Traffic Congestion Analysis of Asaba Road Using Volume to Capacity Ratio and Speed Performance Index

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ABSTRACT: With Nnebis ROAD acting as a case study, this study focuses on the investigation of traffic congestion on Asaba ROAD. The study aims to examine the relationship between vehicle volume and road capacity, enabling transportation authorities to assess congestion levels and make informed decisions to alleviate traffic issues. Peak traffic counts were conducted, revealing the highest traffic flow on specific road sections on different days. The Ibusa – Stadium junction saw the highest volume on Monday, reaching 3,056 vehicles, while Ibusa – Ofili-Ilukwu junction peaked at 3,128 vehicles, also on Monday, and Ibusa – Ogbeongonogo junction hit 3,151 vehicles on Tuesday. Speed performance index varied across junctions and days, generally exceeding 60%. For instance, Ibusa – Stadium Junction ranged from 69.57% to 71.82% from Monday to Friday, Ibusa – Ofili-Ilukwu junction showed values between 63.59% and 68.95%, and Ibusa – Ogbeongonogo Junction ranged from 61.57% to 70.11%. These findings suggest a better road traffic state with higher average speeds. Moreover, the volume to capacity ratio, indicates the level of congestion and delays experienced. The ratio values along the studied road sections ranged from 0.61 to 0.70. These ratios, along with the speed performance index, classify the level of service as class B, indicating moderate congestion and delays with slightly longer travel times, yet still acceptable to users.

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A fundamental aspect of a nation's social and economic progress lies in its transportation infrastructure. As we transition to the era of intelligent transport systems, focus has predominantly been on developed cities, neglecting rapidly developing rural areas assimilated into metropolitan regions. The urbanization of these areas, termed semi-urban cities, escalates traffic volume, stressing the existing transportation system and highlighting the necessity for comprehensive solutions (Singh and Saraswat, 2019). Urbanization leads to heightened vehicular traffic on roadways, causing deteriorating road conditions, particularly during peak hours, with consequential economic, social, and environmental impacts. These include time wastage, elevated accident rates, and increased fuel consumption, as population growth often outpaces infrastructure expansion, diminishing service quality. This underscores the relationship between infrastructure capacity, dictated by traffic volume, and service level (Slimani et al., 2019; Akhtar and Moridpour, 2021). According to Garber and Hoel (2009), traffic flows
smoothly below a roadway’s designed capacity, but congestion and delays arise near or beyond this limit. This is pivotal in highway planning, aiming to design facilities operating efficiently below their maximum capacities. Capacity analysis assesses a road segment’s ability to accommodate traffic quantitatively, determining its maximum volume under prevailing conditions. According to Roess et al. (2011), capacity is the maximum vehicle passage rate within a specific timeframe. "Level of service" (LoS) aids in transportation and urban planning, crucial for trip duration estimation and infrastructure performance assessment. LoS categorizes traffic flow based on speed, density, and delay (Habib et al., 2018). The degree of saturation, defined as the volume to capacity ratio, determines infrastructure LoS (Koringa et al., 2017). Roads are classified by ownership and functionality, forming a hierarchical structure. Ownership-wise, they encompass freeways, arteries, collector/distributor roads, and local roads (US Department of Transportation, 2013).

Freeways, prioritized for high-speed travel, feature limited access and grade separation. Arteries, positioned below freeways, maintain some access control while serving both movement and access functions. Collector/distributor roads facilitate access and connect local roads to the broader network. Local roads, designed for lower speeds and minimal traffic, complete the hierarchy (AASHTO, 2018). In Nigeria, roads are categorized into Trunk A, B, C, and D, representing Federal, state, and local connections (Federal Ministry of Works and Housing, 2013). The road’s serviceability concerns its function regarding traffic flow, encompassing speed and delays (TRB, 2016), vital for transportation planning. Capacity denotes a facility’s ability to accommodate people or vehicles under current conditions, influencing road serviceability (Findley et al., 2016).

Traffic flow theory, addressing infrastructure capacity and quality (Ni, 2016), informs planning by analyzing operations in various scenarios. Design incorporates geometric elements for desired traffic quality, while construction manages traffic around work zones and network congestion. In operations, it maximizes network efficiency, linking traffic control to the environment. Maintenance adapts to traffic patterns and infrastructure decay, initiating a new cycle (Ni, 2016; Elefteriadou, 2014). Monitoring flow, speed, and density are crucial in the dynamic and location-dependent study of traffic flow (Teodorović and Janić, 2017; Roess et al., 2011). It involves assessing macroscopic metrics like volume, speed, and density, alongside microscopic factors such as individual vehicle behavior (Teodorović and Janić, 2017).

On a highway, flow or volume, measured in vehicles per hour (veh/h), indicates the number of vehicles passing a specific point within an hour (Garber and Hoel, 2009; Garber et al., 2011). Equation 1 defines hourly flow rate using N as total cars and T as time.

\[ q = \frac{N \times 3600}{T} \]  

(1)

Daily traffic volumes vary significantly, especially during peak morning and evening commutes, making them unsuitable for design or operational analysis. Traffic engineers prioritize the peak hour, which records the highest traffic volume, using the highest 15-minute flow within that hour for analysis (Roess et al., 2011; Manering and Washburn, 2013). Traffic capacity can be assessed using traffic volumes, but service quality for road users relies heavily on speed (HCM, 2016). Speed represents the distance a vehicle travels within a set time, usually measured in kilometres per hour (km/h) or meters per second (m/s). Speed can be calculated as either the time mean speed \( (u_t) \), determined by averaging speeds as vehicles pass a point, or the space mean speed \( (u_s) \), calculated by averaging speeds over a specific highway stretch at a given moment (Garber et al., 2011). Time mean speed, denoted as \( u_t \), is the simple average of spot speeds measured for all vehicles passing a location over a specific time period, and is given by equation 2.

\[ u_t = \frac{1}{n} \sum_{i=1}^{n} u_i \]  

(2)

Where \( v \) is the spot speed of \( i \)th vehicle, and \( n \) is the number of observations. The time mean speed can be summarized to be the arithmetic mean of the vehicle speeds observed at some designated point along the
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Traffic Congestion

Traffic Congestion Analysis of Asaba Road Using Volume to Capacity (Mannering and Washburn, 2013). Spot speed refers to a vehicle’s speed at a specific point on a road. It's calculated based on the time taken to cover a particular distance.

Spot speed refers to a vehicle's speed at a specific point on a road. It's calculated based on the time taken to cover a particular distance. Space mean speed, on the other hand, is an average of spot speeds but considers spatial weighting rather than time weighting. Space mean speed is often used for traffic modelling, assuming that all vehicles are measured over the same road length (Murthy and Mohle, 2001; Garber et al., 2011; Mannering and Washburn, 2013). The space mean speed is as expressed in equation 3.

\[ v_s = \frac{1}{n} \sum_{i=1}^{n} \left( \frac{1}{t_i} \right) \]  

(3)

Traffic density, a macroscopic traffic flow parameter, is crucial for both drivers and system operators in assessing traffic performance. It's determined by the proximity of vehicles, affecting drivers' freedom and psychological comfort (Al-Sobky and Mousa, 2016). This density, often referred to as concentration, it is the number of vehicles per unit length of highway at a specific moment (measured in veh/km). Its significance lies in characterizing traffic operation quality, making it vital for uninterrupted-flow infrastructures and overall traffic assessment (HCM, 2016; Papacostas and Prevedouros, 2009). The traffic density is given expressed by equation 4.

\[ k = \frac{n}{l} \]  

(4)

Evaluating density directly is challenging as it requires an elevated viewpoint to observe the studied road section. Nevertheless, it stands out as the most crucial of the three fundamental traffic stream factors because it directly relates to traffic demand. Traffic demand is not a rate of flow; rather, it results from diverse land uses contributing to a high vehicle density. The observed flow rate is determined by the interplay of speed and density, as used by traffic engineers to gauge demand (Roess et al., 2011; Walsen and Saleh, 2017). The three basic macroscopic parameters of a traffic stream (i.e., flow, speed, and density) are related by the expression as seen in equation 5.

\[ q = v k \]  

(5)

The foundation for assessing traffic stream parameters lies in the provided definitions and relationships. To comprehensively analyze the operational performance of the traffic stream, it's essential to understand how these macroscopic metrics interact. Speed-flow and speed-density curves are computed once the relationship between speed and density is established (Roess et al., 2011; Mannering and Washburn, 2013). At very low densities, there's minimal interaction among drivers due to the scarcity of vehicles. In this scenario, vehicle performance and posted speed limits are the primary factors influencing speed, referred to as "free flow speed." However, as traffic density gradually increases, especially during the morning rush, congestion may develop in certain situations. In the early hours of the day, traffic density is minimal when the road is nearly empty, and vehicles travel at their maximum speed, known as free flow speed. However, as more vehicles join the roadway, traffic density gradually increases, causing a decline in the average speed. When traffic volume becomes substantial, it can lead to congestion, where vehicles come to a standstill with a speed of zero (Asaithambi et al., 2016). Figure 2 illustrates a standard speed-density relationship, including free-flow speed and jam density, characterized by a linear pattern. This relationship depicts how traffic density affects vehicle speed (Jain et al., 2016).

A linear speed-density relationship is approximation of the reality and is known as the Greenshields model as expressed in equation 6. By multiplying the density \( k \) by speed \( v \) from equation 6, the rate of flow can be defined by the equation 7 derived from equation 5 as

\[ v = v_f \left( 1 - \frac{k}{k_j} \right) \]  

(6)

\[ q = v_f \left( 1 - \frac{k}{k_j} \right) k \]  

(7)

From the above equation it was observed that the flow \( q \) is a quadratic function of the density \( k \).

The graph shown in Figure 3 takes on a parabolic...
shape. As traffic density increases, the flow rate grows from zero to its maximum value \( q_{\text{max}} \), which signifies the road’s capacity. \( q_{\text{max}} \) is often termed traffic flow at capacity, while \( k_{\text{max}} \) represents the density associated with highway capacity. The corresponding speed is \( u_{\text{max}} \). With a further rise in density, the flow rate begins to decline. Eventually, at jam density, the flow rate reaches zero, indicating that all vehicles are at a standstill. Studying density at capacity, \( k_{\text{max}} \), is crucial as it distinguishes between stable (densities from zero to \( k_{\text{max}} \)) and unstable (densities higher than \( k_{\text{max}} \)) traffic conditions. Additional vehicles entering the highway, resulting in densities surpassing \( k_{\text{max}} \), reduce highway flow (Teodorović and Janić, 2017; Roess et al., 2011; Garber and Hoel, 2009: HCM, 2016).

The maximum density is seen in equation 8 and the corresponding maximum velocity that defines this maximum flow is seen in equation 9.

\[
k_{\text{max}} = \frac{k_j}{2} \quad (8)
\]
\[
v_f = \frac{u_f}{2} \quad (9)
\]

The flow at capacity \( q_{\text{max}} \) is as shown in equation 10

\[
q_{\text{max}} = \frac{u_f k_j}{4} \quad (10)
\]

The capacity of a system element represents the maximum hourly flow rate under current constraints (HCM, 2016). In traffic, it signifies the highest possible vehicle flow through a specific point within a timeframe, reflecting a highway’s traffic-carrying capability (Elefteriadou, 2014). Freeway capacity is defined as the maximum sustained 15-minute flow rate, usually in passenger cars per hour per lane (pc/h/ln), accommodating a uniform freeway segment’s traffic in one direction (Garber and Hoel, 2009). Capacity levels include basic, possible, and practical, ensuring reasonable traffic flow and safety (HCM, 2016; Elefteriadou, 2014).

The capacity of the highway as given by Pawar et al., (2015) and Habib et al., (2018) is given by the equation 11

\[
C = \frac{3600}{H_t} \quad (11)
\]

Where \( H_t \) is the time headway.

The Level of Service (LOS) evaluates traffic operational conditions for road users under defined highway and traffic management conditions, indicating roadway performance below capacity (Garber and Hoel, 2009; HCM, 2016). LOS offers a qualitative overview of traffic, considering travel time, speed, and congestion (Mannering and Washburn, 2013). Selecting a performance measure reflecting motorists’ perception, encompassing speed, travel time, delays, comfort, and convenience, is crucial for LOS analysis (Roess et al., 2011; Rogers, 2003; HCM, 2016; Yerawar et al., 2016). In the United States, the Highway Capacity Manual outlines six LOS levels, from A (best) to F (worst) (TRB, 1985), aiding in evaluating service quality based on speed, delays, and other factors (Pandey and Biswas, 2022). Visualizing traffic conditions is facilitated by the speed-flow relationship (Garber and Hoel, 2009). Level A reflects...
near-maximum speed, constrained by design, with low flows, while Level D optimizes flows with moderate speeds. Level F denotes breakdown conditions, indicating severe congestion (TRB, 1985).

The volume-to-capacity ratio, referred to as the degree of saturation (DS), is the ratio of traffic flow (Q) to road capacity (C) in passenger car units per hour (PCU/hr). It is a critical metric for evaluating traffic performance, with higher saturation values indicating poorer performance (Susilo and Imanuel, 2018). This is as given by equation 13.

\[
VCR = \frac{\text{Traffic Volume} (q)}{\text{Road capacity} (C)} \quad (13)
\]

Where VCR = volume to capacity ratio.

This value is less than one and the traffic volume is less than the capacity of the road structure, hence the relationship between the volume to capacity ratio and the level of service is as seen in the Table 1

<table>
<thead>
<tr>
<th>Level Of Service (LOS)</th>
<th>Q/C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt; 0.6</td>
</tr>
<tr>
<td>B</td>
<td>0.61 - 0.70</td>
</tr>
<tr>
<td>C</td>
<td>0.71 - 0.80</td>
</tr>
<tr>
<td>D</td>
<td>0.81 - 0.90</td>
</tr>
<tr>
<td>E</td>
<td>0.91 - 1.00</td>
</tr>
<tr>
<td>F</td>
<td>&gt; 1.00</td>
</tr>
</tbody>
</table>

The traffic congestion index objectively assesses road traffic conditions, aiding in management and planning (Wang et al., 2018), quantifying congestion potential perceived by road users. Vehicle speed, alone or combined with other factors, is crucial for evaluation. The index reflects the ratio of vehicle speed to the maximum allowable speed, typically ranging from 0 to 100. The Beijing Traffic Management Bureau (BTMB) categorizes urban road traffic using values of 25 and 50 (He et al., 2016), employing a speed performance index with threshold values of 25, 50, and 75 to categorize urban traffic conditions. The road segment and road network congestion indices are defined based on this assessment to study traffic congestion on urban road networks. Table 2 displays the speed performance index for a highway section

<table>
<thead>
<tr>
<th>Speed Performance Index</th>
<th>Traffic State Level</th>
<th>Description of Traffic State</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 25</td>
<td>Heavy</td>
<td>The average speed is low, road traffic state poor.</td>
</tr>
<tr>
<td>25 – 50</td>
<td>Mild</td>
<td>The average speed is lower, road traffic state bit weak.</td>
</tr>
<tr>
<td>50 – 75</td>
<td>Smooth</td>
<td>The average speed is higher, road traffic state better.</td>
</tr>
<tr>
<td>75 – 100</td>
<td>Very</td>
<td>The average speed is high, road traffic state good.</td>
</tr>
</tbody>
</table>

The speed performance index is as given by equation 14.

\[
R_u = \frac{u}{u_{max}} \times 100 \quad (14)
\]

Where, \(R_u\) = speed performance index, \(u\) = the average travel speed, km/h; \(u_{max}\) = maximum permissible road speed, km/h.

To establish speed-flow relationships for six-lane divided carriageways across different vehicle types, Jain et al. (2016) derived fundamental traffic flow parameters. The outermost lane experiences slow-moving vehicles in a free-flow state, as per the speed-flow relationship based solely on traffic speeds and flow. Traffic flow dynamics involve interactions among road infrastructure, vehicles, and user characteristics. Raji and Jagannathan (2019) illustrated the stochastic nature of traffic stream flow, resulting in random variations in vehicle movement and interactions. Modal speeds across the road network ranged from 36 to 45 kmph. Generally, the road facility's service level in the study area was designated as LOS A, except for Modal School Road and School Line Road, which exhibited LOS B. Phoenix Bay Road and Delanipur Road, with v-c ratios of 0.6 and 0.7 respectively, showed Level of Service C. However, other roads with v-c ratios ranging from 0.8 to 1.09 indicated LOS D or E. The study concluded that varying v-c ratios and speeds determine the level of service for the same road network in the study area. Pawar et al., (2015) presented an assessment of the
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level of service at highway midblock sections. Three highways (MSH-248, MSH-255, MSH-260) were selected for the assessment of level of service. Level of service of each highway section was assessed by using HCS-2000 Software. The results obtained using HCS-2000 clearly reflects that the deterioration in LOS is due to the increase in traffic volume and decrease in average spot speed. The aim of this study is to analyse traffic congestion at Ibusa junction in Asaba, Delta State by the use of volume to capacity ratio and congestion index. With the objectives of involving the determination of the flow rate and the capacity of traffic, speeds, speed performance index (SPI) of the road section under study, and the volume to capacity ratio, and comparing the speed performance index with the volume of capacity of the roads sections.

MATERIALS AND METHOD
Description of the Study Area: The city of Asaba lies between longitudes 6°38′44″ and 6°44′00″ east of the Greenwich Meridian and between latitude 6°08′00″ and 6°16″00 North of equator (Ojiako et al., 2018). It is the capital of Delta State and located at the Niger Delta Area of the country. It is located at Oshimili South LGA and is bounded to the North by Oshimili North LGA, to the south by Ndokwa East LGA, to the East by the River Niger and to the West by Aniocha South and North LGA respectively (Ochilli et al., 2020). Being the centre of Delta state and the various ministries that are present. With an estimated population of 407, 196, this city is the 40th largest city in Nigeria. Therefore, the number of road networks in the city has increased as a result of the area's expansion (Ojiako et al., 2018). Figure 6 shows the road network in Asaba, Delta State and the study locations.

For this study, traffic counts and speed assessments were conducted at Ibusa junction, focusing on three road sections: Ibusa junction to Stadium junction, Ibusa junction to Ilukwu – Ofili Nwanne junction, and Ibusa junction to Ogbeogonogo market junction. These dual carriageways lack medians, each with two lanes and a width of 16.4m, except for the single carriageway along Ibusa – Ofili-Nwanne Junction. The Ibusa junction to Stadium junction, part of Nnebisi Road, experiences heavy traffic during peak periods from 8:00am to 10:00am and 4:00pm to 7:00pm. Similarly, the Ibusa junction – Ofili Nwanne junction, a section of Ibusa Road, faces high traffic during peak hours. The road connecting Ibusa junction to Ogbeogonogo market junction, also part of Nnebisi Road, experiences similar traffic flow, especially due to the market presence. The study procedures entail a reconnaissance survey of the road network, manual field data collection, and traffic flow modelling using volume-to-capacity ratio and speed parameters. This involves assessing flow concentration, conducting spot speed studies, and estimating congestion indices, including volume-to-capacity ratio and congestion index (CI).

Fig 6 Road Network of Asaba Showing the area of Study

Reconnaissance Survey of the roads Networks: Reliable traffic information is imperative for effective road network planning and decision-making. The reconnaissance study involves defining the roads under study, including their classification, width, lane count, and the types of vehicles utilizing them.

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According to the FMWH manual (2013), Nigerian roads are categorized based on ownership into Federal, State, Local, and Rural Roads. Federal roads are further classified into four classes: A, connecting major urban areas; B, linking cities within a state and to Class A roads; C, connecting local centres; and D, serving minor centres like local markets. Vehicle classification includes passenger cars, trucks, and buses, encompassing various subcategories to aid in road infrastructure planning and management.

**Volume of Traffic Determination:** To ascertain the traffic volume on a road segment, conducting a traffic count is essential, involving the measurement of vehicles passing through the area during a specific time frame. Traffic counts yield critical data used in road design, influencing factors like lane lengths and gradients. Neglecting traffic volumes in road design, akin to designing bridges without considering planned vehicle weights, would be futile (Findley et al., 2016). Manual traffic counts which involve observers manually tallying and classifying vehicles over shorter durations was used. This approach was used because it is cost-effective for single-day or shorter-duration data collection, making it a suitable choice for this study due to its affordability and classification capabilities, unlike automatic equipment, which can be expensive and lack classification features.

**Traffic Speed Determination:** To obtain the speed, the stopwatch method was applied and the length of the road section was determined by using the coordinates at the respective starts points and end points of the roadway under study, the observation was then recorded by the use of stopwatch spot speed data, from which the vehicular speeds were calculated and the time means speed which is the average speed of the vehicles were then determined.

**Determination of Congestion Indices:** The determination of the congestion was then measured based on data from the traffic volume. The measures used in this study include determination of the Speed Performance Index SPI, and Volume to Capacity ratio, which defines the Level of Service of the study.

**RESULTS AND DISCUSSION**

**Summary of Road Characteristics:** Nnebis Road in Asaba, Delta State, connects Summit Road Flyover to the Federal Road Junction. This state-owned dual carriageway comprises two lanes separated by a 3.6m-wide median. Each lane has a covered drainage serving as a 1m-wide sidewalk. In total, the road section is 16.9m wide. The prominent Ibusa Junction is a key intersection along this road, linking Ibuso community and the bustling Ogbeogonogo Market in Asaba. Table 3 in the study provides a summary of this intersection and the road's alignment characteristics.

**Traffic Volume and Road Capacity:** Table 4 revealed the dominance of low-capacity vehicle i.e. 3 wheelers, passenger cars and small buses. At every section of the road, passenger cars have the highest counts follow by 3 wheelers, small buses, medium buses, light goods vehicles and heavy goods vehicles respectively.

Figure 7 summarizes the data as gotten from Table 4.5. It can be seen that the numbers of passenger cars for Friday was the highest, followed by Wednesday, with Thursday, Tuesday and Monday being least. These are also seen with other vehicular class.

**Computation of Volume to Capacity Ratio:** Tables 5 to 7 present the passenger car unit equivalent of the traffic volume. Using the British standard, the PCU factor for each class of vehicle are: 3 wheelers 0.8; passenger car 1.00; small buses, medium buses 2.00; light goods vehicles 1.5 and heavy goods vehicles 3.50 (Kadiyali, 2013).

For a dual carriageway of 2-lanes (7.3m/lanes) under the prevailing condition of been an all-purpose street with high-capacity junctions and with a no waiting restriction, the capacity is put at 1200 PCU/hour for both direction of flow (Ajala, 2019).
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Table 5 Volume/Capacity Ratio along Ibusa – Stadium Junction

<table>
<thead>
<tr>
<th>Vehicle class</th>
<th>PCU</th>
<th>Mon</th>
<th>PCUM</th>
<th>Tue</th>
<th>PCUT</th>
<th>Wed</th>
<th>PCUW</th>
<th>Thur</th>
<th>PCU/Th</th>
<th>Fri</th>
<th>PCUF</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 wheelers</td>
<td>0.8</td>
<td>823</td>
<td>658.4</td>
<td>806</td>
<td>644.8</td>
<td>824</td>
<td>659.2</td>
<td>818</td>
<td>654.4</td>
<td>899</td>
<td>719.2</td>
</tr>
<tr>
<td>Passenger cars</td>
<td>1</td>
<td>859</td>
<td>859</td>
<td>897</td>
<td>921</td>
<td>921</td>
<td>900</td>
<td>900</td>
<td>925</td>
<td>925</td>
<td>925</td>
</tr>
<tr>
<td>Small buses</td>
<td>1</td>
<td>373</td>
<td>373</td>
<td>348</td>
<td>325</td>
<td>325</td>
<td>320</td>
<td>320</td>
<td>310</td>
<td>310</td>
<td>310</td>
</tr>
<tr>
<td>Medium Buses</td>
<td>2</td>
<td>344</td>
<td>688</td>
<td>342</td>
<td>278</td>
<td>556</td>
<td>261</td>
<td>522</td>
<td>258</td>
<td>516</td>
<td></td>
</tr>
<tr>
<td>LGV</td>
<td>1.5</td>
<td>336</td>
<td>504</td>
<td>292</td>
<td>438</td>
<td>278</td>
<td>417</td>
<td>402</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HGV</td>
<td>3.5</td>
<td>321</td>
<td>1123.5</td>
<td>287</td>
<td>1004.5</td>
<td>287</td>
<td>927.5</td>
<td>267</td>
<td>934.5</td>
<td>240</td>
<td>840</td>
</tr>
<tr>
<td>Total</td>
<td>3056</td>
<td>4205.9</td>
<td>2891</td>
<td>3805.7</td>
<td>2834</td>
<td>3732.9</td>
<td>2927</td>
<td>3752.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average capacity/hour

- Mon: 841.18
- Tue: 803.26
- Wed: 761.14
- Thurs: 746.58
- Fri: 750.54

V/C Ratio

- Mon: 0.70
- Tue: 0.67
- Wed: 0.63
- Thurs: 0.62
- Fri: 0.63

Table 5 presents the daily PCU (Passenger Car Unit) capacity for the Ibusa – Stadium junction section. The capacity varies across the weekdays, with Monday having 4205.9 PCU/day, Tuesday 4016.3 PCU/day, Wednesday 3805.7 PCU/day, Thursday 3732.9 PCU/day, and Friday 3752.7 PCU/day. For each day, during a 5-hour survey, the average hourly capacity is calculated. These values are 841.18 PCU/hr (Monday), 803.26 PCU/hr (Tuesday), 761.14 PCU/hr (Wednesday), 746.58 PCU/hr (Thursday), and 750.54 PCU/hr (Friday). Additionally, the volume to capacity ratio (v/c ratio) is determined for each day. The ratios range from 0.70 (Monday) to 0.62 (Thursday). Overall, the level of service for this road section falls within class B, with a v/c ratio of 0.61 – 0.70 according to Roess et al. (2011). This indicates that there are constrains to traffic flow below speed limits, requiring drivers to pay extra attention for safe operations, resulting in reduced driver comfort and convenience.

Table 6 Volume/Capacity Ratio along Ibusa – Ilukwu Junction

<table>
<thead>
<tr>
<th>Vehicle class</th>
<th>PCU</th>
<th>Mon</th>
<th>PCUM</th>
<th>Tue</th>
<th>PCUT</th>
<th>Wed</th>
<th>PCUW</th>
<th>Thur</th>
<th>PCU/Th</th>
<th>Fri</th>
<th>PCUF</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 wheelers</td>
<td>0.8</td>
<td>932</td>
<td>745.6</td>
<td>950</td>
<td>760</td>
<td>948</td>
<td>758.4</td>
<td>958</td>
<td>766.4</td>
<td>878</td>
<td>702.4</td>
</tr>
<tr>
<td>Passenger cars</td>
<td>1</td>
<td>952</td>
<td>952</td>
<td>953</td>
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<td>925</td>
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<td>962</td>
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<td>Small buses</td>
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<td>342</td>
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<td>337</td>
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<td>358</td>
<td>358</td>
<td>328</td>
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<tr>
<td>Medium Buses</td>
<td>2</td>
<td>302</td>
<td>604</td>
<td>331</td>
<td>662</td>
<td>321</td>
<td>642</td>
<td>293</td>
<td>586</td>
<td>286</td>
<td>572</td>
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<tr>
<td>LGV</td>
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<td>322</td>
<td>483</td>
<td>284</td>
<td>426</td>
<td>291</td>
<td>436.5</td>
<td>283</td>
<td>424.5</td>
<td>275</td>
<td>412.5</td>
</tr>
<tr>
<td>HGV</td>
<td>3.5</td>
<td>254</td>
<td>889</td>
<td>265</td>
<td>927.5</td>
<td>258</td>
<td>903</td>
<td>244</td>
<td>854</td>
<td>246</td>
<td>861</td>
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<tr>
<td>Total</td>
<td>3104</td>
<td>4016</td>
<td>4065.5</td>
<td>3128</td>
<td>4049.9</td>
<td>3068</td>
<td>3920.9</td>
<td>3070</td>
<td>3732.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average capacity/hour

- Mon: 803.1
- Tue: 813.1
- Wed: 809.98
- Thurs: 784.18
- Fri: 746.58

V/C Ratio

- Mon: 0.67
- Tue: 0.68
- Wed: 0.67
- Thurs: 0.65
- Fri: 0.62

Table 6 provides insights into the daily PCU (Passenger Car Unit) capacity for the Ibusa – Ofili-Ilukwu junction section. The capacity varies throughout the weekdays, with values of 4016...
PCU/day (Monday), 4065.5 PCU/day (Tuesday), 4049.9 PCU/day (Wednesday), 3920.9 PCU/day (Thursday), and 3732.9 PCU/day (Friday). During a 5-hour survey, the average hourly capacity for each day is calculated, resulting in values of 803.1 PCU/hr (Monday), 813.1 PCU/hr (Tuesday), 809.98 PCU/hr (Wednesday), 784.18 PCU/hr (Thursday), and 746.58 PCU/hr (Friday). Furthermore, the volume to capacity ratio (v/c ratio) is determined for each day.

These ratios range from 0.67 (Monday) to 0.62 (Friday). The level of service for this road section falls within class B, with a v/c ratio of 0.61 – 0.70 (Roess et al. 2011). The drivers along this road section may experience a decrease in comfort due to the impression of being surrounded by other vehicles.

Table 7 presents data related to the PCU (Passenger Car Unit) capacity for the Ibusa – Ogbeogonogo junction section. The capacity fluctuates for each weekday, with values of 4079.6 PCU/day (Monday), 4184.3 PCU/day (Tuesday), 3785.7 PCU/day (Wednesday), 3676.7 PCU/day (Thursday), and 3654.3 PCU/day (Friday).

The average hourly capacity is calculated based on a 5-hour survey, resulting in values of 815.92 PCU/hr (Monday), 836.86 PCU/hr (Tuesday), 757.14 PCU/hr (Wednesday), 735.34 PCU/hr (Thursday), and 730.86 PCU/hr (Friday).

Table 8 Speed Performance Index along Ibusa – Stadium Junction

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>55.29</td>
<td>54.63</td>
<td>54.63</td>
<td>52.85</td>
<td>54.23</td>
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<tr>
<td>Median</td>
<td>53.14</td>
<td>52.59</td>
<td>53.15</td>
<td>51.48</td>
<td>52.20</td>
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<tr>
<td>Mode</td>
<td>66.15</td>
<td>59.41</td>
<td>42.41</td>
<td>65.98</td>
<td>64.36</td>
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<tr>
<td>Minimum</td>
<td>41.12</td>
<td>40.18</td>
<td>39.90</td>
<td>39.06</td>
<td>38.71</td>
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<tr>
<td>Maximum</td>
<td>75.43</td>
<td>74.20</td>
<td>74.83</td>
<td>74.62</td>
<td>74.41</td>
</tr>
<tr>
<td>50th Percentile</td>
<td>53.14</td>
<td>52.59</td>
<td>53.15</td>
<td>51.48</td>
<td>52.20</td>
</tr>
<tr>
<td>98th Percentile</td>
<td>75.00</td>
<td>74.00</td>
<td>74.00</td>
<td>74.00</td>
<td>74.00</td>
</tr>
<tr>
<td>SPI (%)</td>
<td>70.85</td>
<td>71.07</td>
<td>71.82</td>
<td>69.57</td>
<td>70.54</td>
</tr>
</tbody>
</table>

Speed Performance Index Results: Tables 8 to 10 show the results of the summary of the speed study from which the average speed and the 98-percentile speed were derived.

Table 8 shows the summary of the spot speed study of the heterogeneous traffic along the Ibusa – Stadium junction and the speed performance index for the different days of traffic on the road section.

It was observed that for each of the day, the median speed which is also the 50th percentile speed was between the ranges of 51.48km/h to 53.15km/h.

Also, the Speed Performance Index (SPI) has the lowest which is on Thursday with a value of 69.57%, Friday with 70.54%, Monday 70.85%, Tuesday 71.07% and Wednesday 71.82%.

Since the range of 50 to 75% as given by He et al. (2016), suggested that the traffic flow is smooth and no congestion is experienced on this section of the road during the study.
Also, Table 9 shows the summary of the spot speed study of the heterogeneous traffic along the Ibusa–Ogbeogonogo junction and the speed performance index of the traffic. It was observed that for each of the day the median speed which is also the 50th percentile speed was 47.06 km/h on Monday, 47.71 km/h on Tuesday, 48.85 km/h on Wednesday, 48.09 km/h on Thursday and 51.02 km/h on Friday. Also, the Speed Performance Index (SPI) 70.11%, 64.43%, 61.57%, 64.51% and 61.69% for Monday to Friday respectively. In addition, the range of speed performance index was between 50 to 75% in accordance to the study by He et al. (2016), the traffic flow is smooth and no congestion is experienced on this section of the road during the study.

And Table 10 shows the summary of the spot speed study of the heterogeneous traffic along the Ibusa–Ilukwu junction and the speed performance index of the traffic. It was observed that for each of the day, the median speed which is also the 50th percentile speed was 51.88 km/h on Monday, 47.68 km/h on Tuesday, 45.56 km/h on Wednesday, 47.74 km/h on Thursday and 45.65 km/h on Friday. Also, the Speed Performance Index (SPI) 63.59%, 63.61%, 66.01%, 64.99% and 68.95% for Monday to Friday respectively. In addition, the range of speed performance index was between 50 to 75% in accordance to the study by He et al. (2016), the traffic flow is smooth and no congestion is experienced on this section of the road during the study.

**Conclusion:** Analyzing traffic congestion on Asaba road using the volume-to-capacity ratio and speed performance index offers valuable insights for traffic management. By gauging the relationship between vehicle volume and road capacity, authorities can effectively assess congestion levels and make informed decisions to alleviate traffic issues. Nnebisi Road, a major artery connecting the summit area to the Federal Road leading to Onitsha, experiences primarily three-wheelers, passenger cars, small and medium buses, light goods vehicles, and heavy goods vehicles. Notably, three-wheelers and passenger cars dominate the road. Traffic counts during peak periods reveal Monday recorded the highest flow at Ibusa–Stadium junction with 3056 vehicles, Wednesday at Ibusa–Ogbeogonogo junction with 3128 vehicles, and Tuesday at Ibusa–Ilukwu junction with 3151 vehicles. The study indicates a Level of Service B, signifying moderate congestion and delays, resulting in slightly extended travel times but still acceptable to users. The study’s recommendations propose leveraging advanced analytics and predictive modelling to anticipate future traffic demand. Implementing signal timings and prioritizing

**Comparison of Results from V/C ratio and Speed Performance Index:** In the study, employing both methods to analyze road traffic congestion, it was noted that the maximum volume-to-capacity ratio occurred along the Ibusa – Ogbeogonogo section of the road, registering a value of 0.70. This indicates that the road section remained unsaturated during the study period. Furthermore, regarding the speed performance index, the highest index recorded was 71.82%, suggesting smooth traffic flow and levels below congestion thresholds on the road sections.
infrastructure upgrades in high volume-to-capacity ratio areas are suggested strategies to address traffic challenges.

REFERENCES


Panday, A; Biswas, S (2022). Assessment of Level of Service on urban roads: a revisit to past studies. ATS. 57: 49 – 70.


