

# Estimation of Capacity and Level of Service for Urban Arterial Road – A Case Study of Rajkot City

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**ABSTRACT:** In this study signify the concept of capacity and level of service for urban roads for heterogeneous traffic condition. The present study is carried out on Rajkot Urban road. Various Speed - Density relationships have been established in this study, which in turn have been deployed towards the development of relationship between speed and flow eventually leading to the estimation of the roadway capacity. Factors influencing capacity are classified volume of vehicle, average speed and density. Level of Service is found out from density and speed. Speed, Flow and density data are trained in MATLAB using Artificial Neural Network. Speed and flow data are taken as an input and density is taking as an output.

**KEY WORDS:** Capacity, Level of Service, Speed, Flow, Density, Artificial Neural Network (ANN)

## I. INTRODUCTION

In India brisk and incessant increase population is major problem. Due to increase in population the different modes of transportation are increases in cities which are resulted in jammed traffic condition on the road. The vehicle proportion is much more diverse with many inadequately performing vehicles, slow moving vehicles and non-motorised vehicles. For an efficient and increased vehicular traffic it requires better roadway infrastructure with higher capacity. Thus for effectual planning and operation there is a need to find the traffic volume and estimate roadway capacity. Capacity of a road is greatly influenced by roadway, traffic condition and driver condition. The recital of the urban roadway depends on the capacity and actual traffic volume and the purpose of the same will be constructive for monetary and efficient design of road-network. Traffic carrying capacity can be a benchmark for instead of the amount of exploitation of the existing roads which in turn can be used for determining present requirements as well as predict future requirements of the road improvements based on the traffic. Metropolitan cities in India are witnessing for very high rate of population growth, consequently the rise in traffic in their transport corridors. The anxiety about the deterioration in the LOS is due to the uninhibited growth of vehicular traffic volume, shortfall of supply side of transportation capacity, resulting in the supplementary delay, additional fuel consumption, user cost etc. Therefore it is obligatory to assess the level of service of highways passing through the metropolitan cities over a period of time in order to adopt the varied transport improvement programmes on short as well as long term basis for improving the level of service.

## II. LITURETURE REVIEW

A. Chetan R Patel, Dr. G. J. Joshi, "Capacity and LOS for Urban Arterial Road in Indian Mixed Traffic Condition"  
Field Traffic surveys were carried out to capture the classified volume and speed data through manual as well as videographic technique. Multi regime speed-flow relation was developed based on the 5-min. data extracted from the field survey. Unobserved data was simulated by artificial neural network model. The traffic flow behavior in

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Vol. 6, Issue 5, May 2017

heterogeneous traffic in Indian urban context is observed to be quite complex with loose lane discipline and diverse static and dynamic characteristics of the vehicles. The capacity of the six lane divided road comes to be 7450 vehicle and 2480 vehicles per lane which was quite realistic as compared to similar studies in India.

*B. Ebin Nirmal Joseph, Dr.M.S.Nagakumar, "Evaluation of Capacity and Level of Service Of Urban Road"*

They had studied different parameters such as capacity, level of service, vehicle to capacity ratio, average journey time, and average delay in each midblock, peak hour traffic and to provide necessary improvement measures in the mid block. Speed and delay studies were conducted three times during peak and non-peak hour and the average journey time was determined. Average delay of all these mid-blocks were also determined using speed and delay studies. The vehicle to capacity ratio during peak hour was found to be exceeding 1. The level of service of the entire stretch was found to F during the entire survey. The average time required to travel the entire 3.8 km stretch during peak hour was found to be 17 minute and the average travel speed was below 13 kmph. Vehicle composition of the traffic shows that more than 50% of the vehicle composition consists of two wheelers and three wheelers.

*C. Pratik U. Mankar, Dr. B.V Khode, "Comparative Study of Methods used for a Capacity estimation of Road"*

In this study Satish Chandra et.al, (2004) provides the process for capacity estimation of two-lane roads under mixed traffic conditions and calculated the influencing factors which affect the capacity of road and adjustment factors for each of this condition were proposed. Capacity of a two-lane road based on these adjustment factors under heterogeneous traffic conditions was determined. HETEROSIM and VISSIM software was used for estimation of road capacity. PCU values had considerable effect on traffic volume and composition which affects the capacity. Lane width had substantial effect on capacity and capacity of road section increases with increase in carriageway width.

*D. Satish Chandra, Upendra Kumar, "Effect of lane width on capacity under mixed traffic conditions in India"*

In this study data were collected at ten different sections of two-lane roads in different parts of India. To observe the effect of lane width on the PCU for different categories of vehicles and thereby on the capacity of a two-lane road. The capacity of a 7.2m wide road was 2818 PCU/h which was slightly larger than the value specified in HCM (1994) but much lower than the value of 3200 PCU/h suggested in HCM (2000). In this study the second-degree equation developed between the capacity and total width of carriageway was used to derive the adjustment factors for capacity on substandard lane width. The second-degree equation developed between the capacity and the total width of the carriageway was used to derive the adjustment factors for capacity on substandard lane width. These adjustment factors are lower than those given in the HCM (1994). This indicates that the negative effect of mixed traffic was more pronounced on narrow lanes. These results illustrate the importance of widening a lane in congested areas. The first 0.3 m of lane widening corresponds to an increase in capacity of about 14% while 0.6 m of lane widening results in a 24% increase in capacity.

*E. Ahmed Mohamed Semeida, "New Models to Evaluate the Level of Service and Capacity for Rural Multi-Lane Highways in Egypt"*

In this paper they considered the multi-lane highways. Capacity and level of service were most important factors for the road geometry and percentage of heavy vehicles. They had developed capacity model and level of service model using Artificial Neural Network (ANN). In this paper they considered many factors like lane width, pavement width, lateral clearance, no of lanes, median width and percentage of heavy vehicles. Free flow speed and average travel speed were calculated for passenger car. Traffic volume data was calculated from Average Annual Daily Traffic (AADT). For Capacity models and LOS models input variables were taken as SA, LW, PW, LC, MW, HV and output variable was taken as 1 desired variable density. For desert model density was decreased with the increase in PW. For agriculture model density was decreased with the increase in LW. ANN models gave so better and most confidence results compare to regression models in terms of predicting density and capacity.

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Vol. 6, Issue 5, May 2017

## III. DATA COLLECTION

For the intention of the present study Traffic Flow data and Average speed for all type of vehicles are collected through video graphic technique at every five minute interval on selected different urban road section (Dr. Yagnik Road and 150ft. Ring Road) in Rajkot for the duration 8 hours covering morning periods (8:00a.m.-12:00noon) and evening periods (4:00p.m.-8:00p.m.).

## IV. DATA ANALYSIS

### I. Capacity of Different Road Class

To develop a speed-flow model, traffic volume and speed are extracted from the traffic flow data. Volume is converted into PCU units by using equivalent factors and it is expressed in terms of hourly flow rate (PCU/Hr), subsequently density is calculated by using the fundamental formula:

$$K = q/v$$

Where, k = density (PCU/Km), q = hourly flow rate (PCU/Hr), v = traffic stream speed (Km/Hr)

Thereafter, a scatter diagram is prepared by plotting the pairs of speed and density values taking speed on vertical axis and density on horizontal axis. The various speed-density models such as Greenshield's linear model, Greenberg's logarithmic model, and Underwood's exponential model are fitted to the scatter diagram and comparatively the model having better goodness-of-fit is accepted. Thereafter the density values are putted up in the speed-density equation as a result of which revised values of speed are obtained which is in turn multiplied with density values yielding the revised values of flow rate. Subsequently a scatter plot of revised speed and revised flow rate is prepared along with the field data.

For conversion of vehicular volume into passenger car unit, vehicle equivalent factors (PCU values) are used. Existing practice in India is to consider PCU values as static as suggested in IRC 106:1990 and the same are presented in Table 1.

**Table 1 PCU Values Suggested By IRC: 106 (1990)**

| Vehicle Type                              | PCU Factors                                     |               |
|---|---|---------------|
|   | % Composition of Vehicle Type in Traffic Stream |               |
|   | 5%  | 10% and Above |
| Two wheelers motor cycle or scooter etc., | 0.5   | 0.75          |
| Passenger car, pick-up van                | 1.0   | 1.0           |
| Auto-rickshaw                             | 1.2   | 2.0           |
| Light commercial vehicle                  | 1.4   | 2.0           |
| Truck or Bus                              | 2.2   | 3.7           |
| Agricultural Tractor Trailers             | 4.0   | 5.0           |
| Cycle                                     | 0.4   | 0.5           |
| Cycle rickshaw                            | 1.5   | 2.0           |
| Tonga (Horse drawn vehicle)               | 1.5   | 2.0           |
| Hand cart                                 | 2.0   | 3.0           |

### • Capacity of Selected Different Road Section

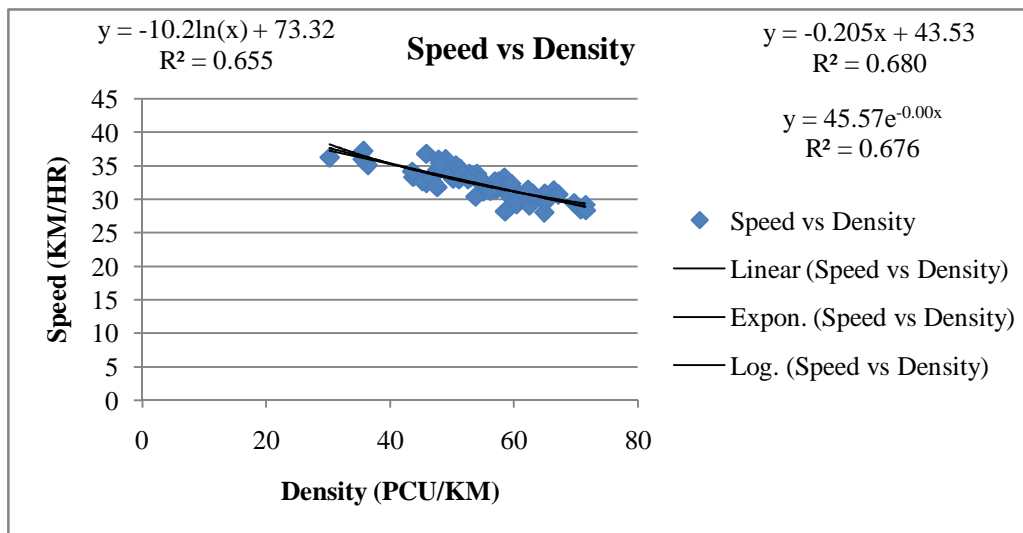
A total of three road sections across the Rajkot city were considered in this study. The Speed-Density models have been developed using static PCUs. Subsequently Speed-Flow models have been developed.

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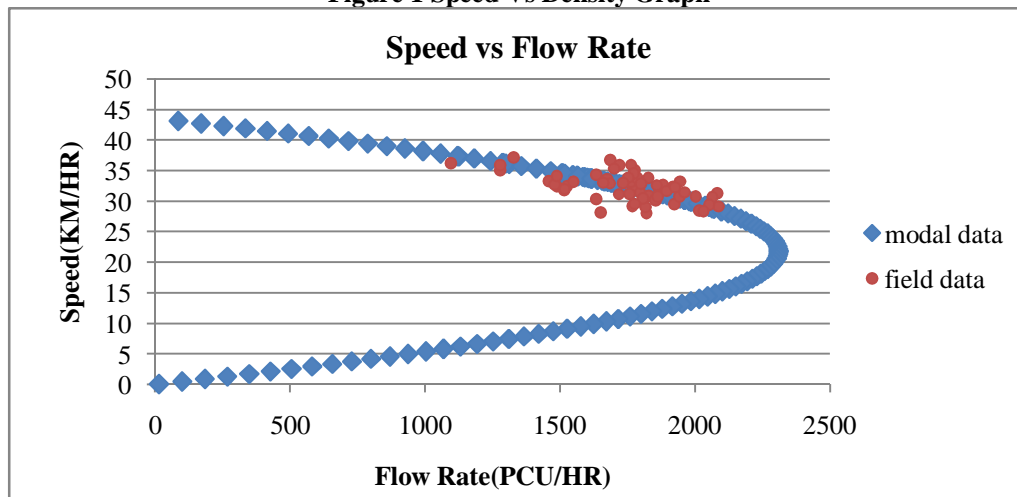
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Vol. 6, Issue 5, May 2017



**Figure 1 Speed Vs Density Graph**



**Figure 2 Speed vs Flow Rate Graph**

**Table 2 Speed - Density Models and Capacity Values Derived For Different Road Sections**

| Test Section                              | Static PCUs                            |                    |
|---|--|--------------------|
|   | Speed – Density Model                  | Capacity (PCUs/Hr) |
| Dr. Yagnik Road Towards Racecourse        | $y = -0.143x + 31.35$<br>$R^2 = 0.765$ | 1718               |
| Dr. Yagnik Road Towards Ramkrishna Ashram | $y = -0.186x + 33.91$<br>$R^2 = 0.724$ | 1545               |

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Vol. 6, Issue 5, May 2017

|  |  |      |
|--|--|------|
| 150ft. Ring Road Towards Indira Circle | $y = -12.5\ln(x) + 84.24$<br>$R^2 = 0.785$ | 3885 |
| 150ft. Ring Road Towards Raiya Chowkdi | $y = -0.205x + 43.53$<br>$R^2 = 0.680$     | 2311 |

**Table 3 Comparison of IRC DSV with Actual Traffic Volume**

| Name Of Stretches                         | Design Service Volume (PCU/Hour) | Capacity (PCU/Hour) |
|---|----------------------------------|---------------------|
| Dr. Yagnik Road Towards Racecourse        | 1500                             | 1718                |
| Dr. Yagnik Road Towards Ramkrishna Ashram | 1500                             | 1545                |
| 150ft. Ring Road Towards Indira Circle    | 3600                             | 3885                |
| 150ft. Ring Road Towards Raiya Chowkdi    | 3600                             | 2311                |

### II. Level of Service for Different Road Classes

For find out level of service counting volume is converted into design hourly volume. For hourly directional volume, design hourly volume is multiplied by D-factor.

Dir.  $V = V * D$  (veh/h)

Where  $D=0.66$  for urban roads

For determine level of service for different road section, the density is determined from the following equation.

Density =  $V_p / ATSp$  (pc/km/lane)

Where  $V_p$  = passenger car equivalent flow rate (pc/h/lane),  $ATSp$  = average travel speed for passenger cars

**Table 4 LOS for Selected Road Section**

| Name Of Stretches | Level Of Service |
|-------------------|------------------|
| Dr. Yagnik Road   | LOS D            |
| 150ft. Ring Road  | LOS C            |

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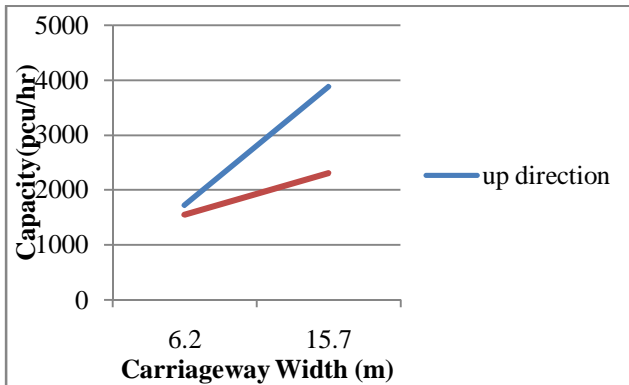


Figure 3 Capacity Related As Carriageway Width

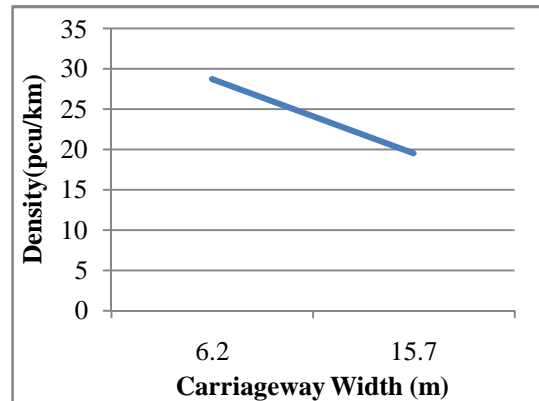


Figure 4 Density Related As Carriageway Width

### III. Artificial Neural Network (ANN)

In this study speed and flow take as input and density take as target. By using ANN MATLAB R 2011 give testing and validation check and regression graph. In ANN 50% take as training data, 25% take as testing data and 25% take as validation data. Hidden layer take as 30.

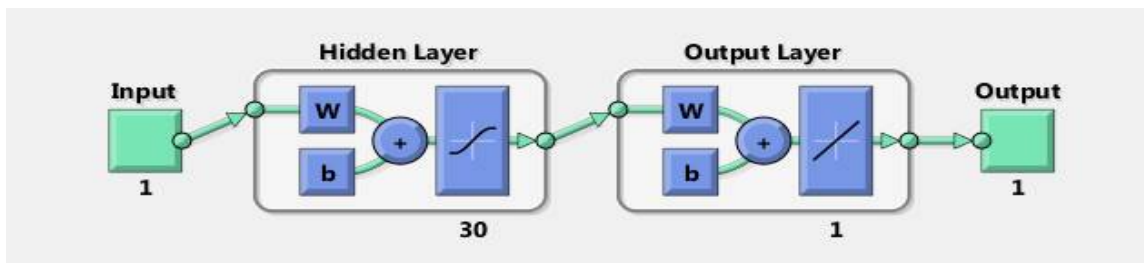


Figure 5 Artificial Neural Network

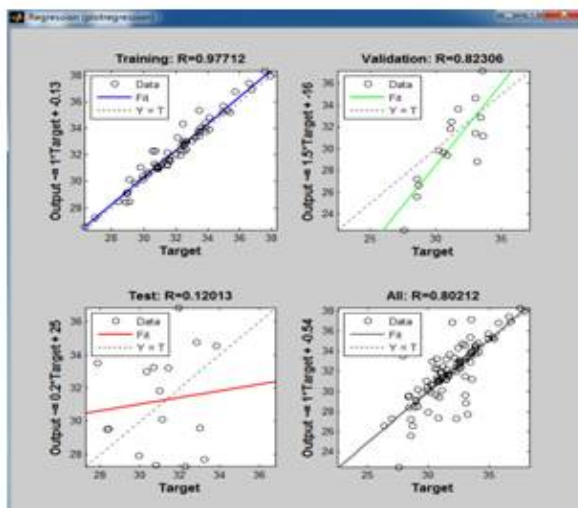


Figure 6 Regression Plot Graph for 150ft. Ring Road

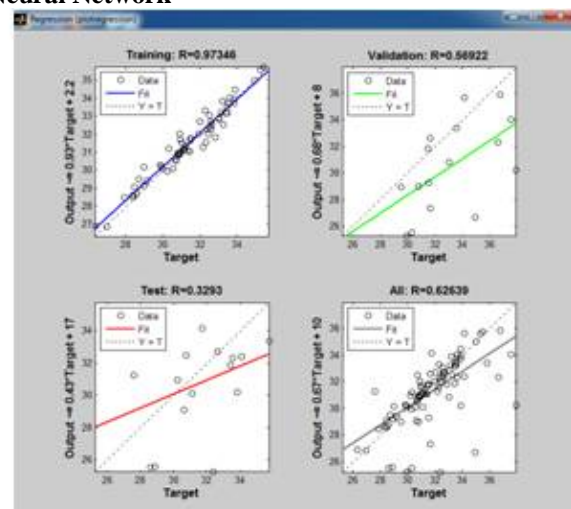


Figure 7 Regression Plot Graph for Dr. Yagnik Road

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Vol. 6, Issue 5, May 2017

## V. CONCLUSION

- ✓ The actual capacity analysis is fundamental to plan and improve the existing traffic facilities.
- ✓ Capacity is increase with increase in width of carriageway for selected different road section and Level of service is increase with the decrease in the width of carriageway.
- ✓ The observed capacity value by the static PCU method is 11% higher than the suggested value by IRC.
- ✓ By using the Artificial Neural Network is give the exact R value in the training data set and in validation check the data set is fail minimum time.

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