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A Methodology for Assessing the Performance of Structural Measures to Mitigate Traffic Congestion: A Case Study of Chittagong Port Flyover

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Abstract

An efficient transport system is characterized by accessibility and mobility of traffic works as an impetus for economic development of a country. Chittagong, the business capital of Bangladesh, requires an efficient transport system in order to boost the economic growth. To do so, Chittagong Development Authority has prepared a long term development strategy for traffic and transport system of Chittagong. Some of these strategies include infrastructure development such as flyover, over-pass and expressway construction. But it is necessary to evaluate whether these infrastructures are improving the efficiency of transport system or not. In order to do so, it is also important to identify the major suitable indicators for assessing the performance of those infrastructures for Chittagong. However, Chittagong Port flyover is one of those infrastructures that have already been implemented. The aim of this study is to determine the efficiency of this substantial flyover through the comparison of different suitable roadway and related factors such as Level of Service (LOS), Vehicular Operating Cost (VOC), and Value of Travel time (VOT) etc. before and after the flyover construction. To find out the information, volume survey, speed survey and questionnaire survey have been conducted. It is found that most of the time free flow exists over the flyover and vehicular operating cost reduced for truck. After separating freight transport from passenger carrying traffic, the level of service of the road just beneath the flyover has also improved. It is also found that for assessing the performance this methodology require less survey instrument, less resource and time. This methodology can be used for assessing the performance of other structural measures not only situated in Chittagong but also in any other area of Bangladesh.

Keyword: Assessment, Flyover, Indicator, Performance, Transport

1. Introduction

Transportation itself is a derive demand. People go from one place to another place for satisfying their purpose of work with the help of transport. In respect of Bangladesh, population is increasing day by day for this reason their trip purpose and number of trip is also increasing. Many problems engendered by this increasing demand are congestion, road accident and country's economic fall etc. Government takes many structural initiatives to manage this increasing demand for transport such as flyover construction, subway, metro rail etc. But sometimes these types of initiatives taken by government fail to fulfill the objective and manage the system. For example, Mohakhali flyover was built in capital city Dhaka but it could not solve the congestion problem of the target

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area rather exacerbated the previous situation (Murshed, 2004).For this reason it is necessary to assess the performance of these structural measures how much it is worthy for solving a particular problem because many of us think these structural measures as panacea. This study develops a methodology to assess the performance of built-up structures in a more uncomplicated way. This methodology broaches those indicators appropriate and expedient for our country where complicated and more complex survey is difficult to conduct with limited resource and time constraint. And the result from the performance assessment of a built structure in return will give a direction to the government in decision making when government to take another new structural initiative.

2. Literature Review

For sustaining a country's economic growth an efficient transportation system is essential as it maintain the connection not only within the country but also to the global world (Harriet, T. 2003:225). So, it can be urged that a relationship exists between transportation and productivity (Luet al. 2009: 2959). On the other hand, urban transportation system covers a wide range of services then the other as it covers access to various types of socio-economic services. Access to these services within the desired time increased the efficiency of the transport system which indirectly augments a county's economic growth. Time savings, cost savings are the direct benefit of an efficient and effective transportation system. (Harriet, T. 2003:226). To obtain an efficiency in other word to ensure accessibility and mobility it is a pre-requisite to remove congestion which causes delay. Before taking any attempt to remove congestion, measuring congestion level is a necessary step. But it is impossible to quantify congestion with a single unit (OECD & ECMT, 2004:11). So, it is necessary to choose carefully the indicator of assessing the congestion level. There is no uniform conceptual framework for assessing the congestion level upon which congestion management approach depends. Traditional approaches of congestion management have focused on managing road systems in urban areas that maximize the physical usage of available road capacity where capacity is expressed in flow, density or by "levels of service". Achieving higher flows, higher densities and higher levels of service within the capacity of the roadway has been seen as performance "improvement" (OECD & ECMT, 2004:18). But more often performance improvement through infrastructure increases the congestion. Specific infrastructures to reduce congestion are different according to different classes of roadways and types of problem. For example, construction of flyover may shift the location of problem without bringing any benefit (B. Maitra, M. Azmi, N. Kumar and J. R. Sarkar, 2004:57). In such situation, performance of specific infrastructure for particular situation is required in determining the congestion level to find out more feasible solution. By comparing present congestion level with past (and expected future) levels after construction, the extent of benefit and the level of reduced congestion could be found. (OECD & ECMT, 2004:19). To do this comparison the assessment could be done in terms of travel speed, travel time, delay time, traffic flow and transit passenger crowding (Zhang .W, Yue L. E. 2001: 2). Increase in speed will increase the volume per hour that means a particular section of road is handling traffic above the capacity (Kadiyali, 2007: 45). Adjusted volume with respect to capacity improves the Level of Service (LOS). The rate of LOS varies from A (best) to F (worst) which helps to establish performance indicator (TDM Encyclopedia, 2014). Improved LOS indicates a free flow where time and cost both is reduced. Compared to the travel time, researcher gives minimum attention on cost as it depends on particular vehicle and road way characteristics. But in reality it has great significance in evaluating transport infrastructure (Barnes, G. Langworthy, P. 2003:3). As vehicular operating cost depends on the type of vehicle, it varies from mode to mode in aspect of fuel, maintenance, tire repair,

depreciation (Barnes, G. Langworthy, P. 2003:5). Because of variation in the characteristics of road, adjustment in calculating cost is required through considering the roughness of surface. (Barnes, G. Langworthy, P. 2003:11). On the other hand, value of time savings actually depends on traveler, trip purpose, hourly income, available transport option (Belenky, P. 2001:4). Basic difference in evaluating cost and time is that the former one reflect the benefits enjoyed by vehicular operator and the later one enjoyed by passenger. (Kadiyali, 2007:763).

3. Study Area

Chittagong is the business capital of Bangladesh. About 92% of import-export of the country is handled through this port (Chittagong Port Authority, 2012). CEPZ was ranked third in the best cost-competitiveness category and fourth as the best economic potential in the global ranking in a survey among the world's 700 economic zones carried out by FDI magazine (Bss, 2010). As a result, an efficient transport system for Chittagong city is not only essential but prerequisite too for expanding the economic growth and to animate the country's business cycle. With the consideration of these reasons the Chittagong Development Authority (CDA) has developed long term development strategy for traffic and transportation in 1995 with an aim to enhance the efficiency of the transport system of Chittagong and to reduce the traffic congestion from Chittagong. Within this plan there are different structural measures among them most are construction oriented and require huge capital investment. Under this plan the CDA along with the Chittagong City Corporation have planned for construction of some flyovers and expansion of the existing roads within the city. There are total 17 flyovers in Bangladesh, among them 4 flyovers are proposed in Chittagong. They are known as Bohoddarhat flyover, Dewanhat to CEPZ (Chittagong Export Processing Zone) flyover/ Elevated Expressway, New-mooring container terminal (NMCT) to port access road flyover and Kadamtali Junction flyover. Among those construction of Bohoddarhat & New-mooring container terminal to port access road flyover are already completed. Between these two completed flyovers Bohoddarhat flyover is not open for use yet. Only New-mooring container terminal (NMCT) to port access road flyover is functioning. So, to assess the performance of structural measures, New-mooring container terminal (NMCT) to port access road flyover is selected as study area. It is located in South Halishahar, 3.10 km away from the sea port, 5.50 km from the main business center, 11.30 km from Shah Amanat International Airport, Chittagong (DPZ-1) (Chittagong Port Authority, 2012).

4. Methodology

Many transport projects are taken by the government to manage the traffic system. How these projects functioning are needed to assess, for this reason this topic is selected. There are 4 flyovers situated in Chittagong. Between the two completed flyover in Chittagong only New-mooring container terminal to port access road flyover construction is using for traffic movement. For this reason we select this study area for performance analysis. Under this project some indicators have been selected for performance analysis of port flyover in respect of data availability, scale of work and other limitations. There are lots of indicators to assess the performance these are delay, emission, safety, miles driven, congestion relief, climate access, reliability etc. (Mero Center, J. P. 2008) From these indicators, vehicle operating cost (VOC), value of travel time (VOT) and level of service (LOS) are selected for assessing the performance depending on the ease of survey, scale of work and availability of data. A reconnaissance survey has been conducted in the area with a vision to build up an initial idea about the study area. Then a review was made on existing traffic condition, availability of previous data for compassion, availability of survey instrument, pecuniary resource and time availability. After the consideration of these limitations it is found

that three types of survey can be conducted– speed survey using moving observer method, volume survey in manual count method and questionnaire survey from drivers and passengers. For speed survey and volume survey both peak (8.00am-10.00am and 8.00pm-10.00pm) and off-peak (11.00am-1.00pm and 4.00pm-6.00pm) time are considered to have the actual scenario. The sample size for the study has been determined as 384 at 95% confidence level and confidence interval of 5 (Index Mundi, 2011). From these surveys we can easily calculate VOC, VOT and LOS for assessing the performance. For these reason VOC, VOT and LOS is considered appropriate indicators for performance assessment of a built up structure. By comparing the previous data of port connecting road with data collected through survey after construction of flyover it is observed that whether there is any improvement or not. Besides these we also find out the feasibility of the system than the previous condition. Based on this analysis we can also decide that either the users prefer this flyover or not. Other indicators require expert surveyor to glean out the information, complex survey techniques and instrument.

5. Data Analysis

For analyzing the performance of the Chittagong Port Flyover three indicators are selected based on the data availability, scale of work and other limitation. Three indicators are level of service (LOS), value of travel time (VOT) and vehicle operating cost (VOC). Previous data of the Port connecting road is collected from "Strategic Transport Plan of Chittagong" prepared by Chittagong Development Authority (CDA). This organization operates survey in 2011. Methods for calculating VOC and VOT are explaining below with necessary information and analysis.

5.1 Level of Service (LOS)

Two types of survey are conducted to calculate the LOS of road and the flyover. Speed survey using moving observer method and volume survey in manual method. From speed survey journey time and delay time is measured. Volume survey counts the number of various types of vehicles within a specified time perion. Then the collected data is converted to Passenger Car Unit (PCU).

It is found form the survey that volume was augmenting with the change of year before and after the construction of flyover. Previous yearly data is collected from Strategic Transport Plan, CDA. Volume in 2014 found from field survey.

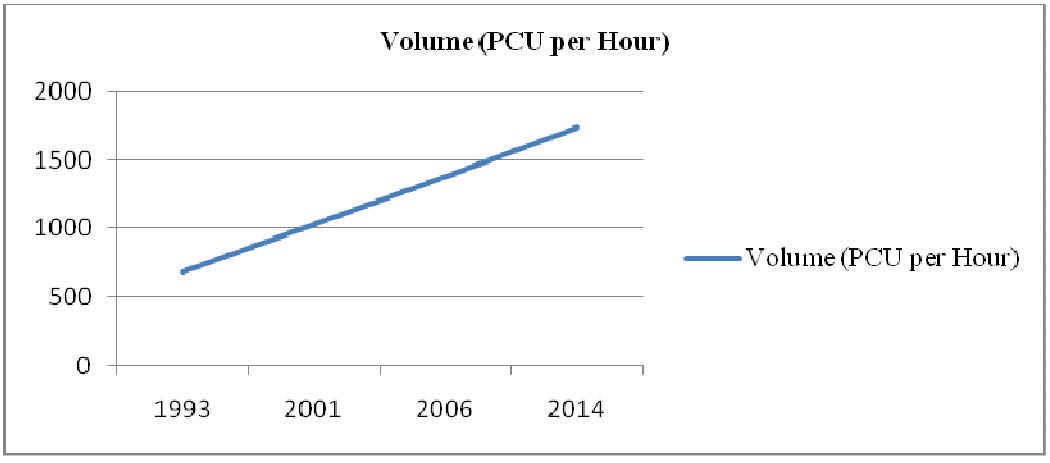

Figure 1: Change of volume per hour over the year in Chittagong Port Link Road

The reason behind the increase of volume before the flyover construction was the rate of increasing freight demand of the port. The early increasing throughput per ship per day is given below. But after the construction of flyover when freight coming from port was segregated from the passenger traffic, the drop in volume found in 2014. The information presented in figure 2 and 3 are collected from Chittagong Port Authority (CPA).

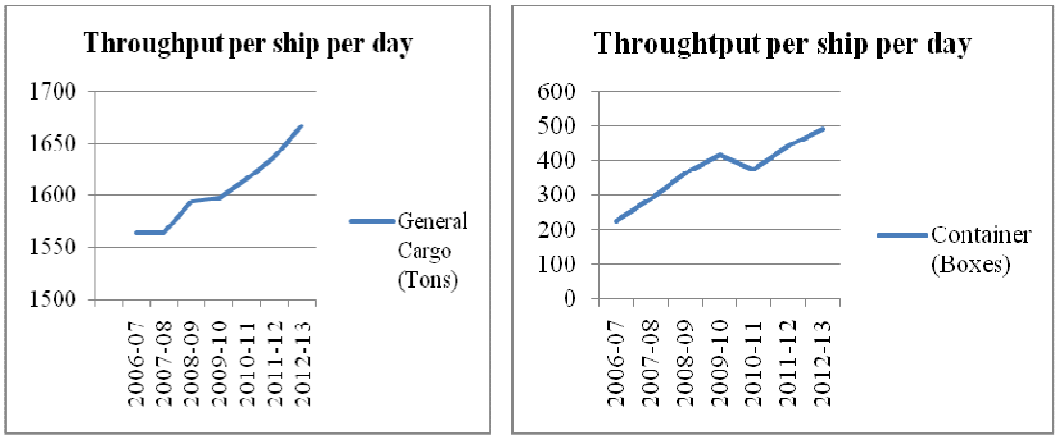

Figure 2 and 3: Change of throughput per ship per day over the year in Chittagong Port

Due to the change in volume over the year it is observed that before flyover construction the LOS of the port link road was D when increased volume within the restrained capacity of road begot unstable flow where drivers have little freedom to maneuver. But after construction of flyover when volume per hour increased more than the previous year and but the LOS on the port link road is found C which is characterized by stable flow with restricted speed of the vehicle. Moreover, over the flyover the LOS is B and also termed as stable flow having freedom of speed choice. It is worth to mention that the reason behind the improvement of LOS despite the increase of volume is the segregation of freight traffic (coming from port) from regular passenger traffic because the maneuver and speed of freight traffic obstructed the regular flow of passenger traffic. It can also be concluded that the up gradation of LOS is the indication of adjusted volume with capacity and increased speed. Moreover increased volume is not responsible for creating congestion, but the influence of one mode with another affects the traffic flow and create congestion. From this analysis it is elucidated that using LOS we can assess the performance of a structural measures by obtaining the capacity and the per hour volume.

Table 1: Speed vs. V/C in Port link road before constructing flyover and after constructing road

Description	Speed (km/hr)	V/C ratio	LOS	Year	Source
Before constructing flyover	28	0.2	D	2011	Strategic Transport Plan, CDA
After constructing flyover	31-32	0.56	C	2014	Field survey
Over flyover	35-40	0.7	B	2014	Field survey

5.2 Vehicle Operating Cost (VOC)

Vehicular operating cost is another performance indicator of a built-up structural measure which denotes the cost savings enjoyed by the vehicular operator through the improvement or development of traffic condition. Vehicle operating cost in 2011 for the Port link Road is collected from "Strategic Transport Plan, CDA" before constructing flyover. VOC for over the flyover is calculated by using rise and fall, carriage way width and roughness of the road. Here vertical clearance is considered as the maximum rise of the flyover. As the flyover is over a plain road, we can consider the vertical clearance as fall of the flyover. Vertical clearance for flyover is 5.48 meter and horizontal clearance 2.10 meter (Chittagong Port Authority, 2012). The length of the flyover is 1.42 km. For plain low curvature and high curvature road rise and fall (RF) meter per kilometer is 0-15 (Kadiyali, 2007:181). Here average value is considered for calculation of VOC of the Port link road. The major road users in the Port Link Road are Truck, Bus and Car. For this reason three mode are considered for calculating the VOC. So,

RF of the flyover = (5.48+5.48)/1.42 = 7.72 m/km

RF of the road = 15/2 = 7.5 m/km

Table 2: Methods of calculating VOC of the Port link Road and Flyover before and after the flyover construction

Description	Vehicle type	Tax payment	Carriageway width	Equation	VOC (taka per km)
VOC of road (Before flyover)	Truck	Don't have to pay	16.5m	Obtained from secondary source	8.45
	Bus				11.56
	Car				10
VOC of road (After flyover)	Truck	Don't have to pay	16.5m	VOC = e^ (1.676 + .00003146*RG + .00863* RF).	5.7
	Bus			VOC = e^ (1.286 + .00003128*RG + .00970* RF).	4.1
	Car			VOC = e^ (0.336 + .00005624*RG + .01023* RF)	1.5
VOC of flyover	Truck	Don't have to pay	10.60m	VOC = e^ (1.676 + .00003146*RG + .00863* RF).	5.75
	Bus			VOC = e^ (1.286 + .00003128*RG + .00970* RF).	3.9
	Car			VOC = e^ (0.336 + .00005624*RG + .01023* RF)	1.5

Source: Strategic transport plan, CDA (2011), (Kadiyali, 2007:789)

The VOC before and after the construction of flyover is presented is Figure 4. It is clearly distinguishable that after the construction of flyover there are drastic fall in the VOC both in the port link road and over the flyover. Maximum fall of VOC is observed for Bus that means the maximum benefit is enjoyed by the bus operator. It is also observed that the VOC for different mode is almost same on the flyover and below the flyover.

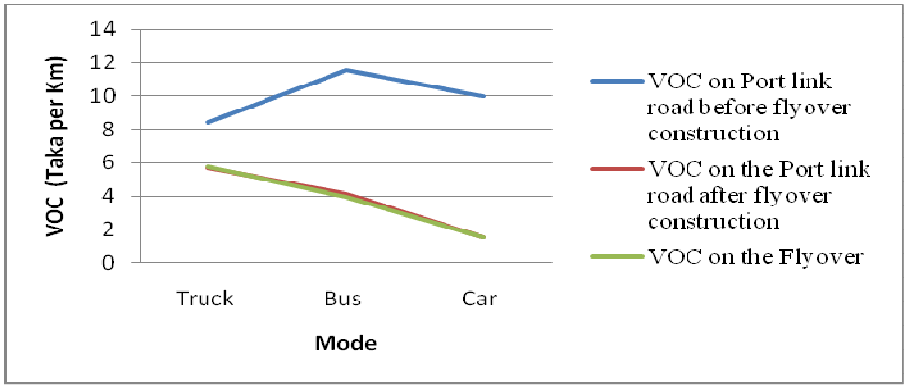

Figure 4: Change in VOC for different modes before and after the flyover construction

5.3 Value of travel time

Value of travel time saving (VOT) is another indicator of performance assessment where it indicates the savings enjoyed by the passenger. Major passenger using Port Link road are Bus, Car and CNG user. For this reason VOT is calculated using wage rate approach for the Bus, CNG and Car passengers. The data was collected according to a well-structured proforma seeking information on the occupation, income, purpose of the journey, origin and destination of travel journey time etc. (Kadiyali, 2007: 803). The time savings enjoyed by passenger after the construction of flyover is presented in Table 3. And the hourly savings enjoyed by the passengers of different mode is presented in Table 4. The maximum time savings enjoyed by the passenger are CNG and Car user. The total hourly time saving is BDT 12,950.27 of which yearly amount will be approximately BDT 11,34,44,365. Compared with the VOC, the bus operators are more beneficiary in respect of cost savings but they are fewer beneficiaries in respect of time savings. On the other hand car users are more beneficiary in respect of cost and time savings compared with the other mode user.

Table 3: VOT of different road user before and after the flyover construction

Mode of transport	Journey time after flyover in seconds	Delay time in seconds before	Delay time in seconds after	Mean income per passenger per month (BDT)	Hourly Wage rate per passenger (BDT)	VOT before the construction of flyover	VOT after the construction of flyover
Bus	590	3	1.7	13125	18.23	54.69	31.14
Car	410	1.5	1	19722	27.39	41.09	27.39
CNG	459.5	2	1.07	12088	16.79	33.58	17.91

Source: Field survey 2014

Table 4: Hourly value of time savings enjoyed by road user (BDT)

Mode of transport	Volume per hour	PCU	Occupancy rate	Per Passenger value of time savings due to less delay	Hourly value of time savings enjoyed by road user (BDT)
Car	224	224	1120	23.55	5275.2
Bus	113	339	20340	13.7	1548.1
CNG	391	391	1173	15.67	6126.97
Total					12950.27

Source: Field survey 2014

5.4 Benefit/Cost ratio

In determining whether the project of port flyover is worthwhile or not, benefit-cost ratio method is chosen depending on the indicators. Here, major benefits are cost savings and time savings enjoyed by the vehicle operator and passenger. The method of calculating yearly cost savings is given below.

Benefits from cost saving

Table 5: Cost Savings enjoyed by vehicle operator

Mode	Number of vehicle per hour (1)	VOC on Port link road before flyover construction (BDT/km) (2)	VOC on the Port link road after flyover construction (BDT/km) (3)	Cost Savings on Road (BDT/km) (4)=(2)-(3)	Total Per hour cost savings (8)=(1)*(4)
Truck	234	8.45	5.7	2.75	637.65
Bus	113	11.56	4.1	7.46	854.28
Car	224	10	1.5	8.5	1904
Total					3390.48

Source: Table 2

Total per hour cost savings enjoyed by vehicular operator=3390.48

Total per year cost savings enjoyed by vehicular operator=3390.48*24*365=29,748,347 BDT

Benefits from time savings

Per hour time savings enjoyed by passenger from Table 4 =12950.27 BDT

Per year time savings enjoyed by passenger =12950.27*24*365= 113,444,365.2 BDT

Total benefit per year=143,192,712 BDT/year

Cost of Project

Project investment cost per year =50930000tk

Maintenance cost = 54*365*1.42*9.9 = 277083.18 tk (Chittagong Port Authority, 2012)

Total cost =(50880000+ 277083.18)=51490151.06tk

Benefit –Cost Ratio

Benefit/Cost =143,192,712 /51490151.06=2.781>1, so the project is worthwhile.

After conducting the benefit-cost analysis it is worth to mention that considering the overall benefit enjoyed by vehicular operator and passenger and construction cost, the benefit is greater than the cost.

6. Findings

Form these study performance level of the Chittagong Port Flyover is justified. After construction of the flyover LOS of the port connecting road is improved despite there is an increase in volume. Before construction LOS of the Port Link Road was D and now it is C. It is also found that this methodology of performance assessment using VOC, VOT and LOS is compatible for quantifying the performance. Here, LOS has determined whether the construction has improved the previous situation or not and VOC and VOT quantify the benefit and at last cost benefit justify the quantification. It is also observed that VOC for every modes of vehicle has reduced after constructing flyover. People waited more time to cross the link before constructing flyover because of congestion but now congestion is reduced and time is saved.

7. Conclusion

Chittagong is called the “Economic life line” of the Bangladesh and it is the principal port. For economic growth of any country transport planning is playing a major rule. To remove congestion and expedite flow of traffic government takes so many measures. For any transport project government needs big budget. If it fails to solve the needthen the government suffers a great loss. It is not feasible for country like us. So before taking any kinds of transport project government should think carefully the condition of the problem and also about its solution. While taking decision about which option would more preferable analogous comparison would be a way to help in selecting solution. Performance of already built-up measures will act as an analogy in determining a solution.

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