

Speed-Flow Analysis and Capacity Estimation of a Six-Lane Road

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Abstract—Capacity of a highway can be defined as maximum number of vehicles that can pass a section of road per unit time under given traffic, roadway and control conditions. Capacity analysis gives a clear understanding that how much traffic a given road can accommodate. Thus capacity of a highway is a quantitative measure of a facility. The paper presents the results of a study conducted for estimation of the capacity of a multi-lane rural highway under heterogeneous traffic flow conditions. For this purpose, two sections of 30 meter stretch were identified as study sections on NH 1 (pipli-karnal road) in Kurukshetra District, Haryana, which is a six lane divided national highway. All the Data of speed flow studies were collected manually for this study. Only normal weekday traffic was recorded. Data collection being carried out for a period of 3 hours. Traffic data consisting of measurement of geometric parameters of road, Classified traffic volume, Speed distribution and Time Headway distribution of vehicles.

Keywords: Heterogeneous traffic, Multi-Lane Rural Highway, Classified Traffic volume, Speed distribution, Time-Headway distribution

1. INTRODUCTION

According to the highway capacity manual (HCM,2010), capacity of a highway can be defined as the maximum hourly rate at which vehicles or persons can be reasonably expected to travel across a point or an uniform section of a roadway during a given time period under prevailing roadway, traffic and control conditions. It is expressed as vehicle per hour or vehicle per day and usually expressed as PCU/hour or PCU/day. The highway capacity depends on the certain factors as listed below;

Traffic Conditions: homogeneous traffic or heterogeneous traffic, proportions of turning movements at intersection, merging or diverging or weaving traffic etc.

Roadway characteristics: geometric parameters of road, number of lanes or lane configuration, lane width, shoulder width, horizontal or vertical alignment, lateral clearance, super elevation etc.

Control conditions: surface condition, signals at intersection etc.

Others: drivers or vehicular characteristics, environmental conditions, presence of pedestrians etc.

2. FIELD STUDY

The data for speed flow studies were collected at mid-block section of NH1 (pipli-karnal road) which is six lane divided (three lanes on either side) road in Kurukshetra District. The data were collected manually. The survey was carried out for a period of 3 hours between 09:45 am to 12:45 pm (Thursday, 29th September, 2016). In addition to the traffic data, the physical data like carriageway width, shoulder width and median width were measured at the survey location. The carriageway width was 10.5 m with paved shoulder of 1.5m width and the width of the median was 4.4 m. cross section of the road is shown in Fig. 1. The survey location shown in Fig. 2 and Fig. 3.

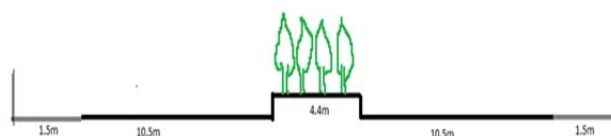


Fig. 1: Section of NH1

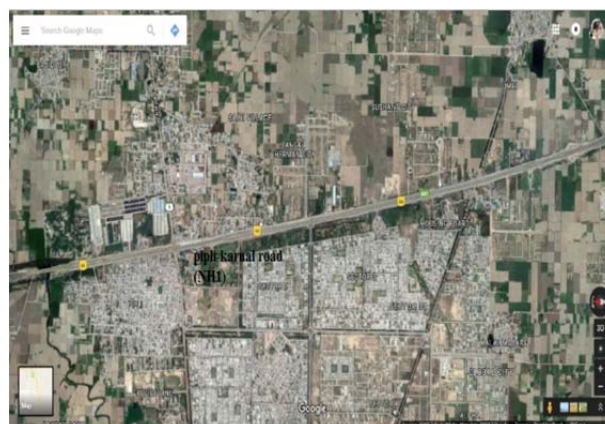


Fig. 2: Study Location



Fig. 3: Study being conducted

Table 1: PCU Values as per IRC: 64-1990

Vehicle type	PCU
Car/jeep/van	1
Bus, truck	3
Tractor	1.5
Truck-trailer, tractor-trailer	4.5
2-wheeler	0.5
3-wheeler	1
cycle	0.5

3. DATA ANALYSIS

Table 2: Composition of vehicles

Vehicles	No. of Vehicles	% vehicle
Car/jeep/van	1511	60.39
Truck	459	18.35
Bus	127	5.08
Truck-Trailer	51	2.04
Tractor	1	0.04
Tractor-Trailer	7	0.28
2 wheeler	333	13.31
3 wheeler	12	0.48
cycle	1	0.04
total	2502	100

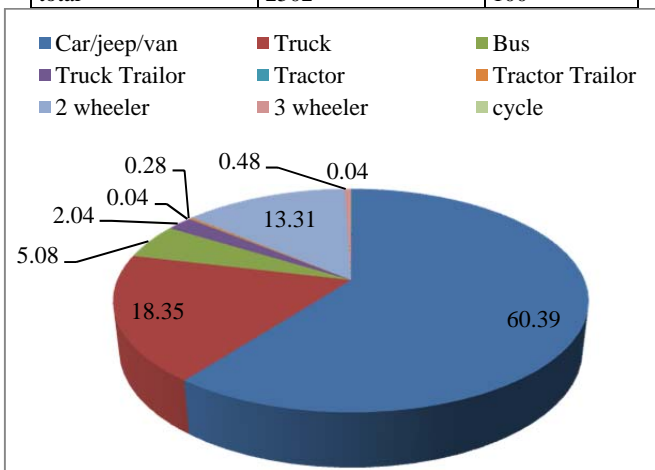


Fig. 4: Composition of vehicles

Table 3: Composition of vehicles in PCUs

Vehicles	% PCU
Car/jeep/van	40.69
Truck	37.08
Bus	10.26
Truck Trailer	6.18
Tractor	0.12
Tractor Trailer	0.85
2 wheeler	4.48
3 wheeler	0.32
cycle	0.01
total	100

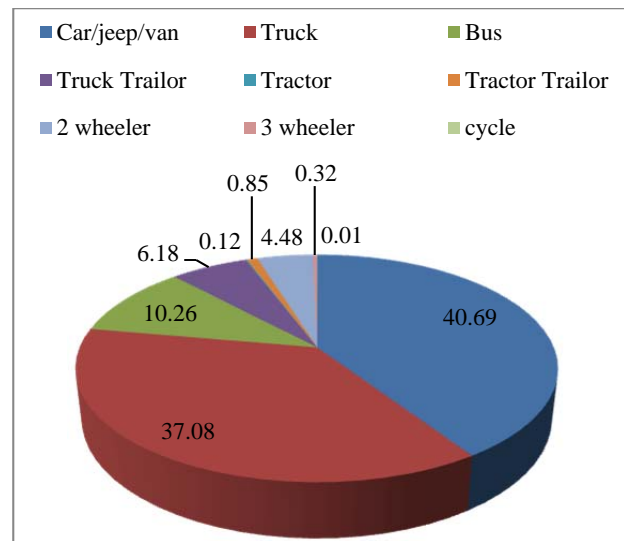


Fig. 5: Composition of traffic in PCUs

Table 4/ Percentage of slow moving and fast Moving vehicles

Type of vehicle	%age
Slow moving vehicles (SMV)	0.84
Fast moving vehicles (FMV)	99.16

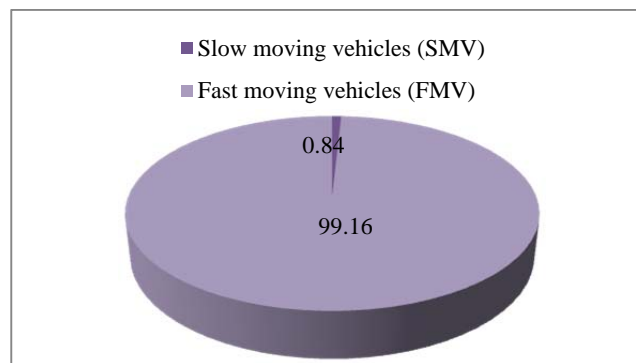


Fig. 6: Fast and Slow vehicles

Table 5: Percentage of commercial and non-commercial vehicles

Type of vehicle	%age
Commercial	25.78
Non-commercial	74..22

Truck-trailer	75	47.99
Tractor	52.17	43.46
Tractor-trailer	47.87	35.23
2-wheeler	107.14	54.72
3-wheeler	52.94	40.23
cycle	16.85	16.85

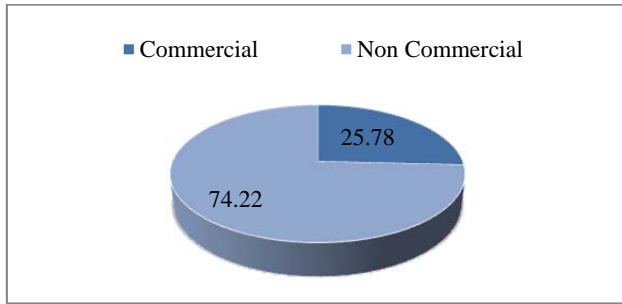


Fig. 7: Proportion of Commercial vehicles

Table 6: Percentage of Vulnerable and Non-Vulnerable Road Vehicles

Type of vehicle	%age
Vulnerable Road Vehicles (Cycle and 2-wheeler)	13.35
Non- Vulnerable Road Vehicles	86.65

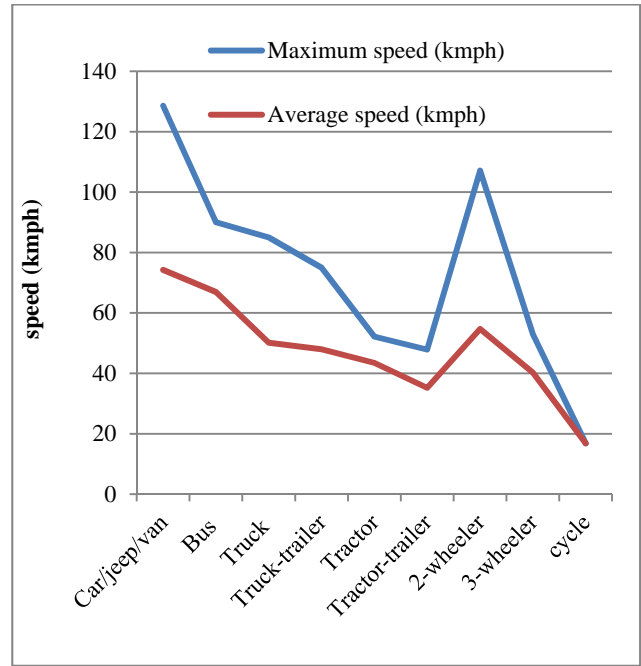


Fig. 9: Maximum & Average Speed of Vehicle

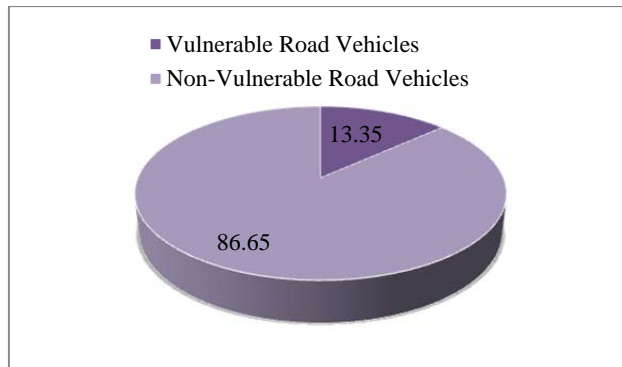


Fig. 8: Proportion of Vulnerable Road Vehicles

Table 9: Variation of classified traffic count in 3 hours duration at NH1

Vehicle	1st hour	2nd hour	3rd hour
Car/jeep/van	463	464	584
Truck	160	159	140
Bus	35	42	50
Truck- trailer	16	20	15
Tractor	0	5	1
Tractor- trailer	1	0	1
2-wheeler	108	102	123
3-wheeler	2	4	6
Cycle	0	1	0

Table 7: Composite PCU value

Total number of vehicles	2502
PCU value	3713.5
Composite PCU	1.484213

Table 8: Maximum and average speed of vehicle Observed during survey

Vehicle	Maximum speed (km/h)	Average speed (km/h)
Car/jeep/van	128.57	74.25
Bus	90	66.92
Truck	85	50.13

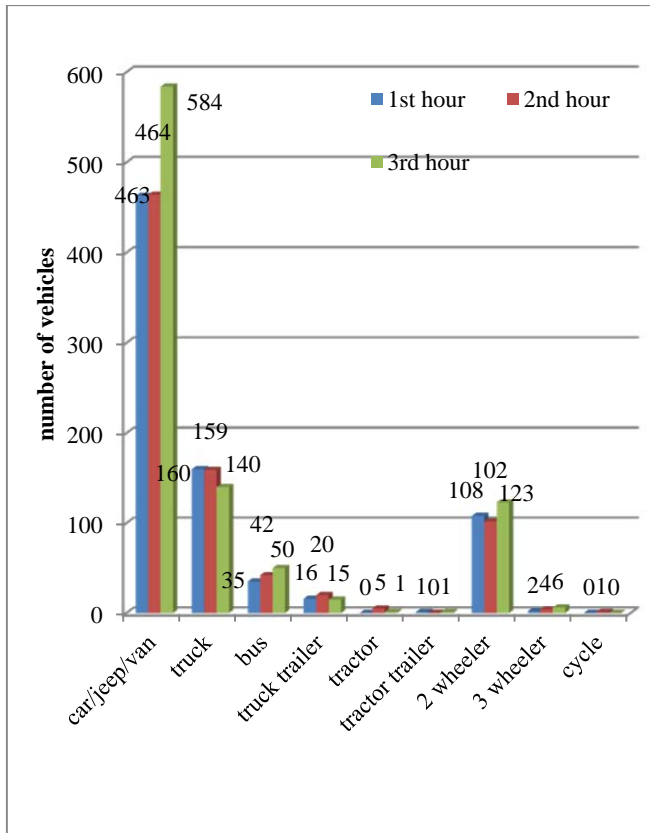


Fig. 10: Classified Traffic of 3 Hours

Table 10: Minimum Headway observed on NH1

Time slot	Minimum Headway for Cars (second)	Time slot	Minimum Headway for Cars (second)
09:45-09:50	0.76	11:15-11:20	1.23
09:50-09:55	0.81	11:20-11:25	1.06
09:55-10:00	0.97	11:25-11:30	1.15
10:00-10:05	0.85	11:30-11:35	1.22
10:05-10:10	0.99	11:35-11:40	1.96
10:10-10:15	0.87	11:40-11:45	1.38
10:15-10:20	0.84	11:45-11:50	0.31
10:20-10:25	0.99	11:50-11:55	0.78
10:25-10:30	0.78	11:55-12:00	1.17
10:30-10:35	0.98	12:00-12:05	0.95
10:35-10:40	1.06	12:05-12:10	1.06
10:40-10:45	0.88	12:10-12:15	1.41
10:45-10:50	0.79	12:15-12:20	1.33
10:50-10:55	1.1	12:20-12:25	0.97
10:55-11:00	1.16	12:25-12:30	1.07
11:00-11:05	1.17	12:30-12:35	1.06
11:05-11:10	1.12	12:35-12:40	0.81
11:10-11:15	1.08	12:40-12:45	0.95

4. CAPACITY ESTIMATION

Headway method:

Average Minimum headway observed, $h = 1.01$
Second

$$\begin{aligned} \text{Capacity} &= 3600/h \\ &= 3600/1.01 \text{ PCU/hour/direction} \\ &= 72000 \text{ PCU/day} \end{aligned}$$

(Taking 10% peak hour factor)

Fundamental diagram method:

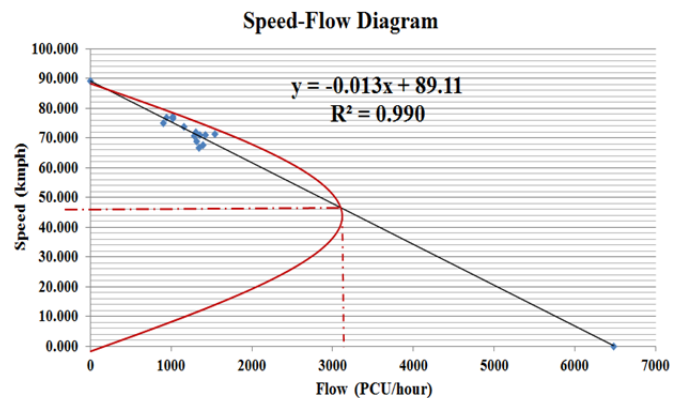


Fig. 11: Speed-Flow Diagram

Free flow speed, $V = 89.11 \text{ km/h}$
 $V/2 = 44.555 \text{ km/h}$
 Flow corresponding to $v/2$ speed = 3456
 PCU/hour/direction
 Capacity = 70,000 PCU/day
 (Taking 10% peak hour factor)

5. DISCUSSION OF RESULTS

It is seen from Table 2 and Figure 4 that the road section under study consists of about 60% cars followed by 18% trucks and 5% buses. In terms of PCUs the road section carried about 40% cars, 37% trucks and 10% buses (table 3 and figure 5). The slow moving vehicles at the section were less than 1% (table 4). It is observed from table 5 and Fig. 7 that traffic on the road consists about 25% commercial vehicles. Vulnerable road vehicles on the road consisting of cyclist and 2-wheeler travellers are found to be 13% (figure 8). Maximum speed of cars is found to be about 130 km/h and average speed of car on the road is 75 km/h (table 8). Similarly, maximum speed for buses is found to be 90 km/h whereas average speed is 65 km/h. As far as hourly variation of traffic is concerned, it is found to be more or less uniform during period of the study as

observed from table 9. The minimum time headway (average) between passage of two consecutive cars in the studied section was found to be 1.01 seconds. Capacity estimation of the road has been made using headway method and speed-flow diagram method. The capacity value is found to be 72,000 PCUs by headway method and 70,000 PCUs by speed-flow diagram method. These capacity values when compared to the HCM method found to be much less than the capacity value for multi-lane roads given by HCM.

6. CONCLUSION

The paper presented the results of the study conducted on a 6-lane section of NH1. Composition of vehicles including commercial vehicles, slow moving vehicles and vulnerable road vehicles is brought out at the field study. The maximum and average speed of vehicles also given. The capacity of 6-lane section of the road determined by headway method and speed-flow diagram method is found to be 72,000 PCUs and 70,000 PCUs respectively which is much less as compared to the capacity of 6-lane road given by HCM method. According to the HCM the capacity of a multi-lane road should be 2200 PCU/hour/lane.

REFERENCES

- [1] IRC (1990), "Guidelines for capacity of roads in Rural Areas", IRC: 64-1990, Indian Roads Congress, New Delhi
- [2] Mathew, T. V., Rao Krishna, K.V.," Introduction to Transportation Engineering"
- [3] Papacostas, C.S., "Fundamentals of Transportation Engineering", Prentice-Hall, New Delhi, 1987.
- [4] TRB (2000), "Highway Capacity Manual 2000", 3rd Edition, National Research Council, Transportation Research Board, Washington, D.C.
- [5] Banks, J.H., "Introduction to Transportation Engineering", Tata Mc-Graw Hill, 2004