EFFECT OF CARRIAGEWAY WIDTH ON PCU AND CAPACITY OF TWO LANE ROADS – A CASE STUDY OF SHIVAMOGGA DISTRICT

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Abstract: For the present study four straight stretches are selected. In that two stretches are on NH-13 and two on NH-206 which connects Sollapur to Mangalore and Bangalore to Honnavara respectively. Classified traffic volume counts and spot speed has been carried out on four stretches. For each class of vehicles PCU values are determined based on their average speed and dimension by Chandra's method. Capacity is evaluated with respect to carriageway width and is compared with surface roughness of roadway which is measured by MERLIN. Road roughness is calculated by International Roughness Index (IRI). Obtained result shows that the increment of roughness decreases the capacity and in all the four stretches it is less than 3200 PCU/hr.

Key words: Capacity, PCU, MERLIN, Roughness.

I. INTRODUCTION

The capacity is main factor for designing, planning and maintenance of road. Highway capacity can be defined as the ability of roadway or traffic lane to allow maximum traffic movement per unit time, which is really vehicles in a path or roadway that can pass a given point in unit time at most elevated rate. Two-lane highways are the predominant portion of National and State Highway system in the country. Traffic operation on a two-lane two-way highway is distinct. Lane altering and overtaking are possible only in the face of on-coming traffic in the opposite lane. The overtaking demand increases quickly as traffic volume increases, while passing opportunities in the opposing. Roadway factors that influence capacity of a two-lane road include lane width, gradient, lateral clearance, width and type of shoulder. Lane and shoulder breadth can have a noteworthy impact on traffic flow. Contracted lanes cause vehicles to move closer to each other laterally by slowing down or by observing large longitudinal gaps for a given speed. This effectively decreases the capacity. Important traffic conditions that influence capacity of a two-lane road are composition of traffic stream, directional split and presence of slow moving vehicles in the stream. Environmental conditions regards to wet pavement or snow and ice conditions are rain, darkness, fog, parking regulation affect the driver performance and hence capacity. There are indications that wet or icy pavement can diminish capacity by 5-15 per cent.

II. OBJECTIVES OF THE STUDY

1. To analyze the traffic flow data at selected locations.
2. To study the effect of influencing parameters like carriageway width and surface roughness on capacity of selected locations.

III. LITERATURE REVIEW

- Dr. Satish Chandra: Study has the objectives for effect of capacity on carriageway width and roughness data which was collected at more than 40 sections of two lane roads on National Highway. The selected sections are straight and the analysis done for the effect of influencing parameters like gradient, lane width, directional split, shoulder width and pavement surface condition on capacity of two lane roads under heterogeneous traffic conditions. A systematic process to assess capacity of a two lane roads under heterogeneous traffic conditions is presented in this paper.

- Satish Chandra and Upendra Kumar**:** They studied effect of carriageway width on capacity. The study was carried out at ten sections of two lane roads in different division of India. The selected sections are straight and level, the width of carriageway ranged from 5.5 to 8.8m. All vehicles are divided into nine categories and their PCU values were calculated at each section. It shows the effect of carriageway width on PCU i.e., PCU values of different vehicles linearly increases with carriageway width. Also capacity which is obtained from speed-volume relationship linearly increases with carriageway width.

- Satish Chandra: The effect of roughness on capacity of two lane roads in National Highway was studied. The Highway Capacity Manual (2000) states that the capacity of two lane rural highway under ideal condition is 3200 PCU per hour. The capacity of two lane road is affected by the surface roughness which is not mentioned in HCM. Here the Capacity of two lane roads is estimated by speed-volume relationship which shows that the capacity and PCU values decrease with increasing in roughness index.

- A.R.Khanorkar and S.D.Ghodmare**:** Studied activity on Indian roads consists of heterogeneous vehicles. The vehicular movement on the highway is classified into dynamic characteristics. Traffic is basically included of bicycles, bikes, three-wheelers, Light commercial vehicle, cars and trucks. This work intends to investigation of traffic stream on Indian highways by assessing Passenger Car Unit (PCU) of various vehicle classes at various segment of highways around Nagpur city. The

main ambition of the study is to work out the passenger car unit PCU for various sorts of vehicles under heterogeneous traffic conditions. Field study was conducted at four highway links and at outside of urban regions and the various sorts of vehicles in Non homogeneous traffic, for a broad range of traffic volume and width of highways.

IV. DATA COLLECTION

Based on the targets of the study, the required information were collected in five stages as follows

- Study of straight stretch selection
- Classified traffic volume count
- Observation and collection of speed of traffic stream by spot speed study
- Measurement of roughness using MERLIN
- Dimension of different category of vehicles as per IRC

Table-1: The physical data of selected location on NH-206 and NH-13

Section	Location	Chainage (km)	Longitudinal trap length (m)	Width of carriageway (m)
1	Koppa, NH-13	511+200	130	6.8+0.5 Earthen shoulder on both side
2	Vitlapura, NH-13	520+700	154	6.6+0.5 Earthen shoulder on both side
3	Veerabairavanakoppa, NH-206	223+600	132	7.5+1.5 Paved shoulder on both side
4	Kumsi, NH-206	233+400	136	7+1.5 Paved shoulder on both side

A. Dimension of different category of vehicles

Table-2: Vehicle classes and their dimensions

SL no	Vehicle Classes	Vehicle built-in	Average measurement(m)	Projected rectangular area on ground (m^2)
1	Car	Car, jeep	3.72X1.44	5.39
2	Bus	Bus	10.1X2.43	24.74
3	Truck	2axle,3axle	7.5X2.35	17.62
4	LCV	Small bus, vans	6.1X6.21	12.81
5	Three wheeler	Auto rickshaw	3.2X1.4	4.48
6	Two wheeler	Bike, Scooter	1.67X0.70	1.16
7	Tractor	Tractor trailer	7.4X2.2	16.28

V. RESULT AND DISCUSSION

A. Determination of Passenger Car Unit (PCU) for different category of vehicle at four sections selected for study.

The spot speed of each category of vehicle at each location is calculated by using longitudinal trap length data which is as shown in Table-2. The PCU of each vehicle is calculated by the formula:

$PCU_i = (V_c/V_i)/(A_c/A_i)$

Where,

V_c = Average speed of car, kmph

V_i = Average speed of i^{th} type vehicles, kmph

A_c = Car projected rectangular area on ground, m^2

Ai = i^{th} type vehicles projected rectangular area on ground, m^2

The average value of spot speed of each vehicle measured is as shown in Table-3 and the PCU values of each vehicle at four locations are calculated from the above formula is as tabulated in Table-4.

Table-3: Calculated Average Speed of vehicles at each stretch

Vehicle class	Speed, kmph			
	Location			
	Koppa	Vitlapura	Veerabairavanakoppa	Kumsi
Car	62.45	64.12	80.63	73.25
Bus	58.31	60.80	72.13	70.88
Truck	38.67	40.09	48.36	49.66
Two wheeler	50.24	57.89	62.24	56.44
Three wheeler	36.14	37.66	46.54	40.86
Tractor	31.55	37.66	37.90	34.66
LCV	44.66	46.23	55.66	54.89

Table-4: Calculated PCU of vehicle at each stretch

Vehicle class	Calculated PCU values			
	Location			
	Koppa	Vitlapura	Veerabairavanakoppa	Kumsi
Car	1	1	1	1
Bus	4.57	4.50	4.77	4.41
Truck	5.27	5.22	5.45	4.82
Two wheeler	0.27	0.24	0.28	0.28
Three wheeler	1.43	1.42	1.44	1.49
Tractor	5.97	5.14	6.42	6.38
LCV	3.32	3.29	3.44	3.17

B: Effect of carriageway width on PCU value of vehicle

The PCU values of all vehicles vary with respect to carriageway width is as shown in figures 1, 2 and 3. Here the decrement of PCU value of vehicle is mainly due to development of surface roughness of roadway.

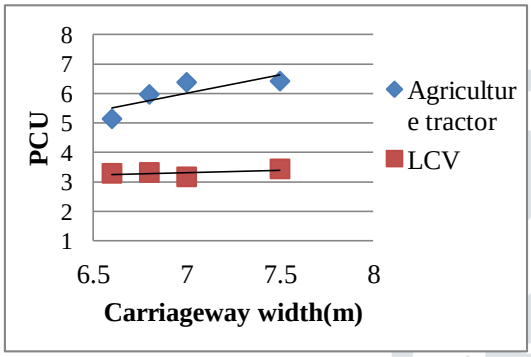

Fig 1: Effect of carriageway width on PCU for Agriculture Tractor and LCV

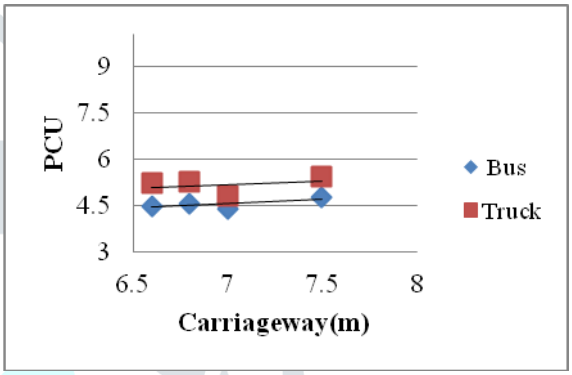

Fig 2: Effect of carriageway width on PCU for Bus and Truck

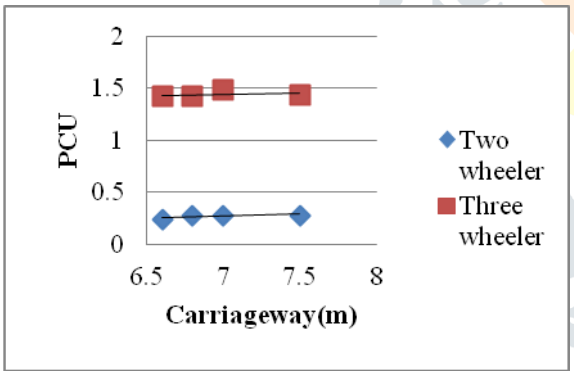

Fig 3: Effect of carriageway width on PCU for Two wheeler Three wheeler and cycle.

C. Effect of carriageway width on capacity

To calculate mean stream speed, trap length is marked on the road which is as shown in Table-1 and spot speed is recorded per hour for all categories of vehicles. Mean speed is calculated by using

$$Vm = \frac{\sum_{i=1}^{k} nivi}{\sum_{i=1}^{k} ni}$$

Where,
k=Total number of vehicle classifications in selected stream
V_m=Mean stream speed (kmph)
n_i= Number of vehicles of classification i
v_i=Speed of vehicle of classification i (kmph)

The capacity of various two lane segment with fluctuating carriageway width was obtained by speed volume relationship is as shown in Figure 4, 5, 6 and 7 respectively. The capacity value of each section with respect to carriage width is as shown in Table-5.

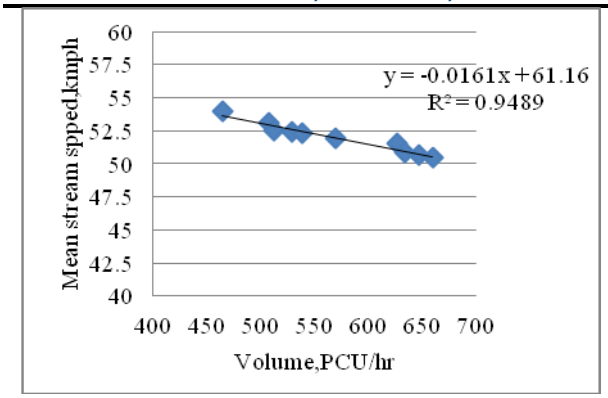

Fig 4: Speed volume relationship at Koppa (NH-13)

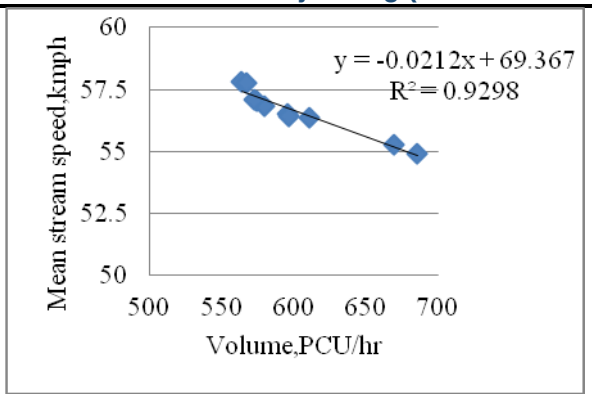

Fig 5: Speed volume relationship at Vitlapura (NH-13)

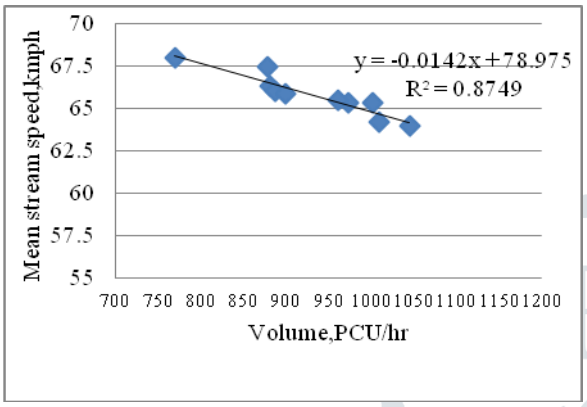

Fig 6: Speed Volume relationship at Veerabairavanakoppa (NH-206)

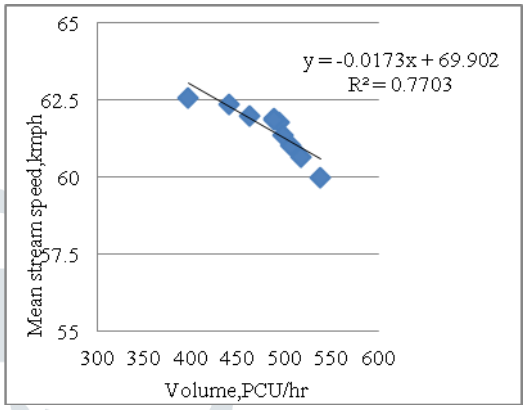

Fig 7: Speed volume relationship at Kumsi (NH-206)

Table -5: Capacity at four stretch, Speed volume relationships Equation and regression value from graph

Location	Carriageway width (m)	Equation	Regression value,R^2	Capacity, PCU/hr
Koppa (NH-13)	6.8	Y = -0.0161x+61.16	0.94	1900
Vitlapura (NH-13)	6.6	y= -0.0212x+69.367	0.92	1637
Veerabairavanakoppa (NH-206)	7.5	y = -0.0142x + 78.975	0.87	2781
Kumsi (NH-206)	7	y = -0.0173x + 69.902	0.77	2021

The Figure. 8 indicate the relation between capacity (PCU/hr) v/s carriageway widths (m). The second degree curve equation obtained delineates greater freedom of movements on wider roads. In the above figure y is the capacity and x represents carriage width.

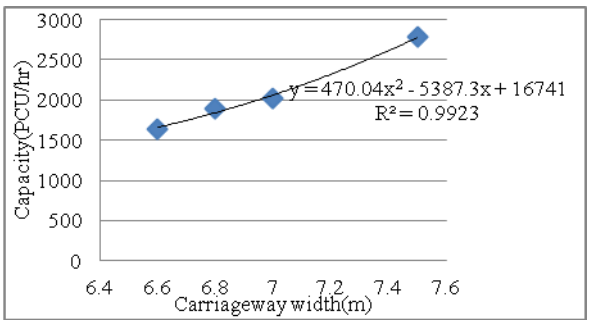

Fig 8: Capacity variation with carriage way width

D. Effect of roughness on capacity

The roughness of the roadway is measured by MERLIN to find unevenness index. The unevenness values are shown in Table-7. Here the capacity of location corresponds to unevenness index is as shown in Table-8 and its values are plotted which is as shown in Figure-9. The plotted values show that increase of unevenness index decreases the capacity of roadway.

Table-7: Roughness index for different stretches.

Section	Location	Chainage (km)	IRI(mm/km)		Average IRI (mm/km)
			LWP	RWP	
I	Koppa	511+2	3188	3170	3179
II	Vitlapura	520+7	3890	3890	3890
III	Veerabairavanakoppa	223+6	2940	2470	2705
IV	Kumsi	233+4	3418	2470	2944

LWP=Left wheel path
RWP=Right wheel path
IRI= International Roughness Index

Table-8: Capacity of location corresponds to unevenness index

Location	Unevenness index (mm)	Capacity, PCU/hr
Koppa (NH-13)	3179	1900
Vitlapura (NH-13)	3890	1637
Veerabairavanakoppa (NH-206)	2705	2781
Kumsi (NH-206)	2944	2021

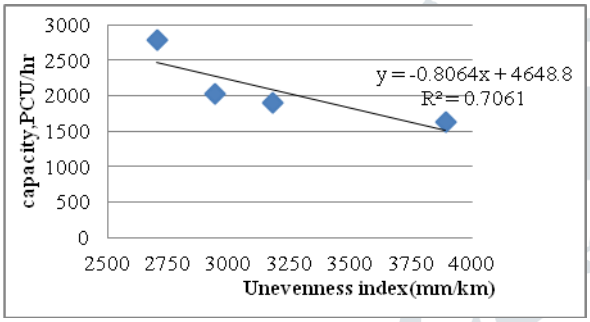

Fig 9: Effect of unevenness index on capacity.

The study describe the augmentation of capacity of roadway not only depends on the increase of carriage width of roadway but it also on decrement of unevenness index.

VI. CONCLUSIONS

1. The present study shows that the PCU of vehicle increases as the carriageway width increases.
2. From the current study, it clears that increase in unevenness index decreases the capacity of roadway.
3. In this study capacity at Veerabairavanakoppa (NH-206) has the highest capacity of 2781PCU/hr and Vitlapura (NH-13) has lowest capacity of 1637 PCU/hr.
4. Capacity obtained at all the four stretches is lower than the suggested value in Highway Capacity Manual (HCM)-2000 i.e., 3200PCU/hour.

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