PROVISION FOR ADEQUATE HEADROOM FOR FOOTBRIDES AND FLYOVERS

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ABSTRACT

Geometric design standard are mainly based on logically derived relationships and engineering judgments. The road environment has been identified as a prime cause of accidents, contributing to about 17 to 34 percent of accident as the sole contributing factor for 2 to 3 percent of accidents. So geometric design standards or guidelines are important factors for safe roadway environment. This paper deals with one of important features of roadway which is vertical clearance of roadway superstructures, the adequacy of headroom provided and required headroom for roadway superstructures for safe traffic operation. Every year, bridges are hit by vehicles which are too high to pass underneath. The damage done to the bridges are not always obvious but can be serious. So there is a need in rechecking the adequate vertical clearance. According to RHD design manual to allow for adequate vertical clearance and the transport of abnormal loads 5.7m headroom should be provided when designing new roads and structures. This provision considered the typical height of the truck which is just over 4m high. But from the vehicle height survey it was found that freight trucks have total height of 5.8m in loaded condition including both freight and passenger traveled above freight. Considering design vehicle height as 5.8m the required headroom for roadway was found 6.3m. Further study was conducted in DCC area on several footbridges along with two flyovers one is Gulisthan-Jatrabari flyover (Mayor Mohammad Hanif Flyover) and another one is Moghbazar –Mouchak flyover (under construction) to identify the structures having inadequate headroom.

Keywords: *Geometric design, roadway environment, superstructure, headroom, abnormal load*

1. INTRODUCTION

Many heavy vehicles have lower performance capability than cars in braking, acceleration, stability, dynamic handling and manoeuvrability. Therefore they need additional road space to fit safely on a road and are likely to operate with a greater degree of safety if the roads and facilities they run on have been designed to take account of their particular operating characteristics. They are also more sensitive to road design features such as road curvature, camber, cross fall due to the high centre of gravity of the loads they often carry and vertical clearance of the roadway superstructures which is the prime contributing factor of bridge hitting problem. Some other factors contributing to bridge hits include; unavailability of penalties for over height violations, driver ignorance regarding vehicle/cargo height, lack of route planning by haulers, drivers not following authorized routes (New York city. Department of Transportation, 2009) and inadequate low clearance warning signs (U.K. Department of Transport, 2004). The damage done to the bridges are not always obvious but can be serious. So there is a need in rechecking the adequacy of vertical clearance provided. Though most traffic accident are product several factors but the road environment has been identified as a prime cause of accidents, contributing to about 17 to 34 percent of accident as the sole contributing factor for 2 to 3 percent of accidents (O'Cinneide & Murphy, 1994). Therefore roadway features should be designed to ensure safer roadway environment. The objectives of this study are to check adequacy of headroom of roadway superstructures provided and determine required headroom for roadway superstructures for safe traffic operation. It also deals with the safety measures to be incorporated to avoid bridge hitting.

2. METHODOLOGY

In total Vertical clearance of 11 footbridges were measured all of them located at Azimpur Bus Stop to Shyamoli Bus Stop corridor except Ramna footbridge which is located near Ramna park. Vertical clearance is considered as the vertical distance from roadway crown to the lowest fiber of the bridge (Indian Roads Congress, 1987). In addition to these measurement was made to obtain the vertical and horizontal clearance of the Mayor Mohammad Hanif Flyover (MMHF). As it is located at a busy road (Dhaka-Chittagong Highway) so it was difficult to use theodolite to measure the vertical Clearance therefore manual measurement was made.

Truck height survey was conducted in the locations having high concentration of HGV like Kawran bazar, Tejgoan truck terminal, Chankharpul etc. It includes vehicles such as fright truck, cover van, double decker bus etc. having height more than 3.0 m. For freight trucks measurement was made for both loaded and unloaded condition. All the measurements were done while vehicles were parked for loading or unloading to ensure no disruption caused to the moving traffic or any change in road user's behaviour.

3. COMPARISON OF GUIDELINES FOR HEADROOM

The minimum headroom depends on the maximum height of heavy goods vehicles (HGVs) and varies from country to country as shown in Table 1. In most European countries the maximum height of heavy good vehicles is 4.0 m; certain countries allow higher values (UK, USA). In the European Union the maximum height of heavy good vehicles is 4.00 m, although the Geneva conventions allow a maximum of 4.3 m. If a margin of 0.20 m is added to these maximum heights in order to absorb vertical movements of the HGV, the minimum vertical clearances required are 4.20m (4.50m) (World Road Association, 2001). Above these minimum clearances, additional headroom is necessary for drivers of HGV's to feel comfortable. This comfort margin is related to the object distance. The minimum height plus the comfort margin yields the maintained headroom. If a value of 0.30m is taken for the comfort margin, the maintained headroom is 4.50 m (Geneva Convention 4.80 m, UK 5.35 m, USA 4.90 m on freeways and 4.30 m on other highways (Table 2)). In case of Bangladesh the minimum vertical clearance for roadway is 5.7m and for railway it is 7.2m (Bangladesh. Roads & Highway Division, 2000).

Table1: International comparison of maintained headroom

Country and name of guidelines or other source	Minimum Headroom above Carriageway (m)	Maintained Headroom above Carriageway (m)	Additional allowance as safety zone for signs, luminaries, fans etc. [m]	Allowance for signs, luminaries, fans etc. [m]	Allowances for later pavement construction [m]
Austria RVS 9.232		4.70	n.s.	min. 0.20	n.s.
Denmark (practice)	n.s.	4.60	0.20	n.s.	n.s.
France CETU	n.s.	4.50 (roads in international network) 4.75 (highest order roads)	0.10	n.s.	0.05 - 0.10
Germany RAS-Q1996/RABT 94	4.20	4.50	n.s.	n.s.	n.s.
Japan Road Structure Ordnance	n.s.	4.50	n.s.	n.s.	n.s.
the Netherlands ROA	4.20	4.50	0.20	0.30	n.s.
Norway Design Guide Road Tunnels	n.s.	4.60	0.10	n.s.	0.10
Spain Instruction 3.1	n.s.	5.00	n.s.	n.s.	n.s.
Sweden Tunnel 99		4.50	0.20	0.40	n.s.
Switzerland (rectangular tunnels)	n.s.	4.50	0.20	0.40	n.s.
Switzerland (oval tunnels)	n.s.	4.50	n.s.	n.s.	n.s.
UK TD27(DMRB 6.1.2)	5.10	5.35	0.25	0.40	n.s.

NS=Not Specified (Source: World Road Association, 2001)

Table 2: AASHTO guideline for ranges of minimum vertical clearance

Ranges for Minimum Vertical Clearance				
Type of Roadway	**Rural**		**Urban**	
	US (feet)	**Metric (meters)**	**US (feet)**	**Metric (meters)**
Freeway	14–16*	4.3–4.9*	14–16*	4.3–4.9*
Arterial	14–16	4.3–4.9	14–16	4.3–4.9
Collector	14	4.3	14	4.3
Local	14	4.3	14	4.3

*17 feet (5.1 m) for sign trusses and pedestrian overpasses. (Source: Federal Highway Administration, 2004)

4. OVERALL HEIGHT OF HGVS

During the survey it was found that mainly four categories of trucks are commonly used in freight transport TATA, HINO, EICHER and ASHOK LEYLAND. Though most of trucks have same height in unloaded condition (3m) but in loaded condition it varies considerably. Another important issue is that sometimes passenger is also carried with freight specially labours who carry goods for loading and unloading the trucks. So additional increment (0.91m) in height is made for passengers travelled with freight. As Shown in Figure 1 measurement was made for 20 trucks and maximum height in loaded condition was found 4.9m, if passenger height is considered than final height will be 5.8 m.

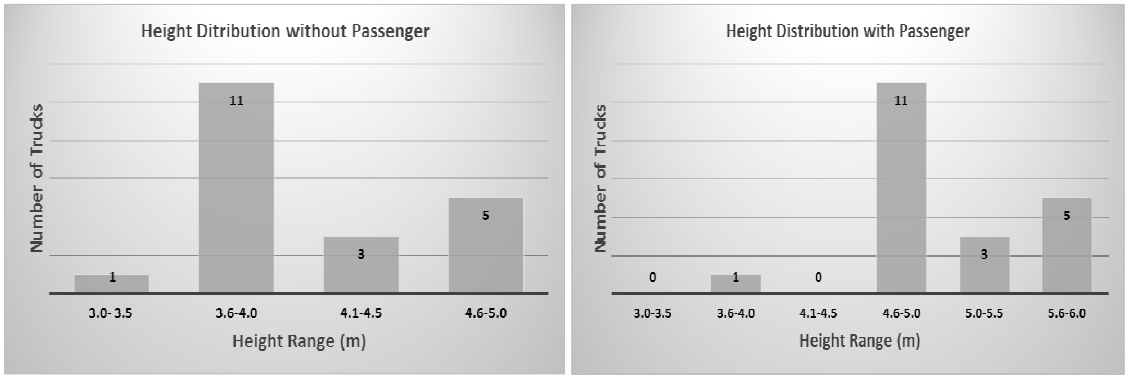

Figure 1: Height distribution of freight trucks (a) without passenger (b) with passenger

Three categories of Cover Vans were more common ASHOK LEYLAND, EICHER and TATA. Overall height of Cover Van depends on container height it carries which is uniform as fixed standard is maintained all over the country. Total height of a cover van so measured is 3.96m (13ft). Similarly standard height of Double Decker Bus is 4.27m which is used as standard vehicle for headroom provision in many countries. But in Bangladesh truck heights in general exceed this range.

5. REQUIRED HEADROOM FOR RODWAY SUPERSRUCTURES

From the vehicle height survey it is found that freight trucks have larger height than Cover Vans or Double Decker Buses. The largest height of truck so obtained considering passenger height is 5.8m. But in Geometric Design Standards for RHD typical height of the trucks was considered as 4m and based on this value allowance (5.7m) was made for vertical clearances for roadway Structures. According to AASHTO Geometric Design Manual a freeboard of 0.3m must be provided above maximum vehicle height for the drivers of HGV's to feel comfortable. In addition to this allowances for future resurfacing must be considered, in case of Bangladesh this allowance must be higher as roads are more frequently exhausted and frequent resurfacing (thickness of resurfacing varies from 0.04 to 0.05 m) is required. For resurfacing 0.2m additional height is considered in general 0.1m is the guideline minimum value (Table 1).

Required Headroom = Maximum Height of HGV+ Freeboard (0.3m) + Resurfacing (0.2 (1)

From equation (1) the required headroom for roadway structures so obtained is 6.3m indicating a significant variation (0.6m) from recommended value (5.7m) of RHD Geometric design Standards. Further consideration is required depending on type of pier used, especially in case of hammer head pier which causes significant reduction in effective vertical clearance. Figure 2 depicted a significant reduction (0.61m) in effective vertical clearance due to hammer head pier. This type of pier is used in RCC and composite type bridges.

Figure 2: Reduced headroom due to hammer head pier (Science lab Footbridge, Field Survey, 2015)

6. HEADROOM ADEQUACY OF EXISTING STRUCTURES

From field survey it is found that vertical clearance of the footbridges varies from 5 to 6m. Among which footbridges located at Sukrabad and Sobahanbag have highest vertical clearance (6m). Though the allowance for headroom is 5.7m but most of the footbridges were found having vertical clearance less than the recommended value. Surprisingly Ramna footbridge located near Ramna Park having a vertical clearance of only 5.3m, due to low clearance it had recently been struck by a freight truck (Figure 3) according to the information obtained secondary source. During the survey several damaged portion of the bridge was found in untreated condition which are clear evidence of bridge strike.

Table 3: Vertical Clearance and Overall Height of Footbridges

No	Location	Headroom	Additional height from bottom face of the slab to crown	Total Height including Shed
1	Balaka Cinema Hall	5.5m	3.96m	9.46m
2	New Market	5.5m	3.35m	8.85m
3	Science Lab	5.5m	–	–
4	Kalabagan	5.5m	3.96m	9.46m
5	Sukrabad	6m	3.96m	9.96m
6	Sobhanbag	6m	3.96m	9.96m
7	Dhanmodi 27	5.8m	–	–
8	Asad Gate	5.8m	–	–
9	College Gate	5.8m	–	–
10	Shyamoli	5.8m	3.81m	9.61m
11	Ramna	5.3m	–	–

Figure 3: Over height Truck stuck with ramna footbridge

More deviation in vertical clearance was found in case of flyovers among which vertical clearance of Moghbazar Mouchak (Combined) Flyover (MMF) varies from a minimum value of 5m to a maximum value of 9.3m (at level Crossing) while in case of Mayor Mohammad Hanif Flyover it varies from a 5.5m to 7.2m (at level crossing) (Figure 4 (a) & (b)). Though in both flyovers maintained headroom at level crossing is greater than the recommended value which is 7.2 m according to RHD Geometric Design Standards but headroom over the roadway is less than recommended value (5.7m). This type of design fault indicates lack of foresight of implementing agencies regarding the problem that may arise from inadequate clearance.

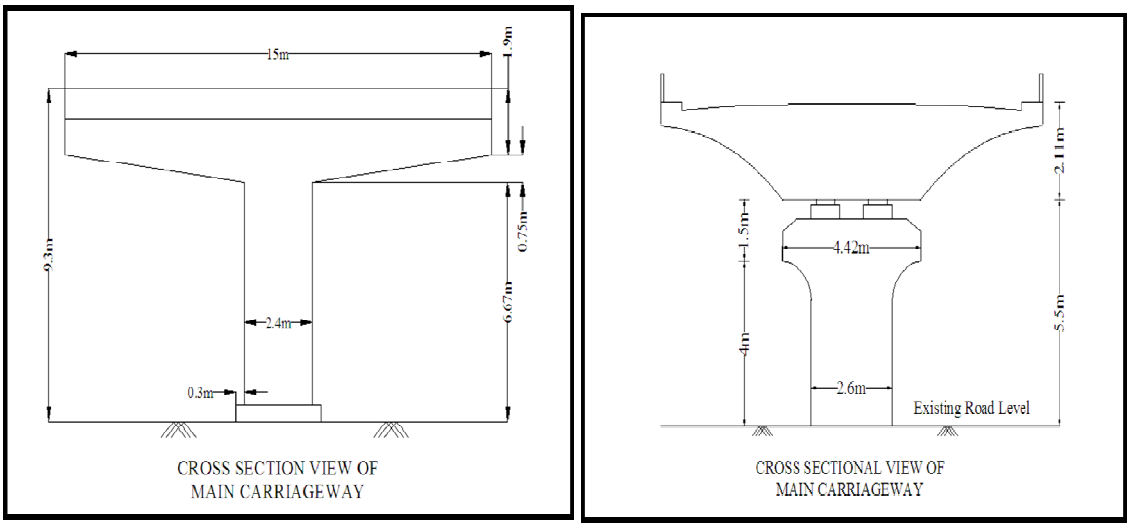

Figure 4: Vertical clearance of (a) Moghbazar-Mouchak Flyover (b) Gulisthan-Jatrabari Flyover

7. HEADROOM CONFLICT BETWEEN FOOTBRIDES AND FLYOVERS

During the study three footbridges were found dismantled to accommodate the construction of flyovers. Among them two footbridges located at Moghbazar Mor and Mouchak Mor were demolished to facilitate construction

of MMF. Another footbridge located at Jatrabari Roundabout on Dhaka-Chittagong Highway was demolished to facilitate construction of MMHF.

It is found from the study that the footbridges at moghbazar and mouchak intersection had same overall height of 9.75m which is far above the designed vertical clearance (5m) of Moghbazar Mouchak (Combined) Flyover. To discard pedestrian safety issue which has arisen due to demolition of the footbridges the minimum vertical clearance of the Flyover should have been 10m considering allowable deflection of the span. But in urban areas providing high vertical clearance may create some problem due to presence of high rise buildings and also aesthetically unsuitable. So only suitable option was to change the proposed alignment of the flyover.

In case of Jatrabari footbridge overall height was 8.65 m, so to accommodate it vertically the minimum vertical clearance of the MMHF should have been 9 m at this location considering allowable deflection of the span. Table 4 shows the conflict of different components of Jatrabari Flyover with the footbridge at the intersection. As shown in Figure 5 three Ramps (Ramp3, Ramp4, and Ramp8) along with the main carriageway are crossing this intersection.

Table 4: Vertical Clearance of Different Components of MMHF at Jatrabari Intersection

Flyover Components	Vertical Clearance of the Components	Required Vertical Clearance	Difference between Vertical Clearances	Remarks
Main Carriageway	5.5 m	9m	3.5m	Conflict Occurs
Ramp 3	12.823 m	9m	-3.823m	No Conflict
Ramp 4	5.283 m	9m	3.717m	Conflict Occurs
Ramp 8	5.308m	9m	3.692m	Conflict Occurs

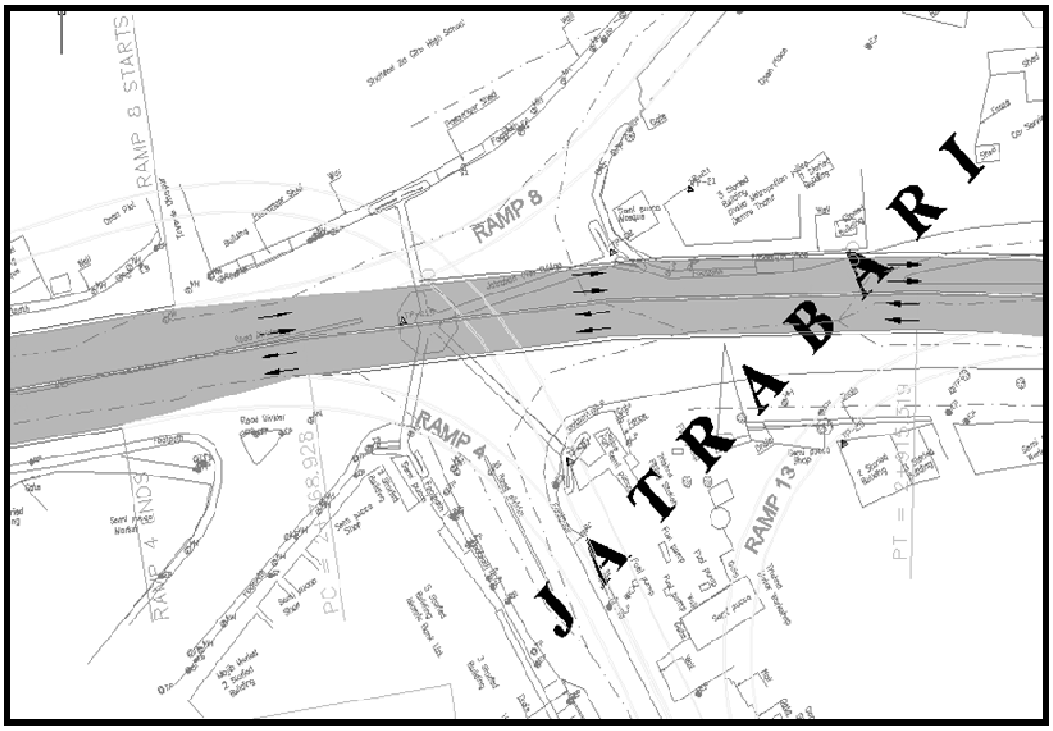

Figure 5: Intercepting Components of MMHF with Jatrabari Footbridge

From Table 4 it is found that Ramp4, Ramp8 and main carriageway have vertical clearance less than the required value but in case Ramp3 (12.823m) it is far above the required value. So if vertical clearances of the components of the flyover were 3.8m higher than the maintained clearance this footbridge would have been accommodated to facilitate pedestrian crossing. Another thing is that as this is located at suburb area so high vertical clearance would not create problems like urban areas as most of the buildings are low rise. Thereby the headroom of the flyovers located at places facilitated by pedestrian overpass must be based on the overall height of the overpass.

8. PREVENTIVE MEASURES TO AVOID BRIDGE STRIKES

To design safer road five design principles should be followed: design for all road users, reduce conflicts, encourage appropriate speeds and behavior by design, avoid surprises and confusion, create a forgiving road (Bangladesh. Roads and Highway Department, 2000). Therefore it is necessary to reassign the recommended value of headroom (recommended value 5.7m) for future construction as it is found inadequate for heavy goods vehicle which requires a headroom of 6.3m. From economic perspective it is not a feasible solution to reconstruct all the bridges especially flyovers having lower headroom as well as it will consume lots of time. Thereby to ensure safe traffic operation in addition to reconstruction process following preventive measures must be taken to avoid bridge strikes where reconstruction is not possible as well as at reconstructed bridges to make drivers of HGVs more confident regarding their maneuverability. It will be based on proper enforcement to limit the travel routes of over height vehicles. Besides, all bridges should have advance warning sign mentioning the headroom available underneath the bridge

8.1 Traffic Sign Regulations

During the survey no Traffic Sign Regulations were found those showing headroom or allowable height of vehicle to be passed underneath the bridge except at Kalabagan footbridge which was unfortunately faded away due to lack of maintenance. To prevent bridge strikes, it is important that the drivers know the height of their vehicle and understand and obey traffic signs. To assist them the Traffic Signs Regulations that shows the maximum headroom in imperial and metric units should be adopted. As shown in figure 6 red circle indicates prohibition and Red triangle indicates warning which is used when head room is non-uniform and the vehicle

Figure 6: Traffic signs used at bridges to show the maximum permitted vehicle height

have to use a specific section. At arch bridges, white lines on the road and 'goal posts' on the bridge may be provided to indicate the extent of the signed limit on vehicle height, normally over a 3 metre width (U.K. Department of Transport,2012). Signing must be installed in advance at the last feasible turning point before the bridge to enable drivers to reroute without having to reverse.

8.2 Vehicle Height Check

Maximum height of the vehicle, its load or its equipment must be checked before commencing a journey and the height must be shown on the headboard to be rechecked by law enforcing agencies to provide permit to use certain route. Maximum height must be rechecked again after every loading, unloading or reloading to ascertain whether the trailer suspension characteristics have changed the height of the vehicle. The maximum height of any vehicle, its load or equipment can be checked using simple hand held devices or fixed depot installations. This process is cheaper than Over Height Vehicle Detection Systems (OHVDS) or Laser Ranging Over Height Vehicle Detection System (LARA-OHVDs) installed at the bridges, therefore more suitable for Bangladesh.

8.3 Route Map with Vertical Clearance of Roadway structures

A survey conducted by U.K. department of transport in 2011 indicated that 11 % of the drivers believed Poor information about low bridges is the prime cause of bridge strike (U.K. Department of Transport, 2012). Therefore the drivers must be provided with proper information regarding low height bridges. Based on this information travel routes must be planned in advance and selected in such a way to eliminate the risk of bridge strike avoiding routes having low height bridges. To do so a route map must be develop containing vertical clearances of roadway structures on a particular route to assist the drivers of HGVs to trace their routes before commencing a journey. This must be available to all transportation agencies and freight transport industry.

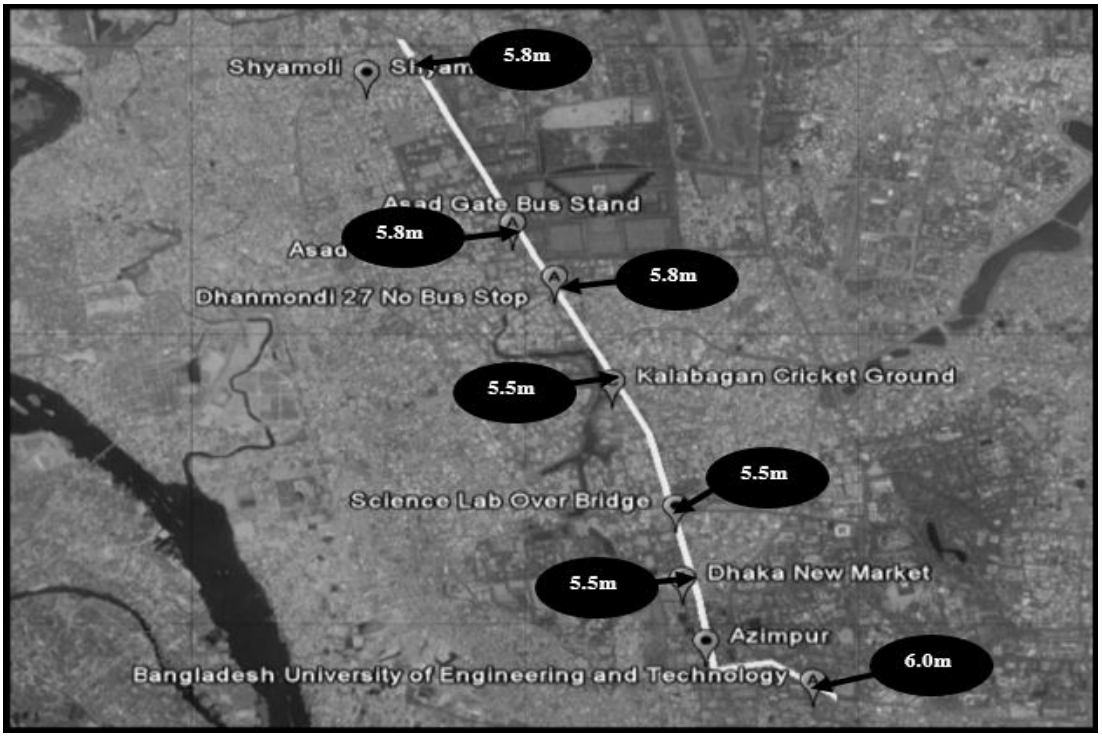

Figure 7: Route map with vertical clearance from azimpur bus stop to syamoli bus stop.

9. CONCLUSIONS

Rather than rely on enforcement which is more uncertain it is better to design forgiving roads to ensure safe traffic operation. Therefore recommended value of vertical clearance of the roadway bridges must be reassigned to 6.3m considering the complex nature of manoeuvrability of HGVs. In addition to this several safety measures like providing proper traffic signs, enforcing over height limit and information system to assist route choice must be taken to ensure freedom in manoeuvrability for the drivers of heavy vehicles. Moreover to ensure safer road consideration must be made for all roadway users and therefore it is not a good practice to demolish pedestrian overpass to facilitate flyover construction. On the pretext of economical flyover design, pedestrian safety must not be compromised rather these grade separated flyover must be designed keeping the provision of footbridge. So at location where flyover alignment intercepted any footbridge either the headroom of flyover to be determined based on overall height of footbridge or construction of pedestrian underpass to be considered. To ensure uniformity in headroom over the roadway steel footbridges with flat headed pier should be given priority rather than RCC or Composite ones with hammer head or flower head pier.

This study is useful for transportation planner to ensure roadway safety for all road user as well as freight industries to ensure safe operation of freight vehicles. The results obtained from the study are based on limited data due to time and resource constraint, further study should be carried out using more data especially large sample HGVs to obtain more precise value of required headroom.

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