Research Article

Identification of Suitable Bus Bay Location Using Capacity and Speed-Flow Relation to Reduce Traffic Congestion in Chattogram City

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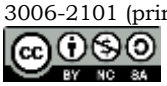

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Abstract

The augmentation of the urban population and the lack of proper planning and management cause tremendous pressure on the transportation system of Bangladesh. Moreover, the unusual competition and behavior among the bus drivers and traffic mismanagement cause phenomena like traffic congestion and roadway accidents. The absence of bus bays in Chattogram is a great obstacle to reducing the issues. Even though there is no proper guideline regarding the provision of bus bays in the relevant transport policies of Bangladesh. Hence, the study deals with the identification of suitable bus bay locations in Chattogram city. The criteria for the provision of a bus bay demand the traffic volume, passenger volume, bus volume, roadway speed, and road accident history, which leads to the evaluation of existing roadway conditions by performing surveys. The moving observer survey for calculating the speed of the roadway, the manual volume count survey for traffic volume count, the physical feature survey to measure the cross-sectional elements of the roadway, the users' opinion survey to review the opinion of users or stakeholders, the parking inventory survey, and road accident data analyses are done to determine the roadway condition. The traffic and the passenger volume are higher during peak hours. Moreover, the determination of the level of service (LOS) indicates the below-average or ineffective condition (LOS 'E' and 'F') of the roadway. Oxygen, Muradpur, 2 No. Gate, GEC, and Lalkhan Bazar are the selected major intersections suitable for setting up bus bays. According to the bus bay design criteria, a minimum distance of 50 meters from the major roadway intersections needs to be maintained.

Keywords: *Bus bay, GIS, Level of Service, Traffic Volume*

Introduction

The rapid urbanization in the megacities of Bangladesh causes a huge migration of population towards the city and creates tremendous pressure on the infrastructure, existing utilities, and amenities. According to Etzold (2014), approximately 38% of the total population resides in urban areas, where the rate was around 4% in 1950. Moreover, the rate of the urban population in Dhaka and Chattogram is 33% and 8% respectively, in 2020, which is growing rapidly. While rapid population growth significantly contributes to challenges in the transportation sector, such as traffic congestion and high rates of road accident fatalities, other critical factors also play a role, including inadequate infrastructure (e.g., poorly maintained roads, insufficient highways and public transit), weak enforcement of traffic laws, high private vehicle ownership, inefficient urban planning, and unsafe driver behavior (Jin, 2022; PwC, 2023; PMC, 2023). Traffic jams can be considered one of the serious

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global issues for both developed and underdeveloped countries (Najneen et al., 2010). According to Akter et al. (2019), the average traffic speed in Dhaka has plummeted from 21 km/h to 7 km/h in the last ten years, and as a result, the speed of the highways may drop to four km/h by 2035, which is slower than walking pace. The traffic problems are severe all over the country. Traffic congestion in Dhaka disrupts about five million working hours every day and costs the country around USD 11.4 billion annually (Rahman et al., 2016). Simultaneously, increasing urban population are creating pressure on the existing transportation system (Shamsher, 2015). Furthermore, according to the Bangladesh Passengers Welfare Association's (BPWA) annual road accident monitoring report for 2020, about 6,686 persons died and 8,600 were injured in 4,891 road accidents in Bangladesh in 2020. In Bangladesh, 18 people died in traffic accidents on average every day that year (Antara, 2020). Chattogram, the second-largest city, also suffers from prolonged traffic delays, largely due to inadequate infrastructure and unregulated passenger pick-up and drop-off points (Haque & Rana, 2021). These traffic inefficiencies not only reduce productivity but also increase accident risks. Bangladesh records one of the highest road accident fatality rates in South Asia, with more than 21,000 deaths annually (WHO, 2018). A significant share of urban accidents occurs due to buses stopping haphazardly on main roads to pick up or drop off passengers, which disrupts traffic flow and leads to collisions (Haque et al., 2020). Again, due to passengers picking up and dropping off by public transportation on the roadway, traffic congestion is exacerbated at bus stops without a bus bay (Mushule, 2012). Therefore, introducing designated bus bays can play a crucial role in reducing congestion and enhancing road safety by ensuring organized stopping points for buses.

In many urban areas of Bangladesh, especially in Dhaka and Chattogram, the absence of a systematic approach for picking up and dropping off passengers has become a critical issue. Buses and minibuses frequently stop at random points along major roads, blocking active traffic lanes, reducing effective road capacity, and contributing significantly to traffic congestion (World Bank, 2018; Hoque et al., 2021). This unregulated practice also increases accident risks, as passengers are often forced to board or alight in unsafe conditions, sometimes in the middle of moving traffic (Haque et al., 2020). Hence, without an organized mechanism for passenger movement, both congestion and accidents are likely to persist in urban transport systems. One practical solution to address these issues is the construction of bus bays. A bus bay is a specially designed area adjacent to traffic lanes, separated from the main carriageway, that allows buses to safely pick up and drop off passengers without disrupting through traffic (Fitzpatrick, 1996; Ahmed & Rahman, 2022). By providing a designated space for buses, bus bays not only enhance passenger safety but also improve roadway efficiency by reducing bottlenecks caused by random stoppages. Recent studies have shown that the implementation of bus bays in congested cities can reduce traffic delays and significantly lower accident risks at bus stops (Ahmed & Rahman, 2022). Furthermore, they are typically built in congested downtown and shopping areas where large groups of passengers may board and disembark (Transportation Research Board, 1985). In modern countries like the USA, Australia, etc., there is provision for a bus bay system, which reduces traffic congestion and social and economic losses due to reckless driving and congestion to a great extent. The US Transportation Research Board (1985) has also emphasized some factors for locating bus bays (TCRP, 2019). According to them, the traffic volume in the curb lane is more than 250 vehicles during the peak hour, traffic speed is more than 40 mph and bus volumes are more than 10 per peak hour, passenger volumes exceed 20 to 40 boarding per hour, the average peak-period dwell time exceeds 30 seconds per bus, frequent accident cases at any intersection, sufficient right-of-way width without obstructing sidewalk or pedestrian traffic, 18 m space in bus-bay length, no bus parking in the curb lane and improvements, such as widening planned for a major roadway. Recent design guidelines suggest that a bus bay should be considered when the curb-lane traffic during peak hours exceeds 250 vehicles per hour, bus volumes are 10 or more buses per peak hour, and average dwell times exceed 30 seconds per bus, especially near intersections where re-entry or merge delays occur. For instance, a 2023 study on Nepal's Araniko Highway measured dwell times of about 73.65 seconds near intersections and 51.65 seconds mid-block during daytime. In addition, guidelines from New Zealand indicate that bus stop capacity drops sharply once dwell times exceed 60 seconds (NZTA, 2023; Bhele & Devkota, 2023).

According to Sultana (2015), the provision of a bus bay in Dhaka city requires a traffic volume of 500 vehicles during the peak hour, bus volumes are 10 or more per peak hour on the roadway, passenger volumes exceed 20 to 40 boarding /hour, average peak-period dwell time is more than 30 seconds per bus, frequent traffic and/or pedestrian accidents history, sufficient right-of-way width without obstructing the sidewalk or pedestrian traffic, a minimum distance of 75 m from the intersections, minimum 15.2 m distance from local street intersections, 18 m space in length and 3 m minimum space in width for the bus bay are the required criteria. Bus bays can be considered an important means, especially in urban areas, for the reduction of traffic congestion and road accident fatality rate in Bangladesh (Zhang, 2018). Therefore, this study focuses on identifying suitable locations for bus bays in Chattogram city, which has been selected due to its rapidly growing urban population, increasing private vehicle ownership, and severe traffic congestion resulting from unregulated bus stoppages along arterial roads. Despite being the country's second-largest metropolitan area and a key economic hub, Chattogram has received relatively less attention in transport infrastructure research compared to Dhaka. The lack of organized bus bays in major corridors contributes not only to traffic delays but also to frequent accidents involving pedestrians and buses.

Study Area

Chattogram is geographically the largest division of Bangladesh. The city is also densely populated (BBS, 2011). Overcrowding or blockage of traffic is a common phenomenon on the roads of Chattogram city. But there is no such bus bay that may facilitate the people using local buses. So, five intersections of Chattogram have been selected to perform the study **(Figure 1)**. The intersections are- Oxygen Circle (22°23'34'' N and 91°49'15'' E), Muradpur Circle (22°22'08'' N and 91°49'59'' E), 2 No Gate Circle (22°21'58'' N and 91°49'22'' E), GEC Circle (22°21'33'' N and 91°49'18'' E), and Lalkhan Bazar Circle (22°20'50'' N and 91°49'09'' E). The selected intersections are a few of the busiest intersections of the city, and hence, suitable bus bay locations with proper design are provided in this study.

Methodology

To assess the suitability of bus bay locations in Chattogram, this study applies a set of operational and safety criteria derived from traffic engineering standards and adapted to local conditions. Intersections and bus stoppages were evaluated where peak-hour traffic volumes exceeded 500 vehicles, with bus frequencies greater than 10 per hour and passenger boarding demand averaging 20 to 30 passengers per hour. Locations with average dwell times of more than 30 seconds per bus, as well as those with a documented history of repeated traffic and pedestrian accidents, were given special consideration. Adequate right-of-way was treated as essential, ensuring that bus bay construction would not obstruct pedestrian movement along sidewalks. Furthermore, spacing standards were maintained by selecting sites located at least 50 meters from major roadway intersections and 16 meters from local street junctions. For design purposes, a minimum length of 18 meters and a width of 3 meters were considered desirable dimensions for each bay. While these parameters were developed in the context of Dhaka, Chattogram experiences similar transport challenges, including congestion, haphazard bus stoppages, and accident-prone intersections. Accordingly, a key research question guiding this study is whether the selected intersections in Chattogram meet these criteria, thereby justifying the need for bus bays. The findings from field surveys will be used to establish this requirement before proceeding with design and policy recommendations.

Based on the criteria, the existing conditions of the roadway are measured. Several physical surveys are performed, for instance, the moving observer survey for calculating the speed of the roadway, the manual volume count survey for traffic volume count, the physical feature survey to measure the cross-sectional elements, the users' opinion survey to depict the opinion of users, the parking inventory survey, etc. Moreover, some secondary data are collected from Chattogram Metropolitan Police Headquarters to figure out the road accident and fatality situation on the roadways. After measuring the condition of the selected roadway section, suitable locations for the provision of bus bays near each selected intersection are located using ArcGIS software. Later, the bus bay design with necessary amenities and guidelines is also provided in this study.

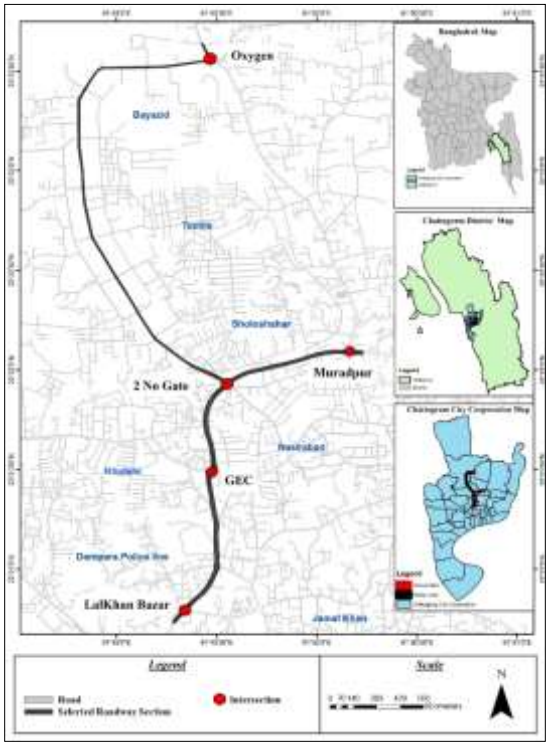

Figure 1. Study Area Map. Source: Field Survey (2022)

Outcome from Physical Feature Survey

The physical or geometric features survey is performed to measure the existing roadway features; additionally, it is required to find out the existing roadway features. The measurement of carriageways, shoulders, median, number of lanes, and availability of features such as traffic signalized systems, foot overbridges, zebra crossings, bus stops, bus bays, facilities for disabled people, etc., are included in this physical feature survey.

Table 1. Availability & Measurement of Roadway Facilities. Source: Field Survey (2022)

Elements/ Intersection	**Dimensions**	**Oxygen**	**Muradpur**	**2 No. Gate**	**GEC**	**Lalkhan Bazar**
Carriageway	Width (Feet)	20	25	27	28	34
Lane	Number	4	4	6	6	6
	Width (Feet)	10	12.5	9	9.33	11.33
Median	Width (Feet)	2	9	9	9	1.5
	Height (Feet)	1.5	1.8	1.8	1.8	3
Shoulder	Width (Feet)	Unpaved	0.75	0.8	0.8	1
Pedestrian Walkway	Width (Feet)	No	2.5	2.5	2.5	3
	Height (Feet)		1	1	1	1
Street light	Availability of services	Yes	Yes	Yes	Yes	Yes
Auxiliary Lane		No	No	No	No	No
Greenery		No	No	No	No	No
Sign & Signal		No	No	Yes	Yes	Yes
Speed Breaker		No	No	No	No	Yes

Zebra Crossing		No	No	Yes	Yes	Yes
Foot overbridge		No	Yes	No	No	No
Flyover		No	Yes	Yes	Yes	Yes
Bus Stop		Yes	Yes	Yes	Yes	Yes
Bus Bay		No	No	No	No	No
Facilities for the Disabled		No	No	No	No	No
Carriageway	Width (Feet)	20	25	27	28	34
Lane	Number	4	4	6	6	6
	Width (Feet)	10	12.5	9	9.33	11.33
Median	Width (Feet)	2	9	9	9	1.5
	Height (Feet)	1.5	1.8	1.8	1.8	3
Shoulder	Width (Feet)	Unpaved	0.75	0.8	0.8	1
Pedestrian Walkway	Width (Feet)	No	2.5	2.5	2.5	3
	Height (Feet)		1	1	1	1
Street light	Availability of services	Yes	Yes	Yes	Yes	Yes
Auxiliary Lane		No	No	No	No	No
Greenery		No	No	No	No	No
Sign & Signal		No	No	Yes	Yes	Yes
Speed Breaker		No	No	No	No	Yes
Zebra Crossing		No	No	Yes	Yes	Yes
Foot over bridge		No	Yes	No	No	No
Flyover		No	Yes	Yes	Yes	Yes
Bus Stop		Yes	Yes	Yes	Yes	Yes
Bus Bay		No	No	No	No	No
Facilities for the Disabled		No	No	No	No	No
Carriageway	Width (Feet)	20	25	27	28	34
Lane	Number	4	4	6	6	6

Figure 2. Illegal Parking and Lack of Pedestrian Walkways at Muradpur and 2 No. Gate. Source: Field Survey (2021 & 2022)

Table 1 shows that the carriageways are not wide enough to facilitate the higher volume of traffic. Again, **Figure 2** depicts that most of the roadway sections are illegally occupied by hawkers or vehicles.

Among the roads, there is no footpath at Oxygen. Moreover, the lack of greenery is also observed. There exists a flyover that covers the Muradpur to Lalkhan Bazar roadway. Though there are temporary bus stops at the intersections, no bus bay is present on the road sections.

Outcome of Users' Opinion Survey

This study adopted a stratified random sampling approach to ensure adequate representation from each of the five selected intersections. According to the standard formula for simple random sampling, achieving a 95% confidence level with a 5% margin of error would require a sample size of approximately 385 respondents. However, due to practical constraints such as limited time and resources, and considering the exploratory nature of the research, a total of 100 respondents were surveyed. The sample was distributed equally across the five intersections, with 20 respondents at each site. This allocation ensured that all intersections were proportionately represented in the dataset, which was a key objective of the analysis. Although a sample of 100 respondents results in a wider margin of error approximately ±9.8% at the 95% confidence level it remains acceptable for exploratory studies in urban planning and transport research. The primary goal of this research is to identify key trends and provide initial insights rather than to produce generalized conclusions for the entire population. In sum, the chosen sample size and methodology strike a pragmatic balance between statistical rigor and operational feasibility, allowing the collection of meaningful data that is sufficiently robust for the intended scope of the study.

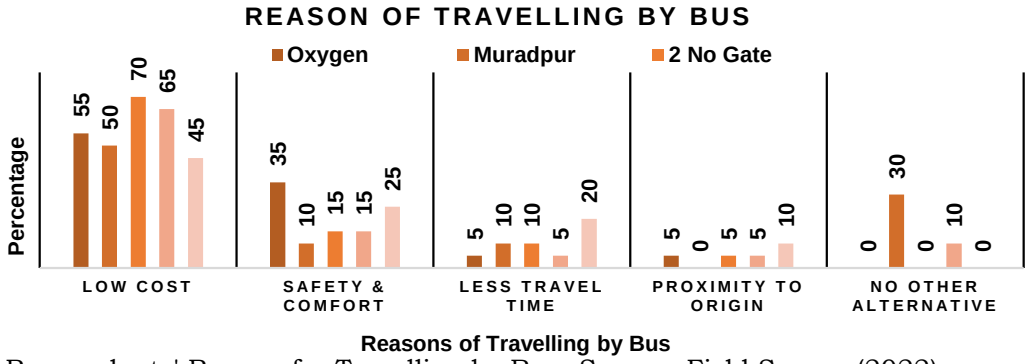

Figure 3. Respondents' Reason for Travelling by Bus. Source: Field Survey (2022)

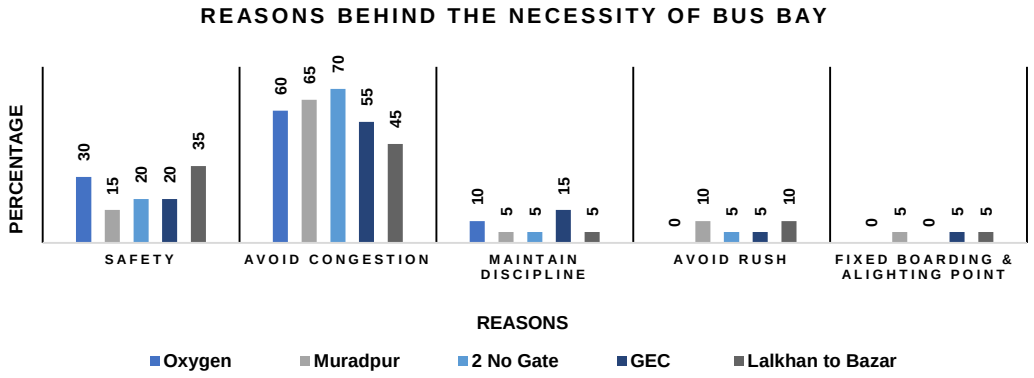

Figure 4. Necessity of Bus Bays According to Respondents. Source: Field Survey (2022)

The outcome shows that most people use the roadways for official purposes. Again, 41% of the respondents chose buses as their mode of transition. The reason for traveling by bus is the low cost of public bus services. Again, a few of them consider the safety provided by the buses shown in **Figure 3**. The necessity of bus bays in the city is presented in **Figure 4,** which shows that the priority is to avoid the unwanted traffic congestion by local buses.

Outcome from Volume Count Study

The manual volume count method is performed by taking a particular section of the selected roads, and then vehicles moving in both directions are counted at the same time. In this study, both motorized and non-motorized vehicles using the selected road sections were counted to determine roadway flow, which was then expressed in terms of Passenger Car Units (PCU). Since different vehicle types occupy road space and influence traffic flow differently, appropriate PCU conversion factors were applied. The survey considered private cars, motorcycles, auto-rickshaws, minibuses, standard buses, trucks, rickshaws, and bicycles. In line with commonly used conversion practices in Bangladesh, a private car was assigned a PCU value of 1.0, motorcycles 0.5, auto-rickshaws 0.75, minibuses 2.0, standard buses 3.0, and trucks 3.5. For non-motorized modes, rickshaws were assigned a value of 1.5 and bicycles 0.5. These values ensured a more realistic representation of heterogeneous traffic in Chattogram, allowing the flow calculation to reflect the varying impacts of different vehicle types on road capacity.

Three different times of the day are selected to count on the traffic volume. 8 am to 9 am, 11 am to 12 pm, and 5 pm to 6 pm hours are taken based on the peak and off-peak hours, and the volume count survey is performed.

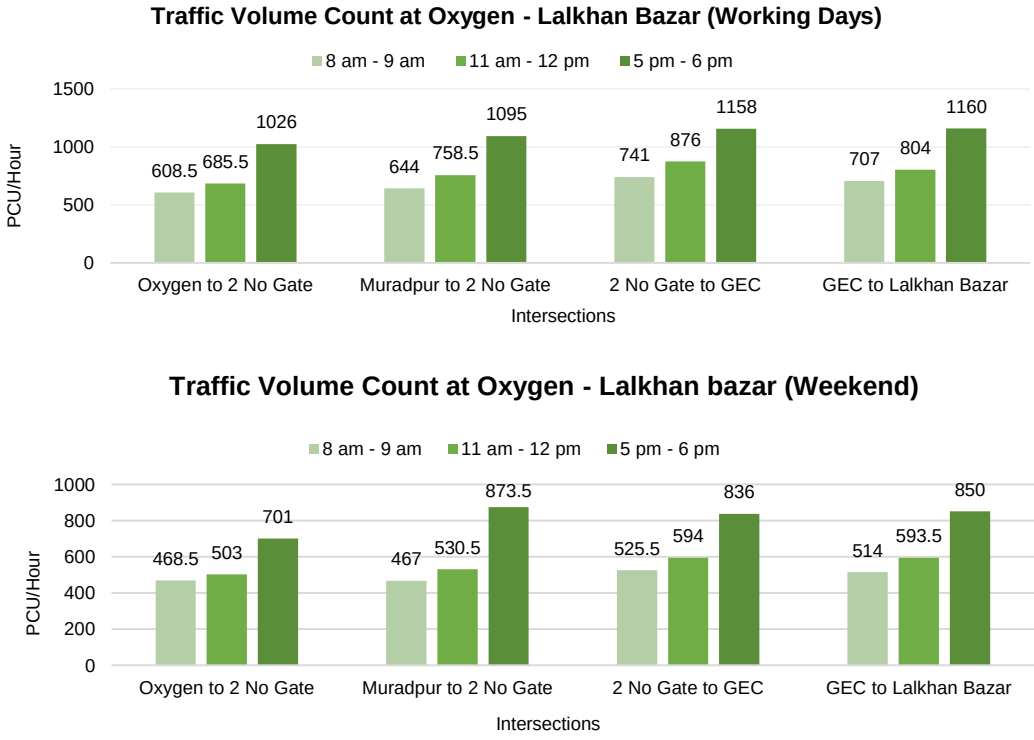

Figure 5. Traffic Volume on weekend and working Days (Oxygen to Lalkhan Bazar). Source: Field Survey (2022)

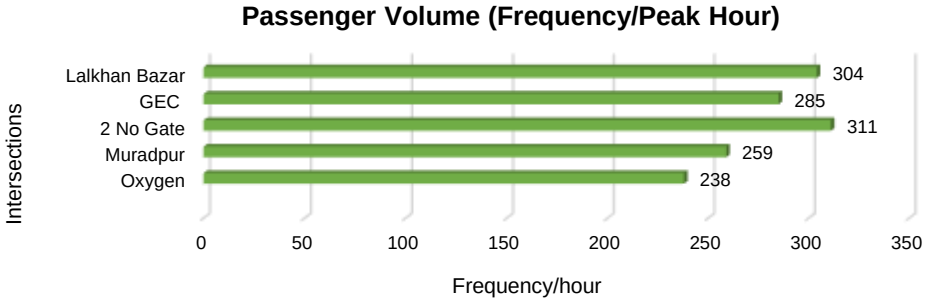

Figure 6. Passenger Volume at Different Intersections on Peak Hours (5 to 6 pm).
Source: Field Survey (2022)

Figure 5 shows that the traffic volume is higher from 5 to 6 pm on weekends. Again, Muradpur to 2 No. Gate Road section has a higher volume of traffic. But **Figure 6** depicts that the volume is found to be higher at the GEC to Lalkhan Bazar roadway section. The traffic volume is comparatively higher on working days. But the traffic flow is less in the morning hours. The passenger volume during peak hours on a working day is collected using the observation method at the selected bus stops. Most of the intersections contain a huge number of passengers at peak hours. The passenger volume is higher at the 2 No Gate intersection. During the peak hour, the volume is 311 per peak hour at that intersection, as presented in **Figure 6**.

Outcome from Speed Study & Level of Service (LOS)

The Moving Observer Method is performed during peak hours (5 pm to 6 pm) and off-peak hours (11 am to 12 pm), both on weekends and working days. The things required to fulfil the survey are journey time, stopped time/ delay, vehicles met with-in the opposing direction, overtaking vehicles, and overtaken vehicles. The speed of vehicles is higher during weekends, as shown in **Figure 7**. Moreover, the speed is near 21 KPH during the evening hours of working days, which indicates the poor condition of the roadway. Again, the level of service is defined as the level of facilities derived from a roadway under different operating characteristics and volumes of vehicles on the roadway (Kadiyali, 1999). It presents the ratio of volume and capacity of any existing roadway. If the level of service of any roadway is 1, it indicates that the volume and the capacity of vehicles in the roadway are equal; that means the roadway contains vehicles following its capacity. If the LOS>1, it indicates that the volume of vehicles is less than the capacity of the roadway.

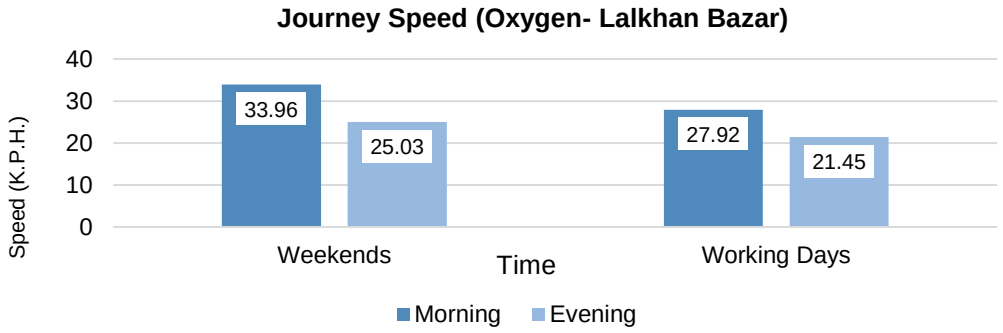

Figure 7. Journey Speed of Vehicles on Oxygen to Lalkhan Bazar Roadway.
Source: Field Survey (2022)

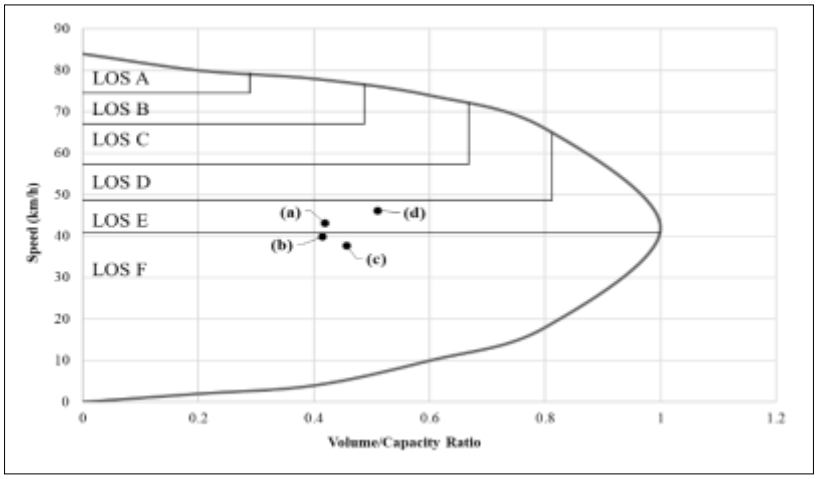

Figure 8. Level of Service (LOS) of Oxygen to Lalkhan Bazar Roadway Section.
Source: Field Survey (2022)

Figure 8 depicts the level of service of several sections of the existing roadway. In the figure, points a, b, c, and d represent Oxygen-2 No. Gate, Muradpur-2 No. Gate, 2 No. Gate-GEC and GEC-Lalkhan Bazar road sections accordingly. The speed vs Volume-to-Capacity (V/C) ratio shows that the level of service lies between 'E' and 'F'. The speed of the roadway is low, whereas the volume seems higher than its capacity. The V/C ratio remains between 0.3-0.5, which is <=1. The volume of vehicles exceeds the actual capacity of the roadways. Hence, the condition depicts the poor and ineffective condition of the selected roadways.

Eligibility for Bus Bay Provision

According to the factors selected for the provision of bus bays for this study, the outcome from several surveys shows that the selected road sections are eligible for the bus-bay provision shown in **Table 2**.

Table 2. Major Outcome According to the Bus Bay Provision Criteria.

Criteria	***Selected Roadway Sections***				
	Oxygen	***Muradpur***	***2 No. Gate***	***GEC***	***Lalkhan Bazar***
Traffic Volume (PCU/hr.)	1026	1014	1095	1158	1160
Passenger Volume (frequency/hr.)	80.67	102	123	116.67	110.67
Bus Volume (PCU/hr.)	186	312	342	336	348
Speed (km/hr)	23.31	21.93	18.401	19.27	20.18
LOS	'E'	'F'	'F'	'F'	'E'
Roadway Features	Insufficient Carriageway; No foot overbridge; No footpath; No bus bay; Lack of signs & signals	Insufficient Carriageway; No zebra-crossing; No bus bay; Lack of signs & signals	Insufficient Carriageway; No foot overbridge; poor pedestrian facilities; No bus bay; Lack of greenery	Insufficient Carriageway; No foot overbridge; poor pedestrian facilities; No bus bay; Lack of greenery	No foot overbridge; No footpath; No bus bay; Lack of greenery; No facilities for the disabled
Bus Bay Criteria Fulfillment	***Yes***	***Yes***	***Yes***	***Yes***	***Yes***

Source: Field Survey (2022)

Selection of Suitable Bus Bay Locations

For the provision of a bus bay at suitable locations, the five major intersections are selected using the shapefile of Chattogram City Corporation. The five selected intersections are Oxygen, Muradpur, 2 No Gate, GEC, and Lalkhan Bazar. According to the Chittagong Strategic Urban Transport Master Plan (2018), there should be no stopping or parking of vehicles within 50m of the intersection. So, the suitable location needs to be at least 50m distant from the major intersection and 16m distant from the local street intersections. The Geographic Information System (GIS) tool is used to identify suitable locations for the provision of bus bays at the selected intersections. Several tools, like the buffer tool,

erase tool, and the multiple to single part tool, are used to figure out the best-suited bus bay locations shown in **Figure 9**. Firstly, the intersections are marked using the continuous line in the shapefile of CCC. Then, a 50-meter buffer is created from each major intersection. The buffer zone is created using the buffer tool. It provides the minimum area that is prohibited from establishing any bus bay. Using the erase tool from the overlay tool, the buffer area was eliminated from the continuous lines. A suitable location is selected after the buffer zone is marked, considering the availability of spaces for the provision of a bus bay.

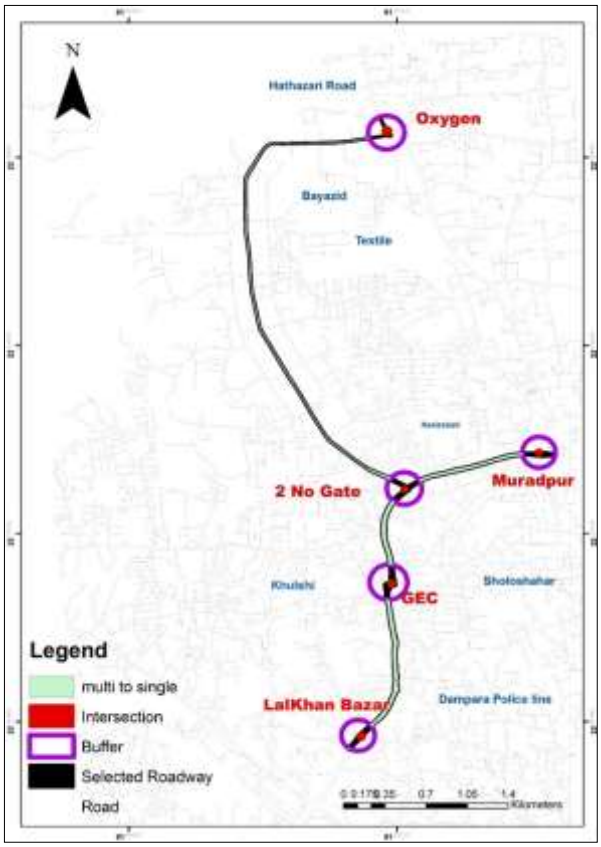

Figure 9. A buffer of 50 m at each selected intersection using ArcGIS. Source: Field Survey (2022)

The bus bays are provided at the five selected intersections, considering the bus bay provision criteria. Among all the intersections, suitable bus bay locations along with bus bay design for the Oxygen intersection are shown in **Figure 10**. As there exist two major intersections at Oxygen, a buffer of 50 meters is taken from both intersections. The two bus bays are located considering the available spaces outside the 50m buffer zone. One of the bus bays will facilitate the buses traveling from Muradpur and Kuwaish roads, and another one will serve the buses coming from 2 No. Gate Road section. The locations are marked for the other four selected intersections for the bus bays in a similar manner. The bus bay design with necessary amenities is also depicted in **Figure 11**. According to the bus bay provision criteria, the bus bay will be 18m in length and 3m in width. A footpath of 1m width is considered along with the bus bay to ensure pedestrian facilities. Moreover, there will be a shelter for the ease of the consumers. The bus bay will not create any hindrance to the carriageway of roads and the pedestrian facilities. The bus bay design will be similar for Muradpur, 2 No. Gate, GEC, and Lalkhan Bazar roadway section as well **(Figure 12)**.

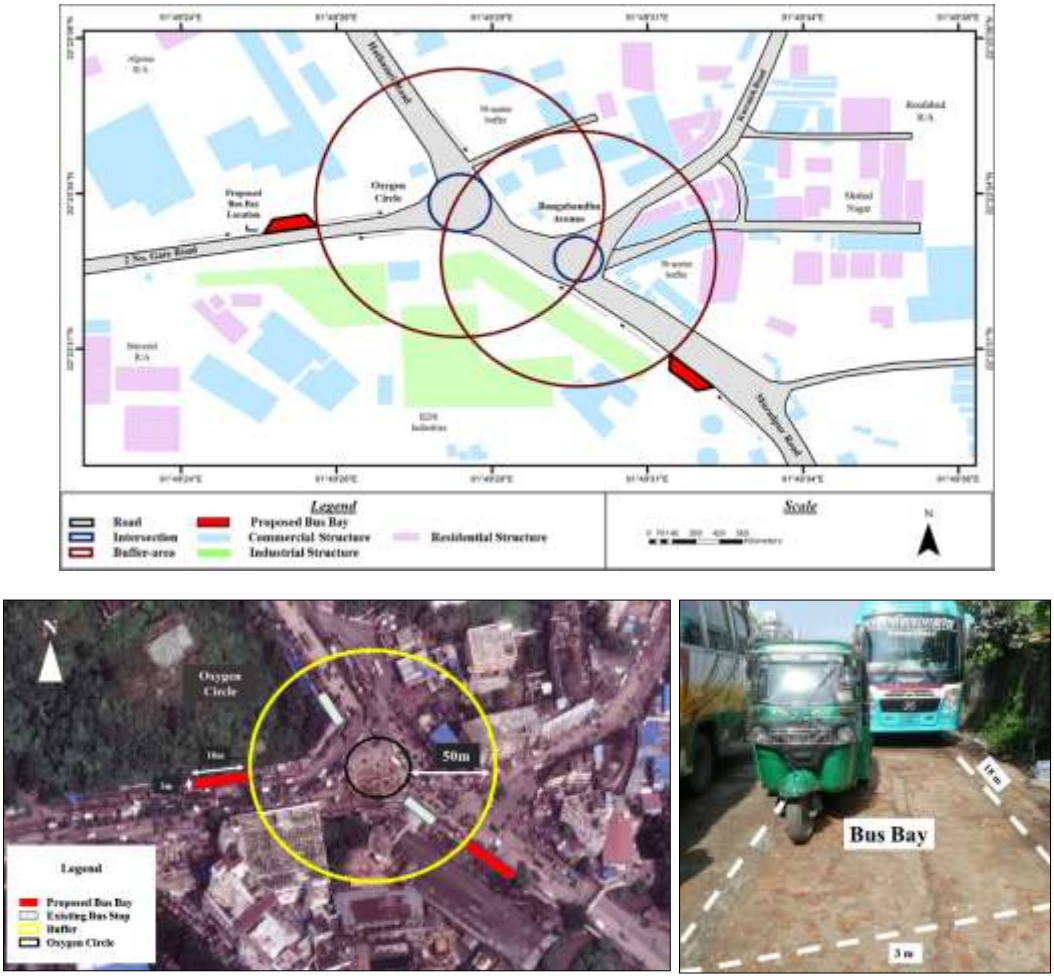

Figure 10. Probable suitable bus bay location at Oxygen. Source: Field Survey (2022)

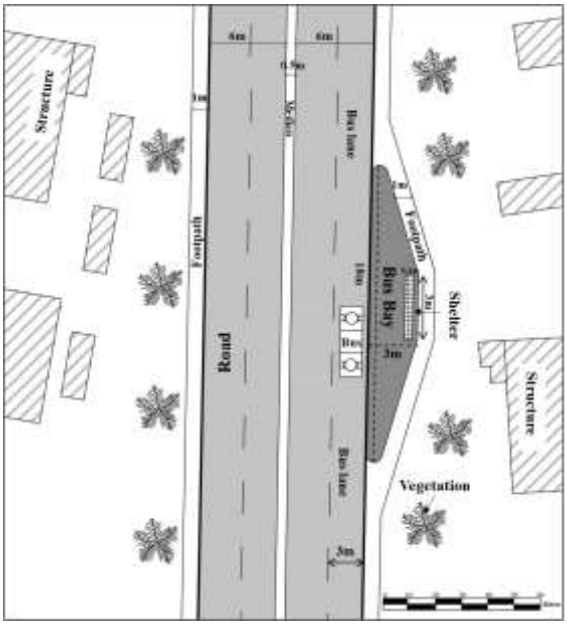

Figure 11. Bus Bay Design with Guidelines at Oxygen Roadway Section.
Source: Field Survey (2022)

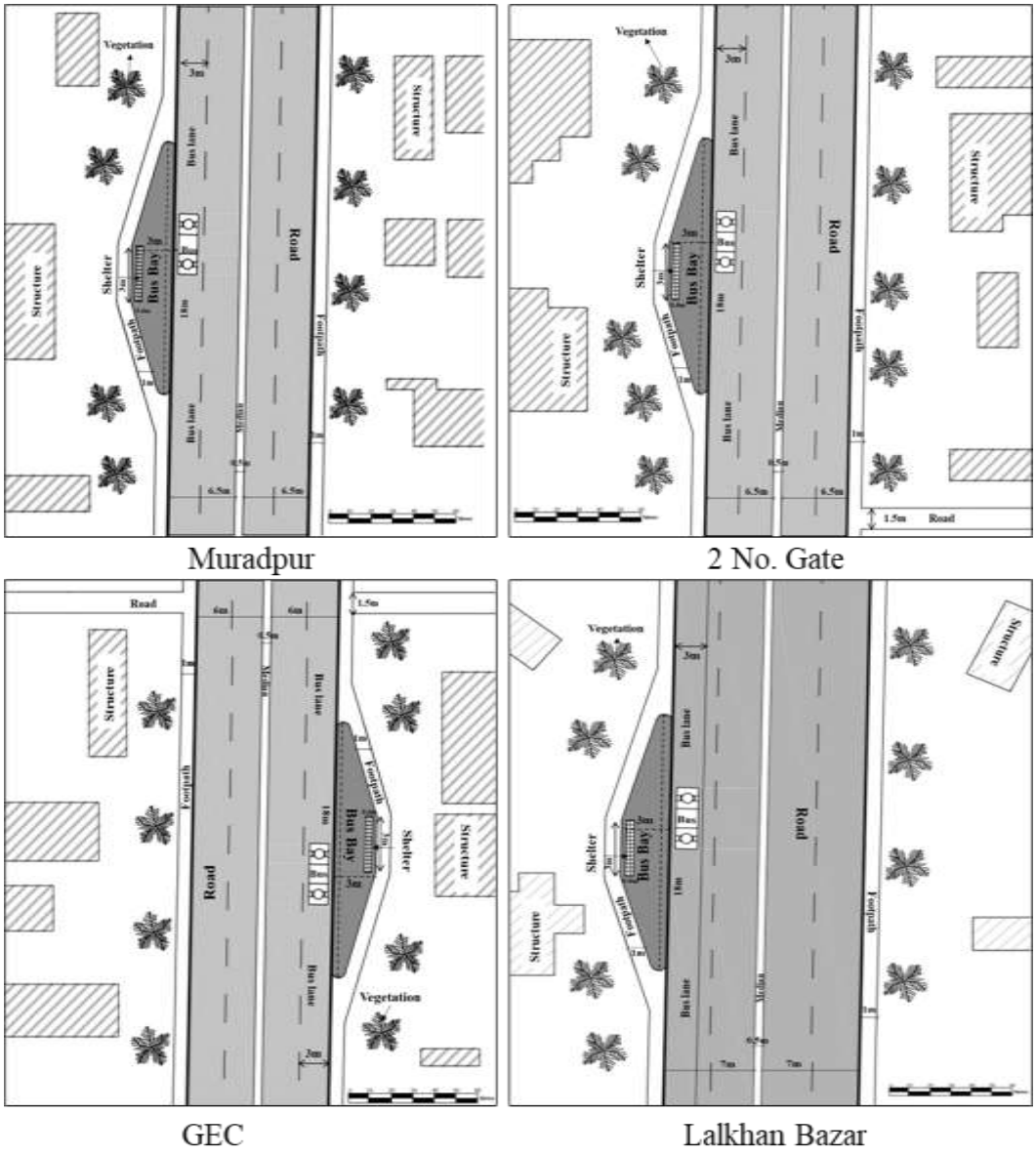

Figure 12. Bus Bay Design with Guidelines for Other Roadway Sections.
Source: Field Survey (2022)

To ensure the effective implementation of the proposed bus bay system, it is important to recognize the roles and responsibilities of different stakeholders. The primary implementing authority would be the Chattogram City Corporation in collaboration with the Bangladesh Road Transport Authority (BRTA) and the Roads and Highways Department (RHD), who are responsible for urban infrastructure planning, regulation, and enforcement. Bus service providers, particularly private operators, would benefit from the scheme through reduced delays during passenger boarding and alighting, which translates into improved schedule reliability and operational efficiency. Organizations that provide buses for employees could be incentivized through subsidies or tax benefits, thereby encouraging greater reliance on mass transport and reducing the use of private cars. Passengers would benefit from safer and more organized boarding facilities, while the general public would experience reduced congestion and improved traffic flow.

At the same time, the design and construction of bus bays carry both environmental and social risks. Land acquisition or roadway widening may displace informal vendors and pedestrians, while construction activities could temporarily worsen congestion and increase air and noise pollution. These risks can be minimized through careful site selection, prioritizing areas with sufficient right-of-

way to avoid displacement, and by enforcing regulations against illegal occupation of sidewalks by shops and hawkers. Environmental impacts can be mitigated by adopting sustainable construction practices and scheduling work during off-peak hours to reduce disruptions. Integrating pedestrian facilities such as continuous sidewalks and safe crosswalks within the design would further ensure that the system improves mobility equitably. Thus, while challenges remain, coordinated planning, stakeholder engagement, and proactive risk management strategies can significantly increase the feasibility of the proposed bus bay system in Chattogram.

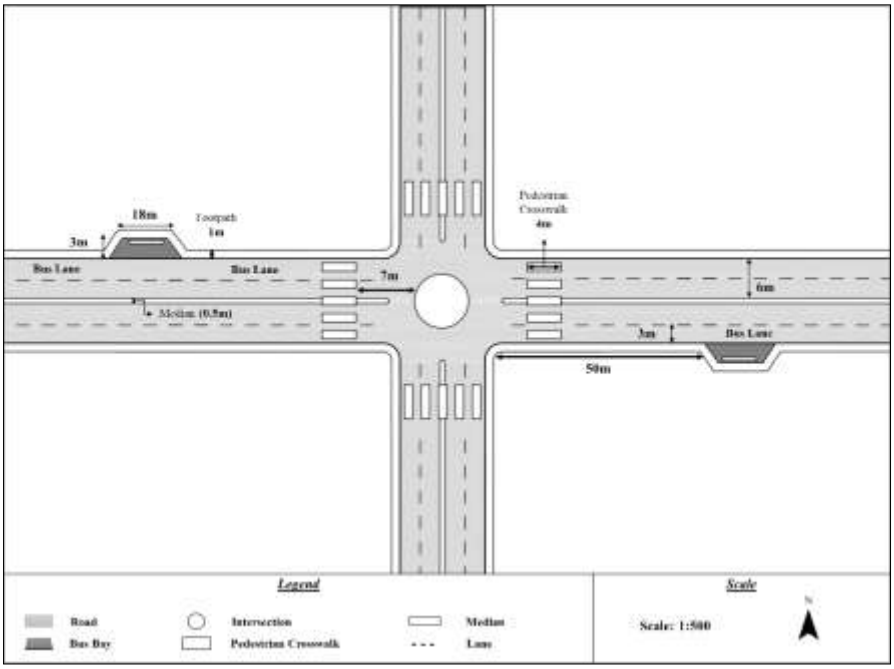

Figure 13. Recommended Facilities for Roadway with Dimensions. Source: Field Survey (2022)

According to the road design manual (RHD, 2000), there is a provision for pedestrian crossing near the busiest intersections of the city. The pedestrian crossings will be around 7 meters away from the centre island. The width of the crossing will be 4-meter approximately. Again, there will be traffic signals for ensuring the safer movement of pedestrians, as shown in **Figure 13**. Moreover, all the pedestrian facilities need to be emphasized to enhance the sustainability of the roadways. Last but not least, the provision of the bus bay can be assured, but the proper maintenance, control, use, and management are mandatory to get better output from the bus bays.

Conclusion

Identification of suitable bus bay locations will assist in reducing unwanted traffic congestion in Chattogram city. The study is performed on one of the major roadway sections with five major intersections in the city. Two significant objectives are set to achieve the goal of the study. There are several criteria to ensure the provision of bus bays at different locations in the city. The first objective is to verify whether the roadways are suitable for the establishment of bus bays. So, the existing roadway conditions are determined by performing some necessary surveys. Several physical surveys are performed, for instance, the moving observer survey for calculating the speed of the roadway, the manual volume count survey for traffic volume count, the physical feature survey to measure the cross-sectional elements, the users' opinion survey to depict the opinion of users or stakeholders, the parking inventory survey, etc. According to the bus bay selection criteria, the study identifies suitable sites for the provision of a bus bay. Moreover, bus bay design and amenities, and necessary recommendations are required to fulfil the objective. According to the bus bay design criteria, a minimum distance of 50 meters from the major roadway intersections needs to be maintained. Moreover, around 18 m in length and a minimum of 3 m in width is considerable for the bus bay. The study depicts the bus bays at suitable locations on the selected roadways of Chattogram. Again, necessary amenities like a bus shelter, pedestrian facilities, etc., are also taken into consideration

while creating the design of the bus bays. Bus bay is a significant part of the modern transportation system. As the city doesn't have any proper bus bay on the roads, the provision of bus bays will ensure sustainability in the transport system of Chattogram city.

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