RT&A, Special Issue № 1 (60)
Volume 16, Janyary 2021

# EFFECT OF TRAFFIC COMPOSITION ON STREAM EQUIVALENCY FACTOR

[1]Milan P. Kacha, [2]Ankit H. Patel, [3]Pinakin Patel, [4]Dr. L.B. Zala

●

[1,2] M. Tech Student (Transportation Engineering),
[3]Assistant Professor Department of Civil Engineering,
[4]Professor and Head Department of Civil Engineering,
Birla Vishvakarma Mahavidyalaya Engineering College, Gujarat, India.
kachamilanbvm@gmail.com

**Abstract**

*India having different categories of highways with various categories of vehicles. The geometric plan of highways and the number of lanes in highways are affected by the various vehicle operations on 2-lane, 4-lane, 6-lane highways. Different characteristics of vehicles moving on the various categories of roads are the characteristic of vehicles, the size of vehicles, weight of vehicles, maximum turning radius of vehicles, speed of various categories of vehicles on the road, acceleration of vehicles, braking, and horsepower of the engine of vehicles are different from vehicles to vehicles on the road. The aim of this study is the estimation of stream equivalency factor (K) for 2-lane, 4-lane, 6-lane roads. The Passenger Car Unit (PCU) values determine with the help of the equation of INDO-HCM 2017 and IRC 106. In this study, 6 different sites of the Gujarat region of India are selected for the study of stream equivalency factor (K). Traffic volume and speed of various categories of vehicles at 5 min interval data are used for calculation of (K) values. In this study, dynamic PCU values are calculated from data, and estimation of stream equivalency factor values. Stream equivalency factor values vary from various categories of roads according to several lanes under mixed traffic conditions. Stream equivalency factor equation have $R^2$ for 2-lane, 4-lane, 6-lane roads are 0.9966, 0.8111 & 0.8023 respectively.*

**Keywords:** Mixed traffic, PCU values, Stream equivalency factor, Indian roads.

## I. Introduction

The Passenger Car unit values (PCU) values for different categories of vehicles are found to be sensitive with the geometric design of road, and nature of traffic. The nature of traffic on India roads is different from other country roads in the world. The roads in India consider several categories of vehicles with different characteristics of vehicles. The rode user characteristics like diver behavior, condition of the road, frog on road, and mist on the road and various vehicular characteristics are different from vehicles to vehicles on the road. So, various types of vehicles on 2-lane road, 4-lane road, 6-lane road convert into one standard unit into a small car. Small car considers engine power less than 1400 CC according to INDO-HCM 2017 and various types of IRC codas. Small car standard dimension with a length of 3.72 m and width of vehicle 1.44 m. The projected rectangular area of a small car is 5.36 $m^2$. Various types of vehicle convent into standard unit SC by Passenger Car Equivalent (PCU) of various categories of vehicle. Passenger Car Equivalent (PCU) values are different for different categories of highways because of PCU values depend on the characteristics of the vehicle and characteristics of road condition. So, a new factor Stream Equivalency factor (K) is introduced to convert total traffic flow (Vehicle/h) to total traffic flow (PCU/h). Passenger Car Equivalent (PCU) values of different categories of vehicles depend on the proportion of two-wheeler, proportion of three-wheeler, proportion of light commercial vehicles, and proportion of

heavy commercial vehicle, the proportion of big car, proportion of small car and traffic volume of vehicles on the highways. The various categories of roads in India like 2-lane road, 4-lane road, 6-lane road, the geometric design is different from various categories of roads and different vehicle composition on the road. Because of different characteristics of highways Stream Equivalency factor (K) values are different for 2-lane, 4-lane, 6-lane road. Various studies were conducted on Stream Equivalency factor values and Passenger Car Equivalent (PCU) for different categories of highways.

## II. Literature Review

[1] study conducted for estimation of (K) value based on four different sites like NH – 47, NH – 04, NH – 08, SH – 15. Speed models are developed based on 4 sites for various categories of vehicles. Stream equivalency factor equation developed with R-square value 0.98 and t-statistical test conducted for the validation of the model. Various categories of vehicles PCU values relationships with the traffic volume graph plotted and show the variation in PCU values in a particular stretch. [2] has been conducted a study for a comparison of PCU values in various categories of terrain in India. Comparison of various methods like headway method, density method, and IRC 106 method for plain and hilly terrain. A study was conducted at south India Vishakhapatnam city for two locations. Data collected for PCU estimation for only 2 hours. In the headway method, PCU values for HCV are 10.82 is very high compare to all method. With the comparison of all methods, IRC 106 method is best for all categories of vehicles on the highway because of this method all types of data of various categories of vehicles include in the equation of IRC 106. [3] conducted a study for new methods like the kriging method. Speed of different categories of vehicle estimate by kriging mathematical model and PCU values determine by IRC 106 procedure. Here 6 six different location data included for estimation of speed values like a crossroad in Dehradun with width 5.5 m, Paschim road in Chandigarh with width 6.2m, Subhash road in Dehradun with width 7.0m, Ring road in Kolkata with width 7.0m and Vigyan path in Chandigarh with width 9.0m, Palam road with width 9.5m in new Delhi. Projected rectangular are for different categories of vehicles are for two-wheeler 1.20 $m^2$, three-wheeler 4.48 $m^2$, for HCV 24.54 $m^2$, BC 8.11 $m^2$, SC 5.36 $m^2$ based on length and width. For traffic volume PCU/h and traffic volume Vehicle/h graph are plotted by Y=1.298X with R- square value 0.18. .[6] have been conducted a study to convert the whole type of vehicle into a small car. Data collected at four sites including Hingna road with width 7.2m and shoulder-width 1.6m, Bhandara Road 7.8m with carriageway width 7.8m and Shoulder width 1.8m, Umred Road with width 7.0 m and Shoulder width 1.6m, and Wardha road width 7.8m and Shoulder width 1.8m. Mean speed of various categories of vehicle estimate for Car 54.40 Km/h, Truck/bus 41 Km/h, Two-wheeler 39.84 Km/h, L.C.V 39.69 Km/h, Rickshaw 39.18 Km/h, Cycle 11.32 Km/h, Trailer 38.53 Km/h. Capacity value estimate for various categories of roads for SH-09 with 1897PCU/h, NH-07 with 2675 PCU/h, NH-06 with 4652 PCU/h, SH-255 with 3738 PCU/h. In this study Motor cycle percentage 78% and 22% of all categories of vehicle. [5] researched PCU estimation and the effect of roadway width on PCU values. PCU estimate by the length of the vehicle, the width of the vehicle, and the speed of various categories of vehicles. Data collected at ten different sites for a study like NH-22 with a width of carriageway 8.8m and shoulder brick on edge 0.3m and 2m earthen, NH-58 of 110km length with a width of carriageway 7.4m shoulder brick on edge 0.3m and earthen 1.5m and NH-31, SH-5, SH-6, SH-14, NH-73, SH-12, NH-38, NH-58. This study calculation of PCU values based on the width of the carriageway. [4] conducted a study PCU value prediction using an artificial neural network. Here traffic volume data Q1, Q2……. Qn considers as input and hidden layer estimate with the help of various functions used in a hidden layer of the model and out-put value is the speed of vehicles.

## III. Study Area Profile

For estimation of PCU and K values for various categories of vehicles require data for traffic volume and speed of each category of vehicles. Data collected at six different sites inroads of India. Data collected by video grapy techniques by the high resolution of the camera. Mark line with plaster of peris (POP) or White cement (WC) on the road for data collection. Line marking throw-out roadway between 50m to 80m in 2-lane, 4-lane, 6lane road under various types of vehicles on the road. Detailed site location information including carriageway width, shoulder width shown in Table-1

**TABLE 2** Details of Study Area Profile

| No | Site Name | Number of Lanes | Width of Carriageway | Width of Shoulder | |
|---|---|---|---|---|---|
| | | | | Paved | Un Paved |
| 1 | Rajkot to Kalawad | 2-lane | 7.0m | 1m | 1.5m |
| 2 | Bakrol to Vadtal | 2-lane | 7.0m | 1m | 1.5m |
| 3 | Makkam to Bhaktinagar Circle (Rajkot) | 4-lane | 15m | 1m | 1.5m |
| 4 | Sorathiyavadi to Nanda Hall (Rajkot) | 4-lane | 15m | 1m | 1.5m |
| 5 | Gondal Chokdi to Kothariya (Rajkot) | 6-lane | 23m | 1.5m | 1.5m |
| 6 | KKV Hall to Mavdi Chokdi (Rajkot) | 6-lane | 23m | 1.5m | 1.5m |

**TABLE 3** Traffic Composition

| Traffic Composition (%) | | | | | | |
|---|---|---|---|---|---|---|
| Section | 2W | 3W | SC | BC | LCV | HCV |
| 2-lane | 21.69 | 18.05 | 21.31 | 8.13 | 12.71 | 18.08 |
| 4-lane | 54 | 14 | 16 | 13 | 2 | 1 |
| 6-lane | 67.76 | 9.76 | 14.32 | 6.76 | 1 | 0.37 |

## IV. Estimation of PCU & Stream Equivalency Factor (K)

PCU values for different categories of a vehicle for different categories of road estimation by a procedure of IRC-106 and INDO-HCM 2017.

$$\text{PCU} = \frac{Vc/Vi}{Ac/Ai} \quad (1)$$

Where, $V_c$ = Clearing speed of car (km/hr), $V_i$ = Clearing speed of vehicle i (km/hr), $A_c$= Projected rectangular plan area of car ($m^2$), $A_i$= Projected rectangular plan area of vehicle i ($m^2$).

**Table 4** Projected Area of Different Categories of Vehicles

| Vehicle Type | Length(m) | Width(m) | Projected Area($m^2$) |
|---|---|---|---|

| **Motorized Traffic** | | | |
|---|---|---|---|
| Standard car (SC) | 3.72 | 1.44 | 5.36 |
| Big car (BC) | 4.58 | 1.77 | 8.11 |
| Motorized Two-Wheeler (TW) | 1.87 | 0.64 | 1.2 |
| Auto rickshaw (3W) | 3.2 | 1.4 | 4.48 |
| Bus (B) | 10.1 | 2.42 | 24.54 |
| Light commercial vehicle (LCV) | 6.1 | 2.1 | 12.81 |
| Two/ Three axle truck (TAT) | 7.5 | 2.35 | 17.63 |
| Multi Axel Truck (MAT) | 12.1 | 2.44 | 29.52 |
| Tractor / Tractor Trailer (TT) | 7.4 | 2.2 | 16.28 |

**Table 5** Range of PCUs Values for Different Categories of Vehicles

| **Vehicle Type** | **Range /Median Values of PCUs** | |
|---|---|---|
| | **Range** | **Median** |
| **Motorized Traffic** | | |
| Big car (BC) | 1.13 - 2.50 | 1.6 |
| Small car (SC) | 1 | 1 |
| Motorized Two-Wheeler (TW) | 0.20 - 0.50 | 0.3 |
| Auto rickshaw (3W) | 1.10 -2.00 | 1.2 |
| Bus (B) | 2.80 - 4.80 | 4.5 |
| Two/ Three axle truck (TAT) | 3.0 - 5.50 | 5 |
| Multi Axel Truck (MAT) | 4.6 - 11.60 | 6 |
| Tractor / Tractor Trailer (TT) | 5.0 - 8.00 | 7 |

Stream Equivalency Factor (K) is the ratio of flow in PCU/hour to Flow in Vehicle/hour.

$$K = \frac{\text{Flow in PCU/hour}}{\text{Flow in vehicle/hour}} \tag{2}$$

Stream Equivalency Factor (K) for various categories of a road depends on the characteristic of various categories of vehicles and the proportion of various categories of vehicles. A minor change in behavior of various categories of vehicle and percentage of vehicle travel on highways various categories of vehicles. For the large size of vehicles like a heavy commercial vehicle, bus, truck dimension is very important for the estimation of PCU and K values. For equivalency factor for various categories of a road depends on the geometric design of various categories of road. The geometric design includes carriageway width, shoulder width, super elevation, condition of a pavement of various categories of highways. For the equation of various categories of a vehicle are shown below.

SEF (K) for 2-lane road

$SEF_{2\text{-lane}} = 1 + 0.174271*P_{2w} + 0.9818 * P_{AR} + 1.3242*P_{LCV} + 0.7414* P_{SC} + 1.3711* P_{HCV} + 1.088* P_{BC} - 133.314 *(1/N)$ ($R^2 = 0.9066$)

SEF (K) for 4-lane road

$SEF_{4\text{-lane}} = 1 + 0.001842*P_{2w} + 0.007366* P_{AR} + 0.016402*P_{LCV} + 0.006793* P_{SC} + 0.04096* P_{HCV} + 0.007336* P_{BC} + 321.329*(1/N)$ ($R^2 = 0.8111$)

SEF (K) for 6-lane road

$SEF_{6\text{-lane}} = 1 + 0.00198*P_{2w} + 0.01058 * P_{AR} + 0.032029*P_{LCV} + 0.007806* P_{SC} + 0.020254* P_{HCV} + 0.013065* P_{BC} + 149.0247*(1/N)$ ($R^2 = 0.8023$)

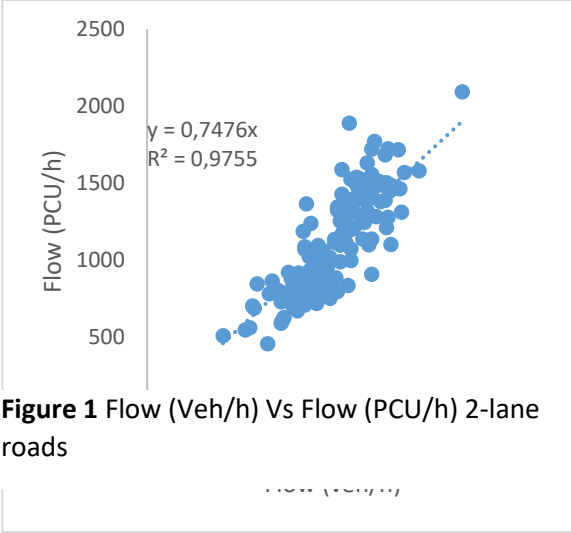
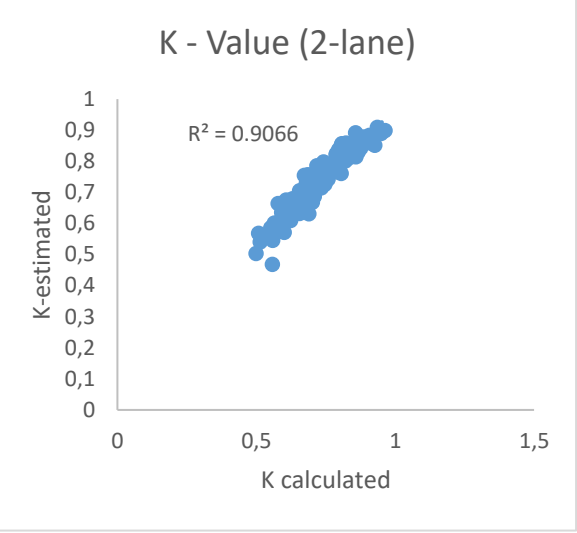



**Figure 1** Flow (Veh/h) Vs Flow (PCU/h) 2-lane roads



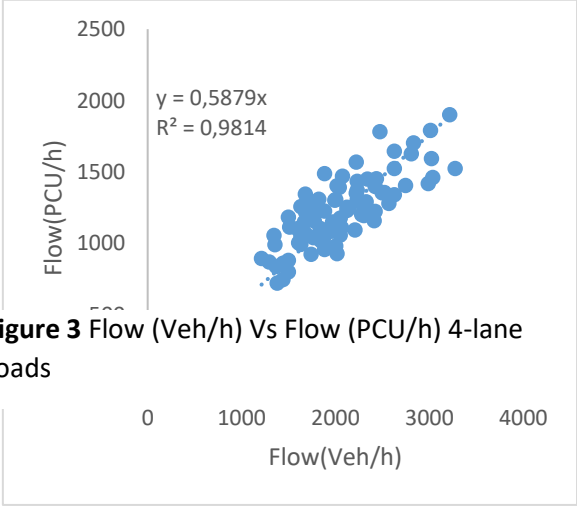




**Figure 3** Flow (Veh/h) Vs Flow (PCU/h) 4-lane roads

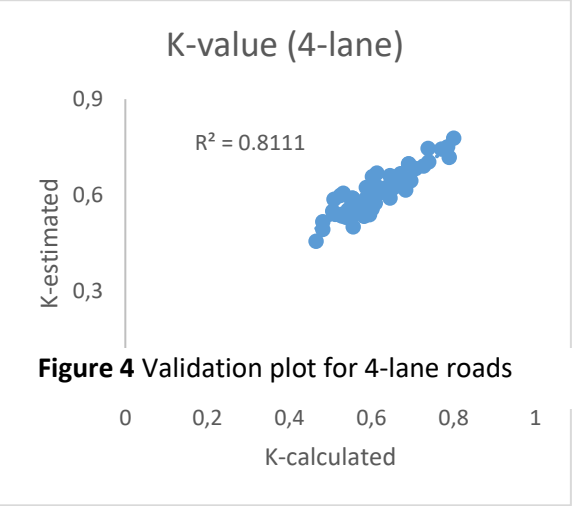



**Figure 4** Validation plot for 4-lane roads

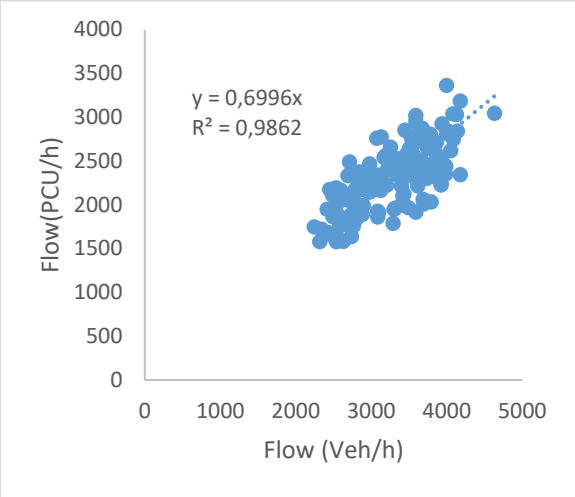



**Figure 5** Flow (Veh/h) Vs Flow (PCU/h) 6-lane roads

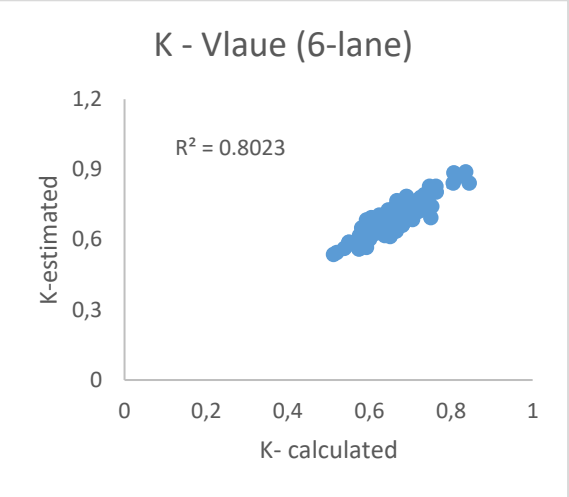



**Figure 6** Validation plot for 6-lane roads

**TABLE 6** SEF Equation Coefficients, T- Stat, P-Values

| **2-Lane Road** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **2W** | **3W** | **SC** | **BC** | **LCV** | **HCV** | **BUS** | **1/N** |
| **Coefficients** | 0.17 | 0.98 | 0.74 | 1.08 | 1.32 | 1.37 | NA | -133.31 |
| **t Stat** | 2.01 | 9.64 | 8.85 | 8.15 | 15.95 | 21.8 | NA | -5.69 |
| **P-value** | 0.04 | 4.92E-17 | 8.93E-33 | 4.37E-15 | 6.03E-46 | 2.26E-13 | NA | 7.57E-08 |
| **4-Lane Road** | | | | | | | | |
| | **2W** | **3W** | **SC** | **BC** | **LCV** | **HCV** | **BUS** | **1/N** |
| **Coefficients** | 0.001 | 0.007 | 0.006 | 0.007 | 0.016 | 0.040 | 0.03 | 321.3 |
| **t Stat** | 2.90 | 2.61 | 3.58 | 2.37 | 2.63 | 2.73 | 5.78 | 4.58 |
| **P-value** | 0.004 | 0.01 | 0.0005 | 0.02 | 0.01 | 0.007 | 1.48E-07 | 1.72E-05 |
| **6-Lane Road** | | | | | | | | |
| | **2W** | **3W** | **SC** | **BC** | **LCV** | **HCV** | **BUS** | **1/N** |
| **Coefficients** | 0.001 | 0.01 | 0.007 | 0.01 | 0.03 | 0.02 | 0.06 | 149.02 |
| **t Stat** | 4.2 | 7.5 | 4.87 | 8.20 | 9.08 | 3.99 | 12.1 | 1.55 |
| **P-value** | 4.40E-05 | 6.45E-12 | 2.92E-06 | 1.36E-13 | 9.40E-16 | 0.0001 | 1.70E-23 | 0.12 |

## V. Conclusion

SEF is for various categories of road developed based on various types of data of road like traffic data and geometric data. SFF was found for two-lane road according to INDO-HCM 2017 between 0.44 to 3.06 but here Y=0.73X for 2-lane road based on calculated and estimated value of K. In this paper developed an equation of SEF for 2,4,6- lane roads and coefficient and P-value and T-stat value for various types of variable shown in Table-5. The $R^2$ value for 2-lane road for SEF is 0.9966 and $R^2$ value for 4-lane road for SEF is 0.8111 and $R^2$ value for 6-lane road for SEF is 0.8023.

## References

[1] Mohammad Mardani Nokandeh, Indrajit Ghosh, and Satish Chandra. (2016). Determination of Passenger-Car Units on Two-Lane Intercity Highways under Heterogeneous Traffic Conditions. J. Transp. Eng., 142(2): 04015040.

[2] Sai Chand. (2016). Comparison of Passenger Car Units on Plain and Hilly Urban Road. Civil Engineering Systems and Sustainable Innovations ISBN: 978-93-83083-78-7.

[3] Subhadip Biswas, Satish Chandra & Indrajit Ghosh. (2017). An advanced approach for estimation of PCU values on undivided urban roads under heterogeneous traffic conditions. The International Journal of Transportation Research. ISSN: 1942-7867 (Print) 1942-7875.

[4] Subhadip Biswas, Satish Chandra, Indrajit Ghosh. (2015). Estimation of Vehicular Speed and Passenger Car Equivalent Under Mixed Traffic Condition Using Artificial Neural Network. Arab J Sci Eng DOI 10.1007/s13369-017-2597-9.

[5] Chandra, S., and Kumar, U. (2003). Effect of lane width on capacity under mixed traffic conditions in India. J. Transp. Eng. (ASCE). 155–160.

[6] Patel P. N. and Dhamaniya A. (2019). Stream equivalency factor for mixed traffic at urban signalized intersections. Transportation Research Procedia, 37, 362-368.

[7] Patel, P.N., Dhamaniya, A., and Katti, B.K. (2015). Effect of mixed traffic characteristics on saturation flow and passenger car units at signalized intersections. European Transport, 59(4), 1-16.