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OPERATIONAL EVALUATION OF OBAFEMI AWOLOWO UNIVERSITY MAIN GATE – EDE ROAD INTERSECTION

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ABSTRACT
Vehicular traffic at Obafemi Awolowo University has increased over the years, resulting in delay at The Main Gate – Ede Road Intersection. This paper evaluated its present level of service with a view to addressing this situation. Geometric survey of the intersection was carried out. Peak hour traffic studies were conducted for a week and the traffic characteristics and volume were determined using standard procedure. The level of service (LOS) of the intersection was thereafter obtained. The geometrics of the intersection showed that, two lanes exist on the East Bound (EB) and West Bound (WB) approaches, as well as a dual lane on the North Bound (NB) and South Bound (SB) approaches. The traffic volume count was 1378, 931, 1168 and 1123 veh/h for the NB, SB, EB and WB respectively. The level of service at the intersection is B, thus implying that it exhibits a slight delay.

Keywords: *Level of Service, Road intersection, Road geometry, Traffic delay*

1. INTRODUCTION

An intersection is a convergent area where two or more roads meet with a provision for changing route of directions. There are different types of intersections depending on the number of roads converging at a point and the structures made available for the flow of traffic at such convergent areas. Basically, intersections can be classified into three categories: At grade, Grade – separated without ramps and Grade – separated with ramps intersections [1]. AASHTO [2], recommends not more than four legs at an intersection. This is because the number of possible conflict points at any intersection depends on the number of approaches, the turning movements, and the type of traffic control present at the intersection. They pointed out that, an un-channelized cross intersection is used mainly at locations where minor or local roads cross, although it also can be used where a minor road crosses a major highway; and noting that, in these cases, the turning volumes are usually low and the roads intersect at an angle that is not greater than 30 degrees from the normal. Furthermore, they remarked that, right turning roadways are provided for four leg intersections when right turning movements are frequent and also in suburban areas where pedestrians are present.

The number of potential conflicts for users increases substantially at intersections with more than four legs [3].

NorwalkTMP [4] pointed out that, intersection includes not only the pavement area but typically the adjacent sidewalks and pedestrian curb cut ramps. Noting that, the intersection encompasses all alterations (for example, turning lanes) to the otherwise typical cross sections of the intersecting streets. Remarking that, intersections are key features of street design, in focus of activity, conflicting movements, traffic control and capacity.

An underperforming intersection affects the flow of traffic which could in turn lead to congestion. Congestion is said to occur when the volume to capacity ratio (v/c) is greater than or equal to 0.77[5].Traffic congestion is a major challenge facing the transportation sector of fast-growing societies with rapid urbanization. Congestion also results from delay caused by convergence of traffic movements at an

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intersection, thus creating conflict points. These conflicts occur when traffic streams moving in different directions interfere with each other. The three possible types of conflicts are; merging, diverging, and crossing [1]. Conflicting vehicle movements at intersections are probably the largest cause of accidents in many developing countries [6]. Thus intersection should be aimed at reducing the potential conflicts of movements of vehicles, pedestrians and facilities [7]. In order to control conflicting and merging traffic streams to minimize delay, intersections are usually needed. Choice of geometric parameters that control and regulate the vehicle path through the intersection could ensure this [8].

Geometric design of an intersection influences the operational performance for all road users. Its operational efficiency is improved by minimizing impedances, eliminating the need for lane changes and merge maneuvers and minimizing the required distance to traverse it. Furthermore, its geometric features influence the service volume or amount of traffic it can process [3]. Saxena [9] pointed out that, intersections are critical spots along a road.

Capacity is the maximum sustainable flow rate at which vehicles or persons reasonably can be expected to traverse a point or uniform segment of a lane or roadway during a specified time period under given roadway, geometric, traffic, environmental, and control conditions; usually expressed as vehicles per hour, passenger per hour, or persons per hour[10]. Furthermore, it is the reasonably expected maximum sustainable flow rate under given conditions. Capacity does not describe the maximum observed flow rate during some short period of time. Rather, it describes the average (expected) maximum flow rate that can be sustained over long time periods under given conditions [11]. Usually, analysis is based on short time intervals, which may not be in a steady state, because traffic conditions change frequently in real world. In [10], the analysis interval is 15 minutes. This is a compromise between considerations on short term fluctuations and stability of macroscopic traffic flow measures. Lesser interval periods allow better adjustment for fluctuations in short traffic. When steady state analyses are applied to finite time intervals, the performance of the facility during these periods will have considerable stochastic variation around the estimated performance. Traffic conflicts between vehicular movements are created when two or more roads crossed each other. Such conflicts may cause delay and traffic congestion with the possibility of road accidents. Thus, each intersection requires traffic control. It is regulated with stop signs, traffic lights, and roundabout. The common type of intersection is the un-signalized intersection, which is used to regulate low volume of traffic flow between the major and minor streets [12]. Slinn et al. [13] proposed the following selection criteria for intersections: two lightly trafficked residential roads – priority junction: the through carriageway of a motorway – grade separation: heavily trafficked urban cross roads with heavy pedestrian flows – traffic signals: and suburban dual carriageways with substantial heavy goods traffic – conventional roundabout.

According to the procedures outlined for two-way stop controlled (TWSC) intersections in [10], estimating level of service requires evaluation of critical gap, follow-up time, and impedance and capacity calculations.

The input data for the analysis of an unsignalized intersection is shown on Figure 1.

Similarly, the level of service criteria for unsignalized intersection is shown on Table 1.

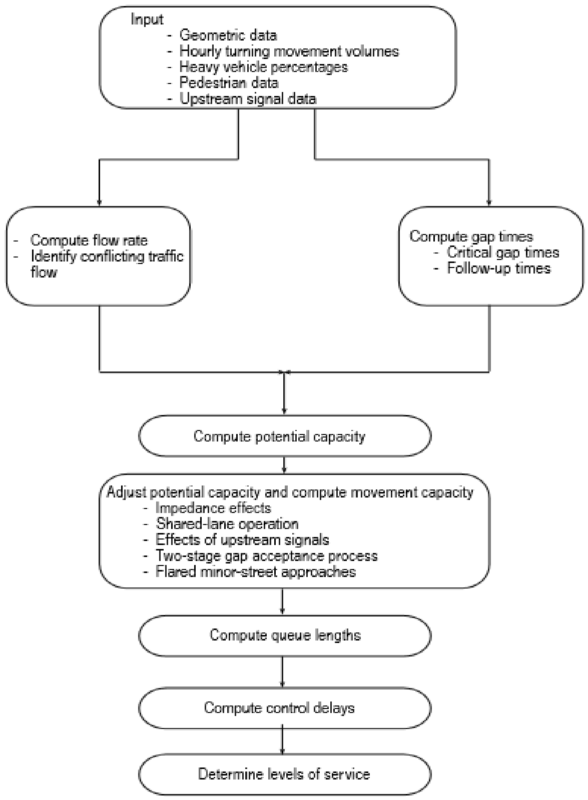

Figure 1: Two Way Stop Controlled (TWSC) Unsignalized Intersection Input Procedures
Source: National Academy of Sciences(2000)

Table 1: Level –of– Service Criteria for TWSC Intersections

Level of Service	Average Control Delay (s/veh)
A	0-10
B	> 10 – 15
C	> 15 – 25
D	> 25 – 35
E	> 35 – 50
F	> 50

Source: Highway Capacity *Manual (2000)*

Population growth at Obafemi Awolowo University (OAU) community has increased over the recent years with a concomitant increase in vehicular traffic. The result is the worsening condition of traffic congestion and delay at The Main Gate – Ede Road Intersection at peak periods. The need to evaluate the present level of service with a view to addressing this situation becomes necessary, hence this study.

2. MATERIALS AND METHODS

The Obafemi Awolowo University main gate – Ede road intersection at Ile – Ife, in Osun State of Nigeria was studied. Figure 2 shows Osun State, Nigeria, while Figure 3 shows the location of the intersection.

The geometric characteristics of the intersection as well as the parameters describing the traffic conditions were determined. Geometric survey of the intersection was carried out using a Total Station. Peak-hours traffic count was conducted for a week, in order to determine the volume and other characteristics of traffic at the intersection. The level of service (LOS) of the intersection was calculated based on standard procedures for a two-way stop controlled intersection. The parameters used for computing the LOS for a TWSC intersection based on appropriate equations in [10] are as follows:

$$PHF = \frac{PHV}{Peak_{15min} * 4} \quad (1)$$

Where:

PHF = Peak hour factor

PHV = Peak hour volume

$Peak_{15min}$ = Peak volume for 15 minutes interval

$$HFR = \frac{PHF}{V} \quad (2)$$

Where:

HFR = Hourly flow rate

PHF = Peak hour factor

V = Volume

$$P_{HV} = \frac{v_t}{v_{t+b+c+m}} \quad (3)$$

Where:

P_{HV} = Proportion of heavy vehicles

V_t = Volume of trucks

$V_{t+b+c+m}$ = Volume of trucks, buses, cars and motorcycles

Figure 2: Map of Nigeria showing Osun States
Source:
http://www.ngex.com/nigeria/places/states/osun.htm

***Figure 3: Intersection Location of** Obafemi Awolowo University Main Gate – Ede Road, Ile-Ife*
Source:Obafemi Awolowo University, Ile-Ife (1986)

$$t_{c,x} = t_{c,base} + t_{c,HV}P_{HV} + t_{c,G}G - t_{c,T} - t_{3,LT} \quad (4)$$

Where:
$t_{c,x}$ = critical gap for movement x (s),
$t_{c,base}$ = base critical gap from Table 2
$t_{c,HV}$ = adjustment factor for heavy vehicles (1.0) for two-lane major streets and 2.0 for four-lane major streets) (s),
P_{HV} = Proportion of heavy vehicles
$t_{c,G}$ = adjustment factor for grade (0.1 for Movements 9 and 12 and 0.2 for movements 7. 8, 10, and 11) (s),
G = percent grade divided by 100,
$t_{c,T}$ = adjustment factor for each part of a two-stage gap acceptance process (1.0 for first or second stage; 0.0 if only one stage) (s), and
$t_{3,LT}$ = adjustment factor for intersection geometry (0.7 for minor-street left-turn movement at three-leg intersection; 0,0 otherwise) (s).

$$t_f = t_{fbase} + t_{fHV} * P_{HV} \quad (5)$$

Where:
t_f = follow up time
t_{fbase} = base follow up time: 2.2 for left turn from major, 3.3 for right turn from minor, 4.0 for through traffic on minor and 3.5 for left turn from minor (s)
P_{HV} = Proportion of heavy vehicles

$$c_{p,x} = v_{c,x}\frac{e^{-v_{c,x}t_{c,x}/3600}}{1 - e^{-v_{c,x}t_{f,x}/3600}} \quad (6)$$

Where:
$c_{p,x}$ = potential capacity of minor movement x (veh/h),
$v_{c,x}$ = conflicting flow rate for movement x (veh/h),
$t_{c,x}$ = critical gap (i.e., the minimum time that allows intersection entry for one minor-stream vehicle) for minor movement x (s), and
$t_{f,x}$ = follow-up time

$$c_{SH} = \frac{\sum_y v_y}{\sum_y(\frac{v_y}{c_{m,y}})} \quad (7)$$

Where:
C_{SH} = capacity of the shared lane (veh/h)
V_y = flow rate of the y movement in the subject shared lane (veh/h), and
$C_{m,y}$ = movement capacity of the y movement in the subject shared lane (veh/h).

$$Q_{95} = 900T\left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}})\right]\left(\frac{c_{m,x}}{3600}\right) \quad (8)$$

Where:
Q_{95} = 95^{TH}- percentile queue (veh),
V_x = flow rate for movement x (veh/h),
$C_{m,x}$ = capacity of movement x (veh/h), and
T = analysis time period (h) (T = 0.25 for a 15-min period).

$$d = \frac{3600}{c_{m,x}} + 900T\left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{(\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}})\right] + 5 \quad (9)$$

Where:
d = control delay (s/veh),
v_x = flow rate for movement x (veh/h),
$c_{m,x}$ = capacity of movement x (veh/h), and
T = analysis time period (h) (T = 0.25 for a 15-min analysis.

3. RESULTS AND DISCUSSION

The intersection geometrics show that the Obafemi Awolowo University Main Gate – Ede road intersection consists of four legs namely: OAU Campus Gate approach (North Bound), Ibadan road pedestrian bridge approach (South Bound), Mayfair road approach (East Bound) and Ede road approach (West Bound) as shown in Figure 4. The road was built as a flexible pavement using asphaltic concrete. The condition of all the legs of the intersection can be considered as good as there is no visible road defect on the main carriageway. The vehicles plying the road are: passenger cars, motorcycles, buses, and trucks.

The Campus Gate and the Ibadan Road Pedestrian Bridge legs of the intersection serve as the minor or stop-controlled approaches while the Ede road and Mayfair road serve as the major street/approach.

Furthermore, there are two lanes on the East Bound (EB) and West Bound (WB) approaches, and a dual lane on the North Bound (NB) and South Bound (SB) approaches with an average lane width of 3.65 m. The terrain is level with a parking facility on the North Bound approach, and an average turning angle of 95°.

Table 2: Base Critical Gaps and Follow-Up Times for TWSC Intersections

Vehicle Movement	Base Critical Gap, $t_{c,base}$ (s)		Base Follow-up Time, $t_{f,base}$ (s)
	Two-Lane Major Street	Four-Lane Major Street	
Left turn from major	4.1	4.1	2.2
Right turn from minor	6.2	6.9	3.3
Through traffic on minor	6.5	6.5	4.0
Left turn from minor	7.1	7.5	3.5

Source: National Academy of Science (2000)

The traffic volume count gave a total of 1378, 931veh/hr for NB and SB approaches respectively. Similarly, there was a total of 1168 and 1123 veh/hr for EB and WB traffic respectively. The highest traffic on the NB approach as shown in the intersection summary sheets in Figure 5 and Figure 6 aptly reflects that the intersection is typical of academic community which is a traffic generating centre. The traffic movements 7, 8 and 9 have queue lengths of 3.34 and 1.78 metres and control delay of 12.94 and 10.31 sec respectively which puts the level of service at B.
Similarly, traffic movements 10, 11 and 12 have queue lengths of 6.20 and 4.66 metres and control delay of 21.52 and 15.94 seconds and therefore termed as operating at LOS: C. The movements 1 and 4 have a queue length of 0.55 and 0.21 metres and control delay of 9.46 and 8.69 seconds respectively corresponding to LOS A. Therefore, the average intersection delay is, 13 sec / veh, which put the overall level of service of the intersection at B, thus implying that there is a slight delay at the intersection which could be attributed to its inadequate geometrics.

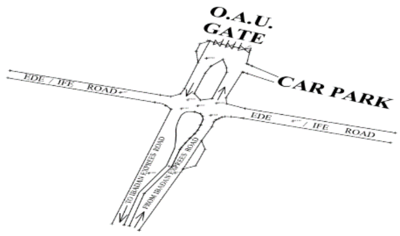

Figure 4: Intersection Configuration of Obafemi Awolowo University Main Gate – Ede Road, Ile-Ife

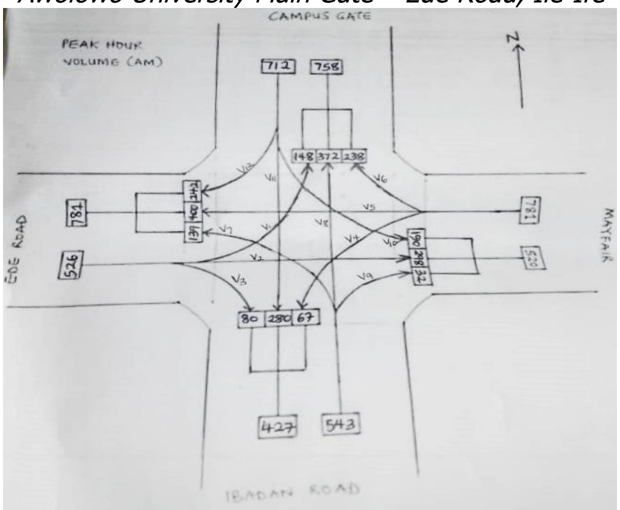

Figure 5: Intersection Traffic Volume Summary Sheet for Peak Morning Hours

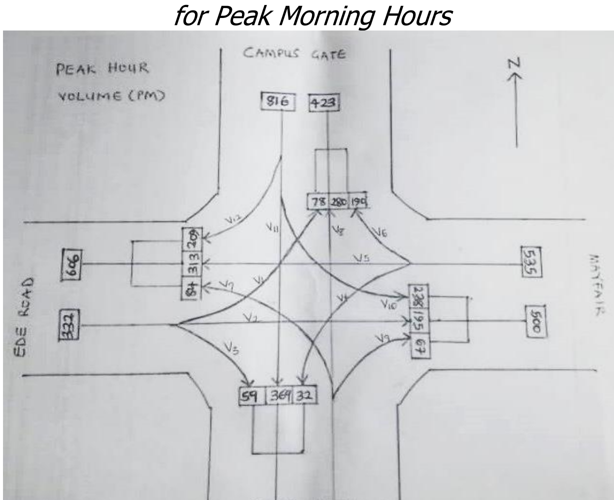

Figure 6: Intersection Traffic Volume Summary Sheet for Peak Evening Hours

4. CONCLUSION

The operational evaluation of the Obafemi Awolowo University Main gate – Ede road intersection was carried out.
The result of the survey of the geometry of the intersection showed that there was no provision for storage lanes on all the four approaches; thus, a contributory factor to the reduced capacity of the intersection.
From the traffic data obtained and analysed, it can be concluded that the Campus Gate approach has the highest traffic, being the destination of majority of the traffic movements at the intersection originating from various parts of Ile-Ife and beyond.

The overall Level of Service (L.O.S.) for the intersection is B. This implies that there is a slight delay at the intersection.

The provision of right turn lanes is recommended for channelizing movements on the right turn so as to reduce the delay experienced by other movements accessing the intersection. This will help in relieving the traffic congestion at the intersection.

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