CHAPTER 1

INTRODUCTION

1.1 General

Signalized intersections are the most complex locations in urban networks. The operational conditions of such intersections profoundly affect the overall efficiency of the entire transportation network in cities. As the operational quality of urban road network gradually deteriorates due to increase in traffic volume, a higher level of service is required and a well-planned and efficient improved scheme is necessary to assure a satisfactory condition of urban transportation at all times. The evaluation of the current status and performance of signalized intersections is one of the important tasks in the management and improvement of urban traffic systems. Based on assessment results, traffic authorities can isolate those strategies and plans that make both the improvement measures and the allocation of limited funds more rational. A number of approaches to evaluate the performance of signalized intersections have been proposed by various researchers and engineers, and they have been implemented in many cities. Researchers in some developed countries such as the United States and Canada have suggested that both the capacity and level of service must be fully considered to evaluate the overall performance of signalized intersections.

Signal control is a frequently used remedy of capacity shortage in urban areas. A sufficiently accurate method of predicting the capacity of signalized intersections is important for correct road way design and for effective traffic management. Signal control is generally considered to be the highest type of control possible at an at-grade intersection. If the signal control plan is not designed properly, the signal control may become counterproductive. The ill effects of improper signal plan can be congestion,
undue delays, fuel wastage, air pollution, reduced intersection capacity and tremendous inconvenience for the road user. To avoid such a situation, it becomes mandatory on the part of the traffic engineer to study the traffic situation thoroughly, to understand it properly and to evolve the optimum cycle time and proper phasing to suit the requirements of the traffic with due consideration to the location geometrics.

The most significant parameter that influences the design of signal plan is the “saturation flow rate”. Saturation flow rate is defined as the maximum rate of flow at which the vehicles from an approach to an intersection can clear the intersection if green time is available uninterruptedly. Saturation flow rate is a key factor determining the capacity of a signalized intersection. It also plays a significant role in the design of signal timing plans. As stated in the current version of the Highway Capacity Manual (HCM) (Transportation Research Board 2000), there are many factors that affect the saturation flow rate for an intersection approach. In other words, the saturation flow rate has a direct bearing on the capacity of a signalized intersection. If the saturation flow rate can be computed to the reasonable accuracy, the capacity of the signalized intersection can be evaluated along with delay statistics and the level of service.

The Highway Capacity Manual HCM 2000 recommends “that local data collection be performed to determine saturation flow rates and lost times, which can lead to more accurate computations.

1.2 Factors Influencing the Saturation Flow Rate

Most of the research carried out both in the western countries and in India has claimed the saturation flow rate as essentially a function of the approach width. The pioneering work carried out by Webster (1958) has proposed a linear relationship between saturation flow rate and the approach width where in the saturation flow
increases with the available width. The work of Webster has paved the way for further research and though the regression coefficients and constants changed, the fundamental linear relationship is the one reported by the researchers throughout the world. There cannot be any question regarding the validity of this relationship, but the Indian urban traffic scenario needs a different dimension of understanding in the absence of lane discipline and the predominant proportion of highly maneuverable vehicles comprising of smaller vehicular groups such as motorized three wheelers, motorized two wheelers and human powered bicycles. Evidently the saturation flow rate is governed by the available width of approach over which the release takes place as well as the way the vehicles distribute longitudinally and laterally within the available space while getting released.

1.3 Indian Urban Traffic and Maneuverability

The rate at which vehicles get released has got a lot to do with the maneuverability they enjoy. The Indian urban traffic is a heterogeneous mix of variety of vehicles with varied physical and operational characteristics. The complexity is further manifested with the absence of lane discipline where in different modes share the same right of way with convenient lateral and longitudinal spacings. The concept of Passenger Car Equivalent may be suitable for homogenous traffic conditions where passenger car is a dominate mode but it fails to explain the quality of flow when the 2/3 wheeler group dominates the traffic composition. This 2/3 wheeler group such as motorized two wheelers, motorized three wheelers like auto rickshaws and the human powered bicycles range from 60 percent of the total traffic, some times as high as 90 percent in a cycle. Because of their smaller physical dimensions and maneuverability, they enjoy both lateral and longitudinal freedom.
The concept of lane is not relevant for these modes as more than one vehicle of this type can move abreast in single lane. They also move through the space gaps available in the traffic stream sharing the same lane with a larger vehicle such as car or a bus. This factor assumes greater significance at a signalized intersection in the formation of queues and their release. These Highly Maneuverable Vehicles (HMVs) weave through the space gaps available in queue and occupy the frontal positions irrespective of their arrival times. When green is given, these are the first vehicles to get released and they utilize the width available to the maximum extent possible.

Most of the standards for capacity and level of service have emerged out of the studies on homogeneous laned traffic. But in case of Indian traffic system, it is a general practice to widen the urban carriageways in increments of a meter or so to save the expenses of a full one lane width. There is no scientific analysis to evaluate the quality of a service rendered by such carriageways. The non-standard road widths have a wider role to play in a mixed mode environment.

The highway capacity manual (1985) has given a detailed procedure has got many inherent assumptions, which are far different from those found in the Indian urban traffic scenario. The varying road widths coupled with a varied spectrum of vehicular widths warrant a different approach in understanding vehicular movement over a given road width. To illustrate the point more clearly, a 3.5m road acts as a single line in case of a passenger car whereas the same carriageway can act as multilane highway in case of a two wheeler facilitating the movement of more than one vehicle abreast in a single lane. This factor must be given due consideration in case of determining the capacity and level of service of a signalized intersection also.
1.4 Need for the Proposed Study

In urban traffic management the evaluation of the current status and performance of signalized urban road intersections is one of the important tasks. Saturation flow rate is the key factor in the performance evaluation of signalized urban intersection, the present study is a step in the direction of realistic computation of saturation flow rates at signalized urban intersections with due emphasis on traffic composition and the approach width. The ever-increasing power of personal computers and search for ITS (Intelligent Transport System) solutions to growing signalized urban intersection problems has led to the emergence of a number of microscopic simulation models as operational analysis tools.

There is great potential for useful application of micro simulation models to the analysis of complex signalized intersection problems in urban areas. Micro simulation is useful due to increasing levels of system complexity and uncertainty involved in the operation of traffic at signalized urban intersections. However, concerns are often expressed regarding misuse of micro simulation. Simulation for capacity analysis, including the dependence of capacity on demand flow rates, modeling of queue discharge (saturation) flow rate, queue discharge parameters at signalized intersections, and relating them to the general queuing, acceleration and car-following models used in micro simulation etc. are heavily dependent on human expertise. The implementation of micro simulation based ITS for Indian urban centers have got its own problems like lack of expensive and inadequate budgetary support for such programs. Absence of an organized administrative setup for traffic management in urban areas is also another constraint for implementation of micro simulation based traffic management.
The use of neural networks is a novel approach with potential applications to a wide class of urban traffic management problems at signalized urban intersections. The neural networks can be used to computerize capacity analysis, delay modeling, saturation flow estimation, vehicle arrival patterns at signalized urban intersections and other prediction problems. It is in this context, the major objective of the present study is unified picture of neuro computation for saturation flow rates at signalized urban intersection.

1.5 Objectives of the Study

An ANN is characterized by the capabilities of nonlinear learning, smooth interpolation and prediction for certain complex relationships between inputs and outputs or to find patterns in data. A more realistic and accurate prediction can be obtained through ANN analysis. Neural networks offer an alternative to regression analysis in the solution of traffic problems associated with nonlinear relationships. The advantages of neural networks over regression analysis are that in regression analysis, it is to choose a model to fit the data, while neural networks are not required to pre-select a model, and that in neural networks, sufficient hidden nodes can provide accuracy required for many different response surfaces. This study is aimed at developing and testing multi-layered feed forward ANNs trained with the back-propagation algorithm to assess saturation flow that occurred at signalized urban intersections with different traffic composition and approach width.

The signal plan has numerous combinations and to study all possible phase plans is beyond the scope of present work. The study is confined to such signalized urban intersections whose signal plan consists of simultaneous release of straight and right flows from a given approach. This phase plan is the most commonly adopted phase plan in Indian traffic conditions because the exclusive right turning phases are...
not usually facilitated by the geometric limitations as well as the absence of
directional lanes.

The broad objectives of the study are

a) To conduct field studies at selected signalized intersections in Hyderabad city for preparing a database on saturations flows under varied signal plans and geometric conditions

b) To evolve a statistical model for estimation of saturation flows based on traffic composition and the approach geometrics

c) To study the configuration and training aspects for development of simple back propagation based neural networks for saturation flow analysis

d) To establish an Artificial Neural Network model based on the data obtained from the field studies to predict the saturation flows.

e) To compare the performance of NN model and statistical model so as to understand which approach is more suitable for experimentation

f) To conduct experimentation with the model identified so as to analyze the saturation flow rates under varied conditions related to traffic composition and road geometry.

1.6 Organization of the Thesis

The thesis is organized in seven chapters. The first chapter explains the background and the need for developing a different approach for the analysis of signalized intersections under Indian urban traffic situation dominated by highly maneuverable group of smaller vehicles.

Chapter 1 spells out clearly the objectives of the present study.

Chapter 2 reviews the earlier works carried out in the areas relevant to the present work. The study of Webster and the Highway Capacity Manual methodology are
discussed in detail as they have considerable bearing on the present study. The Saturation Flow Rate studies and mixed traffic equivalency factor studies are discussed in brief in this chapter. Historical review of application of neural networks in the performance evaluation of signalized urban intersections and state–of-the–art related to the present investigation has been presented in this chapter.

Chapter 3 deals with the collection of saturation flow data at selected intersections in Hyderabad city. The survey methodology adopted, survey formats, survey locations and reduction of field data for analysis are discussed in this chapter.

Chapter 4 deals with the development of multiple linear and non linear regression models for the computation of saturation flow rate based on field data at selected intersections in Hyderabad city.

Chapter 5 presents modeling of saturation flow rate using ANN approach. The details of development of simple BPN model to predict saturation flow rates have been presented in this chapter.

Chapter 6 presents comparison of performance of ANN model and regression models and prediction of saturation flow rates for different traffic compositions and approach widths are explained in this chapter.

Chapter 7 summarizes the total work carried out and the important conclusions of the study are presented in this chapter.