International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

Analysis of Bus-Stops and Lay-Bys Level of Service along Oshodi - Abeokuta Express Road, Lagos, Nigeria

Olorunnimbe R.O[1], Oni S. I.[2], Ege, E.[3], Giwa, O. M.[4]

Department of Geography, University of Lagos, Akoka, Yaba
School of Transport, Lagos State University, Ojo.

Abstract: ***This study had undertaken an assessment of the level of services of bus-stops and lay-bys along Oshodi–Abeokuta Expressway, Lagos metropolis. Five objectives were formulated to actualize the aim of this study and these are to: identify available bus-stops and lay bys; examine the physical characteristics of bus stop and layby infrastructure; identify the factors responsible for the observed traffic characteristics; measure the bus inflow, outflow, dwell time and queue parameters ;and determine the level of service of major bus stops and laybys in the study area. More importantly, primary and secondary data were used. The primary data includes; Traffic count, field measurement and Personal field observation while the secondary data include information gotten from journals and other literatures. The study identified 32 bus-stops from Oshodi – Sango. In general, 8 different infrastructures were identified showing their condition and availability in each bus-stops. Further findings show that the road has 3 lanes on both sides of the highway. It was also observed that six major bus-stops constitute the challenging locations for traffic flow and bus operations out of the eleven identified between Oshodi – Iyana Ipaja. In the findings, it was also discovered that the major bus-stops are always congested during the morning peak period while they caused travel time delays travel and low traffic flow. This study concluded that the bus-stops and lay-bys have significant effects on buses' services, passenger boarding and alighting at each bus-stop so as to ease the flow of traffic and thereby reducing travel time. This study therefore recommends that the government should increase the capacity of bus-stops in the study area so as to reduce delay at bus-stop and encourage free traffic flow along the study area among others.***

Keywords: Traffic congestion, Bus-Stop/Lay- By, level of service, Traffic Flow, bus dwell time

1. Background of Study

Transportation infrastructures are powerful determinants of the economic and social wellbeing of all cities, towns and communities (Nworji & Oluwalaiye, 2012; Gbadamoshi & Ibrahim, 2013; Ali, Barra, Berg, Damania, Nash, & Russ, 2014). Ogwude (2016) defines transport infrastructure as features such as overhead bridges, pedestrian footbridges, lay-bys, bus-stops, motor-parks and other structures that enhance traffic flow and bus operations. Bus-stop is an integral component of the transport infrastructure; it plays a crucial role in the management of traffic and congestion (Allison, 2002). However, illegal parking and abandoned motors at bus stops (Rodrigo and Tyler, 2004) as well as the un-spacious nature of bus-stops in Nigeria are the challenges that make the usage of bus stops ineffective and this hinders the flow of traffic along them. These challenges are more prevalent within the city of Lagos (Olaogbebikan, kpechukwu, Akinsulire and Okoko, 2013).

There are cases of double parking in Lagos cities bus-stops and lay-bys thereby causing traffic congestion. This is due to the non-availability of off-street parking facilities along the transportation routes coupled with inadequate traffic management. Lagos like other known cities of the world is not only congested but also has the problems associated with urban congestions such as road traffic and absence of spacious parking space including inadequate bus-stops facilities. Rapid growth of the private vehicle fleet, combined with reliance on mini buses for commercial vehicles, private car owners and motorcycles (as documented by Lagos State central Office of Statistics, 2006; Odeleye and Oni, 2007; Osoba, 2012; Olaogbebikan, kpechukwu, Akinsulire and Okoko 2013; and Ogwude, 2016) gives poor quality public transport that usually resulted in extreme traffic congestion throughout the city. Lagos Abeokuta Expressway, the study area, is a good example of road highway experiencing the above challenges.

The location and spacing of bus stops is one of the most important elements of the transit service planning process. Both the budgetary resources of the transit provider and the travel times of passengers are affected by the spacing of stops. The trade-offs involved in deciding on stop spacing may appear to be straightforward (i.e., minimizing the transit provider's operating costs versus maximizing passengers' access to service) but the reality is more complex (Dueker et.al., 2004; Tyler, 2004; Matisziw et. al., 2006).

The determination of the appropriate spacing between bus stops involves trade-offs between the convenience of passengers using a bus-stop, and those passengers already aboard a bus who are delayed each time at a bus stop (Kittleson, Associates, Tiker and Klose 2003). The bus stop provides a service to the buses that takes a certain amount of time. As the number of buses attempting to use the bus-stop within a given time period increases, a queue will form. The problem of bus stops and lay-bys capacities is usually intense during the peak hours of the day as the number of buses able to enter the bus stop and lay-bys area in a given time period increases astronomically as the frequency of service increases (Furth & Rahbee, 2000; Saka, 2001; Huan & Robert, 2008)

However, unlike many queuing problems, the service time at the bus stop is also a function of the frequency, because this affects the amount of passengers at the platform and so the time spent by the bus at a bus stop. Besides, the service time also depends on the arrival of passengers at the bus stop. This generates a concurrent queuing problem in which the service time is a function of both the arrival pattern of buses and passengers (Dueker et.al., 2004; Matisziw et. al., 2006; Khoo, 2013).

Traffic control is another major contributor to stick of buses in the bus stop and lay-bys that is traffic control determine how buses leave the bus stop. Traffic signals may constrain the number of buses that can leave (or enter) a stop during a given period of time. If a bus is ready to leave a stop, but a red traffic signal prevents it from doing so, the bus will occupy the stop longer, and the bus stop capacity will be lower as a result of the traffic signal or control.

Bus stop provides service to the buses to be able to fulfill their operational requirement. However, observation has revealed that bus-stop and lay-bys facilities along the study area are inadequate and where they are available cannot take more than 3 or 4 buses. The road transport action is a circulatory structure process and any breach at any point along the line will definitely affect the whole structure and delay its effectiveness. Therefore, location and spacing of bus stop and lay-bys facilities are essential in order to allowed free flow of traffic. Since, location and spacing of bus stops and parking challenges are no longer confined to the city centres, the challenges now extend throughout the urban region in Lagos State.

This existing situation raise some fundamental questions such as: does the presence or absence of bus stop/layby facilities affect traffic flow and bus operation in the study area?, Are the capacities of bus stops and lay-bys along the study area adequate to support the services of commercial buses?, what factor(s) is responsible for the chaotic traffic situation at bus stops and lay-bys facilities along the study area?; how do these factors affect bus stop and layby level of service in the study area?.

This study therefore intends to analyze the level of services of bus stops and lay-bys along Lagos-Abeokuta road, Lagos Metropolis, Nigeria. To achieve the above aim, the study objectives are to: identify available bus-stops and lay bys in the study area; examine the physical characteristics of bus stop and layby infrastructures in the study area; identify the factors responsible for the observed traffic characteristics in the study area; measure the bus inflow, outflow, dwell time and queue parameters in the study area; and determine the level of service of major bus stops and laybys in the study area.

2. Study Area

The study area Lagos-Abeokuta express road is located within the Lagos metropolis. Metropolitan Lagos is located at the centre of Lagos State. Lagos State is one of the smallest of the 36 states in Nigeria, located on south-western corner along the narrow elongated coastal flood plain spanning the Guinea coast of the Atlantic Ocean for over 180km, from the Republic of Benin on the west to its boundary with Ogun State in the east. Lagos State lies between latitude 6º2’ to 6º4’ North; and on longitude 2º45’ to 4º20’ East. It occupies a total geographical area of about 3,475.1km^2 . Lagos Metropolis is made up of sixteen local government areas that are located at the central part of Lagos State (Fig. 1.0). It is home to 85% of the State’s population (Lagos bureau of statistics, 2014) with 21,883,043 in 2013.

The road stretched between Sango overhead bridge to intersect with Agege motor road to Oshodi overhead bridge. The road has about 32 bus stops/laybys with major ones comprising of Oshodi, Shogunle-Ladipo, PWD, Ikeja along, Mongoro, Cement, Iyana-Dopemu,Pako, Iyana-Ipaja, Pleasure, super, Abule-Egba, U-turn, Ijaiye, Alakuko, Kola, toll-gate, and Sango bus stops. Lagos – Abeokuta highway is one of the major arterial roads in Lagos State that has over the years served as a strategic growth pole in the socio-economic landscape of the State. This road not only provides high-capacity urban travel, but has also been an access to subsisting towns and settlements in the Sango axis (Figure 1.0). These towns and settlements along this axis harbor workers that transit between Lagos State and Ogun State on daily basis. The importance of this road cannot be over-emphasized which makes its regular maintenance a priority in the various Development Plans of the State (LMOT, 2016).

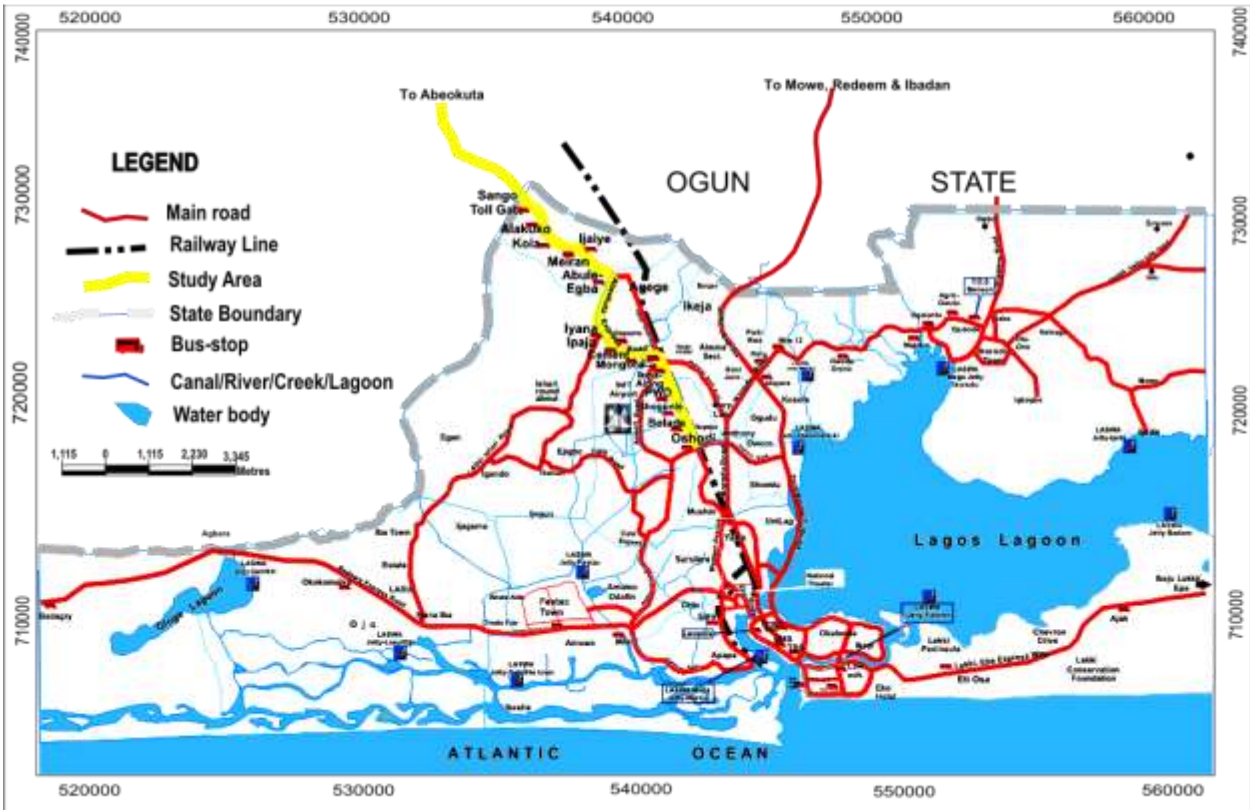

Figure 1.0: Metropolitan Lagos Showing the Study Area and Other Road Highway.
Source: Modified from LMATA, 2011.

3. Research Methods

This research is a survey research which utilizes both qualitative and quantitative research approaches. Data were sourced from both primary and secondary sources in order to identify gap in research and acquire the necessary data for research analysis. Furthermore, the study utilized the combination of purposeful, systematic and stratified random sampling techniques. These techniques were adopted to determine the areas of traffic strength and weakness to be measured along the studied corridor, and to determine the bus stops with sufficient demand and traffic challenges that meet the purpose of the study and for field measurement. Therefore bus stop/lay with low traffic and without substantial demand and bus berthing were not used as they do not meet the purpose of the study.

From the 32 bus stops/laybys identified in the study area, 11 of them were actually feasible for measurement and assessment. This was due to the complete failure of road traffic and the unpredictable delays of vehicles caused by the overhead bridge construction along the Abule-Egba section of the highway. Therefore, the remaining 22 that were located after Iyan-Ipaja were not assessed because of the long queue and overwhelming road density resulting from the construction zone. However, six major bus stops out of the 11 feasible were selected for examination based on the high level of traffic activities and bottleneck observed at their locations and the fact that the ongoing highway overhead bridge at Abule-Egba junction significantly breakdown traffic immediately after Iyana-Ipaja Bus stop, thereby preventing the assessment of bus stop and laybys along this section of the road.

At each of the bus stop/layby, measurement of traffic volume, length of berthing area, capacity of infrastructure, queue length, dwell time and level of services were measured. As part of the objectives of this study which is to evaluate the effectiveness of bus stop infrastructures in enhancing traffic flow, a queue model of vehicular traffic assessment was used to determine the effectiveness and the efficiency of bus stops in serving the buses arriving at the facility.

The required data were collected using instrument such as traffic data sheet, bus stop inventory sheet, stop watch, photographic camera and linen measuring tape. Twelve field assistance were used with two each stationed at each of the bus stops/lays under study. Traffic event such as bus dwell time, arrival rate, length of queue, departure time, boarding time and alighting time were measured in seconds of time and were documented. The data collected from the field through measurement of bus-stop traffic characteristic and observation of queuing events at the bus stops area are presented in the results. Computation of parameters used to determine the behaviour of traffic was done using the M/M/I queuing model which is also presented in the results.

4. Results and Discussions of Findings

Analysis of Bus Stop/Layby Distribution in the Study Area

The distribution of road infrastructures in the study area reflects a general availability of bus stop/layby, dual road carriage way and drainage facilities across the study area. however, much of the road infrastructures such as bus stop shelter, walkway, road kerb, pedestrian bridge, and layby are not evenly distributed across the study area. The implication of this is that certain section of the road studied may function more efficiently than the other sections in terms of traffic enhancement and bus stop efficiency. Table 1 shows that there are 32 identified bus-stops along Oshodi to Sango traffic corridor. In general, 8 different infrastructures were identified in the study area and their availability shown in the table. The availability in respect to both ways of the highway, that is, To and Fro movement from Oshodi to Sango and from Sango to Oshodi was also shown.

Table 1: Available Infrastructure in the Study Area

		Bus Stop		Bus Stop Shelter		Lay-Bye		Walk Way		Road Carriage Lanes		KERB	Pedestrian Bridge	Drainage
S/N	Location	To	Fro	To	Fro	To	Fro	To	Fro	To	Fro			
1.	Oshodi	Avail	Avail	Avail	Avail	Avail	Avail	Not-A	Not-A	3	3	Avail	Avail	Avail
2.	Bolade	Avail	Avail	Avail	Avail	Avail	Avail	Not-A	Not-A	3	3	Avail	Not-A	Avail
3.	Ladipo	Avail	Avail	Avail	Not-A	Avail	Avail	Avail	Avail	3	3	Avail	Not-A	Avail
4.	Shogunle	Avail	Avail	Avail	Avail	Avail	Avail	Avail	Avail	3	3	Avail	Not-A	Avail
5.	Pwd	Avail	Avail	Avail	Avail	Avail	Avail	Avail	Avail	3	3	Avail	Not-A	Avail
6.	Airport	Avail	Avail	Not-A	Not-A	Avail	Avail	Not-A	Not-A	3	3	Avail	Not-A	Avail
7.	Ikeja Along	Avail	Avail	Avail	Avail	Avail	Avail	Avail	Avail	3	3	Avail	Avail	Avail
8.	Mangoro	Avail	Avail	-	Not-A	Not-A	Not-A	Not-A	Not-A	3	3	Not-A	Not-A	Avail
9.	Cement	Avail	Avail	Avail	Avail	Avail	Avail	Avail	Avail	3	3	Not-A	Not-A	Avail
10.	Dopemu Under Bridge	Avail	Avail	Avail	Avail	Avail	Avail	Avail	Avail	3	3	Not-A	Not-A	Avail
11.	Pako	Avail	Avail	Not-A	Not-A	Not-A	N-Ava	Not-A	Not-A	3	3	Not-A	Not-A	Avail
12.	Iyana Ipaja	Avail	Avail	Avail	Avail	Avail	Avail	Not-A	Not-A	3	3	Not-A	Not-A	Avail
13.	Pleasure	Avail	Avail	Not-A	Not-A	Avail	Avail	Not-A	Not-A	3	3	Not-A	Not-A	Avail
14.	Oke-Odo	Avail	Avail	Not-A	Not-A	Avail	Avail	Not-A	Not-A	3	3	Not-A	Avail	Avail
15.	Cele	Avail	Avail	Not-A	Not-A	N-Ava	N-Ava	Not-A	Not-A	3	3	Not-A	Not-A	Avail
16.	Super	Avail	Avail	Not-A	Not-A	Avail	N-Ava	Not-A	Not-A	3	3	Not-A	Not-A	Avail
17.	Abule Egba	Avail	Avail	Not-A	Not-A	Avail	N-Ava	Not-A	Not-A	3	3	Not-A	Not-A	Avail
18.	U Turn	Avail	Avail	Not-A	Not-A	Not-A	Not-A	Not-A	Not-A	3	3	Not-A	Not-A	Avail
19.	Abule Taylor	Avail	Avail	Not-A	Not-A	Not-A	Not-A	Not-A	Not-A	3	3	Not-A	Not-A	Avail
20.	General	Avail	Avail	Not-A	Not-A	Not-A	Not-A	Not-A	Not-A	3	3	Not-A	Avail	Avail
21.	Amadiya	Avail	Avail	Not-A	Not-A	Not-A	Not-A	Not-A	Not-A	3	3	Not-A	Not-A	Avail
22.	Ijaiye	Avail	Avail	Not-A	Not-A	Avail	Avail	Not-A	Not-A	3	3	Not-A	Not-A	Avail
23.	Iyana/Meran	Avail	Avail	Not-A	Not-A	Avail	Not-A	Not-A	Not-A	3	3	Not-A	Not-A	Avail
24.	Adura	Avail	Avail	Not-A	Not-A	Avail	Not-A	Not-A	Not-A	3	3	Not-A	Not-A	Avail
25.	Kola	Avail	Avail	Not-A	Not-A	Avail	Not-A	Not-A	Not-A	3	3	Not-A	Not-A	Avail
26.	Moshalashi	Avail	Avail	Not-A	Not-A	Avail	Not-A	Not-A	Not-A	3	3	Not-A	Not-A	Avail
27.	Alakuko	Avail	Avail	Avail	Not-A	Avail	Avail	Avail	Avail	3	3	Not-A	Not-A	Avail
28.	Ajegunle	Avail	Avail	Not-A	Not-A	Not-A	Not-A	Not-A	Not-A	3	3	Not-A	Not-A	Avail
29.	Toll Gate	Avail	Avail	Not-A	Not-A	Not-A	Not-A	Not-A	Not-A	3	3	Not-A	Not-A	Avail
30.	Gate Way	Avail	Avail	Not-A	Not-A	Avail	Avail	Not-A	Not-A	3	3	Not-A	Not-A	Avail
31.	Delemo	Avail	Avail	Not-A	Not-A	Avail	Avail	Not-A	Not-A	3	3	Not-A	Not-A	Avail
32	Sango	Avail	Avail	Not-A	Not-A	Not-A	Not-A	Not-A	Not-A	3	3	Not-A	Not-A	Avail

Key: Avail= Available, Not-A= Not Available
Source: Author's field survey, March, 2017

Analysis of the Physical Characteristics of Bus Stops/Laybys in the Study Area

The condition of the bus stops in the study area revealed that bus stop platforms are in good (functioning) condition although many of them do not have lay-bys to allow for off-road parking and therefore constitute hindrances to free flow of traffic. Also, walkway and bus shelter are absent in many of the bus stops and laybys in the study area so also is the pedestrian and overhead bridges as shown in table 2.

Table 2: Condition of the Available Bus Stops/Laybys Infrastructure in the Study Area

		Bus Stop		Bus Stop Shelter		Lay-Bye		Walk Way		Road Carriage Lanes Condition		KERB	Pedestrian Bridge	Drainage
S/N	**Location**	**To**	**Fro**	**To**	**Fro**	**To**	**Fro**	**To**	**Fro**	**To**	**Fro**			
1.	Oshodi	Good	Good	Good	Good	Good	Good	-	-	Good	Bad	Good	Good	Good
2.	Bolade	Good	Good	Bad	Bad	Good	Good	-	-	Good	Good	Good	-	Good
3.	Ladipo	Good	Good	Bad	-	Good	Good	Good	-	Good	Good	Good	-	Good
4.	Shogunle	Good	Good	Good	Bad	Good	Good	Good	-	Good	Good	Good	-	Good
5.	Pwd	Good	Good	Good	Bad	Good	Good	Good	-	Good	Good	Good	-	Good
6.	Airport	Good	Good	-	-	Good	Good	-	-	Good	Good	Good	-	Good
7.	Ikeja Along	Good	Good	Good	Bad	Good	Good	Good	Good	Good	Good	Good	Good	Good
8.	Mangoro	Good	Good	-	-	-	-	-	-	Good	Good	-	-	Good
9.	Cement	Good	Good	Good	Bad	Good	Good	-	-	Good	Good	-	-	Good
10.	Dopemu Under Bridge	Good	Good	Good	Bad	Good	Good	-	-	Good	Good	-	-	Good
11.	Pako	Good	Bad	-	-	-	-	-	-	Good	Bad	-		

12.	Iyana Ipaja	Good	Good	Good	Bad	Good	Good	-	-	Good	Bad	-	-	Bad
13.	Pleasure	Good	Good	-	-	Good	Good	-	-	Good	Good	-	-	Bad
14.	Oke-Odo	Good	Good	-	-	Good	Bad	-	-	Good	Good	-	Good	Bad
15.	Cele	Good	Good	-	-	-	-	-	-	Bad	Bad	-	-	Good
16.	Super	Bad	Bad	-	-	Bad	-	-	-	Bad	Bad	-	-	Good
17.	Abule Egba	U.C	U.C	-	-	U.C	-	-	-	U.C	U.C	U.C	-	Bad
18.	U Turn	Bad	Bad	-	-	-	-	-	-	Good	Good	-	-	Good
19.	Abule Taylor	Good	Good	-	-	-	-	-	-	Bad	Bad	-	-	Bad
20.	General	Good	Good	-	-	-	-	-	-	Good	Good	-	Good	Good
21.	Amadiya	Good	Good	-	-	-	-	-	-	Good	Good	-	-	Good
22.	Ijaiye	Good	Good	-	-	Good	Good	-	-	Good	Good	-	-	Good
23.	Iyana/Meran	Good	Good	-	-	Bad	-	-	-	Bad	Bad	-	-	Good
24.	Adura	Good	Good	-	-	Good	-	-	-	Bad	Bad	-	-	Good
25.	Kola	Good	Good	-	-	Good	-	-	-	Bad	Bad	-	-	Good
26.	Moshalashi	Good	Good	-	-	Good	-	-	-	Good	Bad	-	-	Good
27.	Alakuko	Good	Good	Bad	-	Good	Good	Good	Good	Bad	Good	-	-	Good
28.	Ajegunle	Good	Good	-	-	-	-	-	-	Good	Good	-	-	Good
29.	Toll Gate	Good	Good	-	-	-	-	-	-	Bad	Bad	-	-	Bad
30.	Gate Way	Good	Good	-	-	Good	Good	-	-	Good	Good	-	-	Bad
31.	Delemo	Good	Good	-	-	Good	Good	-	-	Good	Good	Good	-	Bad
32	Sango	Good	Good	-	-	-	-	-	-	Bad	Bad	Good	-	Good

U.C.: Under Construction, - : not available
Source: Author's field survey, March, 2017

The condition of road drainages across many bus stops in the study area is good except that 24% of them are bad (not functioning or are not wide enough) and cannot accommodate the flood water during heavy storm leading to over flowing of water on the roads and resulting to traffic congestion due to reduced traffic speed and vehicle breakdown. This problem occurs most often in the rainy season as found from the field.

As at the time of survey, the pedestrian bridges available in the study area are located at Oshodi, Ikeja Along, Oke-Odo and General bus stops respectively. They are also in good condition. Whereas, at the Abule Egba, Dopemu and Cement bus stops, the pedestrian bridges are all under construction and their status cannot be measured until after their completion. This means that there is a high tendency for pedestrian-vehicle conflict that could result to traffic breakdown or reduced traffic speed at these locations.

Apart from the influence of the roadway condition on the bus stop/layby functions, the size and capacity of the bus stops/laybys also significantly affect the efficiency and effectiveness of the bus stop/layby facilities in the study area.

Table 3: Capacity and Size of Major Bus Stops/Lay-Bays in the Study Area.

	Bus Stop	Lay-by Size (Metres)		Lay-by capacity (No. of buses contained)	
	To	Fro	To	Fro	Fro
1.	Oshodi	25	25	6	6
2.	P.W.D.	21	21	5	5
3.	Ikeja Along	25	26	6	6
4.	Dopemu Under bridge	21	21	5	5
5.	Iyana Ipaja	25	25	6	6

Source: Author's field survey, March, 2017

Table 3 shows the capacity and size of the lay-bys at each of the major bus-stop studied. The study carried out shows that Oshodi, Ikeja Along and Iyana Ipaja bus-stops can only accommodate six of 14 seater buses at a time while P.W.D, Cement and Dopemu under bridge bus-stops can only accommodate five of 14 seater buses at a time. This means that the peak period traffic may always be affected at these bus stop locations due to inadequate berthing space, boarding and alighting activities and on-road parking of buses at some of the bus stops. This is also associated with the traffic congestion along the bus stop locations in the study area.

Analysis of the Factors Responsible for Bus Stops Behaviour in the Study Area.

Table 4 shows the causes of delay being experienced at each major bus-stop along the study area most especially at the peak periods.

The cause of delay at Oshodi bus stop/layby is due the fact Oshodi is both a commercial CBD and a transit bus stop connecting multiple other nodal locations in Lagos. Activities of both passengers and vehicles are very high due to influx of people and vehicle either in transit or coming to Oshodi as their destination. At this location main factors for traffic delay are; street trading at layby space, pedestrians not making use of pedestrian Bridge, passenger overcrowding, low capacity bus stop/layby and low enforcement. These factors altogether affect traffic movement and promote bus service delay at the Oshodi bus stop.

Furthermore, it was observed that the cause of delay at P.W.D. bus-stop is as a result of pedestrian crossing due to the schools, commercial and business activities going on around it. These activities generate high demand for both pedestrian and vehicular traffic in and out of the area. The absence of pedestrian bridge, passenger overcrowding, low capacity bus stop/layby and buses not utilizing the bus stop layby due to difficulty of rejoining the traffic stream are other contributing factors at this location.

At Ikeja along, Ikeja is known as a Central Business District (CBD), thus, there are much more passengers volume and overcrowding at this bus-stop with majority of the passengers occupying the bus stop space waiting for buses. Therefore, when the buses arrive to load passengers, they tend to park on the road as the overcrowded passenger had occupied their berthing spaces.

The same scenario was repeated in other bus stops/laybys (Cement, Dopemu, and Iyana-Ipaja bus stops/Laybys) within the study area during the morning and evening peak periods. Figure 2 shows the traffic delay emanating as a result of queue buildup of about 800meters from Dopemu bus stop along the study area.

Figure 2: Long queue emanating from Dopemu bus stop along Lagos Oshodi-Abeokuta Expressway
Source: Author Field Survey, March, 2017

Table 4: Observed causes of delay in each of the identified locations in the study area

		OBSERVED CAUSES OF DELAY	
S/N	Location	To Oshodi	From Oshodi
1.	Oshodi	• Street Trading • Pedestrians not making use of Pedestrian Bridge. • Passenger overcrowding • Low capacity bus stop/layby	• Street trading • Pedestrians not making use of pedestrian bridge. • Passenger overcrowding • Low capacity bus stop/layby
2.	P.W.D.	• Pedestrians crossing on the highway. • Buses do not make use of the lay-by. • Passenger overcrowding • Absence of pedestrian bridge • Low capacity bus stop/layby	• Pedestrians crossing on the highway. • Buses do not make use of the lay-by. • Passenger overcrowding • Absence of pedestrian bridge • Low capacity bus stop/layby
3.	Ikeja Along	• Buses not making use of bus-stops due to the BRT buses occupying the bus-stop bay where the commercial buses needs to stop to board and alight passengers. • Low capacity bus stop/layby	• Buses do not make use of the bus-stops and lay-bys. • Passenger overcrowding • Lack of enforcement • Low capacity bus stop/layby
4.	Cement	• Buses not making use of the lay-by • Pedestrian crossing due to uncompleted pedestrian bridge. • Lack of enforcement	• Pedestrian crossing due to uncompleted pedestrian bridge. • Buses not making use of the layby. • Passenger overcrowding
5.	Under Bridge	• Buses do not make use of the lay-by when boarding and alighting of passengers. • Pedestrians crossing due to the absence of pedestrian bridge. • U-turning vehicles.	• Pedestrian crossing due to the absence of pedestrian bridge. • Buses do not make use of bus-stop when passengers alight and board the bus. • Low capacity bus stop/layby
6.	Iyana Ipaja	• Street trading • Delay of buses at the bus-stop by the tout collecting money on the road. • Pedestrians crossing due to the absence of pedestrian bridge. • Passenger overcrowding. • Buses not making use of bus-stops due to the BRT buses occupying the bus-stop bay where the commercial buses needs to stop to board and alight passengers • Low capacity bus stop/layby	• Street trading • Buses do not make use of bus-stops and lay-bys. • Pedestrians crossing due to the absence of pedestrian bridge. • Passenger overcrowding. • Low capacity bus stop/layby

Source: Author's field survey, March, 2017

Paper ID: ART20181358 DOI: 10.21275/ART20181358

4.4 Analysis of Bus stop/Layby Level of Service in the Study Area

Apart from the condition of the available infrastructure observed in the study area, the effects of bus stops/laybys on traffic flow are very crucial to the sustainable management of traffic in the study area. More importantly, the use of queue theory to calculate the average discharge/release of bus traffic and bus stop efficiency at the studied locations in the morning peak period yielded the desired measure of effectiveness intended by the study (Sundarapandian, 2009; Martin, Abdul-Aziz, Annin & Oduro, 2013; Lee & Liu, 2014; Zukerman, 2014). The results obtained from the analysis are presented below. To employ the queue theory, the arrival rate and service rate data from table 5 were used to obtain the mean performance of the studied bus stops/laybys using the parameters of the M/M/1 queue model as follows:

Where:
Arrival rate (l): the average number of vehicles arriving at the bus stop per minute
Service Rate (m): the average number of vehicles that used the bus stop lay-by in a minute
Traffic Intensity (r): the average utilization of the bus stop lay-by service, r=l/m
Mean time spent in bus stop lay-by = 1/m(3-r)
Mean time spent waiting in queue = r/m(3-r)
Average number of vehicles in the bus stop = r/(3-r)
Average number of vehicles waiting in queue = $r^2/(3-r)$

Table 5: Detail of Parameters Calculation for Each of the Bus Stop/Layby Locations

S/N	Location	Arrival rate of vehicles per minute		Service rate per minute		Vehicle traffic intensity $\frac{l}{m}$		Mean time spent by each vehicle in bus stop (minutes) $\frac{1}{m(3-r)}$		Mean time spent waiting in queue (minutes) $\frac{r}{m(3-r)}$		Mean number of vehicles in the bus stop $\frac{r}{3-r}$		Mean number of vehicles waiting in queue $\frac{r^2}{3-r}$	
		TO	FRO	TO	FRO	TO	FRO	TO	FRO	TO	FRO	TO	FRO	TO	FRO
1.	Oshodi	37	53	22	25	1.6818	2.1200	2.07	2.73	3.48	5.78	1	2	2	5
2.	P.W.D	53	47	29	28	1.8276	1.6786	1.76	1.62	3.23	2.72	2	1	3	2
3.	Ikeja Along	65	60	39	36	1.6667	1.6667	1.15	1.25	1.92	2.08	1	1	2	2
4.	Cement	60	54	29	26	2.0690	2.0769	2.22	2.50	4.60	5.19	2	2	5	5
5.	Under Bridge	58	51	25	24	2.3200	2.1250	3.53	2.86	8.19	6.07	3	2	8	5
6.	Iyana Ipaja	62	56	35	29	1.7714	1.9310	1.40	1.94	2.47	3.74	1	2	3	3
	Total	335	321	179	168	11.337	11.598	12.13	12.9	23.89	25.58	10	10	23	22
	Average	55.8	54.1	29.8	28	1.895	1.933	2.021	2.15	3.98	4.26	1.66	1.66	3.83	3.67

Source: Author's field survey, June, 2017

Table 5 shows the results of the bus traffic analysis and bus stop behaviour assessment conducted at each of the six locations of study. It is clear from table 5 that there is an obvious congestion at all the six bus stop locations studied, with their traffic intensity r>1, as documented by Martin, et.al., (2013) in Kumasi-Ashanti Region of Ghana and as presented by Lee & Liu (2014) and Zukerman (2014). As a result for instance, a vehicle at Oshodi (To) spends 2.70 minutes at the bus stop and 3.48 minutes waiting in the queue, giving an average of 1 vehicle in the bus stop at a time and 2 vehicles waiting in queue at the same time.

According to the model, it is assumed that time interval between successive vehicle arrivals and serving time is independent (Sundarapandian, 2009; Zukerman, 2014) as also found in the study area. Also, the arrival rate per minute which is 55.8 vehicles (To) and 54.1 vehicles (Fro) are independent of service rate of 29.8 vehicles (To) and 28 vehicles (Fro) respectively. These are identically distributed and the average numbers of vehicles that can be serviced in a lay-by efficiently are 3. The rate of arrival and service is also constant. The queuing discipline observed was first-come-first-served (FCFS).

However, the service rate and arrival rate are not constant in the study area. Also, the number of vehicles at the lay-by is more than 3 with additional average of 3 or more vehicles queuing to enter the bus stop. This means that the level of service of bus stops/laybys in the study area is poor during the morning peak period. This is because the average bus stops traffic intensity is more than 1 showing oversaturation, the mean time spent service the buses is more than 1 minute, the mean time spent queuing to berth at the bus stops is more than 1 minute, the mean arrival rate of 55.8 bus per minute is far higher than the mean service rate of 29.8 buses per minute indicating congestion in the system. Service rate must be higher or at least equal to arrival rate in an efficient system. The same behavior will definitely be experienced in the evening peak as the factors that conditioned the morning peak traffic are expected to repeat themselves during the evening peak period at the bus stops/laybys in the study area.

5. Conclusion

The study shows that level of service of bus-stop varied slightly across the six bus stops/laybys studied with no significant difference in their measure of efficiency. All the studied bus stops fall short of the required efficiency of vehicle intensity of less than 1, service rate of greater than or equal to arrival rate, mean time waiting queuing of not more than 90 seconds and dwell time of below 60 seconds. Thus, the queue model could be adequately used to predict the level of bus-stop/layby services in other parts of metropolitan Lagos and by time of the day.

Bus stops are the weakest links in a public transport network because passengers have direct contact with ongoing traffic at these stops. Although many types of bus stops like curbside stops, bus bays, queue jumper bus bays, open bus bays, nubs, and others are present in the cities across the world, only two types of bus stops namely curbside (on-road) bus stops and bus bays (laybys) are predominant in Lagos metropolis. Bus bays normally create problems to bus drivers during re-entering into traffic stream which is one of the reasons for not utilizing the bus stop laybys by bus operators in the study area. While curbside/on-road bus stop create substantial delay due to traffic obstruction on major road especially at the peak periods as traffic queues behind stopped bus and may also cause drivers to make unsafe maneuvers when changing lanes in order to avoid a stopped bus (Samaila, 2014)

Many studies as reported in section 1.0 and in literatures describing side frictional factors and their impacts on road capacity reveal that bus stops have a significant impact on reduction in traffic stream speed and also capacity of the roadway. The Findings show that traffic bottleneck and congestion occurs mainly at the major bus-stops (Oshodi, P.W.D, Ikeja Along, Cement, Dopemu under bridge and Iyana-Ipaja) due to inadequate and absence of off-road bus stops, motor parks and laybys to effectively board and alight passengers without causing obstruction on the roads. Also that the bus operators' negligence of not making use of the bus-stops and laybys causes substantial delay in traffic flow and increases travel time along the study area.

6. Recommendations

In view of the findings and conclusions of this research work, the following recommendations are suggested. The concerned authorities should:

- Increase the capacity of bus stops/laybys in the study area to enhance the service rate and reduce bus queue at the bus stops in the study area
- Enforce a law that every bus driver must make use of the lay-bys.
- Assign traffic officers at every major bus-stop to control and direct the buses as they enter and leave the bus-stops.
- Impose fine on bus drivers that violate the order of traffic at each major bus stop.
- Provide a good and reliable bus shelter at each bus-stop where there is no shelter and maintain the other bus stops that have existing bus shelter.
- Design a good and accessible lay-by at the on-road bus stops so as to separate the bus stop lay-by from the major road.
- Construct extended/ multiple lanes laybys at the six bus stops studied in this research. This will relieve the road from obstruction due to bus berthing and the bus stops and enhances free traffic flow.

With these recommendations, bus stops/laybys level of service in the study area will be grossly improved. Also, the travel time will reduce while bus service efficiency will be enhanced.

References

[1] Adebisi, O. A. (2004). Analysis of intra-Urban Traffic Problems in Nigeria:A study of Lagos State *Metropolis. Indonesian Journal of Geography 40 (1), 31-51.*

[2] Adeniji, M.L. (1986). Analysis of Side Friction Impacts on Urban Road Links in Lagos State. *Doctoral Thesis submitted to Royal Institute of Technology, Stockholm, Sweden*. Pp. 51-56.

[3] Ali R., Barra, A. F., Berg, C. N., Damania, R., Nash, J. and Russ, J. (2014), Transport Infrastructure and Welfare in Nigeria. The World Bank, August 25, 2014,pp 1-58.

[4] Allison, N. (2002). *Accessibility and the bus system: from concepts to practice*. Thomas Telford, London. Pp.41-50.

[5] Altakawi, J. (2006). Effects of a downstream signalised junction on the capacity of a multiple berth bus stop..*Proceedings 24th PTRC European Transport Forum*, London.

[6] Central Office of statistics (2006). *Household Survey 2006*. Ministry of Economic Planning and Budget Lagos State Government, Ikeja Lagos. 1-24.

[7] Chien, D. L., Lisa G., & Nungesser, J. (2003). Texas public transit reference Manual," *Technical Report 1082-1F, Texas State Department of Highway and Public Transportation*, Austin, TX. Pp. 21-27.

[8] Chien, P.R., & Yang, W. (2000). The performance of busway transit in developing cities. TRRL *Research Report RR329, Transport and Road Research*,Laboratory,Crowthorne.

[9] Dueker, K.J., Kimpel, T.J., and Strathman, J.G. (2004). Determinants of bus dwell time. *Journal of Public Transportation*, 7(1), 21-40.

[10] Furth, G.H., &Rahbee, F.A. (2000). An analytic investigation of optimal bus size..*Transportation Research*, 22, 319-337.

[11] Furth, P. and Rahbee, A. (2000). "Optimal bus stop spacing through dynamic programming and geographic modeling." *Transportation Research Record 1731*, TRB, Washington D.C., 5-22.

[12] Gbadamosi, K T. & Ibrahim, S. A. (2013), Land Use Conversion and Traffic Situation in Lagos, Nigeria: An Impact Assessment of Victoria Island. Proceedings of the 13th world conference on transport research, Rio de Janerio, Brazil, 15th-18th July, 2013. pp

[13] Huan, Li and Robert, L. B. (2008). *Optimal Bus Stop Spacing for Minimizing Transit Operation Cost Transportation Engineering*, ASCE, 127(3), 195-199.

[14] Ibeas, S. (2005). Effect of crowding on light rail passenger boarding times. In *Transportation Research Record 908*, TRB. Pp.10-14.

[15] Kittleson, D., Associates, T., Tiker.,& Klose, T. (2003). A new approach to bus stop modeling..*Traffic Engineering and Control*, **42**(7), 240-246.

[16] Klose, J., &Drexl, L. G. (2005). Bus stops, congestion, and congested bus stops. *Traffic Engineering and Control*, 30(6), 291-302.

[17] Lagos Bureau of Statistics (2014). *Basic Statistical Hotline*. Lagos State Government, Ministry Of Economic Planning & Budget, The Secretariat, Alausa Ikeja, Lagos, Nigeria.. PP 1-35

[18] Lee, Y. and Liu, K. (2014). *Modeling Signalized Intersection Using Queueing Theory*. Retrieved 09-05-2014 from: https://www.acis.ufl.edu/~klee/course_output/queueing.pdf

[19] London for Transport Busways (2004): A 'Subway' That Runs Above the Ground," *Mass Transit*, Vol. XXIII, No. 3 (May/June 2004) London. Pp.41-50.

[20] Mabogunje, A. L. (1968), *Urbanization in Nigeria*. African Publishing Corp. N.Y.

[21] Martin, A., Abdul-Aziz, A.R., Annin, k, and Oduro, K.T. (2013). Application of Queuing Theory to Vehicular Traffic at Signalized Intersection in Kumasi-Ashanti Region, Ghana. *American International Journal of Contemporary Research.* (3)7, 23-28.

[22] Nworji I. D. and Oluwalaiye O. B (2012). Government Spending on Road Infrastructure and Its Impact on the Growth of Nigerian Economy. International Journal of Management & Business Studies (IJMBS) (2)2, April - June 2012. Pp 24-30

[23] Odeleye, J. A. (2001), 'Managing Road Traffic Congestion in a Megacity: Case of Metropolitan Lagos, Nigeria', in Ming Sun (ed) *Proceeding of International Conference of Postgraduate Research in the Built and Human Environment,* University of Salford UK.

[24] Odeleye, J. A. and Oni, I. (2007): *A Study of Road Traffic Congestion in selected Corridors of Metropolitan Lagos, Nigeria*.

[25] Ogwude I. C. (2016). Managing Transportation Infrastructure in Nigerian Cities. *FUTA Journal of Management and Technology,* (1)1, 17-28. June 2016.

[26] Okpala D.C. (1981). Urban traffic management in Nigerian cities – The necessity for mass transit priorities", in Onakomaiya S.O. and Ekanem M.F. (Ed.), *Transportation in Nigerian National Development*, Proceedings of a National Conference. NISER, Ibadan, pp. 337 – 351.

[27] Olaogbebikan, J. E., I kpechukwu N., Akinsulire E. S. and Okoko, E., (2013). Traffic Management Problems in Lagos: A Focus on Alaba International Market Road, Ojo, Lagos State Nigeria. *Journal of Economics and Sustainable Development.* (4)4. 2013. Pp. 144-154 (Online). www.iiste.org ISSN 2222-1700 (Paper) ISSN 2222-2855

[28] Oni, S. I and Okanlawon, K. R. (2008). Nigeria's Transport Infrastructure Development: An Integral part of the National Economic Empowerment and Development Strategy (NEEDS). *Journal of Social and Policy Issues*, Lagos, Nigeria. (3)2. Pp. 7-13.

[29] Osoba, S. B. (2012). "Appraisal of parking problems and Traffic Management Measures in Ikeja Central Business District in Lagos, Nigeria". Journal Sustainable Development, Vol. 5, No 8, 2012, pg. 105-115.

[30] Otegbulu, A. (2011). *Economic Valuation of Poor Road Infrastructure in Lagos: A Focus on Urban Households. Global Journal of Human and Social Sciences. 11(10). Pp 6-14*

[31] Oyesiku, O.O. (2002), From Womb to Tomb, 24th Inaugural Lecture, Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria.

[32] Rodrigo, B.M., & Nick, W.L. (2004). *Simulation modelling and analysis*. An analytic investigation of optimal bus size. *Transportation Research*, 22B, 319-337 (1988)

[33] Saka, A. (2001). "Model for determining optimum bus-stop spacing in urban areas." *Journal of Transportation Engineering*, ASCE, 127(3), 195-199.

[34] Samaila, S. (2014), Geographical Information System (GIS)-Based Analysis of Road Traffic Accident Blackspots in Federal Capital Territory (F.C.T.). *Journal of Traffic and Logistics Engineering,(2)2, 108-112.*

[35] Sundarapandian, V. (2009). *Queueing Theory. Probability, Statistics and Queueing Theory*. London: PHI Learning. Pp 56-75

[36] Tyler, M.A. (2004). *Bus boarding and alighting times*. TRRL Laboratory Report LR 521, Transport and Road Research Laboratory, Crowthorne. *University College London.* Pp.39-45.

[37] Zukerman, M. (2014). *Introduction to Queueing Theory and Stochastic Teletraffic Models*. Available from: http://www.ee.cityu.edu.hk/~zukerman/classnotes.pdf, 23rd January, 2017.