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ESTIMATION OF PASSENGER CAR EQUIVALENT FOR DIFFERENT VEHICLES ON SELECTED ROAD SECTIONS IN KHULNA METROPOLITAN AREA USING ARTIFICIAL NEURAL NETWORK MODEL

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ABSTRACT

In a developing country like Bangladesh, the traffics on local urban highway are highly heterogeneous comprising of different static and dynamic characteristics. In order to reduce the heterogeneous behavior and convert the mixed traffic stream into a homogeneous equivalent, the term passenger car equivalent (PCE) is used. The PCE for a vehicle is dynamic in nature and changes with traffic volume, pavement width, shoulder conditions, directional split and percentage of slow moving vehicles. Data were collected from four road sections as Fulbarigate, Daulatpur, New Market and Rupsa in Khulna Metropolitan City. The goal of this study is to develop an Artificial Neural Network (ANN) based model using MATLAB for the estimation of PCE values for different types of vehicles such as Bus, Mini-bus, Large Truck, Medium Truck, Motorcycle, CNG, Mahindra in Khulna Metropolitan City. Finally, the PCE values obtained in this study are compared to the values established earlier. The PCE values obtained from ANN for Bus and Large Truck is within the range of 3.00 to 3.50, for Mini-bus and Medium Truck 2.00 to 2.50, for Motorcycle 0.50 to 0.60 and those for CNG 0.80 to 1.00. These results are finally compared with the values established by Geometric Design Standards for Roads & Highways Department in Bangladesh (MoC, 2000).

Keywords: *Passenger Car Equivalent (PCE) , Mixed Traffic, Artificial Neural Network, MATLAB*

1. INTRODUCTION

Traffic on local urban highways in Bangladesh and many other developing countries in the world are highly heterogeneous. Road transport is a very popular mode of transport used by the public. Road networks are heterogeneous used by the passengers to move from one part from another part of country, by the companies to provide scheduled delivery of their services and to transfer other needs throughout the country. Operating conditions on this roadway becomes complex when all these vehicles of different sizes move on the same road space without any physical segregation and occupy any lateral position on the roadway depending upon availability of the road space. Small size vehicles like motorized two-wheelers penetrate into the gaps between two large size vehicles and make the operating conditions poorer. Expressing traffic volume in terms of vehicles passing a given section of a roadway per unit time will be meaningless in such situations unless volume information is accompanied by the traffic composition.

As a result it is necessary to convert the heterogeneous traffic into a stream of homogeneous traffic by using appropriate passenger car equivalent (PCE) for analyzing the mixed traffic. In addition, appropriate PCE are also used for capacity analysis as well as traffic engineering research.

The concept of 'Passenger Car Equivalent' (PCE) was first introduced in the Highway Capacity Manual (HCM) (Transportation Research Board, 1965) for the analysis of mixed traffic by converting the different types of vehicles into equivalent number of passenger cars.

Thus, these PCE values are essential in carrying out most of traffic analysis. PCE provided by the HCM for trucks and buses on freeways and multilane highways represent their effect when traffic is operating in an ideal conditions. An accurate and easy estimation of PCE factors for different vehicles are useful in determination of traffic volume/capacity and level of service (LOS), which can make the decision of future expansion of highways and roads (widening and improvement) more constructive. Therefore these factors affecting PCE values should be incorporated suitably for accurate estimation of traffic volume. Most of the traffic engineers may use the only set of PCE factors included in the US HCM (Transportation Research Board, 2000) for analysis in different situations, ignoring acknowledged affecting factors resulting in significant amount of error in traffic/capacity studies. It is therefore necessary to determine the PCE on the basis of current roadway and traffic conditions of Khulna metropolitan city, Bangladesh. Passenger car equivalent is not only important for capacity reasons, but also as an input in highway cost allocation studies. The Federal Highway Administration (FHWA) has recently completed a highway cost allocation study to determine the cost responsibilities of the various classes of vehicle using the nation's highway system.

The current study aims at developing an Artificial Neural Network (ANN) based model using MATLAB software for estimating passenger car equivalent (PCE) of different types of vehicles in Khulna metropolitan city. ANN based model is of importance because of a number of independent affecting factors, Results of developed ANN based model are compared with the quoted results and are found with high degree of correlation.

2. METHODOLOGY

Four different road sections were selected where all the vehicles move freely without any restriction. The four different sites are Fulbarigate, Daulatpur, New Market, Rupsa. The selected site was properly visible from the roof of building from which video were taken easily. Figure 1 shows the GIS location map of the selected sites.

2.1 Data Collection

A certain length was fixed for each site. Length was measured by using tape. From the selected site, video was taken by digital camera for a duration of one hour. This video covered the entire length of the carriageway which is being selected. Then, time taken for each vehicle to pass the selected length was counted from the video is being taken. The speed needed for each type of vehicle was calculated by dividing the selected length with counted time. Average speed was measured by dividing the summation of the calculated speed with the number of speed measurements. The selected vehicles are Buses, Mini buses, Trucks, Medium Trucks, Car/Pick up/Jeep, CNG/Mahindra/Atul, Motorcycle. Directional split and percentage of slow moving vehicles were calculated by counting the number of vehicles in both directions. Rickshaws, Bicycles, Van, Easy-Bike etc. were taken as slow moving vehicles. Shoulder of the selected road sections were categorized as very poor, poor, fair, good and excellent. Numerical value for shoulder were taken as 1 for very poor, 2 for poor, 3 for fair, 4 for good and 5 for excellent, respectively. The pavement width of the road sections were measured by using tape.
The dimensions of the selected vehicles were then measured to calculate the PCE values according to the formula (Chandra, 1995). The dimension of the selected vehicles and factors affecting PCE values are shown in the following Table 1 & Table 2.

2.1.1 Data Selection and Data Division

In order to develop ANN architecture, data were collected from four different road sections of Khulna metropolitan city. Some previous data were also collected from previous study in order to train the neural network. In the present work, 10 data sets are randomly selected. Training data set comprises 6 data entries, and the remaining data entries 4 are divided

between the validation and testing sets. To test the reliability of the neural network model, 2 samples were randomly selected as the test set and another 2 samples as the validation set. To construct the neural network model, and an independent validation set to estimate model performance, 70% of the data set was used for training, 15% of the data set was used for validation of the model, and the remaining 15% of the data set was used for testing the neural network model. Figure 2 shows the division of data set.

2.1.2 Inputs and Targets

The accuracy of a neural network depends on the scattering of input information for training of the network. For this reason, classification of input information is very important in training. Therefore the input information is classified in five cases and in each case classification is based on one of the factors affecting PCE values. Factors affecting PCE value includes pavement width, shoulder condition, directional split, surface characteristics, percentage of slow moving vehicles, and so on. In order to develop artificial neural network model, four most affecting factors as pavement width (Yagar, 1983), shoulder condition (Turner, 1982), directional split (Sachdeva, 2004), and percentage of slow moving vehicles (Botma, 1988) are considered as the input and the corresponding PCE values as output or target. The qualitative categorization of shoulder was taken as very poor, poor, good, and excellent which were assigned with numerical values as 1, 2, 3, 4 and 5 respectively. Figure 3 shows the developed neural network model.

3. ILLUSTRATIONS

3.1 Figures and Graphs

Figure 1: GIS Location Map

Figure 2: Division of Data Set

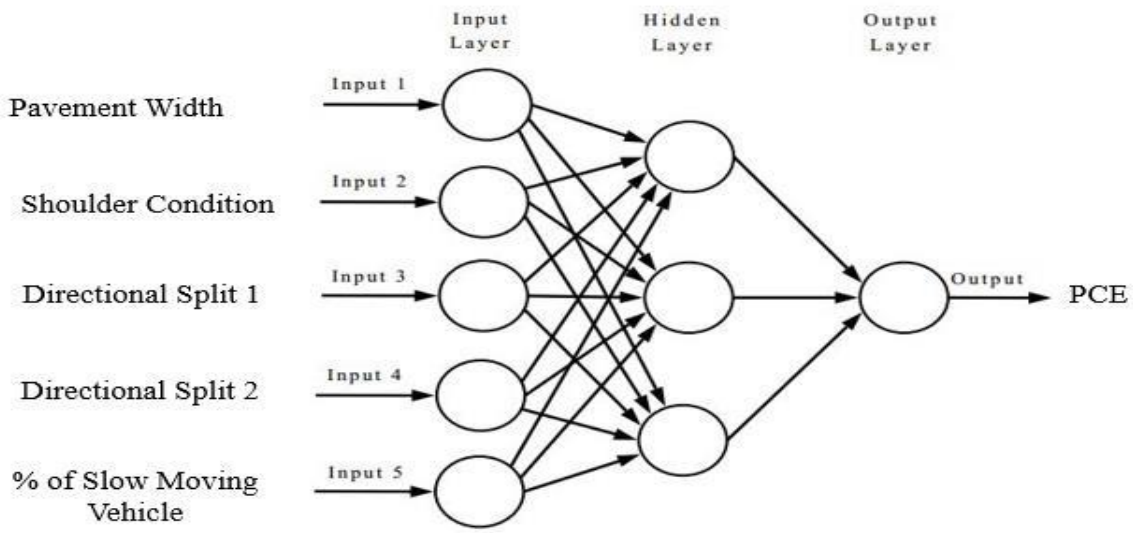

Figure 3: Developed Neural Network Model

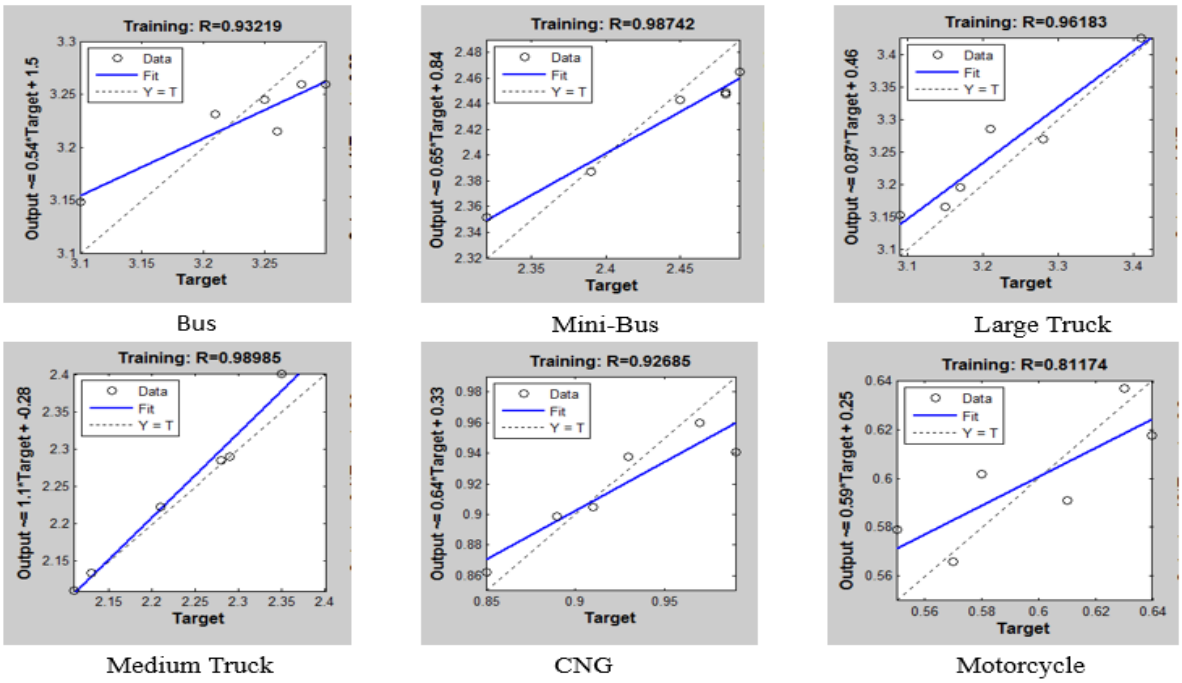

Figure 4: Regression Diagram of Training Set

Figure 4 shows the regression value of training set data were found 0.93219 for Bus, 0.98742 for Mini-bus, 0.961833 for Large Truck, 0.98985 for Medium Truck, 0.92685 for CNG and 0.81174 for Motorcycle. The regression value for Bus, Mini-bus, Large Truck, Medium Truck and CNG are close to 1 which represents that the obtained results are very close to the results established earlier. But for Motorcycle, the regression value of training set data was found 0.81174 of the present study which is not close to 1 because of large variation between the data and small network size.

3.2 Equations

PCE value for different vehicles under mixed traffic situation is directly proportional to the speed ratio and inversely proportional to the space occupancy ratio with respect to the standard design vehicle that is car (Chandra, 1995).

PCEi = (Vc/Vi) / (Ac/Ai)

Where
PCEi = passenger car equivalent value of the ith vehicle.
Vc/Vi = speed ratio of the car to the ith vehicle
Ac/Ai = space ratio of the car to the ith vehicle

3.3 Tables

Table 1: Dimension of Selected Vehicles

Vehicle Name	Length (m)	Width (m)	Area (m^2)
Bus	8.15	2.50	20.38
Mini-Bus	6.06	2.24	13.57
Truck	8.10	2.50	20.25
Medium Truck	5.23	2.33	12.19
Passenger Car / Pick Up / Jeep	4.37	1.52	6.64
CNG / Mahidra / Atul	3.05	1.52	4.64
Motor Cycle	2.20	1.00	2.20

Table 2: Factors Affecting PCE Values

Road Section	Road Name	Pavement Width (ft)	Directional Split (%)	% of Slow Moving Vehicle	Shoulder Condition
01	Fulbarigate	30	55:45	28	Fair
02	Daulatpur	41	57:43	25	Poor
03	New-Market	34	60:40	21	Good
04	Rupsa	38	52:48	32	Fair

Table 3: PCE value obtained from ANN for different road sections

Road Section	Road Name	PCE values Predicted from ANN						
		Car/ Pick up	Bus	Mini-Bus	Truck	Medium Truck	CNG / Mahindra	Motor Cycle
01	Fulbarigate	1.00	3.29	2.39	3.27	2.27	0.91	0.59
02	Daulatpur	1.00	3.26	2.28	3.21	2.11	0.98	0.55
03	New-Market	1.00	3.17	2.47	3.33	2.31	0.90	0.61
04	Rupsa	1.00	3.06	2.32	3.41	2.19	0.88	0.54

Table 4: Standard Value of PCE According to RHD (MoC, 2000)

Vehicle Type	Car	Bus	Mini-Bus	Truck	Medium Truck	CNG	Motorcycle
PCE Value	1.00	3.00	3.00	3.00	3.00	0.75	0.75

Table 3 shows the PCE value obtained from ANN for different road sections and Table 4 shows the standard values of PCE according to Roads & Highway Department. It can be seen that PCE values for buses and trucks is almost near to the standard results given by

Roads & Highways Department. But, in case of other vehicles (mini-bus, medium truck, CNG and motorcycle) the obtained value of PCE is deviated from the standard values. This deviation occurs due to faulty road geometry, insufficient roadway width, poor shoulder conditions, frequent side roads enter, increasing amount of slow moving vehicles on the road, etc. The speed of the vehicles is restricted when slow moving vehicles move through the same lane and speed breakers placed after certain distance. Also, pedestrians move from one side to another by avoiding rules which breaks driver's attention and hence speed is decreased. PCE value of any vehicle is greatly hampered due to these speed restrictions. Furthermore, hawkers and parking vehicles on the road consume a portion of roadway width. For this reason, the vehicles moving on the road can't get sufficient space for free movement and hence reduce speed & roadway capacity.

4. CONCLUSIONS

In the present study, an Artificial Neural Network based model is developed by using four well identified affecting factors such as pavement width, shoulder condition, directional split and percentage of slow moving vehicle for the estimation of PCE values for different types of vehicles on Khulna metropolitan city. In this Artificial Neural Network based analysis 1000 iterations was used. The number of neuron was kept as ten in the hidden layer. The PCE values obtained from ANN for Bus and Large Truck is within the range of 3.00 to 3.50, for Mini-bus and Medium Truck 2.00 to 2.50, for Motorcycle 0.50 to 0.60 and those for CNG 0.80 to 1.00. The results so obtained are compared with the quoted results in the literature and high degree of correlation is observed. This will open a new direction for the traffic engineers for accurate easy estimation of PCE value and hence traffic volume, capacity and level of service in any situation giving due weightiness to different affecting parameters.

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