TRAFFIC SIGNAL DESIGN AND PERFORMANCE ASSESSMENT OF 4-LEG INTERSECTIONS USING WEBSTER'S MODEL: A CASE OF 'SREEKANTAM CIRCLE' AND 'IRON BRIDGE' INTERSECTIONS IN ANANTAPUR TOWN

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Abstract: For two contender social affairs, a fixed-made sign-controlled traffic system for 4-leg at grade intersection was typical of the 'Sreekantam Circle' and 'Iron Bridge' intersections in Anantapur town using Webster's traffic signal concept models and shows evaluated. Numerical intersection plans were evaluated and a manual traffic excuse was given for the regular travel demand (pcu/h) for base year (2020) and extended year (2027) using a 3 percent increase in traffic progress. The design of a 4-Organized traffic control system for the two focal points of the intersection showed that the base year failed. Despite the way in which the increase in the number of lanes from 1 to 2 on major approaches to the Sreekantam Circle junction, as allowed by its decision to continue, sensitively improved its efficiency from Level of Service (LOS) E to D. At the base year, execution of the Iron Bridge Junction failed with the level of unity submersion level. Since the decision to proceed and land-Use characteristics at the intermixing of the Iron Bridge do not allow its number of lanes to be extended, it was suggested to upgrade and advance the roundabout, grade separated or steady flow junction as proposed by different specialists for failed cross-Intersection for improved intersection execution. Usage of annotated pavement markings to sort drivers equally as extraordinary Simple systems to mind street ending around to enhance lane discipline For the assignment of cross-intersections, intersections were suggested to improve the lane limit.

KEYWORDS: Signal-controlled traffic system, Webster's Models, degree of saturation, phase cycle length, Level of Service (LOS).

I. INTRODUCTION

As human beings fill up increasingly in metropolitan areas, the volume of car traffic has also generally increased following expanded convey ability and numerical extension in improving vehicle ownership. This tracks authentic traffic congestions associated with metropolitan areas that affect their tolerability with regard to weakening, defilement, high travel costs, delay, etc. Traffic congestions are reliably refined by superfluous suspensions, all things considered at the intersection point focus. As the impediment of an intersection point is consistently smaller than that of separate street sections, bottleneck effects at the intersections can actually be observed. In fact, if an intersection point cannot move on referring to traffic going into it, there will be a stop.

There are several negative implications for conveying capacity and the environment, including unnecessary delay with associated increase in travel time; prolonged air poison floods and enormous degree of racket emissions due to vehicles moving slowly, halting and reviving; the dissatisfaction of the road intersection to move properly on pushing towards traffic; In the reverse progress of traffic, widened energy use and extended vehicle wear and tear; extended accident change and decreased connection constraints.

Improvements in intersection point concentrations should be administered or even regulated in order to achieve ideal intersection execution. For example, the use of 'Stop' signs or Yield signs; junction channelling, pavement markings and the use of traffic signals, there is a collection of ways to control traffic at the intersection. Traffic signals are uniform contractions for vehicle traffic norm and control, walking and pedal cyclists used at the signalled intersection, signalled walker and bicycle intersection canters, railway intersection and areas where traffic flow control is required. It is entirely isolated that traffic signals are the most capable technique for traffic flow.

One of the essential districts of the State of Andhra Pradesh in India is Anantapur. The road network in Anantapur town, like any other town, is sprinkled with various types of intersections. These points of intersection are not signalized. For the most part, the use of traffic policies during peak hours is the traditional current control system. This control strategy is outdated and not fantastic, as lines can be a bit thick, especially during peak periods. As the amount of traffic in the city winds up exponentially, these lines are constantly getting longer. In addition, during periods of real weather, traffic regulations are normally not available to traffic control.

The city's public authorities have shown little commitment and political will to render and present traffic signals at included road intersections to replace traffic police with guaranteed and fair traffic light at intersection point focuses; this pays no attention to the multiple priorities associated with traffic policies.

In any event, as the traffic situation continues to holler out for thought, there is the possibility that the resulting systems may give the city's very simple respect for traffic signals, which will inevitably notice the replacement of traffic police with traffic signals at intersections, hence the basis for this assessment. The explanation behind this evaluation was to construct a 4-leg, two-way signal-controlled intersection with a fixed-coordinated traffic signal. Using Webster's model, the intersections considered are clearly the **'Sreekantam Circle'** and **'Iron Bridge'** junctions in Anantapur city. The evaluation's unambiguous objections were to provide access to traffic demand at the two contenders' intersections; to develop a fixed-arrange traffic signal control system for the intersection points and to consider, after some time, the implementation of the planned system.

II. WEBSTER'S METHOD OF TRAFFIC SIGNAL DESIGN

In order to help traffic engineers find the optimal coordination of traffic signals and to predict the presentation of Signalized intersection concentrates equivalently as deferrals and line lengths, various types of techniques and computer contraptions have been developed. The Webster method is one such technique. Webster suggested a condition for testing the ideal duration of the cycle that aims to minimize the delay of the vehicle. Various experts have established that at whatever point of flow ratio it is normally unity, this model would fail terribly. This is when deals are roughly equivalent to lane capacity.

For each new turn of events (straight, left and right turning redesigns) and the drenching flow(s) of the approaches, the Webster's framework for traffic signal game-plan includes assessment of traffic interest (q) on all approaches to the intersection stage. Saturation flows are analysed based on lane width, with the flow ratio represented as the degree of the flow rate of traffic demand to the advancement of the submersion flow of individual lane sets. In order to determine signal cycle length, which is the time needed for the full signal cycle, these cut-off focuses are used. Notwithstanding missed events for both processes, the period length explores the green time.

Traffic signals have the effect of causing delay on approaches as clients without the option of continuing with the need to hold it together for the green sign. As demonstrated by [2] and [3], as drivers become confused, lengthy delays at signalized intersections invigorate red light running. As such the late and line length measurement resulting from the role of a sign control system is hallowed and sets up a basic component of the arrangement of traffic signals.

Delay in vehicles to be dispatched from the plan and dynamic cycle intersection [4], as it is the extra improvement time faced by pilots, pioneers or individuals walking close to the actual travel time. For surveying intersection execution and network power, it is a crucial limit. [1, 5 and 6].Developed societies have developed advanced computer gadgets that they use for the assessment and planning of road intersection habitats for significant control systems rather than mathematical models. Inquisitively, much of today's intersection and architecture programming has direct or indirect intersections with the illuminating versions of the Webster that have operated since 1958.
The Split Cycle Offset Optimization Technique (SCOOT) and SPOT provide some of the software, a decentralized and money-related redesign contract for signal settings ceaselessly subject to appearance flow plan specifications for different intersections. These systems (SCOOT and SPOT) have been developed and are used separately in the United Kingdom and Italy and have also been understood by various countries. For example, various tools combine modelling and simulation programming, VISSIM, SIDRA INTERSECTION, TRANSYT, LINSIG, CORSIN, HCM (TRB-2000, etc. [7, 9, 4, and 9].

III. DESCRIPTION OF STUDY AREA

For this evaluation, two current 4-leg un-signalized street intersection centres in Anantapur city, Andhrapradesh district of India, were considered. The junction centres are precisely the middle of Anantapur's **Sreekantam Circle** and the junction of the **Iron Bridge** on the eastern side of Anantapur in the town of Anantapur. **Raju Road, RF Road, Bus Stand Road** and the **old city** that runs from north to south and east to west are linked by the Sreekantam Circle junction. One of which on the eastern bearing prompts the Old Town, and another appears to clock tower for the intersection point on the western side. The other of which prompts the northern bearing bus station, and the other serves for the intersection to sapthagiri circle situated at the southern side. The two paths that run backwards to each other are accomplices to the **Iron Bridge** junction. One of the roads is the 80-foot lane, a dual carriageway that stretches from north to south. The lane that follows is known as Old Town Route, which stretches from east to west. Figure key plan 1 is a Google map screenshot showing the city of Anantapur and areas of the candidate intersections.

Fig:1 KEY PLAN 1

SREEKANTAM CIRCLE 1

IRON BRIDGE JUNCTION 1

Fig.-1: Screenshot of Google Map showing the **Sreekantam Circle** and **Iron Bridge** Junctions in Anantapur town.

a. **Data Collection**

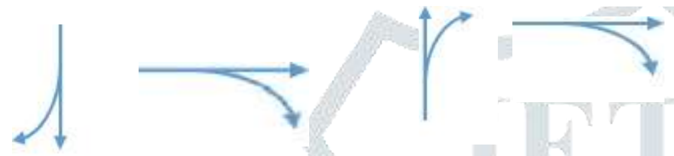
At all of the planned intersections, traffic counts were carried out for seven (7) days from 6:00 am to 6:00 pm. Traffic enumerators actually performed regular checks over a time span of 15 minutes. Cut-off focuses tested at the two intersections included; flow rate of vehicular traffic (pcu/h) at each sudden turn of events (through, left and right); numerical features, such as lanes number and width, and speed-approaching vehicles using speed pistol. The field work checked the base year (2020) limitations used to raise traffic demand at intersections over a 10-year life plan (2030) using a 3% average traffic growth rate. On each approach, saturation flow rates per hour were chosen in the same way using normal lane saturation flow rate considerations suggested by [7].

b. Signal Timing Design Procedure

In comparison to what anyone would imagine feasible for the signal course of operation, both thinking strategies incorporated the peak 15 demand flow rate and the drenching flow rate; these were derived from the intersection traffic control results and geometrical properties assessment. The strategy cycle involved the assessment of flow ratios (represented as the premium flow rate level to the submersion flow rate), phase design, adjustment and clearance interval determination, step duration and green time for each stage.

c. Signal Phasing Plan

For both intersections, a 4-stage signal-control plan was moved on. The styles of improvement of each strategy is right-of-way to proceed, preceded in a given technique by upgrades of another confining approach using 4-stages. Both a through and left-turn advance controlled each point. This stage plan was known taking into account the way that in most situations each had comparable same lane through traffic and turning traffic. The organization and flow configuration displayed in Fig.2 reflects a case of a 4-leg intersection's traffic movement methodology or signal phasing strategy.



Stage 1 Stage 2 Stage 3 Stage 4

Fig. - 2: Signal phasing and Flow Directions

Traffic movement in phases 1, 2, 3, and 4 was allocated to hold right-of-way in phase 4 as seen in Figure 2 to indicate the approaches to the North, East, South and West as they were. Left turning motions were overlooked in this evaluation because they do not establish the flow of simple conflict traffic. It was considered that the green time was adequate to cater to the correct turns for straight and left turning degrees of progress [10, 11].

d. **Cycle Length Estimation**

Using the Webster model provided as eq(1),the optimal cycle duration (Co) was settled.

$$\mathbf{Co} = \frac{\mathbf{1.5L+5}}{\mathbf{1\text{-}Y}} \qquad (1)$$

Where, L is the total lost time per cycle (sec), Y is the sum of flow ratios of individual lanes. Considering, Y equal to $\sum Yi$ where yi, is the flow ratio of individual approaches showed up as I.

e. Estimation of Total Lost Time per Cycle

The period during which any action does not feasibly use an intersection involves the start-up missed time and the open entrance lost time, which is the number of cumulative times found when an improvement is begun and wrapped up. In this attempt, 4 seconds of time was added per stage to resolve the missed events unquestionably (2 seconds for lost start-up time and 2 seconds for lost space to pass time) considering the recommendation of [6]. The lost time per cycle (L) was measured using Eq. (2)

$$\mathbf{L = N\,(ts + tc)} \qquad \mathbf{(2)}$$

Where, N is number of stages, ts and tc address start up and clearance lost events per stage freely.

f. Green Time Estimation

To achieve full scale green time, the total missed time per period was deducted from the total average measurement time. To review the degree of green time to be regulated at each point, the flow ratios were used. Using Eq, the effective green time (gi) was determined for each point. (3)

$$\mathbf{gi} = \frac{\mathbf{y_i}}{\mathbf{\sum Yi}}\ \mathbf{Gt} \qquad (3)$$

Where, **gi** is the flow level of the with way or approach,

Gt is the full scale green time for the cycle. The genuine green time was calculated as the sum of the actual green and total lost times less the amber time.

g. Estimation of Vehicle Control Delay

The model for estimating average vehicle control delay on line for a given approach of a signalised intersection is as given in Eq. (4)

$$d = \frac{C(1-\lambda)^2}{2(1-\lambda x)} + \frac{x^2}{2q(1-x)} - 0.65\left(\frac{c}{q^2}\right)^{\frac{1}{3}} x^{(2+5\lambda)}$$

Where, d is vehicle control delay (s/veh), C is the design

For a step bound by the cycle duration, x is the degree of saturation, s is the saturation flow rate (veh/s) and q is the first rate flow rate (veh/s). The measurement term of the intersection(s) is efficient green time. The first, second and third words of the yield model region typical deferral to vehicles with uniform appearance, delay in the appearance of vehicles and chance of surrender in vehicle appearances obtained by over-saturation of the strategy.

h. Queue Length

List length is another metric of introduction that is used to select the intersection Degree of Operation (LOS) near deferral. As seen in eq (5) the equation used for the evaluation of queue length Q per approach is

$$Q = \frac{q}{3600/C} \quad (5)$$

Where, q is demand flow rate (veh/ln) and C is the cycle length (s). Delay and queue lengths are massive execution measures for road junction that traffic engineers reliably endeavour to restrict to improve the LOS of intersection [12].

IV. INTERSECTION PERFORMANCE ANALYSIS PROCEDURE

The combination of volume capacity, delay and queue length was used to assess the level of operation at the intersection at which the intersections occurred under the conditions indicated. Following the acts given in [5] for each LOS, a LOS was made due to each approach. These measurements are presented with respect to the normal control delay per vehicle and the average queue period used to choose the intersection LOS for the base and expected years ahead.

V. ANALYSIS AND DISCUSSION OF RESULTS

5.1 Sreekantam Circle junction

The structure of the Sreekantam Circle junction and customary traffic flow speeds measured in the passenger vehicle unit (pcu/h) for all approaches for the 2020 base year are presented in Figure 3.

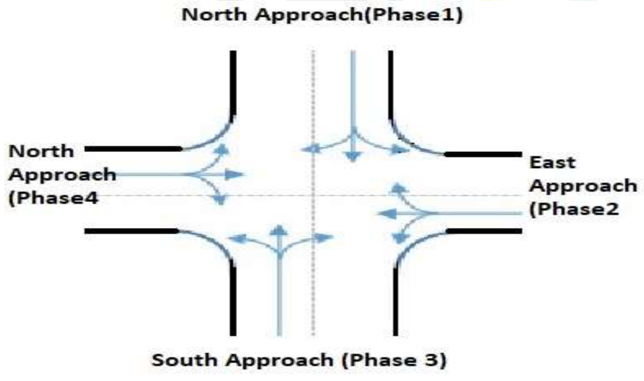


Fig.- 3: Layout and Traffic flow rate (pcu/h) on the Sreekantam Circle junction

As the asserted successful travel demand volume for the base year the amount of left-turning and through movement traffic flow values were secure for each approach. The base year traffic flow rate was raised using a 3 percent change rate to achieve a fair amount of travel demand for the design year (2030), as seen in Table 1.

Table -1: Characteristics of the Sreekantam circle junction

Description	Phases			
	1	2	3	4
Lane width (m)	3.8	3.3	3.8	3.2
Number of lanes	1	1	1	1
Present traffic flow rate(pcu/h)	850	264	510	182
Predicted traffic flow rate(pcu/h)	1142	355	1926	1866
Saturation flow rate per lane(pcu/h)	1926	1874	1926	1866
Present floe ratio(y_i)	0.2966	0.189	0.178	0.131
Predicted flow ratio (y_i)	0.3542	0.190	0.590	0.190

For each lane course, the summation flow ratios for base year (yi) and plan year (yj) are 0.9445 and 1.2694 autonomously. The degree of these criteria is entirely strong and undefined by those around solidarity. This illustrates that the intersection runs at maximum capacity or has a lack of capacity to meet the level of travel demand. As seen by the results of the Highways Agency (2003), where the flow degree scale (∑Yi) for an intersection is greater than 0.8. It illustrates that the intersection has possible breakpoint problems as traffic structures do not run in operation at 100% of their theoretical capability.

Given its present numerical characteristics and the amount of travel demand, it was concluded that the result of the Sreekantam Circle junction is extremely weak because it does not have adequate power in the base year to handle its vehicle traffic demand. This thus called for the intersection to be modified. As allowed by the right-of-way and land-use features including the location, the geometrical configuration of the convergence point was re-evaluated with the proportion of northward and southward lanes linked from one to two on the approaches. As seen in Table 2, the changed characteristics of the Sreekantam Circle intersection for enhanced execution are shown. The new intersection point flow ratios were applied to 0.6448 and 0.8041 respectively in the foundation and architecture years. This illustrates subtly enhanced execution within the revamped intersection's action life course example.

5.2 Signal Timing Design

Input parameters used for the setup of signal organization included; Amber time of 3 seconds, start-up lost period of 2 seconds, all-red season of 2 seconds with an authoritative target of 4 seconds of full-scale lost time per point. This gave the cycle's overall missed season to 16 seconds. The optimal period length for the base year was 82 seconds and 149 seconds for the design year using Webster's model. To achieve the green time of 66 seconds and 133 seconds unreservedly in the base year and design plan year the missed time per cycle was deducted from the all-around cycle term.

Execution cut-off purposes of the intersection of the Sreekantam Circle under signalized condition with respect to queue lengths on lanes, control suspensions and LOS revealed that for the base year the north approach usually conducted in a way that is superior to other methods of procedure with LOS C. The execution of the revised junction fragment is not significantly improved. The Green Time course for each step is as shown in Table 2.

Table- 2: Characteristics of Modified Sreekantam Circle junction

Re design Description	Phases			
	1	2	3	4
Lane width(m)	3.5	3.3	3.5	3.2
Number of lanes	2	1	2	1
Year 2020 traffic volume per lane (pcu/h)	425	264	255	182
Year 2030 traffic volume per lane (pcu/h)	571	355	343	245
Saturation flow per lane (pcu/h)	1890	1874	1890	1866
Year 2020 v/c ratio	0.225	0.141	0.182	0.098
Queue lengths (veh)	9.64	5.99	7.78	4.13
Control Delay(sec/veh)	22.6	28.4	25.5	31.9
LOS	C	D	D	D
Year 2030 v/c ratio	0.302	0.189	0.182	0.131
Queue lengths (veh)	23.49	14.59	14.10	10.06
Control Delay(sec/veh)	36.4	48.1	49.0	55.1
LOS	E	E	E	F

Table 3 shows the performance characteristics of Sreekantam Circle junction.

Table - 3: Signal Timing for redesigned Sreekantam Circle junction

Description	Phases			
	1	2	3	4
Base Year 2020				
Actual Green Time per phase(sec)	22	14	18	10
Effective Green Time per phase (sec)	21	13	17	9
Projected Year 2030				
Actual Green Time per phase(sec)	50	31	30	22
Effective Green Time per phase (sec)	49	30	29	21

5.3 The Iron Bridge Junction

The design and traffic flow rate (pcu/h) at the Iron Bridge Junction for the base year (2020) is as appeared in Fig. 4.

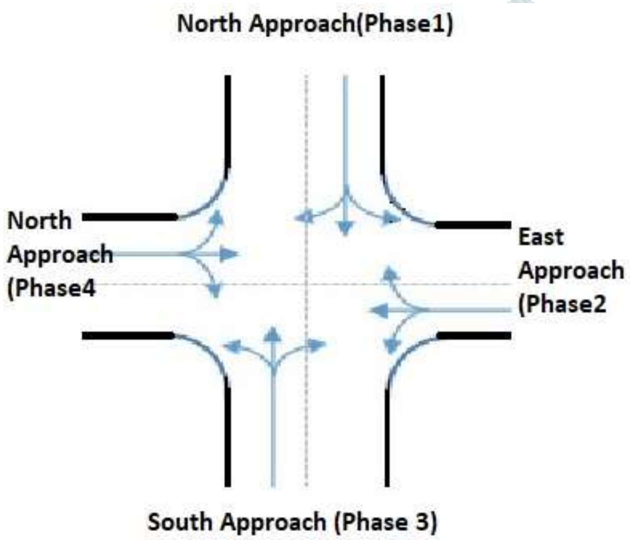


Fig.- 4: Travel Demand on Iron Bridge Junction in 2020

The viable traffic flow rate for base year of Iron Bridge Junction and its mathematical qualities are as appeared in Table 4.

Table- 4: Characteristics of the **Iron Bridge** Junction

Description	Phases			
	1	2	3	4
Lane width (m)	3.6	3.2	3.5	3.0
Number of lanes per approach	2	2	2	2
Actual Demand flow rate in lane group(pcu/h)	1287	369	1169	646
Saturation flow rate per lane(pcu/h)	1910	1866	1890	1850

At the intersection, the summation of saturation flow rates for all sign phases was 0.9196. This shows that the cap on the advancement premium at the Iron Bridge for the base year is appallingly lacking, as the valuation is more than 0.8 (with a cut-off of about 8 percent, which shows a critical break point problem). As broken down in this evaluation, this dull appearance of the junction point in its base year was due to elevated travel demand. In its base year the present numerical course of action of the intersection point weakens projection and upgrade for the future year, as all current techniques each had 2 existing ways, and land-use characteristics and option to proceed with approaches do not allow the path to travel to produce further ways it could include. As the revelations of previous inquiries have demonstrated, change of the flow junction of the Iron Bridge through the new roundabout with or without signalling, or moving a relentless flow together are suitable arrangements for enhanced implementation to understand problems relevant to the Iron Bridge intersection.

VI. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Using Webster's sign strategy models, the approach of the fixed-made, 4-stage traffic signal control system at two 4-leg intersections, the SREEKANTAM CIRCLE and IRON BRIDGE junction in Anantapur area, was completed. The concept plan and implementation evaluation focused on the travel interest in the combined populations in the base year (2020) and extended year (2030). The Sreekantam Circle junction's execution analysis using its existing numerical course of action shows fragile yields. Updating the intersections by rising the number of lanes from one to two in the north and south views showed better implementation for both base and future years. On the other side, the Iron Bridge junction execution assessment showed that the intersection is operating in a state of failure. This was due to the intersection's strong travel interest and its numerical approach and schedule. Therefore it was obtained that the usage of the resuscitated Sreekantam Circle junction at any rate will generally fill the course of action requirement for a common 10-year instance of presence; obviously, the execution of the Iron Bridge junction is currently unimaginably defenceless as such does not need comprehensive evaluation, However, as its joining territory uses features and option to proceed with strategies, rather assembles for having another form of intersection layout do not allow further movement of its extension into lanes for increased traffic capability and reservations.

VII. RECOMMENDATIONS

Taking into account the disclosures of this study, those recommendations were made;

1. If tolerable, assembly plan is resurrected by introducing the proportion of advancing to lanes or increasing lane width to viably oblige demand or transform intersection into roundabouts above what many will deem prospering imaginable and confirmation, or adjustment of cross-section to optimistic flow intersection for enhanced execution.

2. Implementation of road movement in management approaches to control reaching uniform lane widths with pavement markers exposed to sort driver and strengthen path discipline for future intersection use. To decrease the improvement of red light running, which makes disasters and squares free of traffic development, the local authority council should guarantee the presence of traffic regulations and safety working conditions at junctions.

3. In working conditions, traffic policies should take corrective steps against drivers who rot course width by parking on the street aro und the intersection sites to tighten saturation flow and ensure spaces determined for a spare breaking point.

VIII. REFERENCES:

1. Findley, D.J.; Schroeder, B.J.; Cunningham, C.M. and Brown, T.H. (2016). *Highway Engineering; Planning, Design, and Operations.* The boulevard, Langford lane, Oxford, UK.
2. Johnson, M.; Charlton, J.; Oxley, J. and Newstead, S. (2013). Why do cyclist infringe at red lights? An investigation of Australian Cyclists' reasons for red light infringement. *Accident Analysis and Prevention*, 50, 840 –847.
3. Yang, C.Y.D and Najm, W.G. (2007). Examining Driver Behaviour using Data gathered from Red light Photo Enforcement Cameras. *Journal of Safety Research*, 38 (3), 311 –321.
4. Preethi, P.; Varghese, A. and Ashalatha, R. (2016). Modelling Delay at Signalised Intersections under Heterogeneous Traffic Conditions, 11th Transport Planning and Implementation Methodologies for Developing Countries (TPMDC) 2014, Mumbai, India, *Transport Research Procedia*, 17, 529-538.
5. Highway Capacity Manual (HCM) (2000). *Transportation Research Board*, Washington DC: National Research Council.
6. Bang, K.; Wahlstedt, J and Linse, L. (2016). Methodology for Timing and Impact Analysis of Signalised Intersections. International Symposium on Enhancing Highway Performance. *Transport Research Procedia*, 15, 75 – 86.
7. Webster, F.V. (1958). Traffic Signal Setting. Department of Scientific and industrial Research, *Road Research Technical Paper No. 39*. London, England.
8. Webster, F.V. and Cobbe, B.M. (1966). Traffic Signals. Road Research Laboratory, *Road Research Technical Paper No. 56*, London, UK.
9. Zhao, X.; Feng, M.; Li, H. and Zhang, T. (2016). Optimization of Signal Timing at Critical Intersections for Evacuation. *Procedia Engineering*, 137, 334 – 342.
10. Al-Mudhaffar, A. (2006). *Impacts of Traffic Signal Control Strategies*, Doctoral Thesis in Traffic and Transport Planning, Infrastructure and Planning, Royal Institute of Technology, Stockholm, Sweden.
11. Xi, J.; Wang, S. and Wang, C. (2015). An Approach to an intersection traffic delay study based on shift- share analysis. *Journal of Information, Multidisciplinary Digital Publishing Institute*, 6, 246 – 257.
12. Federal Republic of Nigeria – Ministry of Works, Housing and Transportation (2013). *Highway Design Manual*, Nigeria.