Journal of Positive Psychology & Wellbeing
2022, Vol. 6, No. 2, 981 – 987
http://journalppw.com
ISSN 2587-0130

METHODOLOGICAL GUIDELINES FOR INCORPORATING THE TRIMOVIL IN TRAFFIC STUDIES IN THE CITY OF HUÁNUCO

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ABSTRACT

Mobility conditions in Peruvian cities require strategic interventions by the entities in charge of urban transportation. The trimovil as a means of transportation is evolving in terms of the quantity and use that is given to them on the roads; therefore, technical studies of their road capacity are required to be useful for mobility management and the definition of public traffic policies. This paper proposes methodological guidelines to incorporate the trimovil factor about the automobile (current design vehicle) in local traffic flow studies, starting from the analysis of the parameters that influence traffic operation, to propose an application model based on the speed-space of both vehicles, validate it and finally propose numerical values of the ratio factor between the trimovil and the automobile, which incorporates the trimovil as a design vehicle in traffic studies in the city of Huánuco.

Keywords: trimobile, trimobile factor, traffic flow.

RESUMEN

Las condiciones de la movilidad en las ciudades del Perú requieren de intervenciones estratégicas por parte de las entidades encargadas del transporte urbano. El trimovil como medio de transporte está en evolución en cuanto a la cantidad y uso que se les da en las vías, por ello, se requiere de estudios técnicos de su capacidad vial que sean útiles para la gestión de la movilidad y definición de políticas públicas de tránsito. El presente trabajo propone lineamientos metodológicos para incorporar el factor trimovil con relación al automóvil (actual vehículo de diseño) en los estudios del flujo de tránsito local partiendo del

análisis de los parámetros que influyen en la operación del tránsito, para proponer un modelo de aplicación basado en la velocidad – espacio de ambos vehículos, validarlo y finalmente proponer valores numéricos del factor de relación entre el trimovil y el automóvil, que incorpore al trimovil como vehículo de diseño en los estudios de transito de la ciudad de Huánuco.

Palabras clave: trimovil, factor trimovil, flujo de tránsito.

I. INTRODUCTION

The progressive and sustained incorporation of trimovils in the last years in the vehicular flows on urban roads must be seen in an inclusive and normal way in the composition of the traffic of developing cities such as those of our region; where the trimovil already has majority participation in the distribution of the types of vehicles that circulate on the streets, making the trimovil a means of transport of massive use.

In this environment, what happens then with national, regional and local policies on trimovils? They should understand the role of trimovils in the traffic system and promote the regulation of the use of this vehicle in a concrete way to mitigate the possible externalities expressed in accidents and congestion that these vehicles may generate in the transportation system of the cities.

Regarding accidents, there is a tendency to relate the growth of the fleet of three-wheeled vehicles with the increase in accidents, which can also be associated with the road culture of the drivers of these vehicles, which is not as direct as it may seem.

Some of the variables found in the analysis of the road safety of small vehicles are differences in human behavior, which has to do with the variation in the way of driving, which can be modified by the maneuverability of these vehicles and which makes it different from that of other vehicles of a larger size.

Regarding congestion, it is worth mentioning that due to their particular characteristics these vehicles perform unique maneuvers; at a traffic light for example, where congestion is reflected in the lines of vehicles waiting to cross a certain intersection, the trimoviles travel through the spaces left by a vehicle stopped next to another or between the "inter-lanes", which generates greater congestion.

Regarding urban traffic, in the city of Huánuco the authority in charge of regulating this issue is the Provincial Municipality, through its Transportation Department following the General Law of Transportation and Land Transit No. 27181 which in its Article No. 17. 1 establishes that the Provincial Municipalities, in their respective jurisdiction and by the laws and national regulations, have competencies in matters of transportation and land transit. In addition, the National Traffic Regulation approved by Supreme Decree Nº 016-2009-MTC and the National Vehicle Regulation approved by Supreme Decree Nº 058-2003-MTC are applicable. These guiding documents consider as traffic elements the users (pedestrian, driver, passenger), roads and vehicles, among the latter, although it is true that it tangentially considers the three-wheeled vehicles, it does not prioritize them although in many cities of the country they are the vehicles that circulate in greater numbers on the roads. So when any traffic study deals with vehicle capacity, which requires the characterization of the type of vehicles that pass through a defined point at a given time, and the vehicle that has the largest number should be the typical vehicle, however in our case (city of Huanuco) the trimovil is the vehicle that has the largest number in the traffic flow, but the theory and regulations do not reflect this reality.

Concerning current technical regulations, the Manual of Automobile Traffic Control Devices for Streets and Highways describes different parameters that determine the level of service of road infrastructures, such as capacity, volume and speed. This Manual considers the medium-sized automobile as the design vehicle but does not define what to do with vehicles smaller than

an automobile (especially trimoviles) with different physical and mechanical characteristics, which is why they are currently erroneously considered an automobile. The Colombian regulations consider ratio factors for vehicles larger than an automobile, for example for Bus and Truck type vehicles where a comparison factor is exposed as a percentage of an automobile, for the case of Bogota the equivalence factor used is 2.0 for buses (Bus Factor = 2.0) and 2.5 for trucks (Truck Factor = 2.5).

Therefore, since there is no technically defined factor to compare a trimovil with a car, this vehicle cannot be included (or is included in a distorted way) in the different traffic analyses that are carried out and presented for approval to the relevant authorities. For this reason, when calculating road capacity and of course all traffic simulation models, the number of trimoviles (due to their large number) completely alters the traffic parameters and variables,

The physical characteristics of the trams (length, width, height, speed, turning radius), their quantity and dynamics in the traffic flow expressed in road capacity, volume and speeds are the variables to be analyzed and to this extent, it is of great importance for decision making to define a factor of equivalence of a tram with a car, to finally define sustainable mobility policies, which take into account the real participation of trams in the vehicle composition of urban traffic.

If the issue is problematized, then the question arises:

How to identify in the traffic studies as well as in the different mobility analyses of the city of Huánuco, an equivalence factor between the trimovil and the automobile, to consider the important participation of the trimovil as a means of transportation in the urban space?

II. MATERIAL AND METHODS

Object of the study

The object of study was the trimovil circulating in urban traffic in the city of Huánuco.

Level, type and design of research

This was a descriptive and applied research for which the non-experimental cross-sectional design was proposed.

Population, sample and sampling.

Population: The vehicles that make up the traffic in the city of Huánuco.

Sample: The trimovil (Bajaj type).

Sampling: Non-probabilistic, discretionary sampling.

Methods, techniques, data collection instruments and procedures

Method: Deductive

Technique: Observation

Instruments: Double entry format, one the type of vehicle and the other the time they pass (during the 24 hours of the day), where the number of vehicles passing at a given point discriminated by type and time of day can be recorded.

Procedure: Through the Aforo, a count was made of all vehicles passing through a study point during the 24 hours of the day, during 3 days, and the number of cars and their proportion in the vehicular flow had to be counted separately. The speeds of the vehicles under study (trimovil) were also recorded.

Methodology

The methodology used defines only the practical activity to be carried out with the primary and secondary information, which aims at defining an equivalence factor for the operation of the car and the trimotor with continuous flow limitation.

Definition of the study section and the mode of data collection.

A study section was defined on the road to be analyzed, with a length of 100 meters, to obtain relevant information on the traffic operation; in the section, a video data collection was made from a place where the traffic behavior of every one of the vehicles in the flow can be appreciated; where the maneuvers of the vehicle drivers can be appreciated and there is enough visual field to analyze the behaviors of the tri-motorcycle drivers.

The vehicle flow information was collected on mixed-flow roadways, without including non-motorized means of transport, i.e., bicycles.

Definition of static comparison factors.

In the static condition, the Trimoto Factor in static condition FTE is defined as the quotient of the static areas by vehicle type, i.e., the ratio between the static areas of the trimoto (AET) and the automobile static area (ASA), with the following dimensions:

Automobile Static Area (ASA):

2.5 m X 5.0 m = 12,5 m^2;

Static Area Motorcycles (AEM):

2.0 m X 3.0 m = 6.0 m^2.

So then the Trimoto Factor in static condition *FTE* es: 0,48

Filming of the study section.

In the study section, the longitudinal distance was traced using elements of the road that could serve as a reference to divide the section and allow the analysis of the video, to measure volumes and travel times.

At the site, the vehicular flow was recorded on video, in different periods, to characterize different vehicular demands and different conditions of the vehicular flow. These periods depend on the behavior of the demand throughout the day and the hour to be used as the analysis period in the traffic study to be carried out.

Measurement of macroscopic variables.

Macroscopic variables of vehicular flow, speed, volume and density were considered.

At a certain moment of the video, the image was stopped and the vehicles within the study area were identified (i.e., in the roadway section and the defined length); the time used by these identified vehicles to travel the defined distance was calculated, in such a way that the operating speed of each of the vehicles was obtained; with each of these data, the operating speed of cars and motorcycles was determined as an average as indicated for the calculation of speeds in the Peruvian regulations.

The number of measurements (number of screenshots) obeys a statistical analysis where the sample size is calculated and depending on the measured volume, the number of screenshots to be analyzed or the number of vehicles to be analyzed is calculated.

The operating speed of motor vehicles, designated as VA, is calculated as the 85th percentile of the sample (this speed includes the speed of buses and trucks). In the case of tricycles, the operating speed VT is obtained and again calculated as the 85th percentile of the sample; it is important to mention that the magnitude of these speeds involves the impact generated to the current by the participation of heavy vehicles, the lane width, the number of lanes and the volume as such.

As for the volume of vehicles, these identified as Cars (A), Buses (B), Trucks (C) and Tricycles (T), were obtained from the count of vehicles in the time recorded in the video; however, for the analysis of buses and trucks, they are counted as cars, since the exercise does not refer to the analysis of the equivalence of buses and trucks.

Density measurements can be obtained from the video by pausing the video and obtaining from

the image a determined number of vehicles per kilometer per lane; this density is useful to develop other exercises of vehicular flow analysis; however, it is not used in this study because the density does not apply to the analysis of tricycles since it is understood that two or three tricycles can travel in parallel in the same lane.

Calculation of the moto factor (for continuous flow).

According to the literature reviewed in numeral 1.1.2, in countries where motorcycles are of widespread importance in traffic analysis, methodologies have been defined to convert other vehicles into motorcycles; that is, the motorcycle is the unit of measurement and therefore the equivalences are made in terms of motorcycles. One of these methodologies consists of calculating the relationship between the speeds and the occupied areas of the vehicles, which is what is proposed in the following research, making an analogy between the motorcycle and the trimovil, in which the following parameters are related.

Vtc: It is the speed of the trimotorcycles

Vi: It is the speed of the vehicle to be compared

Atc: This is the average track area occupied by the trimotorcycles.

Ai: Is the average track area occupied by vehicle type i

Relating them in such a way as to convert the trimotorcycles into equivalent vehicles, i.e. the Trimoto factor, which is what this work seeks.

Therefore, with the speeds obtained for cars and tricycles separately, the relationship between speeds (Va/Vt) is constructed to validate the differences between the behavior of these two vehicles. This relationship hypothesizes that, to the extent that the difference in speeds between the motorcycle and the automobile increases, the lower the incidence of the trimotorcycle in traffic and the lower the comparison factor of the trimotorcycle to equivalent vehicles will be.

It should be noted that with the value of the trimoto factor it will be possible to convert trimotos into equivalent cars by simply multiplying the number of trimotos measured by the calculated trimoto factor.

Finally, it can be said that the proposed methodology, the analyses carried out and the results obtained, are carried out and serve as criteria to include a "trimoto factor" for the city of Huánuco as the equivalence of an automobile; however, the methodology can be used for other cities as a technical basis for the development of other research and/or applications whose purpose is to obtain the trimoto - automobile comparison factor in terms of road capacity**.**

III. RESULTS

Definition of static comparison factors.

In the static condition, the Factor Trimovil in Static condition FTE was defined as the quotient of the static areas per type of vehicle, that is to say, the relation between the Static Areas of the Trimovil (AET) and the Static Area of the Automobile (AEA), with the following dimensions:

FTE = AET / AEA

Static Area Automobile (AEA):

2.5 m X 5.0 m = 12,5 m^2;

Trimovil Static Area (AET):

2.0 m X 3.0 m = 6.0 m^2. So, then the Trimoto Factor in static condition FTE is equal to a 6 / 12.5 = 0,48

The capacity of the study section.

In the study section, 100 meters was defined as the longitudinal distance of the road that could serve as a reference to divide the section and

allow the analysis of the video, to measure volumes and travel times.

Measurement of macroscopic variables.

Macroscopic variables of the vehicular flow, speed, volume and density were considered.

At a certain moment of the gauging, the vehicles within the study area were identified (i.e. in the roadway section and the defined length); the time used by these identified vehicles to travel the defined distance was calculated, in such a way that the operating speed of each vehicle is obtained, with each of these data the operating speed of cars and trimoviles is determined as an average as indicated for the calculation of speeds in the Peruvian regulations.

The operating speed of automobiles, designated as VA, is calculated as the 85th percentile of the sample (this speed includes the speed of buses and trucks). For the case of tricycles, the operating speed VT is obtained and again calculated as the 85th percentile of the sample; it is important to mention that the magnitude of these speeds is considered, involving the impact generated to the current by the participation of heavy vehicles, the lane width, the number of lanes and the volume as such.

As for the volume of vehicles, these identified as Cars (A), Buses (B), Trucks (C) and Tricycles (T), are obtained from the count of vehicles in the time recorded in the gauging; however, for the analysis, buses and trucks are counted as cars, since the exercise does not refer to the analysis of the equivalence of buses and trucks.

This density is useful to develop other vehicle flow analysis exercises; however, it is not used in this exercise because the density does not apply to the analysis of tricycles, since it is understood that two or three tricycles can travel in parallel in the same lane.

Calculation of the moto factor (for continuous flow).

According to the literature reviewed, in countries where trimovils are of widespread importance in traffic analysis, methodologies have been defined to convert other vehicles into trimovils; in other words, the trimovil is the unit of measurement and therefore the equivalences are made in terms of trimovils. One of these methodologies consists of calculating the relationship between the speeds and the occupied areas of the vehicles, which is what is proposed in the following research by making an analogy between the trimovil and the automobile, in which the following parameters are related.

Trimoto factor (FT) = (Vt/Va) x (At/Aa)

Vt: It is the speed of the trimotorcycles.

Va: Is the speed of the car

At: Is the average track area occupied by the trimotorcycles.

Aa: This is the pre-average track area occupied by the car.

As the ratio At/Aa is what has been previously determined as FTE (trimotor factor in static condition) this factor is replaced and we have that:

Trimotor factor (FT) = FTE x (Vt/Va)

The Vt/Va ratio is equal to;

17.8 / 26.5 = 0.67

Finally, the Trimovil Factor will be;

FT = 0.48 x 0.67 = 0.32

Then, with this value of the trimoto factor obtained, it will be possible to convert the trimotos into equivalent cars by simply multiplying the number of trimotos measured by

the calculated trimoto factor, i.e., if there is a volume of 200 trimotos in one hour circulating on a road in the city of Huanuco, this is equivalent to saying that there are 200 x (0.32) = 64 cars per hour circulating on that same road.

IV. DISCUSSION

Finding that the trimoto factor that was sought to obtain with the present work has a value of 0.32, allows for immediate comparison with the motorcycle factor found in studies conducted in the city of Medellin, which was 0.50, or the one found in the city of Manizales, which was 0.75. 75, it should be noted that these two cities mentioned have very different characteristics from the city of Huanuco, both in size and in the composition of traffic, also in these cities do not circulate the trimotorcycles, preponderant factor in our city, so trying to make a comparison between these factors would not be possible because each city has very particular traffic that makes its macroscopic and microscopic parameters are only valid for that city. Therefore, any factor that relates to these parameters will also be specific to each city.

This study considers the speed and area of the vehicles to establish the equivalence factor; however, the turning radius of the vehicles could also have been considered, an important aspect of the road capacity, which, if considered, would adjust the value of the equivalence factor found.

There are no studies of this traffic factor in cities of our country, which is necessary so comparisons between similar cities can be made.

V. CONCLUSIONS

✓ This study reaches the following conclusions:

✓

✓ The trimovil is the predominant vehicle in the flow of traffic in the city of Huánuco.

✓

✓ For traffic studies in the city of Huánuco, the equivalence factor between a car and a trimovil is 0.32, i.e., for traffic studies in the city of Huánuco, 100 trimovils are equivalent to 32 cars.

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