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Evaluation of Unstable Traffic Flow Characteristics within Port Harcourt Road Intersections using the Trip Generation Model

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Abstract— Congestion has become a major problem in the City of Port Harcourt especially during rush hours, basically due to the vast increase in population growth and poor behaviour of road users which eventually results in a significant increase in travel time. Hence, it became imperative to carry out a trip distribution analysis in some major intersections of the city. From the analysis carried out adopting the doubly constrained gravity model, the traffic assignment loading was generated to identify the unstable flows for each zone in trips per day and trips per hour. Consequently, Agip/Ada-George amounted to 10,635/day and 443/hr, Ada-George/Iwofe 49,602/day and 2,067/hr, Location/NTA 50,375/day and 2,099/hr, Rumuokwuta rotary 73,486/day and 3,062/hr while Wimpey/Iwofe 79,913/day,3,330/hr. However, referring to the Highway Capacity Manual (HCM), the LOS from our analysis was established between LOS D and LOS E ascertaining the unstable nature of the traffic flow network with a class II highway having a maximum delay (PTSF) of 70 to 85% of the time. Our recommendation is that the Government and transportation agencies should carry out proper traffic analysis to generate present day traffic data to better understand the travel demand before the improvement of any intersection.

Index Terms— Assignment, Congestion, Delay, Distribution, Unstable, Constrained, Forecast.

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1. INTRODUCTION:

Transportation is either provided by self or by a second party in response to the socio-economic needs of the user. The nature of emerging urban forms and settlement patterns have given rise to a situation where large number of people with unequal resources needs to go to the same place at the same time for both related and unrelated purposes. The provision of transportation cannot be unlimitedly open neither can the need for transportation be provided either by the public or the private sectors of the economy in exclusion of the other. In developing countries with mixed economies such as Nigeria, goods and services are jointly provided by the public and private institutes. The public concentrates more on service provision and the private on both goods and services. Besides providing the legislative framework for transportation systems and public transportation infrastructure, the government provides transportation modes to users via vehicles that run in and outside cities and towns. In Nigeria, this kind of transportation is provided in the State and Federal level of governments. The city of Abuja today is used as a reference in Nigeria for its integrated public transport system.[1] Over the years, due to its ever-increasing population, movement has become enormously difficult and hence, making transportation a big problem in the city of Port Harcourt. With private car owners, it is the problem of traffic jam while commuters face a compounded problem of both traffic jam and dearth of decent commercial vehicles to move about in. It can be observed, however, that the population distribution in the different neighbourhoods of the city goes a long way in determining the type of transportation problems associated with such areas. [2]

A range of postulations need to be made relating to the criteria behind the choices people make and how they react to a particular transportation alternative. [3]

Transportation modelling and simulation as interface in the planning process plays an important role in enabling spatial development. The development of simplified models in transportation planning is a representation of real-life occurrences which can be used to explore the consequences of particular policies, strategies and spatial changes. The study therefore looks at the neglected obscured facet of transportation planning in Port Harcourt and its impact on the efficiency of transportation provision.

2. MATERIALS AND METHODS:

This chapter describes the procedures adopted in carrying out the distribution model to evaluate the traffic network at the intersections.

2.1 Area of Study

The study will be conducted at critical intersections in Port Harcourt. The intersections are namely; Agip by Ada George (4-legged intersection), Ada George by Iwofe (4-legged intersection), Location by NTA road (3-legged intersection), Rumuokwuta rotary and Wimpy by Iwofe (3-legged intersection)

2.2 Equipment used

Some of the equipment used include; Stop watch, Pencils, Erasers, Sharpeners and Recording traffic data sheet

2.3 Methods

1) Manual traffic count
2) Spot speed studies
3) Travel time
4) Doubly constrained gravity model

The distribution of trips will begin by introducing an origin-destination matrix for all zones. Trip distribution is concerned with establishing the links between several zones for which trip generation calculation have previously been made. The mathematical procedure developed and most widely used synthetic method of trip distribution ''Doubly-constrained gravity model'' shall be applied. Doubly constrained gravity model is an iteration process of calculating values for traffic analysis zone (i) D_i and traffic analysis zone (j) E_j to the point of uniqueness. The formula is stated thus.

$$Tij = \frac{P_i A_j F(dij)}{\sum_{j=1}^{n} A_j F(dij)} \quad (2.1)$$

$$Di^{-1} = \sum_{i=0}^{n} Ej^{-1} A_j F(dij) \quad (2.2)$$

$$Ej^{-1} = \sum_{i=0}^{n} Di^{-1} Pi\ F(dij) \quad (2.3)$$

Where T_{ij} = The predicted numbers of trip between zone i to zone j in a specified amount of time (usually rush hour).

P_i = Total trips produced in TAZi.

A_j = Total trips attracted to TAZj.

$F(d_{ij})$ = Deterrence function between TAZi and TAZj

D_i^{-1} =Iteration factors with respect to TAZi

E_j^{-1} =Iteration factors with respect to TAZj

Notice that the expression for D_i^{-1} includes the term E_j^{-1}, while that for E_j^{-1} includes D_i^{-1}. This means that they must be computed by iteration. The iteration is accomplished by first setting $E_j^{-1} = 1$ and solving for D_i^{-1}. The resulting D_i^{-1} is then plugged into (2.2). The iteration continues until D_i^{-1} and E_j^{-1} no longer changes. The next process is to ascertain the level of traffic on each link of the network. The forecasted values shall be the value numbers. This process is called the trip matrix.

i-zones	**j-zones**				
	Zone 1	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**
1	**P1A1D 1E1 F(d1,1)**	**P1A2D2 E2 F(d1,2)**	**P1A3D 3E3 F(d1,3)**	**P1A4D 4E4 F(d1,4)**	**P1A5D 5E5 F(d1,5)**
2	**P2A1D 1E1 F(d2,1)**	**P2A2D2 E2 F(d2,2)**	**P2A3D 3E3 F(d2,3)**	**P2A4D 4E4 F(d2,4)**	**P2A5D 5E5 F(d2,5)**
3	**P3A1D 1E1 F(d3,1)**	**P3A2D2 E2 F(d3,2)**	**P3A3D 3E3 F(d3,3)**	**P3A4D 4E4 F(d3,4)**	**P3A5D 5E5 F(d3,5)**
4	**P4A1D 1E1 F(d4,1)**	**P4A2D2 E2 F(d4,2)**	**P4A3D 3E3 F(d4,3)**	**P4A4D 4E4 F(d4,4)**	**P4A5D 5E5 F(d4,5)**
5	**P5A1D 1E1 F(d5,1)**	**P5A2D2 E2 F(d5,2)**	**P5A3D 3E3 F(d5,3)**	**P5A4D 4E4 F(d5,4)**	**P5A5D 5E5 F(d5,5)**

3. RESULTS AND DISCUSSION:

The main objective of this chapter is to analyse the field data collected which comprises of Volume studies and Speed speeds at different zones.

Table 3.0: Balanced Trip Productions and Attractions

S/N	ZONES	PRODUCTION	ATTRACTION
1	AGIP/ADAGEORGE	80,566	81,380
2	IWOFE/ADAGEORGE	88,561	84,833
3	LOCATION	50,158	59,843
4	RUMUOKWUTA	157,907	150,520
5	WIMPEY	41,276	41,892
TOTAL		418,468.00	418,468.00

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Table 3.1: Convergence of Estimates by Iteration

50				51			
D_1	166471	E_1	1.4729	D_1	166470	E_1	1.4729
D_2	113956	E_2	1.2756	D_2	113955	E_2	1.2756
D_3	200033	E_3	2.8883	D_3	200032	E_3	2.8883
D_4	109331	E_4	1.1414	D_4	109331	E_4	1.1414
D_5	236229	E_5	2.5597	D_5	236228	E_5	2.5597

Following the above studies, the Resultant trip matrix is gotten by imputing the values of Production, Attraction, convergence values Di and Ej gotten from the iteration and the deterrence functions values as presented in the table 2.0 above. The Resultant Trip Matrix results are shown in table 3.2 below.

RESULTANT TRIP MATRIX

Tij = Pi.Aj. D-1. E-1. F(dij) RESULTANT TRIP MATRIX

I – zones						
	1	2	3	4	5	
1		25877.4922	6226.9945	42569.4460	5892.9232	**80567**
2	3452.3085		1246.2334	72020.1268	11841.3395	**88560**
3	8603.5316	12907.1991		25693.1939	2954.7127	**50159**
4	53226.5503	60224.8765	23251.4552		21202.7666	**157906**
5	7182.6316	10818.4795	2606.5723	20668.7882		**41276**
						418468

Considering the results obtained in Table 3.0 and Table 3.2, we can agree that our Doubly constrained model has reached a solution that fulfils the two constraints.

$\Sigma Tij = Pi$ (Balance of flows from productions)

$\Sigma Tij = Aj$ (Balance of flows to attractions)

Further iteration is unnecessary rounding to four decimal places, since our productions and attractions can only be sensibly represented with whole numbers.

Traffic Assignment

The all or nothing procedure is considered during trip loading. Trips linking two or more modes are been loaded from the calculated resultant trip matrix. At the end of the trip loading the link with the higher number of trips is considered as the design link. The loaded trips on the links as shown in table 4.17

Assignment of Trips from Nodes to Links

Link	Trips on Link
1	3452.3085+7182.6316=10,635
2	25877.4922+12907.1991+10818.4795=49,603
3	25877.4922+1246.2334+23251.4552=50,375
4	25877.4922+1246.2334+25693.1939+20668.7882=73,486
5	25877.4922+1246.2334+25693.1939+21202.7666+5892.9232=79,913

LINK ROADS	TRIPS/DAY	TRIPS/HOUR
1	10,635	443
2	49,603	2067
3	50,375	2099
4	73,486	3062
5	79913	3330

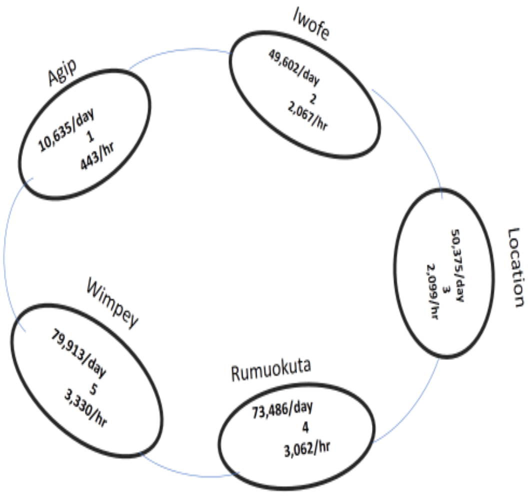

Figure 3.0: Results from link assignment

From the traffic assignment loading in our analysis, we were able to identify the flows for each zone i.e trips per day and passenger cars per hour as shown in the table. From the Highway Capacity Manual, the LOS from our analysis is between LOS D and LOS E. This makes the network unstable flow.

The unstable flow network is a class II highway with a maximum delay (PTSF) of 70 to 85% of the time. Maximum service flow rate under base conditions is between 443pc/hr to 3,330pc/hr.

4.0 Conclusion

Based on the aim of this research, the following conclusions were reached:

The traffic volume obtained at the intersections using manual method and trip generation model are: Agip by Ada-George 10,635 pcu per day, Iwofe by Ada-George 49,602 pcu per day, location by NTA 50,375 pcu per day, Rumuokuta Rotary 73,486 pcu per day and Wimpey by Iwofe 79,913 pcu per day.

Subsequently from the traffic loading, we were also able to identify the occurrence of unstable flows at the intersections which were at Rumuokwuta rotary and wimpy by Iwofe.

Finally, the factors responsible for the continuous congestion at the intersection during peak hours are:

i. Lack of traffic discipline: buses stop near intersections and in lanes just in front and near intersections without any consideration of traffic flow. Buses stop in the middle of the road to pick and drop passengers.

ii. Poor pedestrian facilities: pedestrians walk on the roadway because sidewalks are used by hawkers or illegal parking. This constitutes unsafe situation to lives

iii. Poor Education for Drivers; most of the drivers are not well trained, they got their licenses without being tested on driving skills. They do not even know the traffic rules. I got to know this from some interviews with some of them.

iv. Ineffectiveness of Traffic Control officers.

v. Poor traffic signals: some of the traffic signals are malfunctioning.

4.1 Recommendations

From the analysis and observations, we were able to establish the following recommendations based on the study carried out.

i. Introduction of bus stop facilities.
ii. Introduction of traffic control devices such as road markings, signs and signals.
iii. Introducing pedestrians crossing facilities and introduction of parking facilities of the road.
iv. Strengthening of traffic police.
v. Enforcement of the rule of law.
vi. The researcher is recommending that government and transportation agencies should carry out proper traffic analysis before the improvement of any intersection to generate present day traffic data to better understand the travel demand before construction.

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