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MEASUREMENT OF EFFICIENT TRAVEL TIME OF A HIGHWAY CORRIDOR THROUGH MOVING OBSERVER METHOD: A CASE STUDY ON SAVAR-MANIKGANJ HIGHWAY IN BANGLADESH

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ABSTRACT

Travel time and its variability is one of the biggest controlling factors for trip planning, mode selection and forecasting trip duration. Travel time can be affected by various issues. Savar-Aricha highway is the gateway between south and south-western part of the country. Large variability on this corridor can cause great economic losses. To understand this routes travel time, running velocity and level of service moving observer method was conducted. The survey also includes travel time, stopped time and journey time for two types of public transport present on the corridor: ticket-based bus system and without ticket local bus system. The study found that, Ticket based bus system has lesser travel time and stopped time resulting is less travel time in comparison with local bus system. Speed analysis for both the route also supports this. In consideration of free flow speed, the level of service of this corridor was found A.

Keywords: *Highway Corridor, Level of Service, Moving Observer Method, Public Transport, Travel Time.*

1. INTRODUCTION

Travel time, or the amount of time it takes to travel between two sites of interest, is a crucial metric in the transportation planning (Arahan, 1986). Transportation engineers and planners, business people, commuters, media representatives, administrators, and customers all understand and convey travel time, which is a fundamental concept (Box & Oppenlander, 1976). Since the late 1920s, engineers and planners have employed travel time and delay studies to assess transportation systems and plan improvements. Surveys of speed, journey time, and delay are essential in traffic control and roadway upgrades (Edie, 1974).

Roadside friction, vehicle interaction, and the effect of traffic signals all influence traffic flow on arterial roadways (Hall, 1994). All of these factors have an impact on the capacity and level of service provided by arterial roadways. Capacity of the arterial roads is generally considered by the capacity of signalized intersection along those arterial roads (Lum et al. 1998). The amount of access points alongside arterial highways, land use type, pedestrian activity, parking space, and road shape all contribute to roadside friction (Mortimer, 1957). The average through-vehicle travel speed is used to determine the effectiveness of arterial roadways (Quiroga & Bullock, 1998).

Travel time data can be used to measure a route's efficiency in terms of carrying traffic volume in comparison to other routes, as well as to offer information for capacity analysis of roadway segments (Robertson et al. 1994). Intersection delay only measures the delay at a single intersection on a given approach, whereas travel time reflects the delay on a larger scale (Salter, 1989). By dividing the travelled distance by the journey time, travel speed may be calculated. For corridors, the travel speed can be used to determine the degree of service. Estimation of arterial roads level of service depends on free flow speed and average travel speed as shown in Table 1 (Taylor & Abdel-Rahim, 1998).

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Table 1: Arterial Road LOS by Class.

Highway Corridor	1	2	3	4
Range of free flow speed	90-70 km/h	70-55 km/h	55-50 km/h	55-40 km/h
Range of free flow speed	80 km/h	65 km/h	55 km/h	45 km/h
		Average Travel Speed		
LOS	1	2	3	4
A	>72	>59	>50	>41
B	>56-72	>46-59	>39-50	>32-41
C	>40-56	>33-46	>28-39	>23-32
D	>32-40	>26-33	>22-28	>18-23
E	>26-32	>21-26	>17-22	>14-18
F	≤ 26	≤21	≤17	≤14

The speed flow relationship is another method to estimate the travel time. The travel speed can be estimated based on traffic flow data. Therefore, it is important to estimate a typical speed flow correlation.

In order to improve a country's socioeconomic situation and urban areas, transportation and mobility are critical issues to address. A well-designed and constructed transportation infrastructure not only assists people in getting around, but it also has an impact on a city's rate of growth and level of economic activity (Fahim, et al. 2022). The countrys overall growth lagely depend on efficient connectivity of different partd with the capital. Savar-Manikganj route is very important for the connectivity of the southern part with the capital. Travel time and its variability of this corridor is of great interest for various road users. The choice of traffic mode has a close connection with travel time, comfort and safety. Both ticked based bus and local bus are the main mode of public transport of this route. But the travel time of the bus systems have not been evaluated so far. Moreover, traffic flow and speed in this corridor needs to be determined to better understand it's level of service. The goal of this study is to determine traffic flow and speed on this two-lane interstate highway utilizing the moving observer method. The study then, compares the results from the ticket bus system with the local bus system for determining efficient travel time on this corridor.

This study will help policy makers, transport planners and engineers to understand the existing level of service of the corridor. Also, the knowledge of journey time and stopped time will help policy makers and planners to optimize bottlenecks and reduce effective travel time. Moreover, estimated efficient travel time will help deciding modal choice and trip planning for the road users.

2. METHODOLOGY

2.1 Study Route

Savar to manikganj highway segment is on national highway 5 (N5). This is a 47 km long highway touching Savar Union, Jahangirnagar University, Savar Cantonment, National Martyrs' Monument, Dhamrai and Manikganj. This segment acts as a link between Dhaka and Paturia which connects southern and western part of the country with Dhaka. The major traffic contributors of this segment are public bus and large to medium truck. The route is crucial for both passenger movement and goods transportation. Travel time on this segment is of great interest for transport planners, policymakers and engineers. To conduct a Speed, Journey time and Delay Survey the selection of route is an important phenomenon. Because it is needed to select a route where various traffic modes play on the road. In this respect, "Savar to Manikganj" is a suitable route for the study. Figure 1 shows the GIS map of the selected route.

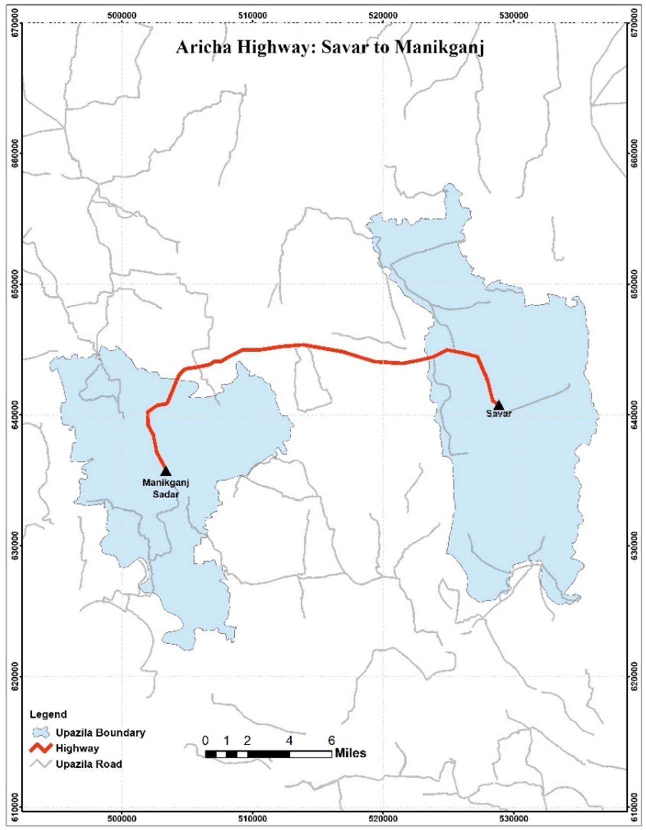

Figure 1: Selected Route "Savar to Manikganj.

2.2 Moving Observer Method

Data on trip time, speed, average flow rate, and traffic density is collected using the moving observer approach. The original "moving observer approach" was presented by Arahan (1986) as a means of measuring the average flow and travel time of vehicles traveling in one direction on a highway segment. The method was developed using data collected by a moving observer in a test vehicle that was immersed in traffic (Taylor & Abdel-Rahim, 1998). The observer drove a test car in the direction of the flow, counting how many vehicles were overtaken and how many were passed (Figure 2).

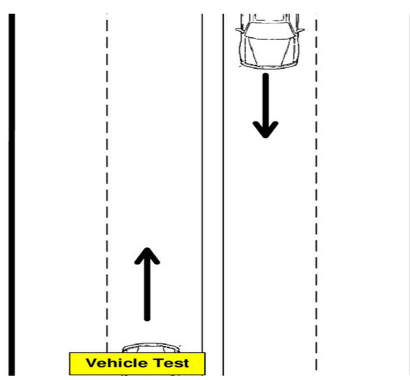

Figure 2: Moving Observer Method.

The number of opposing cars facing in the opposite direction (direction of interest) is counted during the trip by traveling against the flow in the opposite direction (Wardrop & Charlesworth, 1954). The traveling time of the test car is recorded in both directions. In addition, the road segment's length is known. The speed-flow relationship for the road segment in the direction of interest is then calculated using these values. The number of runs is selected as per the Manual of Transportation Engineering Studies to maintain the accuracy (Wright, 1973).

The observer in the test vehicle records information about the number of vehicles passing the test vehicle in front of it, the number of automobiles that passed the test, the number of cars met when traveling in the opposite direction, the observer's segment length, trip time in both directions and with and against the flow of traffic for each run. Arhan (1986) stated that the advantages of using the moving observer method are the observer can collect data on flow and speed at the same time (this is valuable when seeking the relationship between these two variables), the observer can record trip time, as well as the flow rate and average speed of cars, along the length of the road segment. Moreover, when compared to other approaches, the moving observer method requires less manpower and hours to achieve a high degree of accuracy, making it less expensive and vehicles can be grouped, and flow rates for each group can be estimated, if necessary, the observer can record additional information such as the locations and causes of delays. However, Box and Oppenlander (1976) highlighted a number of problems with the moving observer method, including the following: to achieve a specified level of accuracy, the observer requires a number of tests runs when traffic flows are low (200-300 vehicles per hour for two lanes, one direction), which may be impossible. The traffic volume that moves into the test road section changes according to the total number of intersections (Box & Oppenlander, 1976). The accuracy of measuring speed and flow is extremely sensitive to changes in the traffic flow along the road segment at various times of the day.

2.3 Data Collection

After selecting the study route, a conceptualization was developed through several literature reviews. The moving observer method is a method for measuring journey time, flow rate, space mean speed, and delay on a roadway section that incorporates the use of a probing vehicle within a traffic stream. From Saturday, January 24, to Thursday, January 29, 2019, data was collected during off-peak daytime hours between 11:00 a.m. and 1:00 p.m. During the study, a segment of 40.6 km in length was used for data collection. The researcher performed six (6) test runs on each directional segment comprising total 12 test runs in both directions. The observer in the survey vehicle travelled at the average travel speed inside the traffic stream of the chosen stretch under review, according to The Manual of Transportation Engineering Studies, which defines the procedure. However, the observer cannot travel for several miles along the portion without slowing down. Thus, the number of vehicles passed was subtracted from the number of vehicles overtaken by the observer to solve this problem. During the travel the observer also collected travel time data, stopped time data, journey time data for ticked based bus and local bus system.

2.4 Formulation

A several case can occur in conducting moving observer survey, a number of vehicle can overtake the observer. Secondly, a stationary traffic stream of density k can be passed by observer with velocity v_0 or observer can move within the stream. This three cases can be expresses generally by the equation 1.

$$m = m_o - m_p = qt - kv_0t \qquad (1)$$

Where,
m_0 = number of vehicles that will overtake observer
m_p = number of vehicles that will be overtaken by observer
q = traffic flow
t = time period
k = flow density
v_0 = observer speed

This equation is the basic equation of moving observer method, which relates q, k to the counts m, t and v_0 that can be obtained from the test. For generating two equations, the test vehicle is run twice once with the traffic stream and another one against traffic stream, to solve for two unknowns q and k. The above general equation can be written as

$$m_w = qt_w - kv_w t_w \quad (2)$$
$$m_a = qt_a - kv_a t_a \quad (3)$$

where, a, w denotes against and with traffic flow. From the equations 2 and 3 the flow of the traffic stream can be calculated using the following formula

$$q = \frac{m_w + m_a}{t_w + t_a} \quad (4)$$

Where,
q = Flow in the route
m_w = Average number of vehicles overtaking the test bus minus the number overtaken by the test bus
m_a = Average opposing traffic count of vehicles met when the test bus was travelling
t_w = Average journey time when the test bus travelled in the with traffic route
t_a = Average journey time when the test bus travelled in the against traffic route

Mean journey time and mean travel speed can also be calculated from the following equations:

$$t_{avg} = t_w - \frac{m_w}{q} \quad (5)$$
$$v_s = \frac{l}{t_w - \frac{m_w}{q}} \quad (6)$$

Where,
t_{avg} = mean journey time
v_s = mean travel speed
l = length of the roadway segment under observation

3. RESULTS AND DISCUSSION

3.1 Travel Time, Stopped Time and Journey Time

The detailed travel time and delay study on the route Savar to Manikganj shows that, local bus that serves without ticket takes more time to travel compared with ticket-based bus system (Figure 3-4). Moreover, the study shows stopped time for local bus is significantly greater regarding ticket-based bus system. As a result, local bus takes more time to traverse the Savar to Manikganj route. Study on reverse direction, Manikganj to Savar route also shows Local bus systems takes more travel time and stopped time resulting in more journey time.

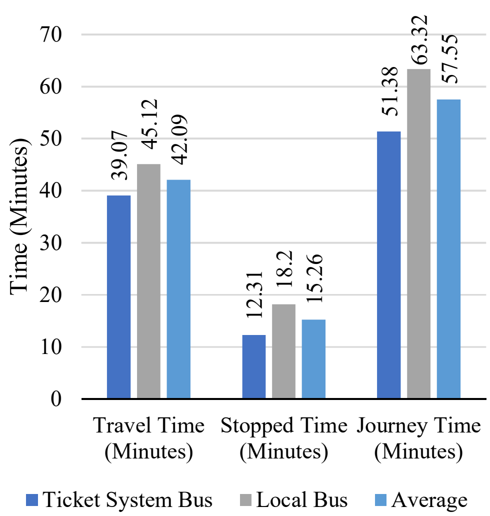

Figure 3: Travel time, stopped time and journey time for Savar to Manikganj.

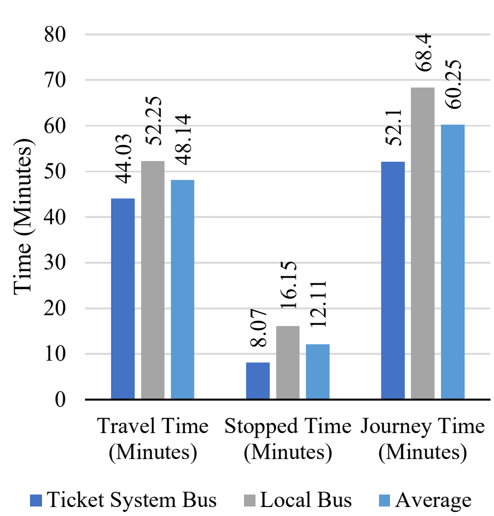

Figure 4: Travel time, stopped time and journey time for Manikganj to Savar.

The average travel time for Savar to Manikganj route is 42.09 minutes while average stopped time 15.26 minute resulting average journy time 57.55 minutes. For the opposite direction, Manikganj to Savar average travel time is 48.14 minutes and stopped time 12.11 minutes so the average journey time is 60.25 minutes. Figure 3-4 also shows that for the both ticket and local bus travel time is larger on Manikganj to Savar route. This is for the presence of side friction and poor traffic management that reduces mean running speed greatly. Though the stopped time is less in this direction, total journey time ncreases slightly. From the detailed journey frame study for Savar to Manikganj route shows that, both in permitted stoppage and non-permitted stoppage exists. The no-permitted stoppage contributes significant delay that is almost 20% of total delay. Thus, lack of traffic management and delay in non-permitted stoppage increases total delay and journey time as a result.

3.2 Traffic Flow

Figure 5 shows that, the flow of the route Savar to Manikganj was found 616.8 PCUs/hour from analysing the survey data using equation 4. Similarly, for the opposite direction, Manikganj to Savar, the flow was found 445.8 PCUs/hour. Comparison of flow among two direction shows that Manikganj to Savar route yields less capacity. The potential reasons for this are, flow obstructions, bottlenecks etc. The larger journey time and travel time of the Manikganj to Savar route supports this finding.

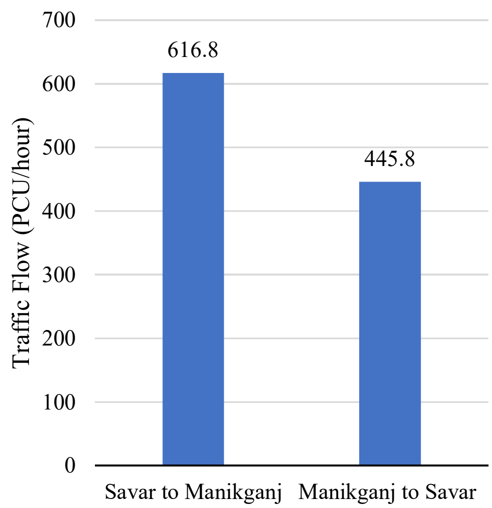

Figure 5: Traffic flow for both direction of Savar to Manikganj Highway.

3.3 Journey Time, Journey Speed, Running Time and Running Speed

The mean journey time is the mean time required to traverse a route. Figure 6 shows that, mean journey time of the Savar to Manikganj route was found 57.40 min. which slightly differs with average journey time. The mean journey speed for this 47 km route was calculated 49.19 kph using mean journey time (Figure 7). Running time in the time while a vehicle is actually in motion during the journey. Mean running time is the difference between mean journey time and stopped delay. For the Savar to Manikganj route Mean running time was found 42.14 min. From that mean running speed was calculated 66.92 kph (Figure 6-7). Mean running time is the actual mean speed of the vehicle during traversing the route. This exhibits the highway category of the route is class 2 (HCM 2000). As the free flow speed is 66.92, which is greater than 59 K.P.H., the LOS of the route is A. That means free flow condition exists on the Savar to Manikganj route.

Figure 6 also shows that, mean journey time of the Manikganj to Savar route was found 59.45 min. which slightly differs with average journey time. The mean journey speed for this 47 km route was calculated 47.43 kph using mean journey time (Figure 7). For the Manikganj to Savar route Mean running time was found 47.34 min. From that mean running speed was calculated 59.57 kph (Figure 6-7). This also exibits the highway category of the route is class 2 (HCM 2000). As the free flow speed is 59.57, which is slightly greater than 59 K.P.H., the LOS of the route is marginally A and a slight reduction of mean running speed can drag down the LOS to B.

From the comparison of the two direction it was found that, mean journey time is larger for Manikganj to Savar route resulting a lower mean journey speed. But the stopped delay in the Savar to Manikganj route is greater, resulting lower mean running time and higher running speed respectively. According to the mean running speed both the corridor is Class 2 and the LOS is A for both ways.

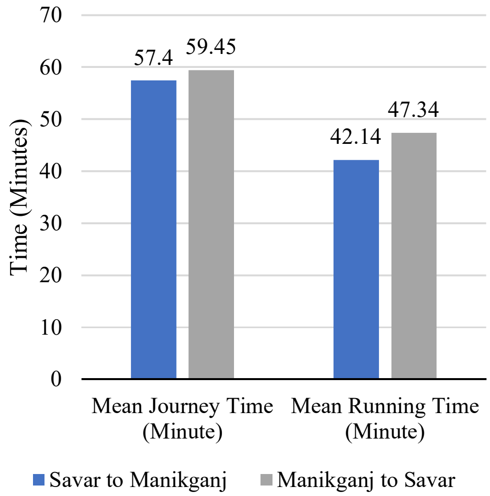

Figure 6: Mean journey time and running time for both direction of Savar to Manikganj highway.

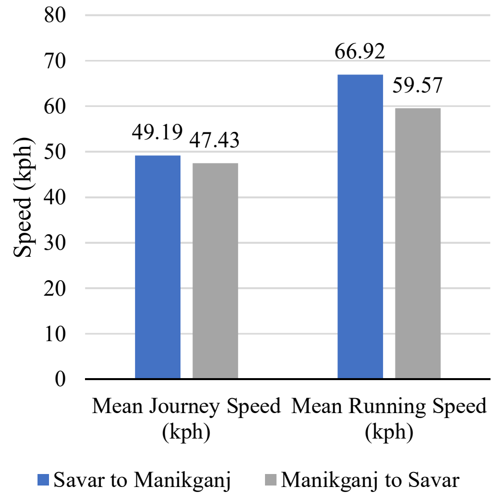

Figure 7: Mean journey speed and running speed for both direction of Savar to Manikganj highway.

3.4 Overtaking Tendency

The overtaking tendency of vehicle often creates road accident, traffic congestion etc. To find out the overtaking tendency the number of vehicles those are overtaken by the bus are counted on manual method. Figure 8 shows that, at the Savar to Manikganj route, ticket-based bus system overtaken more vehicles than local buses, as it has greater running speed. Figure 9 also shows that, at the Manikganj to Savar route, Local bus system overtaken more vehicles than local buses. The comparison of the two direction also shown that the number of overtaking vehicles are greater on Manikganj to Savar diretion. Thus the accident potential of the local bus on Manikganj to Savar direction is greated as they try to rush faster to overtake though several bottlenecks restrain the flow of this direction.

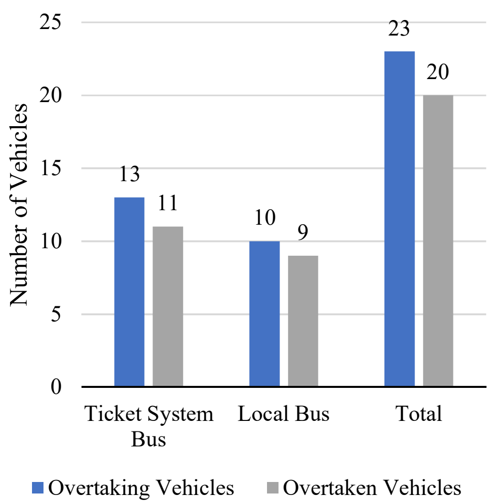

Figure 8: Overtaking tendency on Savar to Manikganj highway.

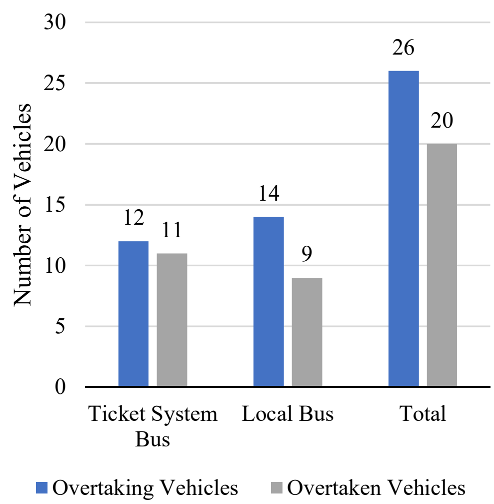

Figure 9: Overtaking tendency on Manikganj to Savar highway.

3.5 Composition of Vehicle

From the number of the vehicles met with in the Opposing Direction provide a useful data about the traffic weight on the road. It represents the amount of traffic flow on the road on the survey period. Figure 10 shows that, for Savar to Manikganj route the opposing vehicle weight mainly consists of large to medium vehicles, which is nearly 96%. Almost 26% contribution comes from passenger car and micro. The next higher contributor is truck or pick-up van which is 29% of the opposing vehicle. The public transport, thus the bus occupies 41% vehicle weightage in the route. The leftover 4% contribution comes from CNG, Taxicab or Motorcycle. The bus and truck consist about 70% of the opposing vehicle.

Figure 11 also shows that, for Manikganj to Savar route, the opposing vehicle weight also consists of large to medium vehicles, which is also 93%. Almost 34% contribution comes from passenger car and micro. The next higher contributor is truck or pick-up van which is 32% of the opposing vehicle. The public transport, thus the bus occupies 27% vehicle weightage in the route. The leftover 7% contribution comes from CNG, Taxicab or Motorcycle. The bus and truck consist about 59% of the opposing vehicle. From the figures, we can see that around 94.5% vehicles are Bus, Car and Truck.

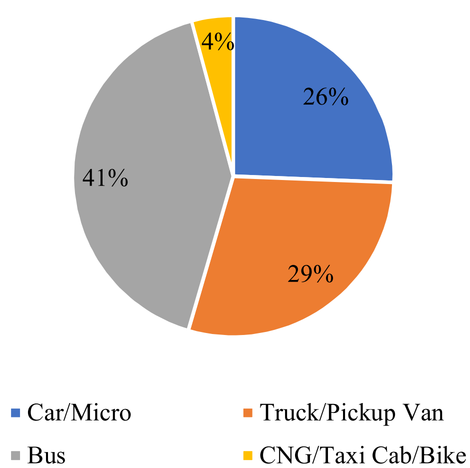

Figure 10: Vehicle composition on Savar to Manikganj highway.

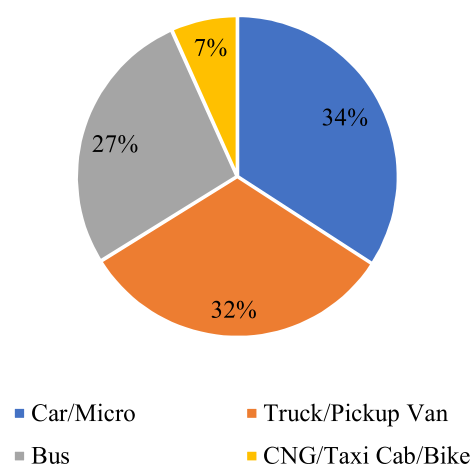

Figure 11: Vehicle composition on Manikganj to Savar highway.

4. CONCLUSIONS

This study has employed moving observer method and conducted Travel time, speed study and delay study on Saval to Manikganj route for ticket-based bus system and local bus system. The results show that, ticked based bus system has less stopped time thus greater running speed and less travel time. On the other hand, local bus system costs more stopped time hence increasing travel time. Level of service of this class 2 Highway Corridor was determined according to running speed and found that free flow occurs during commuting. As a result, overtaking tendency was found greater for ticket-based bus systems compared to local buses ignoring the fitness criteria of the two systems. The study also shows that the main contributors of vehicle weight are large to medium vehicles on the both way of this route.

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REFERENCES

Arahan T. (1986) A guide on geometric design of roads, Kuala Lumpur: Jabatan Kerja Raya Cawangan Jalan. 8/86.

Box P.C. & Oppenlander, J.C. (1976) Manual of traffic engineering studies, 4th ed. Washington: Institute of Transportation Engineers.

Edie, L.C. (1974) Flow theories, traffic science. New York: John Wiley & Sons, Inc.

Fahim, A. U., Rahman, M. M., Abir, F. A., & Bhuiyan, M. A. F. (2022) An investigation of users' perception on non-motorized transport services in a municipality area: A cross-sectional study on Pabna municipality. *Case studies on transport policy*, *10*(1), 657-663.

Hall, F.L. (1994) Traffic stream characteristics. Traffic flow theory and characteristics. Washington: Transportation Research Board.

Lum K.M., Fan H. S.L., Lam S.H. & Olszewski P. (1998) Speed-flow modelling of arterial roads in Singapore. *Journal of Transportation. Engineering* 124(3): 213-222.

Mortimer. (1957) Moving vehicle method of estimating traffic volumes and speeds. Highway Research Board Bulletin 156.

Quiroga, C.A. & Bullock, D. (1998) Travel time studies with global positioning and geographic information systems: an integrated methodology. Transportation Research C 6: 101-127.

Robertson, H.D., Hummer, J.E., & Nelson, D.C. (1994) Manual of transportation engineering studies. New Jersey: Prentice Hall.

Salter, R.J. (1989) Traffic engineering worked examples 2nd Ed. London: MacMillan Education Ltd.

Taylor W.C. & Abdel-Rahim A.S. (1998) Final report on analysis of corridor delay under SCATS control (Orchard Lake Road Corridor), Michigan State University.

Wardrop, J.G. & Charlesworth, G. (1954) A method of estimating speed and flow of traffic from a moving vehicle. Proceedings of the Institution of Civil Engineers, Part II, 3: 158-171.

Wright, C. (1973) A theoretical analysis of the moving observer method. Transportation Research 7, TRB, NRC: Washington, DC: 293–311.