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The Study of Effect of Road Width on Passenger Car Units (PCU) of Vehicles under Heterogeneous Traffic Conditions

by

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A THESIS

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DEPARTMENT OF CIVIL ENGINEERING

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ABSTRACT

Passenger car units (PCU) are used to represent the effects of varying mixed vehicle types on traffic stream. In this paper the required data is collected at eight sections of main highways of Nepal using a digital video recorder which eventually analyzed the traffic characteristics and PCU values was calculated. The study found traffic composition of Bus, Truck, LCV and Car are increasing with the increase in carriageway width but the composition of volume is found to be highest in smaller carriageway width. The speeds of all categorized vehicles are increasing linearly with the increase in carriageway width. It is found that PCU values obtained for motor cycle from all sections are smaller than the values given in NRS and for Bus, Truck, LCV found higher than the value given in NRS 2070 .This study has shown the impact of lane width on the PCU for different categories of vehicles on a Highways. It is found that the PCU for a vehicle type increases with increasing carriageway width.

Keywords: Traffic composition, Speed, Passenger Car Units

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LIST OF SYMBOLS AND ABBREVIATIONS

m	Meter
m^2	Square Meter
S	Second
h	Hour
W	Carriageway Width
m^2	Square Meter
km/h	Kilometer per hour
Vc	Speed of car (km/h)
Vi	Speed of i^{th} type vehicle (km/h)
Ac	Static (projected rectangular) area of a car (m^2)
MCUi	Motorcycle Equivalent Unit of type i vehicle;
Vmc	Mean speed of motorcycles (Km/h)
Vi	Mean speed of motorcycles and type i vehicle, respectively (Km/h)
Amc	The respective projected rectangular area (length x Width) of motorcycles
Ai	The respective projected rectangular area (length x Width) of type I vehicle on the road respectively (m^2)
PCU	Passenger Car Unit
LCV	Light Commercial Vehicle
NRS	Nepal Road Standard
NRRS	Nepal Rural Road Standard
HCM	Highway Capacity Manual
IRC	Indian Road Congress
LOS	Level of Service

CHAPTER ONE - INTRODUCTION

1.1 Background

Nepal road traffic is heterogeneous in nature consisting of vehicles of wide ranging physical dimensions, weight and power sharing the same lane. It is not feasible to improve the standard of road by very small increments and it is standard practice to design and construct new roads and improvement works to withstand the estimated traffic at some future date. In Nepal this forward period (perspective period) shall be 20 years, i.e. roads shall be designed with a capacity sufficient to cater for the estimated traffic volume 20 years after the date of completion of the works.

Different types of vehicles take up differing amounts of road space and have different speeds (For geometric design) and impose differing loads on the road structure (For structural design. It is, therefore, necessary to adopt a standard traffic unit to which other types of vehicles may be related. For geometric design of roads this standard is the 'Passenger Car Unit (PCU)' which is that of a normal car (passenger car), light van or pick-up. Other types of vehicles are taken into account by multiplying by the following equivalency factors (Nepal Road Standard 2070).

In Nepal, Nepal Road Standard 2070 and Nepal Rural Road Standard 2071 has specified PCU values for different vehicle types also such as car, truck, trailer tractors, handcarts, motor cycle, rickshaws, bullock carts etc. and these values are adopted from Indian road standards for rural and urban roads.

The present study was undertaken to identify the effect of width of the carriageway as the lane concept is not strictly followed in Nepal and vehicles tend to move abreast. The term carriageway is used in Nepal for the total width of paved surface of a road excluding its shoulders on the capacity of a two-lane road under mixed traffic conditions.

1.2 Statement of Problem

The PCU values of different types of vehicles, proposed by NRS are in the form of single set of constant values. Hence, it may be inferred that the PCU values are valid for a particular traffic and roadway condition. However, the PCU value of a vehicle category may not be constant as referred by NRS, because it may vary not only on the base of vehicle factors but also with several other factors associated with roadway and

traffic conditions. This thesis intends to find the variation of PCU of vehicles on relation with carriage way width.

1.3 Research Objectives

The present study is under taken with the following objectives:

- To determine the value of PCUs for mix traffic condition of moving vehicles in the traffic stream.
- To determine the relations between the PCU and Carriage way width and to study the effect of road width on PCU of vehicles.

1.4 Limitations

There are certain limitations in the research and are recommended for further study. The limitations of study of the research are:

- The data is collected on at different sections highways with same road surface condition on straight portion. All are straight, level, and free from any restriction to traffic movement.
- The study is limited to effect of road width only and not to the effect of other influencing parameters like gradient, shoulder width, pavement surface roughness.
- Observation is done only of week days. The study of weekends and public holidays are not done due to limited time.
- Only the total longitudinal trap of 20 m is done on the carriageway for the measurement of speed because of problems of coverage of trap length by camera.

1.5 Organization of Thesis

This thesis consists of five chapters.

The first chapter gives the brief introduction to the topic. It includes background of the study, objectives, statement of problem and limitations of the study.

The second chapter is literature review. This chapter includes effect of Lane Width of road on PCU values under mixed traffic conditions of highways.

The third chapter provides details on the methodology used to conduct this study. It includes the topics as: source of data, site selection, data collection and extraction.

The fourth chapter is Data Analysis and Report. This chapter presents the analytical results obtained and brief discussion of them. This includes analysis of traffic distribution, speed distribution, determination of PCU values and effect of carriage way width on PCU values of different vehicles at different locations.

The fifth chapter provides a comprehensive conclusion and recommendations.

CHAPTER TWO – LITERATURE REVIEW

Amit Shrestha (2010) on his study on motorcycle traffic stream characteristic in Kathmandu valley used motorcycle as a common unit for converting heterogeneous traffic into homogenous traffic for volume estimation. The motorcycle unit (MCU) for each type of vehicle in this study was developed with a consideration of dynamic characteristic of moving vehicles. That factor expresses the correlation about speed and occupied space between the mode taken into consideration and a motorcycle. The formula which was used for calculation of MCU is

$$MCUi = (Vmc /Vi) / (Amc/Ai)$$

Where,

MCUi : Motorcycle Equivalent Unit of type i vehicle;

Vmc, Vi: Mean speed of motorcycles and type i vehicle, respectively (Km/h);

Amc, Ai: The respective projected rectangular area (length x Width) of motorcycles and type I vehicle on the road respectively (m^2)

The variations in the MCU values observed in the study are tabulated below:

Table 2.1: MCU factors as estimated at different locations

Section	MCU for Vehicle type				
	Cycle	Motorcycle	Car	Mini Bus	Bus
3.6 m	1.46	1	5.29	13.22	27.10
3.25 m	1.35	1	5.21	12.61	26.32
2.95 m	1.08	1	4.92	12.60	26.49

Sambriddhi Shrestha (2013) on her study in development of saturation flow and delay models for signalized intersection in Kathmandu used multiple regression analysis for determination of PCU values. The vehicles were divided into six different categories: Car, Bus, Truck, Microbus, Two-Wheeler and Tempos. The study found that the values of PCU values of particular vehicle type are not constant for all the intersections. This finding reestablished the fact that unified passenger car unit concept for different vehicles do not always hold good for non-lane traffic based condition.

Satish Chandra and Upendra Kumar (1996) used speed based concept to estimate the

passenger car unit PCU of different types of vehicles under mixed traffic conditions. It utilized the area, as opposed to only the length, and speed of a vehicle. Data were collected at ten sections of two-lane roads in different parts of India. The width of carriageway-this term is commonly used in India for the total width of the paved surface of a road excluding its shoulders ranged from 5.5 to 8.8m. All vehicles were divided into nine different categories and their PCU's were estimated at each road section. The PCU values for different types of vehicles as calculated at different sections show the linear variation in PCU for different types of vehicles with lane width at different sections. The relationship between PCU and Carriageway width is give below in Table 2.2. It was found that the PCU for a vehicle type increases linearly with the width of carriageway. This is attributed to the greater freedom of movement on wider roads and therefore a greater speed differential between a car and a vehicle type.

Table 2.2: Calculation of Passenger Car Unit Factors

Vehicle Type	Relation between passenger car unit and carriageway width (w)	R^2 Value
Bus	PCU = 0.1114w + 3.073	0.92
Truck	PCU = 0.146w + 4.40	0.95
LCV	PCU = 0.097w + 1.956	0.99
Three- Wheeler	PCU = 0.168w + 0.327	0.95
Two-Wheeler	PCU = 0.017w + 0.158	0.97
Cycle	PCU =0.034w + 0.225	0.99
Rikshaw	PCU = 0.054w + 1.132	0.97

A.R Khanorkar, S.D Ghodmare and Dr. B.V Khode (2014) studied impact of Lane Width of Road on Passenger Car Unit values under Mix Traffic Condition in Cities on Congested Highways, it was found PCU values obtained for motor cycle, auto rickshaw, from all sections are smaller than the values given in IRC and for Truck, Trailer and L.C.V found higher than the value given in IRC 64-1990 Code .This study has shown the impact of lane width on the PCU for different categories of vehicles and on the capacity of a two-lane Highways. It is found that the PCU for a vehicle type increases with increasing lane width and impact of highway lane width

on the PCU is apparently linear. The main aim of this study was to assess the credibility of PCU given in IRC for the present type traffic and Highway way condition. The Table 2.3 below shows relationship between carriageway width and PCU values.

Table 2.3: Relationship between Carriageway Width and PCU Values

Vehicle Type	Relation between passenger car unit and carriageway width (w)	R^2 Value
Bus	PCU = 0.124w + 2.073	0.893
Truck	PCU = 0.15w + 4.50	0.805
LCV	PCU = 0.095w + 1.96	0.85
Three- Wheeler	PCU = 0.165w + 0.33	0.96
Two-Wheeler	PCU = 0.0169w + 0.158	0.92
Cycle	PCU =0.032w + 0.31	0.95
Rikshaw	PCU = 0.0384w + 1.108	0.98

Hossain and Iqbal (1999) studied the vehicular free speed characteristics on two-lane national highways and effect of width on PCU values in Bangladesh. An analysis revealed that the free speeds of commonly available vehicles follow a normal distribution. A linear regression analysis was conducted to explore the relationship between free speed and the pavement and shoulder widths. It has been found that increase in width is resulting in higher PCU value for vehicles.

Leong (1968) measured speed and capacity at 31 sites on rural highways in New South Wales. The sites had varying lane and shoulder widths and all sites had gravel shoulders. The data were analyzed using multiple regressions and it was suggested that speed increased with increasing shoulder width. In particular, it was reported that the speed increases with the carriage way width.

Farouki and Nixon (1976) studied the effect of carriageway width on speed of cars in the special case of free flow conditions in sub-urban roads in Belfast. It was found that the mean free speed of cars in a suburban area increases linearly with the carriage width over a certain range of width from 5.2 to 11.3 m.

In the past, various techniques have been adopted for estimation of PCU of vehicles.

Werner and Morall (1976) suggested a headway ratio method to determine PCU values at low levels of service. Aerde and Yagar (1984) used speed parameters to estimate the PCU of trucks, recreational vehicles, and other vehicles on a two-lane highway. Thorne (1965) used a regression analysis technique to find the PCU for buses. Craus et al. (1980) suggested another approach to determine the PCU of trucks on a two-lane highway by considering the actual delay caused by trucks and opposing traffic. Elefteriadou et al. (1997) used a simulation technique with speed as the performance measure.

Krammes and Crowley (1986) have indicated that the variables, which are used to define the LOS should be used to estimate the PCU values also. The LOS on a segment of highway is defined in terms of operating speed (Highway Capacity Manual (HCM) 2000). Therefore, speed is considered a prime variable to determine the relative effect of individual vehicles on the traffic stream in terms of the PCU.

According to the study done by Muhammad Adnan (Department of Urban and Infrastructure Engineering, NED University of Engineering and Technology, Karachi,75270, Pakistan) on estimation of PCE factors for heterogeneous traffic environment prevailing in urban arterials of Karachi city, Pakistan using four methods Time Headway based Methods, Speed Based method, Method based on Multiple Regression Analysis showed the results reported are plausible and explainable; however, there are significant differences noted when obtained values are compared for the four methods and what followed in Karachi. Yahya Saaaraj (2012) developed PCU factors for buses and animal driven carts at signalized intersections in Gaza City. Justo and Tuladhar (1984) concluded that the PCU value of each vehicle category is constant, but varies with several factors such as traffic composition, volume to capacity ratio and other factors associated with roadway, traffic and environment.

Malliarjuna and Rao (2006) used area occupancy in place of density, as equivalency criteria to estimate the PCU values for buses, trucks and motorized two-wheelers. The estimated PCU values, for all the considered vehicle categories are found to decrease with increase in their respective proportion. Recently, a study on Dynamic PCU Value for Urban Roads is carried out by Bais (2007) in the School of Planning and Architecture which provides the variation of PCUs of different types of vehicles as

against change in traffic volume along with change in composition of vehicle.

Chandra and Skidar (2000) observed that PCU for a vehicle type is mainly controlled by homogeneity / heterogeneity of the traffic stream, which in turn, depend upon the relativity proportion of different types of vehicle. PCU for large size vehicle i.e. bus/truck increases and for small size vehicle like 3 wheeler and 2-wheeler decreases with increase in their own proportions in traffic stream. The basic philosophy involved in the development of concept of dynamic PCU is that capacity estimation in a common unit must be same irrespective of stream composition under given physical and controlled conditions. It has been found that method that incorporate vehicles speed along with projected area of vehicles are provide appropriate estimate of PCE values using Speed based method given by (Chandra and Skidar 2000). One important notion because of which speed method is more superior to other methods for calculation of PCU is the incorporation of dynamic and static characteristics of vehicle types; on the other hand headway methods are just based on dynamic characteristics of the vehicles.

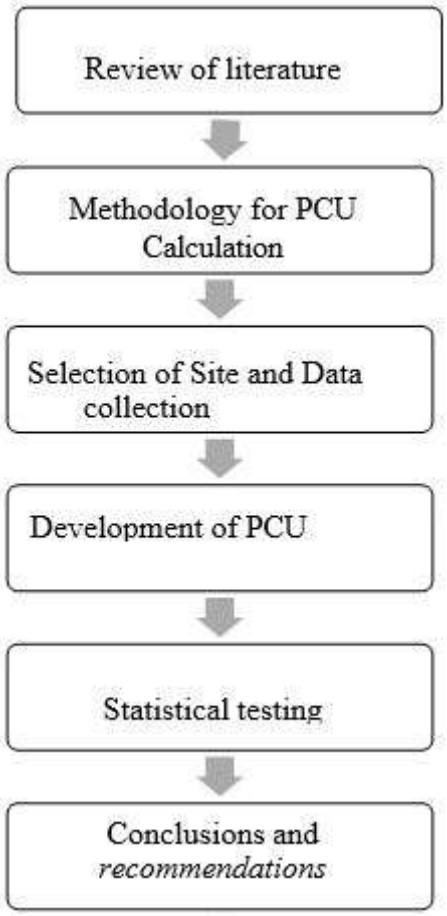
According to HCM 1965, PCE was defined as "number of passengers' car displaced in the traffic flow by a truck or a bus, under the prevailing roadway and traffic conditions. Most of studies used the following formula to work out the PCU vales for a particular mode.

PCU of a particular vehicle = (Ai x Vc) / (Vi x Ac), where Vc and Vi are speed of cars and particular vehicle i respectively and Ac and Ai are their influence area. The reason behind selecting the specific equation is it's widely used in the determination of PCU values for various modes of transport. In the study by Probhat Kr. Paul and P.K Sarkar an attempt has been made to build a number of relationships to appreciate the characteristics of different types of vehicles in regard to their performance and their effect on varying composition of the traffic stream. These include the studies of effect of the share of NMT and heavy vehicles on PCU values of Bus and bicycle, variation of PCU values of different modes of transport against the speed of traffic stream. This study forms the basis for formulation of dynamic PCU values under varying traffic flow composition and speed.

CHAPTER THREE – METHODOLOGY

3.1 Background

The key step by step procedures for applying methodology for determining PCU and its relationship with lane width for the study area are:



3.2 Source of Data

Primary data collected for this study. All the required information is collected from the required section via video-graphic recording. The necessary data were extracted manually via video replaying. Other useful information was recorded on field sheets. No any secondary data was used during the study.

3.3 Site Selection

The sites were selected so as to satisfy the following requirements:

1. There is flow of traffic all classified vehicles required for our study and of variable road width section.
2. It is away from bus stops and other facilities, which may cause the traffic flow to halt.
3. The section is straight and level.
4. An attempt was made to collect data at sites where the directional split of traffic was in the narrow range of 50 – 55%.
5. Data for this study was collected at eight different locations on highways in Nepal.

Location1: Dharke, Naubise

It is a section of Prithvi highway that is having a road width of 6.8 m with a good paved surface and both side shoulder of width 0.8m which is graveled surface. It is free from any encroachment and obstructions.

Figure 3.1: Dharke Site

Location 2: Manhari, Hetauda

It is a section of E-W highway that is having a road width of 6.7m with a good paved surface and both side shoulder of width 0.8m which is graveled surface. It is free from any encroachment and obstructions.

Figure 3.2: Manhari, Hetauda Site

Location3: Sanga

It is a section of Araniko highway that is having a road width of 6.6m with a good paved surface and both side shoulder of width 0.5 m which is graveled surface. It is also free from any encroachment and obstructions.

Figure 3.3: Sanga Site

Location 4: Budol, Kavre

It is a section of Araniko highway that is having a road width of 6.5 m with a good paved surface and both side shoulder of width 0.3 m which is graveled surface**.**

Figure 3.4: Budol Site

Location 5: Pashupatinagar, Hetauda

It is a section of E-W highway that is having a road width of 6.4 m with a good paved surface and both side shoulder of width 0.8 m which is graveled surface**.**

Figure 3.5: Pashupatinagar, Hetauda Site

Location 6: Panchkhal

It is a section of Araniko highway that is having a road width of 6.1m with a good paved surface and both side shoulder of width 0.8 m which is graveled surface**.**

Figure 3.6: Panchkhal Site

Location 7: Jhallari

It is a section of Jhallari, Mahendranagar section of East-West Highway having a road width of 5.8 m with a good paved surface and both side shoulder of width 0.7 m which is graveled surface**.**

Figure 3.7: Jhallari Site

Location 7: Kolfutar, Nuwakot

It is a section of roadway between Galchhi, Dhading to Bidur, Nuwakot having a road width of 5.1 m with a good paved surface and both side shoulder of width 0.3 m which is graveled surface.

Figure 3.8: Kolfutar Site

3.4 Data Collection and Extraction

- The video recording technique was used to collect the data. A longitudinal trap of 20 m was made on the carriageway for the measurement of speed.
- The video camera was mounted on the stand and placed sufficiently high so as to cover the total trap length with some margin on either side. The timer in the camera was switched on and the recording was done for about 4 – 5 hrs on a typical weekday.
- These data were supplemented with manually collected data on the road width, shoulder width, and shoulder condition. The details for these recorded data at each section selected for study is included in Annex-I.
- The recorded film was played on a large screen television and the desired information has been extracted. To make the analysis meaningful, the vehicles were divided into five different categories as shown in Table 3.1. The average dimensions of each vehicle category were measured either by actual field measurements or from the data available on supplier websites

in Nepal. Average dimensions and projected rectangular areas as per survey of each type of vehicle category are also given in Table 3.1.

- The average time taken by each vehicle type to travel the trap length was measured by the time displayed on the screen with an accuracy of 0.1 s. This time has been noted to calculate the speed of a vehicle passing through the section and minimum 300 data of each type of vehicle were extracted from every site.

Table 3.1: Vehicle Categories and their Average Dimensions

Category	**Vehicles included**	**Average dimension**		**Projected Area on Ground (m^2)**
		Length (m)	**Width (m)**	
Bus	Buses	11.12	2.49	27.74
Truck	Truck	7.5	2.35	17.62
Lcv	Minibus,mini truck, micro bus	6.10	2.10	12.81
Cars	Car, jeep, van	3.74	1.44	5.39
Two-wheeler	Scooters, motorcycles	1.87	0.64	1.2

Nepal automobile survey (2016)

CHAPTER FOUR – DATA ANALYSIS & REPORT

The data are analyzed to study the effect of varying lane width on passenger car unit. All vehicles were divided into five different categories and average dimensions and projected area of different type of vehicles as per survey.

4.1 Traffic Distribution

The proportion of vehicles in a traffic stream is very important parameter for geometric and structural design of any pavement. Analysis of traffic composition gives the idea of proportion of wide variety of vehicles. The study shows that Two-wheeler i.e. Motor cycles have the highest percentage in the traffic stream and truck, light commercial vehicle has the lowest percentage in the traffic stream and percentage of car shows slightly variation in volume of traffic. All these traffic distributions at different locations are presented through Table4.1.This study shows that two wheelers traffic is predominant at all the locations and the percentage shares of other vehicles are also given.

Table 4.1 Traffic Distribution at Different Locations

Section Name	Traffic Distribution of different vehicle (%)				
	Bus	**Truck**	**LCV**	**Car**	**Two-wheeler**
Dharke	13.3	2.7	7.3	17.1	59.6
Manhari	12.8	2.5	7.0	16.9	60.8
Sanga	10.5	2.1	6.7	16.5	64.2
Budol	13.5	1.8	5.8	16.2	62.7
Pashupatinagar	7.5	1.75	5.1	15.8	69.85
Panchkhal	6.6	1.6	4.8	14.2	72.8
Jhallari	15.8	1.4	4.5	14.1	64.2
Kolfutar	15.1	1.2	3.9	13.7	66.1

4.2 Speed Distributions

The PCU factor is based on the mean speed values of different vehicle classes. This is calculated by dividing the mean speed value of passenger cars by the mean speed value of any vehicle class. Therefore, a longitudinal trap of 20 m was made on the carriageway for the measurement of speed. The video was recorded and recorded film was played on a large screen television and the data was extracted. The average time

taken by each vehicle type to travel the trap length was measured by the time displayed on the screen with an accuracy of 0.1 s with the help of stop watch. This time was used to calculate the speed of a vehicle passing through the section. The average speed of different vehicle at different section of highways is illustrated in Table 4.2 below.

Table 4.2: Average Speed of Vehicles at Different Locations

Section Name	Speed of different vehicle (km/hr)				
	Bus	**Truck**	**LCV**	**Car**	**Two-wheeler**
Dharke	62.32	58.10	60.03	65.95	53.73
Manhari	61.68	57.27	59.37	64.98	53.47
Sanga	60.29	56.68	58.14	63.40	52.50
Budol	59.45	55.96	57.44	62.40	51.80
Pashupatinagar	59.16	54.99	56.69	61.12	51.06
Panchkhal	57.92	53.38	55.13	59.23	50.06
Jhallari	55.68	51.43	55.00	56.35	48.76
Kolfutar	51.88	49.85	49.39	50.45	48.21

The study shows that speed of all categories vehicles are increasing with the increasing linearly with the increase in carriageway width. The analysis carried out showing the effect of carriageway width on the speed of vehicles, resulting in development of following relationship**:**

For Bus

The study show that speed of Bus is increasing linearly with the increase in carriageway width with the relationship Speed= 5.958W + 21.30 with R^2 value 0.986.The statically testing of regression shows the p-value below zero which proves the significance of derived relationship between speed and carriageway as presented in Table 4.3.

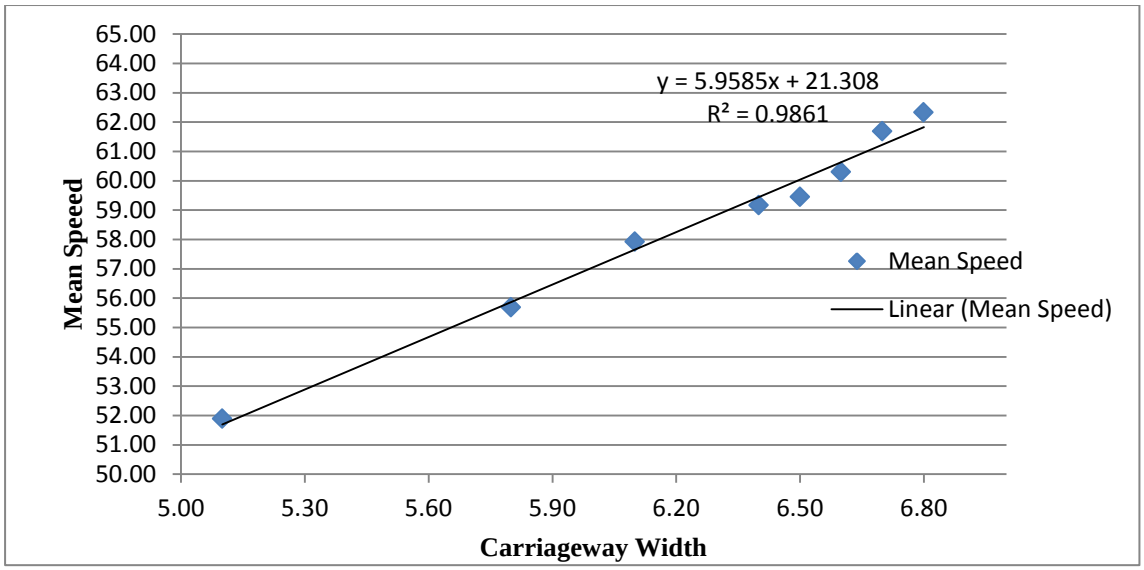


Figure 4.1: Bus; Relationship of speed with carriageway width

Table 4.3 Determination of Significance of Relationship of Speed of Bus with Carriageway width

Regression Statistics	
Multiple R	0.993
R Square	0.986
Adjusted R Square	0.984
Standard Error	0.434
Observations	8.000

ANOVA

	df	SS	MS	F	Significance F
Regression	1.000	80.239	80.2	425.087	0.000
Residual	6.000	1.133	0.18		
Total	7.000	81.371			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	21.308	1.813	11.7	0.000	16.872	25.743	16.872	25.743
X Variable 1	5.959	0.289	20.6	0.000	5.251	6.666	5.251	6.666

For Truck

The study also shows that the PCU values of vehicle type Truck are dependent on carriageway width and have linear relationship, where Speed =5.012W+23.38 with the R^2 value of 0.95. The statically testing of regression shows the P-value below zero which demonstrates the significance of derived relationship as presented in Table 4.4.

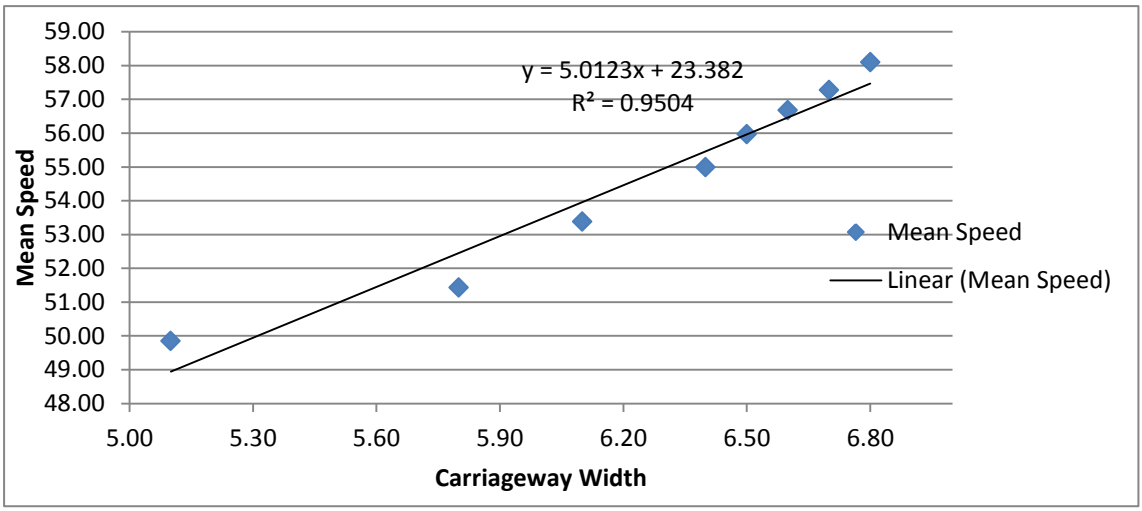


Figure 4.2: Truck; Relationship of speed with carriageway width

Table 4.4 Determination of Significance of Relationship of Speed of Truck with Carriageway width

Regression Statistics	
Multiple R	0.97
R Square	0.95
Adjusted R Square	0.94
Standard Error	0.70
Observations	8.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	56.78	56.78	115.08	0.00
Residual	6.00	2.96	0.49		
Total	7.00	59.74			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	23.38	2.93	7.98	0.00	16.21	30.55	16.21	30.55
X Variable 1	5.01	0.47	10.73	0.00	3.87	6.16	3.87	6.16

For LCV

Similarly, the study showed that the Speed of LCV are dependent on carriageway width and also have linear relationship between them. The linear equation of Speed with Carriageway width is Speed =5.808W+20.09 with the R^2 value of 0.966. The statically testing of regression shows the P-value below zero shows the significance of derived relationship.

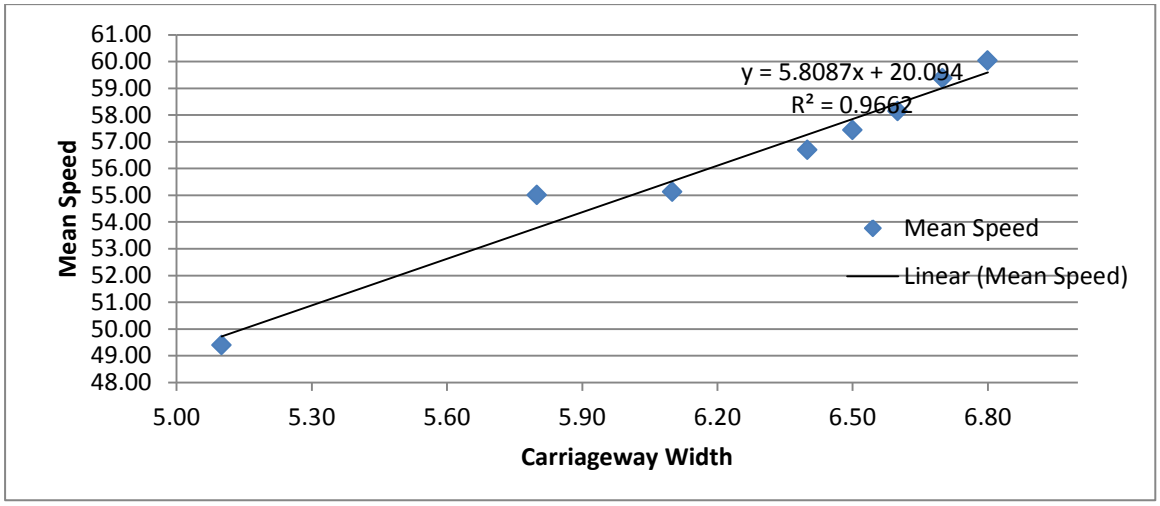


Figure 4.3: LCV; Relationship of speed with carriageway width

Table 4.5 Determination of Significance of Relationship of Speed of LCV with Carriageway width

Regression Statistics	
Multiple R	0.98
R Square	0.97
Adjusted R Square	0.96
Standard Error	0.67
Observations	8.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	76.25	76.25	171.28	0.00
Residual	6.00	2.67	0.45		
Total	7.00	78.93			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	20.09	2.78	7.22	0.00	13.28	26.91	13.28	26.91
X Variable 1	5.81	0.44	13.09	0.00	4.72	6.89	4.72	6.89

For Two-Wheeler

The study showed that the Speed of Two-Wheeler are dependent on carriageway width and also have linear relationship between them. The linear equation of PCU values with Carriageway width is Speed =3.412W+29.87 with the R^2 value of 0.881. The statically testing of regression shows the P-value below zero shows the significance of derived relationship.

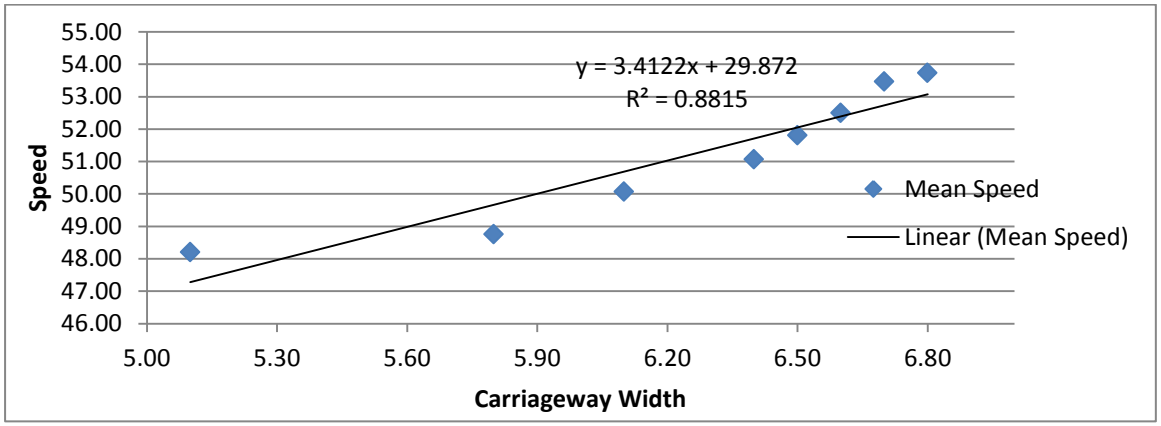


Figure 4.4: Two-Wheeler; Relationship of speed with carriageway width

Table 4.6 Determination of Significance of Relationship of Speed of Two-Wheeler with Carriageway width

Regression Statistics	
Multiple R	0.94
R Square	0.88
Adjusted R Square	0.86
Standard Error	0.77
Observations	8.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	26.31	26.31	44.61	0.00
Residual	6.00	3.54	0.59		
Total	7.00	29.85			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	29.87	3.20	9.32	0.00	22.03	37.71	22.03	37.71
X Variable 1	3.41	0.51	6.68	0.00	2.16	4.66	2.16	4.66

For Car

Similarly, the study showed that the Speed of Car are dependent on carriageway width and also have linear relationship between them. The linear equation of PCU values with Carriageway width is Speed =8.943W+4.589 with the R^2 value of 0.993. The statically testing of regression shows the P-value below zero shows the significance of derived relationship.

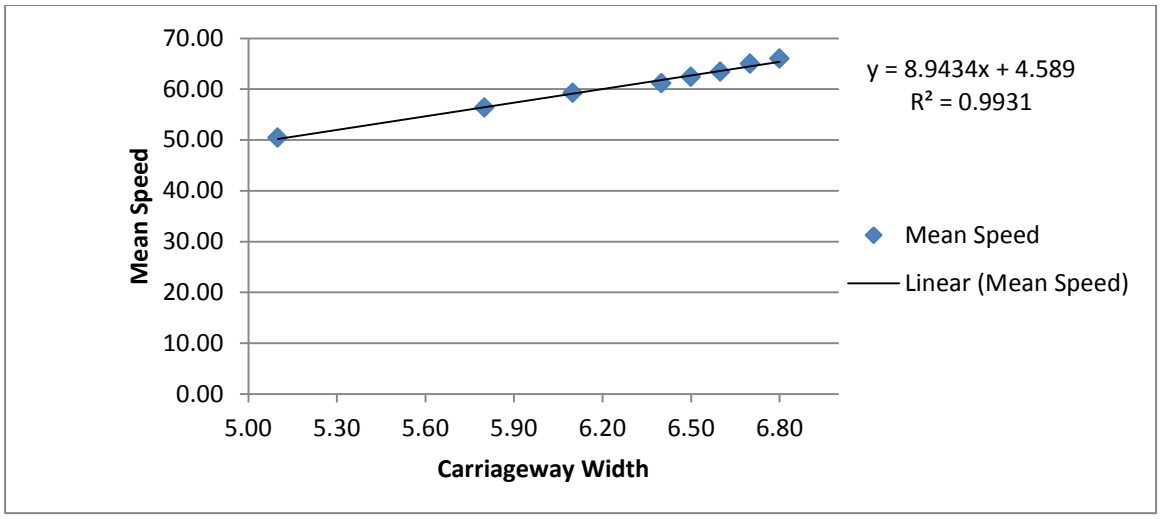


Figure 4.5: Car; Relationship of speed with carriageway width

Table 4.7 Determination of Significance of Relationship of Speed of Car with Carriageway width

Regression Statistics	
Multiple R	1.00
R Square	0.99
Adjusted R Square	0.99
Standard Error	0.46
Observations	8.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	180.76	180.76	867.56	0.00
Residual	6.00	1.25	0.21		
Total	7.00	182.01			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	4.59	1.90	2.41	0.00	-0.07	9.25	-0.07	9.25
X Variable 1	8.94	0.30	29.45	0.00	8.20	9.69	8.20	9.69

Determination of PCU Values

In this study, PCUs values on the highways are determined by using relation given by Chandra & Kumar (2003). The PCU values is directly proportional to the ratio of clearing speed of vehicle, and inversely proportional to the space occupancy ratio of vehicle with respect to the standard Area of vehicle i.e. a car, The PCU of a vehicle type is taken as given by Chandra and Kumar (2003). One important notion because of which speed method is more superior to other methods for calculation of PCU is the incorporation of dynamic and static characteristics of vehicle types; on the other hand headway methods are just based on dynamic characteristics of the vehicles.

$$PCU = (Vc/Vi)/(Ac/Ai)$$

- PCU= passenger car unit value of i^{th} type vehicle
- Speed ratio of the car to the i^{th} vehicle= Vc/Vi
- Space ratio of the car to the i^{th} vehicle=Ac/Ai
- Vc= speed of car(km/h)
- Vi= speed of i^{th} type vehicle(km/hr)
- Ac= static (projected rectangular)area of a car(m^2)
- Ai=static(projected rectangular) area of i^{th} type of vehicle(m^2)

The PCU values for different categories of vehicles calculated at different sections of highways are presented in Table 4.8.This shows the variation in PCU for different types of vehicles with lane width at different section. The PCU factor is based on the mean speed values of different vehicle classes.

Table 4.8: PCU Values for Different Categories of Vehicles Calculated at Different Sections

Section Name	Carriageway width (m)	Bus	Truck	LCV	Two-Wheeler
Dharke	6.8	5.446	3.711	2.611	0.273
Manhari	6.7	5.422	3.709	2.601	0.271
Sanga	6.6	5.412	3.657	2.592	0.269
Budol	6.5	5.402	3.645	2.582	0.268
Pashupatinagar	6.4	5.317	3.633	2.562	0.266
Panchkhal	6.1	5.263	3.627	2.554	0.263
Jhallari	5.8	5.208	3.582	2.435	0.257
Kolfutar	5.1	5.005	3.308	2.428	0.233

4.3 Effect of Carriageway Width on PCU Values of Different Vehicles

The analysis carried out showing the effect of carriageway width on the PCU values of different vehicles, resulting in development of following relationships:

For Bus

The study shows that the PCU values of vehicle type Bus are dependent on carriageway width and have linear relationship between them. The linear equation of PCU values with Carriageway width is PCU=0.260W+3.681with the R^2 value of 0.985.The statically testing of regression shows the P-value below zero which proves the significance of derived relationships as presented in Table 4.9.

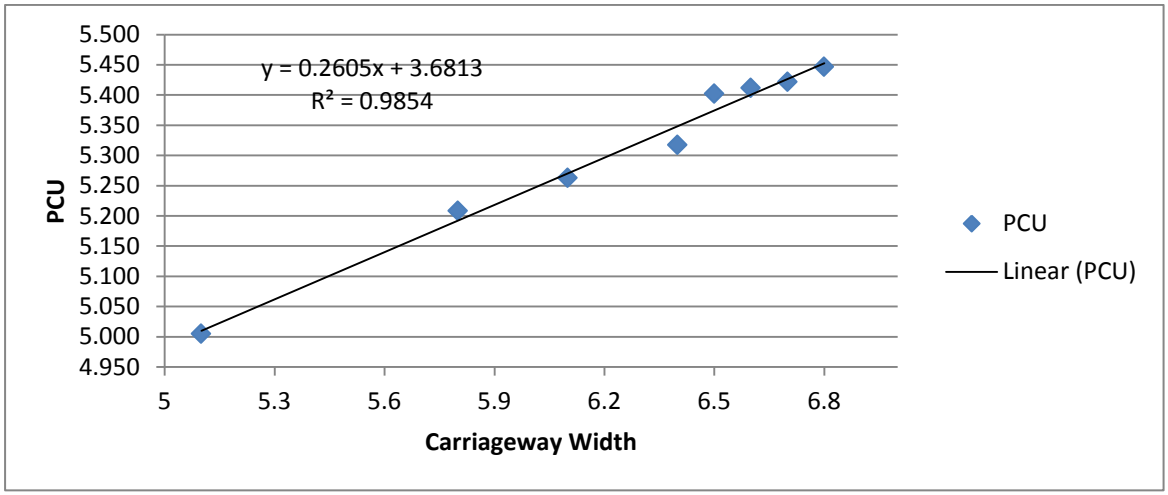


Figure 4 6: Bus; Correlation Chart of PCU with Carriageway width

Table 4.9: Determination of significance of relationship of PCU of Bus with carriageway width

Regression Statistics	
Multiple R	0.99
R Square	0.98
Adjusted R Square	0.98
Standard Error	0.016
Observations	8

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.153	0.153	405.591	9.73406E-07
Residual	6	0.002	0.000		
Total	7	0.155			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	3.681	0.081	45.371	7.68E-09	3.482	3.879	3.482	3.879
X Variable 1	0.260	0.012	20.139	9.73E-07	0.228	0.292	0.228	0.292

For Truck

The below figure illustrates the linear equation of PCU values with Carriageway width for vehicle Truck is PCU=0.214W+2.266 with the R^2 value of 0.899which shows the value of PCU is dependent on carriageway width. The statically testing of regression shows the P-value below zero shows the significance of derived relationships as presented in Table 4.10.

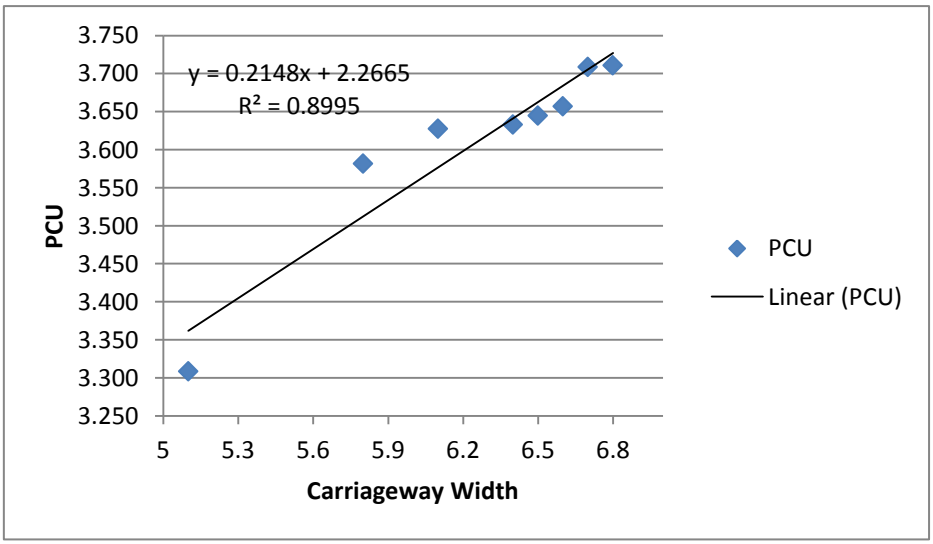


Figure 4.7: Truck; Correlation Chart of PCU with Carriageway width

Table 4.10: Determination of significance of relationship of PCU of Truck with carriageway width

Regression Statistics	
Multiple R	0.948
R Square	0.899
Adjusted R Square	0.882
Standard Error	0.044
Observations	8

	df	SS	MS	F	Significance F	
Regression	1	0.104	0.104	53.712	0.00033	
Residual	6	0.011	0.001			
Total	7	0.115				

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	2.266	0.183	12.32	1.74E-05	1.81	2.716	1.816	2.716
X Variable	0.214	0.029	7.328	0.00	0.14	0.286	0.143	0.286

For LCV

The study also shows that the PCU values of vehicle type LCV are dependent on carriageway width and have linear relationship, where PCU =0.120W+1.790 with the R^2 value of 0.883. The statically testing of regression shows the P-value below zero which demonstrates the significance of derived relationship as presented in Table 4.11.

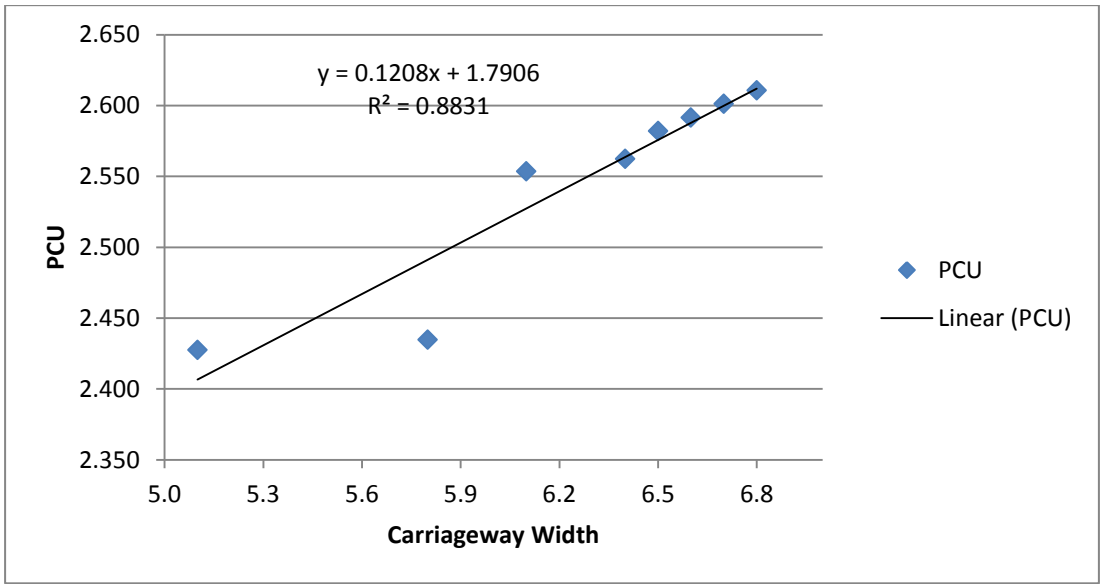


Figure 4.8: LCV; Correlation Chart of PCU width Carriageway width

Table 4.11: Determination of significance of relationship of PCU of LCV with carriageway width

Regression Statistics	
Multiple R	0.939
R Square	0.883
Adjusted R Square	0.863
Standard Error	0.026
Observations	8

ANOVA					
	df	SS	MS	F	Significance F
Regression	1	0.032	0.0329	45.343	0.0005
Residual	6	0.004	0.0007		
Total	7	0.03			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	1.790	0.112	15.91	3.91E-06	1.515	2.065	1.515	2.065
X Variable 1	0.120	0.017	6.733	0.0005	0.076	0.164	0.076	0.164

For Two-Wheeler

Similarly, the study showed that the PCU values of Two-Wheeler are dependent on carriageway width and also have linear relationship between them. The linear equation of PCU values with Carriageway width is PCU =0.022W+0.124 with the R^2 value of 0.944. The statically testing of regression shows the P-value below zero shows the significance of derived relationship.

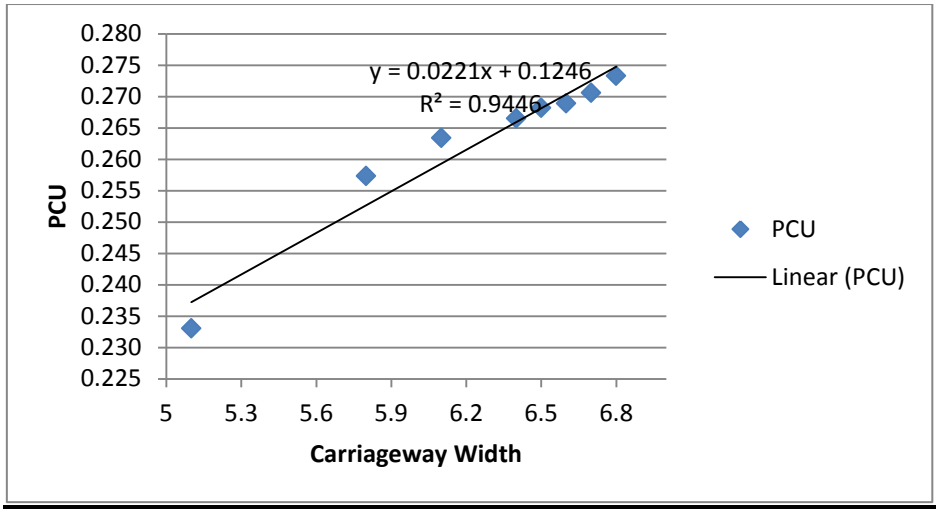


Figure 4.9: Two-Wheeler; Correlation Chart of PCU with Carriageway width

Table 4.12: Determination of significance of relationship of PCU of Wheeler with carriageway width

Regression Statistics	
Multiple R	0.971
R Square	0.944
Adjusted R Square	0.935
Standard Error	0.003
Observations	8

ANOVA					
	df	SS	MS	F	Significance F
Regression	1	0.001	0.001	102.266	5.43E-05
Residual	5	6.47E-05	1.08E-05		
Total	7	0.001			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	0.124	0.0137	9.09330	9.93E-05	0.091	0.158	0.091	0.158
X Variable 1	0.022	0.002	10.11267	5.43E-05	0.016	0.027	0.016	0.027

4.4 Summary of PCUs and Carriageway width Relationships

The overall summary of relationship of PCU of different types of vehicles with carriageway width and its respective R^2 Value are presented below in Table 4.13.

Table 4.13: Summary of Relationship of PCU of different types of vehicles with carriageway width

Vehicle Type	**Relation between passenger car unit and carriageway width (w)**	**R^2 Value**
Bus	PCU=0.260W+3.681	0.985
Truck	PCU =0.214W+2.266	0.899
LCV	PCU =0.120W+1.790	0.883
Two-Wheeler	PCU =0.022W+0.124	0.944

4.5 Effect of Traffic Composition on PCU Values of Different Vehicles

The analysis carried out using multiple linear regression equation considering traffic composition of different class vehicles in percentage of six different sites; Dharke, Manhari, Sanga, Budol, Pashupatinagar, and Panchkhal which are presented in above Table 4.1 and considering PCU values of different vehicles of respective sites calculated using speed based method. The analysis resulted in development of following relationships between traffic composition and PCU for classified vehicle types;

For Bus

The effect of traffic composition of different types vehicles on PCU have been studied using multiple linear regression analysis. The study shows that the PCU values of vehicle type Bus are dependent on traffic composition and have linear relationship between them. The linear equation of PCU values of Bus with traffic composition is

PCU of Bus =0.116522*traffic Composition Bus% + 0.277417*traffic Composition Truck% + 0.391674*traffic Composition LCV% + 0.205797*traffic Composition Car% + 0.157806*traffic Composition Two-wheeler% - 11.865 with the R^2 value of 0.766.

The statically testing of regression shows the P-value below zero which proves the significance of derived relationships as presented in Table 4.14.

Table 4.14: Determination of significance of relationship of PCU of Bus with Traffic Composition

Regression Statistics	
Multiple R	0.978
R Square	0.957
Adjusted R Square	0.766
Standard Error	0.047
Observations	6

ANOVA

	df	SS	MS	F	Significance F
Regression	5.000	0.149	0.030	16.794	0.006
Residual	1.000	0.007	0.002		
Total	6.000	0.156			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-12.641	0.060	2.036	0.001
Bus	0.117	0.018	12.329	0.000
Truck	0.277	0.021	2.110	0.001
LCV	0.392	0.037	2.868	0.064
Car	0.206	0.068	3.042	0.056
Two-wheeler	0.158	0.058	2.725	0.072

For Truck

Similarly the studies have been carried out to study the effect on PCU of truck by traffic composition of different types of vehicles. The relationship of PCU values of truck with traffic composition is

PCU of Truck=1.110639*traffic Composition Bus% + 0.705986*traffic Composition Truck% + 0.283343*traffic Composition LCV% + 0.20817*traffic Composition Car% + 0.059557*traffic Composition Two-wheeler% -22.547 with the R^2 value of 0.864.

The statically testing of regression shows the P-value below zero shows the significance of derived relationships as presented in Table 4.15.

Table 4.15: Determination of significance of relationship of PCU of Truck with Traffic Composition

Regression Statistics	
Multiple R	0.940
R Square	0.883
Adjusted R Square	0.864
Standard Error	0.027
Observations	6.000

ANOVA					
	Df	SS	MS	F	Significance F
Regression	5.000	0.099	0.020	4.496	0.002
Residual	1.000	0.017	0.006		
Total	6.000	0.116			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-21.969	0.014	1.911	0.002
Bus	1.111	0.064	2.973	0.002
Truck	0.706	0.050	2.092	0.003
LCV	0.283	0.015	2.011	0.001
Car	0.208	0.017	1.950	0.001
Two-wheeler	0.060	0.091	2.232	0.001

For LCV

The study also shows that the PCU values of vehicle type LCV are dependent on traffic composition and have linear relationship, where

PCU of LCV=0.414796*traffic Composition Bus% + 0.327521*traffic Composition Truck% + 0.127493*traffic Composition LCV% + 0.094549*traffic Composition Car% + 0.06289*traffic Composition Two-wheeler% -10.178 with the R^2 value of 0.878.

The statically testing of regression shows the P-value below zero which demonstrates the significance of derived relationship as presented in Table 4.16.

Table 4.16: Determination of significance of relationship of PCU of LCV with Traffic Composition

Regression Statistics	
Multiple R	0.932
R Square	0.891
Adjusted R Square	0.878
Standard Error	0.027
Observations	6.000

ANOVA					
	Df	SS	MS	F	Significance F
Regression	5.000	0.032	0.006	4.573	0.002
Residual	1.000	0.005	0.002		
Total	6.000	0.037			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-10.086	0.053	0.858	0.005
Bus	0.415	0.029	7.329	0.000
Truck	0.328	0.085	1.148	0.002
LCV	0.127	0.021	1.050	0.004
Car	0.095	0.060	1.572	0.002
Two-wheeler	0.063	0.051	1.221	0.003

For Two-Wheeler

Similarly, the study showed that the PCU values of Two-Wheeler are dependent on traffic composition and the linear equation of PCU values with Carriageway width is

PCU of Two-wheeler = 0.112134*traffic Composition Bus% + 0.104811*traffic Composition Truck% + 0.044259*traffic Composition LCV% + 0.0239*traffic Composition Car% + 0.021099*traffic Composition Two-wheeler% -3.481 with the R^2 value of 0.819.

The statically testing of regression shows the P-value below zero shows the significance of derived relationship.

Table 4.17: Determination of significance of relationship of PCU of Two-Wheeler with Traffic Composition

Regression Statistics	
Multiple R	0.919
R Square	0.845
Adjusted R Square	0.819
Standard Error	0.057
Observations	6.000

ANOVA					
	Df	SS	MS	F	Significance F
Regression	5.000	0.001	0.000	7.898	0.001
Residual	1.000	0.000	0.000		
Total	6.000	0.001			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-3.490	0.073	2.713	0.007
Bus	0.112	0.014	9.093	0.000
Truck	0.105	0.040	2.648	0.000
LCV	0.044	0.017	2.628	0.008
Car	0.024	0.008	2.864	0.006
Two-wheeler	0.021	0.007	2.954	0.006

4.6 Summary of PCUs and Traffic Composition Relationships

The overall summary of relationship of PCU of different types of vehicles with traffic composition and its respective R^2 Value are presented below in Table 4.18.

Table 4.18: Summary of Relationship of PCU of different types of vehicles with Traffic composition

Vehicle Type	Relation between passenger car unit and Traffic Composition	R^2 Value
Bus	PCU = 0.116522*traffic Composition Bus% + 0.277417*traffic Composition Truck% + 0.391674*traffic Composition LCV% + 0.205797*traffic Composition Car% + 0.157806*traffic Composition Two-wheeler% - 11.865	0.766
Truck	PCU = 1.110639*traffic Composition Bus% + 0.705986*traffic Composition Truck% + 0.283343*traffic Composition LCV% + 0.20817*traffic Composition Car% + 0.059557*traffic Composition Two-wheeler% - 22.547	0.864
LCV	PCU = 0.414796*traffic Composition Bus% + 0.327521*traffic Composition Truck% + 0.127493*traffic Composition LCV% + 0.094549*traffic Composition Car% + 0.06289*traffic Composition Two-wheeler% - 10.178	0.878
Two-Wheeler	PCU = 0.112134*traffic Composition Bus% + 0.104811*traffic Composition Truck% + 0.044259*traffic Composition LCV% + 0.0239*traffic Composition Car% + 0.021099*traffic Composition Two-wheeler% -3.481	0.819

4.7 Validation of Developed PCUs and Traffic Composition Relationships

The above relationships have been developed considering seven different sites and these developed relations are validated with traffic composition of the data collected from the site of Jhallari and Kolfutar as presented in above Table 4.0 and with calculated PCU from speed based method of this site. The values of PCU as calculated earlier from speed based method of Jhallari and Kolfutar site is summarized in below Table 4.19. The values of PCU are also calculated using developed relationships presented in Table 4.18 for different types vehicles and are presented in Table 4.20.

Table 4.19: PCU Values for Different Categories of Vehicles Calculated at Jhallari and Kolfutar Sections from Speed based method

Section Name	Carriageway width (m)	Bus	Truck	LCV	Two-Wheeler
Jhallari	5.8	5.208	3.582	2.435	0.257
Kolfutar	5.1	5.005	3.308	2.428	0.233

Table 4.20: PCU Values for Different Categories of Vehicles Calculated at Jhallari and Kolfutar Sections from PCU and Traffic composition relationships

Section Name	Carriageway width (m)	Bus	Truck	LCV	Two-Wheeler
Jhallari	5.8	5.208	3.582	2.435	0.257
Kolfutar	5.1	5.005	3.308	2.428	0.233

The values of PCU calculated from both the methods are found to be equal as shown in Table 4.19 and Table 4.20 which means the above derived relationship between traffic composition percentage and PCU of vehicle type are accurate.

CHAPTER FIVE – CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The analysis is based on the field studies conducted on eight different locations of Highway of Nepal considering four classes of vehicles which are Bus, Truck, LCV and Two-Wheeler commonly found in Nepal. The study shows that traffic composition of two-wheeler are found predominant in all locations and the volume of vehicles types such as Bus, Truck, LCV and Car are linearly increasing with the increasing in carriageway width where as volume of Two-Wheeler are found to be highest at smaller lane carriageway width. The speed of all types vehicle is found to be increasing with the increase in carriageway width having linear relationship between carriageway width and speed. The study also shows that traffic composition has also effect on PCU values of respective vehicle types and has linear relationship between them. The PCU values for these categories of vehicle are determined at all locations of Highway separately. The range of PCU values as obtained from the study for Bus is 5.466 to 5.005, Truck PCU value is 3.711 to 3.708, LCV PCU is 2.611 to 2.428 and Two-Wheeler PCU is 0.273 to 0.233 with carriageway width varying from 6.8 to 5.1. The study shows the PCU values are not constant and depend on lane width and PCU for a vehicle type increases with increasing lane width. The regression equation and its statically testing show significance relationship exists between lane width and PCU values of vehicles. Impact of highway lane width on the PCU is apparently linear. The New PCU values obtained from site are quite different from the values given in NRS standard. It is found that PCU values obtained for motor cycle from all sections are smaller than the values given in NRS 2070 and for Bus, Truck; LCV found higher than the value given in NRS 2070.

5.2 Further Research Areas

- This study is conducted for Highways of Nepal. Similar studies can be carried out in urban arterial roads.
- The study of effect of carriageway width on non-motorized vehicle and tractor can be conducted.

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APPENDIXES

APPENDIX A: SITE LOCATIONS

Details of Physical Data at Different Sections

Location no.	Section	Width of Carriage way (m)	Shoulder Width
1	Naubise	6.8	0.8m both side graveled
2	Manhari	6.7	0.8m both side graveled
3	Sanga	6.6	0.5m both side graveled
4	Budol	6.5	0.3m both side graveled
5	Pashupatinagar	6.4	0.8m both side graveled
6	Panchkhal	6.1	0.8m both side graveled
7	Jhallari	5.8	0.7m both side graveled
8	Kolfutar	5.1	0.3m both side graveled

APPENDIX –B

Speed of Different Types of Vehicles at Different Sections

S.No	Section Name	Carriageway width (m)	Bus	Truck	LCV	Two-Wheeler	Car
1	Dharke, Naubise	6.80	62.32	58.10	60.03	53.73	65.95
2	Manhari	6.70	61.68	57.27	59.37	53.47	64.98
3	Sanga	6.60	60.29	56.68	58.14	52.50	63.40
4	Budol	6.50	59.45	55.96	57.44	51.80	62.40
5	Pashupatinagar	6.40	59.16	54.99	56.69	51.06	61.12
6	Panchkhal	6.10	57.92	53.38	55.13	50.06	59.23
7	Jhallari	5.80	55.68	51.43	55.00	48.76	56.35
8	Kolfutar	5.10	51.88	49.85	49.39	48.21	50.45

APPENDIX – C

Calculation of PCU at different locations

1. Dharke, Naubise Site		
Site Name	Dharke	
Width of Carriage way	6.8	
Types of Vehicles	Mean Speed	Projected area on ground of vehicle m2
Car	65.95	5.39
Bus	62.32	27.74
Truck	58.10	17.62
LCV (minibus,microbus, vans)	60.03	12.81
Motorcylce	53.73	1.2
Calculation of PCU using equation= (Vc/Vi)/ (Ac/Ai)		
PCU of Bus	5.446	
PCU of Truck	3.711	
PCU of LCV	2.611	
PCU of Motorcycle	0.273	

2. Manhari Site		
Site Name	Manhari	
Width of Carriage way	6.7	
Types of Vehicles	Mean Speed	Projected area on ground of vehicle m2
Car	64.98	5.39
Bus	61.68	27.74
Truck	57.27	17.62
LCV (minibus,microbus, vans)	59.37	12.81
Motorcylce	53.47	1.2
Calculation of PCU using equation= (Vc/Vi)/ (Ac/Ai)		
PCU of Bus	5.422	
PCU of Truck	3.709	
PCU of LCV	2.601	
PCU of Motorcycle	0.271	

3. Sanga Site		
Site Name	Sanga	
Width of Carriage way	6.6	
Types of Vehicles	Mean Speed	Projected area on ground of vehicle m2
Car	63.40	5.39
Bus	60.29	27.74
Truck	56.68	17.62
LCV (minibus,microbus, vans)	58.14	12.81
Motorcylce	52.50	1.2
Calculation of PCU using equation=	(Vc/Vi)/ (Ac/Ai)	
PCU of Bus	5.412	
PCU of Truck	3.657	
PCU of LCV	2.592	
PCU of Motorcycle	0.269	

4. Budol Site		
Site Name	Budol	
Width of Carriage way	6.5	
Types of Vehicles	Mean Speed	Projected area on ground of vehicle m2
Car	62.40	5.39
Bus	59.45	27.74
Truck	55.96	17.62
LCV (minibus,microbus, vans)	57.44	12.81
Motorcylce	51.80	1.2
Calculation of PCU using equation=	(Vc/Vi)/ (Ac/Ai)	
PCU of Bus	5.402	
PCU of Truck	3.645	
PCU of LCV	2.582	
PCU of Motorcycle	0.268	

5. Pashupatinagar Site		
Site Name	Pasupatinagar	
Width of Carriage way	6.4	
Types of Vehicles	Mean Speed	Projected area on ground of vehicle m2
Car	61.12	5.39
Bus	59.16	27.74
Truck	54.99	17.62
LCV (minibus,microbus, vans)	56.69	12.81
Motorcylce	51.06	1.2
Calculation of PCU using equation=	(Vc/Vi)/ (Ac/Ai)	
PCU of Bus	5.317	
PCU of Truck	3.633	
PCU of LCV	2.562	
PCU of Motorcycle	0.266	

6. Panchkhal Site		
Site Name	Panchkhal	
Width of Carriage way	6.1	
Types of Vehicles	Mean Speed	Projected area on ground of vehicle m2
Car	59.23	5.39
Bus	57.92	27.74
Truck	53.38	17.62
LCV (minibus,microbus, vans)	55.13	12.81
Motorcylce	50.06	1.2
Calculation of PCU using equation=	(Vc/Vi)/ (Ac/Ai)	
PCU of Bus	5.263	
PCU of Truck	3.627	
PCU of LCV	2.554	
PCU of Motorcycle	0.263	

7. Jhallari		
Site Name	Jhallari	
Width of Carriage way	5.8	
Types of Vehicles	Mean Speed	Projected area on ground of vehicle m2
Car	56.35	5.39
Bus	55.68	27.74
Truck	51.43	17.62
LCV (minibus,microbus, vans)	55.00	12.81
Motorcylce	48.76	1.2
Calculation of PCU using equation=	(Vc/Vi)/ (Ac/Ai)	
PCU of Bus	5.208	
PCU of Truck	3.582	
PCU of LCV	2.435	
PCU of Motorcycle	0.257	

8. Kolfutar		
Site Name	Kolfutar	
Width of Carriage way	5.1	
Types of Vehicles	Mean Speed	Projected area on ground of vehicle m2
Car	50.45	5.39
Bus	51.88	27.74
Truck	49.85	17.62
LCV (minibus,microbus, vans)	49.39	12.81
Motorcylce	48.21	1.2
Calculation of PCU using equation=	(Vc/Vi)/ (Ac/Ai)	
PCU of Bus	5.005	
PCU of Truck	3.308	
PCU of LCV	2.428	
PCU of Motorcycle	0.233	

Summary of PCU at all locations

S.No	Section Name	Carriage way width (m)	Bus	Truck	LCV	Two-Wheeler	Car
1	Naubise	6.80	5.446	3.711	2.611	0.273	1
2	Manhari	6.70	5.422	3.709	2.601	0.271	1
3	Sanga	6.60	5.412	3.657	2.592	0.269	1
4	Budol	6.50	5.402	3.645	2.582	0.268	1
5	Pashupatinagar	6.40	5.317	3.633	2.562	0.266	1
6	Panchkhal	6.10	5.263	3.627	2.554	0.263	1
7	Jhallari	5.80	5.208	3.582	2.435	0.257	1
8	Kolfutar	5.10	5.005	3.308	2.428	0.233	1