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ANALYSIS OF TRAFFIC CONGESTION IMPACTS AT IBARA INTERSECTION IN ABEOKUTA, NIGERIA

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Abstract: Traffic congestion has been an area of major bother across the globe. The existing infrastructure is not able to cope with the new traffic demand. Furthermore, the restriction of the space and outside activities influencing the traffic congestion. The emerging country like India, where the traffic conditions comprise heterogeneous traffic with no lane discipline, further creates more complicated scenarios for the researcher. A substantial portion of working hours is getting wasted on the roads because of traffic congestion, which imposes the negative effect on the overall economy. traffic congestion is a common phenomenon almost in all the cities of Nigeria. In this study, Traffic movement survey, travel time, delay time and total traffic volume was conducted at Ibara intersections, the level of the traffic congestion at Ibara Intersection was assessed using travel time approach, while Level of Service (LOS) and Degree of Saturation was also estimated at Ibara Intersection, Abeokuta township. It was observed in the study that large percentage of motorcycle vehicles occupy the road, reducing roadway capacity and creating congestion. The study revealed that Level of Service is F for Panseke and Oke-Ilewo approaches at Ibara intersection and the degree of saturation is greater than 1.

Keywords: Transportation system, Traffic congestion, Unplanned activities, Mobility.

1. INTRODUCTION

Traffic congestion occurs when a city's road network is unable to accommodate the volume of traffic. This situation is caused by rapid growth in motorization and with less than corresponding improvement in the road network traffic management techniques and related transport facilities. Thus, traffic congestion is a phenomenon that is associated with urban environment all over the world. While traffic congestion has been managed very well in some developed countries, it has continued to defy solutions in the developing world. The forecast of Global Traffic Volume shows that the phenomenon would double between 1990 and year 2020 and again by 2050 (Engwitch, 1992).

Traffic congestion is a common problem almost in all major cities in Nigeria. The number of traffic is increasing day by day in Abeokuta township. For this reason, traffic congestion occurs at major intersections in this city and congestion problem growing faster. In order to assess the level of congestion at Ibarat intersection, this study has carried out. Many urban centers in Abeokuta suffer from inadequate facilities that could ensure smooth urban movement.

Some land use types constitute nodes of desires and fulfilment in any urban area. Transport assists to even out the spatial imbalance in needs. Often, coincidence arises from individual commuter's journey during peak hour periods. This type of coincidence, if not well managed, may lead to traffic crisis that makes traveling burdensome in addition to wasting man-hour productive time. Ways of mitigating this mobility problem and ensuring a smooth flow of urban traffic have been carried out in different studies as exemplified by the work of urban transport scholars. Some of the researches by these scholars were aimed at identifying the causes and dimensions of transport problems (Anjaneyulu et.al. 2009). Others were pre-occupied with various options for solving transport problems (Ameyan, 1996). So far, the conventional approaches to traffic management have not been able to make the desired impact, judging from the traffic congestion patterns in the city of Abeokuta.

The scope of this study was limited to Ibara intersections, the analysis was segment study rather than area wide or regional study. Hence, it focused mainly on the road segments at the entry of selected intersection and the relative effect of consecutive intersection was not discussed. Since, the main objective of the study is assessment the congestion level, the congestion management procedures and measures were not discussed as it is a wide and need further investigation

2. LITERATURE REVIEW

Qingyu et al. (2007) analyzed qualitative and quantitative of the external costs that the urban traffic congestion pricing. Described the external costs of traffic congestion in terms of extra travel time costs, environmental pollution costs, traffic accident costs, and fuel consumption costs.

Lyman, and Bertini (2008) described congestion measures and travel time reliability measures. Discussed different travel time reliability measures, but considered the buffer index as important measures. They suggested that adding travel time reliability measure can be a superior comprehension for the transportation network.

Padiath et al. (2009) illustrated the traffic congestion indicator in terms of traffic density. In order to establish the practicality, few approaches for density forecast under similar traffic circumstances are tired under the mixed traffic scenario.

Uddin and Sen (2004) addressed the issues of increasing population and vehicles, especially passenger cars with some statistics. He also found that vehicles in India are distributed unevenly He identified that the transhumance of rural inhabitants to metropolitan cities hunting for superior opportunities is the one of the primary reasons of the urban traffic congestion.

Zhili et al. (2009) forecasted the significance of congestion charge as per the locality, land use attributes, and present travel environment. Evaluated the travel situations under congestion pricing depends on travel demand model and given recommendations for executing the congestion charge.

McGroarty (2010) focused on causes of recurring congestion, which is mainly occurring due to capacity and behavioural issues and non-recurring congestion, which is primarily occurring due to events which creates unanticipated congestion. Though the occurrences are different, but the impacts are similar.

Rao, and Rao (2012) focused mostly on urban arterial congestion. The study executed based on measurement metrics such as speed, travel time/delay and volume and level of service. They have adopted the travel time reliability measures to identify the traffic congestion parameters.

Dubey, & Borkar (2015) focused on detection techniques of the traffic congestion. They have described the major problem incurred during the detection of the traffic congestion on the urban road network. They have suggested to adopt GPS based technique for the betterment of the result in accordance with the traffic safety.

He et al. (2016) adopted performance index to determine the existing road network conditions of congestion in urban road networks. For evaluation of traffic congestion, they have adopted the speed performance index as the evaluation indicator of urban road traffic system.

Samal, and Das (2020) have taken the buffer index to predict the congestion level in the specified road network. They have established regression modelling to see the differences in observed value and predicted value. Some of the recommendations have been suggested.

Maitra et. al. (1999) summarizes some of the negative effects of traffic congestion as; considerable loss of travel time, higher fuel consumption, more vehicle emission and associated environmental and health impact, increased accident risk, stress and frustration on commuters and greater transportation cost.

Further to the above; many more researches have been conducted by different researchers and professionals to develop measuring parameters and models (Maitra et. al., 1999; Lomax et. al., 1997). So far, different congestion measures and models have been proposed and used to determine the extent, severity and duration of congestion and also transport professional are still developing different models for congestion prediction and simulation (Moran et. al., 2010).

2.1 Definition of Traffic Congestion

As a general term, congestion is a phenomenon that occurs almost in all walks of life which demand competition for certain service or supply. The Hand Book of Transportation explain road traffic congestion as a phenomenon resulted when vehicles compete or demand for the available road space and the demand reaches or exceeds the capacity.

Hence, there are many definitions given for traffic congestion based on different parameters. The summarized definitions are:

- Traffic Congestion is travel time or delay in excess of that normally incurred under light or free flow travel condition.
- Traffic Congestion is a situation where the traffic demand for the road space exceeds the capacity.
- Traffic Congestion is an excess of vehicle on the portion of the road way at a particular time resulting in slower speed from normal or free flow speed and mostly characterized by stop or stop-go traffic.

As it can be seen from the above definitions and the diagram below, definitions of traffic congestion generally fall in to two major categories. These are definitions which based on the cause and which based on the impact of traffic congestion.
In traffic engineering, flow is an important parameter that shows the state of the traffic movement. In terms of traffic flow, congestion is usually considered as the state where the speed-flow Figure is reverted or sloped positive. Hence, congestion can be defined as a state in the traffic flow pattern which represents the condition at which demand exceeds capacity or the speed is below acceptable value (Yu, et. al., 2010).

Depending on its occurrence congestion can be classified as recurring and non-recurring congestion. Recurring congestion includes congestion due to bottlenecks, traffic signal, and persistent higher demand etc. and they are predictable. Whereas non-recurring congestion is includes those congestion caused by mainly accidents and unprecedented events (Skabardonis et. al., 2003).

2.2 Causes of Traffic Congestion

Different researches and reports identified many interrelated factors that cause traffic congestion in developed and developing countries where the road network and road users' behavior are different (Cambridge Systematics, 2005; Aworemi et.al., 2009). Accordingly, the results showed that in the United States of America the cause and their percentage share are; bottleneck (40%), traffic incidents (25%), work zone (10%), bad weather (15%), poor signal timing (5%) and special events contribute 5% of the traffic congestion.
Adedimila (as quoted by Aworemi et.al., 2009) classifies the major causes of traffic congestion in Lagos metropolitan in to five and the summary of his discussion is shown in the Table 1.

Table 1: Major Causes of Traffic Congestion in Lagos Metropolitan

Item No	Factors	Causes
1	Social and economic	Rising population number together with the rural urban migration Unplanned land use which result unidirectional traffic flow especially at peak hours Increased car ownership in line with the improved living standard
2	Road	Smaller number of lane & Narrow Road with Lack of side walk which result occupation of traffic lanes by pedestrians Distressed pavement which results in a reduced travel speed Uncontrolled traffic Intersections
3	Vehicle	Size of vehicle Age of vehicles
4	Human	Perception of drivers Perception of pedestrians
5	Accident	The severity, number and location of accident

Besides Traffic congestion occurs for limited road capacity, road parking, un-integrated urban planning, and lack of mass transit, accident, poor vehicle condition, and road side illegal trade.

2.3 Congestion Indicators

As congestion is a relative measure unlike the other traffic flow parameters and it is defined on the road user's feedback. It is essential to define or have indicators of the presence of congestion in the system. According to many other researchers LOS is the best empirical indicator of congestion in transport system.

2.3.1 Level of Service (LOS) as Congestion Indicator

The objective of High way Capacity Manual is to provide a consistent system and techniques for the evaluation of the quality of service on highways and street facilities. HCM presents LOS as an easy-to-understand methodology of analysis and performance measure for single homogenous road segments.

Table 2: Typical Highway Level of Service (LOS) Rating

LOS	Description	Speed (Km/hr)	Flow (Veh/hr/ln)	Density (Veh/km)
A	Traffic flows at or above posted speed limit. Motorists have complete mobility between lanes.	Over 96	Under 700	Under 8
B	Slightly congested, with some impingement of maneuverability. Two motorists might be forced to drive side by side, limiting lane changes.	91-96	700-1100	8-13
C	Ability to pass or change lanes is not assured. This is the target LOS for most urban highways	86.5-91	1100-1550	13-19
D	Speeds are somewhat reduced; motorists are hemmed in by other vehicles. Typical urban peak-period highway conditions.	73.5-86.5	1550-1850	19-26
E	Flow becomes irregular, speed vary and rarely reach the posted limit. This is considered a system failure.	48-73.5	1850-2000	26-42
F	Flow is forced; with frequent drops in speed to nearly zero kmph. Travel time is unpredictable.	Under 48	Unstable	42- max

HCM doesn't specify the boundary LOS for congestion state but clearly states that the LOS F is defined as the worst state of flow and represents congested flow. Though there are some reports using other level of service (D and E) as congested flow, LOS F is generally accepted as a state of traffic flow and hence LOS is the most appropriate congestion indicator. The LOS criteria of HCM are summarized in Tables 2.

2.4 Performance Measures Using Travel Time

Each of the dimensions of traffic congestion stated before can be measured with different operational characteristics (speed, delay, travel time, density etc.) or volume characteristics (operating traffic volume, volume to capacity ratio, traffic volume per lane, etc.). Many literatures including the NCHRP report 398 "Quantifying Congestion" provide different measures for congestions based on travel time approach. Most of the measures explain only one or two of the dimensions of congestion and hence it is necessary to use more than one congestion measure to explain the level of congestion at a road section. Accordingly, there are quite a number of congestion measures suggested in different literatures for each congestion dimension.

Summary of Congestion Measures (Source: Lomax, et. al., 1997)

$$Travel\ rate\ \ (minutes/km) = \frac{Travel\ Time\ (minutes)}{Segment\ Lenght\ (Km)}$$

$$Delay\ Rate\ \ (minutes/km) = Actual\ travel\ Rate - Acceptable\ Travel\ Rate$$

$$Delay\ Ratio = \frac{Delay\ rate}{Actual\ Travel\ Rate}$$

$$Delay\ per\ Vehicle\ (annual\ hour) = [Actual\ Travel\ Time\ (minutes) - Lowest\ Travel\ Time\ (minutes)] \times \frac{250\ weekdays}{year} \times \frac{Hour}{60\ miutes}$$

$$Travel\ Time (Vehicle - hour) = Actual\ Travel\ rate\ (minutes/km) \times Lenght\ (km) \times Vehicle\ Volume\ (vehicles)$$

$$Total\ segment\ Delay(vehicle - minutes) = [Actual\ Travel\ Time\ (minutes) - Travel\ Time\ (minutes)] \times Vehicle\ Volume\ (vehicles)$$

3. METHODOLOGY

The methodology employed for a research work was the critical aspect for ensuring the proper result which aligns with the objective. Hence, this part of the thesis discusses the methodology followed to complete the research work.

3.1 Research Approach

The research approach in this study involves quantitative approaches. Quantitative data and analysis were used to determine the level of service of intersections and to measure the congestion levels. Observation, direct field measurements were the main sources of quantitative data. Observations, collecting relevant data and subsequent analysis of the data help to generate inductive conclusions on the level of congestion at the observed or considered Intersections and road sections. Though it is impossible to assess the traffic congestion at all intersections and road sections in the city. However, in this research the intersection and road sections considered is only at the Ibara intersections of the city; which is connecting the highly congested and traffic busy areas of the town.

The congestion indicator parameters used in this research were Level of Service (LOS). The LOS criterion was according to HCM-2000. As travel time approach is easy to understand and interpret by every people and it is easy to convert to other index parameters, the performance measurement parameters used in this research were based on travel time approach.

3.2 Traffic Data Collection

Video observations and physical observation were carried out seeking realistic data collection of the studied intersections. Smart traffic analyzer was later employed to evaluate and analyze the different operational performance indices. The network geometry data considered intersections configurations, lanes alignment, lanes widths, and number of lanes of both the major corridor as well as the minor intersected streets. On the other hand, as an efficient way to obtain traffic data, video observations and traffic counts for the studied intersections recorded were used in this study. The obtained data included the traffic flow, capacity and operational ratio for each approach. The traffic composition of each turning flow from the different approaches was also obtained. The observational periods were during the (6am – 6pm) for a sufficient amount of unbiased data.
In addition, other field measurements were done to gather data on the geometrical features of intersection for capacity analysis. These include, number of lanes, lane width, configurations of lanes, grade, width of median, movement policy etc. These measures were done for the intersections whose level of service is going to be determined.

3.3 Description of Location of Study Intersection

Abeokuta as the capital of Ogun state, witness a major highway facilities transformation and urban renewal in the last seven years, which directly influence the traffic growth of the town that necessitate the determination of it present traffic capacity and analysis traffic study. The selected operating mode of traffic a particular intersection is usually based on a measured or estimated peak traffic volume and spot speed, this may provide efficient traffic flow during rush hours; however, operation during off-peak hours will be far from ideal.
The choice of Ibara intersections is as a result of high vehicular movement due to concentration of public and private business activities along most of the routes that connect to the intersection. The Importance of Ibara Intersection does not only lie in being a carrier route to the business hub of Abeokuta, Oke-ilewo, Ita-Eko, Ibara, and Omida, but the key facilities which are located in the north and south of the intersection, where there is a huge number means these facilities (Schools, banks and malls) and thus witnessing the early morning busy hours and afternoon busy hours create to get to these facilities.
The selected Ibara intesection is a four legged signalized intersection connecting traffic coming from Oke-ilewo, Ita-Eko, Ibara, and Omida. The conditions of traffic and geometric details at signalized intersection were collected with a field survey. The traffic volume in each direction of the intersection was noted by trained investigator using a 5min time interval. The crosswalk length, width of median, number of lanes, free left

turning and sidewalk connection were also measured. The cycle length, green time, flashing green time and red time of the intersections were also recorded. The selected signalized intersection is shown in Figure 1.

Fig. 1: Ibara Intersection in satellite view Courtesy, Google map

4.0 RESULTS AND DISCUSSION

4.1 Data Geometric Conditions of Ibara Intersections.

Data geometric condition of roads and intersections were obtained by direct measurement of the standard geometric parameters of road and intersection segments of roads and intersections affected by traffic expected.

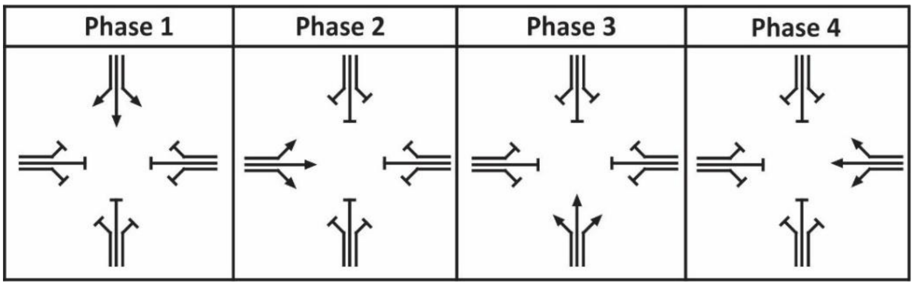

Fig.2 Existing phase design of Ibara signalized intersection

4.2 Volume Count Analysis

Traffic volume count survey was conducted for 12 hours (6 am – 6 pm). The category wise traffic count for each direction for 5minutes interval was recorded. In order to convert different categories of vehicle into a common scale, the passenger car units (PCU) HCM, 2016. The hourly volumes in PCUs/hr were calculated and the survey data was analyzed to obtain the morning and evening peak hour flow of vehicles in each direction. It was found out that the morning peak hour for the study intersection is different at each leg of the intersection.

4.3 Hourly Traffic Volume Trends for the Intersections

Traffic volumes for roadways within Abeokuta generally reflect a traditional peak trend with a directional AM peak and counter-directional PM peak illustrating the respective commute direction. Examination of hourly traffic volumes for the four road legs of Ibara intersection indicates a strong peak directional flow of traffic into Ibara intersection during the AM peak and PM peak, reflecting the significance of the each hours of the day as major traffic generators. The influence of hourly activities on the road leg also indicated in the early occurrence of the directional peaks compared to the traditional School and administrative area traffic peaks. Figure 3 to figure 5 illustrate the hourly traffic pattern of the legs converging at the intersection. The figures indicate Inbounds, Outbound and total traffic volume. A very prominent AM peak of over 3,000 vehicles between 7:15 AM and 845 AM and an earlier sustained PM peak with PM volumes near 3,500 vehicles per hour between 3:00 PM and 4:30 PM. During the afternoon a sustained traffic flow is also observed on Ibara intersection inbound direction, with hourly inbound volumes in excess of 2,000 vehicles generally observed from 11:00 AM to 6:00 PM.

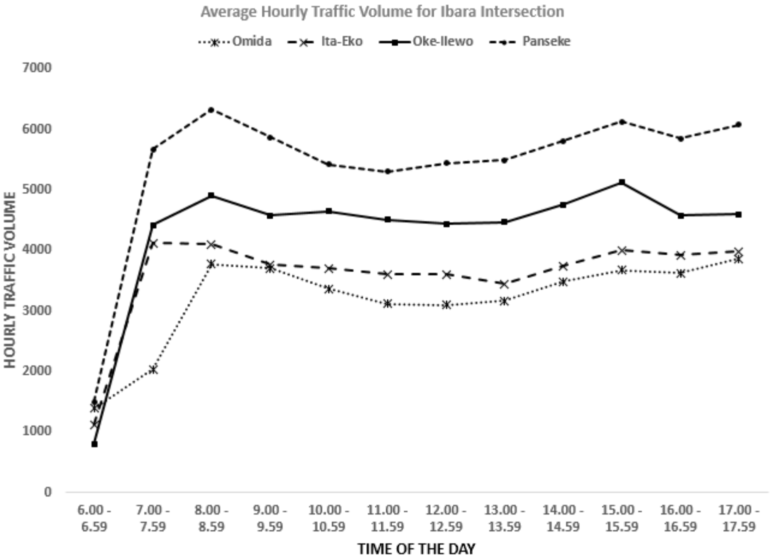

Fig 3: Average Overall Hourly Traffic Volume for Ibara intersection

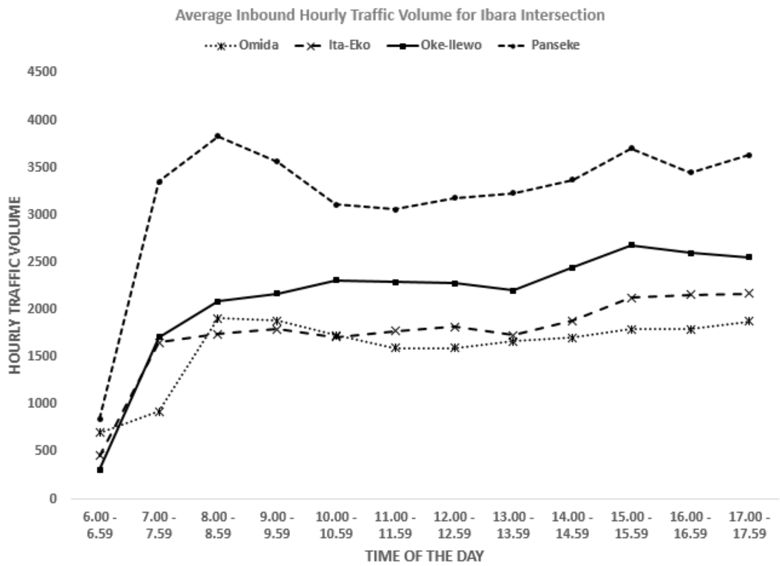

Fig 4: Average Inbound Hourly Traffic Volume for Ibara intersection

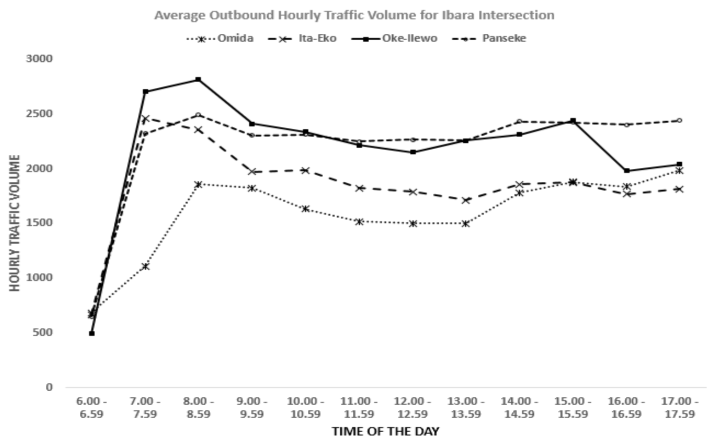

Fig 5: Average Outbound Hourly Traffic Volume for Ibara intersection

4.4 Roadway Link Volume Patterns

Table 1 to Table 4 show the values and hours of the day of ADT and peak hour traffic volumes for the four road legs that link to Ibara Intersection. The figure indicates that roadway ADT volumes vary considerably throughout the Intersection, with the volumes observed ranging from nearly 65,000 vehicles per day on Panseke road down to less than 40,000 vehicles per day on Omida road. Like ADT volumes, peak hour volumes also vary widely throughout the road legs of the intersection. The inbound traffic that has much effect on the intersection varies from nearly 40,000 vehicles per day on Panseke road down to less than 20,000 vehicles per day on Omida road.

Table 3: Omida Average Daily Peak Hour

	Outbound	Inbound	Total
AM PEAK TIME	**8.17 – 9.16**	**8.48 – 9.47**	**8.48 – 9.47**
AM PEAK VOLUME	**1949**	**2058**	**3869**
PM PEAK TIME	**16.30 – 17.29**	**14.15 – 15.14**	**16.44 – 17.43**
PM PEAK VOLUME	**2054**	**1969**	**3835**

Table 4: Ita-Eko Average Daily Peak Hour

	Outbound	Inbound	Total
AM PEAK TIME	**7.17 – 8.16**	**8.07 – 9.06**	**7.19 – 8.18**
AM PEAK VOLUME	**2667**	**1819**	**4425**
PM PEAK TIME	**17.21 – 18.20**	**17.21 – 18.20**	**17.2 – 18.20**
PM PEAK VOLUME	**2025**	**2251**	**4180**

Table 5: Oke-Ilewo Average Daily Peak Hour

	Outbound	Inbound	Total
AM PEAK TIME	**7.33 – 8.32**	**8.44 – 9.43**	**7.47 – 8.46**
AM PEAK VOLUME	**2997**	**2357**	**4987**
PM PEAK TIME	**15.02 – 16.01**	**15.19 – 16.18**	**14.59 – 15.58**
PM PEAK VOLUME	**2484**	**2753**	**5140**

Table 6: Panseke Average Daily Peak Hour

	Outbound	Inbound	Total
AM PEAK TIME	**7.39 – 8.38**	**8.06 – 9.05**	**7.32 – 8.31**
AM PEAK VOLUME	**2589**	**3910**	**6402**
PM PEAK TIME	**15.38 – 16.37**	**15.28 – 16.27**	**17.18 – 18.17**
PM PEAK VOLUME	**2639**	**3872**	**6195**

4.3 Intersections Level of Service (LOS) Estimation

In order to analyze the LOS, installation was made with the options left-hand driving rule and HCM 2000 metric version. As only the level of service (LOS) and Degree of saturation will be determined for an indicative result leaving the other outputs of the program, calibration was not taken as an issue for the purpose. In order to conduct the analysis, the geometric and directional hourly traffic volume data were prepared as an input as summarized below in Table 4.1. However, recommended and default values were taken for other input data; for instance, critical gap, saturated flow.

Table 7: Degree of Saturation and Level of Service (LOS) for Each Road of Ibara Intersection

Approach Leg Name	Degree of Saturation (v/c)	LOS
Panseke	1.22	F
Oke-Ilewo	1.03	F
Ita-Eko	0.87	E
Omida	0.72	E

5. CONCLUSIONS

The findings of the research work concluded below in brief:

i. The traffic flow from the commercial area of the two ends (From Panseke and Oke-Ilewo) are peak during the morning period (8.06 am to 9.44am) and only left lane is congested during one of the peak periods.

ii. The traffic flow from the residential area of the two ends (From Power House and Rupsha) are peak during the morning period (11 am to 12 pm) and only left lane is congested during one of the peak periods.
iii. Traffic congestion during the evening peak hour (3 pm to 6 pm) is more than the morning peak hours. But at the starting of the day and mid-day the roads are not congested.
iv. From LOS and Degree of Saturation analysis, the degree of saturation is almost greater than 1. Level of Service is F for Panseke and Oke-Ilewo approaches, which are road legs from commercial are, Level of Service is E for Omida and Ita-Eko approaches

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