The Design, Fabrication and Testing of Infrared Traffic Counter on Selected Major Dual-Carriageways in Akure - Nigeria

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ABSTRACT

Conventional intrusive traffic counters such as inductive loop, pneumatic tubes, piezo- sensors are expensive to install and maintain, and are not readily available for various urban roads to facilitate traffic data collection, also manual counts by transport professionals have proven to be ineffective and prone to errors. The aim of this research is to design, fabricate and test an infrared traffic counter on the selected major dual carriageways in Akure metropolis. The counter was fabricated from these locally available materials such as Infrared transmitter and receiver, Microcontroller, LCD (Liquid Crystal Display), Oscillator, Connecting Wires, Mother board, Batteries, Capacitor, Resistor, and Pyrex plastic. The circuits for the infrared transmitter, microcontroller and receiver were designed by an existing software programs called "MIDE and "PROTUSE. Also locally designed counter, manual counts method and conventional counter were employed to collect volume. The volume result from the designed counter compared to the conventional counter was found to be 99% accurate. The volume/capacity result shows heavy congestion which shows unstable flow, high density and severe restrictions on a driver's ability to manoeuvre, with poor comfort and convenience. This research has shed light on the need to design locally made traffic counters which has overcame the demerit of manual counting on roads and eradicate the cost incurred in securing or purchasing an automatic counters.

KEYWORDS: Infrared traffic counters, traffic congestion, volume, dual carriageway and transport professionals

1 INTRODUCTION

Large cities in developing countries are characterized by a continuing growth in automobile ownership and insufficient transportation infrastructure and service development. The continuous road congestion in Nigerian cities which started from the 1970's as a result of enhanced household income and increased desire for both private and commercial vehicle ownership is intensifying on daily basis. The daily movement of people in Nigerian cities is becoming more difficult and complex. This is reflected in the increasing bumper-to-bumper traffic being experienced in the major cities during the morning (7:00am – 9:00am) and evening (3:00pm – 6:00pm) peak hours. These cities most often suffer from congestion, echoed by poor mobility and accessibility, and safety problems (Momoh, 2011). Assessing the state of traffic and service condition is an essential task for developing countries transportation professionals.

Traffic volume as defined by FMWH (1993); is the number of vehicles passing a particular section of a roadway at a specified period of time). In cities, the maximum traffic volume occurs just before and after office and college hours; traffic survey carried out during these peak hours provides most of the required information on traffic behaviour. Owolabi (2001) on the study of analysis of vehicular traffic in the central business district of Akure deduced that traffic volume can be used in evaluating existing facilities and planning improvement with regards to traffic operation and control, structural design of pavements and geometric designs of roads, for designing road intersections, light signal timing, channelizing and other control measures, and from the knowledge of volume/capacity ratio, it is possible to deduce operating level of service on the road.

A traffic count is a count of traffic along a particular road, either done electronically or by people counting by the side of the road. Traffic counts can be used by local councils to identify which routes are used most, and to either improve that road or provide an alternative if there is an excessive amount of traffic. They are useful for comparing two or more roads, and also can be used alongside other methods to find out where the Central Business District of a settlement is located. This data can then be used to convince a local council that a particular road needs to have more work done on it or an alternative route needs to be built. A traffic counts can be done manually, and with the conventional traffic counters. In this case trained observers gather traffic data that cannot be efficiently obtained through automated counts e.g. vehicle occupancy rate, pedestrians and vehicle classifications. The most common equipment's used are tally sheet, mechanical count boards and electronic count board systems.

According to Guillaume (2008); generally, traffic count technologies can be split into two categories: the intrusive and non-intrusive methods. Intrusive traffic collection devices such as Inductive loop detectors, Pneumatic tubes, Piezo sensors; Magnetometer can be portable or permanently installed. The main advantage of portable-intrusive devices is the ability to move the devices to various locations. However, portable-intrusive devices exhibit some disadvantages, such as disrupting traffic flow during installation and possible malfunctions due to incorrect installation procedures which will adversely affect the accuracy of the results. Non-intrusive traffic collection devices are those devices that cause minimal disruption to normal traffic operations and can be deployed more safely than conventional methods. Non-intrusive devices do not need to be installed in or on the pavement but can be mounted overhead, to the side, or beneath the pavement by positioning the device from the shoulder. UGPTI (2002), shed more light on various non-intrusive traffic data collection devices including infrared (passive and active), radar, Doppler microwave, pulse ultrasonic, passive acoustic and video detection sensors. While these technologies have been used for many years, most of them have not been used on a large scale to collect traffic data. Video detection sensors are becoming more popular due to advances in computer technology and decreases in price. In addition to collecting various types of traffic data, such as volumes, vehicle classification, and speed, video detection sensors can also provide traffic surveillance functions, such as incident detection and verification.

Infrared devices are available for overhead mounting to view approaching or departing traffic from a side-looking configuration. Passive infrared devices detect the presence of vehicles by comparing the infrared energy naturally emanating from the road surface with the change in energy caused by the presence of a vehicle. Since the roadway may generate either more or less radiation than a vehicle depending on the season, the contrast in heat energy is detected. Active infrared devices detect the presence of vehicles by emitting a low-energy laser beam(s) at the road surface and measuring the time for the reflected signal to return to the device. Previous studies (Bahler et al., 1998) have reported infrared technology as being suitable for monitoring traffic in urban areas, but performance varies under severe weather conditions and main advantage of infrared devices is that they can cover multiple lanes simultaneously. Under normal weather conditions, they can accurately measure vehicle position, speed, and class. The main disadvantage is the lack of accuracy under weather conditions such as rain and fog because the associated changes in air conditions may influence the reflection of the infrared beam.

Conventional intrusive traffic counters such as inductive loop, pneumatic tubes, piezo- sensors are expensive to install and maintain, and are not readily available for various urban roads to facilitate traffic collection data and also manual counts as noted by transport professionals have proven to be ineffective and prone to errors in traffic parameter collection. The aim of this research is to design and fabricate an infrared traffic counter while the objectives are to collect traffic parameters such as flow and volume on the selected routes, determine the degree of traffic congestion and recommend solution to the problem traffic congestion on the studied routes.

2 DESCRIPTION OF THE STUDY AREA

The town Akure is the capital of Ondo State which is located within 7^0 15′north of the Equator and Longitude 5^0 05′ east of the Greenwich Meridian. It covers approximately 340 square km, having a north- south length of 17km and an east- west stretch of 20km. According to [6], the area extent of Akure grew from 1937 ha in 1976, to 5330 ha in 1986 (34.34%) and 7665 ha in 1996 (66.7%). The city has a population of 387,100 according to 2006 census. This consisted of 175,495 (49.68%) males and 177,716 (50.32%) females who are mainly civil servants, traders and peasant farmer. The town has a good road network system, and the existing major road in Akure is dominated by the Oyemeku-Oba Adesida and Arakale roads with important transport facilities such as pedestrian walkways, bus stops, parking facilities, tarring of some feeder roads, erection of street and traffic lights. "Fig. 1" is the Map of Akure showing the Road Pattern.

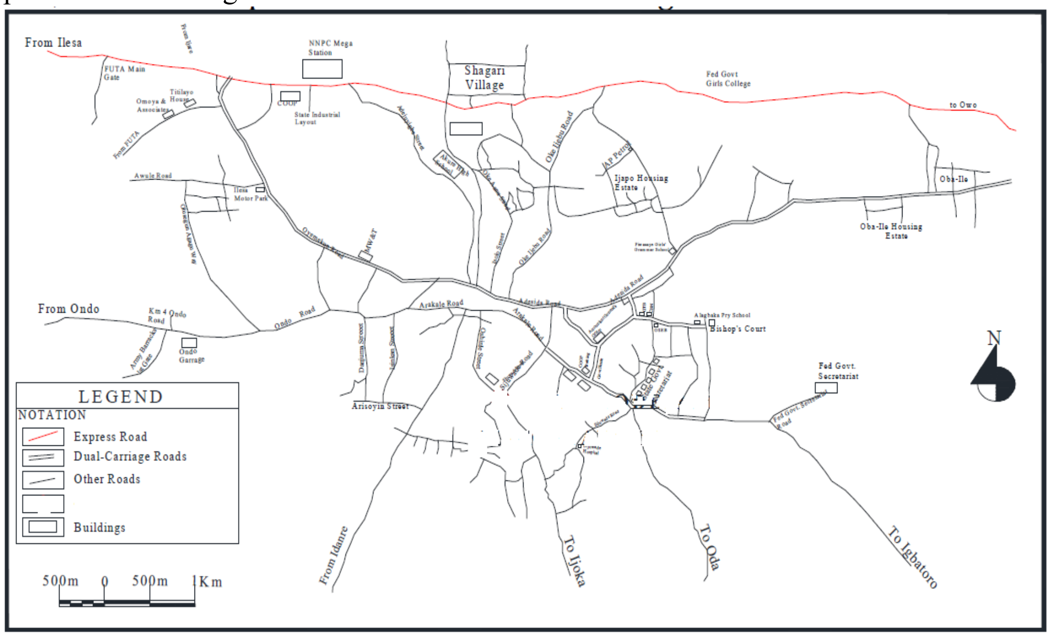

Fig. 1: Map of Akure showing the Road Pattern; Source: (Ondo State Ministry of Works, 2015)

3 RESEARCH METHODOLOGY

The infrared transmitter was firstly designed by a software program called "MIDE" while circuit for the microcontrollers was also designed by a software program called "PROTUSE". The main circuit diagrams are shown in Figures 2 and 3.

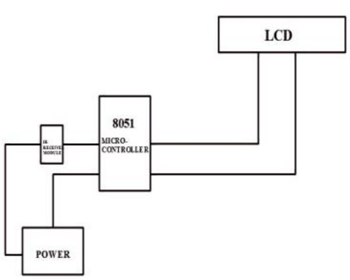

Figure 2: The Main Circuit for fabricated counter

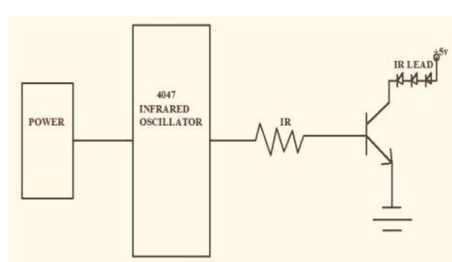

Figure 3: Main Circuit for Fabricated IR Transmitter

3.1 Fabrication of the Counter

The circuit which contains the microcontrollers (2), Liquid Crystal Display and sets of connecting wires were fabricated and welded to the mother board.

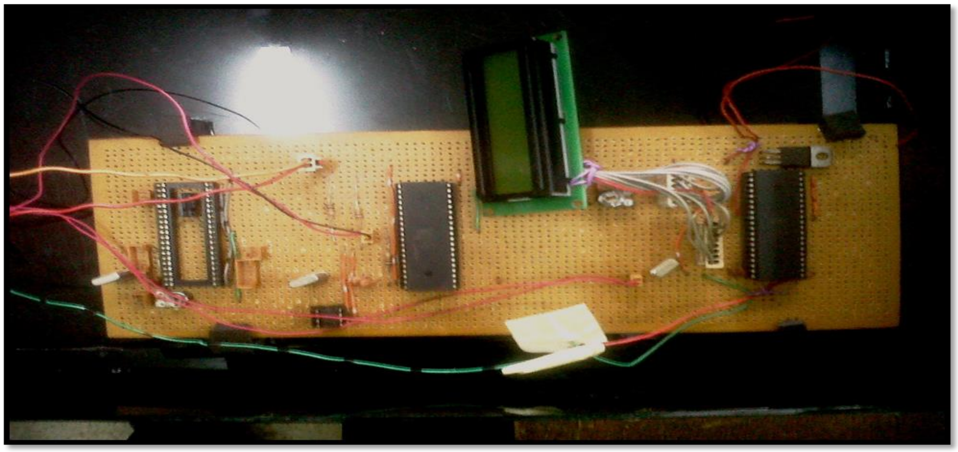

Plate 1: The fabricated first circuit (microcontrollers)

3.1.1 Infrared Receiver Design and Fabrication

The IR infrared was welded to the mother board connected by four wires which were passed outside to join the first circuit (microcontrollers).Two wires were connected to the main wires which were passed out from the first circuit. The other two wires from the IR circuit are for one of the rechargeable battery

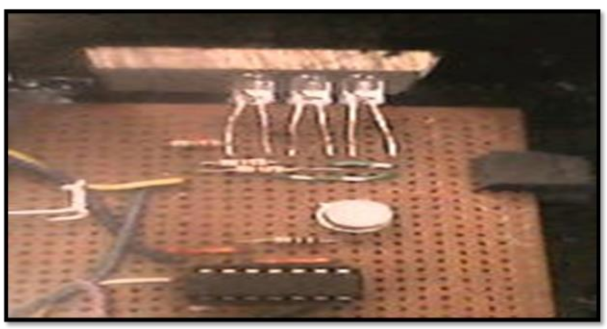

Plate 2: Fabricated Infrared receiver

Plate 3: Fabricated Infrared transmitter

3.1.2 Infrared Transmitter Design and Fabrication

It was designed in such a way that the circuit can stand alone without connecting to the other circuit. The components contained in this circuit are oscillator, transmitter and three connecting wires. These components were welded to the mother board with a soldering iron. The three infrared transmitters were welded to the ferro-board and connected to the oscillator by a wire. Two wires were joined together by the end. Also two wires were passed outside to the remaining battery.

3.1.3 Enclosure in a Plastic Material

Materials made up of Pyrex plastic was cut and shaped to fit the shape of the three circuits, this was done for the purpose of enclosing all the circuits. The Pyrex plastic is resistant to heat and stronger.

Plate 4: Fabricated Infrared receiver

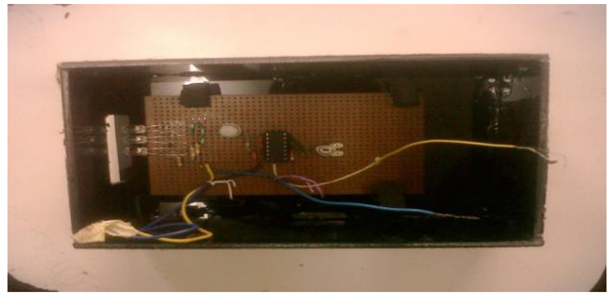

Plate 5: Fabricated Infrared transmitter

Plate 6: Fabricated Traffic Counter (main circuit)

3.2 Manual Counts

A tally sheet was prepared, which contained the types of vehicles i.e motorcycle, cars, vans buses and trucks. These were arranged on the sheet in ascending order of their vehicles capacities. The tally sheet was marked as vehicles pass the reference point on the road; this is Classified Manual Count. The Manual count was done at the peaks periods for each route on both directions and recorded for the purpose of classification of vehicular types. The composition of traffic were determined and expressed in percentages (%).

3.3 Collection with Conventional Counter

A pneumatic tubes counter was hired and used in collecting traffic counts on all the routes. This was done simultaneous with both manual counts. The purpose of this was to compare the results of the automatic counter with the designed one in order to determine the efficiency.

3.4 Collection with Designed Infrared Counter

The test for the infrared counter was carried out on all the routes for about an hour, the following processes were involved:

- Tripod stand; these were used for the purpose of mounting the counter that is, the transmitter and the receiver.
- The receiver and transmitter were powered by a rechargeable battery of 6V each. The transmitter exhibits an infrared ray which was initiated by the oscillator. As vehicles passed, it led to a break in the ray which the microcontroller receives the signal and display the count on the LCD.

- The counter was used to take counts for 2 hours for each peak periods. These peak periods were 7-9am, 12-2pm and 4-6pm for morning, afternoon and evening respectively on weekdays (Mon – Fri); 9-11am, 12-2pm on Saturdays;7:30-9:30am and 12-2pm on Sundays.

4 RESULTS AND DISCUSSION

4.1 Traffic Volume

The detailed information on the routes considered is shown in Table 4. Table 5 is the summary of the highest volume for the weekly counts for all traffic counts on both directions**.** Figures 4 and 5 show the comparison volume results for all devices. The efficiency of the fabricated infrared counter is shown in Table 6 also volume **-** capacity ratio (V/C) of all the segments are illustrated as shown in Table 7 while the international standards (PAG) used to determine their degree of congestion are shown in Table 8 and 9.

Table 4: Detailed Information on the Route Considered

Route segments	Codes	Segment Length (m)	Roads
FUTA junction to Ilesha garage	RA1	3,300	Oyemekun-Oba Adesida road
Ilesha garage to Champion junction	RA2	2,000	
Champion junction to Cathedral	RA3	2,400	
Cathedral to Oba Osupa junction	RA4	3,400	
Isikan market to NEPA junction	RB	4,300	Arakale road
Owena Barracks 1st Gate to Isikan market	RC	5,200	Ondo road

Note: $\mathbf{V_{peak}}$ **D(veh/hr)** is the highest volume for Designed counter, $\mathbf{V_{peak}}$ **C(veh/hr)** is the highest volume for automatic counter and $\mathbf{V_{peak}}$ **M(veh/hr)** is the highest volume for manual counts
RA1; FUTA junction to Ilesha garage, RA2;Ilesha garage to Champion junction , RA3;Champion junction to Cathedral, RA4; Cathedral to Oba Osupa junction, RB;Isikan market to NEPA junction, RC; Owena Barracks 1st Gate to Isikan market

Table 5: Summary of the highest volume for the weekly counts for all devices on both

Routes Segments	To (Direction 1)			From (Direction 2)		
	V_{peak} D(pcu/hr)	**V_{peak} C(pcu/hr)**	**V_{peak} M(pcu/hr)**	**V_{peak} D(pcu/hr)**	**V_{peak} C(pcu/hr)**	**V_{peak} M(pcu/hr)**
RA1	1924	1925	1887	1885	1885	1879
RA2	2051	2052	2045	1944	1944	1923
RA3	2074	2074	2063	2021	2021	1992
RA4	2314	2314	2303	2188	2188	2170
RB	1538	1539	1532	1514	1514	1510
RC	1786	1786	1772	1669	1669	1660

Directions

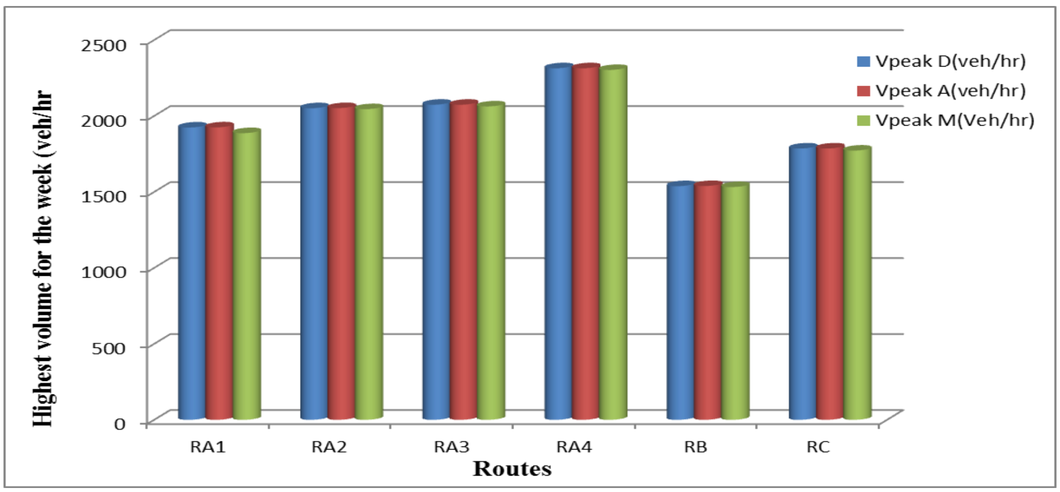

Figure 4: Chart showing comparison of designed, automatic (conventional) and manual counts - Dir. 1

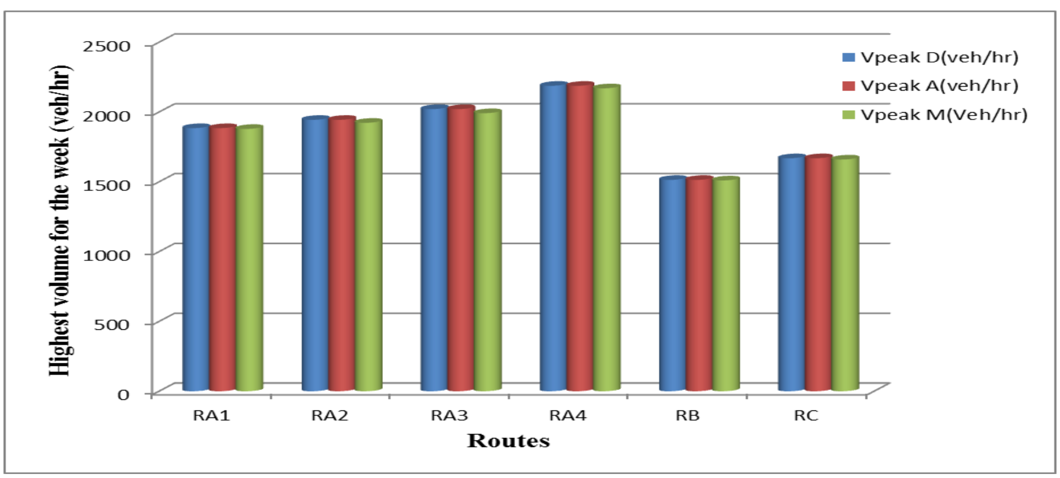

Figure 5: Chart showing comparison of designed, automatic (conventional) and manual counts – Dir. 2

3.2 Determination of the Efficiency of the Designed Infrared counter

Table 6: Summary of the Volume and Designed Counter Efficiency

Segments	(Dir.1)			(Dir.2)		
	V_{peak} D(pcu/hr)	V_{peak} C(pcu/hr)	%	V_{peak} D(pcu/hr)	V_{peak} A(pcu/hr)	%
RA1	1924	1925	99	1885	1885	100
RA2	2051	2052	99	1944	1944	100
RA3	2074	2074	100	2021	2021	100
RA4	2314	2314	100	2188	2188	100
RB	1538	1539	99	1514	1514	100
RC	1786	1786	100	1668	1669	99

V_{peak} D(veh/hr) is the highest volume for designed counter, **V_{peak} C(veh/hr)** is the highest volume for automatic counter and **V_{peak} M(veh/hr)** is the highest volume for manual counts

From Table 6 with comparison with the conventional counter, the efficiency of the designed counter is 99%. Therefore the designed counter volume results were used for the analysis and determination of measures for the congestion for all the routes on both directions.

Table 7: Summary of the Volume-Capacity Ratio (V/C) during the Peak Periods

Segments	To (Direction 1)			From (Direction 2)		
	V_{peak} (pcu/hr)	C (pcu/hr)	V/C	V_{peak} (pcu/hr)	C (pcu/hr)	V/C
RA1	1924	2600	0.74	1885	2600	0.73
RA2	2051	2600	0.79	1944	2600	0.75
RA3	2072	2600	0.80	2021	2600	0.78
RA4	2314	2600	0.89	2188	2600	0.84
RB	1539	2600	0.59	1514	2600	0.58
RC	1786	2600	0.69	1514	2600	0.64

Note: V_{peak} is the peak volume, C is the capacity and V/C is the volume-capacity ratio
RA1; FUTA junction to Ilesha garage, RA2;Ilesha garage to Champion junction , RA3;Champion junction to Cathedral, RA4; Cathedral to Oba Osupa junction, RB;Isikan market to NEPA junction, RC; Owena Barracks 1st Gate to Isikan market.

As given by DMRB (1999), from Table 3: Capacities (veh/hr) of Urban Roads, One-way Hourly Flows in Each Direction, the capacity of dual carriageway is 2600veh/hr.

From the result on Table 9, the degree of traffic congestion according to PAG standard is shown in Table 11 and 12.

Table 8: Degree of traffic congestion for Dir.1 and
Table 9: Degree of traffic congestion for Dir.2

Routes (Dir.1)	V/C	PAG Standard
RA1	0.74	Moderate congestion
RA2	0.79	Heavy congestion
RA3	0.80	Heavy congestion
RA4	0.89	Heavy congestion
RB	0.59	Moderate congestion
RC	0.69	Moderate congestion

Routes(Dir.2)	V/C	PAG Standard
RA1	0.73	Moderate congestion
RA2	0.75	Moderate congestion
RA3	0.78	Heavy congestion
RA4	0.84	Heavy congestion
RB	0.58	Moderate congestion
RC	0.64	Moderate congestion

RA1; FUTA junction to Ilesha garage, RA2;Ilesha garage to Champion junction , RA3;Champion junction to Cathedral, RA4; Cathedral to Oba Osupa junction, RB;Isikan market to NEPA junction, RC; Owena Barracks 1st Gate to Isikan market

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study has been able to design and fabricate infrared counter with locally available materials which the advantages overcame the use of manual counts methods which are not effective in volume data collections. This research has been able to determine the nature of traffic on Oyemekun-Oba Adesida, Arakale, and Ondo roads through metering parameter such as volume / Capacity ratio, evaluated these parameters to determine the degree of congestion. The Cathedral to Oba Osupa junction segment of Oyemekun-Oba Adesida road that was the most congested is the major Central Business District (CBD) where commercial activities, business transactions and schools are in abundant while NEPA junction to Isikan market segment of Arakale road that was the least congested only allow commercial activities and business transactions but in lower proportion when compared to the former segment. The FUTA junction to Ilesha garage segment (RA1) of Oyemekun-Oba Adesida road, Isikan market to NEPA junction segment (RB) of Arakale road and Owena Barracks 1st gate to Isikan market segment (RC) of Ondo road were moderately congested but segment RB, RA1 and RC are heavily congested. The implication of this present degree of congestion for all the routes is unstable flow, high density and severe restrictions on a driver's ability to maneuver, with poor comfort and convenience. Increased volume of traffic, poor parking system, ribbon development /street trading is factors responsible for these results.

Therefore expansion of all the routes, provision of adequate parking facilities for all the routes and lane marking; prohibition of on-street trading and parking; effective traffic management and efficient road maintenance programme should be implemented on the selected road segments to solve the current problem of congestion and accommodate future traffic.

5.2 Recommendations

In respect of the analysis of these traffic parameters and volume results of the fabricated counter, the following recommendations are made:

i. The State government, private sector, and transportation agencies should encourage local production of traffic counters which are cheap to maintain unlike the conventional counters which are expensive and not readily available for traffic data collection.
ii. Traffic parameter collection/analysis such as volume, speed and delay should be conducted on all urban cities roads in order to reduce the menace of traffic congestion.
iii. All urban roads should be designed with the sufficient capacity in order to accommodate future traffic. This can be achieved through adequate traffic planning and management.

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