

EFFECTS OF COMMERCIAL ACTIVITIES ON TRANSPORTATION PERFORMANCE AND ROADWAY FACILITIES IN URBAN CENTERS IN BANGLADESH: A CASE STUDY ON OXYGEN TO 2 NO. GATE ROAD, CHATTOGRAM

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ABSTRACT

Since Chattogram is being developed like other urban areas of Bangladesh, roadside activities are increasing at the same time. Transportation performance (Transit accessibility, productivity, land uses, land consumption, flow, speed, etc.) of any road defines whether the road is good for commercialization and free movement of vehicles or not. Oxygen to 2 No. Gate road section is one of the most important and major road sections of Chattogram city and due to the active growth in population and development of the urban areas, roadside commercialization has a significant impact on transportation performance and roadway activities as well. The study aims to evaluate the effect of roadside commercial activities on transportation performance of the Oxygen to 2 No. Gate roadway section. The level of service of any roadway is a significant indicator in determining transportation performance. As flow and speed are the important factors of evaluating the level of service of any roadway, manual volume count survey and moving observer methods are performed for volume count and journey speed analyses respectively. A parking inventory survey helps to find out the illegal on-street, surface off-street, and basement parking spots, furthermore, depicts the existing parking conditions of the roadway. Most importantly, users are a vital part of the roadway, as a result, users' opinions are utilized to figure out the existing condition, facilities, and various roadway issues and problems. Again, roadway measurements, land use identification, roadway facilities are collected, physical feature survey is accomplished in this regard. Since 48% of the study area serves commercial purposes, the road section remains under tremendous pressure that creates an unpleasant environment on residential character and an unfavorable impact on other roads connected with it. Consequently, most of the trips are generated at Oxygen, Textile, and 2 No. Gate intersections that make these intersections major congestion points. Moreover, the higher volume of traffic at Oxygen, Bayezid, Textile, and 2 No. Gate intersections are the consequences of lower speeds at those intersections. As a result, the level of service (LOS) of the road section is found below average (between the level of service 'E' and level of service 'F') which depicts that the roadway condition is not satisfactory, hence, the transportation performance is not up to the mark. In addition, 51% of the road section is occupied by illegal on-street parking. Besides, users of the selected roadway section also consider insufficient pedestrians, illegal on-street parking, and roadway management problems as major roadway issues. Therefore, the poor roadway condition shows the necessity of better planning and development policies to overcome the current situation. Hence, proper planning is a mandatory and appropriate measure, moreover, policies regarding the improvement of roadway facilities and transportation management should be in favor of users' opinions, and this is how the road can contribute to serving the existing and future population to a great extent.

Keywords: *Roadside Commercialization; Transportation Performance; Journey Speed; Traffic Volume; Parking*

1. INTRODUCTION

Urbanization is a rapidly growing phenomenon in developing countries like Bangladesh. The population growth in urban areas accelerates the development of the cities. The cities are being transformed into sustainable cities by using smart city technologies with the help of developing technology (Suleyman Ay, 2019). Despite having limited resources, the existing infrastructures, technologies, and transportation facilities have to serve a huge population of the cities. Moreover, tremendous pressure on the roads and transportation is created due to the lack of services and facilities, and limited resources (Yeasmin et al., 2019). Hence, severe issues like traffic congestion, road accidents, or problems occur which are terrible global phenomena. Roadside commercialization has been increased to facilitate the increasing number of populations. Commercialization means to develop or organize something to make any service available or more profitable. Roadside commercialization includes the development of roadway facilities, free flow to traffic, efficient level of service, etc. to make a consequential contribution to economic development and growth and guide fundamental social benefits (Engstrom, 2016). According to EPA (2011), transportation performance measures predict, evaluate, and monitor the degree to which the transportation system accomplishes adopted public objectives. Transit accessibility, productivity, land uses, land consumption, flow, speed, level of service of the roadway, etc. are the indicators of transportation performance. Since the roadsides at urban centers are getting commercialized, as a result, the transportation performance gets affected greatly.

A report by ADB (2012) stated that the average speed of roads of Chattogram is around 35 to 40 K.P.H. whereas Hossain and Imam (2019) in their study found that the average speed remains about 10 to 15 K.P.H. throughout the day dropping below 10 K.P.H. during the peak hour including severe congestion at five major intersections of the city. Besides, the maximum traffic flow is above 4000 PCU/hour at the Agrabad intersection according to the estimated Annual Average Daily Traffic (AADT) data. The scenarios depict the drastic change in speed and flow of the roadways of Chattogram over years. Moreover, Ali and Molla (2009) in their study identified the Bahaddarhat intersection as more and Oxygen, Dewanhat, and Tiger pass intersections as least congested areas of Chattogram using satisfaction index. According to them, intersection and terminal areas are more congested areas in this city. The study of Oluwaseyi (2016) resulted in a significant relationship between commercial activities and transportation problems in Nigeria. The roadside commercial activities increase the level of traffic congestion and decrease the level of service of the roads. A case study on the Lalkhan Bazar to Customs road section of Chattogram city depicted the interrupted transportation performance due to excessive roadside commercialization. According to (Islam et al., 2019), most of the trips are generated for commercial purposes which directly or indirectly affects the speed of the roadway and the level of service as well. Even Zannat and Rahman (2008) in their study carried out the disadvantaged transportation performance due to commercial activities along the Satmosjid Road, Dhaka. Due to the expansion and rapid urbanization of the city, the commercial, residential or non-residential activities and transport demand have been increased. Consequently, the traffic problems like traffic congestion become a matter of concern. Furthermore, the roadside commercialization is rapid and the increasing demand has a significant impact on the transportation performance.

The study aims at evaluating the effects of roadside commercial activities on the transportation performance at urban centers of Chattogram city. It deals with finding out the existing condition and facilities of Oxygen to 2 No. Gate roadway section of Chattogram. According to Zannat and Rahman (2008), the rapid increase of volume of motorized vehicles, less roadway speed, poor level of service, illegal parking conditions degrades the transportation performance of any road section. Even unplanned and improper ways of development or commercialization of the roadway make conditions worse. The volume and speed, level of service, parking condition, etc. are the significant indicators of determining transportation performance due to the roadside commercialization of Oxygen to 2 No. Gate roadway of Chattogram city. Though only the motorized vehicles are taken into consideration and all the manual survey methods are used instead of automatic methods, the study will be significant in finding out the existing problems or shortcomings. Moreover, it will assist in taking any further policies to improve the roadway facilities and provide better communication and link up the people of villages and cities by evaluating the impact of roadside commercialization.

2. METHODOLOGY

2.1 Study Area Profile

Chattogram district area is about 5283 sq. km, located in between 21°54' and 22°59' north latitudes and in between 91°17' and 92°13' east longitudes. A variation in the topography of Chattogram differs from the rest of Bangladesh. A huge portion of the division is covered with hilly regions. The southern part of the division is surrounded by the world's longest sea beach, Cox's Bazar (BBS, 2011). The selected study area, Oxygen to 2 No. Gate roadway section is one of the major roadways of Chattogram city. The study area is mostly plain land. Moreover, the existing road is linear in shape and it is a four-lane road, somewhere it is narrow and wide in some places. The road section is connected with Chattogram-Hathazari highway and Chittagong-Kaptai highway, besides, there is a linkage with other major roads of the city. Figure 1 shows the study area map including the district map of Bangladesh and Chittagong, The Oxygen to 2 No. Gate roadway is approximately 4.4 kilometers long.

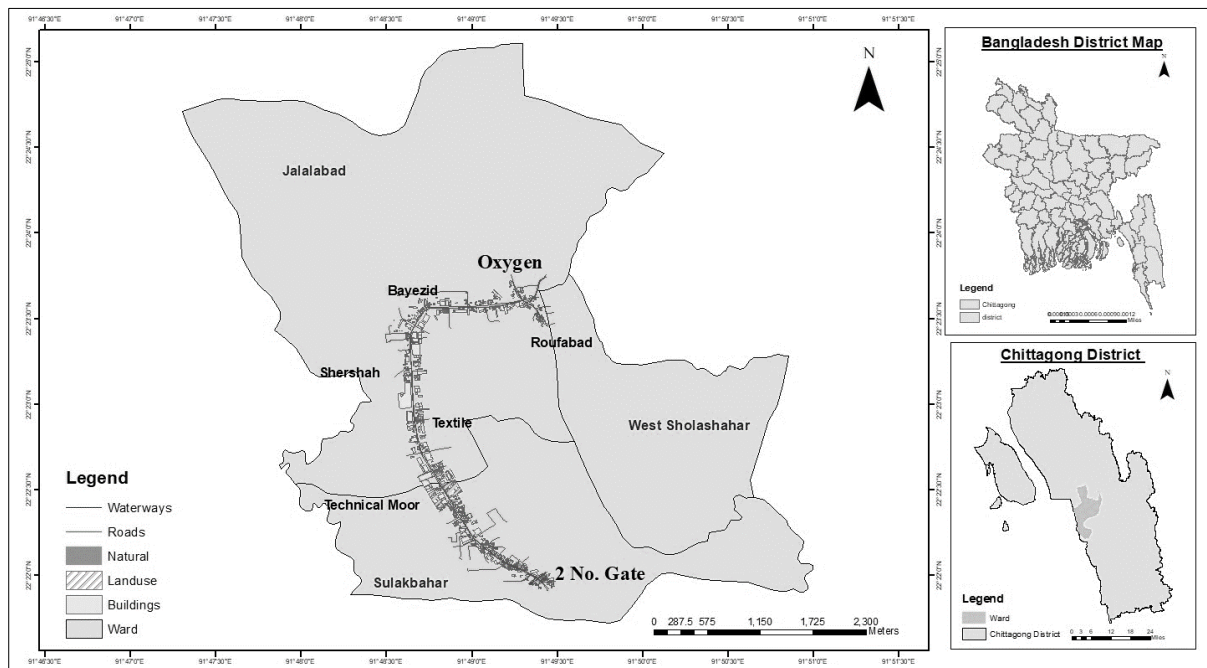


Figure 1: Study area map (Oxygen to 2 No. Gate roadway section)

2.2 Data Acquisition

The study aims to determine the effect of roadside commercialization on transportation performance and so, several traffic surveys are performed. The road section is divided into six intersections that are Oxygen, Bayezid, Sher Shah, Textile, Technical, and 2 No. Gate points or intersections. First of all, the land uses of the roadside are primarily collected and then, it is visualized in the study area map using ArcGIS. Abdulla-Al et al. (2018) counted the volume and speed of the roadway using the Manual Traffic Volume Count method and Moving Observer method consecutively in their study. Again, Sultana (2015) also calculated traffic volume and speed using similar methods to measure the level of service of the roadway. Therefore, the traffic volume count is conducted by persons standing at the roadside and recording passing vehicles on a survey sheet, hence the term is referred to as manual count of traffic volume. The manual count of vehicles distinguishes it from counts by machines that can record passing vehicles automatically, which are known as automatic traffic volume count (RHD, 2001). The survey is done at 8 to 9 am (peak hour), 12 to 1 pm (off-peak hour), and 5 to 6 pm (peak hour) both on the weekend and working day. The Moving Observer method is used to estimate the average flow and journey time of traffic on a road section through the collection of data using a moving vehicle (Wright, 1973). The number of vehicles met in opposite directions, vehicles overtaking and overtaken, journey time and delay time, etc. are recorded. Using equations (1) and (2), the flow of the roadway and journey time are calculated (Kadiyali, 1999).

$$q_n = \frac{x_s + y_n}{t_s + t_n} \quad (1)$$

$$T_n = t_n - \frac{y_n}{q_n} \quad (2)$$

Here, q_n = flow in the north direction, x_s = vehicles coming for the opposite direction, y_n = difference between vehicle overtaking and overtaken traveling north, t_n = journey time while traveling in the north direction, t_s = journey time while traveling in the south direction, T_n = mean journey time.

In this study, parking spaces and vehicles using the parking space are counted by the parking inventory survey. Besides, illegal on-street parking, surface off-street parking, and basement parking are also identified. Using the parking inventory survey method, the existing parking condition of the Oxygen to 2 No. Gate roadway section is depicted. Again, the origin and destination of users, traffic management-related problems, pedestrian facilities, roadway services and facilities, parking facilities, etc. are counted using the users' opinion survey. Around 70 users from different intersections of the roadway are randomly selected to capture their opinion. Moreover, the physical feature survey is done to measure the dimensions and features of the existing road, for instance, measurement of roads, availability of pedestrian facilities and services, facilities like bus stops, street lightings, etc. are collected. Level of service (LOS) is a qualitative measure of the operational performance of any roadway based on quantitative measures like speed, volume, capacity, etc. (Chen & Larry, 2009)

$$C = \frac{1000 V}{S} \quad (3)$$

Here, C, V, and S represent the capacity in the vehicle per hour, speed (K.P.H.), and average spacing of vehicles (m). The capacity is required to measure the level of service. Among LOS-A to LOS-F, level of service A indicates the free-flow condition of traffic and excellent condition of the roadway, and level of condition F is the indicator of poor roadway condition with highest vehicle congestion. Level of service B, C, D, and E indicate the gradual increase of vehicles and congestion at roadway including stable flow (Marufuzzaman and Khanam, 2019). The determination of LOS is significant as it is an important factor for measuring the transportation performance of the selected roadway section.

3. DATA ANALYSIS AND RESULT

3.1 Existing Roadway Characteristics

The existing road section is 4.4 km long. But there is a lack of several roadway facilities which must be present to facilitate the people and vehicles as well.

Table 1: Availability Measurement of Roadway Facilities

Elements/ Intersection	Dimension	Intersections					
		Oxygen	Bayezid	Sher Shah	Textile	Technical	2 No. Gate
Carriageway	Width	40 ft.	44 ft.	40 ft.	45 ft.	44 ft.	46 ft.
Lanes	Number	4	4	4	4	4	4
Lane	Width	9 ft.	11 ft.	9 ft.	11 ft.	10 ft.	10 ft.
Median	Width	1 ft.	1 ft.	1 ft.	1 ft.	1 ft.	3 ft.
	Height	1.5 ft.	1.5 ft.	1.5 ft.	1.5 ft.	1.5 ft.	1.5 ft.
Shoulder	Width	No	2 ft.	No	No	No	1.5 ft.
Pedestrian way	Width		3 ft.				3 ft.
	Height	No	1 ft.	No	No	No	1.2 ft.

The dimensions of carriageways, lanes, medians, pedestrians are depicted in table 1. Considering the roadway facilities in these six intersections, street lights and bus stoppages are available in almost all the intersections except the Sher Shah area. Only 2 No. Gate intersection has greenery features and signalized system, but the system is hardly used. Besides, the speed breaker is found in Bayezid and 2 No. Gate intersections. There is a section of the flyover that is connected to the Muradpur-Lalkhan Bazar flyover. On the contrary, bus bay, foot-over bridges, auxiliary lanes, facilities for disabled people, such facilities are absent at these intersections.

3.2 Existing Roadside Land Use Pattern and Its Impact on Travel Behaviour

The roadside land uses are categorized into seven classes, e.g. commercial, industrial, residential, institutional, mixed-use, open space, and under-construction buildings. Figure 2(a) shows that the study area is dominated by commercial uses (48%). Moreover, mixed land uses (23%), residential (17%) and commercial units, industrial and institutional uses, open spaces, and some under-constructed structures also take place.

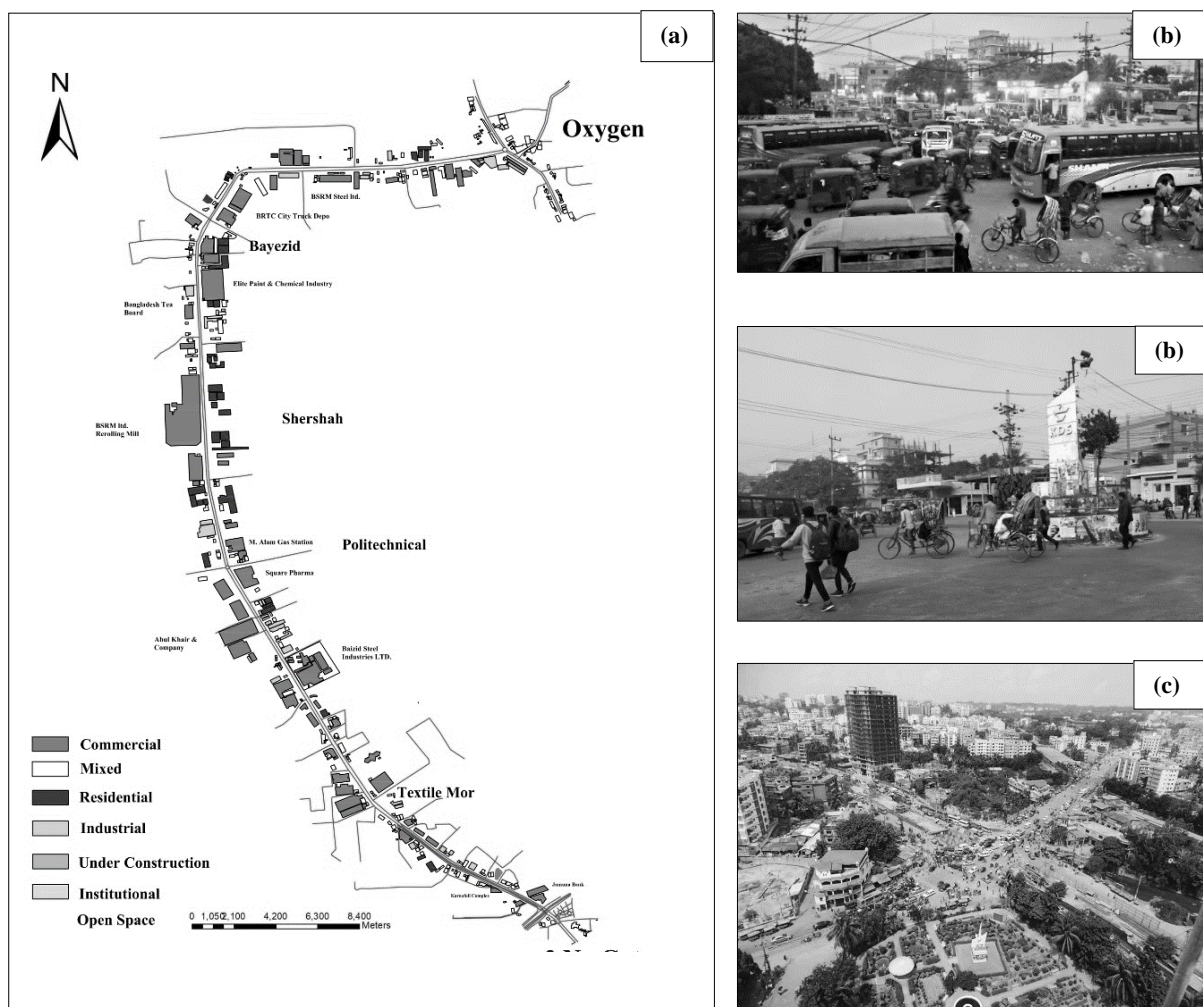


Figure 2: (a) Land use map and (b) Existing condition of Oxygen and (c) Existing condition of 2 No. Gate intersections (Source: Field Survey, 2020)

Roadside land use pattern has a significant influence on travel behavior. Especially, trip generation or attraction points have an important role in determining travel behavior. The study shows that Oxygen and 2 No. Gate intersections are the major trip generation points. Besides, Textile and Technical circles are also trip attraction points. The more commercial and industrial activities occur in these places, the more trips are generated. Consequently, Oxygen, Bayezid, Textile, and 2 No. Gate intersections remain mostly congested, hence, are denoted as congestion points. Insufficient pedestrian facilities, lack of

specific points for loading and unloading passengers, insufficient carriageway width, lack of necessary roadway features, excessive provision of illegal parking, etc. affect the travel behavior pattern significantly. The study depicts some considerable factors that are influencing the travel behavior, such as the pedestrian movement getting interrupted due to broken footpaths, illegally occupied by the hawkers, or the absence of walkways. There is no bus bay at the road sections, but a few points are denoted as temporary bus stops. Still, local buses are seen loading and discharging the passenger in the middle of the roads. Moreover, illegal on-street parking of vehicles is also a major issue. These create unwanted traffic congestion on the roadway. Again, motorized and non-motorized vehicles move on the same lanes, no separated lanes are available for the motorized and non-motorized vehicles. Slow non-motorized vehicles occupy a large portion of the carriageway.

The city has several road networks which connect the whole communication system of Chattogram. Oxygen to 2 No. Gate road is one of them. There are four more roads connected with this road section, two of them are highways. Chattogram- Hathazari highway, Kaptai highway, New Market road, etc. are connected with the roadway section. So, people traveling to the city from villages have to depend on this road. The road section facilitates the huge number of people who reside in the areas and travel by this road for official, commercial, institutional and other purposes. Besides, there are more than 48% of lands are used for commercial purposes and 29% of lands are facilitating industrial and mixed uses. Several offices, shops, garments, industries, commercial buildings, etc. are prominent. So, the roadway has a contribution to the commercialization of those areas. Therefore, the roadway section is vital for internal and external communication and several economic activities take place throughout the city.

3.3 Transportation System Efficiency of the Roadway Section

The efficiency in the transportation system of Oxygen to 2 No. Gate roadway is measured using traffic and transport surveys, for instance, traffic volume study, speed analysis, parking survey, user opinion survey, traffic congestion study, etc. The outcomes of the studies are the indicators of the performance of the transportation system of the roadway.

3.3.1 Outcome of User’s Opinion Survey

Users are the most essential part of any road. They use the road for various purposes. So, the opinion of the users and passengers matters a lot in developing road conditions. The opinion will define the necessities and opportunities for the road. Around 70 random respondents from different intersections participated in the survey. The majority of the users (88%) are local, rest of the users are from outside of the city. Among them, 47% of the users travel for official or commercial purposes. Figure 3(c) shows that the majority of travelers use tempo as a mode of transport to their destinations.

The users of the roadway opined about the roadway facilities and problems, opinions, transportation mode selection, etc. Figure 3(b) depicts that users have ranked various problems and opined about developing the road condition whereas the majority of the users consider illegal parking and insufficient pedestrian facilities as major roadway issues.

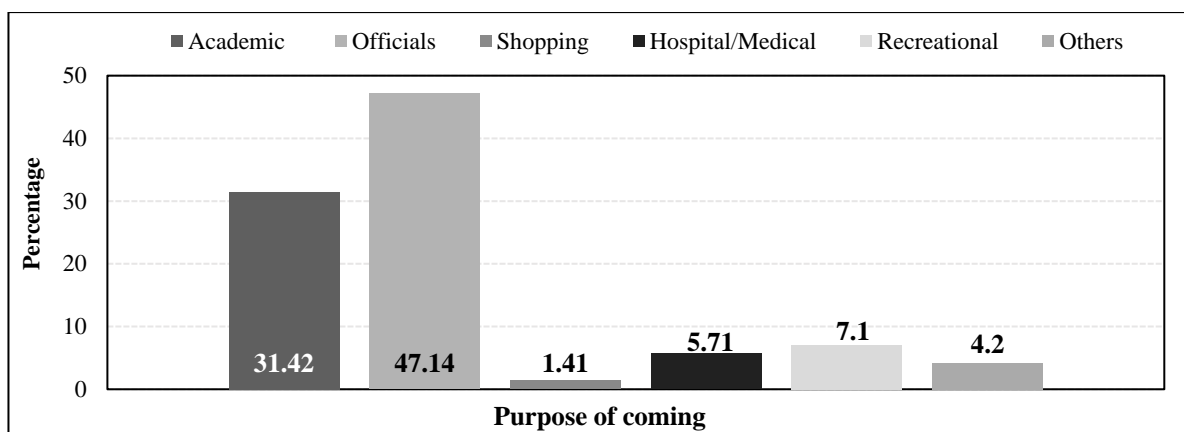


Figure 3: (a) Purposes of people’s coming (%) and traveling

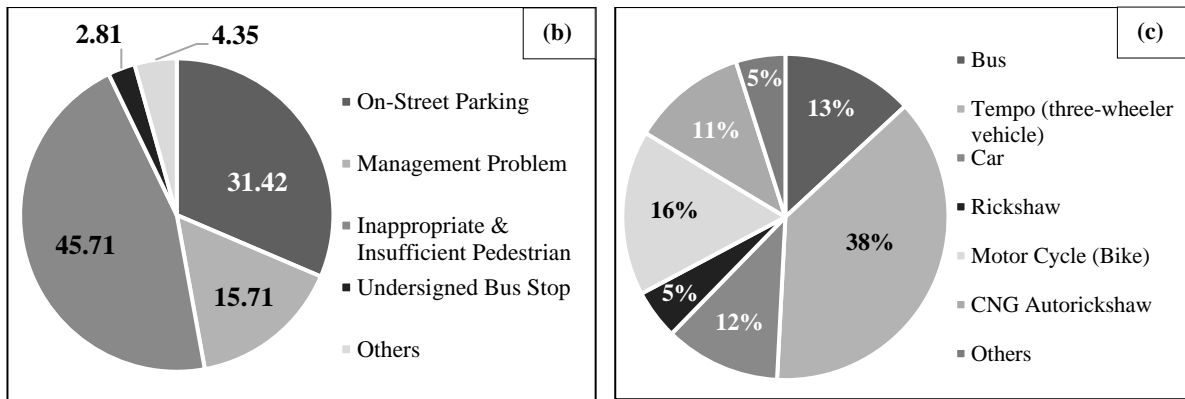


Figure 3: (b) Roadway problems ranked by users (%) and (c) Different modes of vehicles used by travelers (%) (Source: Field study, 2020)

3.3.2 Outcome of Volume Study and Journey Speed Study

The study on manual traffic volume count conducted at three different times of the day found that traffic volume varies drastically at 8 am-9 am (peak hour), 12 pm-1 pm (off-peak hour), and 5 pm-6 pm (peak hour) both on the weekend and working days and in both directions (Oxygen-2 No. Gate and 2 No Gate-Oxygen). Volumes are converted into equivalent passenger car units (PCUs). The volume is higher on working days than weekends while traveling towards both directions of the road section.

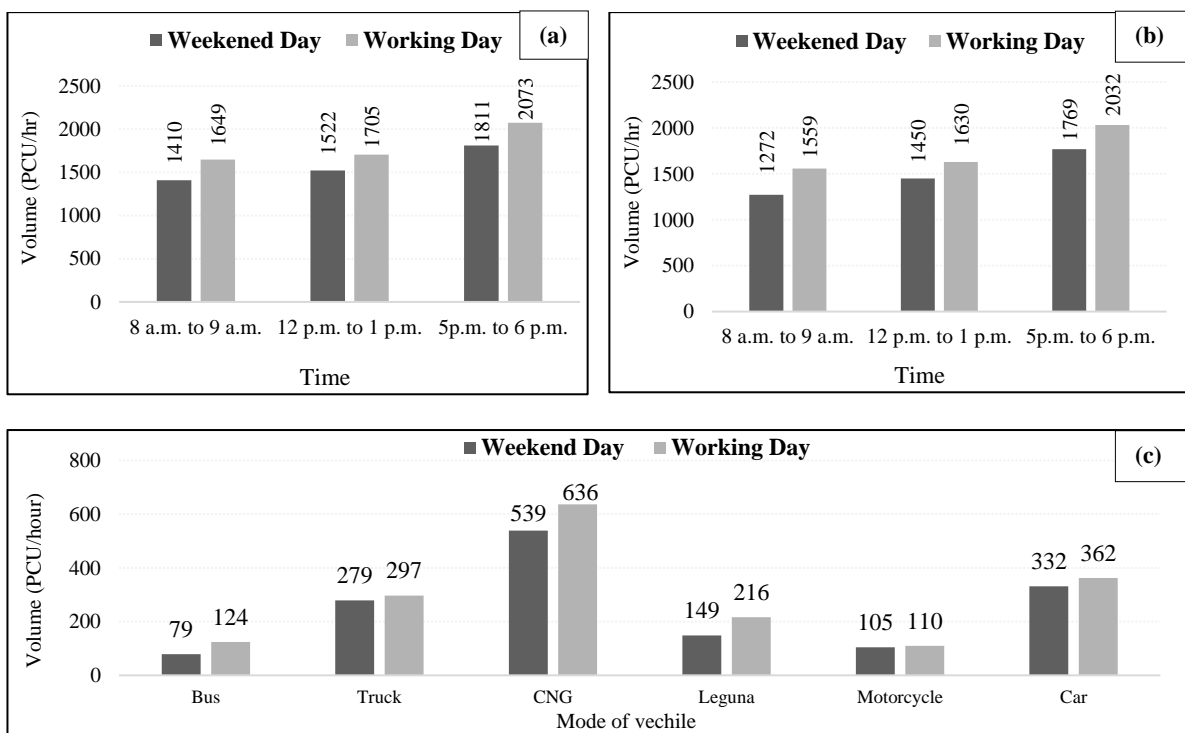


Figure 4: (a) Traffic volume at Roufabad to 2 No. Gate direction (b) Volume at 2 No. Gate Volume to Roufabad direction and (c) Volume of different modes (Source: Field study, 2020)

Besides, the volume of vehicles is higher at peak hours than off-peak hours as there are several institutions, offices, industries, etc. [figure 4(a) and 4(b)]. Again, figure 4(c) shows that different types of vehicles move along the road whereas the volume of CNG auto-rickshaws is the most. Moreover, the moving observer survey is conducted for speed study and hence, the outcome from journey speed shows that the speed of vehicles is higher on weekends than on working days and the speed is less in peak hours (figure 5 a and b). So, the relationship between volume and speed is contradictory. The analysis shows that the speed gets lower on working days than on weekends. But figure 5(a) depicts

that the speed of the roadway is higher on working days than on weekends (12 to 1 pm) because people visit their villages, various commercial places, like, shopping centers, or recreational places.

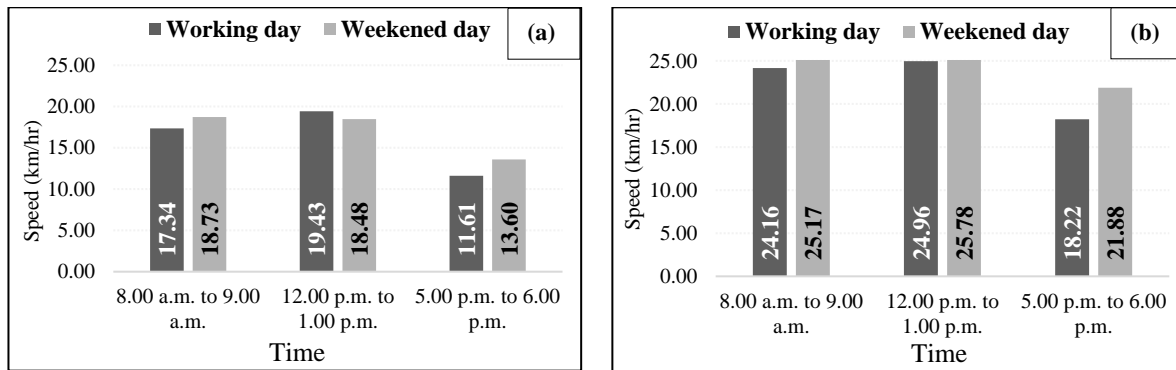
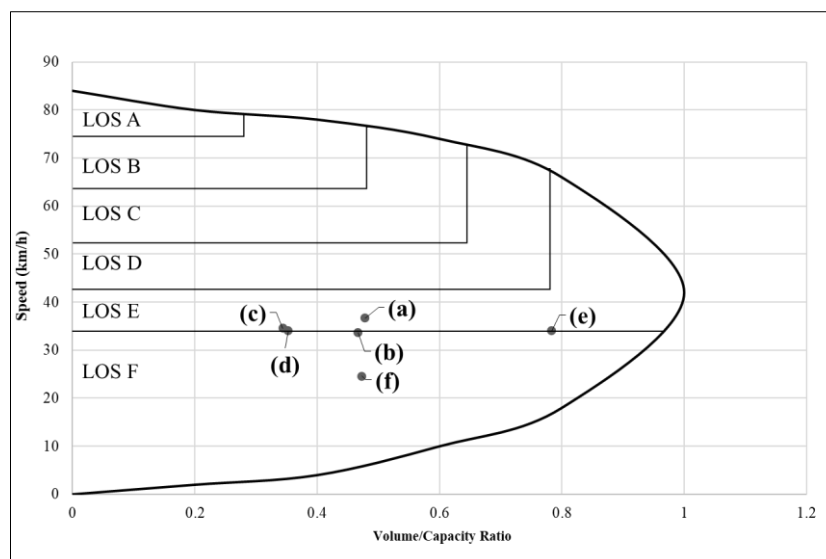


Figure 5: Journey speed at (a) Roufabad to 2 No. Gate and (b) 2 No. Gate to Roufabad both on weekends and working days (Source: Field study, 2020)

3.3.3 Level of Service (LOS) of the Roadway Section

The level of service of any road is a concept to relate the quality of traffic service to a given flow rate (Mathew, 2014). It is dependent on the measurement of volume and capacity of vehicles (equation 3).



Figures 6: Level of service (LOS) of the roadway (Source: Field study, 2020)

The level of service of different intersections of Oxygen to 2 No. Gate Road is below average (figure 6). The volume of vehicles of Oxygen to 2 No. Gate Road is higher than its capacity. So, most of the intersections are in poor condition. The level of services of selected intersections of Oxygen to 2 No. Gate road section lies between LOS E to LOS F, which indicates the slow movement of the vehicle due to heavy volume of traffic and frequent traffic congestion that interrupt the free-flow of traffic.

3.3.4 Outcome of Parking Survey

A parking survey is done to find out the existing parking condition, illegal on-street parking points, surface off-street parking, and basement parking at Oxygen to 2 No. Gate road section whereas illegal parking (51%) of vehicles is the most. Figure 7(a) shows that the roadway section is mostly occupied by illegally parked vehicles. Besides, 40% of the vehicles use surface off-street parking spaces. There are several selected parking points, for instance, Karnafuli Shopping Complex (2 No. Gate), Textile intersection, Bayezid intersection, Oxygen intersection, etc. The spots are marked by the Traffic (North) department of Chattogram Metropolitan Police. Figure 7(c) also depicts the surface off-street parking space for private vehicles provided by the Karnafuli Shopping Complex authority.

Table 2: Speed and illegal on-street parking conditions at different intersections

Link Name	Illegal On-Street Parking (Number of vehicles)	Speed (km/hr.)
Roufabad to Oxygen	26	19.99
Oxygen to Bayezid	31	24.68
Bayezid to Shershah	21	25.49
Shershah to Textile	39	16.30
Textile to Technical	17	27.42
Technical to 2 No Gate	26	21.95

The analysis also shows that the speed of vehicles on different conflict points is low where illegal on-street parking is high (table 2). The speed of the Shershah to Textile section is around 16 km/hr. The section occupies the highest number of illegally parked vehicles on-street.

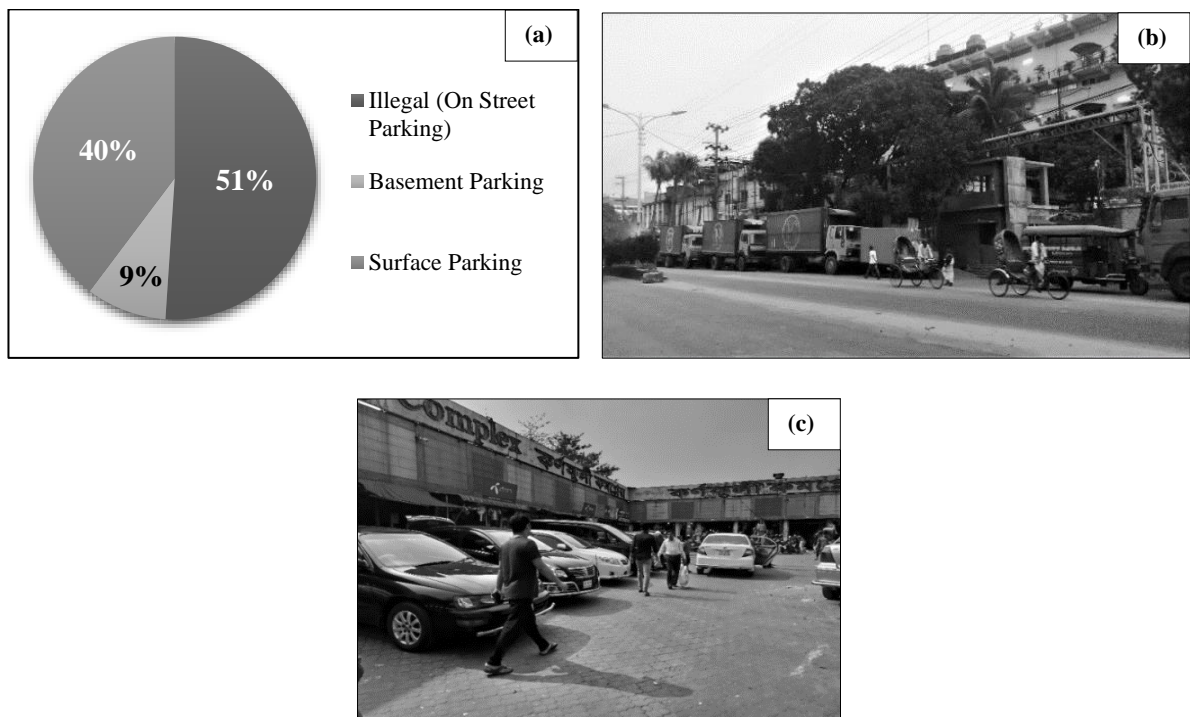


Figure 7: (a) Percentage of parking types (b) Illegal parking at Oxygen and (c) Surface off-street parking at 2 No. Gate (Source: Field survey, 2020)

3.3.5 Correlation among the Variables

The Pearson Correlation is used to figure out the correlation among the two different variables. The correlation coefficient is used to measure the strength of a linear association between two variables. The correlation between journey speed and volume shows that the variables are negatively correlated, which means the increase in traffic volume decreases the speed of the roadway or vice versa. Due to the heavy volume of traffic on the existing carriageway, the speed of the roadway is decreased greatly.

Table 3: Co-relation between traffic volume and journey speed

Time	Pearson Correlation Value	Comments
Working Day	-0.254	Negatively Correlated
Working Day	-0.825	Negatively Correlated

Similarly, the study finds that illegal on-street parking and the speed of the roadway are negatively correlated. It shows that the higher the illegal on-street parking, the lower the speed of the roadway. Both the correlations depict the scenario on weekends and working days.

4. FINDINGS AND RECOMMENDATION

The analyses from the surveys depict those commercial activities mostly take place (48%) along the roadsides. Besides, the road section has a few legal parking spots provided by Chattogram Metropolitan Police. But still, 51% of illegal on-street parking of vehicles is found throughout the roadway section. Moreover, around 50% of the intersections don't have pedestrian walkways and the remaining walkways are not in good condition. Most of the pedestrian areas are illegally occupied by hawkers. The study also shows that the volume of vehicles is higher on working days that is 2073 PCU/hour than the volume on weekends during peak hours (5 pm to 6 pm). On the contrary, the journey speed of the roadway section is found lower during working days (11 kmh^{-1}) than weekends (13 kmh^{-1}). While traveling towards both directions, the speed of vehicles is higher at 2 No. Gate to Roufabad direction than Roufabad to 2 No. Gate direction. According to the users of the road, 47% of them travel on this road due to official purposes, and 38% of the users use tempo (public transport) as their mode of transport. More than 45 percent of the respondents ranked insufficient and inappropriate pedestrian facilities as a major roadway issue. The population growth of the city is rapid and so roadside commercialization is occurring rapidly, but the performance of transportation becomes a matter of concern for all. The level of service of the road section seems very poor (LOS lies between 'E' and 'F'). Hence, transportation performance of Oxygen to 2 No. Gate road section is being degraded with the increase of commercialization along with the Oxygen to 2 No. Gate roadsides.

Proper transportation management is vital and traffic laws are to be enforced strictly to overcome the certain situation. Moreover, the signalized system needs to be introduced at all intersections and monitored all day long. Besides, separation of motorized and non-motorized vehicle lanes may reduce severe traffic congestion and increase the speed rate for motorized vehicles. In addition, a service lane for emergency vehicles is to be introduced. Building up foot-over bridges for pedestrians almost in every intersection like Oxygen, Bayezid, Textile, 2 No. Gate intersections, etc. are significant. The study finds that most of the areas have no footpaths and some of the footpaths are under construction, hence, the construction of footpaths can ensure pedestrian safety. As illegal parking is a severe issue, basement parking for vehicles should be encouraged and emphasized, especially since all large commercial buildings and industries need to provide basement parking facilities. Last but not the least, policies regarding the road should be taken considering public and stakeholders' opinions.

5. CONCLUSION

Oxygen to 2 No. Gate roadway section plays a significant role in the transportation system of Chattogram city. But its transportation performance is degrading gradually with the increase of roadside commercialization of the roadway. The study identified that the speed of the road section is comparatively sluggish with a higher amount of traffic volume. Indeed, the roadway condition has become a matter of concern. Pedestrian conditions and facilities are not furnished enough to serve the consumers. Furthermore, lack of traffic and transportation management ruins the whole transportation system and degrades the transportation performance. People's tendency not to abide by the laws creates massacred situation. Besides, the majority of the consumers of the roadway consider inappropriate and insufficient pedestrian facilities, illegal on-street parking, and improper transportation management as crucial roadway problems. In addition, the lack of proper planning and unplanned growth on the roadsides has become a burden. As a result, transportation performance has been degraded due to the increase of roadside commercialization. Hence, immediate measures are necessary to improve the roadway condition and resolve the existing problem. Proper planning is mandatory and policies regarding the improvement of roadway facilities and transportation management should be in favor of users' opinions and this is how the road can contribute to serving the existing and future population to a great extent.

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