INTRODUCTION

1.0 GENERAL

The study of characteristics of traffic stream such as speed, density, flow rate or traffic volume and their inter-relationships has been the subject matter of basic research in traffic engineering during the past several decades. While the earlier research work concentrated mostly on modelling of those inter-relationships in homogeneous traffic conditions, during the past three decades, considerable interest has been generated in modelling of traffic stream behaviour in mixed mode environment. Of all the models that have been developed, the relationship between the speed and the density of traffic stream has caught the attention of researchers because of its simplicity. Models have been developed for explaining the relationship between the speed and the density, the form of which has varied from simple linear function to multi-regime models. But in many such modelling efforts, lack of appropriate data over the whole domain of interest has been the bane of the researchers, particularly those modelling the mixed traffic
behaviour. Many times the researchers have been compelled to take certain decisions and conclude the research work based on incomplete understanding of phenomena being modelled. One such relationship, which remains as a conjecture, is the suspicion that the speed-flow relationship in a mixed traffic flow situation may be bell shaped, rather than parabolic (Nagaraj et. al. 1990).

It is this kind of conjectures and uncertainties, which has been the motivating factor for taking up this research work in traffic stream modelling under mixed mode environment.

1.1 STATE OF THE ART

There are mainly three approaches for traffic flow modelling, viz., the empirical, the analogy and the simulation. In empirical approach, stream characteristics are expressed in terms of inter-relationships among the variables like the speed, the density and the flow by curve fitting to the observed data. However, there is a limitation to this empirical approach because of the wide variations in the influencing factors, which result in many traffic flow combinations. Quite often, the researchers will be forced to make many simplifying assumptions in the development of models. The models are generally deterministic in nature.

Analogy methods are also macroscopic in nature and in this approach, the stream characteristics are hypothesized to follow certain physical phenomenon. One such approach is the well-known fluid flow analogy. This approach appears to be appropriate only in those flow conditions which bare close resemblance to fluid flow. Like in empirical approach, it is not possible to use this approach also in a comprehensive sense due to interaction among several influencing variables.
Simulation models of traffic stream are based on microscopic approach in which individual vehicles behaviour is considered. It is possible to include many influencing factors and conduct experiments under controlled conditions. Further, they can be used to simulate a wide range of conditions with relative ease and without the need to collect the costly data. Many researchers in India (Marwah 1976, Ramanayya 1980, Badarinath 1993, Kuncheria 1995, etc) have adopted this approach to study mixed traffic flow at urban and rural mid blocks.

A typical simulation model consists of a number of component blocks, each representing a particular sub-system. Generally, many of these component models are developed based on empirical approach using the pre-processed data. However, many of these sub-models could be built to reflect stochastic and dynamic changes in the influencing variables through Artificial Neural Networks (ANN). In order to calibrate these ANN models it is necessary to train the network by the use of real time data reflecting the changes due to several influencing variables.

Gathering data for such a host of situations would be difficult for modelling traffic flow under all possible traffic conditions, different geometrical conditions, environmental conditions, etc, thus limiting the use of ANN approach. Still that approach can be made use of modelling sub-tasks for the main simulation program. Thus, a marriage between simulation and ANN approach would be a useful modelling effort for a study as complex as that of understanding the dynamics of mixed traffic.

1.2 REFINEMENTS NEEDED IN SIMULATION APPROACH

The following are some of the refinements needed in simulation approach:
The arrival times of vehicles at the entry to simulated stretch are generally estimated by sampling from headway models. In mixed traffic, the vehicles often move side by side due to unrestricted mixing. The distribution of headways depends upon the road width, the traffic composition, the flow level, etc., and hence, it becomes very difficult to identify a suitable headway model. Literature survey has often revealed that different researchers in the past have used different headway models even for nearly identical flow levels. This only indicates that the approach based on headway distributions may not be suitable for simulation of vehicle arrivals in mixed traffic. The warm-up zone approach (McLean 1989) is another approach, which has been suggested for controlling the vehicle arrival. This does not require the use of headway models and hence, appears to be a better alternative for generation of vehicle arrivals in mixed traffic simulation.

Another aspect of simulation which needs attention of any researcher is the number of vehicles being simulated for a given road width. While, some of the researchers could simulate flows up to 1000 vehicles only, some could simulate even traffic flow of 12,000 vph for a road width of 7.0m. This excessively high value of flow could have been possible only when the observations might have been taken immediately after the entry point. The results in those cases are likely to be erroneous particularly when the observations are recorded immediately after starting of simulation. The traffic flow must be allowed to stabilise over time and space so that the vehicles get adjusted to the rhythm of movement. It is
essential, therefore, to allow the system to stabilise over time and space before the observations are taken.

iii) The acceleration/deceleration values adopted by many researchers in simulation studies are either constant or based on limited field observations. In reality, a driver accelerates or decelerates at a rate, which he presumes to be safe and causes minimum discomfort to the passengers and based upon the vehicle characteristics. So, the acceleration/deceleration characteristics vary from driver to driver and needs a better presentation in simulation model.

iv) In simulation, the vehicles are generated and moved through the simulated system as per the logic of the model. In the absence of the facilities for observing the movement of simulated vehicles, many inconsistencies such as two vehicles occupying the same position at the same time, etc., will go unnoticed. A visual display of the simulated vehicles as they pass through the system provides an opportunity to check and correct for any inconsistencies in the flow logic, which will not be possible otherwise.

v) The vehicle manoeuvring logic, the core of the traffic flow simulation model, is generally rule based. This also needs to be replaced by a better model for the reasons already discussed.

1.3 VISION STATEMENT

The ultimate goal of this research is to develop a comprehensive simulation model which is capable of being used for the prediction of stream characteristics
such as speed, density and flow under all possible realistic traffic mix compositions, which would minimise the uncertainties and conjectures existing in the present state of understanding the traffic system. Such a model should be versatile and capable of initiating fundamental research in stream characteristics.

1.4 OBJECTIVES AND SCOPE OF THE WORK

The main objective of the work is to conduct traffic flow studies in mixed environment and characterise the traffic stream with the following specific objectives:

i) To identify the methodologies/approaches for describing various component processes of the traffic flow.

ii) To collect and process the required data and to derive models for component blocks.

iii) To develop the simulation model by integrating these component models and to validate the model.

iv) To conduct experiments on the validated simulation model and understand the characteristics of mixed traffic flow.

v) To derive equivalency factors for expressing the influence of various types of vehicles in terms of a representative vehicle in the traffic stream.

Keeping in view the time and other resources available and the complexity of the mixed traffic flow, the scope of the work is limited to study of unidirectional traffic flow at urban mid blocks in mixed mode environment. The idea is to specifically
study the effect of composition of vehicles on the traffic stream parameters and to derive equivalency factors.

1.5 STRUCTURE OF THE THESIS REPORT

Including, 'Introduction' there are nine chapters in this thesis. Chapter - 2 on 'Traffic Flow Modelling Approaches', while reviewing the various approaches that have been followed for modelling the traffic flow, identifies the need for use of simulation approach in order to reduce the ordeal in data collection. In this chapter a subtle refinement is also suggested, like the possibility of introduction of ANN in development of sub models.

Chapter – 3 on 'Artificial Neural Networks', while presenting the various possible applications of ANN in the studies related to traffic engineering, describes nuances of ANN like, learning paradigm, network structure, etc. This chapter has concluded with a recommendation for the use of a multi-layer feed forward neural network, trained, using back propagation algorithm.

The development of component models is the subject coverage of Chapter – 4. In this chapter, several types of models have been developed starting from a simple regression model to the highly sophisticated stochastic models to describe the various components of the simulation model.

Apart from the above models, certain traffic situations are governed by the way the drivers react to the behaviour of the frontal vehicles, also called as leaders. These situations are aptly described by car-following theory. Chapter–5 describes the acceleration/deceleration characteristics of constrained vehicles, which are modelled using the above theory.
Development of acceleration and deceleration models in the free flow condition is the subject matter of Chapter – 6. The models in this have generally two components. While the first component can be called deterministic, the second, which reflects the driver behaviour, can appropriately be described by stochastic modelling.

Chapter – 7 on ‘Development of Simulation Model’ integrates all the sub models developed in previous chapters and provides a complete description of all possible movements achieved in simulation modelling.

All experiments carried out on the simulation model are described in Chapter - 8 on, ‘Experiments Using Simulation Model’. Determination of capacity flow, jam density, flow levels corresponding to different levels of service and equivalent factors for different types of vehicles is the subject matter of this chapter.

The summary and conclusions of the study and indication of the scope for further study based on limitations of the present study are the subject matter of Chapter–9. Many interesting extensions to the present work to refine the basic understanding of the traffic flow phenomena in mixed mode environment are given in this chapter.