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Estimation of Capacity and Level of Service for Four Lane divided Urban Arterial Road

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Abstract: Rapid increased of population and urbanization in urban areas has an impact on road capacity and level of service. Estimation of the capacity and level of service has a significant role in the planning, design and operational performance of the road traffic. The present study considered for estimation of the capacity and level of service in four divided carriageway urban road Rajkot city in mixed traffic condition. Traffic volume and average speed data were collected by videography technique. Mixed traffic volume converted into an equivalent number of passenger car unit (PCU). Various a speed - density, flow - density and speed - flow relationship have been developed based on field data. The capacity of a road is estimated by Green shield model, the relationship between speed and density is developed by SPSS software in a simple linear regression model. The level of service is calculated based on v/c ratio. A directional capacity of four lane divided road is observed 3568 and 4144 PCU/HR respectively.

Keywords: PCU value, Speed, density, flow, capacity, level of service

I. INTRODUCTION

Urban Arterial roads are a major transportation network, which is designed or planned for high traffic flow and high speed; however, local roads are fundamentally designed for accessibility (both low flow and low speeds). But many of the arterial roads in developing countries have less than adequate capacity and performance. A logical point of view, most of the planning and research work is intense on the road system. Knowledge of a road capacity has a vital role in understanding of traffic characteristics properly. Roadway capacity can represent a benchmark for the operation of existing roads, which can be used to establish the existing demand and to expect future road improvements based on actual traffic flow. Mixed traffic, on street parking, pedestrian behavior, driver behavior and poor lane discipline bring a huge amount of traffic problems like, blocking of road, road safety, delay, transportation efficiency and pollution. In present study four lane divided road has selected for observation of the road capacity and LOS.

II. LITERATURE REVIEW

Dr. G. J. Joshi et. Al, (2012) this study considered a capacity and the level of service in mix traffic condition. A Traffic volume and spot speed data were collected by manual and videography techniques during a 16 hour period of access control six-lane divided urban road in Surat city. The unobserved data were simulated by ANN model. The artificial neural network is the precious and useful model for identifying and predicting of input and output variables. The capacity of 6-lane divided road was observed by Green shield model, the attained capacity was 7450 vehicles and 2480 vehicles per lane which was quite realistic as compared to similar studies in India. Ebin Nirmal Joseph et. Al, (2014) in this study traffic volume, speed and delay data were collected three times in 6 mid block road sections in peak and off peak hour period. The level of service was calculated by v/c ratio, the observed level of service during peak hour exceeds 1. The average journey time was in a 3.8 km stretch 17 minutes and the average travel speed was 13 kmph. Gordana Stefancic et. Al, (2012) this study considered a capacity and the level of service in the Zagreb bypass. The capacity of the roadway was estimated by a recommended method of HCM based on the maximum hourly flow of the vehicles on the road section. The capacity of two physically divided carriageways and two unidirectional traffic lanes per carriageway amounts is 9,600 PCU/h. The level of service of 4-lane and 6-lane divided carriageways was calculated on HCS+ software and the observed LOS for Zagreb bypass was A to C. Ahmed Mohamed Semeida, (2013) In this paper the Traffic volume and average travel speed data were gathered by a manual method on a multi-lane highway in Egypt. ANN model is developed for level of service and capacity for agriculture and desert roads. This study considered many factors as input variables or independent variables like, HV, PW, SA, LW, MW, LC and the output variable was density. For the desert road when PW increased density will be decreased. With an increase LW density was reduced for agriculture. It specified that ANN models more accurate than regression model for predicting of capacity and density with R^2 value 0.997 and 0.992 for agriculture and desert road. Dr. Mokaddes Ali Ahmed et. Al,

(2013) this paper is considered capacity of four lane divided carriageway under mixed traffic condition in Silchar of Assam city, India. Traffic volume and speed data were collected by videography technique in selected carriageway. Different models were used for the relationship of the speed-flow for the upper uncongested and the lower congested section like linear, exponential, polynomial, logarithmic, power, Akcelik and Bureau. The observed capacity of the selected roadway section is 2138 PCU which was considerably less than as per IRC guidelines and the attained LOS of roadway was for most of the peak hour E and rarely F. Satish Chandra, et. Al, (2013) this paper considered the effect of lane width on roadway capacity. A traffic volume and an average speed data were collected by videography technique in different road sections of two-lane roads in different part of the India. The capacity of a 7.2m wider road was observed 2818 PCU/h which is a little larger than the value recommended by HCM (1994) but much lower than the value of 3200 PCU/h recommended in HCM (2000). When the road lane extended up to 0.3m the capacity is increased up to capacity about 14%, while widening lane of the road 0.6m the capacity raised up to 24 %. Satish Chandra, et. Al, (2014) this paper considered the effect of an operating speed on road capacity. Traffic flow and spot speed data were collected by a video record method in a various mid block road sections of the urban roads in the north, west, and south of India. Various speeds - density relationship is developed by Green shield, Underwood and Greenberg models. The observed capacity of selected road section was 1482-2105 PCU/h. The second-degree equation was used between operating speed and capacity. It is proved that operating speed has considerable effect on roadway capacity.

III. SELECTION OF THE STUDY AREA

Indian urban roads witnessed a crucial traffic movement with different modes of traffic in a day. Most of the research has been carried out for identification and solution of the urban road problem. In this study try has been made to estimate capacity and level of service in a Riaya road mid block section. The selected stretch is communicable with residential, commercial, educational and recreational area. The selected stretch must be free from intersection, uniform section, straight and free from curvature and a plain terrain. The road inventory survey is made for collection of primary road geometry data in the following table is a primary data.

Table 1: primary data on road geometry

No	Name of road	Type of Road	Carriageway Width (m)	Length of Selected Road Section (m)	Observation Time (Hour)	Observation Technique
2	Riaya road	4-lane divided road	20.4	30	12	Videography

IV. COLLECTION OF TRAFFIC DATA

In the present study the traffic survey is carried out in a sunny and normal working day through a videography technique in a 12 hour period, from 8 AM to 8 PM. The Traffic flow and average speed data are extracted at five minute interval of various types of vehicles from video record. The spot speed data is collected from direct timing technique from video record, with a regard the pavement surface was marked in a 30 meter interval by white cement between two reference points for the enter and exit timing of a vehicle.

V. DATA ANALYSIS

The counted traffic flow is analyzed for hourly variation or peak and off peak hour period and vehicle composition. The most of the traffic flow consisted of 2W, 3W and passenger car. Mixed traffic flow converted into an equivalent number of passenger cars or (PCU) value which is suggested by IRC: 106-1990 in table (2). The following figures show the hourly variation and vehicle composition of Riaya road.

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Table 2 Static PCU value recommended by IRC: 106-1990

Serial No	Vehicle type	5% Traffic composition	10% and above traffic composition
Fast vehicles			
1	Two wheeler motorcycle or scooter	0.5	0.75
2	Passenger car and pick up the van	1	1
3	Auto rickshaw	1.2	2
4	LCV	1.4	2
5	Truck or bus	2.2	3.7
6	Agriculture tractor trailer	4	5
Slow vehicles			
7	Cycle	0.4	0.5
8	Cycle rickshaw	1.5	2.0

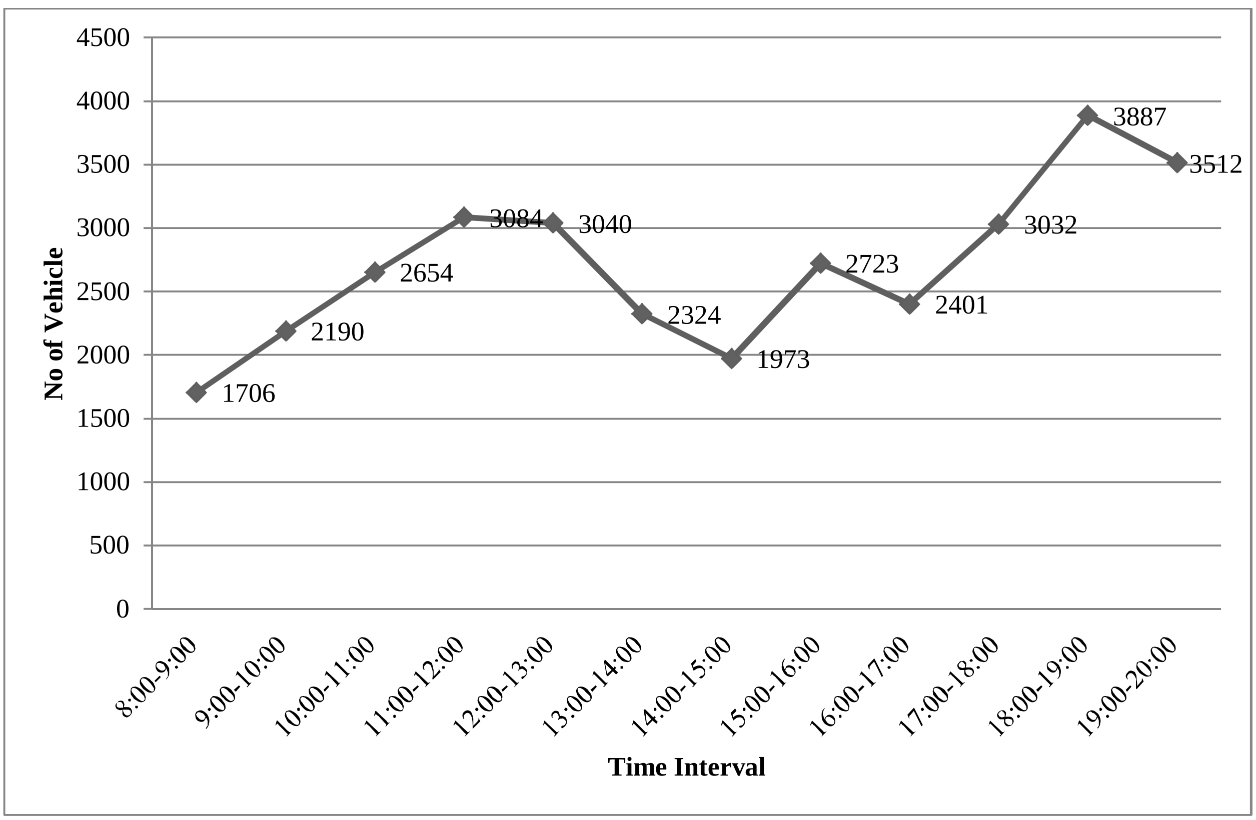

Figure 1 Hourly variation of vehicles Riaya road to 150 ft ring road

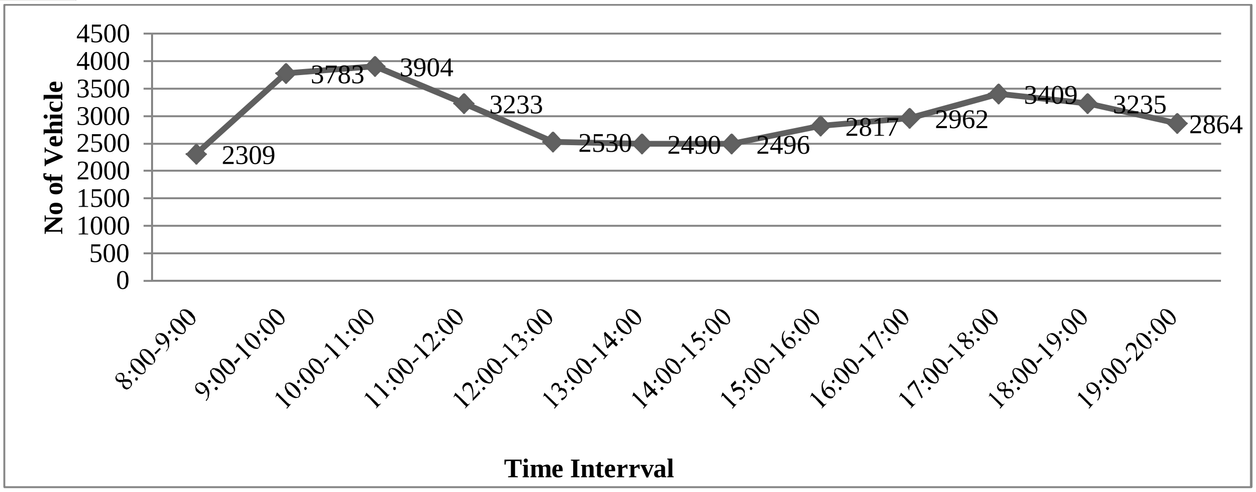

Figure 2 Hourly variation of vehicles Riaya road to Race course road

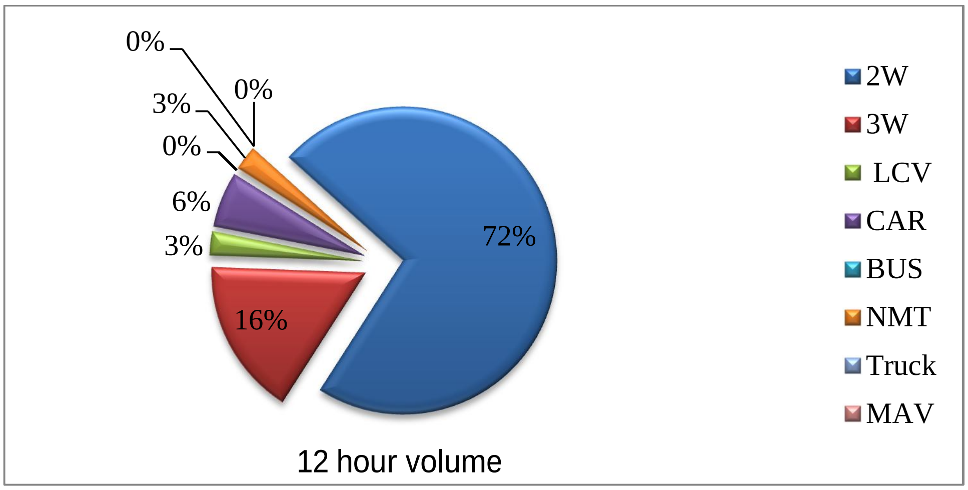

Figure 3 Vehicles composition (%) in Riaya road to 150 ft ring road

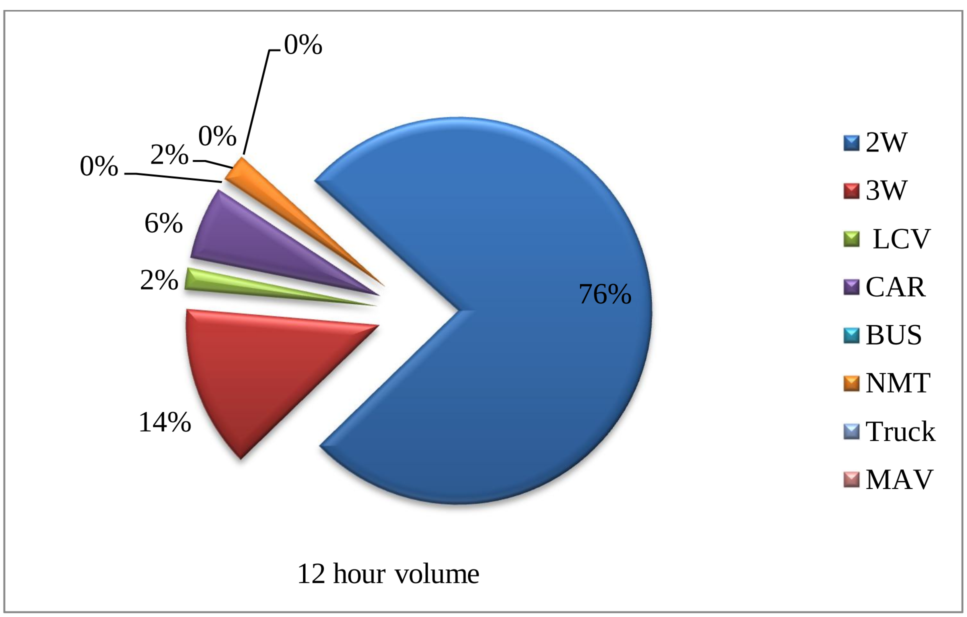

Figure 4 Vehicles composition (%) in Riaya road to Race course road

VI. ESTIMATION OF ROAD CAPACITY

The Capacity of the selected road section was estimated by Green shield model. He purposed linear relationship between speed and density (1930s).

$$v = vf - \left(\frac{vf}{kj}\right) * k$$

Where, v is the mean speed, k is density, v_f is free flow speed and k_j is jam density.

For evaluation and validation of this model simple linear regression model is developed between speed and density. This relationship is carried out in SPSS software. Based on this linear equation subsequently speed-flow model is developed and the capacity of road is estimated.

A. Speed- Density Relationship by SPSS software

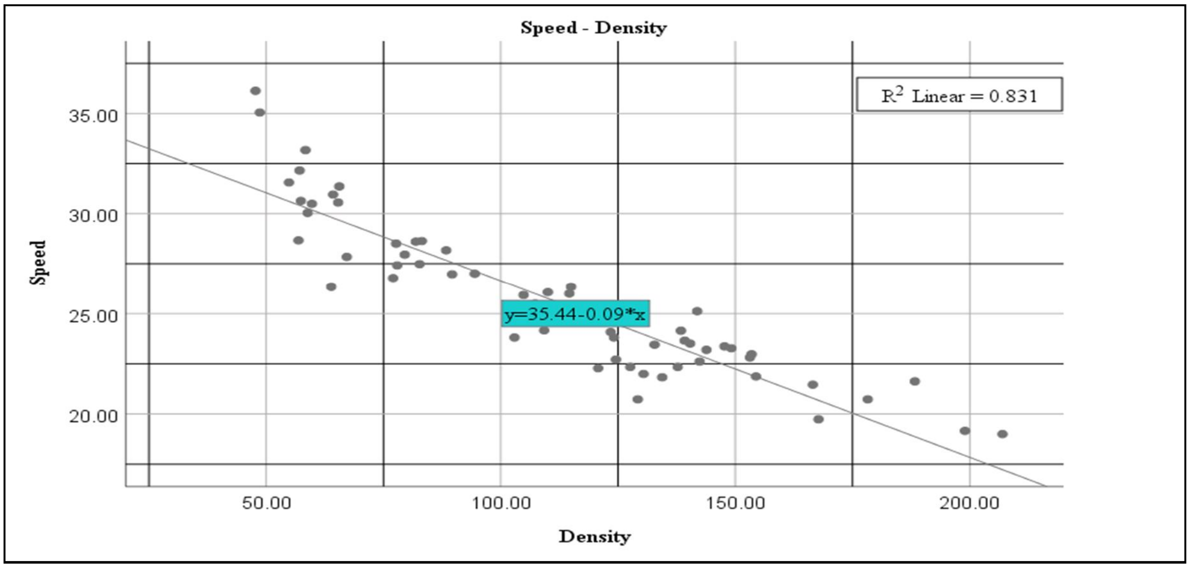

Figure 5 Speed-density graph of Riaya road to 150 ft ring road

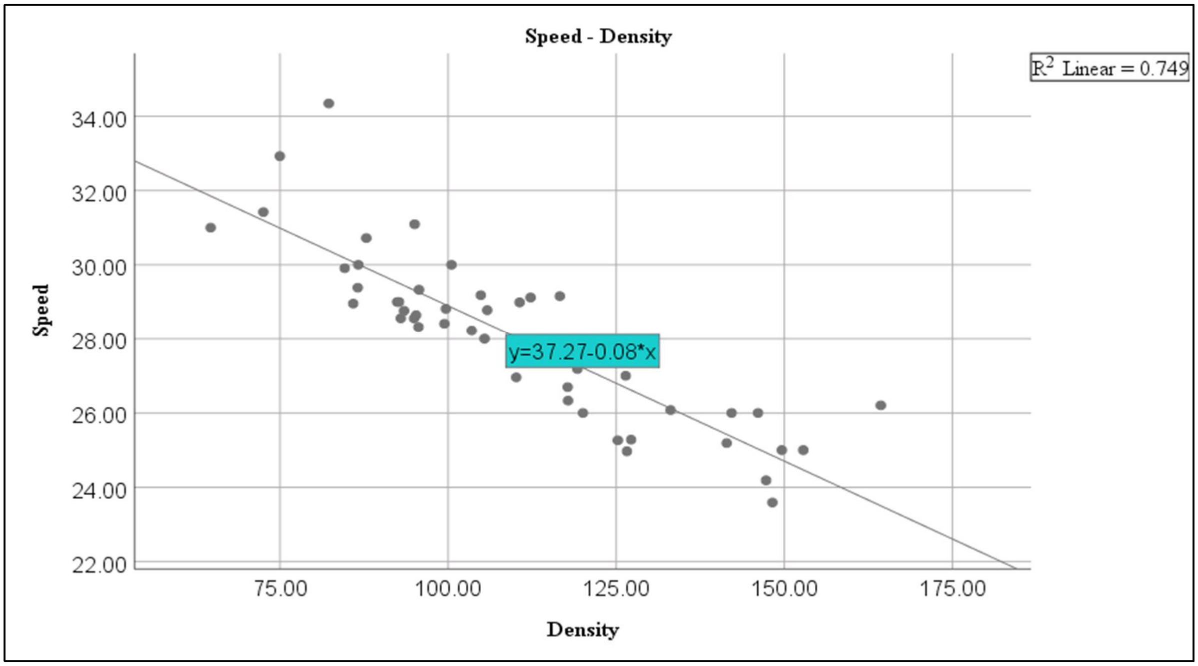

Figure 6 Speed-density graph of Riaya road to race course road

Speed-Flow Relationship based on Green Shied model

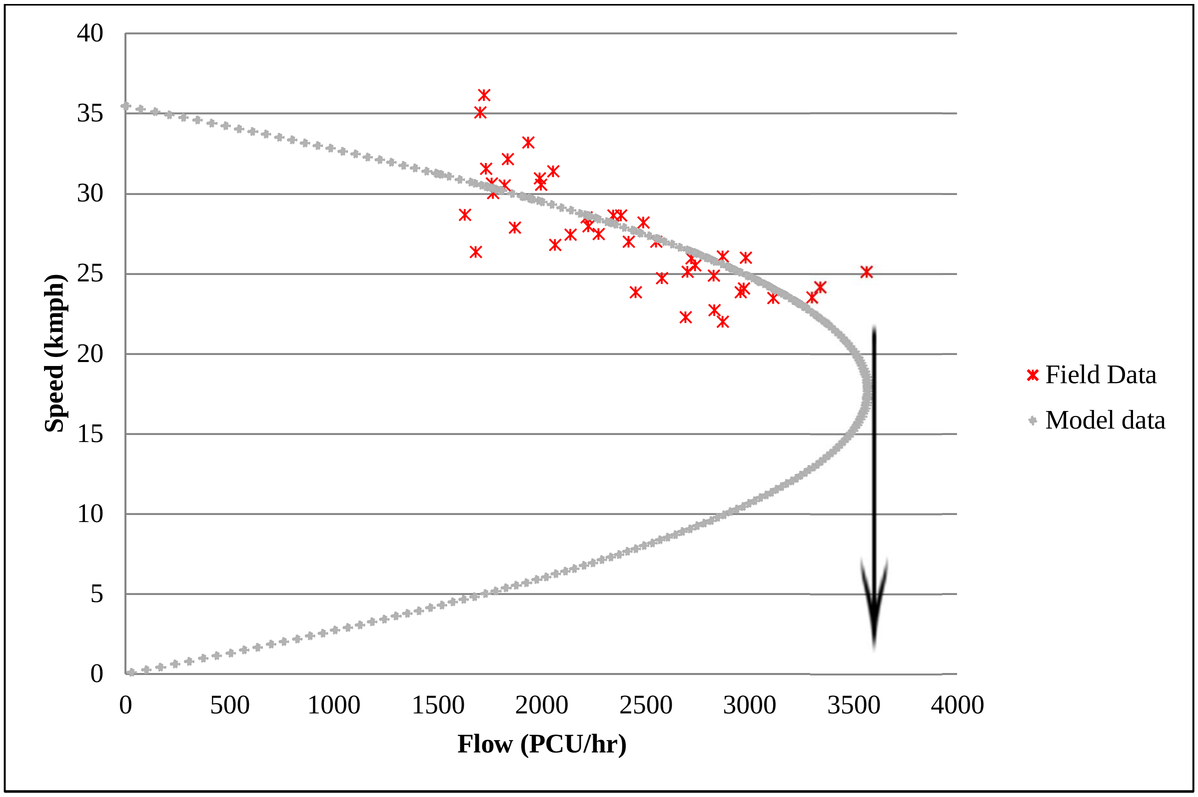

Figure 7 Speed-Flow graph of Riaya road to 150 ft ring road

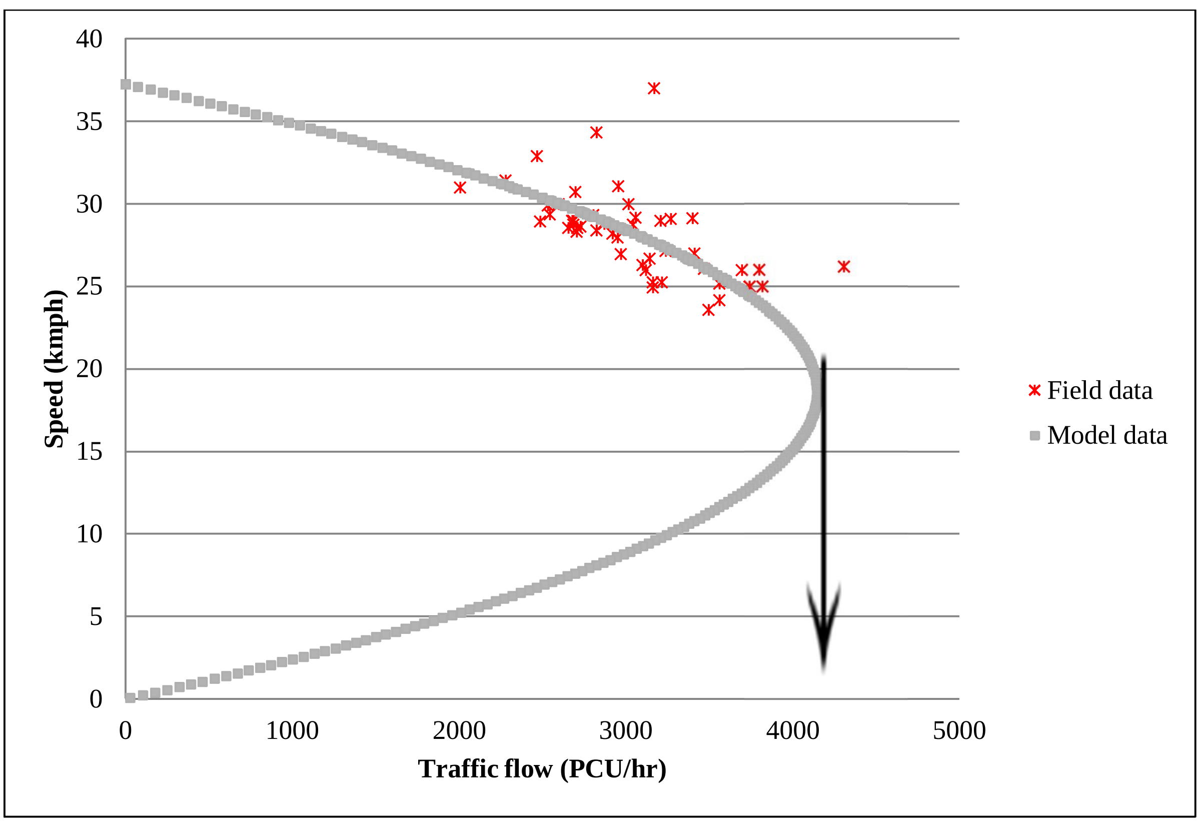

Figure 8 Speed-Flow graph of Riaya road to 150 ft ring road

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Table: 3 Capacity and speed-density model of the Riaya road

No	Road Name	Type of Road	Road Direction	Carriageway width (m)	Speed-Density Model And R^2 value	Road capacity (PCU/Hr)
1	Riaya Road	4- Lane Divided Road	Toward 150 ft Ring Road	20.4	$v = -0.088k + 35.442$ $R^2 = 0.8312$	3569
			Toward Race Course Road		$v = -0.0838k + 37.271$ $R^2 = 0.7486$	4144

Table: 4 Comparison of DSV with observed capacity

No	Road Name	Type of Road	Road Direction	Observed capacity (PCU/Hr)	Design service volume (PCU/Hr)	Difference (%)
1	Riaya Road	4- Lane Divided Road	Toward 150 ft Ring Road	3569	3600	-0.87
			Toward Race Course Road	4144	3600	11.5

VII. LEVEL OF SERVICE OF SELECTED URBAN ROAD

Level of service is a qualitative measure used to relate the quality of traffic service, and it is used to evaluate highways by classifying the traffic flow and assigning quality levels of traffic based on performance measure like speed, density etc. Level of service show the operating condition or quality of the roadway base on the road user,

For operating condition of road six levels of service are selected or designed by HCM, A to F, which the A representing the highest quality free flow condition and the F is representing the worst or jammed condition. In the present study the level of service of selected road section is calculated by volume to capacity ratio (v/c).

Table: 5 Level of service of Riaya road to 150 ft ring road

No	Road Name	Direction	Peak Hours Period	Average speed (Km/Hr)	Observed volume (PCU/Hr)	Capacity (PCU/hr)	Volume to capacity ratio (V/C)	LOS
1	Riaya Road	Toward 150 ft Ring Road	9:00-10:00	23.9	2190.3	3568.0	0.61	C
			10:00-11:00	21.3	2653.6	3568.0	0.74	C
			11:00-12:00	22.2	3084.5	3568.0	0.86	D
			17:00-18:00	24.0	3031.9	3568.0	0.85	D
			18:00-19:00	20.0	3886.8	3568.0	1.09	E
			19:00-20:00	20.9	3512.5	3568.0	0.98	E

Table: 6 Level of service of Riaya road to race course road

No	Road Name	Direction	Peak Hours Period	Average speed (Km/Hr)	Observed volume (PCU/Hr)	Capacity (PCU/hr)	Volume to capacity ratio (V/C)	LOS
1	Riaya Road	Toward Racecourse Road	9:00-10:00	27.3	3782.5	4144.0	0.91	D
			10:00-11:00	24.1	3904.0	4144.0	0.94	D
			11:00-12:00	24.4	3232.8	4144.0	0.78	D
			17:00-18:00	25.6	3409.2	4144.0	0.82	D
			18:00-19:00	24.0	3235.3	4144.0	0.78	D
			19:00-20:00	25.6	2864.5	4144.0	0.69	C

VIII. CONCLUSION

A. The relationship between speed-density is developed by Green Shield model, and this model is validated by linear regression model by SPSS software with an R^2 value more than 0.7.

B. The capacity of the four divided carriageway is calculated by traffic speed- flow model data. The observed directional capacity of this road is obtained 3568 and 4144 PCU/HR respectively.

C. Level of service of selected road section is calculated by v/c ratio, the observed level of service during peak hour periods is C, D, and E.

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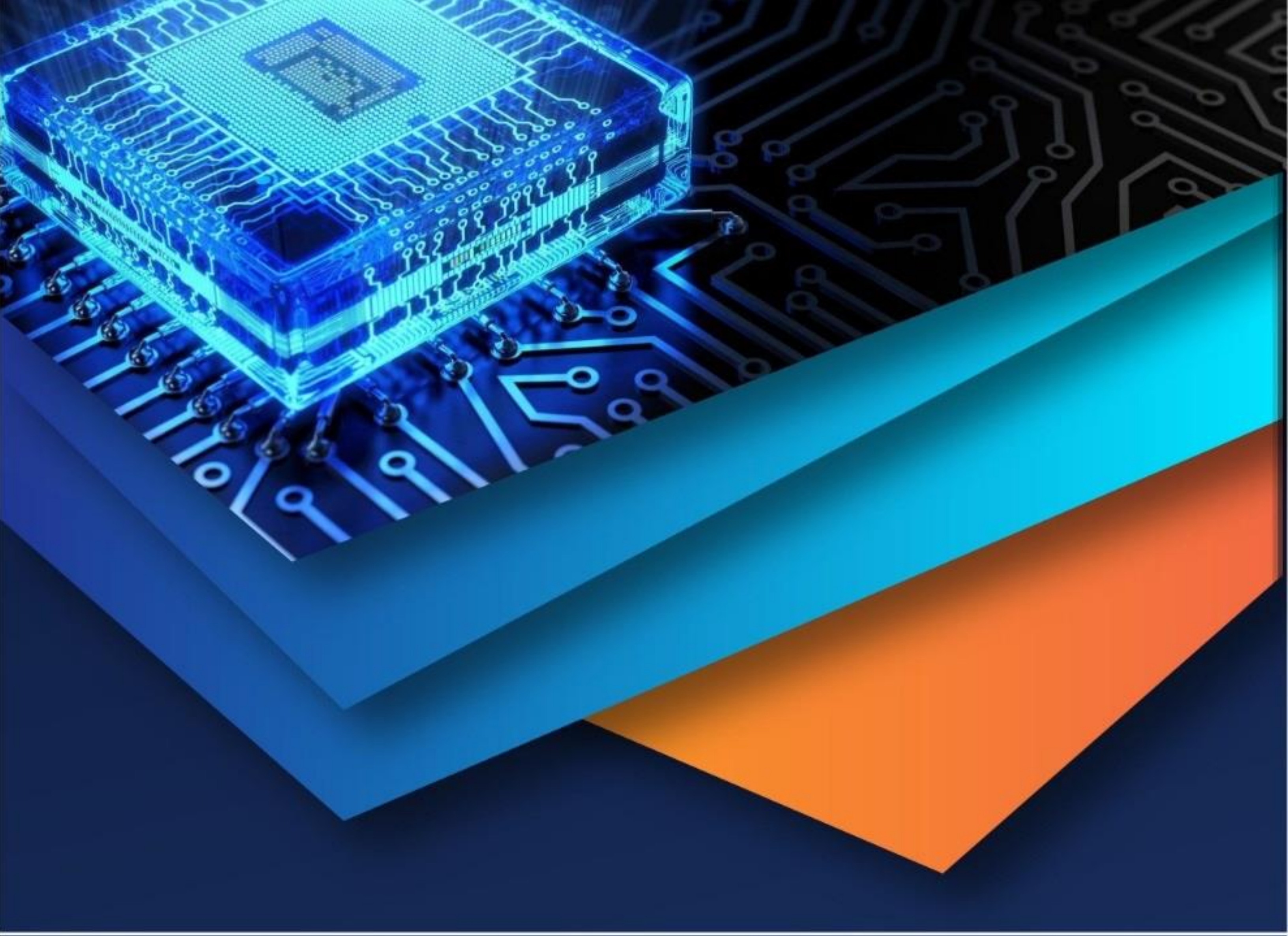

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