OPEN ACCESS

Saudi Journal of Civil Engineering
Abbreviated Key Title: Saudi J Civ Eng
ISSN 2523-2657 (Print) |ISSN 2523-2231 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com/journal/sjce/home

Original Research Article

Analysis of Traffic Characteristics and Design of Traffic Signaling Control for Management of a Four-leg intersection at Nkwo Triangle Nnewi

Nwakaire C.M.[1*], Nwizu I.I[2]

[1]Nnamdi Azikiwe University Awka
[2]Chukwuemeka Odumegwu Ojukwu University

DOI: https://doi.org/10.36348/sjce.2026.v10i03.001 | **Received:** 17.01.2026 | **Accepted:** 10.03.2026 | **Published:** 23.03.2026

***Corresponding author:** Nwakaire C.M.
Chukwuemeka Odumegwu Ojukwu University, Uli

Abstract

Movement is one of the major characteristics of every living thing. Transportation involves the movement of people, goods and services from one place to another and with increased population congestion is inevitable. Eastern mass junction Nkwo Triangle Nnewi North (Cross intersection) is not exempted from traffic congestion as it was taken as a case study for this work which focused on the analyses of traffic characteristics and design of traffic signaling control for management of busy intersections. Eastern mass junction Nkwo triangle Nnewi is connected by four roads leading Eastwards to the junction is Eke Amobi road, Westwards is First bank road, Northwards by Nnobi road and Southwards by Round-About junction road. The geometry of the junction is symmetrical towards North and South (8.1 meters) and asymmetric towards East (13.425 meters) and West (12 meters). Based on traffic volumes converted to the PCU values, a traffic signaling scheme was designed mostly based on the Webster's method of signaling design using the geometries of the roads leading to this junction. Results from signal design showed an optimum cycle lengths of 73 seconds with total effective green times of 55 seconds and amber time of 5 seconds. The designed traffic signal is recommended for Eastern mass junction and other similar junctions to improve their traffic characteristics and reduce the demerits of congestion and delays.

Keywords: Green time, Optimum cycle length, Passenger car unit, Phase diagram, Signal design, Traffic count.

1.0 INTRODUCTION

Traffic is a terminology used to describe vehicles moving on a public highway. Traffic study, also known as traffic analysis, is a systematic examination of traffic conditions, patterns, and behaviors within a specific area (Nwakaire *et al*., 2016). It involves collecting and analyzing data to gain insights into the flow of vehicles, pedestrians, and other modes of transportation on road networks. Seventy-five percent of mobility needs in Nigeria are accounted for by road mode and consequently, more than seven million vehicles operate daily on Nigerian roads (Ajayi and Olusina, 2024). With increasing population growths in cities, vehicular traffics increase as well, leaving transport infrastructures with high levels of congestion. Analyses of the characteristics of resulting traffic becomes necessary for a clearer understanding of the problem and decision on the best approach for the traffic management (Khaissi *et al*., 2021).

When a busy intersection is not controlled, the level of service will drastically reduce.Accidents cases has been recorded in several occasions where vehicles, pedestrians and cyclists maneuver one another in struggle to get a passage during peak hours, which has become very irregular to determine. The accidents are fatal in some cases leading to loss of lives and also causing much injury and damages (Nwakaire *et al*., 2017). Apart from the congestion induced accidents, the congestion itself is a major concern. Congestion leads to much discomfort and fatigue on both drivers and commuters. The cost of the delay is huge as considering that most busy intersections are found in municipalities with high density of business activities. Increased in congestion would also lead to environmental degradation and pavement deterioration. For these reasons, the need for effective traffic con troll schemes cannot be overemphasized.

Barricade is one of the traditional methods used in traffic control and management but seems unsuccessful in congested areas (Rajak, 2019). Umar *et al*, (2019) proposed a density-based traffic management system in Niger State which would replace involvement of human in the management of traffic congestion especially during peak, rainy and sunny hours, management of people and vehicles as they obey the system. Traffic Models is beneficial in controlling high volume of vehicular traffic on major roadways and optimizing the level of complexity of the road network infrastructure (Chao *et al*, 2013). It has been used in recent years to analyze, simulate and predict traffic behavior (volume, speed, density) at different levels of complexity from congested urban setting to rural modeling at the macro and micro scales. Despite all these attempts, implementation of signal controlled schemes remain convenient and efficient.

Traffic signs indicate change in speed restrictions, stops or parking, warning, guidance, regulatory and informative. They include speed limits, pedestrian and stop signs. Drivers and road users are meant to pay attention and understand those signs for its effectiveness to promote safe driving as they were designed to convey critical information quickly (Sikirat *et al*,2022; Mustapha, 2022).Anene *et al*. (2023) conducted a research at Orlu junction and concluded after his design using Webster's method of traffic signal control that application of traffic signal control system would minimize intersection accidents, eradicate jams, bottlenecks especially peak hours and festive periods. Adedeji, (2023) designed a traffic signal at Jibowu under bridge Lagos State employing sensor based systems which takes care of both emergency vehicles using PLC (Programmable logic control) and smart traffic control systems which seems to operate more efficiently than the existing traffic control system resulting in reduced waiting times, improved emergency mode operation and decrease in accident risks in the study area.

The current study addresses the challenges of peak hour traffic at the Eastern Mass junction of Nkwo triangle Nnewi. The trajectory of the traffic bottlenecks were revealed. And the traffic characteristics have been analyzed. A unique traffic signaling design for the specific traffic characteristics observed at the intersection is presented. The implementation of the proposed design promises to effectively mitigate the challenges of traffic congestions in the study area.

2.0 RESEARCH METHODS

2.1 Description of the Study Area

The study area is Eastern mass junction Nkwo Triangle Nnewi, a town in South Eastern Part of Nigeria located in the Southern part of Anambra State and within Igbo land with a population of about 1,301,000 as of January 2024 **(***Nigeria Metro Area Population, 2024).* The area is well known for large scale commercial and industrial activities and referred to as Nkwo Nnewi (The Japan of Africa). Nkwo Nnewi market is the second largest market in Anambra State after Onitsha main market. The market is known for sales of motorcycle, tricycle, motor and generator parts which has contributed to the economic boom of the area, State and Nigeria at large. The area is characterized by high traffic volumes that are much experienced in the morning and evening hours, the traffic worsens during festive periods. This can be noticed by the constant gridlock and prolonged or additional travel time that occurs across the location. The road network of the study location is shown in Figure 1.

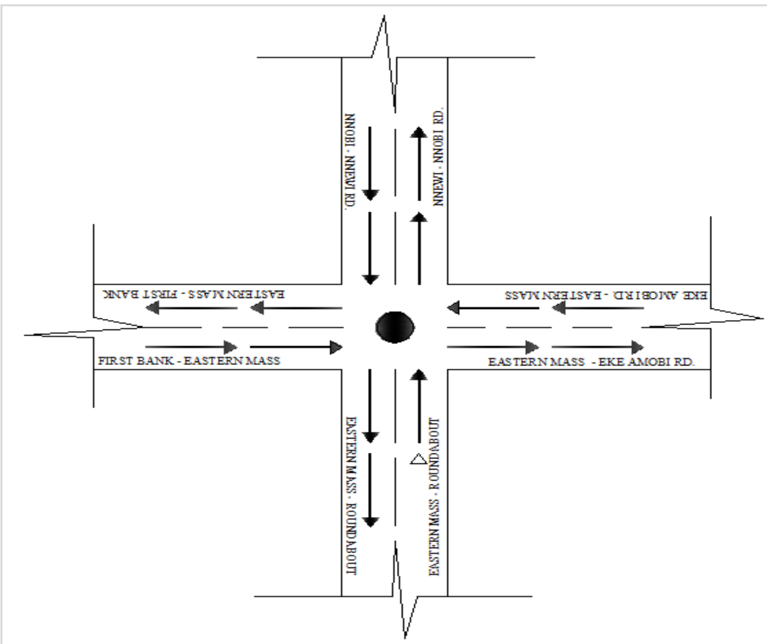

Figure 1: The road network of the study area, Eastern mass junction Nkwo triangle Nnewi

2.2 Data Collection and Signaling Design

The methods used for the traffic data collections and the signaling designs are discussed in this section as summarized in Figure 2.

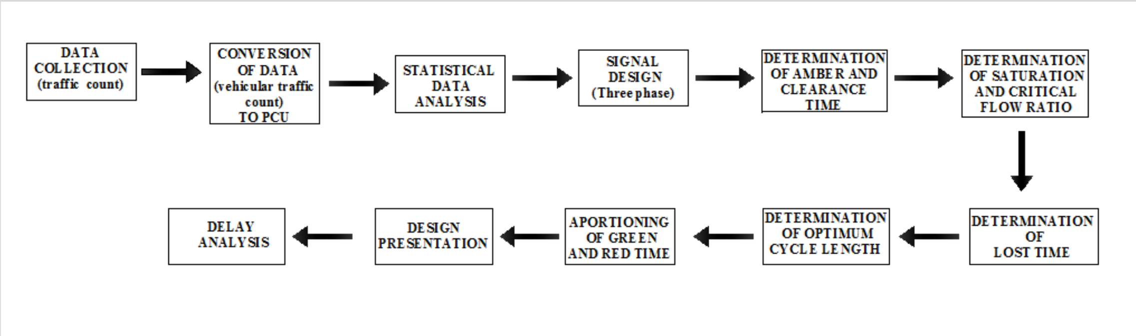

Figure 2: Step used in traffic signaling design

The manual method of data collection was implored to obtain the volume of traffic count in an interval of one hour that is from 7am to 8am, 8am to 9am and 9am to 10am in morning hours and 3pm to 4pm, 4pm to 5pm, 5pm to 6pm four weeks in. After the average of these values were taking in both morning and evening hours to determine average morning and evening daily traffic demands. Since done for four weeks, average weekly demand for morning and evening was also generated. There after the peak hour data which occurs between morning and evening hours were spotted and used for traffic design. The following categories of vehicles will be noted during the traffic count: trucks, buses, cars, tricycles, motorcycles or bikes. The Websters method was adopted for the traffic signaling design, however the Saturation flow was estimated in accordance with IRC:93-1985.

3.0 RESULTS, ANALYSES, AND DISCUSSIONS

3.1. Traffic Volume Studies

Daily traffic flow data at the Eastern mass junction studied are presented in Table 1 for the morning peak hours. The data was collected for four consecutive weeks and are presented in PCU/hr.

Table 1: Traffic flow data in PCU/hr for morning peak hours

Week	Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Average
Week 1	7-8am	1578	641	1909	1900	1979	2259	1312	1682
	8-9am	1673	718	2138	2000	2216	2146	1391	1755
	9-10am	1294	545	1623	1892	1682	1807	1876	1531
Week 2	7-8am	1500	700	2250	1950	2050	2200	1400	1722
	8-9am	1550	750	2230	2050	2140	2250	1500	1781
	9-10am	1480	710	2180	1990	2080	2190	1900	1790
Week 3	7-8am	1520	720	1880	1980	2080	2240	1450	1696
	8-9am	1580	770	1950	2080	2170	2290	1750	1799
	9-10am	1500	735	1890	2020	2110	2230	1950	1776
Week 4	7-8am	1600	670	1940	1985	2010	2280	80	1509
	8-9am	1625	700	1980	2020	2050	2060	100	1505
	9-10am	1575	665	1910	1930	1990	2230	195	1499

In the first week of traffic count the morning peak hour was found to be 8-9 am for all the weekdays. However the highest traffic flow was recorded at 7-8 am on Friday and 9 – 10 am on Saturday. Considering the Modal peak hour and the highest mean peak hourly flow, 8 – 9 am was adopted as the peak hour for the junction. Considering the second week, 8 – 9 am remains the modal peak hour, though the highest mean peak hour was recorded for 9-10 am due to very high traffic observed at 9- 10 am on Saturday. Weeks 3 and 4 follows the same pattern. The 8-9 am and 9 – 10 am were respectively confirmed as the weekday and weekend peak hours for the junction. A 72% drop in traffic flow was recorded on Monday Peak Hour when compared to Sunday. The drop is as a result of the usual sit at home orders being observed by most commuters in the study area. On the average, the traffic volume of 7-8 am is 7.12% less than the traffic volume for 8-9 am. The summary of the average peak hour flow for the days of the week studied over the four weeks is presented in Figure 3.

In week 2 of traffic count studies from 7-8 am, 8-9 am and 9-10 am a trend of traffic was observed averagely i.e 1721 to 1781 (3.49% increase between 7-8 am and 8-9 am in descending order), then a 0.51% increase between 8-9 am and 9-10 am in descending order i.e (1781 to 1790). It also recorded a highest traffic count of 2146 PCU/hr on Friday 7-8 am significantly. In week 3 of traffic count at the junction recorded an average traffic of 1696, 1799 and 1776 PCUs/hr from 7-8 am, 8-9 am and 9-10 am which is a 6.07% increase between 7-8 am and 8-9 am and a 1.29% reduction between 8-9 am and 9-10 am with the highest traffic flow on Friday 7-8 am. Average traffic on week 4 is significant amongst all with a decrease in traffic flow from 7-8 am, 8-9 am and 9-10 am i.e 80, 100, 195 PCU/hr respectively on Saturday owing to sanitation. Averagely, a 0.27% and 0.4% reduction between 7-8 am and 8-9 am, 8-9 am and 9-10 am.

Table 2: Summary of average morning daily traffic in PCU/hr at Eastern mass junction Nkwo triangle Nnewi

Week/Day	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	1012	635	1890	1931	1959	2071	1526
2	1510	720	2220	1997	2090	2213	1600
3	1533	742	1907	2027	2120	2253	1717
4	1600	678	1943	1978	2017	2190	125

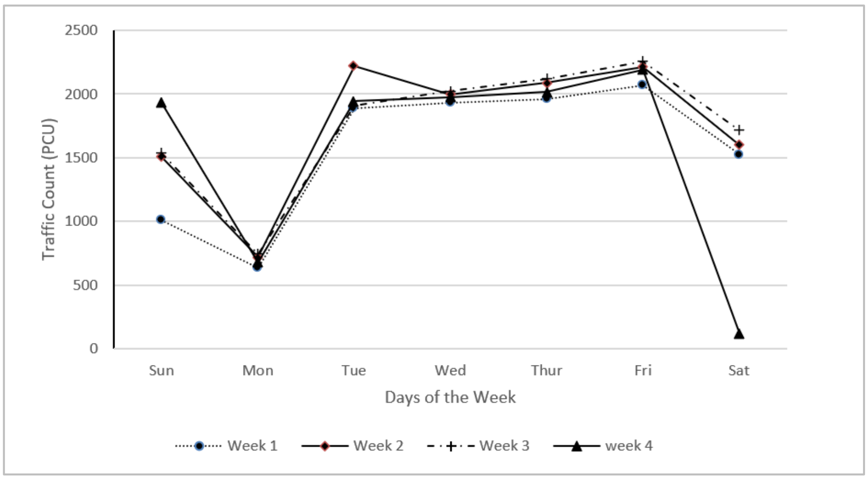

Figure 3: Summary of average morning peak hour traffic on various days of the week

On daily average Friday week 3 and Saturday week 4 has the highest and lowest traffic with 2253 PCU/hr and 125 PCU/hr respectively showing a difference of 2128 PCU/hr. The average lowest traffic which was observed on Saturday is as a result of sanitation exercise in the study location. The graphical representation of the average daily morning traffic volume is shown in Figure 3.

A sharp increase in traffic flow from Monday (lowest) to Tuesday, Tuesday to Friday (high volume days). Wednesday and Thursday maintain stable high flows of 1950 to 2120 PCU/hr. Friday peaks records highest across all four weeks, indicating the busiest commuter and commercial activities. Saturday drops drastically with week 4 recording a very low value (125 PCU/hr) due to general sanitation in the study area pulling down the overall Saturday average. Sunday traffic remains moderate, higher than Monday but below peak weekdays. Traffic count was conducted in evening hours of 3-4 pm, 4-5 pm and 5-6 pm and recorded as shown in Table 3.

Table 3: Traffic flow data in PCU/hr for evening peak hours

Week	Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Average
Week 1	7-8am	1819	1289	2647	2400	2450	2600	2497	2243
	8-9am	1850	1330	2600	2420	2550	2630	2497	2268
	9-10am	1700	1200	2500	2380	2400	2550	2300	2147
Week 2	7-8am	1700	1200	2300	2450	2500	2600	2500	2179
	8-9am	1750	1250	2200	2500	2560	2500	2550	2187
	9-10am	1600	1100	2050	2400	2590	2400	2600	2106
Week 3	7-8am	2520	1720	2590	2550	2470	2590	2610	2436
	8-9am	2570	1770	2280	2520	2570	2560	2580	2407
	9-10am	2600	1620	2080	2430	2520	2550	2635	2348
Week 4	7-8am	2505	1825	2295	2450	2460	2500	2600	2376
	8-9am	2510	1860	2345	2470	2500	2540	2610	2405
	9-10am	2580	1735	2210	2630	2410	2550	2595	2387

In week 1 of evening hour traffic count in the junction, the highest traffic flow was observed on Friday 5-6 pm with a PCU value of 2497 PCU/hr and a significant average weekly percentage increase of 10%,17.89% between 3-4 pm and 4-5 pm then 4-5 pm and 5-6 pm respectively. The observed average peak hour traffic at the junction in PCU is 2179, 2187 and 2106 PCUs/hr from 3-4 pm, 4-5 pm and 5-6 pm respectively. Then an average increase of 0.37% from 3-4 pm to 4-5 pm and 3.85% decrease between 4-5 pm and 5-6 pm respectively. The highest observed PCU value is on Friday 3-4 pm and Saturday 5-6 pm. The traffic count for week 3 evening hour shows an observed highest traffic flow on Tuesday evening 3-4pm with a 2590 PCU/hr value. Averagely there is an observed percentage reduction of 1.2% from 3-4 pm to 4-5 pm and 19.81% between 4-5 pm and 5-6 pm. For week 4, the observed highest traffic flow is on Wednesday evening 5-6 pm with a 2630 PCU/hr value. Averagely there is an observed percentage increase of 1.22% from 3-4 pm to 4-5 pm and 19.71% reduction from 4-5 pm and 5-6 pm. From the daily evening traffic volumes counted, an average evening daily traffic volume was calculated and shown in Table 4.

Table 4: Summary of average evening daily traffic flow in PCU/hr at Eastern mass junction Nkwo triangle Nnewi

Week/Day	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	1790	1273	2582	2400	2467	2593	2431
2	1683	1183	2183	2450	2550	2500	2550
3	2563	1703	2317	2500	2520	2567	2608
4	2532	1806	2283	2517	2457	2530	2602

On daily average Saturday week 3 and Monday week 2 has the highest and lowest traffic with 2608 PCU/hr and 1183 PCU/hr respectively showing a difference of 1425 PCU/hr. The graphical representation of the average daily traffic volume is shown in Figure 4.

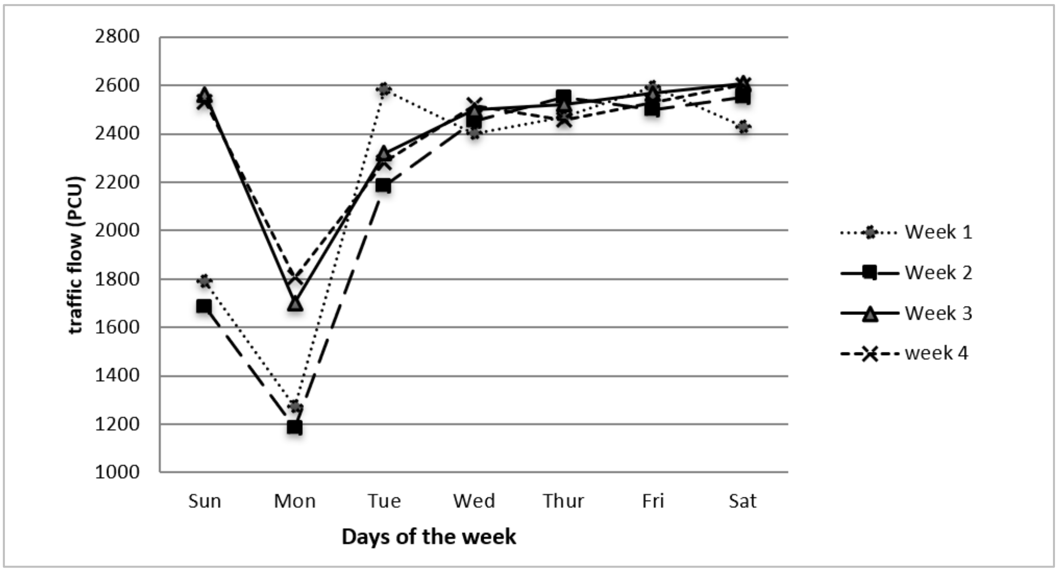

Figure 4: Graphical illustration of average evening daily traffic on various days at different time interval at Eastern mass junction Nkwo triangle Nnewi.

On Sunday and Monday the traffic volumes were relatively low with Monday as the lowest point across all weeks, reflecting reduced evening movements compared to other days. Tuesday is seen to have a sharp rise with traffic jumping from 1600 PCU/hr on Monday to 2300 PCU/hr. This suggests stronger evening commercial and return home activities from Tuesday onwards. From Wednesdays to Fridays the curve flattens at high volumes (2450 – 2560 PCU/hr) showing a stable, consistently heavy midweek traffic. Saturday traffic peaks slightly, recording the highest volumes of the week (over 2600 PCU/hr in week 3 and week 4). This indicates high evening activities, possibly linked to markets, social gathering or weekend movements. The graph forms a valley to peak pattern, with lowest traffic on Monday, gradually rising and peaking towards Saturday. The data from both average morning and evening traffic volume generated was compared as shown in Figure 5.

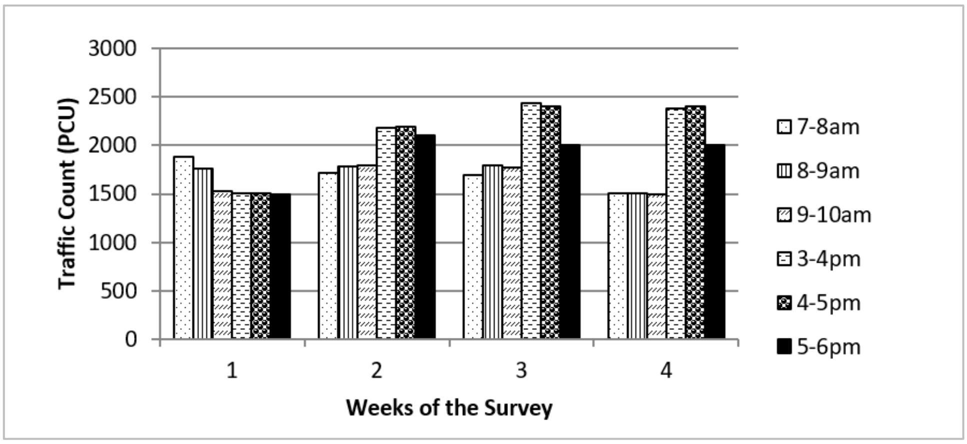

Figure 5: Graphical illustration and comparison of average morning and evening weekly traffic on various days at different time interval at Eastern mass junction Nkwo triangle Nnewi

Week 1,2,3,4 has a total of 5166,5292,5271,4517 PCUs/hr making it a total of 20246 PCU/hr in morning hours from 7-10 am while the total PCUs in the evening hours of 3-6 pm is 24627 PCU/hr with individual weekly PCU of 4513,6472,6852 and 6790 PCUs/hr. This signifies a heavier traffic flow in evening hours in the junction, with overall average 21.64% increase from morning to evening hours in Eastern mass junction Nkwo triangle Nnewi.

Traffic at this junction peaks earlier from 7-9 am, serving commuters and business starters while evening traffic is more intense especially from 3-5 pm showing heavier return flows and commercial closure activities. The highest demands occurs in the evening peak 3-5 pm in week 3 and 4 of 2400 PCU/hr. Evening traffic builds rapidly after 3 pm, peaks between 3-5 pm and slightly reduces by 5-6 pm while morning traffic is heaviest in early hours of 7-9 am then tapers off as the day progresses. Week 1 is an outlier with relatively lower volume while week 3 and 4 show maximum pressure on the junction. Evening traffic is much heavier than morning traffic with flows consistently above 2000 PCU/hr in weeks 2-4.

3.2 Statistical Analysis on the Traffic Survey

The average hourly traffic volumes for the days of the week within the four weeks were subjected to ANOVA test to make inferences on the variations of the traffic volumes for the days of the week and for the weeks of the month within the timeframe of the study. Tables 5 and 6 are the ANOVA results.

Table 5: ANOVA Result on Traffic Volume variations for the Days of the Week

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	7213271	6	1202212	12.50137	5.4E-06	2.572712
Within Groups	2019494	21	96166.38			

Table 6: ANOVA Result on Traffic Volume variations for the Four Weeks

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	582263.8	3	194087.9	2.078676	0.135216	3.098391
Within Groups	1867419	20	93370.96			

From the Table 5, the ANOVA test which was conducted to infer on the variation in the traffic data among the days of the week. The factor for the analysis is the traffic volume count. The hypothesis was stated thus;
H_0: The Traffic volumes remain equal for all the days of the week
H_1: There are variations in traffic volumes among the days of the week

Based on the analysis, the F-value was found to be higher than the F critical with the p-value of 5.4^{X} 10^{-6}. This shows that there is an overwhelming statistical evidence to infer that there is one inequality in traffic volumes among the days of the week. Based on this it can be inferred that there are significant variations in traffic volumes for the different days of the week and for this reason the null hypothesis was rejected. On the other hand, in Table 6 the test for variation in traffic volumes within the four weeks of the traffic count resulted in the upholding of the null hypothesis due to insufficient statistical evidence to infer otherwise. The F-critical was found to be higher than the F-value with a p-value of 0.135. This shows that within the period of the traffic survey, traffic volumes remain similar for the weeks. It is, therefore, imperative that traffic volume count done within a week can be typical for any of the weeks. However within the week, the volumes vary daily. Figure 6 shows the composition of different categories of vehicles that made up the traffic volume. Motobike was seen to be highest, followed by car, bus, tricycle and truck. Motobike is mostly used for ease of movement for dwellers within the study location. All dwellers in the study location have at least 2 to 3 bikes in each household, making a regular mode of transport to date.

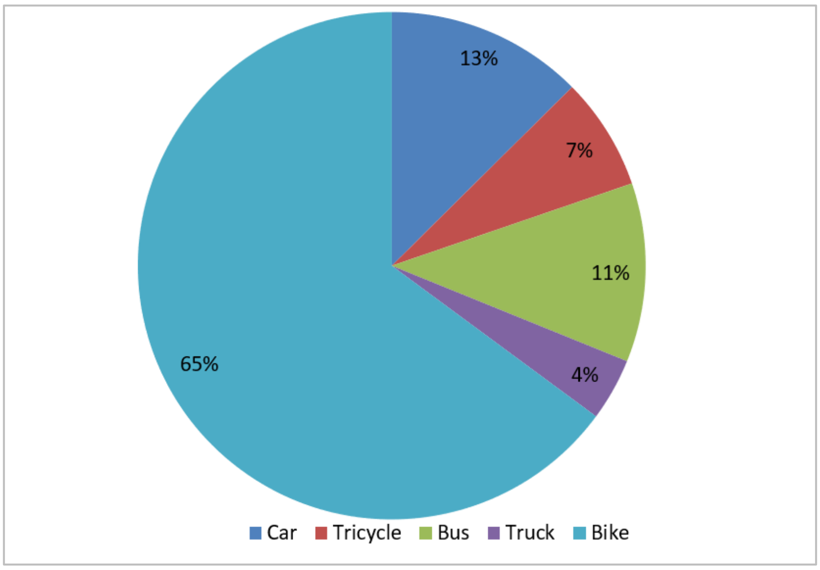

Figure 6: Percentage composition of vehicles at Eastern mass junction, Nkwo triangle Nnewi

3.3 Design Calculations for the Traffic Signal suitable for the Junction

Calculation was made based on the most critical traffic flow (volume) observed on this junction, Tuesday evening 3-4 pm week 1 at Eastern mass junction with traffic flow value of 2647 PCU/hr. Based on the directional flow of traffic at the junction, Figure 7 was produced to described the traffic movements at the junction.

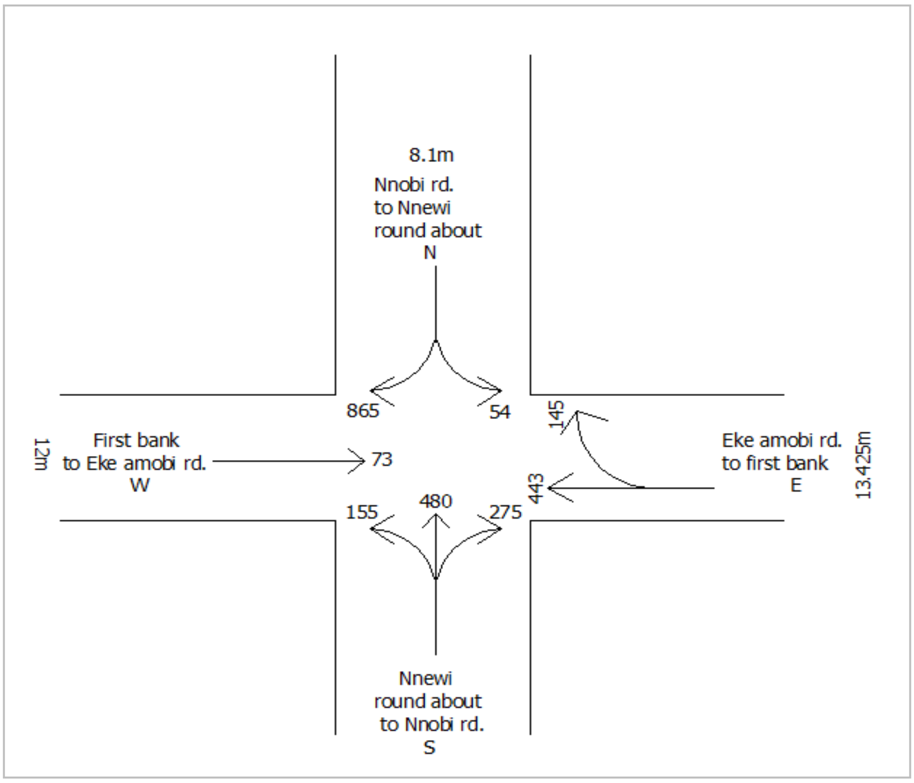

Figure 7: Directional flow of traffic

Calculating using the most critical traffic flow which is Tuesday evening (3-4pm) in Eastern mass junction Nkwo triangle Nnewi with 2647PCU. Using 1.75 correction factor for left turning vehicles, the actual flows and saturation flows were calculated as presented in Table 7.

Table 7: Saturation flow for Eastern Mass junction Nkwo Triangle Nnewi

Phase	Direction of the road approach	Width of road (m)	Actual Flow q (PCU/hr)	Saturation flow S (PCU/hr)	Flow Ratio q/S
1	Nnobi to round about Nnewi	8.1	951	4253	0.23
2	Round about Nnewi to Nnobi	8.1	1026	4253	0.24
3	Eke Amobi to first bank	13.4	588	7048	0.08
4	Frist bank to Eke Amobi	12.0	73	6300	0.01

The southern approach recorded the highest actual flow of 1026 with the least saturation flow of 4253. It is consequently the critical leg for the signaling design. It is expected that the effective green time for the design will be highest for this phase. The critical flow ratio for the Southern approach is 0.24 followed by the Northern approach of 0.23. Approaching from the West is very minimal as there is one directional flow on that carriageway. The total loss time in all the phases is taken as 18 seconds. Using Webster's method, the optimum cycle length or time is the time it takes to complete sequence of changing indications. The optimum cycle time was thus obtained,

$Co = \frac{1.5L+5}{1-yn}$

Where Co = optimum cycle length

L = Lost time = 18 seconds

Y_n = sum of flow ratios = 0.56.

$Co = \frac{1.5x18+5}{1-0.56} = \frac{32}{0.44} = \frac{68.23\ seconds}{1} \simeq 73$ seconds

This time is apportioned for traffic movement in the intersection and denoted by G_t

Gt = Co – L

Where G_t = Total effective green time

Co = Optimum cycle length = 73 seconds

L = Lost time = 18seconds

G_t= 73 -18 = 55 seconds

The green time per phase was deduced by splitting or allocation of effective green to the four phases with the equation as follows:

$$g_t = \frac{Yi}{\Sigma Y} x (Co - L)$$

Yi= $Individual\ critical\ flow\ ratio\ for\ each\ approach$

$\Sigma Y =$ Summation of critical flow ratios for all approaches

The result of the green times, amber times, and red times for the signals are shown in Table 8. The minimal green time for Western approach is as a result of it carrying a one way traffic. Vehicles are restricted from approaching the junction along that particular road. Phase diagram for each approach in Eastern mass Nkwo triangle Nnewi based on this design output is shown on Figure 8.

Table 8: The Summary final signal timing for each phase (Eastern mass junction)

Phase	Direction of approach	Green time (s)	Amber time (s)	Red time (s)
1	Nnobi to round about Nnewi	23	5	45
2	Round about Nnewi to Nnobi	24	5	44
3	Eke Amobi to first bank	8	5	60
4	First bank to Eke Amobi	1	5	67

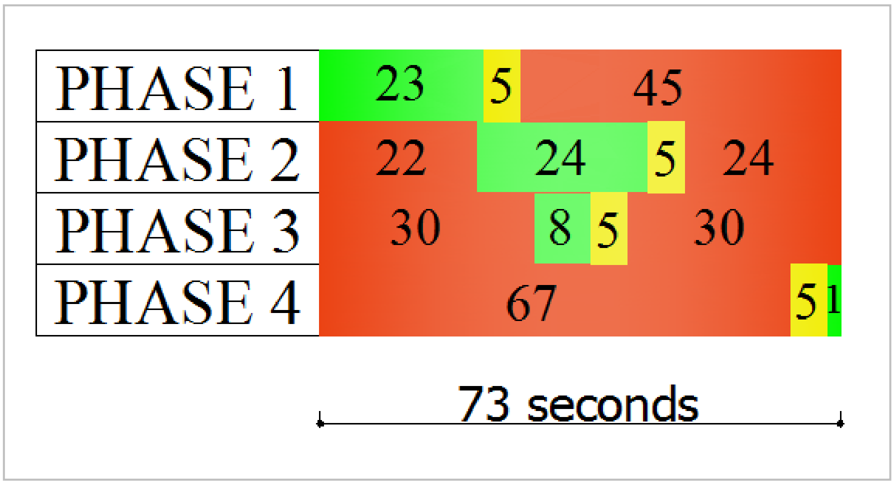

Figure 8: Phase diagrams for each road approach in Eastern mass junction Nkwo triangle Nnewi

4.0 CONCLUSION

Traffic congestion is one of the major challenges facing the world because of increasing population. Eastern mass junction at Nkwo triangle Nnewi city of Nigeria is not exempted as growing markets, schools, churches, parks, recreational centers in the study area poses an extra challenge which includes delays, pollution, accidents leading to injuries, loss of lives, more so loss of human capital as long hours are wasted which cripples the economy of the study area at Local, State and Federal levels. This paper presents the results from the study on the analyses of traffic characteristics and design of traffic signaling control for management of Eastern mass junction of Nkwo triangle. Traffic Volume studies was conducted in the junction and based on the volume studies, traffic signaling scheme was designed.

Generally, traffic in morning hours build up from early peak period commute and school runs while evening peak flows reflect work-trip return peaks with strong market and shopping activities. In most weeks, mid to late week mornings (Wednesday to Friday) and weekend evening periods (Friday-Saturday) were the dominant peaks. Operationally, the morning peak is characterized by short intense surges with relatively quick recovery whereas evening peaks were broader, lasting longer, causing extended queues especially in approaches feeding the market and public transport stands. In other words, traffic is more intense in the evening hours than morning in the junction.

The ANOVA result shows a significant variation in daily traffic and no significant variation weekly with a similar traffic trend from week 1 to week 4. Results from signal design are as follows: optimum cycle lengths of 73 seconds, total effective green time and amber time of 55 and 5 seconds respectively in the junction. Implementation of this signaling design at the junction would significantly reduce traffic delays.

5.0 Recommendations

From the outcome of the study the following are suggested;

1. Increase lane width and turning radii (Left-Turn Storage) of the junction to prevent turners from blocking through traffic.
2. Introduction of pedestrian walkway and pedestrian crossings in the junction to reduce accident risks as parks, schools, churches, markets are situated around the study area.
3. Discouragement of street parking and enacting street parking restrictions can be effective.
4. Installation of a traffic signal control system at Nkwo triangle Nnewi junctions/intersections is recommended in order to save cost, time (delays) and prevent accidents for road users.

REFERENCES

- Adedeji W.O. (2023). Solving traffic congestion at Jibowu under bridge Lagos, Journal of engineering and technology, Vol. 2(1) pg 103-108
- Ajayi O. T, Olusina J. O (2024). Vehicle detection, tracking, counting and classification using deep learning. Journal of technology, vol. 43(4) 2024
- Anene W C, Aguosi, P.T., and OgunjioforE.I. (2023) Design of traffic signal control system at Orlu junction Ihiala Anambra State, Nigeria, International journal of transportation Engineering and traffic system, May 2023. Vol 8(1,2)
- Chao, W., Quddus, M., and Ison, S. (2013). A spatio-temporal analysis of the impact of congestion on traffic safety on major roads in the UK.Transp. A Transp. Sci. 9, 124–148.
- Department of Public Work and Highway Manual (2012) Road Traffic Sign: Land Transportation Office ROAD%20ACCIDENT/Road_Traffic_Signs_v4%20.pdf.
- Khaissi Z. and Salih S. (2021) Traffic Engineering studies. Department of Traffic Engineering University of Ai Moustansiryah
- Mustapha, S.D. and Ibitoye, B.A. (2022) Understanding of Traffic Signs by Drivers on Urban Roads – A Case Study of Ilorin, KwaraState.Journal of Engineering Research and Report. Journal of Engineering Research and Report November 2022.Vol 30(20) pg 20
- Nwakaire, C.M., Chuku, D.E., Udemba, J.N. (2017) The challenges and possible remedies to poor pedestrian safety considerations along and across Nigerian busy roads. MOJ Civil Eng. 2 (1); 36 – 41.
- Nwakaire, C.M. and Chukwu, J.C. (2016) Traffic Assessment for Pavement structural Design using RN 29, LR 1132, and HD26/01 Methods. American Journal of Traffic and Transportation Engineering: 1(4) 47 – 52.
- Rajak-Biru, S. M. A. D. S. (2019). An Efficient Emergency Vehicle Clearance Mechanism for Smart Cities, Journal of Mechanics of Continua and Mathematical Sciences,
- Umar, B.U., Arifa, K.H., and Solomon, T.S (2021) Asmart density based traffic control system with Barricades; journal of Telecommunication and computer Engineering. Vol 13(4), pg 2.