

STUDY THE EFFECT ON DELAY AND FUEL CONSUMPTION ON TOLL PLAZA

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ABSTRACT

Indian roads carry a huge volume of traffic, more than 40% of the total traffic is carried by national highway having length less than 2% of total road length in India. Thus the national highways contribute to carrying a great proportion of traffic density. With the great significance of national highways, existing checkpoints in Indian road like toll plaza, intersection, cause a halt in the vehicular movement. Further, the ever increases traffic volume causes delay in journey time and hence result in extra fuel consumption.

In the current study, delay in journey time and the resulting extra fuel consumption at Gharaunda toll plaza (Haryana) is estimated on NH 44 (earlier NH 1). The delay in journey time is computed by using Control Delay Method of Highway Capacity Manual (HCM 2000). The control delay method has initial delay, queue time, stop delay and acceleration delay. Considering this control delay method, a stretch of total 400 meters around the toll plaza is taken for the delay time assessment study, that is, a point from where vehicle start decelerating from 80% of design speed, moving towards zero speed and again accelerating to the 80% of design speed. The study includes surveys of traffic volume for determination of Lean Hours, Average Hours and Peak Hours, called as Congestion levels. The survey is conducted during weekdays and weekend both, to minimize the abruptions in experimental data. Assessment of total delay during Peak Hours, Average Hours and Lean Hours is done manually using stopwatch. And, the extra fuel consumption of different type of vehicles due to a specific non optimum speed range is calculated. For assessing the fuel consumption at non optimum speed, values of fuel consumption are taken from the graph of Speed v/s Fuel Consumption curves from CRRRI Annual Data Report, 2009-10. Computed extra fuel consumption and delay give a better insight into comparing the results at different level of congestion and thus providing a base for better planning of road infrastructure.

Keywords: Fuel consumption, geometric delay, immobilized, toll plaza, acceleration

1. INTRODUCTION

Delay at toll plaza is associated with the time lost by the vehicle because of toll collection and traffic conditions. Delay is defined as the actual travel time and travel time in ideal conditions (absence of traffic control, geometric delay, any incident and when there are no other vehicles on road). Capacity of toll plaza and estimation of level of service procedure are built around the concept of average Control Delay per vehicle. Control Delay can be categorized into deceleration delay, stopped delay and acceleration delay. Stopped delay is easier to measure which is defined as the delay when vehicle is fully immobilized, while the delay measured by acceleration and deceleration vehicle is categorized as acceleration and deceleration delay, respectively. As per HCM 2000, Control Delay is comprised of initial deceleration delay, queue move up time, stop delay, and final acceleration delay.

2. OBJECTIVES OF THE STUDY

The study includes assessing the traffic volume data, traffic composition and speed flow data on NH 44 from Panipat to Jalandhar and Jalandhar to Panipat at Gharaunda toll section.

The main objectives of the study:

1. To analyse traffic volume data on NH 44 at Gharaunda Toll Plaza section, collected from NHAI.
2. Identification of Peak hours, Average hours and Lean hours.
3. To estimate the delay in journey time on selected site due to Toll Plaza.
3. To quantify the fuel losses on the same selected site.
5. To determine the cost of extra fuel consumed.

3. SCOPE OF THE STUDY

In this study, classified traffic volume data is collected at Gharaunda toll plaza on National Highway 44. This traffic volume data is used to analyze the Lean Hours, Average Hours And Peak Hours during morning, evening and night. The delay data is counted manually during Lean, Average and Peak Hours covering morning, evening and night hours to know the delay in journey time and extra fuel consumption and also the monetary loss because of this extra fuel

consumption. Results are based on the traffic volume data collected during 16 December 2016 to 21 December 2016. Current study is limited to Gharaunda toll plaza on NH44,

4. LITERATURE REVIEW

Sekhar et. al. [2013] estimated the delay and fuel losses during the idling of vehicles at signalized intersection in Ahmedabad through a 16 hour classified traffic volume count survey at four intersections. To find the delay characteristics and existing speed on the selected patch, GPS based velocity box (V-Box) was installed in the car. It was done by using VISSIM micro simulation software with the help of GEH statistics. GEH is a widely used statistics for comparing the modeled values and observed values evolved through simulation tools.

Pal and Sarkar [2012], determined delay, noise pollution and fuel loss during idling in Agartala city. This is done experimentally by filling the fuel tanks and running them at idling condition. As per the study results it is analyzed that the delay at all intersections under study during peak hours is more than 60 seconds/ vehicle. Another study at Agartala shows a wastage of 389.68 liters of diesel and 810.38 liters of petrol per day during vehicle idling. Tiwari et. al. [2013] also estimated fuel wastage due to idling of vehicle at road traffic signal in Indore, Madhya pradesh. The classified traffic volume study was conducted for 12 hours. (8:00a.m. to 10:00p.m.). The study is conducted at seven signalized intersection in Indore for a complete week (Monday to Sunday) to estimate the extra fuel consumption because of idling of vehicles on signalized intersection. This study shows that about 5.9×10 liters per year petrol & diesel (3.6×10 liters petrol and 2.3×10 liters diesel) are being wasted. Parida and Gangopadhyay [2008] estimates the fuel loss when vehicles are in idling condition at signalized intersection in Delhi. 12 signalized intersections of varying traffic volume are considered to estimate fuel loss of vehicles in idling condition. Out of these 12 intersection 2 were of low volume, 2 were of medium volume and 8 were of heavy volumes. The intersections having 75000 vehicles per day were categorized as low volume, 75000 100000 were as medium volume and > 100000 were taken as high volume intersection. To collect the classified traffic volume data, 24 hours traffic survey is conducted at high volume intersection and 16 hours survey at low and medium volume intersection. For idling fuel consumption measurement, FP213S detectors, DF210A for two wheelers including two stock and four stock engine respectively are used, also FP2140H flow detector and DF 210 for four wheeler fuel consumption are utilised. The study reflects that 0.37 million kilograms of CNG, 0.41 million liters of petrol and 0.13 million liters of diesel is wasted just because of idling of vehicles every day in Delhi. Worth of this much amount of fuel is Rs. 27.25 million per day and Rs. 9944.5 million per annum.

5. METHODOLOGY

The current study uses traffic volume data and speed data to analyze the delay in journey time and extra fuel consumption due to Toll Plaza. Also this analyzed data is further used to compare the actual distance travelled by the vehicle and the distance that can be travelled by the vehicle with the same amount of fuel in absence of toll plaza at a non-optimum speed.

SITE SELECTION

The study area of Gharaunda is in Karnal (Haryana). It is a toll Plaza which is at the entry of Karnal from Southern direction. Considering the rapid city development, it is likely to experience more travel demands. NHAI data shows an annual traffic growth of 13%. The elected toll plaza site is 13.8 kms away from the city Karnal.

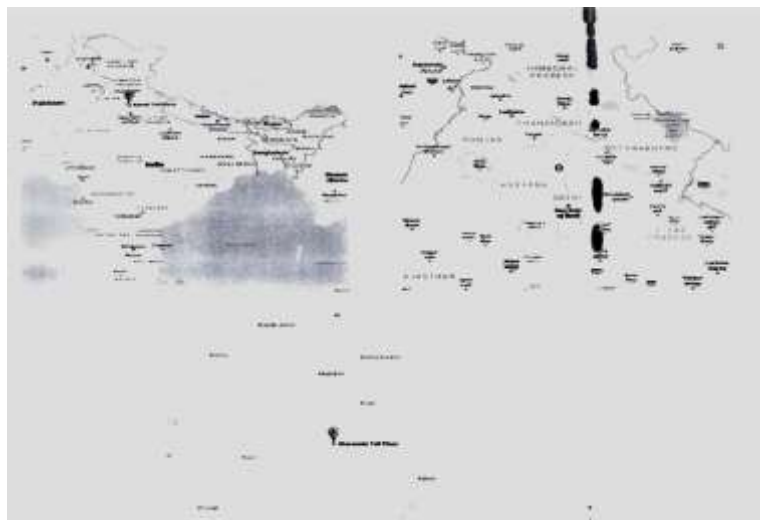


Figure.1 Location of Gharaunda Toll Plaza

There are total 13 toll gates at Gharaunda toll plaza from Panipat to Jalandhar and 13 toll gates from Jalandhar to Panipat.



Figure.2 Gharaunda toll plaza

6. METHODS OF DATA COLLECTION

Traffic volume data and speed data is collected at the selected location. Hourly classified traffic volume is located from NHAI, where-as for delay and fuel consumption study, delay time and speed data is collected with the help of Stop Watch and Radar Gun.

Traffic Volume Data of NHAI- Hourly classified traffic volume data is obtained from NHAI for 24 x 7. The data was collected by a team of expert by manual method. Traffic data collected by NHAI during december 2022 is own in Table 1 to Table 6 in Annexure for both Panipat to Jalandhar and Jalandhar to Panipat section. Daily Average on the hourly basis for Panipat to Jalandhar and Jalandhar to Panipat shown in Table below respectively.

Table. 1 Panipat to Jalandhar Average Daily Traffic

Time	Car/Jeep/van	Bus	LCV	HCV	Tractor	Vehicles
8 am - 9 am	475	52	121	153	10	811
9 am – 10 am	475	52	106	133	14	780
10 am – 11 am	578	89	116	150	14	947
11 am – 12 noon	570	82	123	156	16	947
12 noon – 1 pm	577	85	111	156	17	946
1 pm – 2 pm	616	73	119	169	15	992
2 pm – 3 pm	565	60	125	179	18	947
3 pm – 4 pm	468	65	108	155	15	811
4 pm – 5 pm	573	68	123	168	17	949
5 pm – 6 pm	523	66	126	156	17	888
6 pm – 7 pm	509	68	120	148	13	858
7 pm – 8 pm	453	65	116	144	10	788
8 pm – 9 pm	441	51	178	243	11	924
9 pm – 10 pm	399	61	167	259	8	894
10 pm – 11 pm	345	57	171	266	8	847
11 pm – 12 am	339	51	201	308	9	908
12 am – 1 am	308	43	166	279	10	806
1 am – 2 am	246	47	150	264	7	714

2 am – 3 am	242	37	167	262	9	717
3 am – 4 am	206	33	177	277	8	701
4 am – 5 am	186	35	152	257	8	638
5 am – 6 am	217	38	160	251	9	675
6 am – 7 am	241	43	160	245	9	698
7 am – 8 am	244	44	124	194	9	615

Table. 2 Jalandhar to Panipat Average Daily Traffic

Time	Car/Jeep/van	Bus	LCV	HCV	Tractor	Vehicles
8 am - 9 am	285	52	82	113	5	537
9 am – 10 am	324	45	88	118	7	582
10 am – 11 am	493	60	109	123	15	800
11 am – 12 noon	577	56	118	131	11	893
12 noon – 1 pm	580	54	117	123	15	889
1 pm – 2 pm	543	65	119	123	16	866
2 pm – 3 pm	542	79	125	125	13	884
3 pm – 4 pm	520	66	119	115	13	833
4 pm – 5 pm	549	66	130	132	17	894
5 pm – 6 pm	595	74	143	138	15	965
6 pm – 7 pm	526	78	141	143	8	896
7 pm – 8 pm	514	71	176	173	7	941
8 pm – 9 pm	419	44	198	306	13	980
9 pm – 10 pm	363	45	184	318	12	922
10 pm – 11 pm	353	42	164	282	11	852
11 pm – 12 am	307	40	146	288	11	792
12 am – 1 am	281	50	163	273	9	776
1 am – 2 am	222	43	208	290	11	774
2 am – 3 am	194	63	193	300	8	758
3 am – 4 am	165	92	180	241	10	688
4 am – 5 am	155	60	176	259	9	659
5 am – 6 am	157	50	176	244	13	640
6 am – 7 am	196	48	163	258	16	681
7 am – 8 am	227	42	195	287	11	762

Speed Study and Delay Data

In the presence of toll plaza vehicles moving on design speed decelerate, crosses the toll and again accelerate to achieve the design speed.

In the present study delay is computed as the extra time taken by the vehicles to cross the toll location. In order to calculate this delay, time consumed by the vehicles to cross the Toll Plaza location is work out by following process. An observer observes the vehicle approaching the toll location with radar gun and starts stop watch as soon as the vehicles speed reduces to 80% of the design speed. After crossing the toll vehicle start accelerating and the stop watch is stopped as soon as vehicles attain 80% of design speed. Radar Gun is a device used to measure the speed of a moving object. A radar gun may be hand- held, mounted in a vehicle or mounted on a tripod stand also. It works on the phenomenon of Doppler Effect.

TRAFFIC ANALYSIS

The analysis of hourly traffic volume and traffic composition helps in appropriate geometric sign and pavement design for the road traffic. This traffic data is also very helpful in planning different facilities for different type of vehicles. Traffic regulatory measures to control traffic roads are based upon peak hour traffic conditions. Total traffic volume is converted into PCU data as per the guideline given by IRC 64-1990. Peak hours relate the daily traffic to the maximum hourly traffic and lean hours relate to minimum hourly traffic. As the effect of traffic volume is exponential on delay therefore delay analysis is carried out for Lean, Average and peak hours separately and accordingly extra fuel consumption is calculated at toll location.

AVERAGE HOURLY TRAFFIC VARIATION

Highways are designed to provide fast, safe and comfortable transportation of goods and passengers. The efficient functioning of a road is indicated by the speed and safety of its traffic. While deciding the geometric features of a road, design speed is the most important criteria. Normally traffic increases from lean hours, reaches to maximum during peak hours and then parts decreasing to up to lean hours. Therefore it is very clear that traffic movements are dependent on hourly and daily conditions. In this study, the hourly traffic volume (PCU) on NH 44 (earlier NH 1) from Panipat to Jalandhar and Jalandhar to Panipat is presented in the Table given below:

Table: 3 Panipat to Jalandhar Average Daily Traffic Volume Data (PCU)

Time	Car/Jeep/van	Bus	LCV	HCV	Tractor	Vehicles
8 am - 9 am	475	156	182	689	45	1547
9 am – 10 am	475	156	159	599	63	1452
10 am – 11 am	578	267	174	675	63	1757
11 am – 12 noon	570	246	185	702	72	1775
12 noon – 1 pm	577	255	167	702	77	1778
1 pm – 2 pm	616	219	179	761	68	1843
2 pm – 3 pm	565	180	188	806	81	1820
3 pm – 4 pm	468	195	162	698	68	1591
4 pm – 5 pm	573	204	185	756	77	1795
5 pm – 6 pm	523	198	189	702	77	1689
6 pm – 7 pm	509	204	180	666	59	1618
7 pm – 8 pm	453	195	174	648	45	1515
8 pm – 9 pm	441	153	267	1094	50	2005
9 pm – 10 pm	399	183	251	1166	36	2035
10 pm – 11 pm	345	171	257	1197	36	2006
11 pm – 12 am	339	153	302	1386	41	2221
12 am – 1 am	308	129	249	1256	45	1987
1 am – 2 am	246	141	225	1188	32	1832
2 am – 3 am	242	111	251	1179	41	1824
3 am – 4 am	206	99	266	1247	36	1854
4 am – 5 am	186	105	228	1157	36	1712
5 am – 6 am	217	114	240	1130	41	1742
6 am – 7 am	241	129	240	1103	41	1754
7 am – 8 am	244	132	186	873	41	1476

Traffic volume fluctuates throughout the day, on the basis of traffic volume data, duration of 24 hours is bifurcated into three segments of Peak Hours, Average Hours and Lean Hours. Graphical representation of average hourly variation of traffic volume is shown in Fig. 4.1

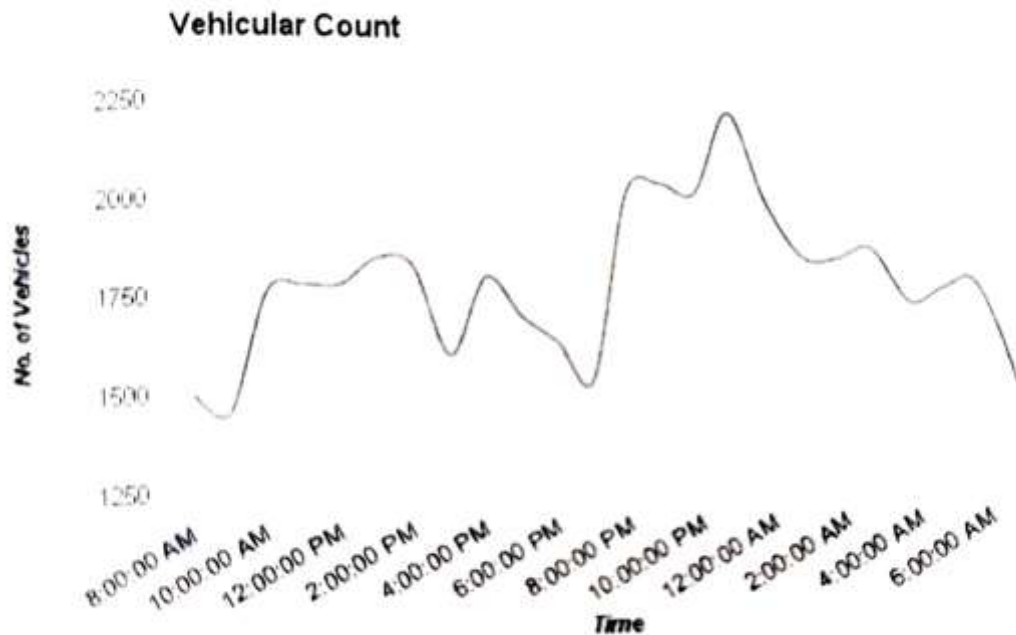


Figure: 3 Average hourly variation (Panipat to Jalandhar)

In order to identify Peak hours, Average hours and Lean hours, hourly traffic volume is arranged descending order and first 8 hour of this sorted data is considered as Peak hours and similarly middle and last 8 hours are considered as Average Hours and Lean Hours. On Panipat to Jalandhar carriageway, Peak hours are identified as 1:00 p.m to 2:00 p.m. , 8:00 pm to 2:00 am and 3:00 am to 4:00 a.m. During these 8 hours traffic varies from 1832 PCU to 2221 PCU. identified Average hours are 5:00 am to 7:00 am, 10:00 am to 12:00 p.m in morning, 12:00 am to 1:00 p.m , 2:00 p.m to 3:00 p.m, 4:00 pm to 5:00 p.m in evening and 2:00 am to 3:00 am night. Traffic variation during these 8 hours is from 1742 PCU to 1824 PCU. Lean hours Identified for the same stretch are 4:00 am to 5:00 am, 7:00 am to 10:00 am, 3:00 pm to 4:00 pm and 5:00 pm to 8:00 p.m and hourly traffic variation for these 8 hours is from 1452 PCU to 12 PCU. The lean hours, average hours and peak hours are shown in Table below.

Table.4 Identified of hours (Panipat to Jalandhar)

	Morning	Evening	Night	Total Hours
Lean Hours	4:00 a.m-5:00 a.m	3:00p.m-4:00 p.m		8 hours
	7:00 a.m-10:00 a.m	5:00 p.m-8:00 p.m		
Average Hours	5:00 a.m-7:00 a.m	12:00 p.m-1:00 p.m		8 hours
	10:00 a.m-12:00 p.m	2:00 p.m-3:00 p.m	2:00 a.m-3:00 a.m	
		4:00 p.m-5:00 p.m		
Peak Hours		1:00 p.m-2:00 p.m	8:00 p.m-2:00 a.m	8 hours
			3:00 a.m-4:00 a.m	

Table :5 Identified of hours (Jalandhar to panipat)

Equivalency factor	1	3	1.5	4.5	4.5	
TIME	Car/jeep/van	Bus	LCV	HCV	Tractor	Vehicles
8a.m.-9a.m.	285	156	123	509	23	1096
9a.m.-10a.m.	324	135	132	531	32	1154
10a.m.-11a.m.	493	180	164	554	68	1459
11a.m.-12p.m.	577	168	177	590	50	1562
12p.m.-1p.m.	580	162	176	554	68	1540
1p.m.-2p.m.	543	195	179	554	72	1543
2p.m.-3p.m.	542	237	188	563	59	1589
3p.m.-4p.m.	520	198	179	518	59	1474
4p.m.-5p.m.	549	198	195	594	77	1613
5p.m.-6p.m.	595	222	215	621	68	1721
6p.m.-7p.m.	526	234	212	644	36	1652
7p.m.-8p.m.	514	213	264	779	32	1802
8p.m.-9p.m.	419	132	297	1377	59	2284
9p.m.-10p.m.	363	135	276	1431	54	2259
10p.m.-11p.m.	353	126	246	1269	50	2044
11p.m.-12a.m.	307	120	219	1296	50	1992
12a.m.-1a.m.	28	150	245	1229	41	1693
1a.m.-2a.m.	222	129	312	1305	50	2018
2a.m.-3a.m.	194	189	290	1350	36	2059
3a.m.-4a.m.	165	276	270	1085	45	1841
4a.m.-5a.m.	155	180	264	1166	41	1806
5a.m.-6a.m.	157	150	264	1098	59	1728
6a.m.-7a.m.	196	144	245	1161	72	1818
7a.m.-8a.m.	227	126	293	1292	50	1988

Traffic volume fluctuates from 1096 PCU to 2284 PCU on Jalandhar to Panipat stretch. Graphical representation of average hourly traffic volume variation is shown in Fig. below.

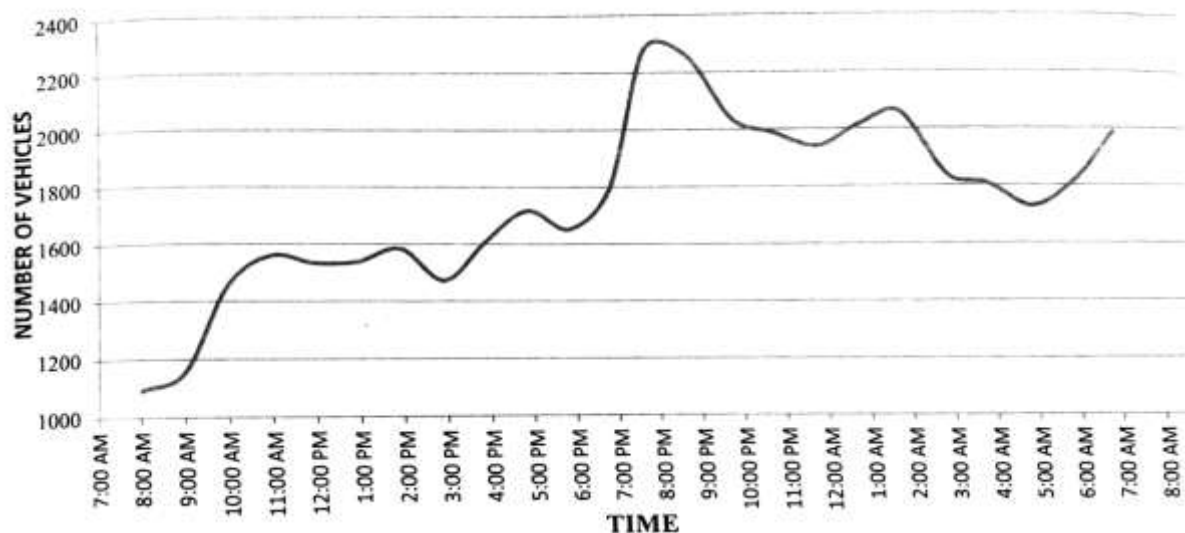


Figure:4 Average hourly variation (Jalandhar to Panipat)

Similar procedure is adopted for identification of different hours on Jalandhar to Panipat carriageway. Identified lean hours , Average hours and peak hours are shown in table 4.4

Table : 6 Identification of hours (Jalandhar to Panipat)

	Morning	Evening	Night	Total Hours
Lean hours	8 am – 12 pm	12 pm – 4 pm		8
Average hours	4 am – 7 am	4 pm – 8 pm	3 am – 4 am	8
Peak hours	7 am – 8 am		8 pm – 3 am	8

TRAFFIC COMPOSITION

Highway traffic is composed of variety of vehicles such as Cars/van, Bus, HCV, LCV etc. Each type of vehicle has an influence on the performance of traffic. Gharaunda toll plaza has two way traffic i.e from Panipat to Jalandhar and Jalandhar to Panipat. At Gharaunda toll plaza traffic composition is divided as Car/Van/Jeep, Bus, HCV, LCV and Tractor + Trailer. Light Commercial Vehicle (LCV) includes mini LCV, LCV 4W, LCV 6W and Heavy Commercial vehicle (HCV) includes 2 Axle Truck, 3 Axle Truck, MAV (4-6 Axle). MAV (more than 6 Axle). The traffic composition is shown in the pie chart. Different pie charts are made on the basis of analyzed data that have been shown in the Fig. below.

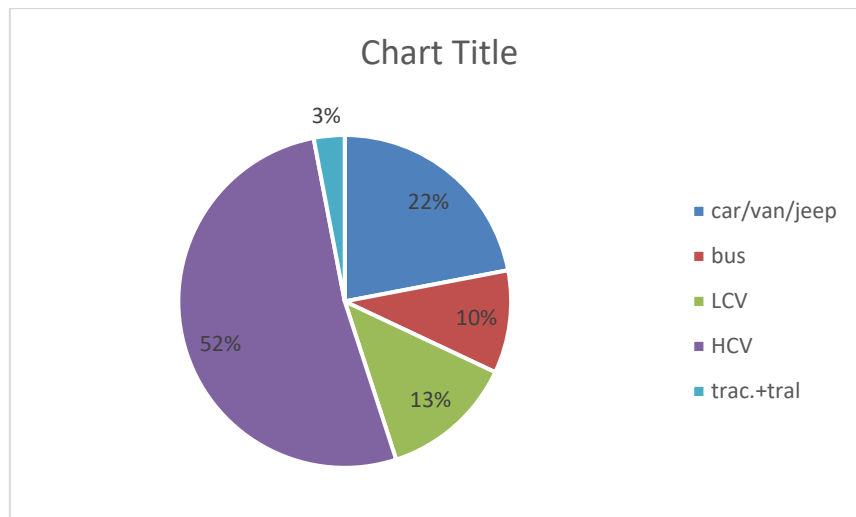


Figure: 5 Traffic Composition Jalandhar to panipat

From the traffic bifurcation it is observed that traffic composition is similar on both the carriageway consisting of maximum H.C.V (53%), Car/Van/Jeep (22% / 23%), L.C.V (12% -13%), Bus (10%) and Tractor-trailer (<3%). As traffic composition is almost similar on both the carriageway, delay studies are carried out for Panipat to Jalandhar carriageway only. Same may be applicable for Jalandhar to Panipat carriageway.

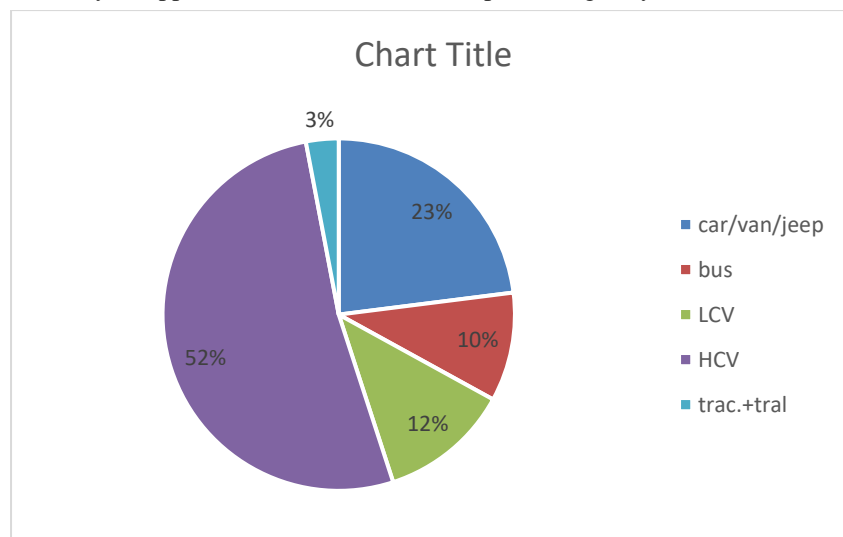


Figure:6 Traffic Composition Panipat to Jalandhar

7. CONCLUSIONS

The study presented in dissertation has been conducted to evaluate the effect of toll plaza on delay and fuel consumption. The site selected for the study is Gharaunda toll plaza on NH 44 (earlier NH 1) in Karnal. Following main conclusion are drawn from the work:

- i. It is observed that the variation of traffic on NH 44 at Gharaunda toll plaza indicates an average of maximum 992 vehicles (1843 PCUs) passing during 1:00p.m. to 2:00 p.m. (peak hour) and a minimum of 615 vehicles (1476 PCUs) during 7:00 a.m. to 8:00 a.m. (lean hour) from Panipat to Jalandhar.
- ii. The average hourly traffic data reflects the variation of traffic on NH 44 at Gharaunda toll plaza indicating a maximum 2221 PCUS (908 vehicles) passing during 11:00 p.m. to 12:00 a.m. (peak hour) and a minimum of 1452 PCUs (780 vehicles) during 9:00 a.m. to 10:00 am. (lean hour) from Panipat to Jalandhar. This may be attributed to the more number of buses and LCVs plying from 11:00 p.m to 12:00a.m.
- iii. Further, variation of traffic on NH 44 at Gharaunda toll plaza shows a of maximum 980 vehicles (2284 PCUs) passing in the span of 8:00p.m. to 9:00p.m. (peak hour) and a minimum of 537 vehicles (1096 PCUs) passing during 8:00 a.m. to 9:00 am. (lean hour) from Jalandhar to Panipat.
- iv. Classification of PCU data is done in different congestion levels: 4:00 a.m. to 5:00a.m. and 7:00 a.m. to 10:00 a.m. are Morning Lean Hours, 3:00 p.m. to 4:00 p.m. and 5:00 p.m. to 8:00 p.m. are Evening Lean Hours (total 8 hours). 5:00 a.m. to 7:00 a.m. and 10:00a.m. to 12:00 p.m. are Morning Average Hours, 12:00 p.m. to 1:00 p.m., 2:00 p.m. to 3:00 p.m. and 4:00 p.m. to 5:00 p.m. are Evening Average Hours. In addition to this, 2:00 a.m. to 3:00 a.m. are Average Night Hours (total 8 hours). 1:00 p.m. to 2:00 p.m. are Evening Peak Hours, 8:00 p.m.
- v. Similarly for Jalandhar to Panipat stretch, classification of congestion levels is as follows, 8:00a.m. to 12:00 p.m.- Morning Lean Hours and 12:00 p.m. to 4:00 p.m.- Evening Lean Hours (total 8 hours). 4:00 a.m. to 7:00 a.m.- Morning Average Hours, 4:00 p.m. to 8:00 p.m.- Evening Average Hours and 3:00 a.m. to 4:00 a.m. are Night Average Hour (total 8 hours). Observed Peak Hours are 7:00 am, to 8:00 a.m. during morning and 8:00 p.m. to 3:00 a.m. during night (total 8 hours).
- vi. In terms of PCU, traffic composition for Panipat to Jalandhar traffic flow has 53% Heavy Commercial Vehicles, 23% car/van/jeep followed by 12% Light Commercial Vehicles. The total percentage of buses is 9.6% and the share of tractor + trailer amounts to 3%.
- vii. For Jalandhar to Panipat, observed traffic composition for Heavy Commercial Vehicles composition is 53%, for car/van/jeep, it is 23% followed by Light Commercial Vehicles having a share of 12%. The total percentage of buses is 10% and the share of tractor + trailer is <3%
- viii. The delay as ascertained from the study due to toll plaza is 3. 5 and 8 minutes Lean, Average and Peak Hours respectively.

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