ABSTRACT

Traffic flow modelling has been the subject matter of traffic engineering research for several decades. Many approaches have been suggested for modelling the traffic flow phenomena, which include empirical models at one end of the scale to rigorous micro simulation models at the other end. Keeping pace with the developments in modelling of traffic flow phenomena by the researchers in developed countries, many researchers in India have also developed simulation models for both unidirectional and bi-directional movements.

However, many such valuable efforts have not been successful in developing a comprehensive theory for traffic flow phenomena in mixed mode environment. The main reason for this inadequacy lies in lack of clear understanding of vehicular movements in mixed traffic situation and perhaps crude approximations made in describing these movements. Quite often, heroic recommendations were made based on partial and imprecise data. Due to such decisions, several conjectures were created in the minds of the researchers. One such conjecture that had arisen was the reported bell shaped relationship between speed and flow.

The objective of the research work being reported in this thesis was to minimise these uncertainties to a greater extent through repeated experimentation using simulation model so that certain amount of consistency could be achieved in the conclusions.

The literature review has revealed that among many of the approaches available, simulation approach is by far the best method for modelling the traffic flow
because of the parsimony permitted by it in the data input. Interestingly these simulation models have been developed based on several sub models, which may vary in their rigour – ordinary regression models at one end to stochastic behavioural models at the other end. For many of these sub-models, the causative structure are not very clear and hence, both probabilistic and deterministic models may not be adequate. In such cases, Artificial Neural Networks (ANN) provide a promising alternative. In this thesis, an attempt has been made to integrate the ANN and simulation models to utilise the best advantages of both.

The following improvements have been incorporated into the simulation model:

➢ Introduction of a warm-up zone approach for vehicle arrivals so that the vehicles on the test section could achieve both temporal and spatial stability.

➢ Incorporation of models that describe the vehicle movement in a more realistic way through the use of neural networks for various component models.

➢ Incorporation of acceleration and deceleration models derived based on field observations either by ANN or regression models.

➢ Improvement in the placement of vehicles in the test section by closer monitoring of linear and lateral placements that could arise in the mixed traffic situation.

➢ Development of a graphic simulator to generate the images of vehicles on the computer screen following the intended logic so that inconsistent and illogical features could be traced and structure revised accordingly.
A neural integrated simulation model was built by incorporating all the above factors and was concurrently validated using the field data. This field validated simulation model was then used for conducting several experiments in mixed mode environment in a unidirectional traffic flow situation. The major conclusions resulting from the experiments carried out on simulation model are as follows:

i. There is no much justification in using models other than single regime linear model for modelling speed-density relationship in mixed traffic conditions. Consequently, the speed-flow and the flow-density models could be adequately described by parabolic relationships.

ii. The Passenger Car Unit (PCU) values at capacity flow conditions for two-wheeler, auto-rickshaw and bus have been worked out to be 0.65, 0.8 and 1.49 respectively in this study.

iii. The capacity values for two-lane unidirectional flow for single vehicle streams of two-wheelers, auto-rickshaws and buses have been found to be 4335, 3334 and 1890 vph respectively, in this study.

iv. A regression equation developed in this study for prediction of capacity flow in mixed traffic based on 51 mixed vehicle combinations is able to predict the capacity of the mixed traffic very close to the reality. However, it is to be used only in situations of mixed traffic and not for streams with only single type of vehicle.

v. Experiments conducted by varying the percentage of auto-rickshaws in the traffic stream while keeping the two-wheeler and car percentages constant, have indicated that the capacity flow Vs percentage auto-rickshaw is linear, but those linear graphs for varying percentages of
cars may intersect with one another, suggesting that there may be more than one mix combination for which the capacity flows may be identical. Hence, vehicles do interact to modify the capacity flow.

vi. Capacity flow in traffic stream is highly correlated with bus and two-wheeler percentage, but in opposite sense. This means that larger the percentage of buses the lesser the capacity flow. However, larger the percentage of two-wheelers greater the capacity flow. Similar inference, as in above, is possible for jam density also. But the contribution of both the car and the auto-rickshaw are found to be statistically significant in jam density calculations.

vii. Equivalent passenger car units calculated in this study for different types of vehicles at various levels of service have indicated that the PCU values for two-wheelers and auto-rickshaws vary quite considerably over different levels of service. On the other hand, change in equivalent PCU values for bus was found to be not very significant

The major contributions of the study are:

i. Development of a Neural Integrated Simulation model for experimentation related to vehicular movements in mixed traffic environment.

ii. Further refinement of basic simulation models by incorporation of linear and lateral placement of vehicles, acceleration/deceleration characteristics of vehicles, vehicle manoeuvring logic, etc, through neural network approach.

iii. Introduction of warm up zone approach in simulation modelling of traffic flow.
iv. Simulation of vast possible scenarios for a given set of input situation by randomising the seeds for generation of random number sequences.

v. Graphic display of simulated movements of vehicles and introduction of appropriate corrections to the flow logic when found necessary.

vi. Determination of capacity and jam density values for single and multiple vehicle streams by the development of a simple linear regression equation.

vii. Demonstration of the suitability of linear speed-density and parabolic speed-flow and flow-density models even in mixed traffic situation.

viii. Study of sensitivity of capacity values and jam densities to composition of the vehicles in the stream.

ix. Development of equivalent passenger car units and service volumes at different levels of service and study of variable PCU values.

One of the limitations of the study is that the simulation model is useful only for one directional uninterrupted traffic movements under ideal geometric conditions. Separate models have to be developed for bi-directional movements and for study of influence of the geometrical factors. From the output of the simulation experiments, it has been observed that at the free flow and at the capacity flow conditions the scatter of points are large. In order to quantify this variability a quantity called $q/ku$ was found out and these were plotted against density of traffic stream. It has been noticed that this ratio is not equal to unity and it is suspected that this ratio either may be a constant or a function of density itself. That ratio appears to be a proxy similar to porosity or void ratio in soil structure. Further research can perhaps bring about the nature of this $q/ku$ relationship with density.