PASSENGER CAR UNIT VALUES AT SIGNALISED INTERSECTIONS FOR SRI LANKA

by

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Introduction

The Passenger Car Unit (PCU) values for various types of vehicles in a traffic stream are important parameters for traffic engineering and planning purposes. For example, PCU values are widely used in designing controlled intersections with light signals, roundabouts, turning prohibitions etc. The PCU values are also used in traffic management schemes such as uniflow systems, tidal (reversible) flows, bus only lane designs etc.

The PCU values applicable for a particular road-vehicle-environment-driver behaviour system are not readily transformable to another system. For instance, PCU values applicable in a developed country is not suitable for designing and planning purposes in a developing country. The vehicle composition and age, road conditions, driver behaviour, and other traffic considerations are different from country to country.

Although PCU values are widely used by traffic engineers and planners, the methodology of determining PCU values is not well documented. Usually, the engineers and planners in developing countries extract the PCU values from standard manuals like Road Research Laboratory (1) or Transportation Research Board (2), which have been obtained in a different environment.

This paper describes a simple cost effective method of determining the PCU values at a signalised intersection under saturated flow conditions. Neither a test track nor any sophisticated equipment are required in this method. The values obtained from this method for Sri Lanka are compared with PCU values from U.K., Canada and India.

The Road Research Laboratory, U.K. (1), now known as Transport and Road Research Laboratory, employed the method of determining the passenger car unit of a vehicle at a signalised intersection by noting the time headways between individual pairs of vehicles in a test track. However, Kimber et. al (3) describes a similar method which does not require a test track. The Central Road Research Institute, India (4), has evaluated PCU values for different categories of vehicles, by considering the ratio of congestion of a particular type to that of the passenger car. Bhattacharya and Mandal (5) investigated the effect of PCU values due to cycle time, clearance time, time headways, lag time, clearing length of the approaches etc. They formulated a generalised model for determination of PCU values at a signalised intersection and determined the variations in PCU values. Teply (6) used an optimisation technique to determine PCU values under saturated flow conditions at a signalised intersection.

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Proposed Methodology

The PCU values are determined under the saturated flow conditions. Variation of PCU values during the green period is neglected in the methodology adopted in this paper. It is assumed that the measurements were made during similar conditions. Therefore, the following mathematical model can be formulated to determine the PCU values.

$$T = L + H_c N_c + \sum_{i \in n} h_i N_i \qquad (1)$$

where T = vehicle counting period in a green period

L = any lost time in the period T

H_c = the average time headway for a car to pass the stop line

N_c = the number of cars counted in the period T

h_i = the average time headway for a vehicle i to pass the stop line

N_i = the number of type i vehicle counted in the period T

The PCU value for the i^{th} vehicle type is given by the following equation.

$$PCU_i = h_i / h_c \qquad (2)$$

Hence, if h_i values and h_c are known, then the PCU values for different types of vehicles can be determined.

The equation (1) defines that the vehicle counting period T during a saturation flow period of the green phase is composed of any lost time and the total vehicular discharge time across the intersection stop line. The equation (1) takes into account the respective time headways of individual types of vehicles in calculating the total vehicle discharge time. For that purpose, the average time headway of a particular vehicle type i is assumed to be h_i. Hence the discharge time of a particular vehicle type i, which had N_i vehicles crossing the stop line during the counting period is $h_i N_i$.

The equation (2) provides the definition of PCU values. This equation is based on the Road Research Laboratories (1) definition for PCU values. This definition has been previously described in this paper.

The N_i values in equation (1) are obtained by the traffic survey. The description of the survey procedure is described later in the paper. When the survey is conducted for several green periods, a large number of simultaneous equations can be obtained using equation (1). In this set of equations, the variable T, N_c and all N_i are known. Therefore when a multiple regression is carried out with T values as the dependent variable, and N_c and N_i values as independent variables, the resulting regression coefficients yield the h_c and h_i values. The regression constant provides the lost time L.

Site Description

The Galle Road is the busiest highway corridor to the south of Colombo. The survey was conducted on Galle Road at Wellawatte, about 8 km south of Colombo city. The observations were made on the south bound traffic at the signalised T intersection with the W.A. Silva Mawatha. The layout of the intersection is given in the Figure 1.

At the survey location, the green period for the south bound traffic is approximately 30 seconds in a 75 second fixed cycle setting. During the south green phase, the right turning traffic movements from other approaches face a red phase. The traffic survey was conducted only on the centre lane of the south bound traffic which contains only

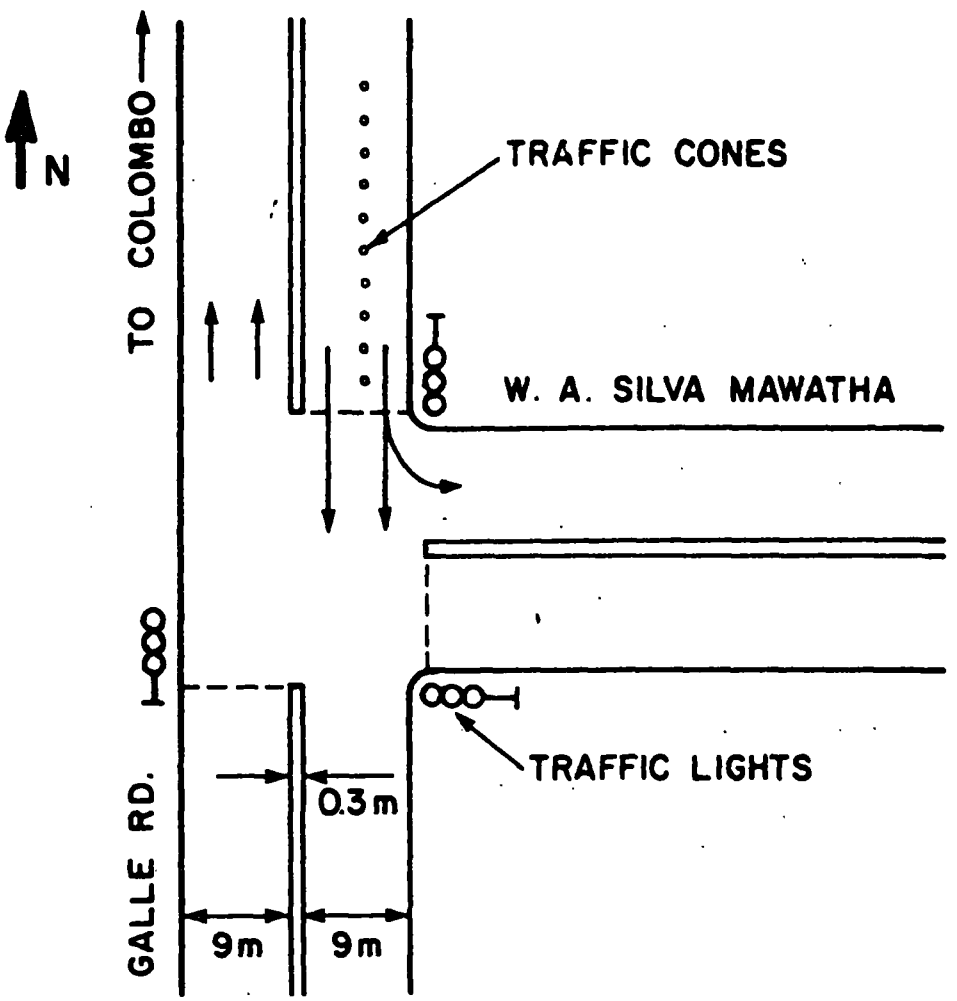

Figure 1. Layout of the Intersection.

the straight through traffic. No U-turns are allowed at the intersection.

There were no bus stops in the immediate proximity of the intersection. During the survey, there were no parked vehicles close to the intersection. With Police assistance, all the pedestrians were compelled to use the overhead pedestrian bridge near the intersection. Guard rails are provided at the intersection to prevent jay walking.

The road surface at the intersection is relatively good, and consists of a curb. The speed limit in the area near the intersection is 48 kmph (30 mph).

The three approaches are straight and are on level ground. They have no lane markings except for the stop lines. Therefore, traffic cones were placed to form 2 south bound lanes approaching the intersection. This temporary lane separation was in effect for a length of approximately 50 meters.

Survey Method

Three persons participated in the data collection procedure. One person was responsible for timing the green phase with the aid of a stop watch and informed the time to begin and terminate vehicle counting.

Table I - Vehicle Types

	Vehicle Type	Description
1)	Passenger Car	All types and sizes of saloon and sports cars, station wagons, taxis.
2)	Vans	Light Commercial Vehicles and passenger carrying vehicles of 10-20 seats capacity.
3)	Small Buses	Seating Capacity 25-39
4)	Medium Buses	Seating Capacity 40-59
5)	Large Buses	Seating Capacity more than 59
6)	Small Trucks	Goods vehicles. (Generally known as "half sized lorries". Maximum tare weight 1.7 metric ton).
7)	Large Trucks	Goods vehicles ("Full sized lorries"). Maximum 3 axels.
8)	Trishaws	Motor driven 3 wheeled vehicle.
9)	Motorcycles	Two wheeled power driven vehicles. Includes scooters.
10)	Pedal Cycles	Two wheeled pedal driven cycles.

In order to ensure saturation flow conditions, the vehicle counting began 5 seconds after the beginning of the green phase. The counting was terminated at 25 seconds from the beginning of the green phase. If there were no vehicles immediately following a vehicle at any instance during the counting period or contained a vehicle type not described in the Table 1, then the data collected during the particular green period was removed from the data set. The data were required at saturation traffic flow conditions. Therefore, vehicles were not counted in the first 5 seconds to remove any initial unsaturated flow. The traffic flow was deemed to be saturated throughout the 20 seconds period if there was a steady stream of vehicles.

The second person in the survey classified the vehicles crossing the stop line by visual identification, and immediately reported the classification to the third person. The third person recorded the sequence of vehicles orally reported by the second person. Perhaps the survey can be conducted with only two persons by combining the duties of the second and third persons.

The survey was conducted for a period of about one and a half hour a day for 5 weekdays. There were 232 useable equations in the form of equation (1) from the traffic survey.

Method of Computation

For each time period of 20 seconds the respective N_i values in equation (1) were obtained manually from the data sheets. Since the data were collected during the saturation period, the initial and final lost time, the L, in equation (1) is assumed to be zero.

The multiple linear regression was conducted using the SPSS computer package for the above data. The regression curve was fitted through the origin because the lost time is zero for the counting period. At this stage, the pedal cycles showed an insignificant t-statistic. Therefore, all the equations containing the pedal cycles were removed from the data set. The remaining 196 simultaneous equations were used for the regression analysis.

At the next step of the analysis, a statistical test was performed to determine whether significant differences of headways existed between different categories of vehicles [Walpole and Myers, (7)]. This test allows to group some vehicle categories into one class of vehicles with the same headway characteristics.

At 10% significance level the 6 Vehicle Types given in Table II remain as statistically different. The final regression analysis performed on the basis of these new groupings are given in the Table II.

The PCU values are obtained from the above headways using equation 2. The PCU values are reported in the Table III.

Table III also shows the comparison of the PCU values obtained for Sri Lanka from the above procedure with those reported in Canada [Teply (6)], United Kingdom [RRL (1)] and India [Bhattacharya and Mandal (5)].

Conclusions

The procedure adopted for the determination of PCU values in this paper is a simple, low cost method which could be effectively used in any developing country. Further, this method can be extended to determine the PCU values in urban and rural roads under saturation flow conditions. In such cases, if the numbers of vehicles in different categories passing a section of the road are determined for a given period, then,

Table II - Headway parameters after final regression with modified vehicle groupings

Vehicle Type		Time Headway (seconds)	Standard Deviation of Time Headway	t-statistics
(1)	Passenger cars	1.750	0.090	19.43
(2)	Vans	2.040	0.202	10.10
(3)	Large & Medium buses and large trucks	2.210	0.362	6.10
(4)	Small buses and small trucks	1.640	0.531	8.03
(5)	Trishaws	0.582	0.419	1.40
(6)	Motorcycles	0.862	0.144	6.00

Standard deviation of T = 3.52

R square = 0.97

Table III - Comparison of PCU values

Vehicle Type		PCU Values			
		Sri Lanka	Canada	U.K.	India
(1)	Passenger Cars	1.00	1.00	1.00	1.00
(2)	Vans	1.20	0.9	1.00	--
(3)	Large and Medium buses and large trucks	1.25	1.4	2.25	2.30
(4)	Small buses and small trucks	0.90	0.9	1.00	1.50
(5)	Trishaws	0.35	--	--	--
(6)	Motorcycles	0.50	0.6	0.33	0.35

their time headways can be calculated using regression analysis.

The comparison of PCU values given in Table III shows that the values for Sri Lanka differ from the values reported for Canada, U.K. and India. The required statistical test could not be conducted to check the compatibility of the PCU values in different countries due to the unavailability of standard deviation of time headways for the other countries.

The relatively low PCU value obtained for Sri Lanka for the category of small buses and small trucks may be attributed to the fact that the fleet of small private buses operating in Colombo is comparatively new. The difference in driver behaviour between passenger cars and the category consisting of small buses and trucks could also be another factor which reduce the PCU values for the latter category.

The comparatively higher PCU value obtained for motorcycles may be due to the low engine capacity of most motorcycles in Sri Lanka. In general there are more than one rider in motorcycles in Sri Lanka. This high occupancy may also contribute for a comparatively high PCU value for motorcycles in Sri Lanka.

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