Estimation Of Motorcycle Equivalency Unit(Mceu) In A Hetergeneous Traffic Mix In Minna, Nigeria

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Abstract: In designing a road, the impact of various vehicle types is accommodated using standard vehicle which is often than not a theoretical passenger car represented as passenger car equivalency unit(PCEU). However, in Nigeria like some developing countries of Africa and Asia, motorcycles constitute a larger portion of traffic mix on some road sections, thus the need to use the motor cycle as the standard vehicle (motor cycle equivalency unit -MCEU) which other vehicles can be converted to, so as to have a hypothetical homogeneous traffic. This study estimates MCEU at some locations. The results can provide an insight into the planning and evaluation of road segments in developing countries where small wheeled vehicles like motorcycles dominate the traffic mix.

Keywords: Traffic Composition, Motorcycle Equivalency Unit MCEU, Passenger Car Equivalency Unit PCEU, Heterogeneous Traffic

Introduction

Planning and designing of roads often requires the impacts of different vehicle types on the overall traffic composition. In mid 60s the trucks and buses were thought to affect the vehicular traffic, as a result this effect was captured by converting all other vehicles into a single standard vehicle represented as passenger car equivalency unit (PCEU). In essence this concept tries to make a heterogeneous traffic into a homogeneous one, that is, conversion all vehicle types into one single dominant vehicle on a particular road section [5]. By homogeneous traffic we mean a hypothetical traffic which is dominated by one single vehicle type an example of which can be found in developed economies where personal cars are more prevalent on the road space. This results in a more organized traffic movement on the road and thus, making planning and design of road segments more simplified. Heterogeneous traffic on the other hand is a mixed traffic

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using the same road space and may most certainly result in chaotic movement because different vehicles having different operational characteristics [1].

Several operational characteristics of vehicles are sensitive to different road types and facilities and also sensitive to the nature of the traffic mix[11]. In literatures, different parameters are used for homogeneous and heterogeneous traffic in the estimation PCEU. For homogeneous traffic factors such as speed, headway, queue discharge flow etc. are common while for heterogeneous traffic, parameters such as area occupancy, time occupancy, influence area, effective area, to mention a few were also used. Therefore, because of these operational differences between them, various methods have been used for estimating PCEU values for different facility types and locations e.g. midblock section, signalized intersection, and uncontrolled intersection etc. [10].

However, similarities between both developed economies and developing economies in terms of traffic composition is that both tends to move towards personal mobility. While developed countries mostly uses the four wheeled passenger cars, developing countries tends to use a lower class in the form two wheeled vehicles commonly motor cycles. Motorcycle traffic, which has very distinguishable characteristics such as smaller in size than other vehicle types allowing it to occupy every useable spaces while in motion and with high maneuverability they can significantly affect the traffic condition. In addition, at signalized intersections, they often stay in front of the queue and this may increase the loss time due to start of the vehicles behind [3].

In Some African countries motorcycles serve as a mode of transit service used as public transit and also personal transport [7,9]. Also a report on informal transportation states that, most Nigerian cities with population of 250,000 mainly uses motorcycles for urban public transport services [12]. According to [8], half of the newly registered vehicles in the year 2016 in Nigeria were motorcycles which may be due to large population with poor economic status, cost (of owning, maintenance of vehicles etc.), ease of access and convenience in overcrowded traffic with poor road infrastructure, lack of efficient public transportation system and others.

Hence, it makes more sense in such cases that the motorcycle should be

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considered as the standard vehicle in which other vehicles can be converted to. The concept of motorcycle equivalent unit (MCEU) to account for other vehicles in the traffic flow becomes relevant, since on those roads where they dominate, traffic flow properties will be more of their operational characteristics. Therefore, the objective of this study is to estimate MCEU of a mid-block section) of a road where we have high percentage of motor cycles when compared to other vehicles.

Standard Vehicle Equivalency Unit (PCEU/MCEU) Estimation Method

PCEU can be defined as the number of passenger cars that will have the same operational impact as a single vehicle of a particular type under specified roadway, traffic and control conditions. Most studies carried out in the developed countries are with regards to behavior of passenger car traffic which is reflected in their predominant use of PCEUs. In mixed traffic conditions, [15] presented the new concept using speed as a primary variable to determine the PCEU of vehicles on urban midblock. They mentioned that, the speed of any vehicle type is a true representation of overall interaction of that vehicle type with other vehicle types. According to their concept, PCEU is directly proportional to speed ratio and inversely proportional to projected area ratio with respect to the standard vehicle.

In contrast, little studies have been carried out with regards motor cycle traffic even though it is prevalent in some developing countries. For motorcycle analysis, [15] analyzed the motorcyclist behaviors in a mixed traffic flow on different road widths and they developed traffic volume-density relationships and speed-density relationships under different percentage of motorcycles. Also, in a similar work, [3], provides a basic understanding of characteristics of motorcycle traffic by using motor cycle as the standard vehicle which other vehicles were converted to. In a more recent study by [4] proposes a new approach to estimate the value of MCEU with some adjustments. The proposed model describes the relationship between MCEU values and significant parameters such as trajectory, velocity, and safety distance. Their results suggest that, the MCEU values estimated with the proposed model are quite stable and that the proposed model can be applied to many types of roadway geometries, such as road segments at intersections. The physical size of a vehicle is an indicator of space occupancy, which is crucial in operational characteristics of traffic stream [2]. Nevertheless, the value of the physical size of a

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vehicle is constant. They considered speed to be a prime variable to determine the relative effect of individual vehicles on traffic stream with respect to a standard vehicle.

$$Standard\ Vehicle\ Equivalency\ Unit = \frac{V_{stc}/V_v}{A_{stc}/A_v} \qquad (1)$$

Where

V_{stc}, V_v, mean speeds for standard vehicle and type v vehicle.

A_{Stc}, A_V is the projected rectangular area(m^2)

Case Study

The study area is Minna the capital city of Niger State, Nigeria. See the map of the township road network in the Figure 1 below. A road segment suspected to have high percentage of motorcycles was divided into 3 sections. Two free section and One section where speed is impeded. Spot speed studies were conducted on all the three locations.

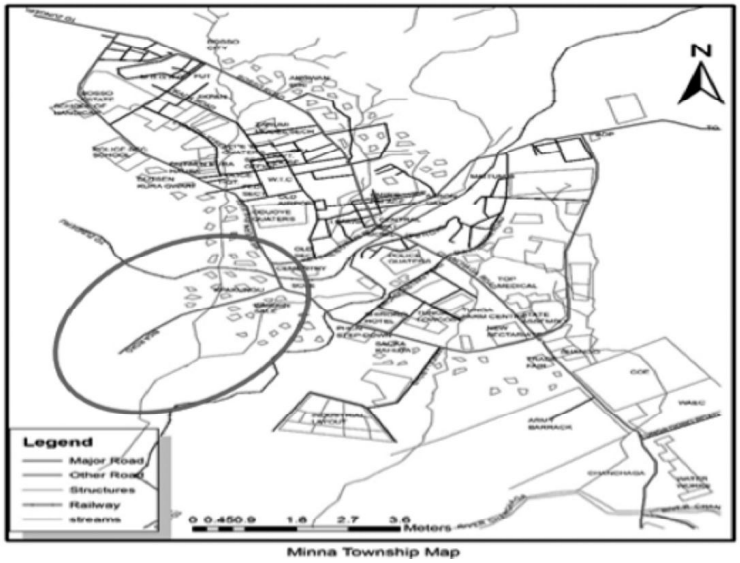

Figure 1 *Study Area*

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Result and Discussion

Depending on the traffic composition at the study location, researchers classify the vehicles into different categories. Vehicles which are similar can be grouped together because considering each vehicle type with no significant share in the traffic by itself can be challenging. This simplification, allows the usage of standard values for their characteristics which can be found in well documented literatures even though care must be taken not to over simplify so that the various classes can at least be a representative of the characteristics of the various groups included in the group. So many researchers in developing countries used the standard categories and their average dimensions proposed by Chandra and Kumar [2]. In this study, the traffic composition was classified into four different categories, Motorcycle, Passenger Car, Truck, and Bus and their projected rectangular area was extracted from the aforementioned authors' work as shown in the Table 1 below.

Category	Projected Rectangular Area(m^2)
Passenger Cars	5.39
Motor Cycles	1.2
Bus	12.81
Trucks	17.62

Table 1 *Vehicle Projected Rectangular Area*

Also, along the stretch of the road segments three locations were surveyed to estimate the traffic composition and spot speed. The Figure 2 below shows the traffic composition among various categories. In all the locations, the average percentage of motorcycles of all the locations is approximately 70% which is much higher than other categories. This road segment is clearly dominated by motorcycle traffic.

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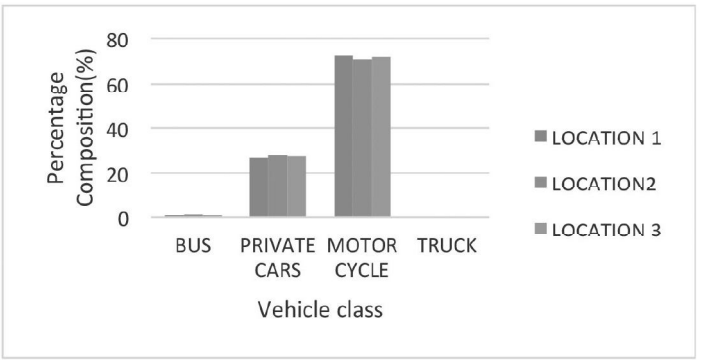

Figure 2 *Vehicle Percentage Composition*

Spot speed studies are used to determine the speed distribution of a traffic stream at a specific location. Spot speed studies was carried out at the three locations and the median speed and 85th percentile speeds were evaluated. 50th percentile represents the speed at which half of the observed vehicles are below and half of the observed vehicles are above. This speed represents the average speed of the traffic stream. The 85th percentile is the speed at which 85% of the observed vehicles are traveling at or below. This percentile is used in evaluating/recommending posted speed limits based on the assumption that 85% of the drivers are traveling at a speed they perceive to be safe. In other words, only 15% of the vehicles exceed this speed at the point. See Table 2 for the results of the spot speed studies.

	85th Percentile	50th Percentile	85th Percentile	50th Percentile	85th Percentile	50th Percentile
Motor Cycle	55.5	42	38	27	18	12.5
Passenger Car	52	40	37	21	17	12.5
Bus	42	28	26	16	12	6.7
Truck	35	28	25.5	15	9.8	5.5

Table2 *Speed Percentiles*

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Chandra et al. (2003) considered speed to be a prime variable to determine the relative effect of individual vehicles on traffic stream in respect passenger cars. In this study, Chandra et al. 2003 method in equation 1 was adopted for estimating both MCEU.

$$MCEU = \frac{V_{mc}/V_v}{A_{mc}/A_v} \qquad (2)$$

Where

V_{mc}, V_V, mean speeds for cars and type v vehicle.

A_{mc}, A_V is the projected rectangular area(m^2)

Using the above equation 2 the results of the MCEU using 85th percentile speed and the 50th percentile speeds are presented in Tables 3 and 4 below.

	Motor Cycle	Passenger Car	Bus	Truck
Location 1	1.00	4.77	14.11	23.28
Location 2	1.00	4.59	15.60	21.88
Location 3	1.00	4.73	16.01	26.97

Table 3 *MCEU Estimation Using 85Th Percentile Speed*

	Motor Cycle	Passenger Car	Bus	Truck
Location 1	1.00	4.69	16.01	22.03
Location 2	1.00	5.74	18.01	26.43
Location 3	1.00	4.47	19.92	33.37

Table 4 *MCEU Estimation Using 50th Percentile Speed*

From table 3 and 4, it can be seen that the MCEU values changes with change in the speed of the vehicles since average area of vehicles are used. These results are similar to those obtained in literatures even though there

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is marginal increase in MCEU with change is speed. The effect of one car, bus, truck is equivalent to approximately 5, 16 and 24 motorcycles respectively.

Conclusion

This study applies the basic principle in the estimation of motorcycle equivalency unit using the average area of the vehicles concerned and their speeds. The results of the MCEU estimations along this road section for car, bus, truck are 4.69, 15.24 and 24.04 respectively. These values changes with change in speed as stated in the literatures that various methods of estimating MCEU depends on the facility type and nature of traffic. Although this method does not necessarily reflect reality as the average projected area of the vehicles to represent space occupancy might be dependent on several other factors other than speed but it can be used to gain a baseline idea of the traffic flow relationships, highway capacity estimates and in general, can be used to formulate policies for traffic management and control relating to motor cycle traffic operating behaviors. It is recommended however that; a better model be developed which will account for the various aspects for determining space occupancy on the road and depict more clearly the inter operational relationship between motor cycles and other vehicles.

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