CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 Summary

A signalized intersection is the most crucial component of the urban transport infrastructure whose operation influences the total system performance. The capacity of the signalized intersection depends on the saturation flow rate possible from various approaches. In fact, the capacity can not be defined for the signalized intersection as a whole. The overall intersection performance depends on the individual approach capacities. The pioneering work on the performance of the signalized intersections is reported by Webster who has proposed a linear relationship between the saturation flow rate and the width available for the movement. The highway capacity manual suggests a detailed procedure for the operational analysis of the signalized intersections and the procedure is largely applicable to the homogeneous traffic situation dominated by the passenger cars where there is a strict lane discipline. It is observed that the Indian urban traffic scenario is different, where there is no standard carriage way width and the traffic is predominantly composed of smaller vehicular modes which have a high degree of maneuverability. In the present study these vehicles comprising of motorized three wheelers, motorized two wheelers and the human powered bicycles are grouped into a category and are called highly maneuverable vehicles. The vehicles belonging to this group can have a multifile movement in a given width and they can share the carriageway width with any other larger vehicle also. The lane concept has no relevance for this group. Earlier studies carried out for the estimation of the saturation flow rate under mixed traffic conditions have resulted in some models that can give saturation flow rate in PCU/hour depending on the width available. But the composition of highly
maneuverable group is not given due consideration in these works. It is also not justifiable to express the traffic flow in PCU/hour in situations where the functionality of lane is absent and the traffic is not dominated by the passenger cars.

An attempt is made in the present study to develop a relationship for the estimation of saturation flow rate in veh/hour as a function of the available width for the movement and the proportion of the highly maneuverable vehicles. The present study considers four legged urban intersections where the phasing involves releases of the straight and right movements simultaneously. The signal plan is the most commonly adopted one in the field and therefore the same is adopted in the study. Saturated green time studies are conducted at selected signalized intersections of Hyderabad city and the cycle wise saturation flow rates are analyzed. A parameter called saturation flow ratio is introduced in the study. Saturation flow ratio is the saturation flow rate over a meter width of carriageway and is expressed as veh/hour/m. A relationship between the Saturation Flow Rate and the parameters affecting it is evolved in the present study.

Need to investigate the role of artificial neural networks in the present study is identified. The implementation strategy is then decided. Accordingly, the configuration and the training process for the ANN are studied in detail. The training examples are obtained from the field studies. The problem of modeling by ANN is then adopted. The inputs to the model are the width and proportion of HMV. The output of the model is Saturation Flow Rate. The model is validated with the field data and found to be satisfactory. A comparative analysis is carried out between statistical models namely Multiple Linear Regression and Multiple Non Linear Regression and ANN model to establish suitability of either of the statistical models or ANN model for the present study. The developed ANN model is used to estimate
the saturation flow rate for different combinations of road widths and proportion of HMV.

7.2 Conclusions

1. The Saturation Flow Rate from a given approach depends on the available width for the lane group movement and the proportion of highly maneuverable vehicles in the traffic. The multiple linear regression model explain the relationship is given by

\[ S = -9656 + 13279 \text{propohmv} + 821 \text{w} \]

Where \( S \) is the Saturation Flow Rate in vph, \( \text{propohmv} \) is the proportion of highly maneuverable group and \( w \) is the width available for the movement. The equation has exhibited an \( R^2 \) value of 0.51. The t-ratios associated with the constant as well as the independent variables are quite good when compared to table values indicating a reasonable degree of correlation with the dependent variable. The \( f \) value of the equation is 69.96 and the table value for (268) degrees of freedom at 1% significant level is 4.61. The maximum percentage error observed in the predicted saturation flow rate with the model is 29.82.

2. The saturation flow ratio is also found to be affected by the proportion of highly maneuverable group. The saturation flow ratio increases with increase in the proportion of highly maneuverable group. The study resulted in the following relationship for the saturation flow ratio;

\[ \text{SFR} = -825 + 1763 \text{propohmv} + 2679/w \]

Where \( \text{SFR} \) is the Saturation Flow Ratio in vphpm \( \text{propohmv} \) is the proportion of highly maneuverable group and \( w \) is the width available for the movement. The equation has exhibited an \( R^2 \) value of 0.47. The t-ratios associated with the constant as well as the independent variables are quite good when compared to
table values indicating a reasonable degree of correlation with the dependent variable. The \( f \) value of the equation is 90.228 and the table value for(268) degrees of freedom at 1% significant level is 4.61. The maximum percentage error observed in the predicted saturation flow rate with the model is 31.03.

3. The study also resulted in the following multiple non linear relationship for the Saturation Flow Rate;

\[
S = 2719 \times (\text{propohmv})^{1.24} \times w^{0.594}
\]

Where \( S \) is the Saturation Flow Rate in vph, \( \text{propohmv} \) is the proportion of highly maneuverable group and \( w \) is the width available for the movement. The equation has exhibited an \( R^2 \) value of 0.33. The t-ratios associated with the constant as well as the independent variables are good when compared to table values indicating a reasonable degree of correlation with the dependent variable. The \( f \) value of the equation is 54.76 and the table value for(268) degrees of freedom at 1% significant level is 4.61. The maximum percentage error observed in the predicted saturation flow rate with the model is 31.26.

4. The functionality of ANN model is good when compared with statistical models. The predicted saturation flow rate values of ANN model are with very good agreement to the observed values in the field. The prediction capability of saturation flow rate by ANN model is 29.67 percent more than multiple linear regression model and 31.11 percent more than multiple non linear model.

5. The present study found that for a given width, if the proportion of HMV increases by 20 percent, the saturation flow rate increases by 875 vph. In order to effect the same change keeping the proportion of HMV constant, the width is to be increased by 2 m. Every addition of a lane of 3.5 m results in an increase in the saturation flow rate by 1950 vph at 0.5 proportion of highly maneuverable vehicle to 5200.
vph at 0.9 proportion of smaller vehicle group and indicating a direct bearing of proportion of highly maneuverable vehicle group on the saturation flow rate.

7.3 Limitations of the Study

The following are the limitations of the present study:

(a) The speed and acceleration characteristics of the vehicles are not considered in the field studies because of complexity involved in quantifying them for the mixed traffic.

(b) The right and straight flows are combined into a lane group and the group is treated as aggregate flow. The ANN model as well as statistical models developed for the estimation of saturation flow rate is for the combined flow implying that the straight and right streams exhibit same behavior while releasing. The assumption may be true when the proportion of HMV is high in both the directional flows. In a situation where the proportion of Buses or Cars is high in right turning, the saturation flow rate equation may need a modification.

7.4 Further Scope of the Work

The present study is limited to four legged signalized intersections only where the straight and right movements from an approach are released together. There is a need to understand the saturation flow rate changes when exclusive right turning is provided. A comprehensive study encompassing all the possible intersection lay outs and phase plans is necessary so that a generalized procedure may be evolved for the performance evaluation of any signalized urban intersection under mixed traffic conditions. Further refinement is possible in the ANN model established so that an integrated neural network model may be developed for the prediction of saturation flow rate. The ANN model can be further improved by incorporating the acceleration
and deceleration characteristics of the vehicles. In the present study, simple BP network has been adopted. On the other hand hybridization of fuzzy systems with simple BP network may be attempted and their efficacy may be compared with simulation based analysis.