Dhaka.* M.Eng. Thesis, Department of Civil Engineering, BUET.
Mystkowski, C and Khan, S. 2000. Estimating Queue Lengths by Using SIGNAL94, SYNCHRO3, TRANSYT-7F, PASSER II-90, and CORSIM. *Transportation Research Record 1683,* 99-117.
Park, B; Pourhail, NM and Sacks, J. 2000. Assessment of Stochastic Signal Optimization Method Using Microsimulation. *Transportation Research Record 1748,* 01-23.
Perin, J; Martin, PT and Hansen, BG. 2001. Connecting SCOOT to CORSIM: Real-Time Signal Optimization Simulation. *The 27th Annual Conference of the IEEE Industrial Electronics Society.*
Prevedouros, PD, and Wang, Y. 1998. "Simulation of Freeway/Arterial Network with CORSIM, INTEGRATION, and WATSim." Proc., 78th Annual Meeting, Transportation Research Board, Washington, D. C.
Rilett, LR; Kim, K and Raney, B. 2000. A Comparison of the Low Fidelity TRANSIMS and High Fidelity CORSIM Highway Simulation Models Using ITS Data. *Transportation Research Record 1739:*1-8.
STP. 2004. *Strategic Transport Plan,* Dhaka.
Trueblood, M and Dale, J. 2003. Simulating Roundabout with VISSIM. *2nd Urban Street Symposium (Anaheim, California).*
Vandebona, U and Richardson, AJ. 1985. TRAMS: Transit Route Animation and Modeling by simulation. *Journal of the Advanced Transportation,* 19(2):153-177.
Yang, XK and Zhou, HG. 2004. CORSIM-based Simulation Approaches to Evaluation of Direct Left Turn Versus Right Turn Plus U-turn from Driveways. *Journal of Transportation Engineering,* ASCE.

DEMAND AND SUPPLY ANALYSIS OF PARKING IN MAJOR COMMERCIAL SPACES IN CHITTAGONG CITY – A CASE STUDY OF CHITTAGONG SHOPPING COMPLEX AND LGED BUILDING

M. R. H. Kauser*, M. M. Rahman, N. N. Uddin, K. Zannat & M. S. G. Adnan

Department of Urban and Regional Planning, Chittagong University of Engineering and Technology, Chittagong, Bangladesh
**Corresponding Author: mdrhkauser@gmail.com*

ABSTRACT
In Chittagong, quick urbanization, advancement in transportation, enhancement of people's living standard and availability of low cost fuels motivate people to use motorized vehicles. This vast amount of vehicles need accommodation place in both residential houses and commercial spaces. Parking is an essential part of transportation system. On-street auto parking and illegal parking are currently making serious transport problems within main highways of Chittagong town. This particular paper aims at determining actual car parking situation at main public and private spaces of CDA avenue road by taking sample of a govt. office and a public shopping complex that are extremely busy. For this reason the site-specific research had been carried out rather than city or nationwide perseverance associated with car parking features. The required data has been collected by two types of car parking direct surveys- parking space inventory and parking usage survey by patrol, carried out upon two individual working days addressing 4 hours intervals. After performing analysis it is found that most of the time the parking spaces are occupied by the particular vehicles. Finally, this study will provide latest and reliable information about the parking scenario of Chittagong city and this will help to advocate parking policies for Chittagong Metropolitan Area basically for the commercial and office spaces.

Keywords: Parking Accumulation; patrol survey; off street parking

INTRODUCTION
Parking is very essential element and fundamental issues in urban area for controlling transportation and communication factors. Not only need for an urban area but also need to manage transportation systems in rural area the requirement of parking space is beyond description. By the way the parking system needs to be well efficient and organized to serve the demand. The estimated population is 4.1 million in an area of 177 sq. Km (Centre for Urban Studies(CUS), 2006). Chittagong is the 2nd largest city and port city of Bangladesh. Chittagong has also great importance in economy and the economy is directly or indirectly fully depends on transportation system. That's why Chittagong has been also facing great load on transportation. Although the scenario of Chittagong is much better from other larger cities like London, Tokyo, New york but it is on the most developing heavy traffic zone (Corporation). So a lot of parking spaces are required to accommodate the transports. As per BRTA source the average right of way of the major roads of Chittagong 100 to 130 feet. Every day a significant percentage of drivers in single-occupancy vehicles search for a parking space. Detailed recommendations for provision of on street parking were made in Annex B5 of the "Immediate action plan" report (Authority, 2008). As per CDA master plan, 2008 commercial buildings over 4 floors in height should have one floor or its equivalent area dedicated to vehicle parking. According to vehicle ordinance, Chittagong City Corporation is in charge to introduce on street and off street parking areas for vehicle in Chittagong metropolitan area and control illegal parking. Though the rules were found in policies the reflection of those rules didn't found in implementation.

LITERATURE REVIEW
Vehicle connotes the principle qualification in a very method of travel process. And typically it has the affect on often the proficiency connected with targeted visitors mobility evades all of our attention. This is due to all of our conception connected with method of travel will be limited together with the myth of

motion although vehicle will involve the illness in the event the autos usually are standing. It can be to become critical a significant dealing with often the method of travel process given it has effects on the actual supply of an urban center (Litman, 2013) . Inside the circumstance regarding escalating privately owned automobile title. So that you can recognize the specific situation or perhaps determine the particular best interests regarding problems, the regarding auto parking room, degree regarding it is makes use of and also dedication regarding auto parking requirement is quite crucial. It is also needed to calculate the particular auto parking costs and also lifelong auto parking. According to the terrain make use of qualities the need regarding auto parking may differ, which can be impacting the availability details. This specific will become a lot more essential inside a degenerated vehicles supervision circumstance that way current inside Dhaka metropolis just where a lot of people would rather make use of automobiles inside the active business facilities. Regularly and many significantly the actual issue is based on identifying the actual essential need that should become accommodated. The actual Start associated with Transport Technicians (ITE) in the time period statement created a suggestion indicating the amount of car parking bays necessary for 1000 sq. ft. of every group of property utilize. With regard to shops, ITE suggested 5.05 car parking bays with regard to 1000 sq. ft. section of this particular property utilize (ITE, 2010) . This region consists of stores as well as eating place areas due to its substantial impact upon car parking need (ITE, 2010), Parking Occupancy- Data collection, 2013. ITE has created this particular regular within a circumstance in which a large numbers of excursions are created through vehicles as well as wherever option transportation choices minimum (Soup, 1999) .
There are a number of research related to parking has already been done in Dhaka city, but there was no such effort done with Chittagong city that deals with off-street and on-street parking. Off-street auto parking implies auto parking your car everywhere yet around the roadways. These are generally typically auto parking amenities. Off-street auto parking may be the two in the house and also out-of-doors. Off-street auto parking also incorporates privately owned a lot and also vestibule. On the other hand, on street parking implies auto parking car by the side of the road or both side of the road. The parking space inventory survey was needed to identification of the parking space where the parking is done and was also needed to measure the parking demand, where patrol survey was helpful (Zannat, 2013).

METHODOLOGY

To find out the existing condition of the parking area several surveys have been conducted in many times. The existing parking surveys falls into two categories, first one is area parking survey and another is site-specific parking survey (Council, 2013). Area parking survey considers all available parking spaces of an area. As a result it contains all available possibility of shared parking among different land uses. So, it provides the information about compatibility of parking supply and demand considering local zoning requirements.

The site-specific parking survey is conducted in a small area or a land use to find out the local parking supply and demand (Council, 2013). The data which is found form the survey provides more realistic parking characteristics of the area. It is also batter than the traditionally developed national level parking ratios runs the risk of providing unused extra spaces and thus resulting wastage of money.

The existing parking demand and supply conditions of Chittagong shopping complex and LGED building have been explicated through seven measures of parking – parking accumulation, parking volume, parking load, parking turnover, average parking duration, parking spill-over and probability of rejection. These seven parking measures have been evaluated by using the data gathered by conducting two parking surveys parking space inventory and parking usage survey by patrol (Kadiyali, 1997). To collect data the surveys had been done on two separate working days. In first day, parking inventory survey had been done to collect data on the quantity, type and location of parking space actually or potentially available for parking in those areas. Parking usage survey by patrol had been done in next day which included counting parked vehicles number at 15 minutes intervals through a period of four hours, covering both the morning and evening peak periods. Pilot survey showed that the influx of customers were high during 10:00 to 12:00 and 16:00 to 18:00. This excludes the period in the early morning when the market is yet to open and the lunch period in the afternoon.

STUDY AREA

This two under study commercial buildings have all types of parking facility and deals with huge traffic in every working day. Which two surveys have been done for collecting data this two building covers all criteria for parking demand supply analysis. Chittagong shopping complex is located in CDA Avenue in Chittagong which has front parking. The parking space is situated on the premises of the 2 storied building which makes huge parking demand like other busy places in the city. On the front of the building there are provision of 51 vehicle parking spaces and an undesignated circulation space by the side which sometimes used as parking space. There were another sampled site was selected for survey named LGED building located near Sholashahar railway station with ground and front parking. Its underground parking dimension is 115'x90' with a huge entrance sloping downward. Front parking dimension was 125'x90'2" The dimension of ground parking was 95'x40' which provides the provision of parking of 15 motorcycle vehicles.

Fig. 1: Study area map (Source: Google Earth)

RESULTS AND DISCUSSIONS

Existing Parking Condition

Chittagong Shopping complex is located near 2no gate beside the CDA Avenue highway. The parking area of the Chittagong shopping complex is surface parking. The open space in front of the market is used for parking. This parking area is designated for cars. But most of the sign of designation has been removed. Total parking area of the shopping complex is 7231 sq. Feet. There are 51 parking lots in the parking space. These parking lots are perpendicular to the shopping complex structure. In Chittagong Shoppng complex there is no specific parking sign for cars and vehicles. Most of the parking lots are used by C.N.G taxi or motorbikes. At the parking bay there is no entry or exit points. Vehicles park on the bay haphazardly most of the time. Chittagong City Corporation is the owner and on manegerial duty of the market.

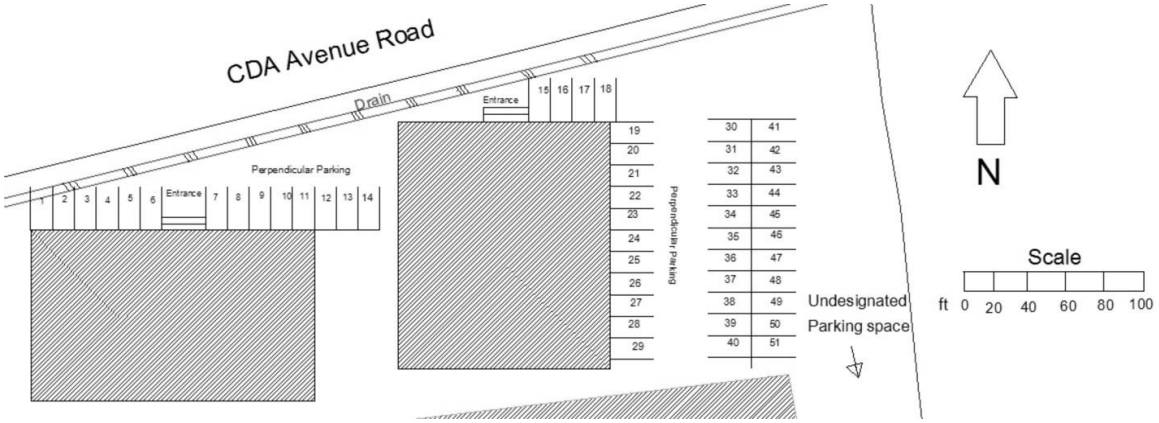


Fig. 2: Parking inventory plan of Chittagong Shopping Complex (Source: Field survey, 2014)

LGED building is located near sholashahar railway station. It has ground parking, underground parking and front parking. The underground parking has a dimension of 115'×90'. Its parking capacity is 30 private cars. It has a huge entrance of 30'×20' sloping downward. The front parking is is 125' in length and 90'2"in width. It has a capacity of maximum 20 private cars. It is surrounded by ornamental plants. At the entrance there is a guard room of 10'×10'. The ground parking has a dimension of 95' length and 40' width. Its parking capacity is maximum 15 vehicles most of which are motorcycle.

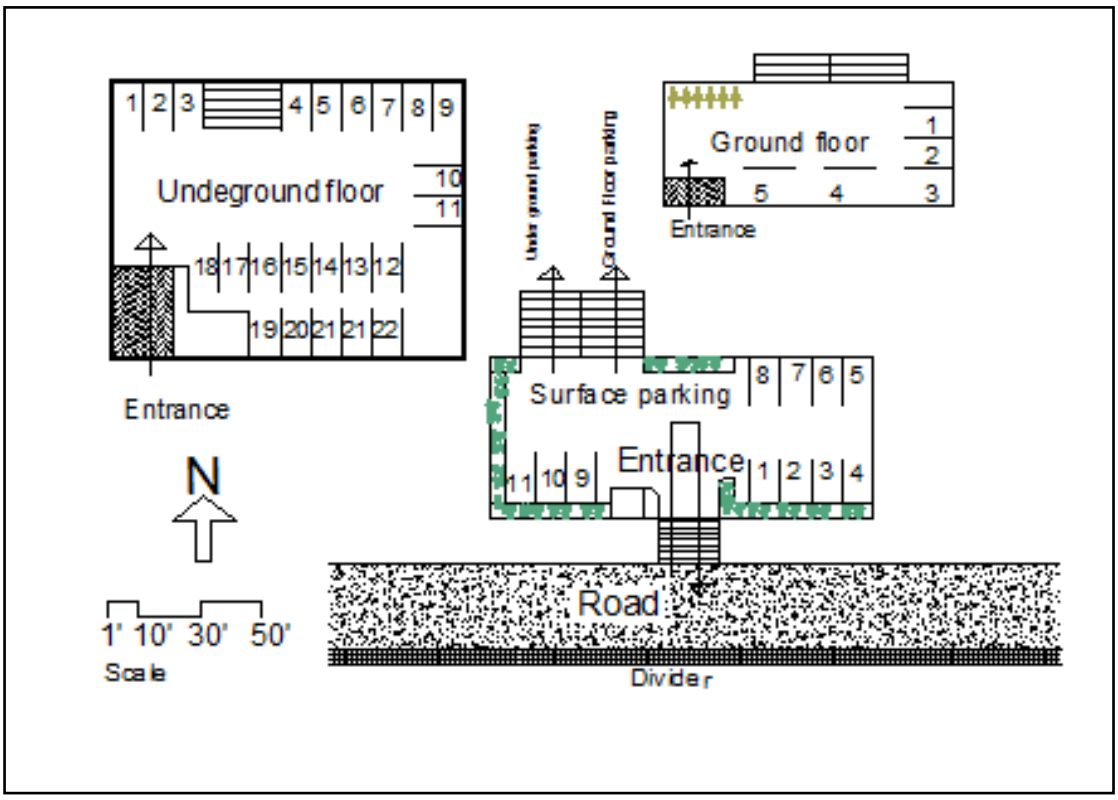


Fig. 3: Parking inventory plan of LGED building (Source: Field survey, 2014)

Parking Usage Survey by Patrol

It has seen from the [Fig. 4] that number of cars of Chittagong Shopping Complex is very less in the morning time. Maximum number of parking spots remains empty in the morning time. The maximum time a car staying in a parking spot is 2 hours & the time it was in 4-6 PM. The minimum time spending a car was found only 15 minutes. The average supply of parking at Chittagong Shopping Complex is 9.5 & it is the 25.6% of the total area. The overall volume has been 38 vehicles per hour. The number of vehicle parked at a given instant of time is shown in the Fig-4. Some motorcycles and C.N.G have also been parked in this space along with private cars. It has been found from Fig-4 that the maximum

number of cars parked in Chittagong Shopping Complex is at the time range of 4.30-4.45 PM where vehicle number is 14. It has also been found that the minimum number of cars parked at Chittagong Shopping Complex is at the time range of 10-10.15 AM which is 6.

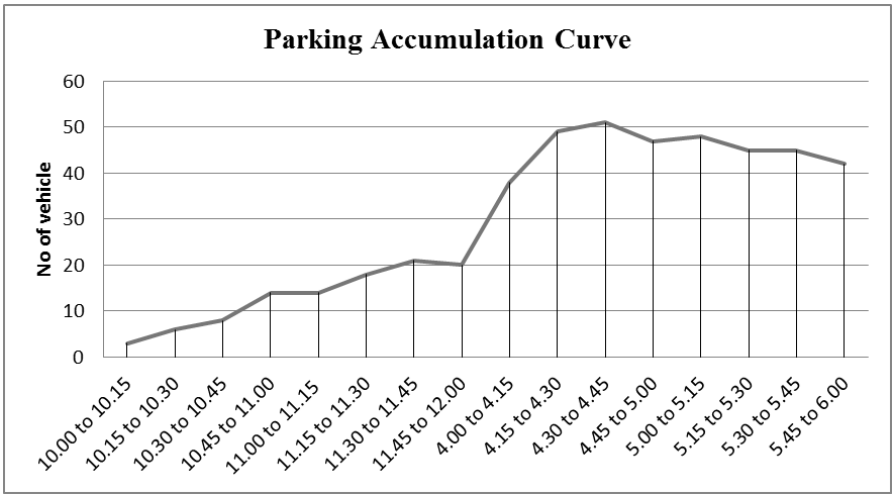


Fig. 4: Parking accumulation curve of Chittagong shopping complex (Source: Field survey, 2014)

In case of LGED building is found that the number of parking vehicle increases continuously from 10:00 am when working time start. At middle of the noon the maximum number of vehicle park at the building. In the peak hour vehicle has been parked in front of the building as an illegal on street parking. Generally the employees use the underground parking. In the time of seminar or program on that building creates huge parking demand which is not full fill by the existing parking facilities. Finally, to meet the existing demand more 40 parking lots has demanded.

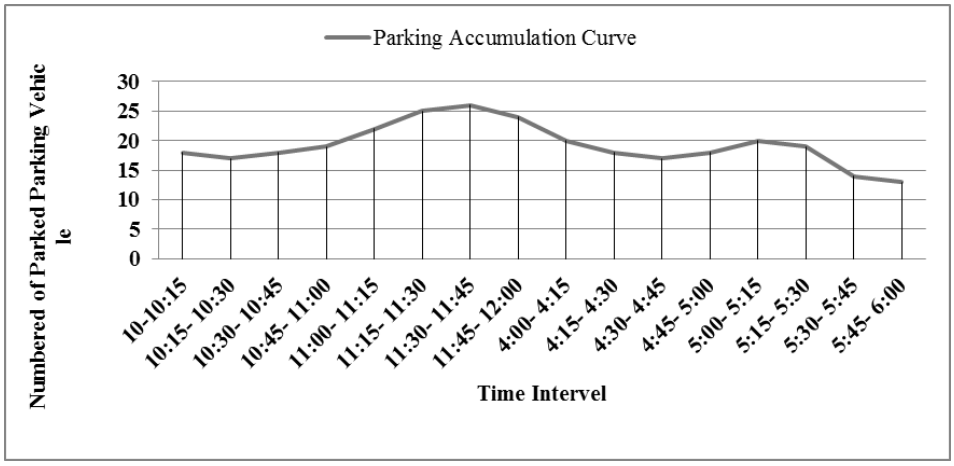


Fig. 5: Parking accumulation curve of LGED building (Source: Field survey, 2014)

RECOMMENDATIONS

1. Illegal on-street parking in front of commercial spaces should be removed so that regular traffic flow of vehicle remains undisturbed on the main road.
2. The regular parking charge should be increased in such amount that the car owners will tend to park their cars for less time as possible.
3. All parking areas for individual vehicles should be marked clearly which will provide clear direction to park the vehicle properly
4. The parking space available in the sampled site is inadequate in serving parking facility to the users. Current parking space should be increased and shared parking and multi storied parking can be introduced to solve the increasing parking need in the site.
5. People should be encouraged to use public transport instead of use private vehicle like car.

CONCLUSIONS

Considering one commercial and one office building may help to understand the parking scenario of the commercial spaces of Chittagong city. If the average spill-over found from the survey is taken into consideration, most of the time the parking area is fully loaded. There is much gap between the demand and supply of those areas. It is found that 30 more parking bays in Chittagong shopping complex need and 40 in LGED Building to be added to avoid front on street parking. Since this increase in supply would not alone reduce the parking pressure, it should be supplemented by optimum parking pricing policy. The parking facilities provided in this area is off-street parking and there is also some on-street parking which occupies the limited road space designated for movement of traffic. Therefore, on-street parking cannot be a reasonable solution on the parking problem and should be discouraged accordingly. Finally, it can help to provide a advocate parking policies for Chittagong Metropolitan Area basically for the commercial and office spaces.

ACKNOWLEDGMENTS

At first all praises belong to Almighty Allah, the most Merciful, very kind to man and his action. We would like to express our gratitude to our parents and other family members from the core of our heart for their love. This dissertation is done as a departmental project work of Transportation Planning and Management Studio. We want to specially thank to all of our friends for helpful and provide encourage to accomplish the dissertation. There is no word to express our profound gratitude and indebtedness to our teacher of Dept. of URP, CUET for their valuable advice, comments, sympathetic co-operation and systematic guidance at all stages of this field work & this report. Finally, our special appreciation goes to all the dwellers of the Chittagong city for their response and co-operation provided during the survey work.

REFERENCES

Authority, CD. 2008. Chap 3. *Long term Development strategy for Traffic and Transportation in Chittagong*, 15-16.

Centre for Urban Studies(CUS), N. i. (2006). *Slums of Urban Bangladesh: Mapping and Centre.* Chapel Hill, USA: Centre for Urban Studies.

Corporation, CC. (n.d.). *Effectiveness of Flyover construction to Mitigate Traffic Congestion in the City.* Retrieved February 23, 2015, from CCC: http://www.ccc.org.bd

Council, MA. 2013. *How to do a parking study*. Retrieved from MAPC: http://www.mapc.org/resources/parking-toolkit/parking-study-howto

Engineers(ITE), I. o. 2010. *Parking Generation.* Washington D.C.: ITE.

Engineers(ITE), I. o. 2013. September 19). *Parking Occupency- Data collection*. Retrieved 2015, from http://www.ite.org/parkinggeneration/datacollection.asp

Kadiyali, L R. 1997. *Traffic Engineering and Transport planning, 6th ed, Chap 6, 67- 71.* Delhi: Khanna publcation,.

Zannat, TA. 2013. Parking Demand and supply Analysis of Major shopping centers in Dhaka - A case study of New Market Shopping Center along Mirpur Road. *Journal of Banglaesh Institute of Planners*, 161- 172.

Litman, TA. 2013. *Parking Management- Strategies, Evaluation and Planning.* http://www.vtpi.org/park_man.pdf: Victoria Transport Policy Institute.

Soup, D. 1999. *The trouble with minimum Parking Requirements, Transportation Research Part A, 549 - 574.*

ROAD SURFACE DRAINAGE AT HAT-BAZAAR OF RURAL AREA: A CASE STUDY

J. Amin *, R. B. Ahmed & S. K. Palit

Department of Civil Engineering, Chittagong University of Engineering &Technology, Chittagong, Bangladesh.
**Corresponding Author:fahadcuet123@gmail.com*

ABSTRACT
The average annual rainfall in Bangladesh varies from 1429 to 4338 millimeters (BMD, 2014). During rainy season, this water causes serious water logging on roadways due to improper drainage system & local road dwellers behavior. Without proper drainage of water, it creates hazardous impact on daily activities of rural as well as urban area people. Pahartali is a Local Hat-Bazaar of Raozan upazilla on Chittagong- kaptai road. During rainy season, this bazaar becomes water logged for long time due to absence of proper drainage system and drainage maintenance system, which cause nuisance for consumers and sellers.

The present study includes a field investigation on a selected hat-bazaar area related to water-logging as well as to find out a probable solution for water logged area. In this regard, a suitable solution may be providing a permeable pavement along the both side of the pavement along with proper drainage system so that a sustainable & effective drainage system can be achieved. The overall benefits of permeable pavements may include; improved storm water drainage, improved skid resistance, reduction of mud spray to drivers and pedestrians as well as a potential for noise reduction. This techniques can be used for local hat-bazaar area of Bangladesh which are usually suffered from water logging during rainy season.

Key Words: Hat-Bazaar; permeable pavement; drainage system; water logging; CRMB (Crumb Rubber Modified Bitumen)

INTRODUCTION
Due to rapid modernization of human life, rapid growth of population, Bangladesh generates numerous economic places on roadside such as Hat-Bazaar. A Bazaar is a permanent enclosed merchandizing area, market place or streets of shop where goods and services are exchanged or sold. In each and every rural area of Bangladesh, there are some bazaars whether shaded or open where rural people fulfil their daily essentials.

Hat-Bazaar area has been facing extensive water logging problem during monsoon period due to poor drainage system & drainage maintenance system. Water logging provides many problems for traffic & road users and sometimes the whole transportation system become useless. Road development is independent compare to other mode of transportation. Without road transportation, other transportation system will become functionless. Only a well-defined & well developed road network can serve a country and its population properly. Water logging is one of the problem which is responsible for the damage of road & sudden break down of smooth as well as comfort transportation system, causing local water logging, spreading diseases, environmental problem, economic degradation & many more. That's why the study of water logging problem at Hat-Bazaar area is too much necessary.

Permeable Pavement (CDT, 2016) is an alternate solution that can be used with proper drainage system to overcome this problem. Pahartali Bazaar is situated on Chittagong-Kaptai road which is a regional highway (Medium volume road). For laboratory investigation & to make a comparison between normal bitumen & CRMB M30-10 have been used for permeable pavement. CRMB M30-10 is a modified binder that a mixture of 10% (by wt. of bitumen) waste crumb rubber (passes through #30 sieve) with bitumen. To determine stability, flow & Optimum Bitumen Content (OBC) Marshall

method of mix design has been used (AASHTO 2350). Also OBC has been calculated by Equation [1] (Kadiyali, 2003).

OBC = Bitumen content at (max. stability + max. density + avg. air void + 80% VFA)/4 … (1)

Moreover, to determine moisture susceptibility, Indirect Tensile Test have been conducted in the laboratory. And hence Tensile Strength Tensile Strength Ratio (LS-297) have been calculated by Equation [2] and Equation [3] respectively.

$$ITS = \frac{(2000 * P)}{(\pi * h * d)} \quad \dots (2)$$

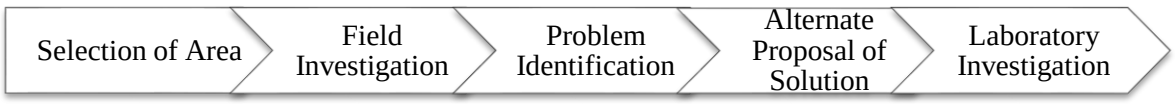
$$TSR = \frac{ITS(wet)}{ITS(dry)} * 100\% \quad \dots (3)$$

The purpose of this paper is to provide a guidance for road concerning officials and other relevant organizations regarding proper road surface drainage. This paper also describes the causes of road surface drainage problem and its remedial measures at rural-hat bazaar area. In this era of drainage problems the following objectives have been selected for the present study.

- To ascertain the causes of water logging on selected hat bazaar area.
- To find out the suitability of permeable pavement.

METHODOLOGY

Water logging has been creating enormous problems due to improper drainage system. It impacts on local dwellers with respect to economic and normal activities. To overcome this problem, a sustainable and effective solution have to be implemented. The aim of this study is to find out a solution for water logging problems at Hat- Bazaar areas. The total investigation has been done by the following ways.



Selection of Area

There are many Hat-Bazaar areas in Chittagong. Out of these, Pahartali Bazaar is being selected for the present study as it is situated very near to Chittagong University of Engineering and Technology (CUET) and it has been facing water logging problem almost throughout the year.

Field Investigation

From field investigation, we have identified some problems regarding water logging; during the monsoon period, with very little amount of rain the roads of Pahartali bazaar become water logged and road surface is heavily damaged which has been shown in Figure1
The logged water cause serious traffic problem on the road has been represented in Figure 2.

Field investigation includes the study of the present scenario, the causes of water logging is,

- The Pahartali Bazaar becomes water logged during and after rainfall due to non-availability of adequate camber, proper drainage system, disposal system and maintenance system is shown in Figure 1.
- The adequate cross slope does not exist due to the blockage of the drain that was provided for the carry out of excess water has been represented in Figure 2.
- The drain which lay alongside of the road is severely blocked due to the solid waste thrown by local dwellers &due to soil siltation which has been shown in Figure 3.
- The road become very narrow due to the wastage are dumped on the road is shown in Figure 3.

Fig. 1: Damaged &Water Logged Areas at Pahartali, Raozan, Chittagong.

Fig. 2: Traffic problem & Blockage of drainage at Pahartali, Raozan, Chittagong.

Fig. 3: Dumped waste and Soil siltation on road side.

Alternate Proposal of Solution

From field investigation and problem identification data, this study realize that water logging problem has to be removed by using a sustainable solution. The excess water is to be drained by using elevated road surface along with a proper drainage system. In addition, to accelerate the water drainage, a permeable pavement which is a new technique can be implemented within the roadway pavement on both side.

Laboratory Investigation

To implement permeable pavement, laboratory investigation is needed to determine its feasibility. Laboratory Investigation includes selection of aggregate, selection of binder and the selection of design method.

Selection of Aggregates

The aggregates used in the permeable pavement consists of crushed angular stone with maximum size not exceeding 19 mm which has been shown in Table 1 according to AASHTO-2350.

Table 1: Aggregate gradation for permeable pavement (AASHTO- 2350)

Sieve Size, mm	Percentage Passing %
19	100
12.5	85 – 100
9.5	55 – 75
4.75	10 – 25
2.36	5 – 10
0.075	2 – 4

Selection of Binder

Permeable pavement consists of a high percentage of interconnected air voids. Because of high amount of air voids, aging resistance of the binder becomes crucial. Void content in asphalt mix determines the rate of aging by controlling oxygen access to the binder. Aging makes bituminous materials harder and more brittle, thus increasing risk of pavement failure, such as raveling and cracking. Crumb Rubber Modified Bitumen (CRMB) has been shown to have the ability to improve the rutting resistance, resilience modulus and fatigue cracking resistance of asphaltic mixes. CRMB is produced by mixing normal bitumen (80/100) with reclaimed crumb rubber (Palit, 2001).

To compare Marshall Stability, flow, OBC value and water sensitivity in addition to CRMB, normal bitumen also used in this investigation.

Selection of Design Method

This laboratory investigation has been carried out on the basis of Marshall Mix Design. (Kadiyali, 2003).

EXPERIMENTAL RESULTS & DISCUSSION

To investigate the properties of aggregate & binder, physical characteristics have been tested in the transportation laboratory, Department of Civil Engineering, CUET. The physical properties of aggregate & binder have been represented in Table 2 & Table 3 respectively.

Table 2: Physical Characteristics of Aggregate

Serial No.	Desirable Property of Aggregates	Name of the Experiment	Result	Permissible Value Specified by IRC (for bituminous surface course)
1	Specific Gravity	Specific Gravity	2.67	2.5 to 3.2
2	Toughness	Aggregate Impact Value	10.73%	< 30%
3	Shape of Aggregates	Flakiness Index	14.35%	< 15% and should not exceed 25%
		Elongation Index	13.56%	< 15 %
4	Hardness	Abrasion loss	26.38%	< 40 %
5	Water Absorption	Water Absorption	0.54%	should not exceed 1%

Table 3: Comparison of binder properties between Normal bitumen & CRMB

Type of Test	Normal Bitumen	Modified Bitumen(M30-10)CRMB
Penetration Value(mm)	99	74
Ductility (cm)	100	45
Softening Point (°C)	46	56
Flash Point (°C)	302	248
Fire Point (°C)	318	266
Loss on Heating	0.25%	0.31%
Specific gravity	1.019	1.03

From Table 2, it has been found that the values obtained are matched with the recommended value of Indian Road Congress (Kiran, 2014).

Performance Test

To determine stability, flow & OBC of the bituminous mixes Marshall Method has been used for heavy duty road. The Marshall parameters have been found out for varying content of binder. The experimental results of Marshall Mixes have been presented in Table 4 & OBC has been calculated according to Equation [1].

Table 4: Comparison of Marshall Parameters between Normal bitumen & CRMB

% Bitumen	Marshall parameters for Normal Bitumen					Marshall parameters for CRMB				
	Stability (KN)	Flow (mm)	Density (gm/cm^3)	Air Void %	VFA %	Stability (KN)	Flow (mm)	Density (gm/cm^3)	Air Void %	VFA %
4%	6.14	3.62	2.20	10.43	45.28	7.22	2.08	2.23	10.16	46.0
4.5%	6.21	3	2.23	10.17	49.14	8.65	2.75	2.25	10.15	49.20
5%	6.64	3.7	2.21	10.05	51.90	6.64	2.83	2.24	10.02	51.99
5.5%	5.50	2.8	2.19	9.98	54.28	5.79	3	2.21	9.64	55.23
6%	3.90	2.6	2.18	9.41	57.85	5.6	3.95	2.19	9.50	57.60

From Table 4, it has been found that CRMB bituminous mixes has shown higher stability than normal bitumen. OBC values for CRMB mixes & for normal bituminous mixes have been found 4.6% and 4.8% respectively. Therefore, respective OBC has been used for water sensitivity test and the results have been presented in table 5. It is seen from Table 5 that CRMB shows more tensile strength than normal bitumen.

Table 5: Results of Indirect Tensile Strength Ratio

Type of Bitumen	No. of Blows	Tensile Strength at Dry Condition (KPa)	Tensile Strength at Wet Condition (KPa)	Tensile Strength Ratio %
CRMB	75	238.9	186.4	78.10
Normal	75	212.8	138.32	65.45

As CRMB bituminous mixes show higher performance in terms of stability and water sensitivity than normal bituminous mixes, permeable pavement can be constructed by using CRMB binder. A typical cross section of a road pavement along with permeable pavement and surface drainage system has been proposed and depicted in Figure 4.

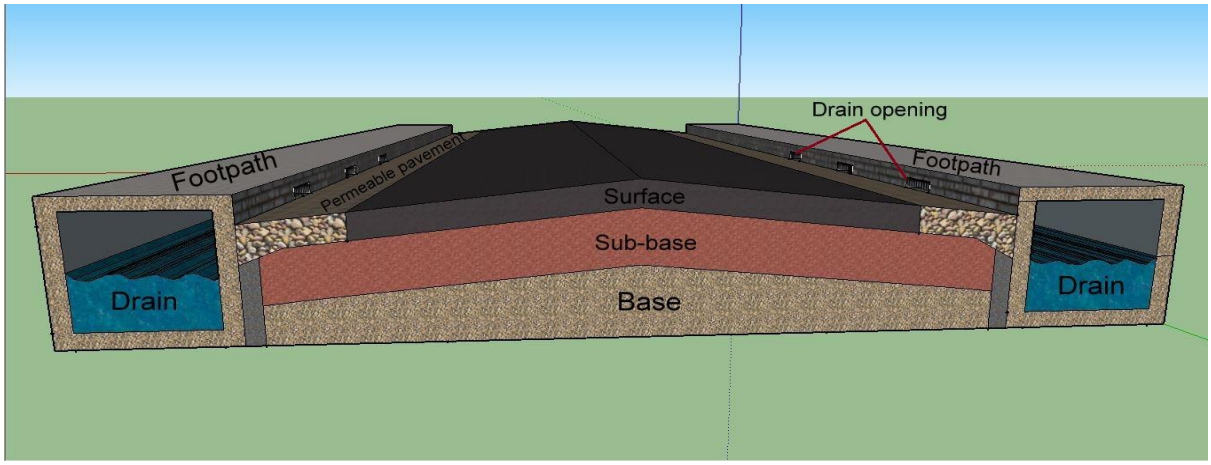


Fig. 4: Proposed cross-section of a road pavement along with permeable pavement & surface drainage system

CONCLUSION

Hat-Bazaar is the center of local activity. During rainy season, this Bazaar become water logged due to improper drainage system & drainage maintenance system. So, the water logging becomes a threat to the local dwellers for social as well as economic activities. Due to lack of awareness of local people, waste such as polythene, domestic waste etc. is thrown to the drain, creating clogging of drainage system. It's a serious matter that require immediate attention & available solution. So a proper drainage system along with proper drainage maintenance system is a crying need for bazaar as well as for other water logged areas. Nothing can be implemented properly if the solid waste management has not been done properly. To imitate these problems, drainage management system have to be handled carefully. The road surface must be elevated from the drain so as to drain out of water swiftly. Permeable Pavement can be used on both side of the roadways to accelerate the drainage capacity. So a proper drainage system along with permeable pavement can be a better solution to remove water logging from Hat-Bazaar areas to establish a healthy & economic environment.

LIST OF REFERENCE

AASHTO 2350, Hot Mixed Asphalt-Porous Pavement.

Bangladesh Meteorological Department (BMD), Dhaka.

Kadiyali, LR and Lal NB. 2003. *Principles and Practices of Highway Engineering.* India.

Kiran, K; Manjunatha, S and Prasad, SN. 2014. Porous Asphalt Pavement A Tentative Mix Design Guidelines – By New Generation Open Graded Friction Course Approach. *International Journal of Engineering Science Invention Research & Development*, I(III).

LS-297, The Determination of Indirect Tensile Strength of Expanded Asphalt mix, Ministry of Transportation, Ontario, Canada, 2001.

Palit, SK. 2001. *An Investigation on Bituminous Mixtures Modified With Reclaimed Crumb Rubber*. *PhD* Thesis, Indian Institute of Technology, Kharagpur, India.

Pervious Pavement Design Guidance, California Department of Transportation (CDT), May 2016. [Online]. Available at: http://www.dot.ca.gov/hq/oppd/stormwtr/.

OVERFLOW OF MIRZA KHAL OF CHITTAGONG CITY AND IT'S EFFECTS ON ROAD

M. A. Hossain* & S. K. Palit

Department of Civil Engineering, Chittagong University of Engineering and Technology, Chittagong, Bangladesh
**Corresponding Author: altafsunnycuet@gmail.com*

ABSTRACT
Chittagong is the business capital and one of the most important cities of Bangladesh. The effect of uncontrolled runoff during monsoon becomes a burden and possesses a serious threat to urban road, human health & wellbeing of citizen. Overflow is one of the main causes which damages the road and disrupts the normal life of city dwellers. For ensuring a normal city life and efficient road network system, overflow must be prevented by any means. The present investigation on the overflow of Mirzakhal reports the identification of the causes of overflow, effects on road and remedial measures. Using waste water data, run-off co-efficient and rainfall data, the flow through the canal is measured. After completion of the run-off estimation, it is found that the total discharge is higher than present drainage capacity of the canal, which results overflow. Besides, siltation, vegetation, disposed solid waste, formation of excessive bends etc. are also causes of overflow of the canal. People, living in this area, face a lot of problems especially during monsoon period. The roads passing through this area are badly damaged and hence various types of pavement distresses and deteriorations create that affect the safety and riding quality of the pavement. To eradicate the overflow problem, some remedial measures have been suggested for the Mirzakhal.

Keywords: Overflow problem; Chittagong city (Mirzakhal); drainage capacity; roads damage

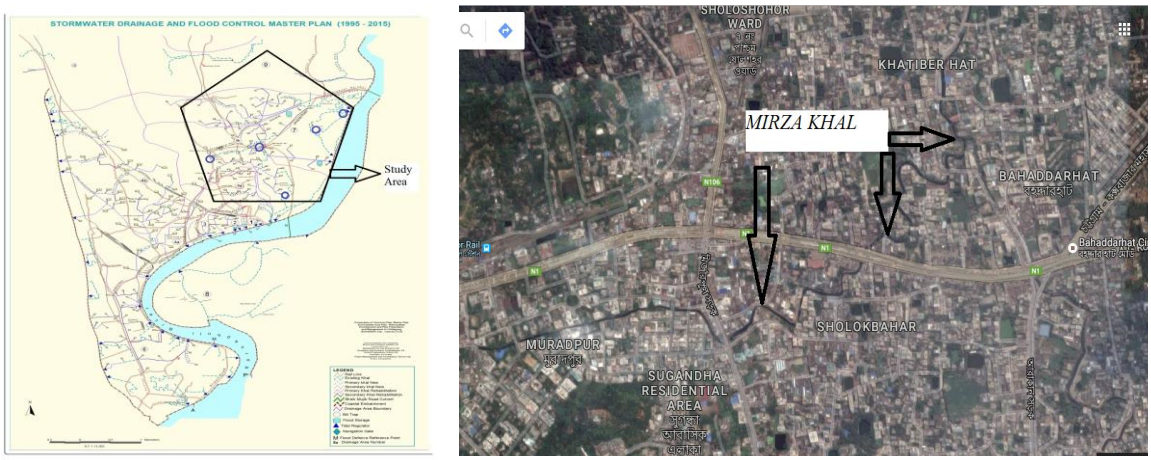
INTRODUCTION
The rapid development of an urban area largely depends on its proper drainage system which may be disturbed due to overflow of water from canal. When the discharge of a water body is more than its design capacity, it is said to be overflowing. Roads get damaged in the rainy season due to water logging as water is the main contributor to the failure and damage of roads. Many researches evidently representing that poor drainage can adversely affect pavement performance. Owuama et al. (2014) suggested that construction of road network in an urban or semi – urban settlement requires a good drainage system that can convey rainfall surface runoff from impermeable surfaces created by road surface and built up areas. The efficiency of such a drain depends upon the road, construction standard and ethics adopted, and maintenance culture. Rokade et al. (2012) stated that inadequate drainage leads to major cause of pavement distresses due to large amount of costly repairs before reaching their design life. Cedergreen et al. (1973) evaluated early field tests that included both drained and undrained pavement sections. Based on the field data, he estimated that a flooded undrained pavement experiences 10 to 70,000 times the damage from a load event compared to a drained pavement. To achieve proper drainage, drains or ditches a long side of road are essential to collect water from road surface and surrounding areas and lead it to an exit point where it can be safely discharged.

Chittagong is located in the tropical zone. Annual rainfall in the city fluctuates between 2100mm and 3800mm, of which 2400mm occurs only during the monsoon (Arafat, 2015). However, such climate has been there for centuries, while water logging is a comparatively recent phenomenon. The problem of water logging in Chittagong has reached such an extent that the first monsoon rain is enough to shut down the city. In the last decade or so, this problem has been increasing due to population growth, economic agglomeration with unplanned urbanisation, illegal refilling of natural water channels, and encroachment of drains. Most of the drainages are obstructed by building structures,

that have overtaken the natural gravitational drainage systems of the city, which were organised enough to cope with the natural rainfall.

Study Area

Mirzakhal is one of the most important natural drainage systems in Chittagong city. The study drainage system covers the area like Muradpur, Chittagong Development Authority (CDA) Avenue, Nasirabad, Shulakbohor and some portion of Bahaddarhat. The location of Mirzakhal in Stormwater Drainage and Flood Control Master Plan, 1995 (Chittagong Development Authority) and in Google Earth is shown in Fig. 1 (a) and Fig. 1 (b) respectively.



(a) (b)

Fig. 1: Study Area

Drainage Capacity of Existing Khal

During field investigation, different cross section along the canal has been measured at which overflow occurs. A critical section near the Asian Housing Society has been considered for measuring the drainage capacity of the existing canal which is shown in Fig. 2. The cross section has been considered as a smooth trapezoid section and total discharge from this channel section is calculated by using the formulae of open channel hydraulics (Chow, 1959) which is 22.02m^3/sec.

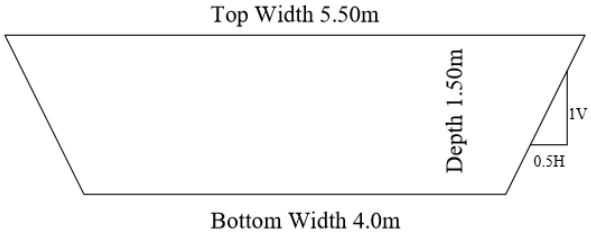


Fig. 2: Existing dimension of canal

The primary objective of this paper is to investigate the effects of overflowing on roads and urban people's life. To achieve this objective a field survey program was conducted on Mirzakhal. The field survey was carried out by visual inspection to evaluate the existing conditions of the drainage system and investigate its effects on road performance.

CAUSES OF OVERFLOW

Overflowing occurs mainly during the period of heavy rainfall. The drainage system cannot drain out of excess water. Also during monsoon period, tidal flows enter into the natural drainage which has connection with surrounding river. Siltation, vegetation, topography, poor management system, lack of public awareness etc. are responsible for overflowing in a drainage system.

Excessive Rainfall

Heavy rainfall is one of the main reasons for water logging in Chittagong City. Relatively low intensity of rainfall also causes serious water logging problems for certain areas of the city. Average monthly precipitation over the year (Rainfall, Snow) in Chittagong is given in Table 1 (World Weather & Climate Information, 2016).

Table 1: Average monthly precipitation in Chittagong, Bangladesh

Month	Rainfall (mm/30days)	Month	Rainfall (mm/30days)	Month	Rainfall (mm/30days)
January	6	May	256	September	330
February	36	June	537	October	168
March	64	July	600	November	59
April	148	August	528	December	9

Calculation of actual discharge

Estimation of Run-off

For determining the actual discharge, total catchment area is divided into 19 small areas consisting of 1.13 km^2 which are illustrated in Fig. 3 and calculated total run-off is run-off 7.13m^3/sec.

Fig. 3: Various Catchment Areas for determining the actual discharge in Mirza khal

Estimation of waste water discharge

Total waste water coming from the drains situated in 2 no. gate to Bahaddarhat area is 12.55m^3/sec. Disposed waste water in Mirzakhal from the area of Shulokbohor, West Sholoshahar, Panchlaish, East Sholoshahar and Muradpur are 5.0 m^3/sec, 3.25 m^3/sec, 2.90 m^3/sec, 1.60 m^3/sec and 3.21 m^3/sec respectively (Chittagong City Corporation¸ 2015). Total waste water discharge is 28.51 m^3/sec and total discharge is 35.64 m^3/sec. As, the drainage capacity of the existing canal is less than the total discharge consists of runoff estimation and waste water discharge, so overflow will occur at that section.

Siltation Problem

Siltation problem reduces the width of the canal. Many residents of the city have blamed that a number of sluice gates operated by Chittagong Water and Sewerage Authority (CWASA) and these gates are causing siltation in rivers and water logging. So that one of main natural drainage system of Chittagong city lost its runoff capacity and increased impervious area due to siltation. Significant amount of siltation in Mirzakhal has taken place during the last few years which is shown in the following Fig. 4.

Vegetation Problem

Water logging tends to exclude oxygen from the soil and plants have evolved many ways to deal with this, leading to the evolution of hundreds of specialist wetland and waterside species which is known as vegetation. Vegetation problem arises after siltation takes place in the canal. Many places along the Mirzakhal are covered by the vegetation problem which is illustrated in Fig. 5.

Solid Waste Disposal

Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets, industrial and hospital solid waste deposition along the Mirzakhal is creating obstacles in the flow path of water is shown in the Fig. 6.

Illegal Construction works

Developmental work like construction of high rise buildings, office centre etc. are operated illegally on the bank of the Mirzakhal shown in the following Fig. 7. It bends excessively in some places like Mirzapool, Nasirabad, and Asian Housing Society. The unplanned development activities and growth of population are causing encroachment or retention areas and natural drainage path with little or no care of natural drainage system that creating obstacles to properly drain out the urban runoff.

Fig. 4: Siltation in Mirzakhal

Fig. 5: Vegetation problem in Mirzakhal

Fig. 6: Solid waste in Mirzakhal

Fig. 7: Construction work on the bank of Mirzakhal

EFFECTS OF OVERFLOW

Urbanization disrupts natural drainage patterns. Natural water course are destroyed, and existing drainage system cannot drain excess water. It causes overflow. The increase in volume and rate of runoff causes erosion and siltation. It causes various problems like disruption of traffic movement, disruption of normal life of the urban inhabitants, damage of structure, water pollution, and increase of water borne diseases.

Social Problem

Overflow affects various social sectors. It disrupts normal traffic movement. Where the storm water cannot drain out, puddles will form. Overflow creates inconvenience for road users which is shown below in Fig. 8 and Fig. 9.

Fig. 8: Disruption of normal traffic flow (Location: 2 No. Gate)

Fig. 9: Inconvenience for road users (Location: Muradpur)

Fig. 10: Road damaged due to water logging (Location: Muradpur)

Fig. 11: Bad effect of overflow on road (Location: Bahaddarhat)

Physical Problem

Overflow accelerates the damages of structure, infrastructures, and underground service lines. It contributes to ground heave, subsidence and dampness. Water logging causes the damage to roads (both paved and unpaved) in the rainy season every year leading to the movement problem and interrupts the journey. Serious damage of road has occurred in many locations of study area, few examples of which are illustrated in the Fig. 10 and Fig.11.

Environmental Problem

Storm water generated from the catchment areas carry significant amount of pollutants. In poorly drained areas, urban runoff mixes with sewage from overflowing latrines and sewers, causing

pollution and a wide range of problems associated with water borne diseases. Sometimes the poor people had to rely on surface or shallow groundwater sources that are polluted as they don't have access to potable water during the monsoon period. Moreover contamination of groundwater also leads adverse health impacts.

Economic Problem

As it is stated earlier that water logging reduces the life span and damages the roads and metalloid pipes of various underground utility services such as water, telephone, sewerage etc. It needs a huge cost to replace these facilities. The city authority had to spend about Taka 7 to 8 billion every year to replace and maintain infrastructures damaged by water logging. Damage to substructure brick foundations, houses in slums and low-income areas due to water logging means the huge economic losses for the inhabitants.

DISSCUSSION

Rapid population growth, unplanned land filling to develop new residential areas, uncontrolled and haphazard disposal of solid wastes and garbage into the existing drainage system, and encroachment on lakes, canals and rivers with unauthorized construction are the summarized general man made activities related to the disappearance of natural drainage system. Lack of comprehensive and planned maintenance program, equipment, adequate budget, staffing, proper monitoring program and institutional set up to effectively operate and maintain the drainage, natural siltation, indefinite drainage outlets are accounted for main causes of blockage in drainage system and overflow.

REMEDIAL MEASURES

The Mirzakhal which earlier had a depth of 15 feet has now become as shallow as 2 feet. As a result the canal becomes unable to pass the water fully in a normal way due to the obstruction in natural flow path and turning of the wide flow path into a narrow one. Due to the overflow problem of Mirzakhal, water logging occurs measuring up to 6/7 feet even when there is light rain leaving the residents in immeasurable trouble. Following are the some remedial measures proposed to minimize overflow problem.

Reducing excessive bends

Mirzakhal includes many places where excessive bend has taken place. Formation of excessive bend along Mirzakhal in Shulokbohor has been shown in Fig. 12. The excessive bends of the canal should be reduced by ensuring that the bank of the canal is protected from illegal possession. The channel with excessive bends can be abandoned by the formation of a straighter and a shorter channel or by introducing artificial cut off. Three important junctions have been identified shown in Fig. 12, where artificial cut-off can be applied to reduce the excessive bend. The proposed alignment after applying artificial cut-off is shown by dark line in Fig. 12 and proposed artificial cut-off near N. Mohammad Plastic Industry is shown in Fig. 13.

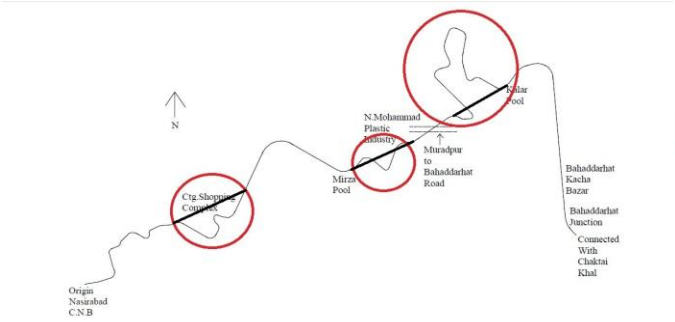


Fig. 12: Proposed alignment of Mirzakhal by the formation of shorter and straighter channel

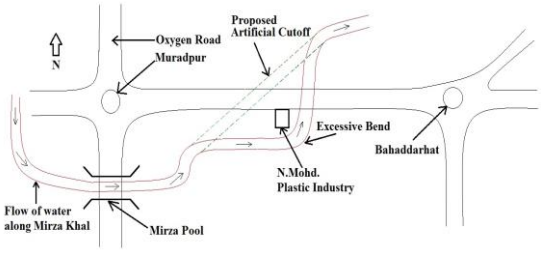


Fig. 13: Proposed artificial cut-off near N. Mohammad Plastic Industry

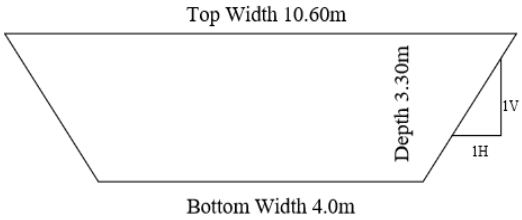
Silt trap construction

Silt trap can be placed at that point of the canal where siltation occurs frequently. It has a basket with an approximate 50 litres capacity which is easy to remove, ensuring simple, low cost servicing and

maintenance of the canal. When water flows along the canal, carrying silt, the silt will be trapped into the box. Regular cleaning of the box will help to keep the water depth sufficient enough.

Proposed Design section of Mirzakhal based on flow capacity

Alignment of the canal should be fixed before going for developing structure along it so that sudden excessive bend can be avoided. A channel section is designed based on the flow capacity of Mirzakhal by using the formulae of open channel hydraulics (Chow, 1959) illustrated in Fig. 14.



Design parameters:
Bottom width= 4.0 m, Side slope = 1H : 1V
Velocity of flow = 1.5 m/sec
Design:
Discharge= 35.64 m^3/sec
Hence, Area=23.78 m^2, Depth= 3.30 m Top width=10.6m
Slope of canal= S = 0.000449 or 1 in 2226

Fig. 14: Proposed Channel Section

CONCLUSION

The study investigated cases of pavement failures and damages due to overflow of Mirzakhal experienced during the last few years on a number of roads in Chittagong city. On Basis of the previous experiences in design and construction of drainage, the study proposes design channel section, a straighter and a shorter channel alignment and introduction of artificial cut-off in order to reduce excessive bends and construction of silt trap to reduce siltation problem as well as vegetation for a proper and efficient drainage system. The concerned authority should ensure regular and careful maintenance of Mirzakhal through proper monitoring program to stop illegal construction works. Consistent yearly evaluation of drainage systems is an essential part of maintaining and managing road. Drainage facility should be improved before making any pavement surface improvements. It is most efficient and effective to plan and upgrade drainage as part of road surface improvements.

LIST OF REFERENCE

Arafat, SMGB. (July 01, 2015). The “sorrow of Chittagong City”. ***The Daily Star.*** [Online Report]. Available at: http://www.thedailystar.net/op-ed/politics/the-%E2%80%9Csorrow-chittagong-city%E2%80%9D-105313 [Accessed 18 August 2016].

Cedergreen, HR; Arman, JA and O’Brien, KH. (1973). Development of Guidelines for the Design of Subsurface Drainage Systems for Highway Pavement Structural Sections. *FHWA-RD-73-14, Federal Highway Administration, Washington, DC.*

Chittagong Development Authority, 2016. *Stormwater Drainage and Flood Control Master Plan 1995*. Available at: http://cda.gov.bd/download/miscellaneous/Drainage%20master%20plan.pdf [Accessed 26 August 2016]

Chow, VT. 1959. *Open-Channel Hydraulics*. McGraw-Hill, New York: International Edition.

Owuama, CO; Uja, E and Kingsley, CO. (April 2014). Sustainable Drainage System for Road Networking. *International Journal of Innovation, Management and Technology,* Vol. 5, No. 2.

Rokade, S; Agarwal, PK and Shrivastava, R. (2012). Study on Drainage Related Performance of Flexible Highway Pavements. *International Journal of Advanced Engineering Technology (IJAET)*, Vol. 3, Issue 1, PP 334-337.

World Weather & Climate Information, 2016. *Average Precipitation (Rain/Snow) in Chittagong*. [Online]. Available at: https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine, Chittagong,Bangladesh. [Accessed 19 September 2016].

REMODELING AND MODERNIZATION OF KAMALAPUR RAILWAY STATION

H. M. Ahsan, D. A. Parvez & M. Hasan

Department of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh
**Corresponding Author: hmahsan@ce.buet.ac.bd*

ABSTRACT
Railway station is one of the most important components in transportation network system which may serve various purposes like passengers and goods transport as well as container depot. Kamalapur Railway Station is the major railway station of the capital city Dhaka which served over 7 million passengers and 1 million kg of goods in 2015-16. Nearly 67,000 Twenty feet Equivalent Unit (TEU)s were also handled at Kamalapur Inland Container Depot (ICD) in 2014-15. From some recent field visits and reports degradation in safety, operation, maintenance along with low speed, increased delay time, frequent accidents etc have been observed. Moreover, government decides to take some development projects which will eventually increase more demand of this station. This paper aims at to find out some sustainable development options in comparison to other developed countries like increase of man power, modernization of train coaches, tracks, platform, parking facilities, digitalization of ticketing, signalling etc for remodeling and modernization of Kamalapur Railway Station.

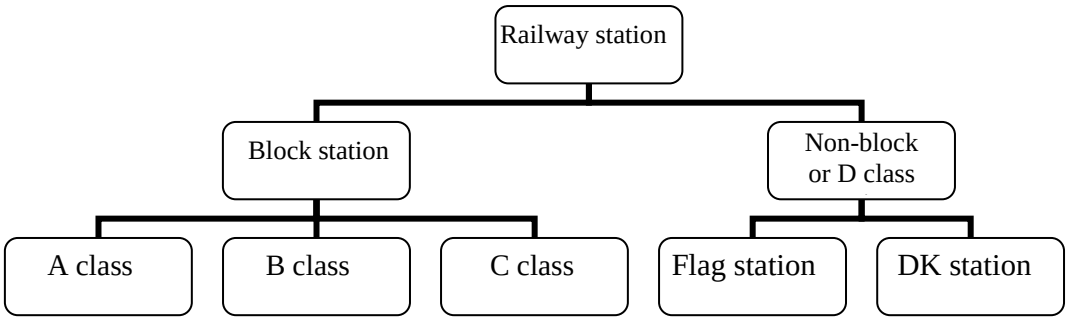
Keywords: Modernization; transportation network; projects; demand; sustainable

INTRODUCTION
Railway transportation system is the most environment friendly and cost effective transportation system in the world and stations are the most important components in this system. During British empire, there was only one railway station at Fulbaria in Dhaka. After the partition of Bengal, Dhaka became an important city and Kamalapur was selected for extension. At the beginning of the 1960s the station was built and it was designed by Robert Boughey, who was a professor of architecture at BUET (See Figure 1 and Figure 2) (Wikipedia, 2016).

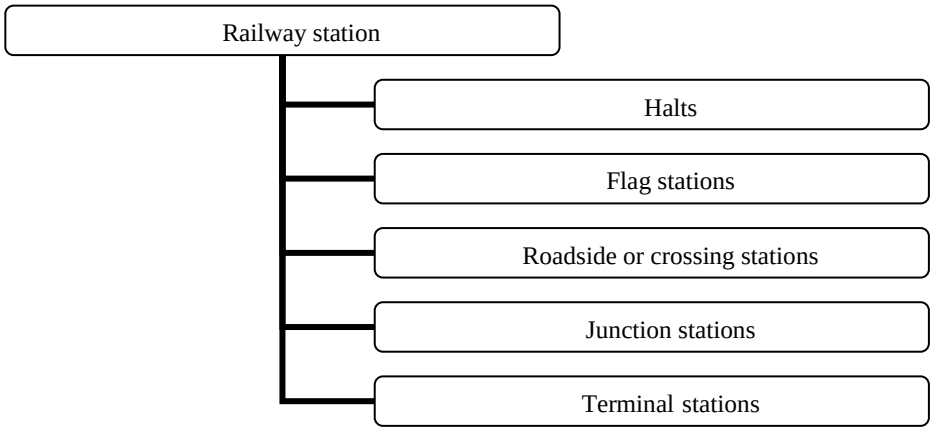
Fig. 1: Old Fulbaria Railway Station

Fig. 2: Kamalapur Railway Station

Bangladesh Railway (BR) is divided into two zones such as East zone and West zone. Kamalapur Railway Station falls under East zone. Different kinds of stations have different operational and functional characteristics. Under operational considerations, railway stations can be divided as follows (Agarwal, 2007).



Furthermore, based on functional characteristics, stations can also be divided into following five categories (Agarwal, 2007):



Considering above classifications, Kamalapur Railway Station is a Block station of Class A and also a Terminal station. Bangladesh Railway has 456 stations among which 337 stations are Block Station and 119 are Non-Block Station (Information Book, 2014).

In 2015-16 almost 70 million passengers were carried by Bangladesh Railway, among which almost 7 million were traveled by this station and also almost 1 million kg of TEUs were carried by this station in the same year (Information Book, 2014). About 138 trains arrive and depart Kamalapur Railway Station every day. Government decides to remodel and modernize this station in order to increase its capacity to meet future demand. Some of the major objectives of remodeling and modernization of this station are to safe movement of passengers and goods train with reduced travelling time, increase capacity of loading and unloading of passengers and goods, reduce delay time, increase accessibility and better container handling in Kamalapur ICD. In this regard integration with planned Mass Rapid Transit (MRT) is also very important.

PRESENT CONDITIONS

Kamalapur Railway Station serves not only as a staion but also a container depot with fuelling, repairing and maintenance facilities at station yard (See Figure 3). To serve the 20-25 thousands incoming and outgoing passengers every day making it an important busy place (Mahmud and Haque, 2014). There are only 12 approach track lines which are not sufficient enough to facilitate uninterrupted train movement in Kamalapur Railway Station. Poor accessibility at platform to platform, platform to exit point and poor inter-modal transfer facilities at parking area are some of the major problems in this station. Amenities like food courts, ATMs, book stores etc are non-uniformly distributed and scattered at station premises that causes obstruction of movement of passengers and goods. There are 12 passenger platforms, waiting rooms for VIP's, 1st class's, 2nd class's and 3rd class's passengers, 21 ticket counters along with only 2 restaurant in front of ticket counters which are not sufficient against the demand (Dhaka Urban Transport Network Development Study, 2010).

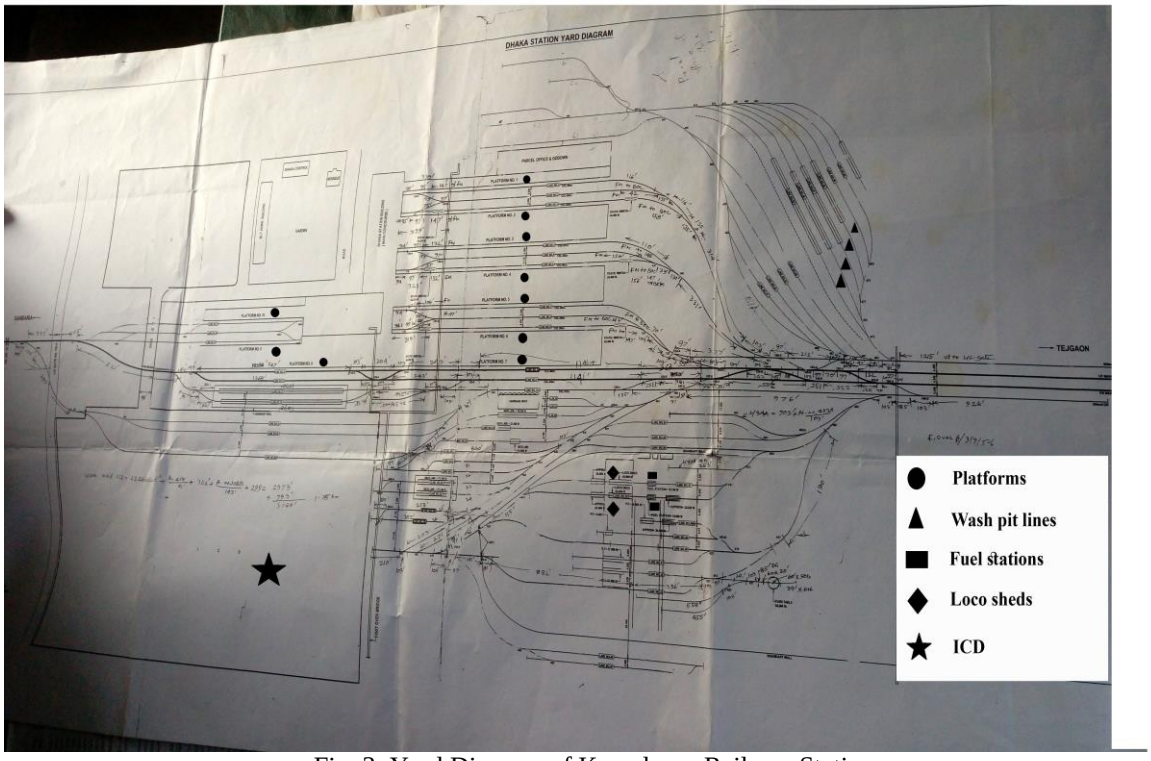


Fig. 3: Yard Diagram of Kamalapur Railway Station

Recently Kamalapur Railway Station authority started providing wifi facilities to the passengers at station premises. Though Kamalapur Railway Station has Computer Based Interlock (CBI) system but there is no Central Traffic Control (CTC) system for which efficient train operation is interrupted (Biswas, 2015). Poor fencing and unauthorized occupation of station properties poses threats to the safety and security of the passengers and railway properties. There is only 4 wash pit lines, 2 fuelling stations and 2 loco sheds in this stations which is not adequate to meet the demand. Moreover, time required at wash pit, dock pit for washing, maintenance work and refuelling at fuelling stations is increased because of their reduced capacity and inadequate and unskilled man power. Rest room and sanitation facilities are not satisfactory at the station. Kamalapur ICD was built on 33 acres of railway land with annual capacity of more than 72,000 TEUs (See Figure 4). This ICD has been practicing custom clearance under an automated system since 2008.

Fig. 4: Kamalapur Inland Container Terminal (ICD)

Some of the statistics regarding Kamalapur Railway Station and ICD are presented below in Table 1 and Figure 5 & 6:

Table 1: Number of passengers travelled by this station and TEUs handled by ICD

Fiscal year	Number of passengers travelled by the station (in Millions)	Number of TEUs handled at Kamalapur ICD
2014-15	5.48	66,847
2015-16	7.05	68,489

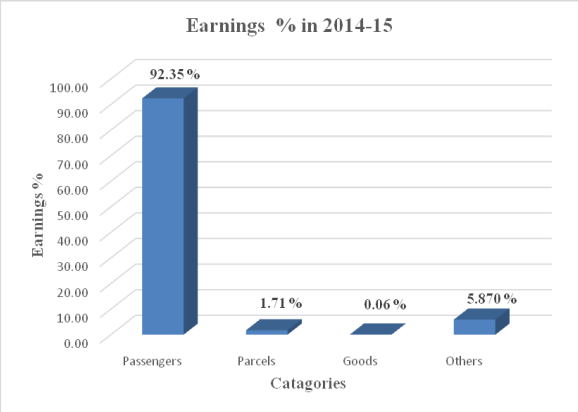


Fig. 5: Percentages of earnings in 2014-15

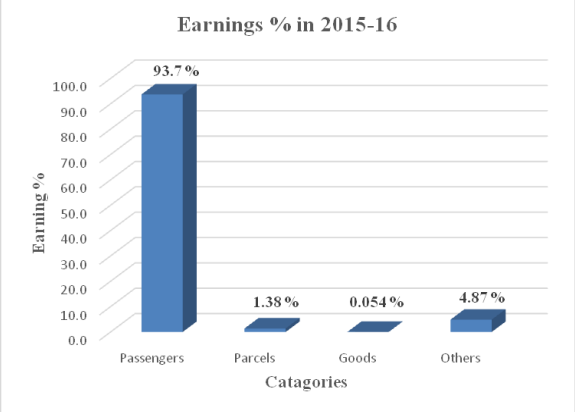


Fig. 6: Percentages of earnings in 2015-16

There are still some problems regarding safety and security measures. In 29 December 2014, 6 people died and 11 other injured in an accident at Kamalapur ICD which indicated poor freight handling capacity and security at container depot.

SCOPES FOR IMPROVEMENT

Recently, government has taken some development projects which include modernization of Kamalapur Railway Station (Rail Master Plan, 2014). Major three projects among them are as follows:

Padma Bridge Rail Link Project:

This new rail link will certainly increase usage of this station. Under this project 3 km long Dhaka-Gendaria double line will be constructed with modern signalling and interlocking system. As a result capacity of this station will be increased as well as delay time will be reduced.

Dhaka-Narayanganj Dual Gauge Rail Link Project:

Signaling and interlocking system at Kamalapur Railway Station already equipped with computer based bi-directional signaling and interlocking system (CBI), but it has to be modified for double line construction at Dhaka-Narayanganj route (Inception Report, 2016)

Dhaka-Tongi 3rd and 4th Line Project:

Already Dhaka-Tongi route has double lines but after completion of this project 2 new approach track lines, platforms will be constructed. This project will cost almost 849 crores BDT (Programme Costs and Phasing, 2010).

There are also some other projects to be undertaken by BR like constructing overpass in important level crossing gates in Dhaka which will increase the average speed of the track near the station. Feasibility Study for construction of circular MG rail line around Dhaka city is another ongoing project which may also integrate Kamalapur Railway Station (Programme Costs and Phasing, 2010).

To increase the level of service and accessibility in Kamalapur Railway Station overpass and parking facilities should be improved. Amenities like rest rooms, wash rooms, book stores, food courts, ATMs etc should be distributed uniformly throughout the public space of the station, and not be concentrated particularly at the entry/exit points where they will interfere with passenger and goods movement (Raaj et al., 2016). Ticketing facilities should be more digitalized by introducing rechargeable smart card system to reduce the hassles of booking ticket (Station design principles, 2015) (See Figure 7). This

rechargeable smart card system will prove much efficient if it is introduced in commuter trains in various routes like Dhaka-Narayanganj, Dhaka-Tongi.

Many developed and developing countries like UK, Japan, China, India etc are using smart card technology for providing rail service. As a result station capacity along with quality of rail services are greatly increased and delay time is reduced as well. Parking facilities outside of stations are also very organized on those countries which have made passenger movement more easier and convenient. In India, major railway stations have taxi stand and taxi hiring booth outside of those stations. Passengers can book taxis by buying token from those booths and pay a fixed amount of money per kilometre basis. Recently close circuit cameras have set at the station premises including platforms, exit and entrance point at Kamalapur Railway Station. But other monitoring measures like provision of fire detection and alarm system including audible and visible alarm should also be introduced at platforms (See Figure 8).

Fig. 7: Restricted entrance with rechargeable smart card system

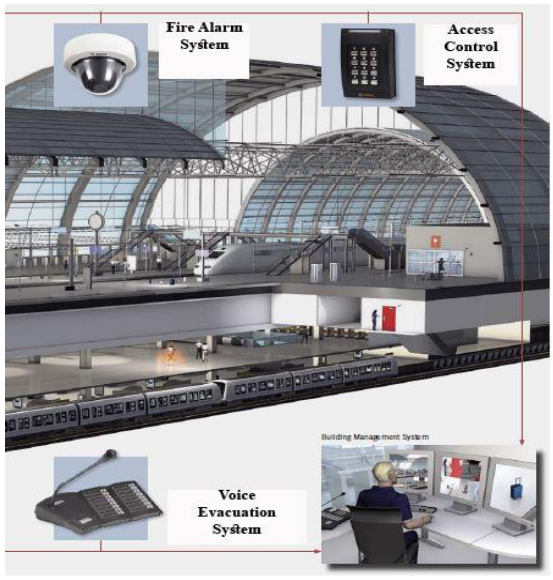


Fig. 8: Fire alarm and evacuation technologies

For easiness of boarding and alighting on train central platform system would be the most convenient system (Ministry of Railway, Government of India, 2009*)*. For anticipated increasing number of future traffic number of fuelling station, wash pit lines should be increased in order to minimize fuelling time and maintenance time respectively. But without sufficient man power and work force, all of these technologies and logistic supports cannot provide desired service efficiently. So it is necessary to arrange proper trainings and workshops for the officials and workers then appoint skilled and trained man power where it is needed.

CONCLUDING REMARKS

To achieve the goal to be the middle income country by 2021, it is much needed to develop our transportation network system and railway could be the key point in this regard. Without developing this central railway station it is not possible to achieve sustainable development in railway network system. So it is now crying need to look into the development options of Kamalapur Railway Station to be able to meet up the future traffic demand.

REFERENCES

Bangladesh Railway, *Bangladesh Railway Information Book. 2014.* Chief Planning Officer, The Rail Bhaban, Dhaka.

Bangladesh Railway, *Inception Report on Construction of a dual gauge line parallel to the existing meter gauge line in Dhaka-Narayanganj Section. 2016.* Development Design Consultants Limited,Dhaka.

Bangladesh Railway, *Rail Master Plan. 2014.* Chief Planning Officer, The Rail Bhaban, Dhaka.
Biswas, PK. 2015. *A Study on Modernization of Rail Traffic Signal System in Bangladesh Railway.* Undergraduate Thesis, Department of Civil Engineering, Bangladesh University of Engineering and Technology, Bangladesh.
Chandra, S and Agarwal, MM. 2007. *Railway Engineering,* Oxford University Press. 453.
Dhaka Urban Transport Network Development Study. 2010. Available at: http://open_jicareport.jica.go.jp/pdf/11996782_06.pdf [Accessed 1 September 2016]
Kamalapur Railway Station. Available at: https://en.wikipedia.org/wiki/Kamalapur_railway_station [Accessed 1 September 2016].
Mahmud, SMS and Haque, MS. 2014. *Interchange facilities between different modes of transport in Dhaka city.*
Ministry of Railway, Government of India. 2009. *Manual for Standards and Specifications for Railway Stations.* Available at : http://indiatransportportal.com/indian-railways-modernization-of-railway-stations-34654 [Accessed 25 May 2016]
Network Rail. 2015. *Station design principles.* Available at: http://www.networkrail.co.uk [Accessed 29 May 2016]
Programme Costs and Phasing. 2010. Available at: http://railway.portal.gov.bd/sites/default/files/files/railway.portal.gov.bd/page/69956fe3_d1f6_4b6f_9b57_80237fcf9813/9.%20Programme%20cost%20_Phasing.pdf [Accessed 1 September 2016]
Raaj, NRM; Manikandaprabhu, S and Arokiaprakash, A. 2016. *Planning and Scheduling for Modernization of Tambaram Railway Junction as a City Terminal,* S.R.M University, India.

RAIL CONNECTIVITY INBANGLADESH: PRESENT AND FUTURE

H. M. Ahsan*, F. Rahman & T. Hayder

Department of Civil Engineering, Bangladesh University of Science and Technology, Dhaka, Bangladesh
**Corresponding Author: hmahsan@ce.buet.ac.bd*

ABSTRACT
Rail transport plays a major role in regional development and economic growth in the present world. Rail communication is considered as social obligatory service, cheapest, environment-friendly, comfortable and efficient mode of transport both in developed and developing countries.The history of Railway in Bangladesh is of 150 years. Bangladesh Railway has a rail network of 2877.10 kilometres connecting 44 districts. It carries almost 20% passengers among all transport sectors of Bangladesh. But Bangladesh Railway is suffering from various operating bottlenecks. Different gauge system at different regions, missing rail links, speed restriction, lack in international connectivity are the main problems hindering its improvement. Relevant information in this regard reveal that gauge rationalization, high speed rail, installation of new rail links, modernization of rail tracks are considered to be the key options to improve the poor rail connectivity in Bangladesh. In this context, the present government has taken many projects such as construction of double line track from Tongi to Bhairabbazar, track doubling between Laksham and Chinki-Astana, construction of single line dual gauge track from Dohazari to Cox's Bazar, etc. Most of the projects are expected to be completed within the year 2022.

Keywords: Rail connectivity; rail service; gauge; development projects

INTRODUCTION

Rail connectivity is necessary for regional development and economic growth in the present world. Railway is an efficient mode of transport as a train carries more than a four lane road and needs 50-70% less energy to transport a given number of passengers or a given tonnage of freight than by road (Yasin, 2010*).* The history of Railway in Bangladesh is of 150 years (Banglapedia, 2016). Railway operation in today's Bangladesh began on November 15 in 1862 when 53.11 kilometres of broad gauge line was opened for traffic between Darshona in Chuadanga and Jagotee in Kushtia (The New Nation, 2014).Bangladesh Railway (BR) has around 2877.10 kilometres of railway network which connects 44 Districts out of 65 districts. In the year 2014, Bangladesh Railway transported 65 million passengers and 2.52 million tons of freight (BR Information Book, 2014).This sector shares around 20% passengers among all transport sectors in Bangladesh (Rahaman and *Rahaman*, 2009*).* Intercity trains account for about 40% of Bangladesh Railway's passenger travel and for more than 75% of passenger revenue (Sector Assessment, Railway Rolling Stock Project, 2016). Railway is expected to play a major role in the communication sector of Bangladesh. The objective of the study is to determine the status of railway tracks and services from the connectivity viewpoint and it also recommends some improvement options.

EXISTING STATUS OF RAIL TRACKS IN BANGLADESH

Bangladesh railway has 2877.10 kilometres of railway network connecting 44 districts out of 65 districts. Districts wise route kilometres are shown in Table 1.

Table 1: District wise Route Kilometres

Sl No	District	Kilometres	Sl No	District	Kilometres	Sl No	District	Kilometres
01	Bagerhat	40.53	16.	Joypurhat	54.00	31.	Gazipur	89.80
02.	Khulna	23.24	17.	Thakurgaon	43.75	32.	Dhaka	30.00
03.	Jessore	55.92	18.	Panchagarh	21.18	33.	Narayan-ganj	9.50
04.	Jhenaidaha	47.40	19.	Nilphamari	61.79	34.	Narsingdhi	38.97
05.	Chuadanga	46.71	20.	Kurigram	42.56	35.	Sunamganj	13.90
06.	Faridpur	76.81	21.	Dinajpur	167.96	36.	Brahmanbaria	74.64
07.	Gopalganj	24.13	22.	Lalmonirhat	113.15	37.	Habiganj	72.92
08.	Rajbari	88.72	23.	Rangpur	68.33	38.	Moulovi Bazar	125.33
09.	Kushtia	57.85	24.	Gaibandha	85.65	39.	Sylhet	50.64
10.	Serajganj	42.00	25.	Bogra	85.75	40.	Noakhali	29.40
11.	Pabna	59.00	26.	Tangail	95.20	41.	Chandpur	40.66
12.	ChapaiNawabganj	64.01	27.	Jamalpur	109.55	42.	Comilla	106.40
13.	Rajshahi	63.00	28.	Netrokona	65.00	43.	Feni	51.73
14.	Natore	37.00	29.	Kishorganj	73.75	44.	Chittagong	178.45
15.	Naogaon	27.00	30.	Mymen-singh	128.33			

(Source: BR Information Book, 2014)

Barguna, Barisal, Bhola, Jhalokati, Patuakhali, Pirojpur, Bandarban, Cox's Bazar, Khagrachhari. Lakshmipur, Rangamati, Madaripur, Manikganj, Munshiganj, Shariatpur, Magura, Meherpur, Narail, Satkhira, Sherpur, Magura-these 21 districts have no rail connectivity.

The railway network was inherited from British Indian Railway with two-different gauges; metre gauge (MG) and broad gauge (BG). With the railway link over Bangabandhu Multipurpose Bridge, the east-west railway system has been interconnected using a dual gauge (DG) configuration. East Zone has 1,187 route kilometres of metre gauge and 35 route kilometres of dual gauge track only. West Zone has 535 route kilometres of MG, 659 route kilometres of BG and 375 route kilometres of DG track (BR Information Book, 2014). Only 8% of the route under BR has double track or part of this route length has double track (Rail Master Plan, 2013) (See Figure 1). Thus rationalization of gauge is one of the main problems for smooth connectivity in the country.

From 1970-2003, 13 branch lines were closed. The closed branch lines are: Faridpur-Pukuria, Vharamara-Riota, Lalmonirhat-Moghalhat, Pachuria-Faridpur, Kalukhali-Bhatiapara ghat, Rupsa East-Bagerhat, Feni-Belonia, Habiganj-Shaistaganj, Shaistaganj-Balla, Kulaura-Shahbazpur, Serajganj Bogra-Serajganj Ghat, Kurigram-Old Kurigram, Modukhali-Kumarkhali (BR Information Book, 2014). Most of them were closed considering them as economically loss projects (Yasin, 2010). In order to improve, the track condition, a feasibility study for improvement and rehabilitation of branch lines of Bangladesh Railway was undertaken in 2007. The study indicated that 1009 Km of tracks needed urgent rehabilitation and 1,647 Km of tracks were in good condition, which needed only proper routine maintenance (Rail Master Plan, 2013).

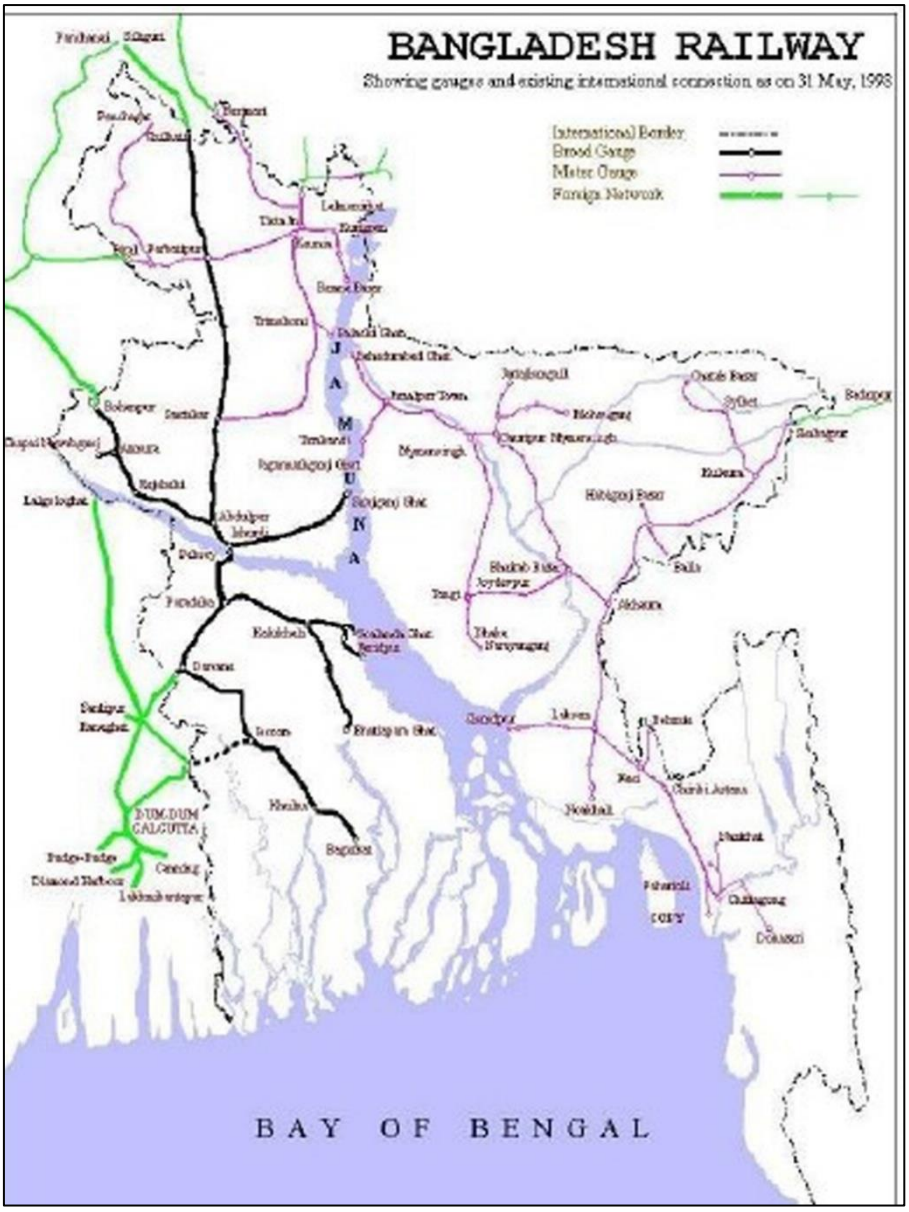


Fig.1: Rail network map of Bangladesh

In the year 2001-02 total route kilometres of BR was 2,765.99 Km and till 2013-14 total route kilometres was increased by 4% (BR Information Book, 2014). Figure 2 shows the increase of metre gauge, broad gauge and dual gauge rail tracks of BR over the year 2001-2014.

Rail transportation is very much attractive for long distance uninterrupted route network. But Bangladesh is a riverine country. There are about 546 numbers of major railway bridges, having lengths more than 40 metres and 3,104 numbers of minor bridges.Most of the railway bridges are old (Rail Master Plan, 2013). Besides during rainy season direct route links are often disrupted in many points (Ahmed, 2015).

Bangladesh Railway was not designed to serve the present geographic territory. Due to truncation from the main railway system, there are a number of missing links in different sections (Rahman, 2009). In Bangladesh Railway system, practical capacity is 75% of the theoretical capacity (Rail Master Plan, 2013). Speed restriction also creates drawback in rail communication. A staggering 47% of the network of Bangladesh Railway has speed restriction of less than 50 km/h (Rail Master Plan, 2013). Whereas China has the fastest train running at a speed of 300 km/h (Takagi, 2011) and neighborhood country India maintains train running with a speed of 160 km/h (Wikipedia, 2016).

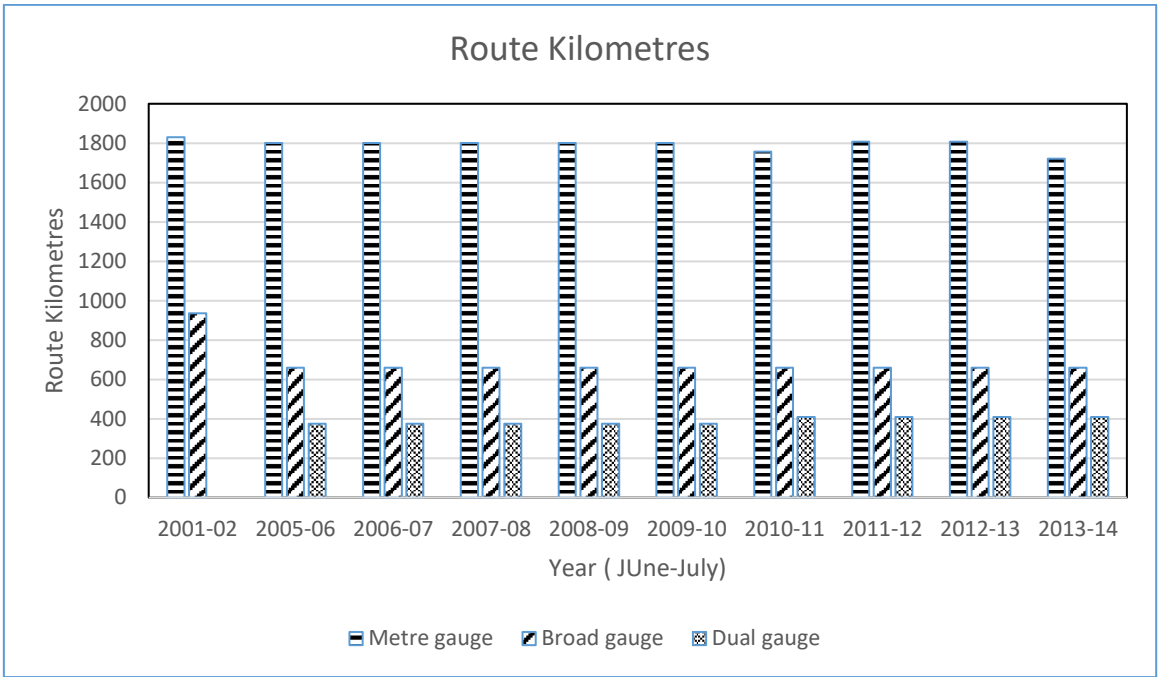


Fig. 2: Route Kilometres of rail track over the years 2001-2014

Bangladesh Railway has very few provisions for international communication. At present three broad gauge rail corridors through Benapole, Darsana and Rohanpur connect Bangladesh with India (Rail Master Plan, 2013).

DEVELOPMENT PROJECTS

Connectivity by rail in Bangladesh should be made wider. All metre gauge lines should be converted into dual gauge line. In areas where the tracks are very busy, double lines should be introduced. Bangladesh and its neighboring countries could be benefited largely if connectivity with India, Nepal and Bhutan is developed (Rahmatullah, 2009).Bangladesh is joining her rail tracks with India and Trans Asian Railway. For the improvement of rail sector, various projects have been taken by the government such as:

a) Construction of double line track from Tongi to Bhairabbazar.
b) Track doubling between Laksham and Chinki-Astana.
c) Construction of single line dual gauge track from Dohazari to Cox's Bazar.
d) Construction of new rail line from Ishurdi to Dhalarchar.
e) Construction of Pachuria-Faridpur-Bhanga sections of Bangladesh Railway.
f) Rehabilitation of Kalukhali-Bhatiapara section.
g) Construction of a new railway from Ishurdi to Dhalarchar via Pabna.
h) Rehabilitation of Laksham-Chandpur section of Bangladesh Railway.
i) Construction of 2nd Bhairab and 2nd Titas bridge with approach rail line.
j) Construction of Kashiani-Gopalganj-Tungipara new rail line.
k) Rehabilitation of Sholoshohor-Dohazari and Fateabad-Nazirhat section.
l) Rehabilitation of Kulaura-Shahbazpur section.
m) Construction of 3rd and 4th dual gauge line in Dhaka-Tongi and dual gauge double line in Dhaka-Joydevpur section.
n) Construction dual gauge double rail line and conversion of existing rail line into dual gauge between Akhaura and Laksham.
o) Construction of Khulna-Mongla port rail link.
p) Construction of dual gauge line in Dhaka-Narayanganj section, etc. (BR, 2016).

Most of the projects are expected to be completed within the year 2022 (The Daily Star, 2016). The new 120 Km Dohazari-Cox's Bazar rail line would be part of Trans-Asian railway network (Asian Development Bank, 2016). The Padma Multipurpose Bridge is designed with a single freight rail

track(Wheeler et al., 2010). The total length of the future railway structure is 15.85 Km including those over main bridge (6.15 Km), railway viaducts (2.789 Km at Mawa side and 2.899 Km at Janjira side) and approach railway (2.45 Km at Mawa side and 1.7 Km at Janjira side) connecting two stations at bridge ends (BBA, 2010).

Upcoming projects of Bangladesh Railway are: construction of dual gauge double track from Joydebpur to Bangabandhu Bridge East, construction of dual gauge double track from Bangabandhu Bridge West to Ishurdi, rehabilitation of Shayestagonj-Balla section of BR, construction of rail line between Hathazari-Rangamati, construction of rail line from Barisal to Kuakata, construction of rail line from Jamalpur to tourist spots of Sherpur, etc. (Rail Master Plan, 2013).

The government of Bangladesh has taken an initiative to reduce the traffic congestions in Dhaka by proposing Metropolitan Railway Transit (MRT) systems and for the districts adjacent to Dhaka, commuter train services. Presently, the capital is connected to Jamalpur, Dewanganj, Brahmanbaria, Akhaura, Mymensingh, Joydevpur and Narayanganj by totally 44 up and down train services. According to Bangladesh Railway approximately 40,000passengers are carried per day to and from Dhaka by these commuter rail services. The existing commuter rail services connecting Dhaka with surrounding districts is progressively attracting more passengers. However it has become difficult to increase service frequency due to the decaying single railway tracks and other infrastructures (Wang et al., 2014).

CONCLUDING REMARKS

For a developing country like Bangladesh, a high capacity, cost efficient and environment friendly transport system is required. That is why rail communication should be given priority in a large extent. The vision of Bangladesh Railway is to play an important and dominant role in an integrated transport system for the country by emphasizing its strengths. The country needs a rail communication system where every corner of the country can be connected by rail.

ACKNOWLEDGMENT

Heartiest gratitude to Md. Abdus Salam, Deputy Director (Procurement), Bangladesh Railway, for providing valuable information.

REFERENCES

Ahmed, F. 2015. *Bangladesh railway infrastructure*. Faculty of Macro Economics, School of Business, Independent University, Bangladesh.

Asian Development Bank. 2016. Bangladesh: SASEC Chittagong-Cox's Bazar Railway Project, Phase 1, available at:http://www.adb.org/projects/46452-002/main [Accessed 24 May 2016].

Bangladesh Bridge Authority (BBA). 2010. BAN: Padma Multipurpose Bridge Project- Draft Environmental Impact Assessment.

Bangladesh Railway Information Book. 2014. Chief Planning Office, The Rail Bhaban, Dhaka.

Banglapedia. 2016. Available at: en.banglapedia.org [Accessed 5 May 2016].

Rahmatullah, M. 2009. Regional connectivity: Opportunity for Bangladesh to be a transport hub. *Journal of Bangladesh Institute of Planners*, 2:13-29, SSN 2075-9363.

Rahaman, KR and Rahaman, MA. 2009. *Service Quality Attributes Affecting the Satisfaction of Railway passengers of selective routes in southern part of Bangladesh, theoretical and empirical researches in urban management*, Urban and Rural Planning Discipline, Khulna University.

Rahman, MS. 2009.*Reorientation of Bangladesh Railway: A market integration study*, Department of Marketing, EMBA Program, Faculty of Business Studies, University of Dhaka.

Rail Master Plan 2013. Bangladesh Railway (BR), Rail Bhaban, Dhaka.

Sector Assessment, Railway Rolling Stock Project (RRP BAN 49094). 2016. Available at: http://www.adb.org/sites/default/files/linked-documents/49094-001-ssa.pdf [Accessed 11 April 2016]

Takagi, K. 2011.*Expansion of high-speed rail services development of high-speed railways in China.*

The Daily Star.5 May 2016.

The New Nation. 16 August 2014.

The official website of Bangladesh Railway (BR). Available at: http://www.railway.gov.bd/ [Accessed May 02, 2016].
Wang, R; Nakamura, F and Tanaka, S. 2014. A CostBenefit Analysis of Commuter Train Improvement in the Dhaka Metropolitan Area, Bangladesh.*The 9th International Conference on Traffic & Transportation Studies (ICTTS'2014)*.
Wheeler, WK; Aves, R.J; Aecom, CJT; Zaman, M and Islam, MR. 2016. Detailed design of the Padma Multipurpose Bridge, Bangladesh- An overview. *Bangladesh Bridge Authority, Government of Bangladesh, Dhaka, Bangladesh.*
Wikipedia- the free encyclopedia. 2016. Available at: en.wikipedia.org. [Accessed 10 May 2016]
Yasin, MT. 2010. *Status of Railway Tracks and Rolling Stocks in Bangladesh*, Master of Civil Engineering (Transportation), Department of Civil Engineering, Bangladesh University of Engineering and Technology.

DEMAND AND SUPPLY OF PARKING FACILITY AND THE EFFECTS OF ON STREET PARKING ON ROADWAY CAPACITY

M. M. Banu[1*] & M. M. Rahman[2]

[1]*Department of Civil Engineering, Chittagong University of Engineering and Technology, Chittagong, Bangladesh*
[2]*Department of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh*
[*]*Corresponding Author: muktabanu@cuet.ac.bd*

ABSTRACT
Parking demand in Dhaka city is increasing greatly due to the increase in number of vehicles especially passenger cars and the trip attractions to the shopping centers, hospitals and other commercial buildings which are developed in an unplanned way and without following Bangladesh National Building Code (BNBC) properly. It is found from the analysis that 60% of the organizations do not have adequate parking facility as specified in BNBC. Improper management, operation and maintenance are also present even if enough parking supply is provided in some cases. Due to the lack of proper parking facilities and strict regulations, on street parking has become a very common phenomenon in Dhaka city which decreases the roadway capacity and creates severe problems like congestion, delay, accident potentiality and some other relevant problems. 50-65% reduction in roadway capacity due to on street parking is found on the roads of Shapla Square, Motijheel. The percentage of reduction is 52% in case of Mirpur Road in front of New Market. 43% reduction in operating speed is found due to on street parking on Mirpur Road. To get a smooth flow of traffic stream on roads, it is necessary to ensure proper parking facility and prohibit on street parking completely where possible; and where it is not possible, proper parking operation and management policy should be adopted. Before that, unplanned land use should be controlled and restrictions should be imposed on automobile usage to control the demand for parking as well as congestion and other transportation related problems.

Keywords: BNBC; parking demand; operating speed; congestion

INTRODUCTION
Dhaka is the capital as well as the largest and most densely populated city of Bangladesh. Due to the nature of central development in industrial, commercial, educational, health and all other sectors, people from every corner of the country are coming to Dhaka for their livelihood. So the population of Dhaka is increasing largely day by day. This increasing number of population increases the demand for travel as like as other basic needs. To fulfil that need, the number of vehicles is also increasing alarmingly that is shown in Table 1. Besides the population growth, unplanned growth of shopping malls, hospitals and other commercial buildings leads to the problems of congestion and increases the demand for parking spaces. The number of registered private car was 143379 in 2009 whereas after June 2015 it has been increases to 214987 which show almost 70% increase in growth within only five years. The total number of motor vehicles is 903803 (June 2015) among which 24.9% are private cars carrying only 5.1% of total trip (Development of EST in Bangladesh 2010). This increasing number of car needs not only roads to move but also space for parking (A. Ahmed and M.S., 2012). So the provision of parking facilities is very much essential for any type of building. But this is ignored most of the time or provided little importance. Lack of parking provision along with the improper facility location encourages the vehicles to be parked on street. This unauthorized on street parking reduces traffic flow and roadway capacity, increases accident potential and hampers vehicular and pedestrian movements. Hospitals, Shopping malls and commercial buildings are essential part of

daily urban life. To prevent these essential buildings from creating problems due to on street parking, planners and designers are responsible to provide proper off street parking facilities within shortest possible distance from the individual building or within the building. This study is aimed to assess the existing parking conditions for the Shopping Malls and Hospitals in Dhaka City through analysing demand and supply situations directly. Besides, analysis of the ill effects of on street parking on roadway capacity and flow behaviour is also the aim of the study. The objectives of the present study are the followings:

- To obtain information regarding parking capacity of selected Shopping Centers and Hospitals to compare with the requirements as per BNBC.
- To obtain geometric data to compare between the capacity calculated from geometry with and without on street parking.
- To compare the Level of Service (LOS) and operating speed with and without on street parking.

METHODOLOGY

For the fulfillment of the objectives, the study is conducted in several steps. First of all, data on parking supply facility and weekly data of parked vehicle was collected from some selected shopping centers and hospitals of Dhaka city. They are: New Market, Bashundhara City, Concord Arcadia, Metro Shopping Center, Pink City, Plaza A.R, Apollo Hospital, Bangabandhu Sheikh Mujhib Medical University, Central Hospital, Square Hospital and United Hospital. Hourly parking demand data was collected from field survey at New Market and Dainik Bangla to Shapla Square, Motijheel Road. Geometric Survey was conducted on Mirpur Road in front of New Market and the Roads of Shapla Square. Then, volume and speed count survey was conducted on two sections (i.e one at bottle neck created by unauthorized parking and another at full width) on both working day and market off day. Volume and speed count survey was also conducted on the roads of Shapla Square. Roadway capacity from geometric data was calculated by following Highway Capacity Manual (FHWA, USA).

Roadway Capacity = Capacity at ideal condition* Passing Sight Distance Factor* Lane width Factor*Clearance Factor

Fig. 1: Study Area (New Market, Dhaka)

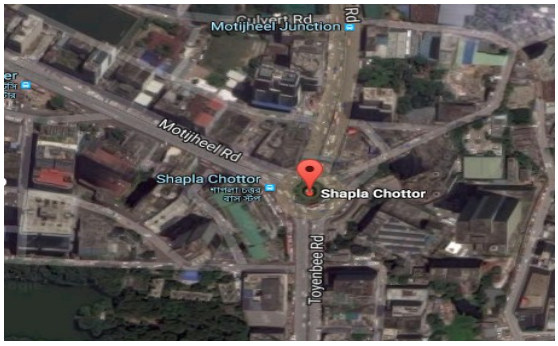


Fig. 1: Study Area (Shapla Square, Dhaka)

RESULTS AND DISCUSSIONS:

Parking supply survey was conducted by counting the allotted parking space for the vehicles in the selected shopping malls and hospitals. According to BNBC, space should be allotted for 1 car for every 200 m^2 for business purposes and 1 car for every 300 m^2 for health care purposes. A 23 m^2 parking space is required for one car. But 60%of the selected organizations have not followed this standard. Figure 3 shows the deficiencies of parking supply of the selected shopping centers and hospitals of Dhaka city. Besides this, space for loading-unloading purposes is not provided by the organizations except Bashundhara City. And most of the organizations are located by the side of busy roads and some of them are at intersections. Due to on-street parking and loading-unloading activities on the busy roads, roadway capacity decreases greatly and creates a lot of congestion, accident potentialities, hindrance to movements of pedestrian and traffic.

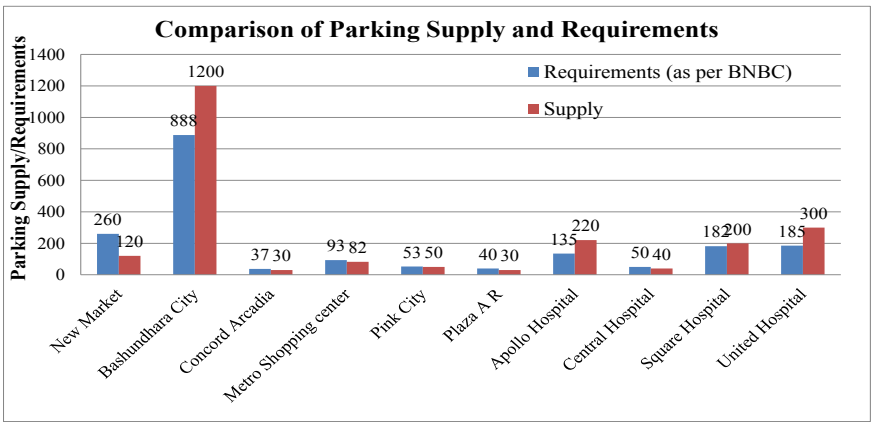


Fig. 3: Comparison of Parking Supply and Requirement as per BNBC

Parking data of a week was collected from the above mentioned shopping centers and hospitals. The parking patterns of all the shopping centers are all most same. The maximum parking was noticed in weekends (i.e Friday and Saturday) and minimum or zero parking was on the off day. On the other hand, the parking pattern of hospitals is almost same for all days of the week. If there is any off day of the hospital, minimum or zero parking was recorded on that day.

Hourly Parking Demand

Among the selected shopping centers and hospitalas, the hourly parking demand data was collected from field survey at New Market. There are four parking spaces available around New Market (i.e in front of Gate 1, Gate 2 and Katcha Bazar) with a total parking capacity of 120 cars at a time. From survey data, it is found that the supply rarely satisfies the parking demand (Figure 4). As a result, parking on active road is practiced greatly.

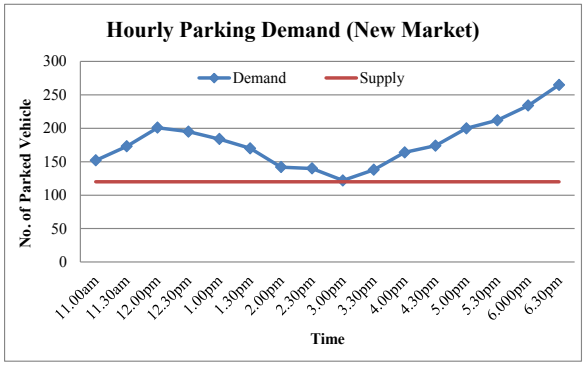


Fig. 4: Hourly Parking Demand in New Market

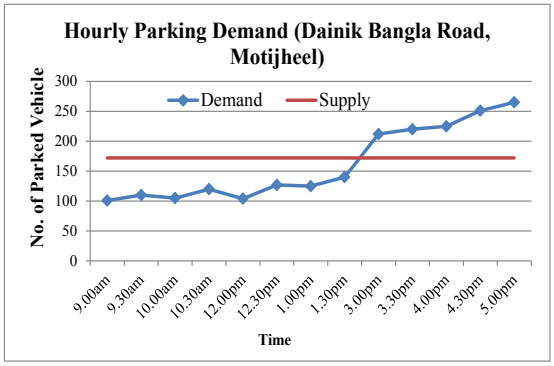


Fig. 5: Hourly Parking Demand in Dainik Bangla Road, Motijheel, Dhaka

Motijheel is the major business and commercial hub of Dhaka city. More offices and business institutions are located there than any other part of the city as well as it is home to the largest number of corporate headquarters in the nation (Jahan and Amin 2011). All these activities generate a large volume of parking demand per day. Buildings of this area do not have enough provisions for parking. On street parking facilities are provided by the city corporation along the road. The parking demand is more than the provided facility (Khatun, Ahmed, Suman, Rafiq, Md., Akhter and Hasan, 2013). Parking Supply and Demand data were collected from a whole day survey to analyze the on street parking condition which is shown in Figure 5.

Due to the lack of proper parking facility, on street parking has become a common phenomena on the roads of dhaka city. Unauthorized on street parking decreases the active roadway width which in result decreases roadway capacity and operating speed. The effects of on street parking on Level of

Service and Operating Speed in Mirpur road (in front of New Market) are shown in Table 1, below.Fig. 6 and Fig. 7.

Table 1: Effects of On Street Parking on Capacity and Operating Speed (at Mirpur Road)

Effective Carriage way Width (feet)	Capa -city (PC U/hr)	Capa c-ity Red uctio n (%)	Servic e Volum e (PCU/ hour)	Volum e/ Capacit y Ratio	Level of Service	Operati ng Speed Miles/h r	Speed Reduc- tion (%)
At different sections on same time							
38 (Full width)	2856	60	1915	0.67	C (Stable)	15.5	43
24(Bottle neck)	1371		1697	1.24	F (Forced)	8.9	
At same section on different time							
38 (Without Parking)	2856	60	1576	0.55	B (Reasona- bly Free)	13.5	34
24 (With Parking)	1371		1697	1.24	F (Forced)	8.9	

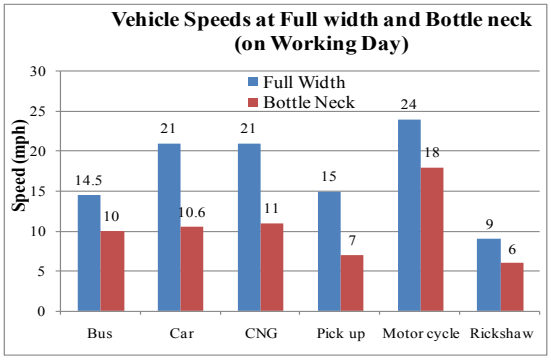


Fig. 6: Speedof vehicles at two sections full width and bottle neck created by on street parking

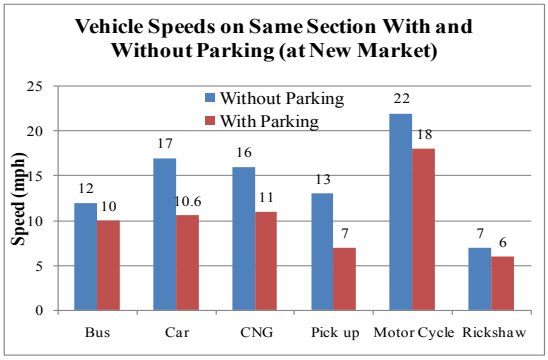


Fig. 7: Speed at same section at full width and bottle neck

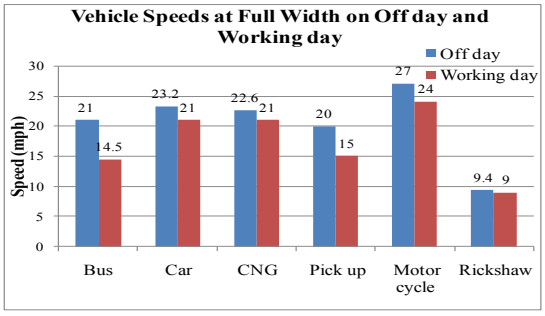


Fig. 8: Speed at same section of full width with and without parking

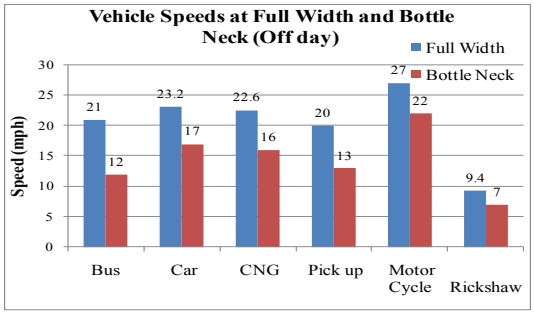


Fig. 9: Speed at two sections without parking

On street parking not only affects the speed and volume capacity ratio along length where there is parking, but also a longer distance from parking space. There is a considerable difference between the speeds (Figure 8) of vehicles on the working day and off day at the section of full width though that section was parking free. That might be happened due to the parking at a distance behind this section.

The operating speed on working day is found to be 9% less than that of an off day. Vehicle speed on both the sections should be same on off day as there remain no parking. But even then, there is almost 23% difference in operating speed (Figure 9). The reasons may be the loading and unloading activity of public vehicles, pedestrian activity and hawkers' activity in front of New Market.
Due to the on street parking in one row and sometimes more than one row on the roads of Shapla Square, Motijheel,Dhaka , the effective carriageway width is reduced greatly. Among four lanes, almost two lanes are occupied by parking. This reduced roadway width is one of the major reasons of capacity loss and results congestion. The effect of unauthorized on street parking on Level of Service is shown in Table 2 below.

Table 2: Effects of on street parking Level of Service (at Shapla Square)

Road	Effective Carriageway Width(ft)	Capacity (PCU/ hour)	Service Volume (PCU/ hour)	Volume/ Capacity Ratio	Level of Service
Shapla Square to Dainik Bangla	46(without parking)	3694	1838	0.5	A (Free)
	22(with parking)	1330	1838	1.38	F (Forced
Shapla Square to Notre Dame College Road	44(without parking)	3694	2095	0.57	B (Reasonably Free)
	30(with parking)	1871	2095	1.12	F (Forced)
Shapla Square to Tikatuli	45(without parking)	3694	1587	0.43	A (Free)
	21(with parking)	1248	1587	1.27	F (Forced)

Though the Level of Service of all the roads is F which is the indication of congestion, vehicles were relatively in better speed on Shapla Square to Notre Dame College road as parking, hawkers' and pedestrian activity is less on that road. So the speeds of vehicles of other two roads are compared with speeds of that road which is shown in Figure 10. Figure 11 shows the comparison between the speed of vehicles in a section with on street parking in one row and two rows.

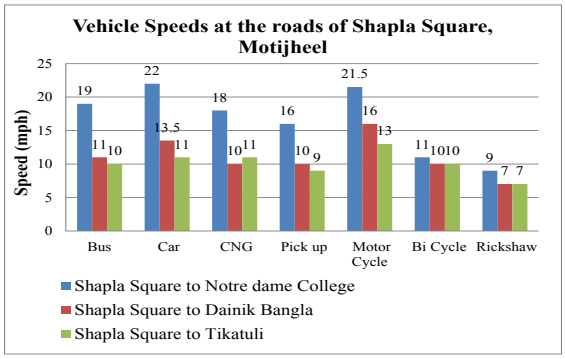


Fig. 10: Vehicle Speed at the roads of Shapla Square

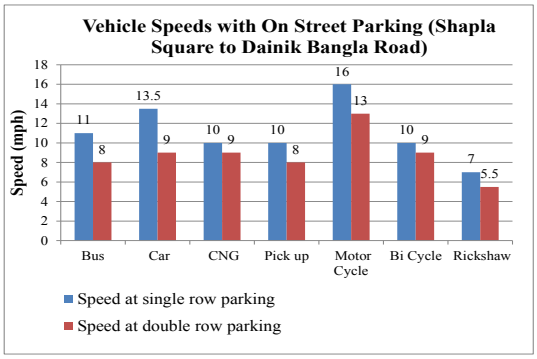


Fig. 11: Comparison of Speed at one row and two row on street parking

As unauthorized on street parking reduces the active roadway width and thus reduces capacity and speed, it is very much necessary to stop this practice for the mobility of the city. Some general recommendations are given below:

- A detailed development plan, framework and policy should be adopted to prevent any unplanned institutional development
- Inspection of the buildings should be made by the authority to check if the building construction guidelines are properly followed or not.
- Development of any commercial building near the intersection or by the side of busy roads should be controlled strictly by the authority (Saifuddin Ahmed, 2013).
- Restrictions must be provided on using private vehicles and the number of vehicles should be minimized by improving public transits. Road pricing and congestion pricing policy should be adopted for private automobiles.
- Proper inspection of roads should be ensured to avoid on street parking. Parking charge should be applied on hourly basis where on street parking can't be prohibited completely.
- Side frictions like hawkers' activity, pedestrian activity, loading-unloading activity of transits etc. should be controlled for better performance of the road.

CONCLUSION

Parking is a basic type of requirement for any type of development. The areas with development of shopping centers, hospitals and other commercial buildings attract a lot of trips as well as increase the demand for parking. Due to the lack of adequate parking facility, unauthorized on-street parking is practiced which affects the roadway capacity greatly and creates some relevant problems. So, it is necessary to adopt policies for the allotment of adequate off-street parking facilities, proper operation, management and maintenance of both on-street and off-street parking facilities for the better performance of the road and a balanced transportation growth.

REFERENCES

Ahmed and Hoque, MS. 2012. Parking Policy: Neglected but Important. *Proceedings of the Global Engineering, Science and Technology Conference* 2012, 28-29 December 2012, Dhaka, Bangladesh.

Bangladesh Road Transport Authority (BRTA) Development of Environmentally Sustainable Transport (EST) in Bangladesh, 2010. Available at www.uncrd.or.jp/env/5th-regional-est.../BS1-2_Bangladesh.pdf

Highway Capacity Manual 2000, Transportation Research Board, National Research Council

Jahan, J and Amin, SBB. 2011. A study on Factors Influencing the Corridor Choice of Bus Users and Demand-Supply of Bus Services from Mirpur-10 to Motijheel", BURP Thesis, Department of Urban and Regional Planning, BUET, Dhaka.

Khatun, A; Suman, Rafiq, Md., Akhter, Hasan. 2011. Parking Demand and Supply Analysis of Major Shopping Centers in Dhaka- A case study of New Market Shopping Center along Mirpur Road. Journal of Bangladesh Institute of Planners, Vol.6, December 2013, pp. 161-17.

Saifuddin Ahmed, 2013. *Analysis of Existing Parking Facilities of Some Selected Shopping Centers and Hospitals of Dhaka City*. BSc Thesis, Department of Civil Engineering, BUET, Dhaka.

.