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MITIGATION OF TRAFFIC CONGESTION: A TOOL FOR DEVELOPMENT AND URBANIZATION

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ABSTRACT

Traffic congestion is a condition on road networks that occurs as use increases. This is characterized by slower speed, longer trip times and increased vehicular queuing. This can be demonstrated by the physical use of roads by motor vehicles. Congestion results when traffic demand is large enough such that the interaction between vehicles slows down the speed of the flow of traffic. When this occurs at an intersection, huge traffic congestion results and as such, it is traditionally referred to as traffic jam or traffic snarl-up and a good road network is the most important key to the spatial organization of society. The Calabar Metropolitan City road network intersections comprising; Calabar road, Murtala Muhammed High way (MMHW), Etta Agbor, Marian, MCC Roads, Parliamentary Extension, Good Luck Jonathan Bye Pass, Atimbo Road, Mary Slessor Road, Tinapa and Odukpani Junctions and environs or adjoining streets and internal roads in the metropolis and the UNICEM/Lafarge Factory- Odukpani Junction alternative evacuation road were studied. Though not all of them are signalized, therefore needing the services of traffic controllers to facilitate traffic. The case of Calabar Road- MMHW-Odukpni Road traffic jam or traffic snarl-up has worsened. The lack of maintenance and expansion of these roads is becoming evident by the day as commuters and other road users manoeuvre through narrow and poorly built roads or having to sleep on the road or spend 3 hours to 8 hours for a journey of 20 to 30 minutes. It is conventional that towns grow into cities in an ad-hoc manner, with usually no provision made towards scaling road capacities, eventually resulting into several bottleneck roads, which remain congested for extended periods of time. More so, Calabar has witnessed a geometric growth in her vehicular population resulting in the failure of traditional traffic management strategies.

Contribution/ Originality: This paper presents new and concise ways of mitigating traffic problems. Calabar has faced these challenges over the years, therefore the need for this research work. With the implementation of the recommendations in this work, development will be enhanced. These models can be applied anywhere with similar problems.

1. INTRODUCTION

The definitions of the term congestion mention such words as "clog," "impede," and "excessive fullness." For anyone who has ever sat in congested traffic, those words should sound familiar. In the transportation realm, congestion usually relates to an excess of vehicles on a portion of roadway at a particular time resulting in speeds that are slower—sometimes much slower—than normal or "free flow" speeds. Congestion often means stopped or stop-and-go traffic. According to Federal Highway Administration's (FHWA) Office of Operations, (2002) [1] Congestion is relatively easy to recognize; roads filled with cars, trucks, and buses, sidewalks filled with pedestrians.

In addition, traffic congestion is a condition on road networks that occurs as use increases. This is characterized by slower speed, longer trip times and increased vehicular queuing. This can be demonstrated by the physical use of roads by motor vehicles [2]. Congestion results when traffic demand is large enough such that the interaction between vehicles slows down the speed of the flow of traffic. When this occurs at an intersection, huge traffic congestion results and as such, it is traditionally referred to as traffic jam or traffic snarl-up. Thus, intersection is a major cause of traffic jam in a road network, thereby contributing to congestion. Delay at intersections is the major factor in the analysis of traffic jam. Because junctions are complex areas of traffic interactions their physical characteristics i.e. number of lanes, gradient, geometric layout, bus stops and pedestrian crossings traffic use (volume and turning movements, speeds and pedestrian flow) and forms of traffic control (signals, channelization all influence the nature of delay. The situation become worst in all un-signalized intersections as impatient motorists always insist on crossing the intersection first, thereby creating heavy traffic jam at the intersection. Some examples of intersection include; signalized intersections, un-signalized intersection and roundabouts.

It has been said that a good road network is the most important key to the spatial organization of society. Hence, the place of efficient road network can never be over emphasized. Aderamo and Magaji [3] noted that a good road network promotes national unity and socio economic integration, which encourages togetherness and understanding of a diversified society. More so, is the obvious fact that most cities are found in foci of transport route-rail, water, road and air Oni and Okanlawon [4].

In this study, the Calabar Metropolitan City road network intersections comprising; Calabar road, Murtala Muhammed High way (MMHW), Etta Agbor, Marian, MCC Roads, Parliamentary Extension, Good Luck Jonathan Bye Pass, Atimbo Road, Mary Slessor Road, Tinapa and Odukpani Junctions and environs or adjoining streets and internal roads in the metropolis and the UNICEM/Lafarge Factory- Odukpani Junction alternative evacuation road were studied. Though not all of them are signalized, therefore needing the services of traffic controllers to facilitate traffic.

The case of the Calabar road network intersections is worrisome because of the negative social trend that adds to make mobility a herculean task couple with the fact that there is only one access and exit or entry into Calabar Metropolis with just a single lane carriage way. This social menace result because Calabar is the second largest City where Tank Farms are located, The Calabar Free Trade Zone (CFTZ), Port Authority, Lafarge Cement Factory at Nfamoseng, Granite Quarries located at Akamkpa supplying products to the North East, North Central, South East and South-South regions of the Country and when Trucks conveying Petroleum Products, Cement, Quarry products and other goods and services in and out of the metropolis start moving through the only entry/exit single lane carriage way (Murtalla Muhammed-Odukpani Road) creates traffic bottle necks thereby, encouraging wanton disregard of traffic rules and unnecessary build-up of traffic along the Metropolis.

Therefore, this work investigates the ways of improving this road network in a bid to eliminate or reduce to the barest minimum, the bottlenecks generated by road use and the activities of miscreants on the road network.

Calabar, like other growing Cities have found itself at the brink of massive traffic explosion, hence bears on her ability to manage traffic. The case of Calabar Road- MMHW-Odukpni Road traffic jam or traffic snarl-up has worsened. The lack of maintenance and expansion of these roads is becoming evident by the day as commuters and other road users manoeuvre through narrow and poorly built roads or having to sleep on the road or spend 3 hours to 8 hours for a journey of 20 to 30 minutes. It is conventional that towns grow into cities in an ad-hoc manner, with usually no provision made towards scaling road capacities, eventually resulting into several bottleneck roads, which remain congested for extended periods of time. More so, Calabar has witnessed a geometric growth in her vehicular population resulting in the failure of traditional traffic management strategies.

According to Boddapaty [5]; Box and Alroth [6] drivers often are not trained sufficiently to follow lane discipline. The impact of lane indiscipline, especially at road junctions, deteriorates the already overcrowded junction situation. It is easily observed that drivers frequently jump red lights or disobeyed traffic warders and ultimately block the intersection, causing further traffic congestion. These problems are compounded by the fact that traffic law enforcement is poor, thereby providing no incentive for drivers to follow the rules.

In Ali [7] like most cities and states in Nigeria, Cross River State does not have efficient mass transit system, forcing people to operate private vehicles. This problem is compounded by the social stigma, where people view operating a private vehicle as a sign of prosperity, while public transport is viewed as being used by the lower echelons of society.

Bunting [8]; Chijioke and Ugwuanyi [9] traffic junctions are often unmanned, thereby allowing drivers to drive in a chaotic manner. Even if a junction is controlled by a cop or a traffic light, the traffic junctions are largely independent of any traffic management strategy, only optimizing the respective junction traffic flow, in the direction of maximum traffic build up. Furthermore, these approaches enhance traffic mismanagement in already congested roads, accelerating congestion collapse.

From Downs [10] a significant amount of investment is required to set up a traffic management infrastructure which can scale with increasing traffic. Such an infrastructure not only involves measuring and analyzing real – time traffic data but also focuses on enhancing congestion detection, solving real time congestion and forecasting congestion scenarios.

In Newman and Kenworthy [11]; Olagunju [12] good road network provides access to social amenities, public facilities and socio economic activities. It provides the diffusion of new technology and techniques, increases production, reduce marketing cost, increase spatial interaction and increase link access to education and health facilities and also increases mobility and reduce isolation in other words Development and Urbanization.

Apart from the civil service and the educational system that has employed a large number of the work force in the old City of Calabar, the transportation system is also a huge employer of labor and hence, has served as the backbone of urban activities in the state. Eight Miles-Odukpani as a residential suburb with a growing population and diversified land-use activities needs her transportation system (majorly roads) to be updated or readjusted. This is because any lag between growing transportation demand and network capacity, results in traffic congestion. This further leads to economic losses and environmental pollution.

In the case of Calabar situation; there has been a deliberate inability to understand the factors causing problems and the lack of proper planning to improve the situation. To cope with the situation, it is important to ensure proper use of available facilities and the development of infrastructure through optimum utilization of available infrastructures and facilities and the development of infrastructure through optimum utilization of available infrastructure and resources. How much of this optimum utilization is based on informed analysis of traffic information?

It is important also to treat the case of touts (unofficial road traffic controllers) extorting money from commuters at Nasarawa Junction at eight miles. This singular act condones and encourages the flagrant abuse of traffic laws and use of available infrastructure. Aliogo [13]; Bartone, et al. [14] the demand for a good road network is closely related to economic activities, land-use, population and its distribution. Its development involves huge amount of money and a substantial amount of time. From the foregoing, any decision regarding an improvement on a road network requires adequate amount of planning, which should be justified by efficient vehicular data analysis that ensures that the existing roads as they are, are utilized to their designed capacities. There is also a near absent traffic management agency charged with the responsibility of advising and disseminating the collated traffic information.

2. MATERIALS AND METHODS

2.1. Analysis of Traffic Congestion in Calabar Road Network Intersections

Traffic congestion can be attributed to various ills ranging from infrastructure to social misbehavior, leading to disparity between transportation demand and supply. When economic activities lag behind the transportation system, it results in traffic congestion which has already become a part of urban road system. Such traffic congestion not only cause problems to urban transportation activities but also causes degradation to natural environment by increasing the magnitude and intensity of air pollution.

It may become a futile effort to eliminate completely traffic congestion from the transportation network, but minimizing traffic congestion is the real challenge for transportation/traffic engineers and other urban planners.

The methodology been developed is based on one parameter which is; traffic congestion. This parameter was computed for the study area and interpreted to determine the severity or otherwise of the current traffic situation in the study area and proffer ways of improving the situation. This may be in the form of advice to urban planners to help alleviate the traffic congestion problem from Calabar in Cross River state.

The procedures adopted include:

i. *Description of study area*
ii. *Generation of data on vehicular count*
iii. *Employment of various indices for quantifying the overall vehicular traffic volume within the study area.*

Calabar is the capital city of Cross River State, the city is divided into Calabar Municipal and Calabar South. Calabar Metropolis is a city in Cross River State, coastal South Eastern Nigeria. It stands on latitude 04^0 15^0 and 5^0 N longitude 8^0 25^0E. It is bounded in the North by Odukpani, East by Akpabuyo local government areas, south by the Atlantic.

2.2. Traffic Volume Count

The method employed was that of a field team to record traffic volume on the prescribed record sheets. This is preferable as data which cannot be collected by mechanical counters are obtained. This includes; vehicle classification, turning movements and counts where loading conditions or number of occupants are required. This implies that physical counting (manual) is a good method as adopted by the researcher. It could include 5, 10, 15, or 30 minutes. This method is very commonly adopted due to specific advantages over other methods. Traffic volume counts are performed at major intersections and important links only in the period of peak flows as assessed by twelve-hour traffic volume count. The traffic volume is expressed as passenger car unit per hour (PCU/h).

2.3. Intersection Classification Count

The main objective of the Manual Traffic Counts was to obtained information on traffic volume and composition. Manual Classified Count was carried out for three days at all the intersections.

The idea of this count is to collate vehicular movement data within the study area that will give a good picture of the current traffic on the Calabar road network intersections. The total number of vehicles by type moving in each direction was recorded. The counts were carried out for 12-hours each day. A field team was assembled for this purpose as one enumerator recorded vehicles by type in one direction of the project road and the other enumerator also undertook the same exercise in the opposite direction. The 12-hours count conducted at these stations forms the basis for computing the Traffic Flow Characteristics, Traffic Variation Factors, Hourly Traffic Distribution, and Traffic composition. The following classes of vehicles were used: Tricycles, Taxis, Cars, Buses, Light Trucks/Pick-ups, Heavy Trucks/ Trailer.

2.4. Ways to Quantify Congestion

The following congestion indexes were selected for the study and are described in the successive subheadings. Even though a number of studies have been carried out by a number of researchers and professional organization to develop congestion indices (National Cooperative Highway Research Program (USA); Texas Transportation Institute (TTI), and Federal Highway Administration etc), these indices so proposed are mainly for freeways, corridor analysis or arterial roads etc. For regional or area wide analysis such type of indices cannot be used directly, hence themes can be translated to suit this particular study.

2.5. Road Capacity

$$c = \frac{3600}{t_s + t_m} \tag{2.1}$$

Where;

c = capacity on a given approach or lane (veh/hr)

t_s = average service time or service delay on the approach or lane (sec)

t_m= average move-up time (sec)

Service time is the time span that a minor stream vehicle stays at the stop line position. Move-up time is the minimum time required for a vehicle to reach the stop line position after the previous vehicle leaves the stop line.

Capacity can be calculated as the number of vehicles that can be served during a one-hour period (3600 seconds).

The service time is affected by vehicles on the other intersection approaches. At two way stop control (TWSC) intersection, minor stream vehicles must yield the right-of-way to major stream vehicles. Generally, move-up time is not affected by traffic conditions on the other approaches. Therefore, a constant value of two (2) seconds representing typical conditions can be used or the move-up time. In order to have capacity estimation, only individual service times need to be measured.

2.6. Total Delay

Service time and other delay times can be obtained by recording the following vehicle events; time a vehicle enters a queue; time a vehicle reaches the stop line until the vehicle exits the stop line. The total delay for each individual vehicle can be measured as the time span when a vehicle enters a queue until the vehicle exits the stop line.

Thus, the procedure for measuring delay at an un-signalized intersection is as stated below. The method involves counting the number of standing vehicles (queue length) at 15-seconds intervals, which yields the total delay in terms of vehicle-hours using the following equation:

$$D = \sum_{i=1}^{n} L_i \times \frac{15}{3600} \tag{2.2}$$

Where;

D=Total delay (Veh-hrs)

L_i=Queue length observed in the interval 'i'

n=number of 15-second intervals in an hour (3600/15)

2.7. Queue Length

The equation below can be used to establish the relationship between average queue length and average delay.

$$\bar{L} = d \times \frac{V}{3600} \quad (2.3)$$

Where;

$\bar{L}$=average queue length (Veh)

d=average total delay (sec/veh)
V=traffic volume (veh/hr)
Equation (3.3) can be easily transformed into equation (3.2) using the relationship shown in equations (3.4) and (3.5) as shown below.

$$\bar{L} = \frac{1}{n}\sum_{i=1}^{n} L_i \quad (2.4)$$

$$d = \frac{D}{V} \times 3600 \quad (2.5)$$

Field queue length was collected based on 30 seconds intervals and was compared with the queue length calculated based on equation (2.3).

2.8. Delay and Capacity

This method can be proposed for field measurement of capacity and delay based on the following principles. Queue length can be measured by counting the number of vehicles in a queue based on a certain time interval, say 15 or 30 seconds. At the same time, the number of vehicles departing from the stop line must also be counted. The average queue length and the hourly flow rate over the measurement period can then be calculated. Average total delay can be calculated using Equation (2.6). Using the models given in the 1994 HCM, capacity can then be calculated. For TWSC intersections, the model is given in Equation 2.6:

$$d = \frac{3600}{C} + 900T\left[\frac{V}{C} - 1 + \sqrt{\left(\frac{V}{C} - 1\right)^2 + \frac{\left(\frac{3600}{C}\right)\left(\frac{V}{C}\right)}{450T}}\right] \quad (2.6)$$

Where;
d = average total delay (see/veh)
V = movement volume (veh/hr)
C = movement capacity (veh/hr)
T = analysis time period in hours (generally use 0.25)
By solving Equation (2.7) for capacity, the following equations (2.8; 2.9; 2.10) can be obtained:

$$C = \frac{-a_2 + \sqrt{a_2^2 - 4a_1a_3}}{2a_1} \quad (2.7)$$

Where;

$$a_1 = d^2 + 450d \quad (2.8)$$

$$a_2 = 101250V - 2(d + 225)(3600 + 225V) \quad (2.9)$$

$$a_3 = 3600(3600 + 450V) - 1620000V \quad (2.10)$$

Capacity can be estimated given volume and delay values.

2.9. Congestion Severity Index (CSI)

It is used by Federal Highway Administration Authority (FHA, USA) in reporting the results of system analyses using "Highway Performance Monitoring System" data. The CSI has units of roadway delay per million vehicle kilometre of travel. For the present study, the CSI would be the ratio of the average total delay experienced to the traffic queue length at the instant in travel, and then the equation of CSI would stand as follows:

$$CSI = \frac{\text{Average Total Delay (Sec/Veh)}}{\text{Traffic Queue Length } (Veh)} \quad (2.11)$$

It indicates the loss of Vehicle-hour per Thousand Vehicle-Kilometre travel.

2.10. Traffic Growth Rate

Traffic growth rates would be determined by comparing traffic data collected at the same locations in two different years (i.e. in the past year and the current year). In the case of Sekondi-Takoradi Metropolis, the last data collection was done in July 2003 and the present in November 2008. The formula used in the computation of the traffic growth rates from the previous traffic data obtained by the Department of Urban Roads (DUR) Sekondi-Takoradi is discussed given as:

$$P_f = P_p(1 + r)^n \quad (2.12)$$

Where;

P_f= Future Traffic Volume

P_p= Past Traffic Volume

r = Rate of growth in decimals

n = Number of years between the previous and expected traffic data

This actually measures the growth in traffic over a period of time within an area.

2.11. Mobility Level

Sometimes the mobility level of an individual link is measured by volume-capacity ratio.
Such type of measure is proposed by Houston-Galveston Council of Traffic Modelling which is shown in Table 2.1.

Table-2.1. Scale of Different Mobility Levels

Level of Mobility	Volume / Capacity
Tolerable	<0.85
Moderate	≥0.85<1.00
Serious	≥1.00<1.20
Severe	≥1.20

(**Source:** Highway Capacity Manual (HCM) [1])

This type of measure divides the roadway lengths of the network into a number of classes, expressed as a percentage of total lengths according to mobility levels.

3. RESULTS AND DISCUSSIONS

Traffic in the study area was surveyed for three days each at the different intersection where traffic data were collected. The result of the data obtained was summarized into tables and graphs to clarify the road traffic pattern obtainable in the study area. The analysis of the results of the field studies has been presented.

3.1. Intersection Classification Counts

Data for the Classification Counts were collated and analyzed to obtain traffic flow characteristics, variation factors, hourly distribution factors, traffic composition and traffic growth rates.

3.2. Traffic Flow Characteristics

The results from Table 3.1 shows the general summary of Traffic Flow Characteristics of the Calabar Metropolis Road networks highlighting four (4) major intersections/Junctions, indicating the Average 12-hour daily volumes, the Average AM-peak and PM-peak volumes, Average 24 hours' volumes and various traffic variation factors in view of the 24-hours average totals. The results show that the average 12-hour daily flows at the major intersection/Junction form more than 70% of the average total of the 24-hours flow. The data for this result were collected and analysed for a period of three (3) days each at various intersections/Junction in the study which is presented in table 3.1

Table-3.1. Traffic Flow Characteristics at the Major Intersections in Calabar Metropolis.

Ref.	ODUKPANI JUNCTION - TINAPA JUNCTION			U.J ESUENE STADIUM - ATIMBO JUNCTION(UNICEM ROAD)			ETIM EDEM - MARY SLESSOR - UNICAL MAIN GATE			MELLENNIUM PARK - WATT MARKET ROUNDABOUT		
Average Weekday Hour Volume	2236	2335	2258	1834	1796	1840	2822	2817	2863	2140	2136	2321
	6.78%	6.82%	6.72%	7.18%	7.21%	7.23%	7.16%	7.00%	6.93%	6.44%	6.57%	6.77%
AM Peak Hour	2355	2375	2338	2033	2205	2081	4260	4250	4230	2676	3283	3498
	7.14%	6.93%	6.96%	7.96%	8.85%	8.18%	10.81%	10.56%	10.24%	8.05%	10.10%	10.20%
PM Peak Hour	2928	2881	2965	1932	1963	2045	4690	4768	4913	2474	3737	4150
	8.88%	8.41%	8.82%	7.56%	7.88%	8.04%	11.90%	11.84%	11.90%	7.44%	11.50%	12.10%
Average Hour 7AM - 7PM	26836	28016	27098	22004	21552	22075	33869	33806	34354	25683	25632	27847
	81.35%	81.79%	80.65%	86.14%	86.55%	86.81%	85.93%	83.97%	83.18%	77.24%	78.87%	81.19%
Average Hour 24hour	32989	34252	33601	25545	24902	25428	39414	40258	41300	33250	32500	34300
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Akeke M.Eng Thesis, 2018

Table-3.2. Average of Traffic Flow Characteristics at the Major Intersections at Calabar Metropolis

Ref.	ODUKPANI JUNCTION - TINAPA JUNCTION	U.J ESUENE STADIUM - ATIMBO JUNCTION(UNICEM ROAD)	ETIM EDEM - MARY SLESSOR - UNICAL MAIN GATE	MELLENNIUM PARK - WATT MARKET ROUNDABOUT
Average Weekday Hour Volume	2276	1823	2834	2199
	6.77%	7.21%	7.03%	6.59%
AM Peak Hour	2356	2106	4247	3152
	7.01%	8.33%	10.53%	9.45%
PM Peak Hour	2925	1980	4790	3454
	8.70%	7.83%	11.88%	10.36%
Average Hour 7AM - 7PM	27317	21877	34010	26387
	81.27%	86.50%	84.34%	79.12%
Average Hour 24hour	33614	25292	40324	33350
	100%	100%	100%	100%

Source: Akeke M.Eng Thesis, 2018.

From Table 3.2, the Odukpani Junction – Tinapa Junction (1) recorded the highest 24 hours' traffic of 47080 veh/day, followed by Millennium Park – Watt Market Roundabout (3) with 41324 vch/day. It also followed by Etim Edem- Mary Slessor Unical Main Gate (4) and finally the U.J Essene Stadium – IBB – Atimbo Junction with 33417 vch/day and 29519 vch/day.

The Millennium Park- Watt Market Roundabout intersection (3) recorded the highest AM peak hour and PM peak hour volumes of 4247 (10.28%) veh/day and 5799 (14.01%) veh/day. It is followed by Etim Edem – Mary slessor – Unical main gate (4) recording an AM peak hour and PM peak hour volumes of 3152 (9.43%) veh/day and 3456(10.34%) veh/day. Odukpani Junction – Tinapa Junction (1) followed with an AM peak hour volume of 3308 (5.80%) veh/day and PM hour volume of 3288(5.76%) veh/day U.J Esuene Stadium – IBB –Atimbo Junction (Unicem Road) (2) recorded an AM peak of 2528(8.57%) veh/day and with a PM peak of 2422(8.20%) veh/day.

3.3. Variation Factors at the Intersection Classification Count in Calabar Metropolis

It was obtained from the 12-day, 24 hour classified count carried out in this study; Average of 24-hour daily traffic was calculated using Microsoft Excel Spread sheet. The total average 24-hour traffic for each Junction/Intersection was divided by the average total 12-hour count to obtain the variation factor (VF) for the various Junctions. The Table 3.3 shows the variation factors obtained at the various junctions used in this study.

Table-3.3. Traffic Variation Factors at the Major Intersections in Calabar Metropolis

Reference	1 Odukpani Junction to Tinapa Junction	2 UJ Esune Stadium to IBB to Atimbo Junction	3 Milenium park to Watt Market round about	4 Etim Edem to Mary Slessor to Unical Main gate
12hrs to 24hrs	5.34	7.41	6.43	4.81
AM Peak - Hour to 24hrs	1.14	1.07	1.06	1.06
PM Peak Hour to 24hrs	2.56	3.52	3.56	3.34
Typical 1 - hr: AM Flows (10:00 - 11:00) to 24hrs flows	1.24	1.29	1.32	1.28
Typical 1 - hr: PM Flows (04:00 - 05:00) to 24hrs flows	57.45	58.35	52.11	31.95

Source: Akeke M.Eng Thesis, 2018

Table-3.4. Hourly Traffic Distribution at Odukpani junction-Tinapa Junction (1) Traffic Flow Characteristics at the Major Intersections in Calabar Metropolis

HOUR OF DAY	DAY 1		DAY 2		DAY 3	
	%Total	%Cuml	%Total	%Cuml	%Total	%Cuml
7:00am – 800am	5.84	5.84	5.62	5.62	5.45	5.45
8:00am -9:00am	6.68	12.53	6.47	12.09	6.92	12.37
9:00am-10:00am	7.14	19.66	6.93	19.02	6.96	19.33
10:00am -11:00am	6.13	25.79	6.20	25.22	6.03	25.36
11:00am – 12:00am	5.57	31.36	5.42	30.64	5.58	30.93
12:00pm – 1:00pm	5.57	36.93	5.81	36.45	5.61	36.54
1:00pm - 2:00pm	6.13	43.06	7.58	44.04	6.17	42.71
2:00pm – 3:00pm	6.85	49.92	7.28	51.32	7.05	49.76
3:00pm - 4:00pm	6.94	56.86	6.94	58.26	6.89	56.65
4:00pm – 5:00pm	7.02	63.87	6.91	65.17	6.59	63.24
5:00pm – 6:00pm	8.60	72.47	8.22	73.38	8.59	71.82
6:00pm – 7:00pm	8.88	81.35	8.41	81.79	8.82	80.65
7:00pm – 8:00pm	7.90	89.25	7.45	89.24	7.86	88.51
8:00pm – 9:00pm	3.99	93.24	4.18	93.43	4.75	93.25

9:00pm – 10:00pm	2.97	96.21	2.95	96.37	3.08	96.34
10:00pm – 11:00pm	0.61	96.82	0.62	97.00	0.74	97.08
11:00pm – 12:00am	0.54	97.36	0.48	97.48	0.43	97.51
12:00am – 1:00am	0.16	97.51	0.16	97.64	0.15	97.65
1:00am – 2:00am	0.19	97.71	0.19	97.83	0.17	97.82
2:00am – 3:00am	0.25	97.95	0.22	98.05	0.24	98.06
3:00am – 4:00am	0.25	98.20	0.21	98.26	0.25	98.31
4:00am – 5:00am	0.38	98.58	0.45	98.72	0.33	98.64
5:00am – 6:00am	0.64	99.22	0.63	99.35	0.60	99.24
6:00am – 7:00am	0.78	100.00	0.65	100.00	0.76	100.00
Total No. Vehicle		32989.00		34252.00		33601.00

Source: Akeke M.Eng Thesis, 2018

Table-3.5. Hourly Traffic Distribution at UJ Esuene Stadium-IBB-Atimbo Junction (2)

HOUR OF DAY	DAY 1		DAY 2		DAY 3	
	%Total	%Cuml	%Total	%Cuml	%Total	%Cuml
7:00am – 800am	6.23	6.23	6.24	6.24	6.10	6.24
8:00am -9:00am	8.41	14.64	8.85	15.10	8.18	15.10
9:00am-10:00am	7.96	22.60	8.24	23.34	7.95	23.34
10:00am -11:00am	7.14	29.74	6.83	30.17	7.11	30.17
11:00am – 12:00am	6.92	36.66	7.21	37.37	7.24	37.37
12:00pm – 1:00pm	6.66	43.32	6.50	43.87	6.97	43.87
1:00pm - 2:00pm	6.69	50.01	6.25	50.12	6.74	50.12
2:00pm – 3:00pm	6.69	56.70	7.13	57.25	6.76	57.25
3:00pm - 4:00pm	6.96	63.66	7.33	64.58	6.28	64.58
4:00pm – 5:00pm	7.47	71.13	7.84	72.42	7.73	72.42
5:00pm – 6:00pm	7.56	78.69	7.88	80.30	8.04	80.30
6:00pm – 7:00pm	7.45	86.14	6.24	86.55	7.71	86.55
7:00pm – 8:00pm	3.83	89.97	3.87	90.41	3.60	90.41
8:00pm – 9:00pm	3.42	93.39	2.66	93.08	3.21	93.08
9:00pm – 10:00pm	2.08	95.47	2.36	95.44	1.97	95.44
10:00pm – 11:00pm	1.25	96.72	1.25	96.69	1.26	96.69
11:00pm – 12:00am	0.82	97.54	0.85	97.54	0.84	97.54
12:00am – 1:00am	0.22	97.76	0.25	97.79	0.22	97.79
1:00am – 2:00am	0.17	97.93	0.16	97.96	0.17	97.96
2:00am – 3:00am	0.13	98.05	0.13	98.09	0.13	98.09
3:00am – 4:00am	0.17	98.22	0.17	98.26	0.15	98.26
4:00am – 5:00am	0.25	98.48	0.24	98.50	0.22	98.50
5:00am – 6:00am	0.44	98.92	0.45	98.95	0.40	98.95
6:00am – 7:00am	1.08	100.00	1.05	100.00	1.01	100.00
Total No. Vehicle		25545.00		24902.00		25428.00

Source: Akeke M.Eng Thesis, 2018

Table-3.6. Hourly Traffic Distribution at Millennium Park-Watt Market Roundabout (4)

HOUR OF DAY	DAY 1		DAY 2		DAY 3	
	%Total	%Cuml	%Total	%Cuml	%Total	%Cuml
7:00am – 800am	5.94	5.94	5.26	5.26	5.26	5.26
8:00am -9:00am	8.05	13.98	10.10	15.36	10.20	15.46
9:00am-10:00am	7.10	21.09	6.44	21.80	7.00	22.46
10:00am -11:00am	6.58	27.67	5.44	27.24	5.22	27.68
11:00am – 12:00am	6.04	33.71	5.44	32.68	5.36	33.03
12:00pm – 1:00pm	6.24	39.94	5.30	37.98	5.10	38.13
1:00pm - 2:00pm	5.94	45.88	5.52	43.50	6.00	44.13
2:00pm – 3:00pm	6.04	51.92	5.10	48.61	5.20	49.33
3:00pm - 4:00pm	5.53	57.45	5.50	54.11	6.22	55.55
4:00pm – 5:00pm	6.12	63.57	5.80	59.91	6.32	61.87
5:00pm – 6:00pm	6.23	69.80	7.46	67.37	7.22	69.09
6:00pm – 7:00pm	7.44	77.24	11.50	78.87	12.10	81.19
7:00pm – 8:00pm	5.53	82.78	7.12	85.99	6.36	87.55
8:00pm – 9:00pm	4.06	86.84	3.56	89.55	3.42	90.97

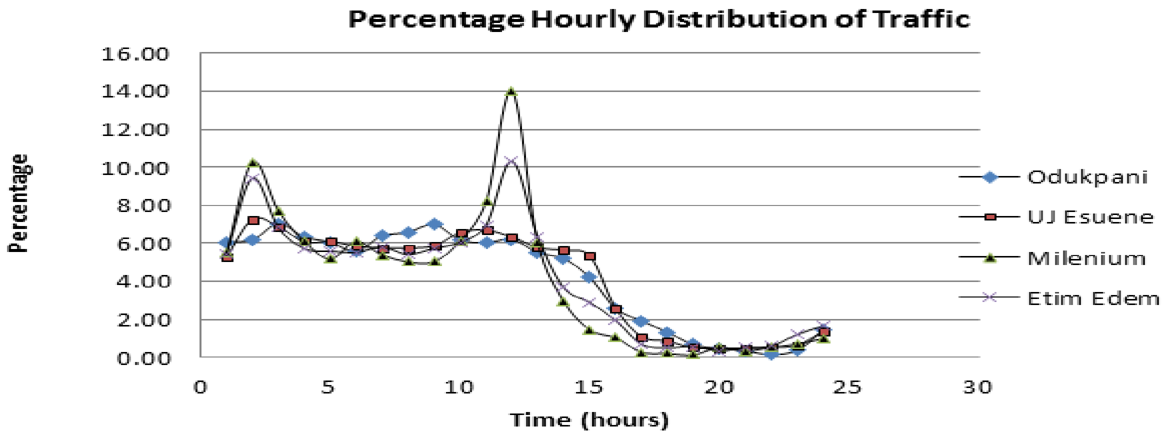
9:00pm – 10:00pm	3.12	89.96	2.70	92.25	2.92	93.89
10:00pm – 11:00pm	2.56	92.51	1.76	94.01	1.60	95.49
11:00pm – 12:00am	0.99	93.50	0.44	94.45	0.70	96.19
12:00am – 1:00am	0.52	94.02	0.40	94.85	0.64	96.83
1:00am – 2:00am	0.48	94.51	0.68	95.52	0.56	97.39
2:00am – 3:00am	0.34	94.85	0.50	96.02	0.22	97.61
3:00am – 4:00am	0.20	95.06	0.50	96.52	0.26	97.87
4:00am – 5:00am	1.23	96.28	0.24	96.76	0.40	98.26
5:00am – 6:00am	1.81	98.09	1.34	98.10	0.54	98.80
6:00am – 7:00am	1.91	100.00	1.90	100.00	1.20	100.00
Total No. Vehicle		33250.00		32500.00		34300.00

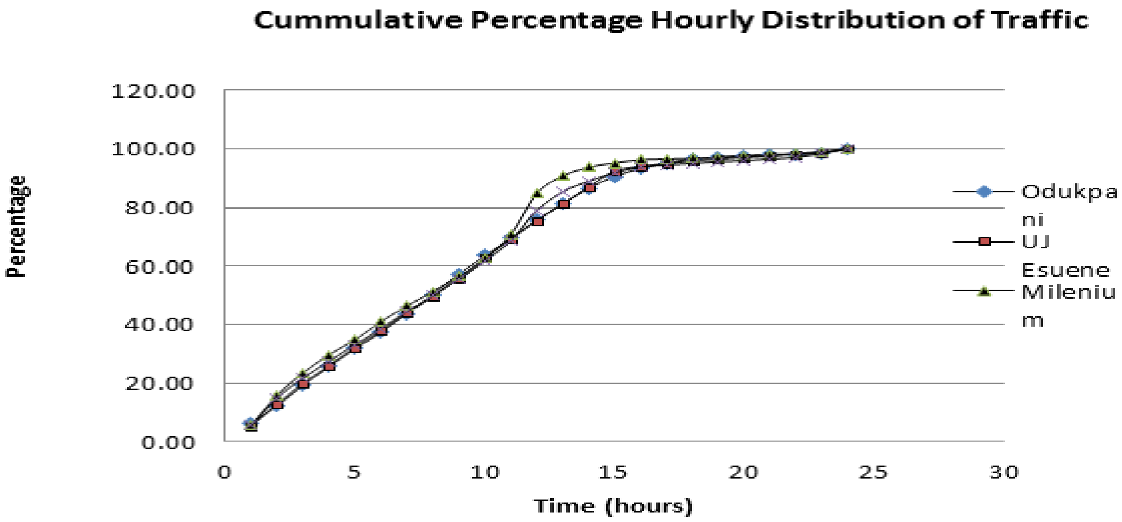
Source: Akeke M.Eng Thesis, 2018

Table-3.7. Summary of Hourly Traffic Volume in Calabar Metropolis

Hour of day	1 Odukpani Junction to Tinapa Junction			2 UJ Esune Stadium to IBB to Atimbo Junction			3 Milenium park to Watt Market round about			4 Etim Edem to Mary Slessor to Unical Main gate		
	No of Veh.	% Total	% Cuml	No of Veh.	% Total	% Cuml	No of Veh.	% Total	% Cuml	No of Veh.	% Total	% Cuml
7:00 – 800am	1895.00	5.64	5.64	1565.00	6.19	6.24	2282.67	5.66	5.66	1829.33	5.47	5.49
8:00 -9:00am	2248.00	6.69	12.33	2145.00	8.48	14.94	4246.67	10.54	16.20	3152.33	9.43	14.94
9:00-10:00am	2356.00	7.01	19.34	2035.33	8.05	23.09	3186.67	7.91	24.11	2285.33	6.83	21.78
10:0 -11:00am	2057.33	6.12	25.46	1778.33	7.03	30.03	2520.67	6.25	30.36	1915.33	5.73	27.53
11:00 – 12:00pm	1855.33	5.52	30.98	1800.67	7.12	37.14	2143.33	5.32	35.67	1871.00	5.60	33.14
12:00pm – 1:00pm	1904.00	5.66	36.64	1697.67	6.71	43.69	2521.00	6.25	41.92	1848.67	5.53	38.69
1:00pm - 2:00pm	2231.33	6.63	43.27	1659.33	6.56	50.09	2231.67	5.53	47.46	1942.00	5.81	44.51
2:00pm – 3:00pm	2374.67	7.06	50.33	1734.00	6.86	57.07	2080.00	5.16	52.62	1816.00	5.43	49.95
3:00pm - 4:00pm	2326.67	6.92	57.25	1734.00	6.86	64.27	2087.67	5.18	57.80	1920.33	5.74	55.70
4:00pm – 5:00pm	2298.33	6.84	64.09	1942.00	7.68	71.99	2534.00	6.28	64.08	2028.67	6.07	61.78
5:00pm – 6:00pm	2845.33	8.47	72.56	1980.00	7.83	79.77	3385.00	8.40	72.48	2324.67	6.96	68.75
6:00pm – 7:00pm	2924.67	8.70	81.26	1805.67	7.13	86.41	4790.33	11.88	84.36	3453.67	10.33	79.10
7:00pm – 8:00pm	2600.00	7.74	89.00	952.33	3.77	90.27	2484.67	6.16	90.52	2111.67	6.33	85.44
8:00pm – 9:00pm	1447.33	4.30	93.31	783.67	3.10	93.18	1219.33	3.02	93.55	1227.00	3.67	89.12
9:00pm – 10:00pm	1008.67	3.00	96.31	540.33	2.14	95.45	606.00	1.50	95.05	972.00	2.91	92.03
10:00pm – 11:00pm	221.67	0.66	96.97	317.67	1.26	96.70	432.67	1.07	96.12	657.00	1.97	94.00
11:00pm – 12:00am	161.67	0.48	97.45	211.67	0.84	97.54	118.00	0.29	96.42	237.00	0.71	94.71
12:00am – 1:00am	52.33	0.16	97.60	58.00	0.23	97.78	91.00	0.23	96.64	174.67	0.52	95.23
1:00am – 2:00am	61.67	0.18	97.79	42.67	0.17	97.95	60.33	0.15	96.79	191.00	0.57	95.81
2:00am – 3:00am	79.00	0.24	98.02	32.67	0.13	98.08	221.00	0.54	97.33	117.00	0.35	96.16
3:00am – 4:00am	79.67	0.24	98.26	41.67	0.16	98.25	143.67	0.35	97.69	106.67	0.32	96.48
4:00am – 5:00am	130.33	0.39	98.65	60.67	0.24	98.49	224.33	0.55	98.24	207.33	0.62	97.10
5:00am – 6:00am	209.67	0.62	99.27	108.67	0.43	98.94	298.00	0.74	98.98	407.00	1.22	98.33
6:00am – 7:00am	245.33	0.73	100.00	264.67	1.05	100.00	415.33	1.02	100.00	554.33	1.66	100.00

Source: Akeke M.Eng Thesis, 2018





4. CONCLUSION

From the results and analysis carried out from this study, the following conclusions can be drawn:

i. Since Cross River is a tourist attraction state and with population explosion, it was however noted that the existing roads have become too narrow such that the obviously unplanned settlement may never enjoy wider roads without huge compensation on the part of Government in order to increase the existing road capacity.

ii. The most congested intersection in Calabar Metropolis is from Odukpani axis through Tinapa (1) which is the only access into the metropolis. It recorded the highest 24 hours' traffic of 33614vehs/day.

iii. The study found out that the highest peak hour traffic volumes of 4247 vehs/hr and 5790 veh/hr was recorded at Millennium Park through watt market roundabout intersection (3) during AM and PM peaks periods. It was therefore observed that this same area constituted (10.28%) and (14.01%) of traffic during the AM and PM peak periods.

iv. The traffic variation factors are not much noticed at different locations but the Millennium Park through watt market roundabout was quite different with 6.59 at 12hrs to 24hrs.

The composition of traffic in Calabar Metropolis indicates that the Taxis were the modal class of vehicles types in the metropolis. This was followed by privately owned cars, Heavy Trucks/Trailers, Light Trucks/Pick-ups and Tricycles, (keke). The buses were also the most popular modal vehicles types used for transportation recording a traffic composition of 23% and 20% at different intersections.

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