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Speed Determination for Effective Traffic Management using Moving Observer Method : Case Study Tombia Roundabout-Berger Road, Yenagoa Town in Bayelsa State of Nigeria

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Abstract: *Effective traffic management is dependent on reliable traffic data acquisition and analysis.Economically obtaining reliable traffic data is crucial and the moving observer method plays a pivotal role in this regard. Focusing on the dual lane roadway of Tombia roundabout-Berger road located in Yenagoa Town, Bayelsa, where proper road management is required for the increasing number of vehicle population,the moving observer method was adopted for the determination of the running and journey speed in both direction.The field traffic data was collected on a moving test car in both direction of traffic. The journey and running speeds in the north and south bound lanes were computed as; 45.6kilometer per hour(K.P.H) 48.2 K.P.H and 49.7 K.P.H, 52.7 K.P.H respectively. The result reveals that the south bound lane have a higher value of the journey and running speeds than the north bound lane, which provides insight into the traffic flow efficiency and areas for potential improvements in lanes usage.It is recommended that parking management and traffic regulation enforcement should be entrenched to optimize the overall performance and reduction of congestion in Tombia roundabout to Berger road .*

KEYWORDS: Moving observer method, Runningspeed, Journeyspeed, North bound direction and South bound direction.

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1. INTRODUCTION

A. Background of the Study

The rapidly evolving urban landscape in cities around the world has initiated traffic congestion as a critical challenge, necessitating innovative solutions for efficient traffic management (S. Sharma et al., 2019). With urbanization, the number of vehicles plying the roads increased enormously, which becomes a cause of traffic congestion, pollution, and sometimes delays in emergency services (Poudenx, 2008).

Traffic management plays a crucial role in the construction of road projects, which constitutes a major transportation corridor that links various rural and urban sectors (FHWA, 2020; Garber & Hoel, 2014).Speed in relation to traffic management refers to the rate at which vehicles travels on roads and highways. Managing speed is crucial for ensuring road safety, optimizing of traffic flow, and minimizing travel times (Elvik, 2009).The major challenge lies in improving traffic dynamics along this route to reduce congestion, ensure efficiency, and enhance overall safety.

Urbanization and the population increase add to the increased quantum of vehicular traffic, thus enforcing the necessity of measures for effective traffic management (Poudenx, 2008). The determination of vehicular speed emerges as a crucial factor in controlling the flow of traffic and hence, safety on the road (Chen 2017). Understanding traffic flow patterns through data analysis will help with traffic signal optimization, congestion control, and road safety enforcement (FHWA, 2020). That is, an understanding of actual traffic patterns, points of congestion, and the effects of speed variations becomes a crucial aspect in the formulation of a targeted intervention.

A dynamic technique,the moving observer method (MOM)is notably adopted by highway traffic engineers in obtaining traffic data in which a car, referred to as the observer, drives through the traffic and logs real-time information about its speed and distance traveled between predefined route. This approach is both economical and adaptable since it uses GPS and other instruments to collect precise data on traffic density and speed without the requirement for fixed infrastructure (Wang et al., 2014). This approach is especially helpful for short-term traffic studies, where installing permanent sensors might not be feasible. Furthermore, (Svestka et al., 1976), suggest that integrating MOM with cutting-edge technologies like GPS and automated data logging systems could improve its precision and dependability.When moving against traffic, for instance, the quantity of approaching cars can be used to estimate the flow of traffic; however, moving with traffic makes it easier to judge density and speed.

Yenagoa metropolis in Bayelsa state of Nigeria is a fast growing city with its attendant traffic debacles such as congestion,delays and accidents on major roads within the city. The economic lost of this traffic issues is quite over bearing. It is therefore necessary to economically obtain traffic data to understand the traffic dynamics of road networks within the city for effective traffic management. The moving observer method (MOM) is therefore most suitable for obtaining the necessary traffic data owing to its cost effectiveness and reliability with respect to real-time traffic data. The aim of this studyis therefore to determine vehicular speed using moving observer method to improve traffic flow along Tombia roundabout to Berger road in Bayelsa stateNgeria by obtaining the running and journey speeds of vehicles.

B. Study Area

The study area is(figure 1) the road from Tombia roundbout to Berger bus-stop in Yenagoa town, Bayelsa state, Nigeria. Bayelsa state is located between latitudes 04°4'N and 05°02'N, and longitudes 006°15'E and 006°24'E, in the southern region of Nigeria (Adekeye, 2018).

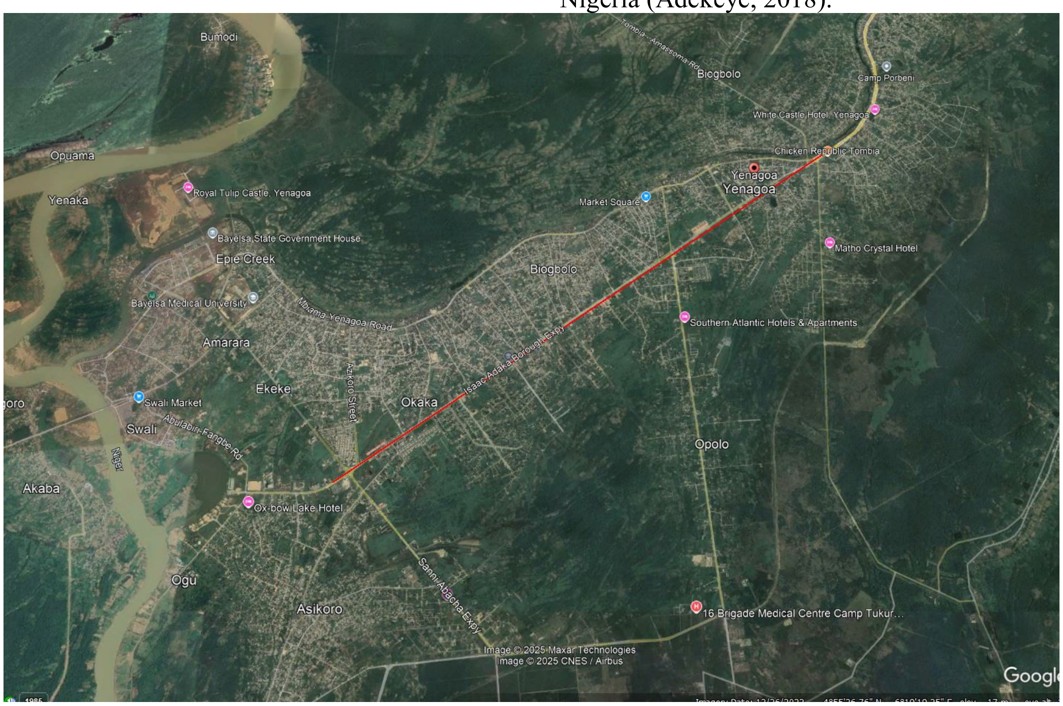

Fig 1: Map of Yenagoa showing Tombia Roundbout –Berger (Source: google map,2025)

II. MATERIALS AND METHODOLOGY

A. Overview

The methodology adopted in this research work is to obtain the running and journey speeds of vehicles through driving along the Tombia roundabout to Berger bus stop in a test car in North and South bound directions to obtain the necessary traffic data.

B. Materials

Materials used in the study includes:

1).Test vehicle with three personnel on board.

2).A stopwatch or timer used to keep track of time during the traffic observation.

3).A traffic log book for recording the data in course of the observation in North and South bound direction (figure 2).

4).Hand tallies

C. Data Collection Process

One observer in the test car counts for opposing traffic, using hand tallies. The second observer who carries a journey log prepared in advance as shown in Fig 2, who records the totals from the hand tallies and times at predetermined points en-route, together with the times of stopping at intersections. Two stop watches were used, one for recording the continuous time at different points en-route, and the other for recording stoppage time (delays). The third observer records the number of overtaking and overtaken vehicles.

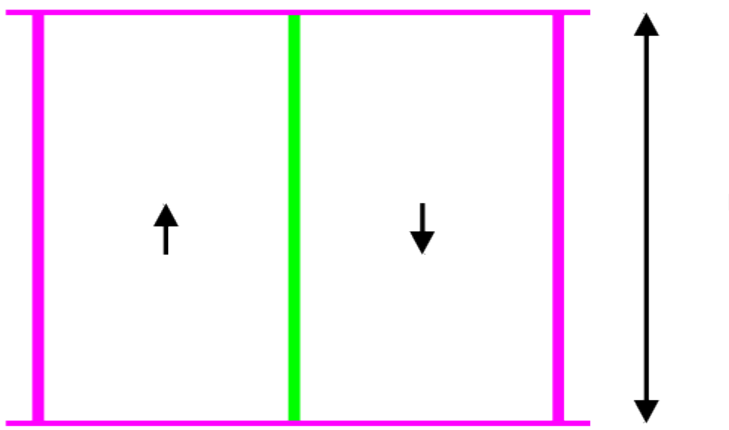

Fig 2: Illustration of moving observer method (Tom, 2023)

D. Speed Calculation

Journey speed, also known as overall travel speed, is the effective speed of a vehicle between two points, and the distance between the two points divided by the total time taken by the vehicle to complete the journey, including all delays incurred en route.

Running speed, which is the average speed at which a vehicle travels while it is moving, excluding any time spent, stopped or delayed, such as at traffic signals, intersections or in congestion.

$$\text{Journey speed} = \frac{distance}{mean\ journey\ time} \quad [1]$$

$$\text{Running speed} = \frac{distance}{mean\ running\ time} \quad [2]$$

$$q = \frac{x+y}{(ts+tn)} \quad [3]$$

$$t_n = tn - \frac{y_n}{q_n} \quad [4]$$

$$t_s = ts - \frac{y_s}{q_s} \quad [5]$$

where;

q is the flow in passenger car unit(PCU);the number of cars counted per minute or hour,

x is the opposing traffic count of vehicles

y is number of vehicles overtaking the test car minus the number overtaken by the test car

ts and tn are the journey times in South and North bound directions;the time take to travel going through and in the opposite direction of traffic

t_s is the mean journey time in the South bound direction

t_n is the mean journey time in the North bound direction

The Moving Observer Method was chosen for this study due to its accuracy and efficiency in measuring traffic speed. The speed and flow can be obtained by traveling in a car against and with the flow, noting down the journey time, the number of vehicles met with from the opposite direction, and the number of vehicles overtaking the test vehicle.

III. RESULT AND DISCUSSIONS

A. Data Presentation

The traffic data as captured during the studies from the moving observer method and the calculation are presented in Table 1 below:

Table 1: Journey log data for north bound

							Journey:- North Bound	
Run No.	Journey Time (minutes)	Stopped Time (minutes)	Vehicles met within the opposing direction				Vehicle in the same direction	
			Car	Bus	Truck	tricycle	Over Taking Vehicles	Over Taken Vehicles
1	9.31	0.60	107	7	7	240	5	32
2	9.41	0.65	110	5	6	255	9	42
3	9.44	0.66	125	4	6	271	6	45
4	9.47	0.71	127	6	6	280	4	54
5	9.54	0.72	132	6	5	288	7	63
Total	47.17	3.34	601	28	30	1334	31	236
			PCU=	601+	28x3+30x3.5	+1334x0.45		
					5			
AV	9.43	0.67		=278.06			6.2	47.2

Table 2: Journey log data for south bound

							Journey:- South Bound	
Run No.	Journey Time (minutes)	Stopped Time (minutes)	Vehicles met within the opposing direction				Vehicle in the same direction	
			Car	Bus	Truck	tricycle	Over Taking Vehicles	Over Taken Vehicles
1	9.52	0.70	145	8	7	270	8	48
2	9.46	0.65	134	9	6	262	7	39
3	9.43	0.63	130	5	5	256	6	36
4	9.36	0.62	120	7	4	254	5	31
5	9.29	0.58	110	6	5	244	7	24
Total	47.06	3.18	639	35	27	1286	33	178
			639+	35+3+	27x3.5+	1286x0.45		
				5				
AV	9.41	0.64		=283.44			6.6	35.6

Table 3: Parking data for north bound direction

North Bound

Run No.	No. of vehicles parked
1	77
2	74
3	86
4	93
5	100
Total	430

Table 4: Parking data for Southbound direction

South Bound

Run No.	No. of vehicles parked
1	83
2	76
3	74
4	70
5	67
Total	370

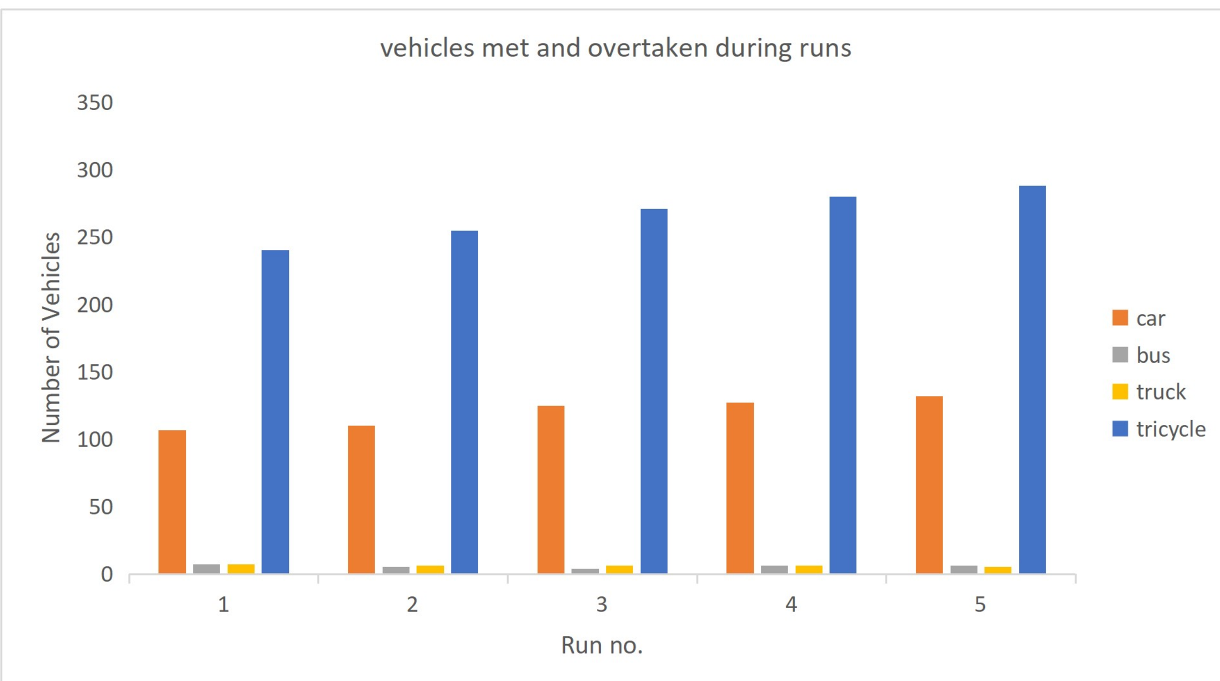

Fig 3: North bound bar chart

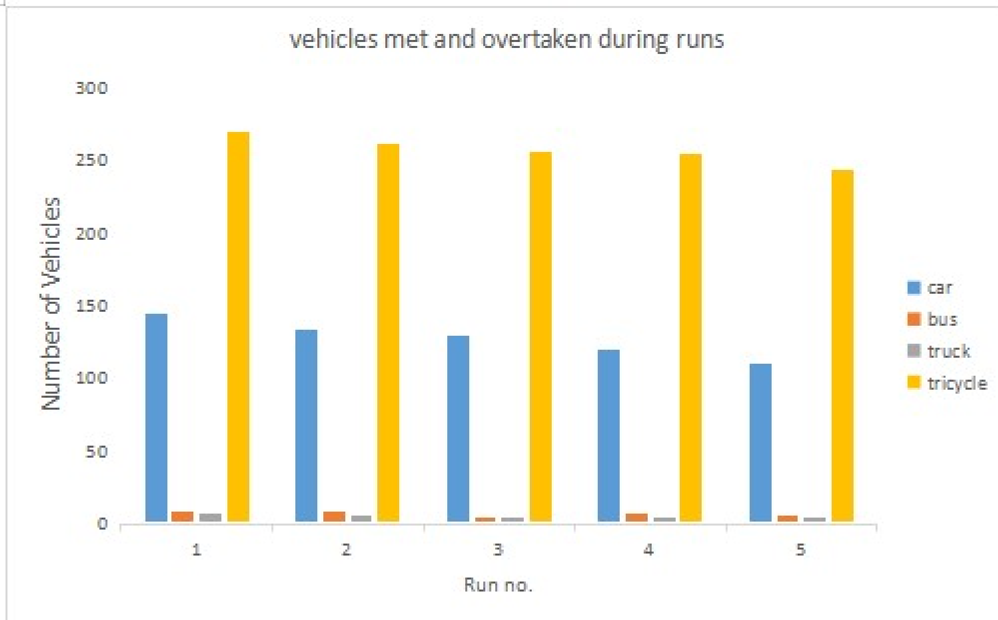

Fig 4: South bound bar chart

B. Traffic Data Analysis

Using the formula, $q = \frac{x+y}{(t_a + t_w)}$

The PCU per hour refers to the rate at which traffic passes a point on the highway, expressed in terms of passenger car equivalents, over the course of an hour.

The Equivalency factor of one per car used in the analysis above was 1, 3 for bus, 3.5 for truck and 0.45 for tricycle which was assigned according to their impact or inconvenience of traffic flow, relative to a standard passenger car.

Using the suffix n for north bound and s for south bound traffic,c calculation for the flow in the north bound direction is obtained as:

$q_n = \frac{(x_s + y_n)}{(t_n + t_s)}$

$= \frac{283.44 + (6.2 - 47.2)}{9.43 + 9.41} = \frac{283.44 - 41}{18.84}$

= 12.87Pcu$_s$/min = 772.2 Pcu$_s$/hr

Calculation for the south bound direction flow:

$q_s = \frac{(x_n + y_s)}{(t_n + t_s)}$

$\frac{278.06 + (6.6 - 35.6)}{9.43 + 9.41}$

$\frac{278.06 - 29}{18.84}$ = 13.22 Pcu$_s$/min

= 793.2Pcu$_s$/hr

Calculation of the mean journey time in the north bound direction:

$t_n = tn - \frac{y_n}{q_n}$

$= 9.43 - \frac{(6.2 - 47.2)}{12.87} = 9.43 - \frac{(-41)}{12.87}$

= 9.43+3.19 = 12.62 min

Calculation of the mean journey speed in the north bound direction:

$= \frac{Distance}{Time}$

$= \frac{9.6}{12.62} \times 60$ = 45.6 K.P.H

Calculation of mean journey time in the south bound direction:

$t_s = ts - \frac{y_s}{q_s}$

$= 9.41 - \frac{(6.6-35.6\ )}{13.22} \quad = \ 9.41 - \frac{(-29)}{13.22}$

$= 9.41 + 2.19 \ = 11.60$ min

Calculation of the mean journey speed in the south bound direction:

$$= \frac{Distance}{Time}$$

$$= \frac{9.6}{11.60} \times 60 \quad = \quad 49.7 \text{ K.P.H}$$

Calculation of mean running time in the north bound direction:

t_n, Mean journey time - Stopped time

I.e 12.62 - 0.67 = 11.95 min

Running speed in the north bound direction:

$$; \ \frac{Total\ Distance}{Mean\ running\ time} \quad = \quad \frac{9.6}{11.95} \times 60$$

= 48.2 K.P.H

Calculation of mean running speed in the south bound direction:

t_s, Mean journey time - Stopped time

11.60 - 0.64 = 10.96minRunning speed in the south bound direction:

$$; \ \frac{Total\ Distance}{Mean\ running\ time} = \frac{9.6}{10.96} \times \ 60$$

= 52.7 K.P.H

C. Discussion of Results

In terms of traffic management, the calculation of journey and running speed plays a vital and important role in accessing the efficiency and performance of a road network or route. Figures 1 and 2 shows the presence of peak flow at the south bound during the early hours of the day than the north bound direction, because the north bound lane leads to various industries, markets where commercial activities are carried out and travellers going for a distant journey tends to leave during the morning hours and a reverse case in the evening because the south bound lane leads to a lot of residential houses as the day's work closes. As earlier discussed, Journey speed is the overall speed of a vehicle, taking into consideration stops or delays during the trip, whereas the running speed refers to the average speed that a vehicle maintains while it is in motion. The analysis above gives an in-depth idea into the traffic flow and possible congestion issues.

D. North bound result analysis (Tombia roundabout to bergerbustop)

The running speed of the north bound direction (Tombia roundabout to bergerbustop) which is 48.2 K.P.H, while the corresponding value of the journey speed is 45.6 K.P.H. The difference is 2.6 K.P.H implies that the lane experiences some delays or major interruptions, as the journey speed is lower than the running speed. According to Khisty and Lall (2003), Journey speed are lower than running speed because it accounts for the actual time taken for a trip, including any stoppage encountered.The bar charts in figure 3 and 4 gives a clear indication of this ;as there are more tricles in both direction of traffic.

The differences between the running and journey speed in the north bound direction (Tombia roundabout to Berger bustop, implies that in course of vehicles while travelling at a relatively high speed, there are factors that influences the reduction in journey speed are:

1.Traffic interruption : The difference between the journey and running speed can be related to the delays that occur while the vehicle was in motion, such as the traffic signals, where the vehicles waited for sometime before the journey continues, also the stop signs by the traffic wardens and lots of intersections from the side streets as seen in table 3 and 4 where there are a lot of cars parked in both direction of traffic causing free flow of traffic.

2.Congestion Level : A moderate congestion can be associated for this difference between the journey and running speed, whenever congestion builds up, vehicles tends to slow down, stop more frequently and will have to take longer time to cover same distance. Congestion on this north bound route (Tombia roundabout to Berger bus stop) was as a result of some factors such as high volume of traffic during the peak hour closure time of the day work and some road work maintenance which was ongoing in course of movement. Studies have shown that traffic congestion has a profound impact on journey speeds, sometimes lowering them by as much as 50% of the running speed during heavy traffic conditions (Papageorgiou et al., 2003).

3.DriverBehaviour and Road condition :There was presence of poor surface quality, and it tends to narrow lane. In this way, all drivers will have to follow the part of the lane which will eventually lead to journey speed reduction.

E. South Bound Result Analysis (BergerBustopto Tombia Roundabout)

The south bound lane with a running speed of 52.7 K.P.H and a journey speed of 49.7 K.P.H, which amounts to a difference of 3.0 K.P.H, which implies that there is a higher running speed in this lane, which gives a clear insight that traffic is moving more freely as compared to that of the north bound direction or lane, which was attributed to the various factors and one important factor observed in the south bound lane is:

Congestion level : As discussed earlier in the north bound lane, roads with high congestion level tends to experiences a lesser journey speed, taking longer time to cover the same distance. In this case, there was less congestion on the road, because people are no longer going to work since it a metropolitan area e.t.c. so vehicles are able to move freely on this lane (Berger bustop to tombia roundabout). which there was not much interference of vehicles from the side street as seen in table 4.

F. Parking Effect on Running and Journey Speed

Parking values of vehicles along a road plays a vital role in the influence of both journey and running speed of the north and south bound lanes. In the north bound lane, there is a presence of 430 parked vehicles along the road(table 3) which suggests a higher parking activity, and which disrupt traffic flow. The disruption along the road stem from vehicles which are maneuvering in and out of parking spaces, picking and dropping off passengers along the road corridor, causing other vehicles to slow down or stop. As a result, it also affects the running speed in the north bound lane to be reduced to 48.2 K.P.H and the journey speed also to be reduced which accounts for delays and stops.

On the other hand, the finding shows that the 370 vehicles (table 4) parked along the road corridor, experiences fewer interruptions, because there was no much maneuvers by drivers along which leads to an increased value of running and journey speed of 52.7 K.P.H and 49.7 K.P.H respectively. This relationship between parking density and traffic efficiency is supported by existing research, which demonstrates that high parking activity on urban roads can significantly slow down traffic due to frequent merging and deceleration, while lower parking activity tends to promote smoother and faster traffic flow. (Johnson, 2019 & smith, 2020).

G. Impact of Journey Speed

The journey speed of 49.7 K.P.H for the south bound lane (Bergerbustop to Tombia roundabout) represents a small reduction from the journey speed, the fact that the journey speed is more higher suggests little delay due to stopping. And this aligns with the Highway Capacity Manual (HCM, 2010) guidelines, which lay emphasis that higher journey speeds indicates more efficient traffic flow and minimal interference from external factors such as frequent stops or congestion.

IV. CONCLUSION

The analysis of journey and running speeds on the northbound and southbound lanes has provided valuable insights into traffic flow efficiency. The findings highlight significant differences in traffic flow efficiency between the two lanes, with the southbound lane exhibiting a higher journey and running speeds. From the findings, at average when a person is to travel in either of these road corridor, he will likely spend more time in the north bound direction. This disparity underscores the importance of optimizing traffic management strategies to minimize delays and improve overall performance.

The study's results demonstrate that road conditions, driver behavior, and urban sections significantly influence journey speed reduction. Effective traffic management can optimize traffic flow, reduce congestion, and minimize delays. By addressing the factors contributing to delays and interruptions, traffic engineers can enhance traffic flow efficiency, reducing congestion and promoting safer, more reliable transportation systems. The optimization of traffic management strategies is crucial to improving traffic flow efficiency, reducing congestion, and promoting safer transportation systems. The findings of this study provide valuable insights for transportation planners and engineers to develop targeted solutions to enhance traffic flow and reduce congestion, ultimately improving the overall travel experience.

Recommendations

Based on the findings as regards to the north bound lane having a running speed of 48.2 K.P.H and journey speed of 45.6 K.P.H, while the south bound lane has a running speed of 52.7 K.P.H and journey speed of 49.7 K.P.H. These recommendations aim to reduce stoppages, improve traffic flow, and optimize travel speeds for both directions, which are listed below to improve the overall traffic on both lanes.

1).Parking zones should be cited away from main road, and bus-stop should be set up in a clearly marked spot on the road for drivers to drop and pick up passengers safely.

2). The need for parking management such as no-parking zone should be enforced and traffic wardens or law enforcement agencies should patrol frequently to impound parked vehicles in restricted parking zones, which will discourage illegal parking.

3). There should be awareness to the public on obeying all traffic rules and regulations an organized traffic flow and road safety.

4). There should be an improvement in road side infrastructure in order to improve traffic flow efficiency.

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