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Operational Evaluation of Road 2 – Road 6 Intersection at Obafemi Awolowo University, Ile – Ife, Osun State, Nigeria.

Hussein Mohammed

Department of Civil Engineering, Obafemi Awolowo University, Ile – Ife, Nigeria

* E-mail of the corresponding author: hmesteem@yahoo.com

Abstract

Over the recent years traffic at the Road 2 – Road 5 intersection has been observed to be high at peak hours. This situation sometimes becomes frustrating as a result of long queues. Accidents have even occurred in some instances. The need to proffer solution to this problem, therefore becomes imperative, hence this study. The geometric characteristics and the traffic and the signalized conditions of the intersection were determined using standard procedures The intersection geometrics show that, there are two lanes on all approaches, with an average width of 3.65 m. The terrain is level and there is no storage bay. Raised islands are provided to separate the traffic streams. There are no lane and pedestrian markings. The saturation flows (s), for the East Bound (EB), West Bound (WB), North Bound (NB) and South Bound (SB) traffic, were, 2306, 1948, 1561 and 1569 veh. / h respectively, while the critical v/c ratio value for the intersection was, 0.54.The uniform delay, d_1,for EB and WB, and NB and SB, were 10 and 26 sec. / veh. respectively; while the values for their incremental delays, d_2, were, 0.44, 0.56, 0.41 and 0.47sec. / veh. respectively. The average intersection delay is, 13 sec / veh., which put the level of service (LOS), at B. It can therefore be concluded that, there is a slight delay at the intersection, which could probably be attributed to the inadequate geometrics of the intersection. A new geometric configuration was therefore proposed to eliminate this delay.

Keywords: Intersection, Geometrics, Saturation Flow, Critical v/c Ratio, Average delay and Level of Service (LOS).

1. Introduction

An intersection is an area shared by two or more roads, whose main function is to provide for the change of route directions. Intersections vary in complexity from a simple intersection: which may have only two roads crossing at a right angle to each other, to a more complex intersection at which three or more roads cross within the same area. Drivers, therefore have to make a decision at an intersection concerning which of the alternative routes they which to take. This effort which are not required at non-intersection areas of the road, is the part of the reason why intersections tend to have a high potential for crashes (Garber and Hoel, 2010)

An intersection is an important part of a road because, to a good extent, the efficiency, safety, speed, cost of operation and capacity depends on its design (Oguara, 2006).

Intersection channelization is used mainly to separate turn lanes from through lanes. A channelized intersection consists of solid white lines or raised barriers which guide traffic within a lane so that vehicles can safely negotiate a complex intersection. When raised islands are used, they can also provide a refuge for pedestrians.

One of the most effective ways of controlling traffic at an intersection is the use of traffic signals. Traffic signals can be used to eliminate many conflicts because different traffic streams can be assigned the use of the intersection at different times. Since these results in a delay to vehicles in all streams, it is important that traffic signals be used only when necessary. The most important factor that determines the need for traffic signals at a particular intersection is the intersection's approach traffic volume (Garber and Hoel, 2010).

The operation of an intersection is influenced by its geometric layout and the type of traffic control which affects its accident potential and capacity. Queue lengths and delays at an intersection are a function of the inadequate capacity at an intersection, volume of traffic and vehicle operating characteristics (FMT, 2007). In developing an intersection design AASHTO recommends the consideration of the following elements – traffic consideration, physical elements, economic factors and functional intersection area. One of the most critical aspects of intersection design is the determination of the number of lanes needed on each approach. Furthermore, considerations of capacity, safety, and efficiency, all influence the desirable number of lanes (Roess *et al*., 2004).

According to Federal Ministry of Transportation(Woks), 2007, the design of an at grade intersection is based on traffic volume and turning movements, the time and duration of peak traffic volumes, traffic distribution and composition of vehicular traffic during peak hours. Design is further influenced by the extent of control required as determined by factors such as vehicle speeds, design capacities, pedestrian movements and accidents data. It added that, an intersection is considered to be safe when it is perceptible, comprehensible and manoeuvrable..

Signal timing at an intersection, reduces the average delay of all vehicles and the probability of crashes; which are achieved by minimizing the possible conflict points when assigning the right of way to different traffic streams at different times. Consequently, delay is an important measure of effectiveness to use in the evaluation of a signalized intersection (Garber and Hoel, 2010). For signalized intersection, capacity and level of service are analyzed separately, and unlike other types of facilities, the two are not related to each other. It is however necessary that both capacity and level of service be fully considered in the evaluation of the overall operation of a signalized intersection. Capacity is based on the concept of saturation flow rates. Saturation flow rate is the maximum rate of flow that can pass through a given intersection approach or lane group under prevailing traffic and roadway conditions, assuming that the green phase was always available to the approach. The flow ratio for a given approach or lane group is defined as the ratio of the actual flow rate to the saturation flow rate (Ogura, 2006). Level of service may be based on such things as travel times (or speed), total delay, probability of delay, comfort, and safety amongst others (Banks, 2004).

The tasks involved in an operational analysis of an intersection include; identifying and recording the geometric characteristics, identifying the traffic and signalized conditions, lane grouping and demand flow rate, saturation flow rate, capacity analysis (*v/c)*, and performance measures (Garber and Hoel, 2010).

The input data for an intersection analysis is as shown on Table 1.

Level of service criteria for signalized intersection is shown in Table 2.

Over the recent years traffic at this intersection has been observed to be horrendous at peak hours. This situation sometimes becomes frustrating as a result of long queues. Accidents have even occurred in some instances. The need to proffer solution to this problem, therefore becomes imperative, hence this study.

2. Materials and Methods

The intersection studied is the road 2- road 6 junctions at Obafemi Awolowo University, Ile – Ife, Osun State of Nigeria. Figure 1 shows Osun State, Nigeria, while Plate 1 shows the intersection location.

The geometric characteristics and the traffic and the signalized conditions of the intersection were determined using standard procedures.

The following parameters were thereafter determined using appropriate equations (Highway Capacity Manual, 2000):

(i) $v = V/PHF$ Equation 1

Where, v = demand flow rate (veh./h), V = demand volume (veh./h) and PHF = peak-hour factor

(ii) $s = s_o N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{RT} f_{LT} f_{Rpb} f_{Lpb}$ Equation 2

Where:

S = saturation flow rate (veh./h)

S_o = base saturation flow rate per lane(pc/h/ln)

N = number lanes in lane group

f_w = adjustment factor for lane group

f_{HV} = adjustment factor for heavy vehicles in the stream

f_g = adjustment factor for approach grade

f_p = adjustment factor for existence of parking lane and parking activity adjacent to lane group

f_{bb} = adjustment factor for blocking effect of local buses that stop within intersection area

f_a = adjustment factor for area type

f_{LU} = adjustment factor for lane utilization

f_{RT} = adjustment factor for right turns in lane group

f_{LT} = adjustment factor for left turns in lane group

f_{Rpb} = pedestrian – bicycle adjustment factor right-turn movement

f_{Lpb} = pedestrian – bicycle adjustment factor left-turn movement

(iii) $c = s_i \, g_i / C$ Equation 3

where

c_i = capacity of lane group i(veh./h)

s_i = saturation flow rate

g_i = effective green ratio for lane group

C = cycle length (s)

(iv) $X_i = v_i \, C / s_i g_i$ Equation 4

where

$X_i = (v/c)_i$ = ratio for lane group i

v_i = actual or projected demand flow rate for lane group(veh./h)

s_i = saturation flow rate for lane group (veh./h)

g_i = effective green time for lane group (veh./h)
C = cycle length (s)

(v) $Xc = \sum \left(\frac{v}{c}\right) ci\left(\frac{C}{C-L}\right)$ Equation 5

where
X_c = critical v/c ratio for intersection

$\sum \left(\frac{v}{c}\right) ci$ = summation of flow ratios for all critical lane groups i

C = cycle length (s)
L = total lost time per circle, computed as lost time, t_L, for critical path of movement

(v) $d=d_1(PF)+d_2+d_3$ Equation 6

where
d = control delay per vehicle (s/veh.)
d_1 = uniform control delay assuming uniform arrivals (s/veh)
PF = uniform delay progression adjustment factor, which accounts for effects of signal progression
d_2 = incremental delay to account for effect of random arrivals and oversaturation queues, adjusted for duration of analysis period and type of signal control.
d_3 = initial queue delay
Assumptions: arrival time type – AT 3, PF = 1
No initial queue, d_3 = 0

Therefore,
$d=d_1+d_2$ Equation 7

where:

$d_1=\frac{0.5C\,(1-\frac{g}{C})\text{^}2}{1-[\frac{\min(1,X)g}{C}]}$ Equation 8

$d_2=900T\,[(X-1)+\sqrt{(X-1)\text{^}2+8KIX/cT}]$ Equation 9

take K =0.5 and I =1

$d_A=\frac{\sum\ d_iv_i}{\sum\ v_i}$ Equation 10

where
d_A = delay for approach A (s/veh.)
d_i = delay for lane group i (veh./h)
v_i = adjusted flow for lane group i (veh./h)

3. Results and Discussion

The intersection configuration is as shown on Figure 2 and is of cross road type (Slinn *et al.*, 2006). The intersection geometrics show that, there are two lanes on all approaches, with an average width of 3.65 m. The terrain is level. There is no storage bay, which means that there is no provision for left turn vehicles. In addition the single lane configuration indicates that there is no provision for right turn vehicles either. Raised islands are provided to separate the traffic streams. There are no lane and pedestrian markings.

The traffic count and signal parameters are as shown in Table 3. The demand volume (veh. / h), for the East Bound (EB), West Bound (WB), North Bound (NB), and South Bound (SB) traffic were 364, 405, 44 and 66 respectively. The larger volumes of East Bound and West Bound traffic recorded are typical of collector roads as aptly indicated on the location map. The peak hour factors (PHF), for EB, WB, NB and SB were, 0.72, 0.82, 0.56 and 0.74 respectively. Random arrival of vehicle was adopted for the intersection, which put arrival type (AT) at 3 (Garber and Hoel, 2010). There are no provisions for pedestrian crossing, bicycle approach and parking. Zero (0) was therefore, entered for, parking maneuvers, N_m, bus stopping, N_B (buses / h), and min. timing for pedestrian, G_p (S). The green timings for EB and WB, and NB and SB are 30 seconds and 10 seconds respectively. While their yellow timing are 3 seconds and 5 seconds respectively. Their cycle timings are 70 seconds and 63 seconds respectively. The volume adjustment and saturation flow rate are as shown on Table 4. The adjustment flow rate, v_p (veh. / h), for EB, WB, NB and SB, were 506, 494, 79 and 89 respectively. Same values were adopted for adjustment flow rate in lane group, v (veh. / h), since there was no provision for either left turn or right turn vehicles. The resulting saturation flows (s), for EB, WB, NB and SB, were therefore, 2306, 1948, 1561 and 1569 veh. / h respectively.

The critical v/c ratio value for the intersection was, thereafter determined to be 0.54, which indicates that, the intersection is operating at under capacity. It also means that, the cycle length provided is adequate for all critical movements. (Garber and Hoel, 2010)

The uniform delay, d_1, for EB and WB, and NB and SB, were 10 and 26 sec. / veh., respectively, as shown on Table 5, while the values for their incremental delays, d_2, were, 0.44, 0.66, 0.41 and 0.47 sec. / veh., respectively, as shown in Table 6. The approach lane group delay, d, for EB, WB, NB and SB, were, 10, 11, 26 and 26 sec. / veh., respectively as shown on Table 7; while their level service (LOS), were, B, B, C and C, respectively. The average intersection delay was therefore determined to be, 13 sec / veh., which put the level of service (LOS), at B. This indicates a slight delay.

Since the intersection is operating at under capacity, this slight delay can be eliminated, by a reconfiguration of the geometrics of the intersection as shown in Figure 3. This new geometrics provides for all turn movements by creating additional lanes and storage bays.

5. Conclusion

The operational evaluation of road 2 – road 6 intersection was carried out.

The geometric configuration showed that, there is no provision for turning movement, and no lane and pedestrian markings.

The critical v/c ratio was 0.54, average intersection delay 13 sec / veh., and level of service of, B.

It can therefore be concluded that, there is a slight delay at the intersection, which could probably be attributed to inadequate geometrics of the intersection.

A reconfiguration of intersection is hereby proposed, to eliminate its under capacity operation and slight delay.

6. Acknowledgement

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References

Banks, J. H. “Transportation Engineering”, Malt House Press Limited, Lagos, Nigeria, 2006.

Garber N. J and Hoel, L. A. “Traffic and Highway Engineering”, 2nd Edition, McGraw Hill New York, USA, 2004.

Highway Capacity Manual, National Academy of Sciences, USA, 2000.

Oguara, T. M. “Highway Engineering: Pavement Design, Construction and Maintenance”, Malt House Press Limited, Lagos, Nigeria, 2006.

Federal Ministry of Transportation (Works),”Highway Manual Part 1: Design”, Federal Ministry of Transportation (Works), 2007

Roessi, R.P, Prassas, E.S and McShane, W.R, “Traffic Engineering”,3th Edition, Prearson Prentice Hall, USA 2004.

Slinn,.M, Guest, P and Matthews, P. “Traffic Engineering Design’ Elsevier Limited, New Delhi, India, 2005.

Source: http://www.ngex.com/nigeria/places/states/osun.htm

Figure 1: Map of Nigeria Showing Osun State State

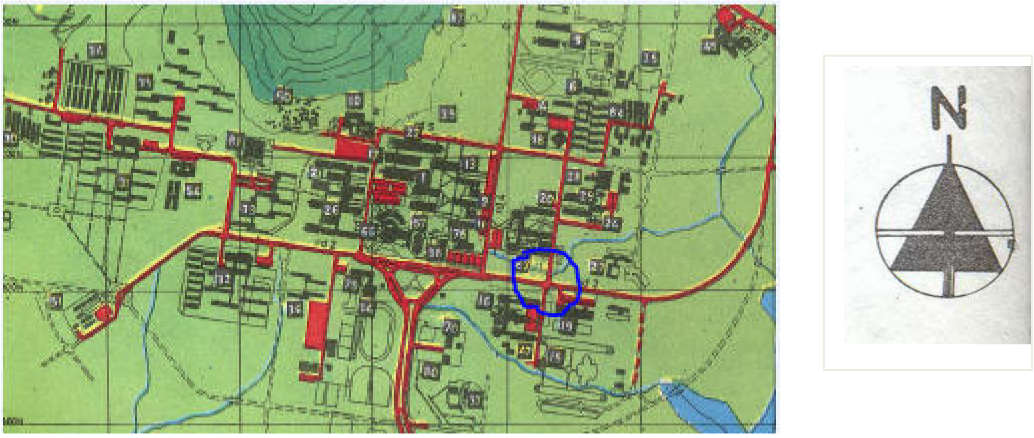

Plate 1: Intersection Location

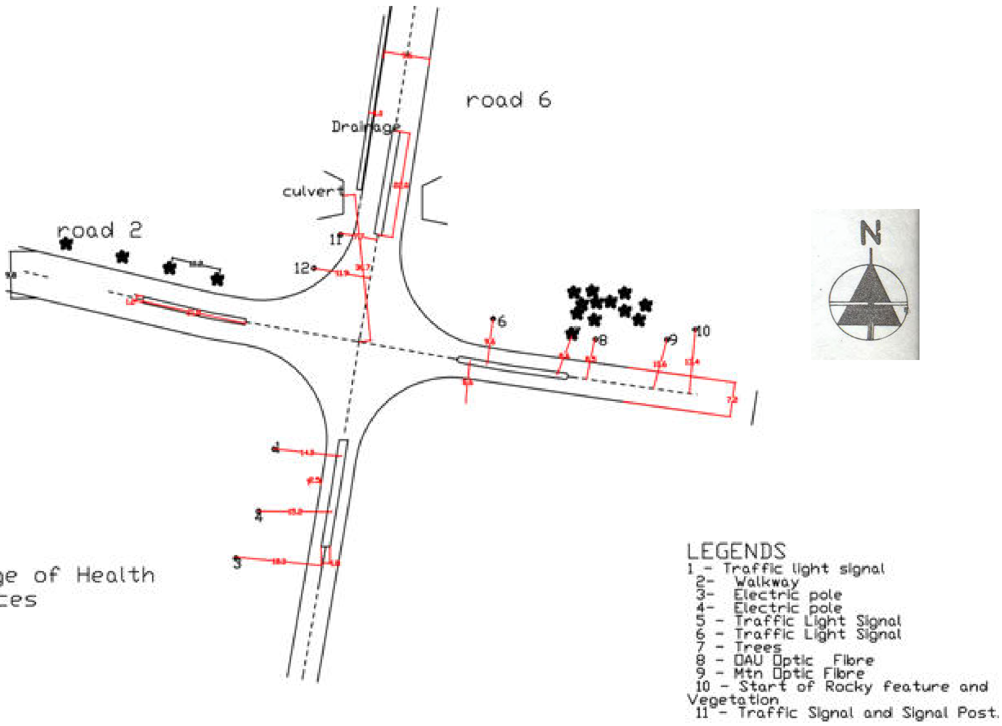

Figure 2: Intersection Configuration

Table .1: Input Data Needs for Each Analysis Lane Group

Type of Condition	*Parameter*
Geometric conditions	Area Type
	Number of lanes, *N*
	Average lane width, (m)
	Grade, *G* (%)
	Existence of exclusive LT or RT lanes
	Length of storage bay, LT or RT lane, *Ls* (m)
	Parking
Traffic conditions	Demand volume by movement, *V* (veh/h)
	Base saturation flow rate, *so* (pc/h/ln)
	Peak-hour factor, *PHF*
	Percent heavy vehicles, *HV* (%)
	Approach pedestrian flow rate, *vped* (p/h)
	Local buses stopping at intersection, *NB* (buses/h)
	Parking activity, *Nm* (maneuvers/h)
	Arrival type, *AT*
Signalization conditions	Cycle length, *C* (s)
	Green time, *G* (s)
	Yellow time), *Y* (s)

Source: Garber and Hoel, 2010.

Table 2: Level-of-Service Criteria for Signalized Intersections

Level of Service	*Control Delay Per Vehicle (sec)*
A	≤ 10.0
B	>10.0 and ≤ 20.0
C	> 20.0 and ≤ 35.0
D	> 35.0 and ≤ 55.0
E	> 55.0 and ≤ 80.0
F	> 80.0

Source: Garber and Hoel, 2010.

Table 3: Volume and Timing Input

Parameter		EB			WB			NB			SB	
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume,V(veh./h)		364			405			44			66	
% heavy vehicles, % HV	4	2	2	0	2	2	0	3	1	1	4	1
Peak hour factor, PHF		0.72			0.82			0.56			0.74	
Arrrival type, AT		3			3			3			3	
Approach pedestrian volume, v_{ped}.(p/h)		N			N			N			N	
Approach bicycle volume, v_{blc} (bicycle/h)		N			N			N			N	
Parking (Y or N)		N			N			N			N	
Parking maneuvres, N_m(maneuvres)		0			0			0			0	
Bus stopping, N_B (buses/h)		0			0			0			0	
Min. timing for pedestrians,G_p(s)		0			0			0			0	
Timing			G = 30, Y = 3							G = 10, Y = 5		
Cycle length			70							63		

Table 3 : Volume adjustment and Saturation Flow Rate

Parameters	EB			WB			NB			SB		
	LT	TH	RT	;LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume,V(veh./h)		364			405			44			66	
Peak hour factor, PHF		0.72			0.82			0.56			0.74	
Ajustment flow rate, v_p = V/PHF (veh./h)		506			494			79			89	
Ajustment flow rate in lane group, v = (veh./h)		506			494			79			89	
Proportion of LT or RT (P_{LT} or P_{RT})	0.14	0.82	0.04	0.04	0.85	0.04	0.5	0.06	0.46	0.49	0.03	0.48
Base flow, s_o(pc/h/ln.)		1900			1900			1900			1900	
Number of lanes, N		1			1			1			1	
Lane width adjustment factor, f_w		1.12			1.13			1			1.13	
Heavy vehicle adjusment factor, f_{HV}		0.994			0.994			0.994			0.994	
Grade adjusment factor, f_g		0.993			0.993			0.993			0.993	
Parking adjusment factor, f_p		1			1			1			1	
Bus blockage adjusment factor, f_{bb}		1			1			1			1	
Area adjusment factor, f_a		0.9			0.9			0.9			0.9	
Lane utilization adjusment factor, f_{LU}		1.225			1.175			0.908			0.908	
Left-turn adjusment factor, f_{LT}		0.994			0.984			0.931			0.928	
Right-turn adjusment factor, f_{RT}		0.993			0.998			0.977			0.976	
Left-turn ped./bike adjustment factor, f_{Lpb}		1			1			1			1	
Right-turn ped./bike adjusment factor, f_{Rpb}		1			1			1			1	
Adjustmted saturation flow s (veh./h),) $s = s_o N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{RT} f_{LT} f_{Rpb} f_{Lpb}$		2306			1948			1561			1569	

Table 5: Uniform Delay, d_1 (sec. / veh.)

Lane Group	d_1
EB	10
WB	10
SB	26
NB	26

Table 6: Incremental Delay, d_2 (sec. / veh.)

Lane Group	d2
EB	0.44
WB	0.66
SB	0.47
NB	0.41

Table 7: Approach Lane Group Delay, d (sec. / veh.)

Lane Group	d
EB	10
WB	11
SB	26
NB	26

Table 8: Level of Service (LOS) by Lane Group

Lane group	Delay s/veh.)	LOS	Remarks
EB	10	B	Slight delay
WB	11	B	Slight delay
SB	26	C	Acceptable Delay
NB	26	C	Acceptable Delay

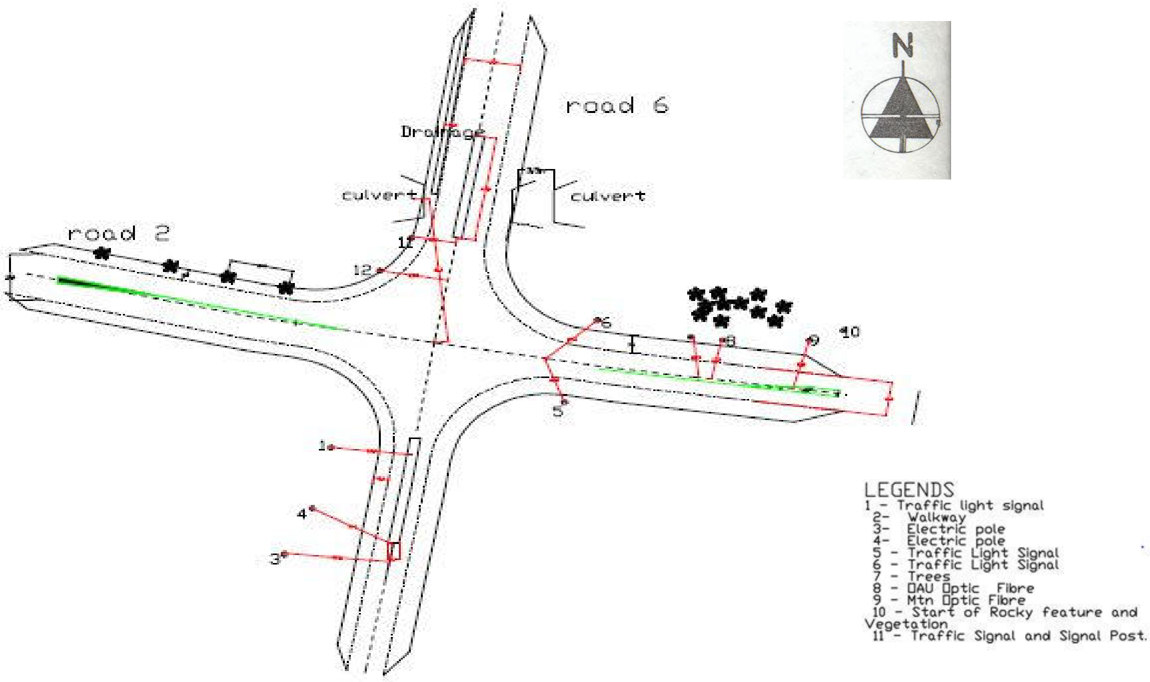

Figure 3: Proposed New Configuration of Intersection.

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