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# A Survey of Traffic Congestion Measure Towards a Sustainable Traffic Flow at Garrison Intersection in Port Harcourt, Nigeria.

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## ABSTRACT
*The huge increase in motor vehicles on Port Harcourt Road is causing traffic problems like accidents, congestions, delays etc., especially at intersections. This paper examines the traffic problems and sustainable improvement of Garrison intersection along Port Harcourt – Aba Expressway. A proper traffic study at the intersection was carried out and the factors of the intersection causing delay were identified using the Relative Importance Index (R.I.I) from a well-developed questionnaire of about 250. Data regarding the traffic volume and pedestrian movement activities were collected through direct field surveys. Analysis of the collected data revealed that the major causes of traffic congestion at Garrison Intersection based on the R.I.I ranking are Inadequate Bus Stop Capacity, Poor Traffic Control, Poor Driver Habit, No Pedestrian Crossing Facility, and Inadequate Road Capacity. Various remedial measures are also proposed, focusing on the intersection improvement with the provision of U-turnings, Pedestrian crossing facilities, Bus stop bays off the road.*

**KEYWORDS:** Traffic, Congestion, Intersection, Free Speed, Flow rate.

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## 1.0 INTRODUCTION
Port Harcourt city is undergoing many-sided problems because of speedy urbanization. One of these problems is traffic congestion. Traffic congestion is one of the unbearable problems of urban areas because of sudden increment in the private transport sector which is affecting urban society and economy (Kumar & Sing, 2017). This is a typical situation in Port Harcourt city. Road traffic congestion constitute serious challenges in large and growing cities (Rahane & Saharkar, 2013). According to Kumar and Sing (2017), congestion stops the movement of traffic leading to unbearable increase in travel time. Traffic congestion is a condition in transport that is characterized by slower speeds, increased vehicular queueing and longer trip times. Traffic congestion brings about losses to drivers (increase in fuel consumption), stress or vexation, delays, inability to forecast travel time accurately. Traffic congestion in Port Harcourt has been a constant problem for the sustainability of transportation development.

There are numerous arguments in respect of congestion and its principal cause at Garrison intersection where a new flyover was constructed. Also, many suggestions towards a lasting solution have been put forward. However, in this part of the world, the arguments incline to either be political or myopic. They mostly focus on the problem that is most relevant to their situation ignoring the other factors that may be related across the road network. Some studies in major cities in Nigeria has stated some main causes of congestion. Recently, Otto and Simeon (2022) in a study revealed the major factors responsible for congestion at Slaughter roundabout. The causes were: illegal trading around the intersection, road user behavior, lack of pedestrian crossing facilities, absence of pavement markings, and lack of packing facilities. According to Uwadiegwu (2013), factors responsible for congestion include physical, technical, land use and human factors.

Road users in Port Harcourt have long been concerned about traffic congestion at the Garrison intersection. Recently, the state government constructed a flyover as shown in Plate 1 to reduce traffic at the intersection, but the congestion is still there. The idea of constructing new roads, has been seen as a temporary relief because it does not work always for different reasons such as political, environment, or financial, and sometimes it may attract traffic and increase the road occupancy (Kumar & Sing, 2017; Rahane & Saharkar, 2013). This has been confirmed with the construction of the new flyover at Garrison intersection. Therefore, there may be other factors that may be responsible. This study seeks to identify the main causes and provide lasting solutions.


**Plate 1: Garrison Intersection on Google Map**

## 2.0 MATERIALS AND METHODS

### 2.1 Materials

Field observers conducted the investigations using tally sheet papers, a pen, a stopwatch, and a measuring tape.

### 2.2 Methods

The procedure of reaching the study's goal was divided into two parts: an office desk study and a field survey. During the survey, traffic volumes and physical geometric aspects of adjacent road alignments at the intersection was determined. The manual counting approach was used in the data collection. The geometric features of

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Garrison intersection were manually measured and recorded using standard measuring tape. At the crossroads, a manual traffic count was also conducted.

The data was collected for 3 months (5 days in a week) at an appropriate location along each approach leg from 06:30am to 10:30am and 04:30pm to 08:30pm, which are the intersection's two peak traffic periods. A traffic count for buses, trucks and private cars was conducted at each location. The recorded traffic volumes for each vehicle were converted to its equivalent Passage Car Units (PCU). This was done to ease the analysis. Similarly, the geometric characteristics of adjacent roads was measured and recorded.

### 2.3 Determination of Factors Responsible for Traffic Congestion

A wide-ranging causes of traffic congestion at garrison intersection was produced from the road users comprising drivers of both Private and Commercial vehicles, passengers, pedestrians, and traffic control officers. The causes, effects, and solutions to traffic congestion along the road were listed in well-structured questionnaire and administered to 250 road users (Drivers, pedestrians, passengers, and traffic control officials). Results obtained from the questionnaire were analyzed using Relative Importance Index (R.I.I).

The Relative importance index was used to determine the actual cause of traffic congestion at the intersection. It is a four-scale system converted to Relative Importance Index (R.I.I) for each factor as shown in Equation 3.1 (Lim & Alum 1995).

$$R.I.I = \frac{(4n_1+3n_2+2n_3+n_4)}{4N} \qquad (2.1)$$

Where:

$n_1$ = Number of respondents for strongly agree

$n_2$= Number of respondents for agree

$n_3$= Number of respondents disagree

$n_4$ = Number of respondents for strongly disagree

N = number of respondents

### 2.4 Traffic Speed Determination at the Bottleneck Sections of the Intersection

The Lighthill and Whitham theory was adopted to understand the traffic flow at the intersection. According to Lighthill and Whitham theory as explained in Kadiyali (2011), to understand traffic flow, the knowledge of fluid flow based on kinematic waves is important. This theory applies "continuous flow" approach in fluid dynamics in solving traffic problems. Noting that, at any point on the road, the flow (Q) is a function of the concentration (K).

In solving the problem related to this study, the application of the above theory is narrowed to dealing with bottlenecks for flow greater than the capacity of the bottleneck only.

The point A represents a traffic condition with flow $Q_A$ greater than the bottleneck capacity $Q_{max}$. The speed of the vehicles through the bottleneck drops from $\frac{Q_A}{K_A}$ to $\frac{Q_{max}^l}{K_j}$. The point B represents the flow condition on the second half of the Q – K curve of the road away from the bottleneck, with a concentration equal to the bottleneck capacity $Q^1_{max}$. The crawl speed of traffic behind the shock wave is represented by $\frac{Q_{max}^l}{K_B}$ which is very much lower than the speed of vehicles through the bottleneck itself. This shows that the speed of vehicles through the bottleneck itself is higher than the speed of crawl behind. The speed of the shock wave is represented by the

$$\text{slope of the line AB} = \frac{Q_A - Q_{max}^l}{K_B - K_A} \qquad (2.2)$$

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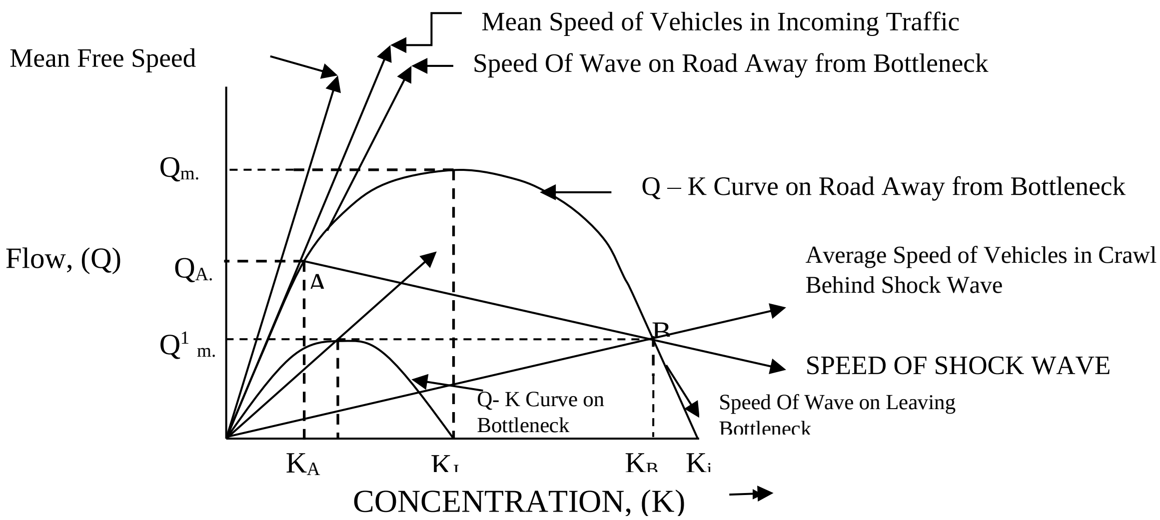


**Fig. 1 Q – K Curves of Bottleneck, with Flow Greater Than Bottleneck.**

In solving the mathematical traffic problems related to this research, the two major equations used were:

Jamming concentration, $K_j = \frac{1000}{s}$ (2.3)

Traffic volume/ flow, $Q = \frac{V_{sf} \times K_j}{4}$ (2.4)

Where:
$K_j$ = Jamming concentration.
S = Average spacing.
Q = Traffic volume/ flow.
$V_{sf}$ = Average mean speed.

## 3.0 RESULTS AND DISCUSSION

The results of the traffic count carried out are presented in the Table 1 and Table 2.

**Table 1** Average Traffic Volume Count at Garrison Intersection

| Direction | Right (PCU/hr) | Left (PCU/hr) | Straight (PCU/hr) | Returning (PCU /hr) | Total (PCU /hr) |
|---|---|---|---|---|---|
| From CFC | 955 | | 120 | 365 | 1440 |
| From Waterlines | | 728 | 323 | 105 | 1156 |
| From Trans-Amadi | 287 | 826 | | 82 | 1195 |
| | | | | **Total** | **3791** |

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**Table 2:** Vehicle Distribution in Percentage (%)

| Vehicle Type | Private Car | Bus | Trucks | Taxi |
|---|---|---|---|---|
| Number | 1592 | 1119 | 398 | 682 |
| % | 42 | 29.51 | 10.5 | 17.99 |

In the results presented in Table 1, the average traffic volume entering Trans-Amadi is the highest. That is, vehicles from CFC turning right (955PCU/hr) plus vehicles from Waterlines turning left (728 PCU/hr) given a total number of 1683 PCU/hr. This value is about 44.4% of the total vehicles attracted to Garrison intersection. This is expected since Trans-Amadi is an industrial area with so many companies.

Considering Table 2, the traffic count shows that private cars are more on the road followed by buses, taxies and then trucks with the following percentages 42%, 29.51%, 17.99% and 10.5% respectively. This is expected since there is no functional public transportation system in Port Harcourt couple with the fact that insecurity has taken the order of the day.

### 3.1 Observed Causes of Traffic Congestion at Garrison Intersection

During the traffic survey, a well-structured questionnaire was developed from responses made by road users. The results from the questionnaire are presented in Table 3.

**Table 3:** Questionnaire Responses/Causes of Traffic Congestion at Garrison Intersection

| S/N | Causes | n1 | n2 | n3 | n4 | N | R.I.I | Ranking |
|---|---|---|---|---|---|---|---|---|
| 1 | No pedestrian crossing facility | 72 | 81 | 45 | 10 | 208 | 0.75841 | 4 |
| 2 | Poor driver habit | 94 | 85 | 42 | 15 | 236 | 0.77331 | 3 |
| 3 | Inadequate road capacity | 71 | 81 | 33 | 16 | 201 | 0.75746 | 5 |
| 4 | No packing facility | 73 | 52 | 43 | 36 | 204 | 0.69853 | 7 |
| 5 | Roadside market | 61 | 94 | 67 | 42 | 264 | 0.66477 | 9 |
| 6 | Too many buses and taxis | 87 | 91 | 65 | 42 | 285 | 0.69561 | 8 |
| 7 | Poor traffic control | 111 | 91 | 40 | 18 | 260 | 0.78365 | 2 |
| 8 | Inadequate bus stop capacity | 120 | 89 | 44 | 11 | 264 | 0.80114 | 1 |
| 9 | No U-turning facility under the flyover | 99 | 62 | 41 | 52 | 254 | 0.70472 | 6 |

In Table 3, 250 questionnaires were given out but 212 were collected. Using the Relative Importance Index (R.I.I), inadequate bus stop capacity ranked number 1 showing that it is the major cause of traffic congestion at the intersection. This is true because, the bus stop is just 5m away from the intersection with no bus stop marking or adequate bay for parking. It was also observed that the buses waste so much time at the bus stop for boarding and alighting of

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passengers. this leads to long queues. See Table 5. This causes a lot of delay. These causes have been shown in some studies (Raheem *et al*, 2015). However, from the field observation the number of private cars seen moving and parked on the road are more (See Table 2). With the increasing population in Port Harcourt if not controlled, this menace will continue to increase.

### 3.2 Traffic Flow Rate at Garrison Intersection

The traffic flow rate at Garrison Intersection because of the observed bottlenecks are presented in Table 4 and the observed queue length caused by the bottleneck is presented in Table 5 and show graphically in Figure 1.

**Table 4: Traffic Flow Rate at Garrison Intersections as a Result of Bottlenecks**

| Direction | Free Speed (Km/hr) | Spacing (m) | Density (k) (Veh/km) | Jam Density (k) (Veh/km) | Observed Flow (Q) (Veh/hr) | Maximum Flow (Q) (Veh/hr) | Minimum Flow (Qm) (Veh/hr) | Speed at Bottleneck (km/hr) Before | At | After |
|---|---|---|---|---|---|---|---|---|---|---|
| From CFC | 68 | 8.5 | 117.64706 | 235.29412 | 1440 | 4000 | 2000 | 10.625 | 34 | 61.20 |
| From Waterlines | 68 | 8.5 | 125 | 250 | 1156 | 4250 | 2125 | 11.172919 | 34 | 63.00 |
| From Trans-Amadi | 70 | 8.5 | 117.64706 | 235.29412 | 1195 | 4117.647059 | 2058.823529 | 11.373123 | 35 | 64.48 |
| Average | 68.67 | | | | | | | 11.06 | 34.33 | 62.90 |

Table 4 shows the flow rate at Garrison intersection. From the results, an average free speed of 68.67Km/hr was observed. However, because of the bottlenecks introduced because of indiscriminate on-street parking, pedestrian crossings, and boarding/alighting of passengers at bus stops close to the intersection, the speed reduced to 11.06Km/hr before the bottleneck and increased to 34.33Km/hr and 62.90Km/hr as the vehicles gradually pass through the bottleneck areas. The reduction in speed is 16.11%, 49.99% and 91.60% respectively. The number of bus stops and location have great effect on traffic flow. It has been seen as a major bottleneck on roads in urban areas (Tang *et al*, 2009).

Table 5 and Figure 1 explains the delay behavior of the queue formed at the intersection. As the stop time spent at the bus stop increases, the queue length increases at an average rate of 100%. This is because one lane of the two-lane roadway has been blocked. This blockage has been noted to be the major problem causing traffic as identified using the R.I.I method of analysis from the responses and observations made during the study.

**Table 5: Observed Queue Length**

| Time (Sec) | Speed (Km/hr) | Queue Length (m) |
|---|---|---|
| 30 | 11.06 | 92.17 |
| 60 | 11.06 | 184.33 |
| 90 | 11.06 | 276.50 |
| 120 | 11.06 | 368.67 |
| 150 | 11.06 | 460.83 |
| 180 | 11.06 | 553.00 |
| 210 | 11.06 | 645.16 |

## 4.0 CONCLUSIONS

The conclusions to this study were made based on a complete finding based on the set objectives. The conclusions are as follows:

i. The volume of traffic at Garrison Intersection is three thousand, seven hundred and ninety-one vehicles per hour. This comprises of 42% of private cars, 29.51% of buses, 17.99% of taxies and 10.58% of trucks.

ii. The actual cause of traffic congestion at Garrison Intersection is Inadequate Bus Stop Capacity.

iii. The average free speed before the intersection is 68.67Km/hr. The speed reduced to 11.06Km/hr before the intersection caused by the bottleneck introduced at the bus stop. And increases to 34.33Km/hr and 62.90Km/hr as the vehicles gradually pass through the bottleneck areas. The reduction in speed was observed to be 16.11%, and later increases 49.99% and 91.60% respectively as the vehicles pass through the bottleneck.

iv. The length of queue at the intersection increases at an average rate of 100% as the time of delay increases.

The following recommendations were made based on the findings and conclusions of this study.

i. U-turning should be provided under the flyover before the intersection to reduce the number of vehicles at the intersection coming from Waterlines and CFC approaches respectively.

ii. A bus stop bay should be constructed off the road to ensure that the two-lane road always is free for traffic movements.

iii. Introduce pedestrian walkways and crossing facilities to avoid vehicle to pedestrian accident. It also eliminates bottlenecks caused by pedestrians crossing the road.

iv. Ensure the rule of law is upheld for every road user who acts against traffic laws.

v. Reduce the height of the walls serving as barriers to reduce the rate of accidents at the intersection.

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