Estimation of PCU's in Heterogeneous Traffic by Different methods

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Abstract. Transportation gets more intricate when cities get busier. Increased motor vehicles are moving into towns, which means increased traffic jams. The impacts of urbanisation are pervasive and include, but are not limited to, traffic performance, road safety, pollution, and traffic congestion. The rising number of people in the nation is driving up demand for personal vehicles including cars and motorcycles. Adding additional lanes is not enough to solve traffic congestion effectively. So, studying passenger car units (PCU) in heterogeneous traffic becomes necessary. Efforts to derive PCU values for cities roads with various traffic situations are made on this article. Using the density technique, we got somewhat different PCU values for the remaining three cars, but Chandra's method gave us PCU values of 1.99, 3.37, and 1.33, respectively. The data shows that buses make up a significant portion of the traffic in this region, constituting 23% of the total. Of the entire traffic volume, cars account for 16%. There are 19% fewer cars and trucks on two wheels in the research region. Of the total vehicles in the research region, buses constitute 21%. Nineteen percent of all traffic is caused by cars. It has been found that according to site 1 in the research region, three-wheeled vehicles constitute 18% of total traffic.

Keywords-: Heterogeneous traffic, Passenger car unit, Speed, Traffic volume

1. Introduction

While the traffic situation is somewhat consistent in industrialized nations, it is not in emerging nations such as India. The vast majority of vehicles travelling on city streets exhibit static, followed by dynamic, features, and the traffic itself is quite diverse [1]. Because there isn't a change in physical segregation and vehicles must share the same lateral area of the roadway, driving on these routes is challenging. Vehicles can be roughly grouped into the following types: buses, trucks, light commercial vehicles, passenger cars (including jeeps), three-wheelers, and two-wheelers [2-4].

When it comes to the planning, design, and operation of traffic elements, external variables like traffic volume and speed are what you need. In terms of visible physical dimensions, the mixed-traffic urban road speed varies from 20 to 60 kmph [5]. Because they are free to move in any direction along the road, the majority of cars likewise do not adhere to lane discipline. Traffic volume, as measured in units of the number of cars traversing a certain segment of road per unit of time, won't be applicable under these conditions [6]. Consequently, in order to assess traffic flow, equivalent number of passenger car units (PCUs) are commonly used. The PCU values of each vehicle are different. In addition, for analyzing the traffic flow, these PCU values are estimated [7]. PCU is also utilized for assessing the capacity of various road types and will be put to use for section improvement. Further, previous studies highlighted a notable difference in the PCU values based on projected areas of vehicle [8]. Therefore, these PCU values may not be static but rather fluctuate according to a number of related circumstances, such as the nature of the traffic on the road [9-11]. This article makes an effort to comprehend the basic connections between traffic flow parameters as to calculate the PCU values under various traffic scenarios. In addition, the criteria laid forth by the Indian Road Congress (IRC) are used to evaluate these PCUs [12].

To accommodate this, the Passenger Car Unit (PCU) takes into consideration the traffic volumes generated by different vehicle types. Past work on PCU estimate has focused on a wide range of vehicle types [13]. This study discusses the pros and cons of several PCU estimate methods. There was a discrepancy between the PCU's range and its trend of change regarding other regulating elements [14]. The findings of several research on PCU estimate on urban roadways are presented in this publication. The main emphasis of PCU estimates has been on split urban roadways and interurban highways [15]. The traffic patterns on split urban roadways are very different from those on undivided ones. The purpose of this research is to examine one-lane urban roadways. It is necessary to consider the speed of each vehicle separately in order to determine the PCU. The skid resistance of a multi-lane highway changes from one part to another when it rains. This may occur on porous pavement surfaces after heavy rainfall or when the surface layer becomes obstructed. This study uses an analytical numerical technique to analyze the skid resistance reduction capabilities of porous pavement and a function of route width [16].

The focus of this research was on strategies for maintaining service on a multi-line tube system during peak hours [17]. The term for the method of controlling the flow of passengers who are boarding and boarding many lines or stations simultaneously is "multi-station coordinated passenger flow control." Using entering passengers who do not need to wait in queue at specific locations, it controls the number of cars that may access a highway stretch, much as ramp metering. Manage the flow of passengers an example of a lower-level problem is the assignment of stochastic user equilibrium using logic [18]. Issues like as route selection, dynamic costs, and passenger evolution are part of a two-pronged strategy to optimize system efficiency [19]. The capacity of underground stations to evacuate people during an emergency is established utilizing a bilevel programming model that takes into consideration the time required to traverse through different types of crowded locations [20-23]. While higher-level models optimise the effectiveness of evacuation facilities, lower-level models help direct evacuees to safer places. Improving upon the original particle swarm optimization approach allows us to solve the model. Using the Beijing Subway's capacity estimate for the Fuxingmen Station as an example, this evacuation simulation finds the optimal pathways and that provide the most accurate capacity estimate. When there is an emergency, the capacity of a station is estimated using the following metrics: passengers per unit time, network crowdedness [24]. Passenger density is an essential metric for urban rail system planning and operation. The expensive infrared and video-based counting devices limit the sample sizes. The end effect is that the official passenger counts for several rail lines are off [25]. Errors are often flow-dependent in both manual and computer counting systems since the level of uncertainty grows with the number of things counted. This study is beneficial in determining the passenger density for urban rail system planning and operation [26]. A key aspect of the research that takes into consideration the PSU in the system is traffic estimation [17, 18]. To improve the system's efficiency, studies on traffic distribution have been conducted [28].

2. Research Methodology

2.1 Chandra's Method

This approach outlines a quantitative approach for estimating the Passenger car units (PCU) of various forms of cars, that is a concept used in traffic engineering to evaluate the traffic go with the flow of different varieties of vehicles with that of passenger automobiles. The PCU price allows in assessing avenue ability and visitors composition via changing special kinds of vehicles into equivalent numbers of passenger motors. PCU values are calculated based totally on principal parameters: the projected area of the automobile and its speed. Projected area refers to the size of the vehicle whilst regarded from above, which impacts the distance it takes up on the street. the rate adjustment takes into consideration the distinction in relative speed among the vehicle in question and a popular passenger automobile.

Chandra's approach offers a quantitative framework for estimating the Passenger car units of numerous styles of vehicles, a concept considerably hired in traffic engineering to look at the visitors drift of numerous car types with that of passenger vehicles. The PCU price serves as a essential metric for assessing road functionality and placement traffic composition by means of standardizing numerous automobile types into equivalent numbers of passenger vehices. This approach includes calculating PCU values based mostly on primary parameters: the car's projected area and its speed. The projected region of a automobile refers to its size as perceived from above, which highly affects the amount of area the automobile occupies on the road. Large vehicles generally have larger projected regions and for that reason occupy extra street area, doubtlessly impacting traffic volume and congestion factors. By way of quantifying the projected area of each automobile type, Chandra's method permits traffic engineers to account for the spatial requirements of various vehicles even as assessing avenue potential and making plans to adopt traffic management strategies. Further to projected area, Chandra's approach additionally considers the relative speed difference among the vehicles which are passenger vehicles. This pace parameter recognizes that automobiles travelling at certainly one type of speeds may have various influences on traffic conjestion. It is observed from the study that, if an automobile moves much slower than a passenger vehicle, it has the affect of producting hinderance in traffic flow and hence contribute to congestion, whihc is therby lead to a higher PCU costs. How every the analysis showed that is there are automobiles that move at equivalent or faster speeds when compared with the passenger vehicles, it may have comparatively lower PCU values than in the first case which brings baout the

conclusion that it has a less significant impact on traffic flow. The studied method of Chandra also provides a comprehensive framework for assessing the relative impacts of different vehicle types on traffic flow and and its congestion which is done after incorporation of all projected area of vehicles and speed factors. the methods hence will assist researchers in making educated decisions about route design, help in designing vehicle management strategies, and infrastructure investments that will aim to optimise traffic flow, along with reduction in congestion that will lead to improvement in overall transportation performance.

For calculating PCU technique, the equation is expressed as:

$$PCU = \frac{V_c/V_i}{A_c/A_i} \qquad \ldots(1)$$

Were,
PCU= passenger car unit
Vc= Speed of car
Vi= Speed of ith vehicle
Ac= Projected area of car
Ai= ith vehicle projected area
By way of making use of this method, the relative effect of various kinds of vehicles on traffic flow can be quantified. for example, it would have a better PCU value if a bigger car is travelling slower than a vehicle, indicating that it consumes greater street area and probably reduces traffic drift overall performance compared to a passenger automobile. Conversely, if a automobile is faster or smaller than a modern day car, it would have a PCU rate of less than one, indicating that it has much less impact on traffic flow than a passenger car.

Table 1: Table for the Area of Different type of vehicle

Type	Vehicle	Dimension	Projected Area
Car	Car, Jeep, Van	3.69 x 1.39	5.12
Bus	Bus	9.18 x 2.31	21.20
Truck	Truck	7.1 x 2.29	16.25
LCV	Mini bus/trucks	5.9 x 2.9	17.11
M-Truck	Multi-axle truck	2.24 x 11.8	26.43
Bikes	Scooter, Motorbike	1.78 x 0.66	1.17
Cycle	Pedal Cycle	1.88 x 0.39	0.73
Autos	Auto, Tempo	3.17 x 1.38	4.37

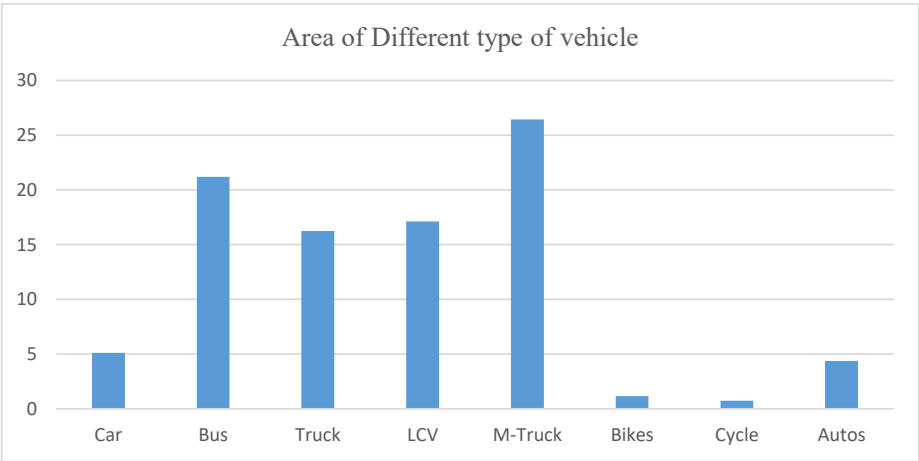

Fig. 1: Area of Different type of vehicle

Table 1 and Fig. 1 categorizes vehicles by their typical dimensions and calculates their projected areas, crucial for traffic analysis and road planning. Cars have dimensions of 3.69 meters by 1.39 meters, resulting in a projected area of 5.12 square meters. Buses are larger, with dimensions of 9.18 x 2.31 meters and a projected area of 21.20 square meters. Trucks

and Light Commercial Vehicles (LCVs) have considerable sizes, with respective regions of 16.25 and 17.11 square meters. Multi-axle trucks have the most important area at 26.43 rectangular meters. Bikes and cycles have smaller footprints, with projected areas of 1.17 and 0.73 .Seventy three square meters, respectively. Autos, along with car-rickshaws and tempos, have a mid-variety location of 4.37 rectangular meters.

2.2 Density Method

To calculate PCU underneath special traffic densities, a specific approach referred to as the density method is brought to use, in particular it is being appropriate for heterogeneous traffic situations where multiple types of cars are used This approach integrates the idea of automobile density (variety of acarss per unit area of street) and the spatial footprint (width) of the automobiles under different traffic conditions. The density approach makes use of formula described below :

PCU = (Kcar/ Wcar) / (Ki/Wxi)
Where, Ki = density of a specific type of vehicle.
Kcar = car's density.
Wcar = width occupied by vehicles in varied traffic conditions.
Wxi = width considering a variety of traffic conditions, driven by the relevant class of vehicles.

Through evaluating the ratio of automobile density to its occupied area with that of other kinds of car , this method provides a relative measure of how many passenger cars might be equal to at least one unit of different automobile type under different traffic conditions. This calculation enables in providing the effect of various car types on traffic flow and congestion, permitting greater correct traffic plans and control with the aid of accounting for the diverse mix of automobiles on the road.

.2.3 Methodology

The steps described to represent a systematic approach to conducting highway surveys to estimate automobile units. (PCU) for different vehicles and their driving directions. The process ensures that data collection is accurate and thoughtful. Real conditions, allowing better traffic management and better route planning:
Step I: Step one involves choosing the suitable area for the survey. This area should be representative of the traffic conditions underneath study and free from external affects that might skew the records, inclusive of nearby intersections or uncommon road capabilities.
Step II: The chosen area is then divided into two sub-places, each 30 meters apart. This division permits for the collection of statistics at distinctive factors alongside the same stretch of road, offering a greater complete view of visitors drift and automobile speeds.
Step III: A stopwatch is used to report the flow and speed of automobiles in five-minute durations. This time frame is chosen to offer a stability between taking pictures enough records for accuracy and maintaining attainable portions of records for evaluation.
Step IV: The traffic mix, which refers to the composition and type of automobiles using the street, is determined by counting the range of every type of automobile. This step is critical for expertise the diversity of traffic and for later calculating the PCU values precisly.
Step V: The PCU values acquired from discipline measurements using the density technique and the Chandra approach are then as compared with general values supplied by means of the Indian Roads Congress (IRC). This comparison facilitates validate the sphere statistics and ensures that the PCU estimates are in line with set up benchmarks.
Step VI: In the end, the real physical dimensions of the road, inclusive of the length of the lane and the width of the shoulders, are measured the usage of an inch tape. This statistics is crucial for determining the street's ability and for contextualizing the traffic records accrued.
Researchers and traffic engineers can appropriately determine the PCU via car type and direction with these steps , which is critical for powerful visitors control and street design.

3. Structure Results and Discussion

3.1 Traffic Composition

When designing a path, it is important to think about how many cars will be using it. Estimating the relative proportions of different vehicle kinds on the road is possible using traffic composition analysis. It is crucial to be aware of the functions performed by the different parts of the road. One factor that raises traffic congestion is passenger car units, or PCUs. The proportion of different types of vehicles on the location is displayed in Fig. 1.
The structural study aims to understand the dynamic response of a multi-story G+9 RCC framed building to wind loads by considering the full architectural plan and elevation. The multistory RCC frame building is meticulously simulated for the three wind zones, I, II, and III. Wind load analysis with fixed support conditions is performed on building models using Staad Pro. Every floor has a fixed height of three metres, which is the height of the plinth. The building materials include concrete of grade M25 and steel reinforcing of Fe415. According to IS 875(part-3):2015, the building is located

in wind zones I, II, and III, with corresponding wind speeds of 33 m/s, 39 m/s, and 44 m/s. This analytical study sheds light on how the structure behaves in different wind conditions.

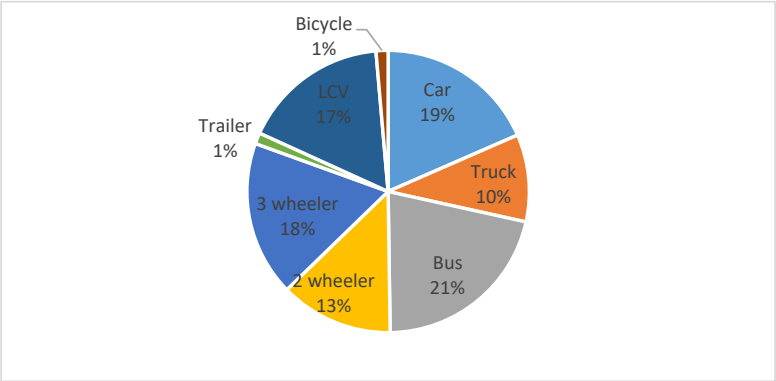

Fig. 2: Percentage of individual vehicle for location 1 (morning hours)

The pie chart in Fig. 2 shows that buses make up 21% of traffic, indicating a high use of public transportation. Cars follow closely at 19%, indicating high private vehicle usage. Three-wheelers make up 18%, with LCVs accounting for 17%, suggesting significant goods transportation. Two-wheelers make up 13%, with trucks accounting for 10%. Trucks contribute to heavy goods movement, possibly contributing to commercial or industrial activities. Tractors and bicycles make up 1% of traffic, suggesting minimal heavy-duty transportation and cycling activity. This information can be used for traffic management, urban planning, and policy-making to address congestion, pollution, and infrastructure development.

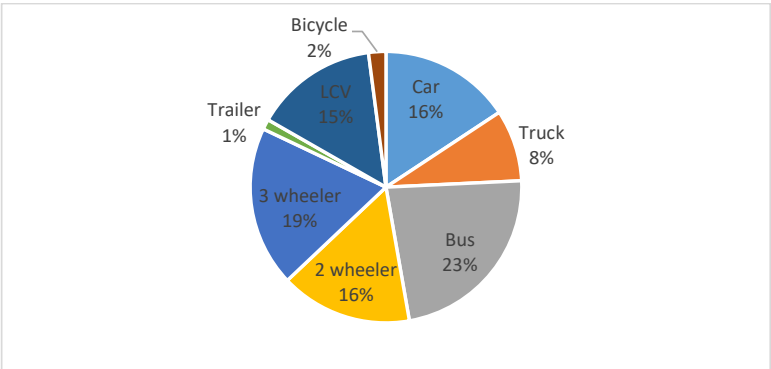

Fig. 3: Percentage of individual vehicle for location 1 (5evening hours)

The pie chart supplied in Fig. Three gives a comprehensive photograph of the distribution of automobiles within a particular vicinity, supplying valuable insights into the various modes of transportation utilized by people in that place. The chart exhibits that buses constitute the biggest share of automobiles, accounting for 23% of the complete, observed carefully by way of using three-wheelers at 19%. Additionally, -wheelers and vehicles every constitute 16% of the automobile blend, at the same time as mild business vehicles comprise 15%. Trucks, bicycles, and trailers make up smaller quantities of the whole, at eight%, 2%, and 1%, respectively. These figures underscore the various kind of transportation options available to commuters and citizens inside the region below interest. From public transit modes like buses to personal vehicles together with motors and -wheelers, as well as opportunity modes like bicycles and 3-wheelers, the pie chart highlights the numerous alternatives and goals of humans on the subject of commuting and transportation. The importance of this distribution extends beyond mere records; it underscores the importance of accommodating and integrating a huge range of automobile sorts in visitors control and urban planning strategies. Effective transportation planning calls for a holistic approach that considers the numerous wishes of commuters, promotes sustainable modes of shipping, and guarantees green use of infrastructure. By spotting and accommodating the numerous modes of transportation depicted in the pie chart, urban planners can develop extra inclusive and resilient transportation systems that cater to the various wishes of the network at the same time as selling mobility, accessibility, and sustainability.

3.2 Estimation of PCU

The Passenger Car Unit (PCU) serves as a important device in standardizing diverse traffic patterns for the cause of capability estimation and layout in transportation engineering. Researchers often make use of special methodologies, inclusive of the density approach and Chandra's model, to check PCU values for a variety of motors, taking into

consideration greater accurate evaluation and making plans of traffic waft. In the Indian Roads Congress (IRC) suggestions, the PCU fee for buses is determined to be three, at the same time as vans are assigned a PCU fee of four.Five. However, employing Chandra's approach yields slightly unique PCU values, with buses having a PCU value of three.24 and trucks having a PCU value of 6.5. These versions in PCU values among methodologies highlight the importance of choosing the best model primarily based on the specific characteristics of the traffic surroundings being analyzed.

Table 2: Comparison of PCU values

Type of Vehicle	Morning hours		Evening hours	
	Density method	Chandra's method	Density method	Chandra's Method
Car	1.00	1.00	1.00	1.00
Truck	6.5	6.46	6.85	6.01
Bus	3.24	5.75	7.1	6.39
2 wheeler	0.45	1.33	1.48	1.33
3 wheeler	0.76	1.99	1.95	2.01
LCV	1.6	3.37	3.66	3.71
Bicycle	0.42	1.64	2.13	1.6

Table 2 offers a evaluation of Passenger Car Units (PCU) for special car kinds, calculated the usage of Density and Chandra's techniques. PCU serves as a standardized degree to quantify the impact of various car kinds on site visitors flow, with passenger vehicles generally assigned a PCU fee of 1.00. The table exhibits varying PCU values for one of a kind vehicle categories, losing light on their relative impact on site visitors dynamics, especially throughout evening hours:

- Cars: As the standard measure, cars are assigned a PCU price of one.00. This suggests that they function the baseline for assessing the impact of other vehicle types on visitors flow.
- Trucks and Buses: Trucks and buses are assigned higher PCU values in comparison to automobiles, suggesting a more impact on site visitors glide at some point of evening hours. These large automobiles usually occupy greater space on the road and might have slower acceleration and braking abilities, leading to increased site visitors congestion and delays.
- Two-Wheelers and Three-Wheelers: Two-wheelers and three-wheelers exhibit decrease PCU values than cars, indicating less impact on visitors. These compact vehicles are extra manoeuvrable and take up much less space on the road, enhancing traffic drift specially in congested urban areas.
- Light Commercial Vehicles (LCVs): Light commercial vehicles (LCVs) show higher PCU values, indicating an increased impact on traffic in the evening. This increase can be attributed to factors such as commercial activities during those periods, increased distribution and service of vehicles.
- Bicycles: Bicycles have the bottom PCU values, indicating minimal effect on traffic waft. However, it's noteworthy that the PCU values for bicycles growth throughout evening hours, reflecting changes in road usage or situations, consisting of the superiority of recreational cycling or the presence of devoted motorcycle lanes.

3. Conclusion

The Bhopal region served as a comprehensive testing ground for field experiments that encompassed a wide array of vehicle types found in India. These experiments aimed to analyze and understand traffic patterns, vehicle behavior, and road usage characteristics specific to the area. By including almost every kind of vehicle, from motorcycles and cars to buses and trucks, the study provided detailed insights into the dynamics of urban and rural traffic within the Bhopal vicinity. This diverse inclusion ensures the findings are representative of the varied transportation modalities employed by the Indian population in daily commutes and logistics**.**

a. In the IRC, the PCU number for Bus is 3 and the Truck PCU value is 4.5, while in Chandra's technique, the values are 3.24 and 6.5, respectively. Using the density technique, we got somewhat different PCU values for the remaining three cars, but Chandra's method gave us PCU values of 1.99, 3.37, and 1.33, respectively.
b. The data shows that buses make up a significant portion of the traffic in this region, constituting 23% of the total. Of the entire traffic volume, cars account for 16%.
c. There are 19% fewer cars and trucks on two wheels in the research region. Of the total vehicles in the research region, buses constitute 21%. Nineteen percent of all traffic is caused by cars. According to site 1 in the research region, three-wheeled vehicles constitute 18% of total traffic.

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