Journal of Geotechnical and Transportation Engineering
Volume 2 | Issue 1
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Received 2/23/2016 Accepted 3/29/2016
Published 4/15/2016
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Evaluation of Traffic Flow Parameters and Level of Service on Daura to Kongolom Niger Republic Border Road

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Abstract

The evaluation of the traffic flow parameters and relating the parameters to the level of services in Daura to Kongolom Niger Republic Border road is presented in this paper. The study was carried out by using moving car observer method. Data was collected for seven consecutive days, a distance of 14 km was considered for 12 runs which make a total coverage of 336 km/day. The result shows that the traffic volume was 220 veh/h (two ways) in which the proportions of trucks, buses, cars and cycles were respectively 30 %, 30 %, 23 % and 19 %. The percent time spent following was 29.42 % and the average travel speed was 72 km/h. This corresponding to level of service "C' this showed that the flows falls under a zone of stable flow.

Keywords: Traffic volume, Average travel speed, Percent time spent following and Level of services

1. Introduction

Level of service (LOS) is a qualitative measure that describes the traffic condition in term of speed, travel time, freedom to maneuver, comfort, convenience, traffic interruption and safety [1]. LOS denotes any one of a numerous number of differing combinations of vehicular and roadway operating conditions that may occur on a given lane or road while it is accommodating various traffic volume [2]. It is an important parameter for traffic engineers, transport planners and road users. Therefore, levels of service should be consistently defined and understandable to all of them.

According to [2], Level of service on two-lane highways, was described in the [6] by three parameters: (a) average travel speed, (b) percentage of time delayed, and (c) capacity use. The percentage of time delayed, the primary measure of service, is defined as the average percentage of time that all vehicles are delayed while traveling in platoons because of their inability to pass. In this paper an effort was made to evaluate the traffic flow parameters and level of service of a two-lane highway linking Daura to Kongolom border using moving car observer method.

The study was conducted on Daura Kongolom Niger Republic border road. Daura is a town and Local Government Area in Katsina State, northern Nigeria. The map of the area is shown on Fig. 1 below. It is the spiritual home of the Hausa people. Population of Daura was 156,872 as at 1991 and 224,884 as at 2006 census, and was projected to be 261,280 as at 2011. Daura has area of 316 km2 [7]. Daura is located at Latitude 13° 2′ 11″ N, (13.036389), Longitude 8° 19′ 4″ E (8.317778), Altitude 474m and local time in Daura is GMT +1 hours [8]. Daura Kongolom road is one of the important legal border routes of Nigeria Niger Republic. The route is characterrised with heterogeneous flow of traffic and this has led to the interest in conducting this study in this route.

Fig. 1. Map of Nigeria showing the location of the study area

2. Literature Review

The study of the level of service (LOS) of road networks has received very little attention in the relevant literature. However, [2] have made effort in this direction and conduct a Study on Passing - Overtaking Characteristics and Level of Service of Heterogeneous Traffic Flow. The study was conducted in streets of Dhaka, the capital of Bangladesh, based on their studies they classified them into four groups; LOS I (Free-flow condition), LOS II (Partial-constraint flow condition), LOS III (Constraint

flow condition), and LOS IV (Congested-flow condition). Similarly, [5] conducted a study of Determination of Level of Service of Agrabad to CEPZ Road at Chittagong in Bangladesh, and they discovered that the LOS vary at different time of the day due to various activities of the road users. The above studies and many more like that of [3], [9] and [10] lead to the further investigation evaluation of traffic flow parameters and level of service on Daura to Kongolom Niger Republic Border Road.

3. Methodology

Moving car observer method was used in conducting this study. The data was obtained by starting trips from Daura round-about and ended at the Kongolom Border of Nigeria - Niger Republic and vice versa. The data was collected for seven consecutive days, a distance of 14km was considered for 12runs which make a total coverage of 336 km/day.

Test car, stop watch and a tally counter were the equipment used during the data collection. Vehicles met during the exercise were the vehicles moving against the direction of the test car, vehicles overtaking the test car and the vehicles overtaken by the test car. Five persons were used in taking the data for each trip - a driver, a time keeper and three persons counting the number of vehicles met, number of vehicle overtaking the test car and the number of vehicles overtaken by the test car respectively.

Geometric details of the roads were measured and observed in the field during conducting the exercise. These include road width, shoulder width, number of lanes, terrain type, etc. The result obtained is shown in Table 1.

Table 1: Geometric features of Daura to Kongolom road

Parameter	*Value*
Road width	*9.7 m (shoulder inclusive)*
Number of lanes	*2 lanes (2-ways)*
Lane width	*3.65 m*
Shoulder width	*1.2 m*

4. Results and Discussion

Table 2 and 3 presents one-day data obtained during moving car observer (MCO).

4.1. Composition Traffic Volume of Daura to Kongolom road

Fig. 2 presents the composition of vehicles observed in the study are. It shows that the major contributors to traffic at the intersection are Trucks (30%), Buses (30%), Passenger Cars (23%) and combination of Motorcycles and Tricycles (23%).

4.2. Volume and Average Travel Time

The volume and average travel time in the direction of Daura to Kongolom and vice-versa were computed using equations (1) to (4) respectively, as follows:

$$V_D = \frac{(N_K + O_D - P_D)\times 60}{T_K + T_D} \quad (1)$$

$$V_K = \frac{(N_D + O_K - P_K)\times 60}{T_K + T_D} \quad (2)$$

$$\overline{T}_D = T_D - \frac{(O_D - P_D)\times 60}{V_D} \quad (3)$$

$$\overline{T}_K = T_K - \frac{(O_K - P_K)\times 60}{V_K} \quad (4)$$

Where,

V_D – Volume in the direction of Daura to Kongolom

V_K – Volume in the direction of Kongolom to Daura

N_D –Average No. of vehicles in opposite direction when the test car was travelling in the direction of Daura to Kongolom

N_K –Average No. of vehicles in opposite direction when the test car was travelling in the direction of Kongolom to Daura

O_D –Average No. of vehicles passed the test car when the test car was travelling in the direction of Daura to Kongolom

O_K –Average No. of vehicles passed the test car when the test car was travelling in the direction of Kongolom to Daura

P_D –Average No. of vehicles passed by the test car when the test car was travelling in the direction of Daura to Kongolom

P_K –Average No. of vehicles passed by the test car when the test car was travelling in the direction of Kongolom to Daura

$\overline{T}_D$ – Average travel time in the direction of Daura to Kongolom

$\overline{T}_K$ – Average travel time in the direction of Kongolom to Daura

Therefore, VD =111.82 veh/hr, VK =108.71 veh/hr, $\overline{T}_D$ = 15.95 min, $\overline{T}_K$ = 16.99 min

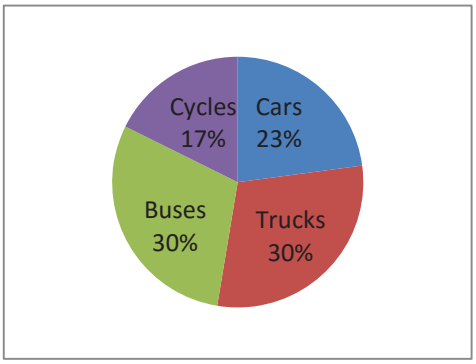

Fig. 2. Composition of Traffic volume of Daura to Kongolom road

4.3. Percent-Time Spent Following (PTSF)

Percent-time spent following (PTSF) was computed using equation (5) as follows:

$$PTSF = BPTSF + f_{d/np} \quad (5)$$

Where:

PTSF - Percent-time spent following

$f_{d/np}$– Adjustment in PTSF to count for the combine effects of both directional distribution of traffic and per cent of non-passing zones BPTSF – Base percent-time spent following

$$BPTSF = 100[1 - e^{-0.000879vp}] \quad (6)$$

$$V_p = \frac{V}{(PHF)\times(f_G)\times(f_{HV})} \quad (7)$$

Where:

V_p – Passenger car equivalent flow rate for the peak 15 min period

V – Demand volume for the entire peak hour, veh/ hr
PHF – peak 15 min volume

f_G – Grade adjustment factor for level and rolling terrain

f_{HV} – Adjustment factor to account for heavy trucks in the traffic stream

$$f_{HV} = \frac{1}{1+P_T(E_T-1)+P_R(E_R-1)} \quad (8)$$

Where

PT and PR – Decimal proportion of trucks and RVs in the traffic stream
ET and ER – Passenger car equivalent for trucks and RVs respectively
For the two ways two lane highway under consideration, using the field data obtained, Volume = 220 veh/h (two way), Percent of trucks = 30 %, Percent RVS = 23 %, Percent no-passing zone = 40%, Percent directional split = 50-50 and Peak hour factor = 0.95.

Table 2: Data for moving car observer in the direction of Daura to Kongolom

Number of Runs	Journey time (min.)	No of vehicles in opposite direction	No of vehicles passed the test car	No of vehicles passed by the test car	No of cars	No of trucks	No of buses	No of cycles
1	15.13	57	4	3	13	20	17	7
2	15.42	62	0	2	10	22	20	10
3	15.02	64	3	4	15	15	21	13
4	16.00	53	0	2	12	15	18	8
5	15.02	59	2	4	14	19	17	9
6	14.17	62	3	5	16	17	19	10
7	16.03	43	0	2	11	14	12	6
8	13.07	58	2	5	14	15	18	11
9	14.15	57	2	4	12	15	17	13
10	15.00	62	1	5	10	22	20	10
11	15.33	59	2	7	16	19	17	7
12	13.70	56	1	2	12	15	20	9
Average	14.84	57.67	1.67	3.75	12.92	17.33	18.00	48.25

Table 3: Data for moving car observer in the direction of Kongolom to Daura

Number of Runs	Journey time (min.)	No of vehicles in opposite direction	No of vehicles passed the test car	No of vehicles passed by the test car	No of cars	No of trucks	No of buses	No of cycles
1	16.00	62	1	3	14	17	20	11
2	15.50	60	3	5	10	22	18	10
3	16.42	64	0	4	12	26	19	7
4	15.92	60	2	6	16	9	21	14
5	16.33	58	1	2	12	20	14	12
6	14.83	48	2	2	10	15	17	6
7	15.83	58	4	2	13	17	20	8
8	16.00	73	0	4	20	13	19	21
9	15.00	65	0	3	17	18	16	14
10	15.70	68	2	4	14	17	17	20
11	14.42	47	0	6	10	17	11	9
12	16.02	44	2	5	17	17	8	2
Average	15.66	58.92	1.42	3.83	13.75	17.33	16.67	11.17

Using equation (7) V_p 220/0.95 =232 pc/h. And for V_p less than 600 pc/h and level terrain, [4] has provided values for f_G in Table 9.4 as f_G = 1.0, and values for E_T= 1.1 and E_R= 1.0. Using equation (8), (7) and (6) respectively, $f_{HV} = 0.973$, V_p = 238 pc/h and BPTSF =18.88%. Similarly, [4] has also provided value for $f_{d/np}$ in Table 9.3 as $f_{d/np}$ = 10.54 % by interpolation.
Therefore, PTSF = 29.42 % using equation (5).

4.4. Average Travel Speed (ATS)

Average Travel Speed (ATS) was computed using equation (9) as follows:

$$ATS = FFS - 0.00776 V_p - f_{np} \quad (9)$$

Where:
ATS - Average Travel Speed
FFS – Free Flow Speed
V_p – Passenger car equivalent flow rate for the peak 15 min period (defined in equation (7) above).
f_{np} – Adjustment for the percentage for the percentage no passing zone
Therefore, FFS was computed using equation (10) as follows

$$FFS = BFFS - f_{LS} - f_A \quad (10)$$

Where:
BFFS - Base Free Flow Speed (mi/h), BFFS has a value between 45 – 65 mi/h depending on local condition regarding the desired speed of the driver. Since the design speed of the road under consideration is 100 km/h, the BFFS = 60 mi/h
f_{LS} – Adjustment for lane and shoulder
f_A - Adjustment for access points
Using BFFS = 60 mi/h, for 3.65 m lane width and 1.2 m shoulder with, using Tables 9.9 and 9.10 provide by [4], $f_{LS} = 1.3$ and $f_A =$ 10.0 respectively. And FFS = 48.7 mi/h using equation (10). Similarly, values for E_T= 1.7 and E_R= 1.0 using Table 9.8 provided by [4]. Using equations (8) and (7) respectively f_{HV} = 0.836 and V_p = 277 pc/h. By interpolating Table 9.6 provided by [4] f_{np} = 1.9.
Finally, ATS = 71.44 km/h $\approx$ 44.65 mi/h using equation (9)

4.5. Discussions of Results

From the above calculations, the percent time spent following PTSF was found to be 29.42 % which corresponding to level of service 'A' and the average travel speed ATS was 45 mi/h which corresponding to level of service 'C' using Table 4 below. Since values of PTSF and ATS do not correspond to the same LOS, the lower LOS value is used [4]. Therefore, the level of service of the above road is class C.
This shows that the flows approaches zone of stable flow, but speeds and maneuverability are closely controlled by the traffic volume. Most of the drivers are restricted in their freedom to select their own speed, change lanes, or pass. A relatively satisfactory operating speed was obtained, with service volume suitable for urban design practice.

Table 4: Level-of-Service Criteria for Two-Lane Highways in Class I

Level-of-Service	*Percent Time-Spent-Following (%)*	*Average Travel Speed (mi/h)*
A	*< 35*	*> 55*
B	*> 35 -50*	*> 50 – 55*
C	*> 50 – 65*	*> 45 – 50*
D	*> 65 – 80*	*> 40 - 45*
E	*> 80*	*< 40*
F	*Whenever the flow rate exceeds the segment capacity*	

Source: [4]

5. CONCLUSION

On the basis of experimental studies carried out by using moving car observer method and analyses performed, the following conclusions are drawn:

1. The result shows that the traffic flow toward Daura to Kongolom road is higher compared with the traffic flow towards Kongolom to Daura road. This is expected because more traffic was moving toward Border of Niger republic. It also shows that there is more traffic in weekend compared to those obtained on week days.
2. The geometric feature of the road showed that the road is a two lanes two ways highway with road with of 9.7 m (shoulder inclusive) and the area has relatively level terrain.
3. The traffic volume was 220 veh/h (two way), the proportion of trucks was 30 %, the percent time spent following was 29.42 % and the average travel speed was 45 mi/h equivalent to 72 km/h. This corresponding to level of service "C' this shows that the flows approaches zone of stable flow.

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