Study on Effect of Gradients on PCU and Capacity Factor for Undivided Two Lane National Highway (NH-209)

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Abstract—In India, the quick development in mechanical and monetary advancement in the urban zones. In urban ranges the size and nature of activity stream will be not quite the same as provincial zones. In the respect, information of the roadway limit is a vital parameter for arranging, examination and operation of roadway framework. Passenger car units are used to represent the effect of varying mixed vehicles types on traffic stream. Traffic on congested highways is of the mixed nature to access the different types of vehicles on highways. This study is concerned to determine the PCU values of vehicles under mixed nature traffic flow at congested highways. An intension of this work is to analyze capacity of two lane undivided national highway in heterogeneous condition. For the capacity estimation it is relatively tough to estimate traffic volume on the road. The problem of measuring flow may addressed by using dynamic PCU values. In this present study the complete process of capacity estimation for NH 209 undivided two lanes has been expressed and the result obtained.

Keywords— Volume, dynamic PCU, PHF, speed distribution and Capacity estimation

1. INTRODUCTION

In India, the length of total road network presently is 4.2 million km still people groups in India, confronting enormous challenges in giving prevalent Vehicular movement stream. As growth in population altered modes of transportation are rises and resulted in congested traffic flow situation on road, for the transport of goods and passengers for short to medium distance's roads plays a significant role and road transportation package is much flexible than further modes of transport available. The issue for the estimation of volume of activity measures of vehicles having a place with various sorts identified with its proportionate traveler autos values and communicating its volume basing on Passenger Car Unit (PCU) every hour. It is constantly extremely difficult to figure the association between the vehicles under heterogeneous movement conditions.

Fig 1. Heterogeneous traffic

2. OBJECTIVES

1. Establishing the relationship between Speed and Volume it is necessary to analyze the spot speed of different vehicles (Car, LCV, HCV, Bus etc.)
2. Determination of Dynamic Passenger car units (PCU), Speed, Peak hour factor (PHF) and Capacity of different gradients.
3. Comparison of capacity values at selected points (gradients) on two lane undivided national highway between actual capacity and capacity obtained according to Chandra's method and linear regression analysis.

3. LITERATURE REVIEW

Dr.Satish Chandra has studied "Capacity Estimation Procedure for Two-lane Roads under Mixed Traffic Condition". in his paper stated that the objective is to determine the PCU, grade percentage in both up and down movements, directional split, effects of grade, lane width, and road roughness. The results show that there is 2.61% decrease of capacity in upgrade and 3.09% increase in capacity in downgrade. Pothula sanyasi Naidu studied "Capacity of road with vehicle characteristics and road geometrics" . In this paper stated that the objective in studying variation in capacity with respective various width of road elements. Results obtained shown that the variation in capacities calculated in two methods are not more than 10%. Dr.B.V.Khode studied that "Impact of lane width of road on passenger car unit capacity under mix traffic condition in cities on congested highways". The objective is to estimate the value of PCUs for mixed traffic condition of moving vehicles in the traffic flow. The capacity of a 7.2 m wide road in pcu values is estimate 3348.48 pcu/h which is larger than the value of 3,200 pcu/h suggested in HCM 2000. Deepika Mohan studied that "Study on effect of gradient on stream equivalency factor for undivided two lane highways". To develop stream equivalency factor for undivided two lane highways with the main focus in its effect on varying gradient. The result from four sites a model for predicting SEF values were developed and the same was found valid for the fifth site.

Study area: The study was carried out on NH-209 of Kanakapura city in south part of Bangalore city. To meet the study requirements specific study sites are chosen from the various section of national highway stretches of Bangalore. To develop the capacity estimation of traffic volume primarily 3 sites were chosen.

4. DATA COLLECTION / EXTRACTION: Analysis for the estimation of capacity is carried out for the gradient section at Kanakapura road of national highway-209. The traffic studies were carried out to determine the traffic volume, average daily traffic (ADT), composition of traffic stream, and the speed of different types of vehicles at the selected road sections. The traffic volume survey is carried out on typical weekdays and weekends for a period of 12 hours from morning 7am to 7pm for **7 days** on each site.

GEOMETRIC DETAILS

Site	Gradient 1	Gradient 2	Gradient 3
Study stretch	NH 209	NH 209	NH 209
Location	Hanumantha nagara	Thoppaganahalli	Jattipalahalli road
Direction	Bangalore towards kanakapura	Bangalore towards kanakapura	Kanakapura towards malavalli
Carriageway condition	Undivided	undivided	undivided
Number of lanes	2	2	2
Width of carriageway	7.13m	7.06m	7.6m

Table 1. Geometric details of selected site

GRADIENT CALCULATION

Sl no	Gradients	Slope	Grade%
1	Gradient 1	1 in 17	5.88
2	Gradient 2	1 in 40	2.5
3	Gradient 3	1 in 17	1.11

Table 2.Gradient calculation

ANALYSIS OF DATA: The rectangular projected area of different vechicles are shown below.

Sl no	Category	Dimension		Projected area
		length	breadth	
1	Car	3.72	1.44	5.39
2	Bus	10.10	2.43	24.74
3	Truck	7.50	2.35	7.62
4	LCV	6.10	2.10	12.81
5	HCV	2.35	12.0	28.60
6	Bikes	1.87	0.64	1.20
7	Cycle	1.90	0.45	0.85
8	Auto	3.20	1.40	4.48

Table 3.Rectangular projected area of vehicles

CHANDRA'S method

$$PCU = \frac{(V_c / V_i)}{(A_c / A_i)}$$

ADT AND PERCENTAGE COMPOSITION

| Types of Vehicles	ADT Total Vehicles		% composition	
	towards Bangalore (descending gradient)	towards Kanakapura (ascending gradient)	towards Bangalore (descending gradient)	towards Kanakapura (ascending gradient)
cars	5111	5265	21.37%	28.03%
LCV	7233	2271	30.25%	12.09%
HCV	310	297	1.30%	1.58%
buses	1412	1261	5.90%	6.71%
2w	9846	9691	41.18%	51.59%
Total Vehicles	23912	18785	100.00%	100.00%

Table 4.Percentage composition
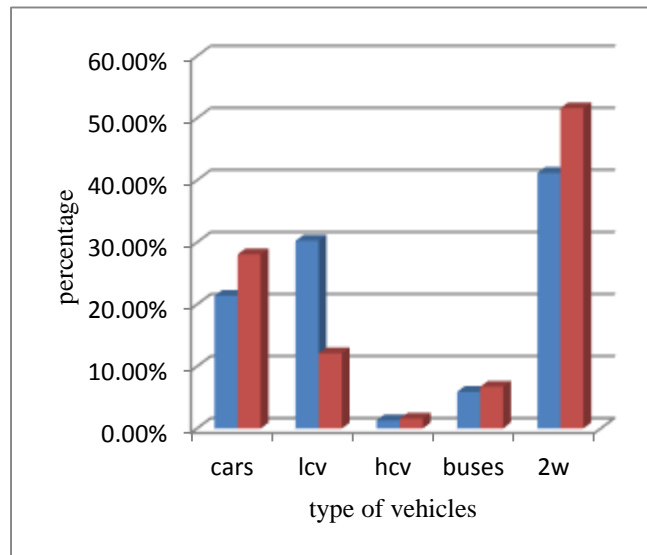
Fig 2. Bar chart of percentage composition

Traffic volume variation graphs: The volume count has been done for 7 days on each gradient and then converted into average daily traffic (ADT) . Then the traffic volume variation graphs are drawn .
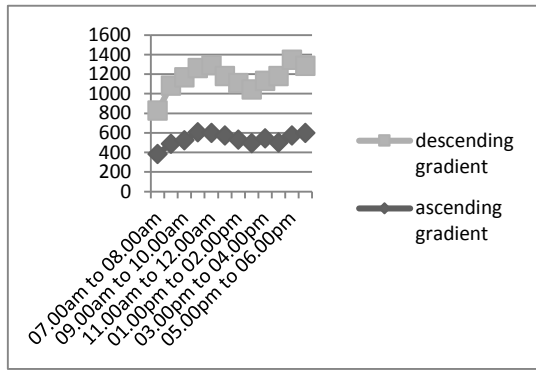
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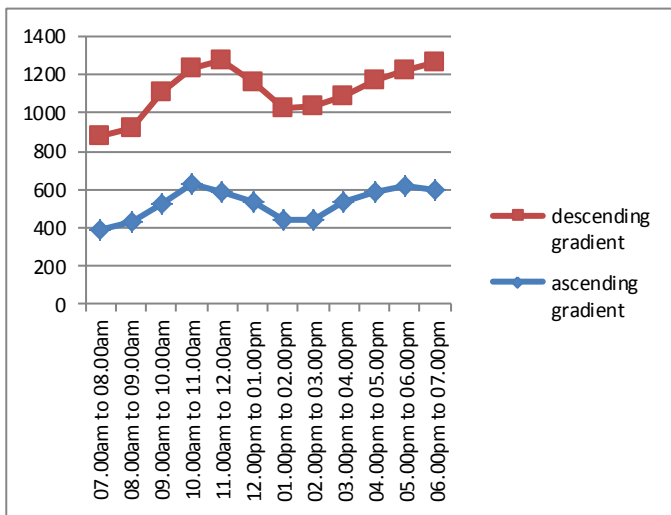
Fig 3.Traffic volume variation of Gradient 1

Fig 4 .Traffic volume variation of Gradient 2

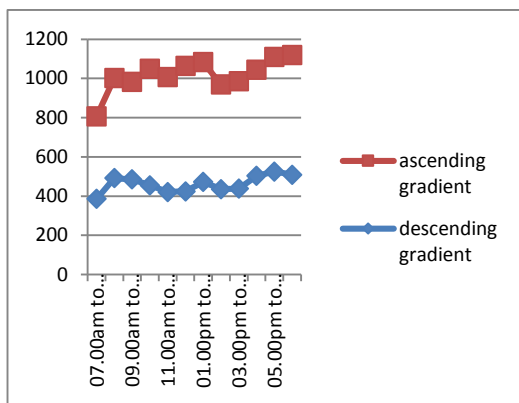
Fig 5.Traffic volume variation of Gradient 3

Effect of Grade: The PCU values of different types of vehicles are given in table (a). Speed of the vehicles is given in   table (b). The capacities with grade at different sections are also noted in table(c).

SL NO	GRADE %	SPEED (kmph)				
		CARS	BUSES	2W	LCV	HCV
1	+5.88	56	39	50	38	32
2	+2.5	58	41	53	40	35
3	+1.11	60	48	58	42	38
4	-1.11	68	57	79	53	41
5	-2.5	69	66	81	55	44
6	-5.88	70	68	83	56	45

Table (a)

SL NO	GRADIENT %	PCU				
		CARS	BUSES	2W	LCV	HCV
1	+5.88	1	6.59	0.25	3.50	5.72
2	+2.5	1	6.49	0.24	3.45	5.42
3	+1.11	1	5.74	0.23	3.40	5.16
4	-1.11	1	5.48	0.192	3.05	5.42
5	-2.5	1	4.80	0.190	2.98	5.13
6	-5.88	1	4.72	0.188	2.97	5.09

Table (b)

Sl no	Grade %	Actual Vol.	Capacity (Chandra's Method)	Capacity (Regression Analysis) based on grade	Error b/w both methods (%)
1	(+)5.88%	606	866	806	6.92%
2	(+) 2.5%	687	816	817	0.12%
3	(+)1.11%	659	793	824	3.76%
4	(-)1.11%	573	621	750	17.2%
5	(-)2.5%	633	766	720	6.0%
6	(-)5.88%	787	912	713	21.8%

Table (c)
Capacity Estimation by Chandra's Method

GRADIENT	Total lane width	Vehicle type	VOLUME		PCU		CAPACITY (vol/hr)	
			descending	ascending	descending	ascending	Descending	ascending
5.88%	7.6	Cars	245	195	1	1	912	866
		Buses	58	39	4.72	6.59		
		LCV	77	70	2.97	3.5		
		HCV	18	17	5.09	5.72		
		Bikes	389	285	0.18	0.25		
2.50%	7.13	Cars	194	189	1	1	766	816
		Buses	33	45	4.8	6.49		
		LCV	77	74	2.98	3.45		
		HCV	11	15	5.13	5.42		
		Bikes	365	298	0.19	0.24		
1.11%	7.13	Cars	173	196	1	1	621	793
		Buses	30	36	5.48	5.74		
		LCV	58	72	3.05	3.4		
		HCV	9	13	5.42	5.16		
		Bikes	303	342	0.19	0.23		

Table 5. Calculation of Capacity

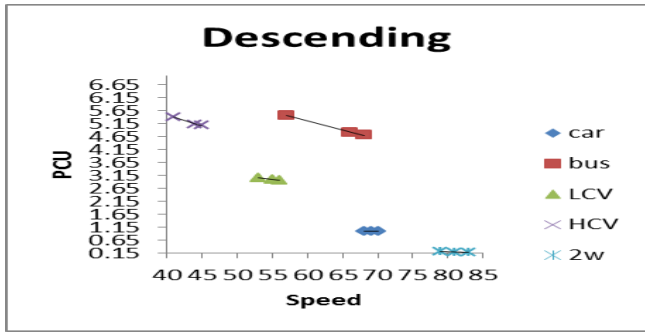PCU variation with respective speed

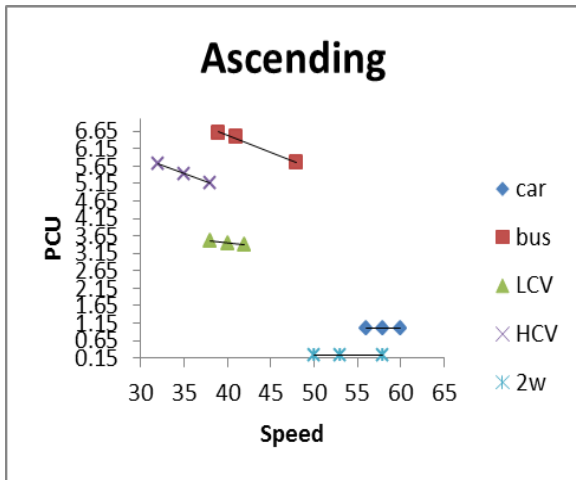Fig 6. PCU variations on descending gradients

Fig 7. PCU variations on ascending gradients
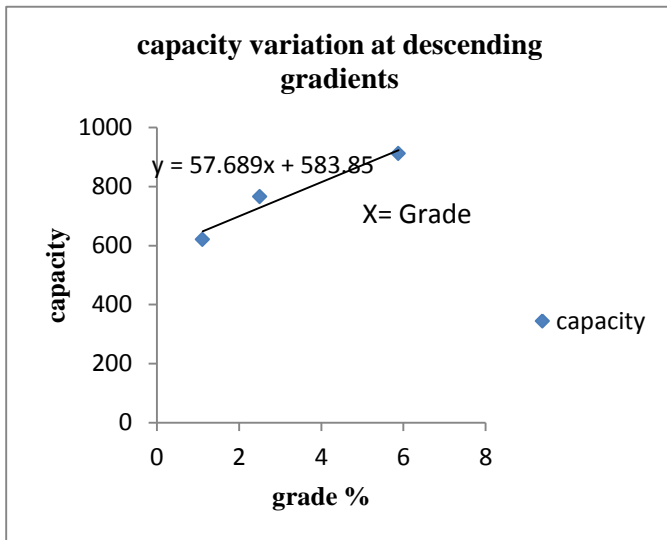
Capacity variation with respective grade %
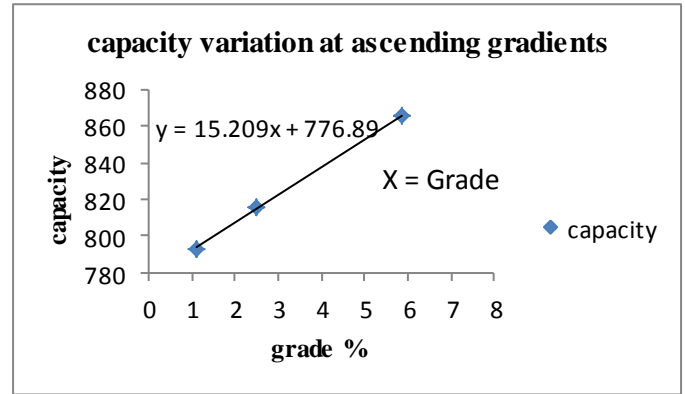

Fig 8. Capacity variation on descending gradients

Fig 9. Capacity variation on ascending gradients

5. RESULTS

1. After seven days of volume count the average percentage of vehicles in the total volume shows majority of two wheelers i.e.46.38%, cars 24.7%, LCV 21.17%, buses 6.3%, HCV 1.44%

2. The average spot speed of all vehicles are tabulated and speed is found to be varying i.e. while vehicles travels on ascending gradient the speed is getting reduces as the % gradient increases and vice-versa.

3. PCU values for different types of vehicles at different sections on varying gradients are found as per Satish Chandra's method and it is observed values are varying at ascending and descending gradients even though lane width is same i.e. only because of speed variation.

4. Attempts have been made to develop linear regression equation to obtain capacity for two lane undivided optional highways based on lane width and % difference of gradient.

5. The equation obtained are as follows, capacity based on lane width at ascending gradient is y=256.25x-107.75 and descending gradient is y=910.42x-2547.6 and capacity based on grade % at ascending gradient is y=15.209x+776.89 and descending gradient is y=57.689x+583.85.

6. CONCLUSIONS

1. The width of carriageway at three different gradients varies the PCU values and capacity of the road.

2. After analyzing the collected data we determined PCU values which varies according to the speed of a vehicles on both ascending and descending gradients.

3. The capacity is estimated by considering 2 methods i.e. Chandra's method and linear regression method.

SCOPE OF FUTURE WORK

1. The studies can be made at intersections, curves and bus stops.

2. By the collected data we can develop capacity modal at different location on highways.

3. To calculate PCU we have consider only frontal area of vehicle we may extend our work considering carriageway, roughness and driver characteristics.

4. In this work we have compared the actual capacity for 2 methods Chandra's method and linear regression method. This work can be extended with other methods.

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