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EVALUATING THE EFFECT OF HEAVY VEHICLES ON TRAFFIC PARAMETERS BY USING HEAVY VEHICLE FACTOR

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Abstract

Safe, convenient and timely transportation of goods and passengers is necessary for development of nation. After independence road traffic is increased manifold in India. Modal share of freight transport is shifted from Railway to roadways in India. Road infrastructures continuously increased from past few decades but there is still need for new roads to be build and more than three forth of the roads having mixed traffic plying on it. The impact of freight vehicles on highway traffic is enormous as they are moving with slow speeds.
Nature of traffic flow is dependent on various traffic parameters such as speed, density, volume and travel time etc. As per ideal situation these traffic parameters should remain intact, but it is greatly affected by presence of heavy vehicle in mixed traffic due to Svehicles plying on two lane roads. Heavy vehicles affect the traffic flow because of their length and size and acceleration/deceleration characteristics. This study is aimed to analyse the impact of heavy vehicles on traffic parameters.

Keywords: Traffic Parameters; Heavy Vehicles; Two Lane Roads; Mixed Traffic.

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1. Introduction

Transportation is vital cog for the growth and development of nation. Transportation in India comprises of various modes such as Roadway, railway, aviation, waterways and shipping, though more emphasis given to transportation by roadways and railways (especially for internal transportation of passengers and goods). Road transportation gradually rising in terms of the modal share with respect to rail share. Rail share declined from 86.2% to 39.9% and 74.3% to 13.3% for freight transport and passenger transport respectively. Road network provides the integrated network which facilitate trade, transport, social integration and economic development. It is used for the smooth conveyance of both people and goods. Transportation by road has the advantage

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over other means of transport because of its easy accessibility, the flexibility of operations, door to door service and reliability. Consequently, passenger and freight movement in India over the years have increasingly shifted towards roads in comparison with other means of transport. As more traffic started to get accumulating on the road network, more the road network needed to be built in order to meet the demand of overtly increment in number of vehicle. -Only 16% of the roads are more than 4 lane roads and have divided carriage way. So, there will be great impact on the flow parameters due to different geographical features and movement of the heavy vehicles plying on the road.

There is also rapid increase in the number of commercial freight vehicles over the past decades which give rise to increase in mixed flow traffic operating over the various types of roads. As of 2016, there are in total 1,501,895 commercial freight vehicles (source: MORT&H) have been sold which is around 40% increase from previous year. This growth will only going to be increased as of population and demand for various goods in service of this population.

Due to various types of vehicles running on the same right of way on undivided road it causes the various problems to be arise due to the movements of trucks (heavy vehicle generally a freight). In Indian traffic condition generally two wheelers, three wheelers, car, bus, truck, LCV, bicycle, non-motorized vehicles moving without lane discipline. This will result in the delays for the normal traffic flowing over the roads. Various traffic parameters such as speed, flow and density will be affected by this maneuver. Traffic parameters will be affected by the slow moving vehicles resulting in the delays and increase in the density of the road.

This study is aimed to analyse the impact of trucks on traffic flow parameters. For that, a highway section between Modasa-Bayad-Pankhiya is selected because continuous heavy trucks and other vehicles are moving on this section. The major truck flow between Mumbai to Delhi is using this section. Therefore it is interesting to study effect of heavy trucks on traffic flow parameters.

2. Objective and Scope of Study

Objective of the current research is to investigate the impact of heavy vehicles on traffic parameters by calculating the speed, volume and density characteristics of the traffic. The research is mainly concerned for the selected road sections on SH 59 in the route between Modasa to Pankhiya in Gujarat. Some factor needs to be introduced to find the influence of heavy vehicle is related only for this section.

3. Literature Review

Speed, flow and density is basic traffic parameter that governs the characteristics of the traffic. Many researchers investigated the effect of heavy vehicles on this parameter by using various methods. Al-Kaisy & Jung used passenger car equivalency (PCE) factor to show the influence of increase in heavy vehicle (HV) percentage with the help of simulation model. In the model PCE increase or decrease with respect to heavy vehicle percentage and followed some trend. Pokulwar et al. (2016) also studied the effect of heavy vehicles on other parameters with the help of vehicle conversion and lane changing model. Sone (2010) used simulation model VISSIM to find impact of HV on emission capacity at several roundabouts. Kong et al. (2016) used cellular autonomous (CA) model which considered both the performance difference between passenger cars and trucks

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as well as behavioral change in passenger cars under the influence of trucks. CA model showed that there was significant impact of trucks and indicate that impact increased with increase in percentage pf trucks. Comparison charts were provided with help of CA model for car following car condition and car following truck condition which showed the amount of change occurred due to presence of truck and same study was carried out for different percentage of trucks and it was found that higher percentage of trucks results in higher impact. Semeida (2017) have shown impact of HV in terms of capacity loss that occurred due to various percentage of heavy vehicles.

As observed from above mentioned researches that have been carried out earlier mainly aimed to use simulation model to come up with the effect of HV on several parameters. Here, in this research some simple factor is calculated to deduce the effect of HV, so that one can easily understand.

4. Study Area And Data Collection

As mentioned in introduction, route between Modasa to Pankhiya was selected for this research which is part of SH 59 of Gujarat. This particular route was selected because it two lane road and thus resulting in mixed traffic flow. Also, as discussed in introduction, it is part of the route for freight transport between Delhi and Mumbai, so major share of traffic plying on it resulting in HVs. For this research six different location based of difference in geometry was chosen where 1 Km section is selected to collect the data. Data is collected with the help of videography and then it is retrieved in intervals of 2 minutes. Data collection included data regarding classified volume of traffic, percentage of heavy vehicles and average travel speed of vehicles. Data collection sheet is given in Annexure1.

5. Methodology

It is required to analyse the impact of HV on traffic parameters. For that purpose data was collected as mentioned above. To determine the impact of HV on traffic parameter in simplistic manner, first idea came up is to compare speed directly with respect to percentage of HV. But, it might not show good trend in the plot of speed vs HV fraction (percentage). Same could be followed for comparison between speed and density of vehicles plying in that section. Plot is given below in figure 1 & 2 which clearly indicate the zig zag relation between speed and either of HV fraction and density in that time at the section.

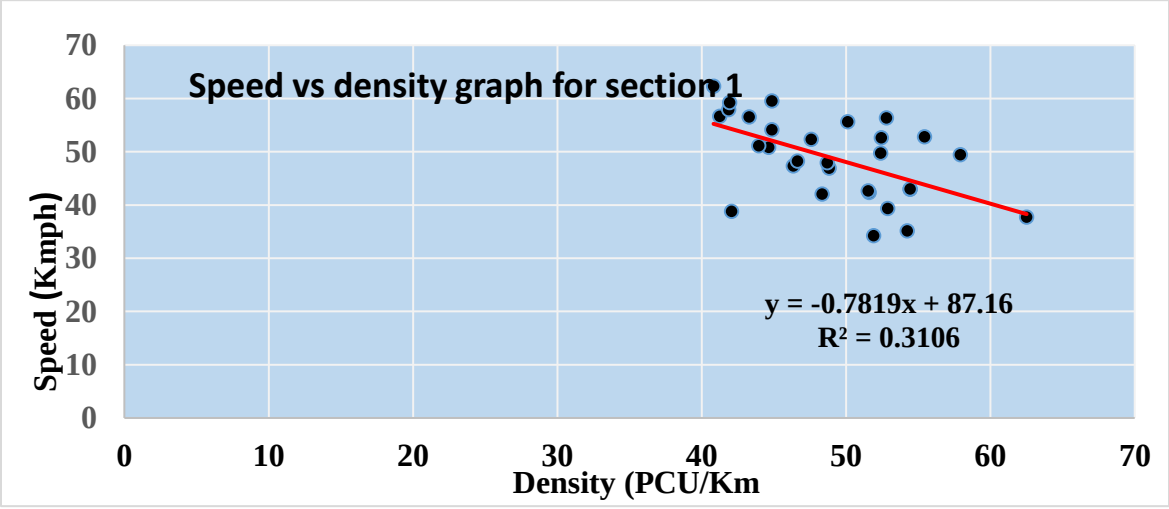

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Figure 1: Plot of speed vs traffic density

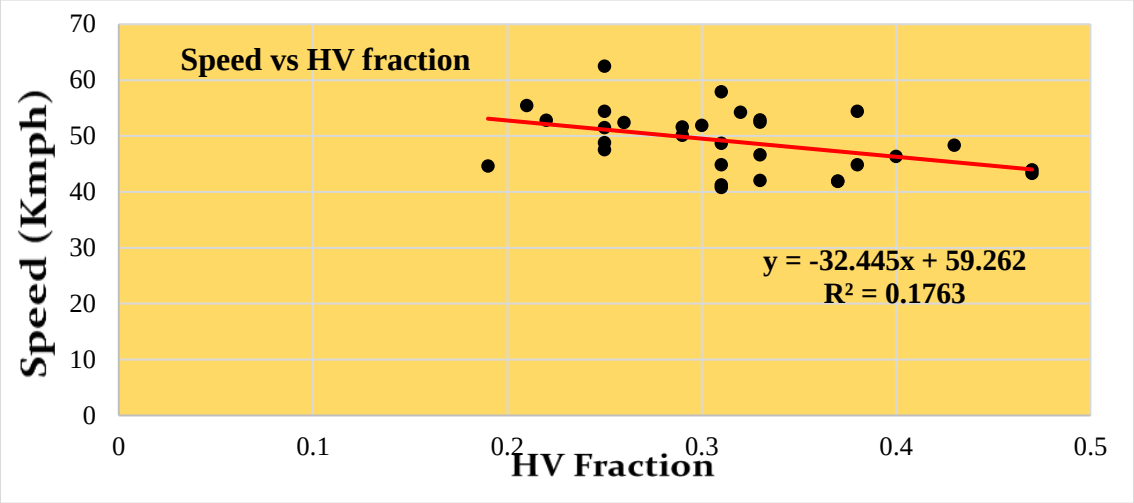

Figure 2: Plot of speed vs HV fraction

5.1. Introduction to Heavy Vehicle Factor

So, it was required to come up with some other useful factor or function which could represent the effect of heavy vehicle on the speed (one of the other inter related traffic parameters). To carry out the same function and to fulfill the purpose, some new factor is introduced which is termed as heavy vehicle factor (HV factor) which represent both HV fraction and traffic density.

HV factor is defined as the product of traffic density in PCU/Km and HV fraction (HV fraction = number of HV/ total vehicles). So,

HV factor= traffic density * HV fraction.

This HV factor was coined from the observation in pilot survey that, sometimes traffic flow have higher density but having less HV fraction, speed is not that affected. So it was concurred that traffic density alone did not affect the flow very much. Also, when HV fraction is more than .5 (traffic having more than 50 % of HVs.) but traffic density being very low, the speed of other vehicles not affected that much as that would have been if traffic density would also be more. So, it was clearly understood that density and HV fraction have combined effect on traffic flow rather than individual effect. Therefore, term HV factor was coined. Plot was drawn in similar way as given in figure 3. Equation of relation between the two can be obtained from the plot and free flow speed (FFS) can be calculated with the help of equation or by extension of curve as shown in figure 3.

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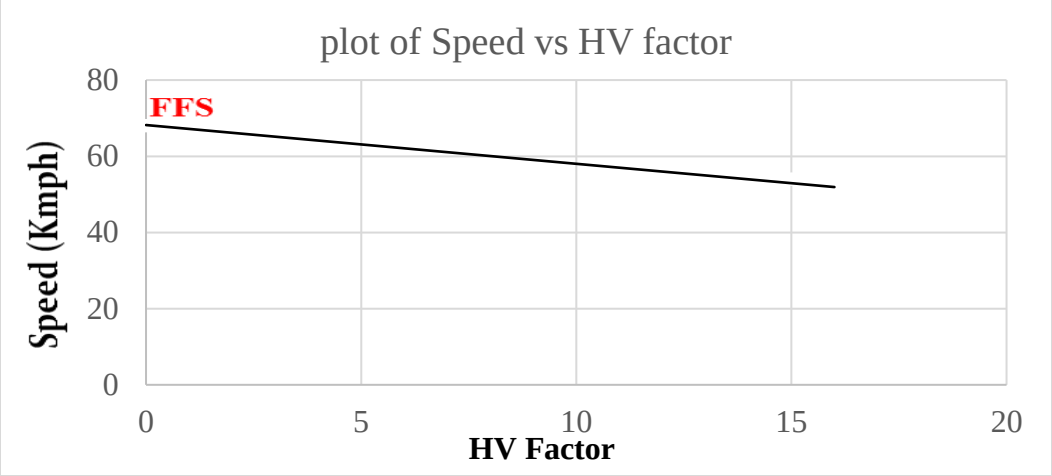

Figure 3: Plot of speed vs HV factor

5.2. Validation of Result With the Help of HCM-2000

Results could be obtained by using HV factor might show good trend in plot and conclude good relationship with speed, but it may not be valid for all scenario as it was developed by trial and error algorithm. So, some validation of results needed to be carried out. For that purpose, HCM (highway capacity manual) was used. From the plot obtained using HV factor or by using LINEST function, equation of plot or relationship could be obtained. Free flow speed was determined from the equation derived when HV factor is zero.

For validation, FFS is also calculated by the method given in HCM-2000 for two lane mixed traffic flow. Average travel speed, flow rate in pcph and HV percentage is required to determine as per chapter 20 of HCM-2000.

FFS is calculated by using following formulae:

$$\text{FFS} = (\textit{average speed}) + \frac{0.0125 * \text{flow rate}}{Fhv}$$

Fhv is heavy vehicle adjustment factor which can be calculated with the equation given in HCM-2000.

$$\text{Fhv} = \frac{1}{(1+PT(ET-1)+PR\,(ER-1)}$$

Where,
PT = proportion of trucks in the traffic stream, expressed as a decimal,
PR = proportion of RVs in the traffic stream, expressed as a decimal,
ET = passenger-car equivalent for trucks, obtained from Exhibit 20-8 or Exhibit 20-9, and
ER = passenger-car equivalent for RVs, obtained from Exhibit 20-8 or Exhibit 20-9.
Exhibit 20-8 and exhibit 20-9 were given in HCM.

6. Effect of heavy vehicles on flow using HV factor

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In order to determine the effect of HV on traffic parameters, one of the parameters that is speed was taken to illustrate the effect as all the parameters are interrelated to one another. Above described method of HV factor is used to plot the graph in order to have some relationship. Six locations were selected on study area and graph is plotted for the same which is given below in figure 4-9.

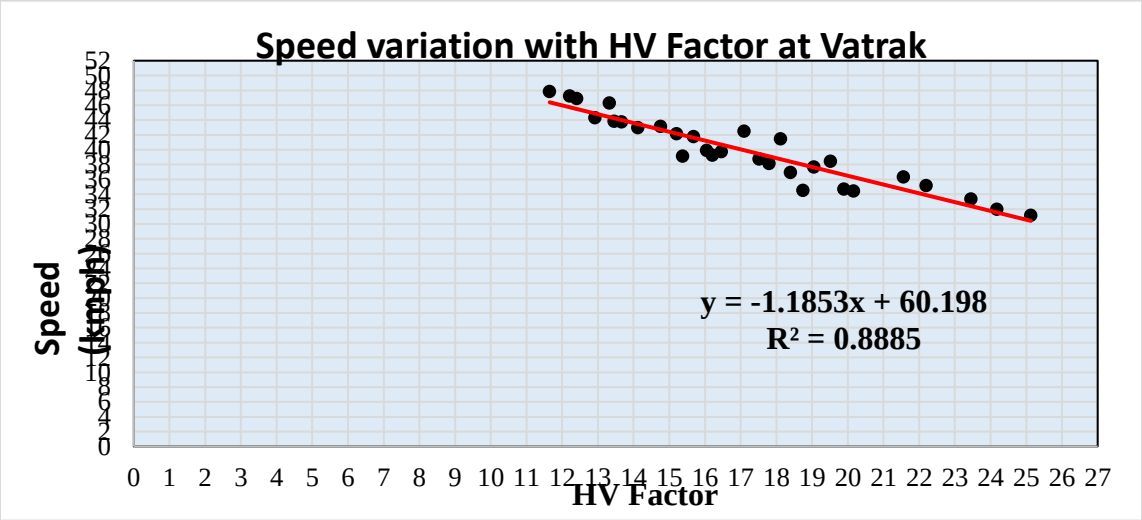

Figure 4: Speed variation with HV factor at Vatrak

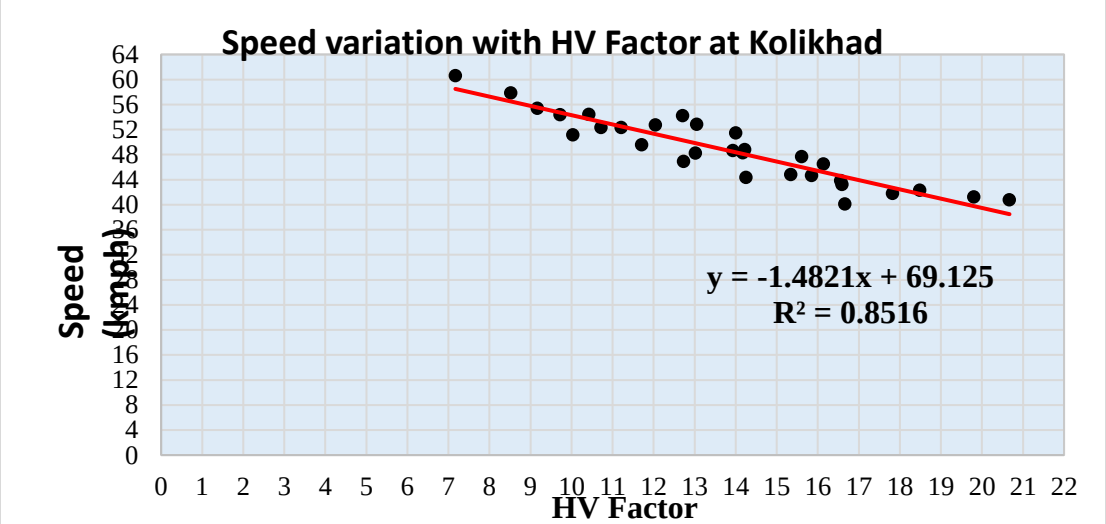

Figure 5: Speed variation with HV factor at Kolikhad

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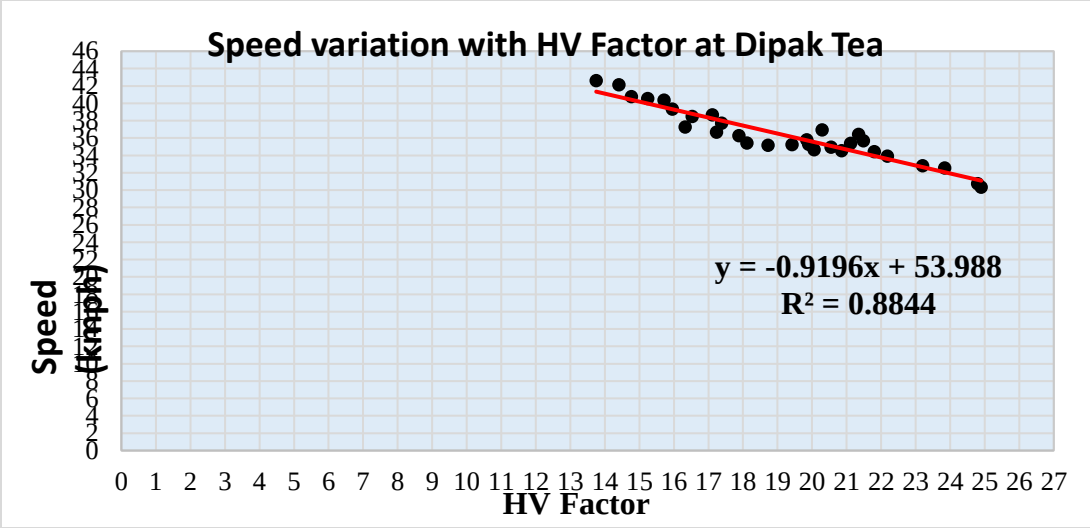

Figure 6: Speed variation with HV factor at Dipak tea

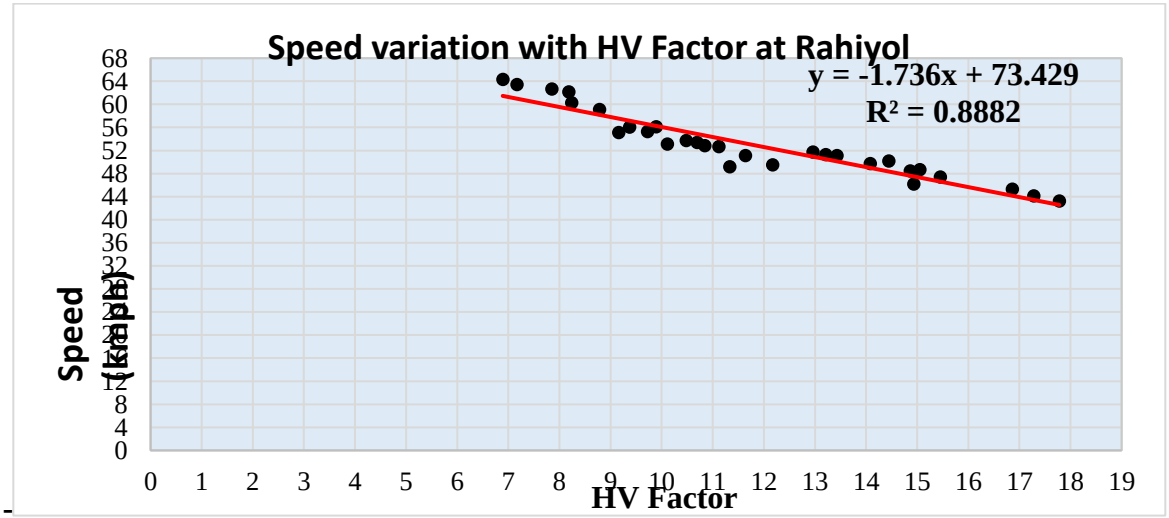

Figure 7: Speed variation with HV factor at Rahiyol

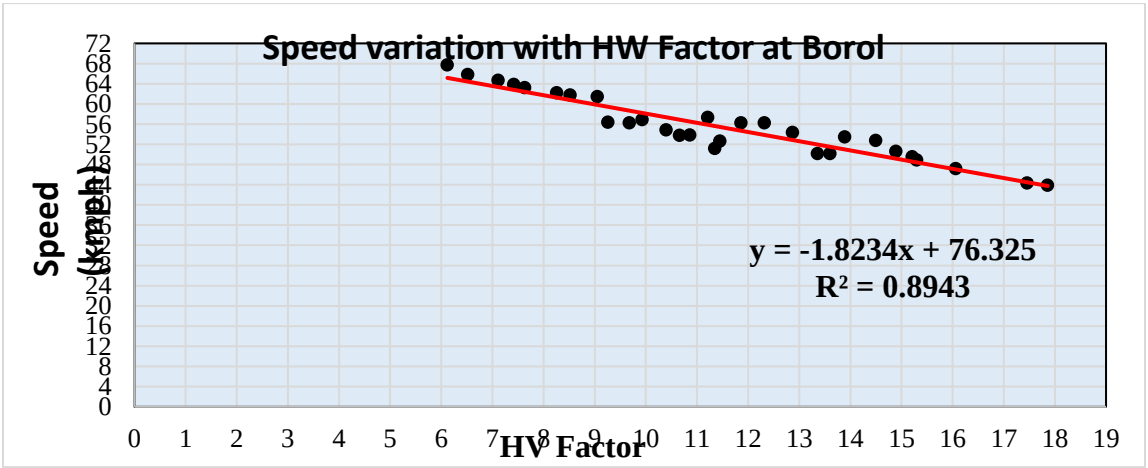

Figure 8: Speed variation with HV factor at Borol

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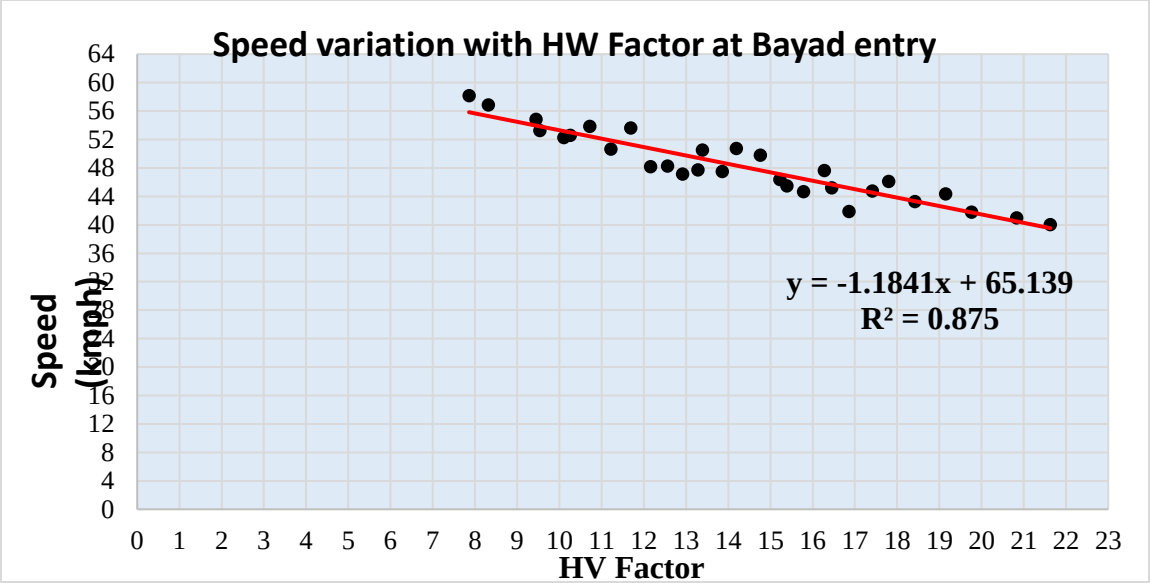

Figure 9: Speed variation with HV factor at Bayad entrance

As it is clearly seen from the plots given above speed followed inverse relation with the HV factor. Degree of inclination and FFS is depended further on the road geometric conditions. Where there is nearly straight road with no hindrance which resulted in higher value of FFS.

Validation for HV factor by comparison with HCM FFS

In order to validate the result obtained from heavy vehicle factor, FFS obtained from the plot is compared with the calculated FFS by method given in HCM-2000. Calculation procedure of FFS by HCM-2000 method and difference between two FFS value is listed in table 1 given below.

Table 1: Comparison ofFFS by plot and HCM-2000 method

Location	Ave. Speed	Fhv	PCPH	FFS (HCM)	FFS (HV Factor)	Difference	% diff.
Kolikhad	49.3	0.97	1464.9	68.18	69.12	0.94	1.38
Dipak Tea	36.3	0.94	1070.2	50.53	53.25	2.72	5.38
Rahiyol	52.95	0.971	1511.4	72.41	73.43	1.02	1.41
Vatrak	39.8	0.94	1134.5	54.89	60.2	5.31	9.67
Borol	55.38	0.97	1532.2	75.12	76.33	1.21	1.61
Bayad Entrance	48.28	0.94	1195	64.17	65.14	0.97	1.51

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It is clearly noted that there is not much difference between the two values apart from one location Vatrak, where there is difference of nearly 10 %. The difference is accountable as geometric constrain is present at that particular location. Lane width is reduced at that location thus somewhat creating bottleneck situation and hence average speed of vehicles were reduced significantly. So HCM-2000 calculated value is less than expected value as it is given for two lane road with uniform road width. So, difference between FFS is more. Second significant difference is occurred at location near Dipak tea stall. This location is also attributed with geometric constrains as number of curvatures along with several speed bumps present at that particular location. These results in reduction of overall average speed of travelling vehicle be it in congested condition or be it in free condition. So, in this case HCM method gave more accurate account of constrains than that of HV factor method. Overall HV factor method resulting in good result and could be used because of its simple working procedure.

7. Conclusion

It is clear to everyone that HVs have significant effect on traffic flow. Many complex studies were carried out to study the effect but rarely someone tried to use some simple factor that show the trend of effect of HVs on traffic flow. Evaluation of FFS by using HV factor as carried out in this research clearly indicated the effect of HVs on flow. FFS varied inversely with respect to HV factor and gave similar results to those were calculated by using HCM. HV factor also shown good trend for various geometric conditions, be it change in lane width, curvature change or presence of bumps in section. HV factor also compensated for change in lane width which could not be attributed while calculating with the help of HCM.

Overall it is concluded that HVs do have significant effect on FFS and thus on other traffic flow parameters. It is also concluded that use of HV factor gave accountable results to show the effect of HVs on traffic flow parameters.

Annexure

License plate method by videography
Date: Distance:
Location:

Interval (Min)	No. of vehicles entered (A)	No. of vehicles departed (B)	Total vehicles in section (A)-(B)	Density (vehicles/km)
0-2				
2-4				
4-6				
6-8				

Travel time and average speed calculation
Date: Distance:

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Location:

Type of vehicle	Licence plate	Entry time	Exit time	Travel time	speed

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