Road Intersection Analysis – Case Study in a Intersection in the City of Palmas - TO

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ABSTRACT: *This paper aims to perform an intersection analysis located in the municipality of Palmas - TO, the location was chosen due to the kneecap is suffering from major congestion at peak caused by the mixture of the traffic of the BR-010 with the urban traffic coming from from the Taquaralto and Taquari neighborhoods. The study site is an area with large population growth and with many traffic generating poles, causing long queues and consequently increasing the accident rate mainly at peak times. This work seeks the current flow of vehicles as well as future estimation, identification of conflict points and their proper origins. The traffic studies have provided the identification of optimal geometry for the roads that intersect in order to seek minimal solutions of boxes and shoulders as well as the ideal number of lanes on the roads and then provide the driver with safer and more comfortable traffic.*

Keywords— Road intersection, Geometry, Road safety.

I. INTRODUCTION

Currently in Brazil, the highway modal has a much higher demand in other modes, both for transporting goods and for people transport due to ease of access throughout the country. The big demand for road transport demands the same amount of investment in planning, projection, execution, conservation and inspection of road networks ensuring a safe, economical and efficient transport for the population. (VALIM; ALVES, 2016).

Intersections between highways where to give access to municipalities or roads represent a delicate challenge for Brazilian civil engineers, since it is the need for efficient and safe convergence needs to be met for all vehicle classes, from passenger cars to vehicle combinations of cargo (VALIM; ALVES, 2016).

The accelerated increase in vehicle fleets is a very important factor to be because it generates a demand that demands greater investments in the solutions for road modes that meet the new needs in a viable way and economic (FAVERO, 2017).

According to Valim and Alves (2016) the points considered most critical for a driver are at the road intersections where in a short period the driver must make decisions about route changes, accessibility, and traffic preferences.

In the present study we collected recent data found through the Denatran (2019) and IBGE Estimated for (2018), referring to the newest capital of the showing that in Palmas - TO the index of people for each vehicle is equal to 2, thus proving a huge increase over the years and awakening the need for analyzes and measures to alleviate the negative effects of increased fleet and circulation of individual vehicles.

Road congestion is a negative point for transport where it affects not only the economy but also people, which due to the Waiting times can suffer from diseases such as stress and anxiety. (SOUZA, 2015).

According to Favero (2017) the modifications that affect the networks of transport have social consequences, and it is up to engineers to evaluate the negative and positive impacts to seek a broader social solution.

Given this need, a study of traffic, quality of flow and access to the highway in the city of Palmas - TO, using real data that presented a current scenario in the most accurate way. For the improvements it was need to meet future demand so that road investments also have positive long-term impacts.

The objectives of this paper, therefore, is to evaluate the technical analyzes concerning the interpretation of traffic demands, classifications and limits geometry of roads in order to find the traffic scenarios and to evaluate the congestion at peak times relating to geometric measurements and thus seeking a conception of concepts and parameters in segments road.

II.   METHODOLOGY

2.1   PLACE OF STUDY

The study site was an intersection on BR-010 where access to Taquaralto in the city of Palmas - TO. At this intersection, currently, conversions are carried out by means of a roundabout with central road traffic as for urban traffic where they intersect.

The kneecap intersection contains 5 branches and has a large congestion at peak times. This intersection is part of BR-010, a commercial avenue and other avenues with access routes to the bus terminal, schools, state and local authorities, hospitals, colleges, downtown and several other traffic generating poles.

Based on this data, the location (Figure 1) was selected as a point critical in the flow of vehicles in the city and for being of great social interest, as it aims to improvement for local traffic where growth in nearby neighborhoods is quite large.
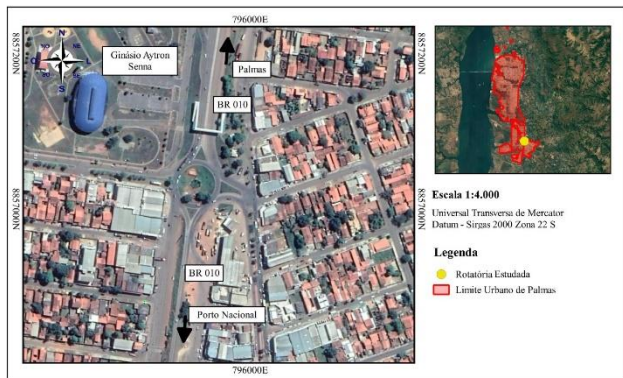

Figure 1 - Analysis Location

2.2 TRAFFIC RESEARCH

Traffic surveys were performed based on the Study Manual Traffic - DNIT (2006) through direct observation recording all traffic phenomena without disturbing it. The place of the research was exactly at the intersection site in order to raise flows from the intercept and their connecting branches. It took 4 counting points (Figure 2), then find the total number of vehicles passing at the roundabout.

Figure 2 - Location of counting points
Source: Adapted from Google Maps (2019)

2.2.1 Counting Method

The counting method was the manual method. Counts were recorded data transcription cards and cameras for filming at higher flows for future counting. The grouping criteria adopted were: cars, buses and trucks.

It took a total of 4 people to do the counting simultaneously 1 researcher for each point, to have the total number of vehicles crossing the roundabout at the exact count time. The survey was conducted in 3 weekdays for a total of 3 hours per day divided into 15-minute intervals. Having no disruption to traffic caused by accidents, works or track sinking the survey then took place according to (Table 1).

Monday	Wednesday	Friday
07:00 to 08:00	07:00 to 08:00	07:00 to 08:00
12:00 to 13:00	12:00 to 13:00	12:00 to 13:00
18:00 to 19:00	18:00 to 19:00	18:00 to 19:00

Table 1 - Days and times of counts

2.3 DETERMINATION OF CURRENT TRAFFIC

Current traffic was determined from counts made in field and with that it was possible to find the day of the week and the time of greatest flow of vehicles that crossed the roundabout. After counting was necessary calculate the Peak Hour Factor that measures precisely the variation between the minutes of count and determine the degree of flow uniformity. For the calculation of the Time Factor Peak was applied the following formula.

$$FHP = \frac{Vhp}{4V15max} \quad (1)$$

Where:

FHP = Peak Hour Factor;

Vhp = Peak hour volume;

V 15max = 15-minute period volume with highest traffic flow within the hour peak.

2.4 DETERMINING FUTURE TRAFFIC

Future traffic was found through the growth factor calculated by varying the fleet of vehicles for two different periods, the survey was conducted on the IBGE website. In the calculation of the growth factor the following formula is used.

$$Fc = \frac{FV2017}{FV2007} \quad (2)$$

Where:

F c = growth factor;

F v = Vehicle fleet.

After finding the growth factor it was applied in the following formula to then arrive at the traffic result for the year 2027.

$$Tf = Fc * Ta \quad (3)$$

Where:

T f = future traffic;

F c = growth factor;

T a = Known traffic in a given year.

2.5 STUDY OF GEOMETRY IN RELATION TO TRAFFIC VOLUMES

This analysis required a field study to find the current measurements of the intersecting roads then were the studies focused on the tables will be presented below. In this analysis we considered only the points 1 and 4 represented in (Figure 2) which are the busiest roads and generate congestion at peak times.

VALORES ESTIMADOS POR HORA NAS VIAS		
Local plano; Equivalência: 1 caminhão = 4 veículos de passeio	50veíc/h	Largura inferior a 6 m
	190 veíc/h	Largura inferior a 6 m
	620 veíc/h	Largura mínima de 6 m
	1400 veíc/h	Largura superior a 8 m
	> 1500 veíc/h	Largura igual ou sup. a 12 m

Table 2 - Estimated values per hour
Source: Fajersztajn (2012)

FUNÇÃO	VOLUME MÁXIMO/DIA		VOLUME MÁXIMO/DIA	VOLUME MÁXIMO/HOR	GEOMETRIA NECESSÁRIA	
	VEÍCULOS LEVES	CAMINHOES E ÔNIBUS	TOTAL DE VEÍCULOS	ESTIMADO 10% DO TOTAL	LARGURA DA CAIXA (m)	Nº FAIXAS
Via local residencial com passagem	400	20	480	50	4 a 5	1
Via coletora secundária	1500	100	1900	200	5 a 6	2
Via coletora principal	5000	300	6200	650	6-7	2
Via arterial	10000	1000	14000	1500	> 8	≥ 3
Via arterial principal ou expressa	> 12000	2000	20000	2000	> 12	≥ 4

Table 3 - Road classes - Study of traffic volumes and relationships with their geometry
Source: Fajersztajn (2012)

LARGURA DA RUA (A) m	LARGURA DA CAIXA (B) m	LARGURA DOS PASSEIOS (C) m
6-7	4	1,0-1,5
7-8	4 - 5	1,5
8-10	5 - 6	1,5-2,0
10-12	7	15-2,5
12-14	8	2,0-3,0
14-15	9	2,5-3,0
15-16	10	2,5-3,0
16-17	11	2,5-3,0
17-18	12	2,5-3,0
18-20	13	2,5-3,5

Table 4 - Basic dimensions in relation to box width
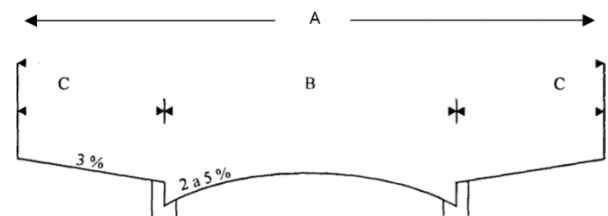*Source: Fajersztajn (2012)*

Figure 3 - Paving project model
Source: Fajersztajn (2012)

Note:

Equivalence adopted:

1truck = 4 light passenger vehicles.

1 bus = 4 light passenger vehicles.

III.   RESULTS AND DISCUSSIONS

3.1 CURRENT TRAFFIC

On Friday, in the period from 18:00 to 19:00 was finding the largest volume of vehicles that crossed the roundabout, a total of 3,808 during peak hours, 3,318 automobiles, 226 buses and 264 trucks. In the 15 minutes of highest flow It had a total of 1003 vehicles, of which 870 cars, 64 buses and 69 trucks.

So, we got a Peak Hour Factor of 0.95 indicating large volume of capacity-restricted traffic during peak hours, ie

with congestion within the highest flow period, verified during the survey (Figures 4 and 5).
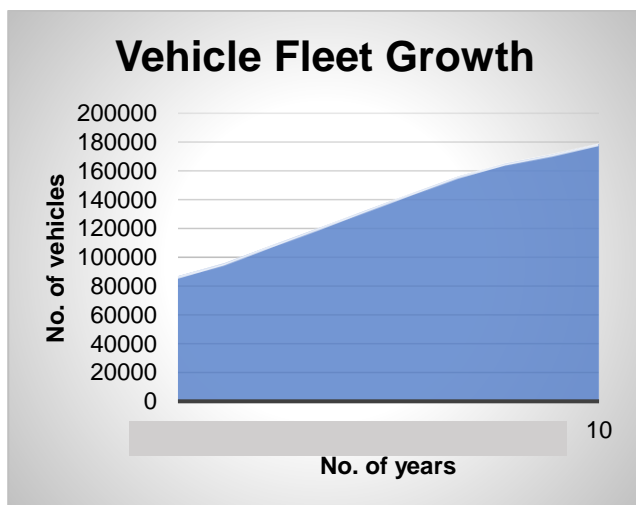

Figure 4 - Intersection congestion

Figure 5 - Extended Congestion

3.2 FUTURE TRAFFIC

According to IBGE in 2007 there was a fleet of vehicles equal to 86,993 and in 2017 the fleet was 178,752 as shown in (Graph 1), ie increased more than double over a 10-year period.

Graph 1 - Vehicle fleet growth

With significant vehicle fleet data for a decade can find the Growth Factor equal to 2.05, with this result was future traffic of 367,297 vehicles is expected for the year 2027.

3.3 ROUTE GEOMETRY IN RELATION TO VEHICLE FLOW

In traffic studies it was possible to find vehicle volumes per hour for each point that enters the intersection in the current situation and with that it was possible calculate the flow estimate for the year 2027 at each counting point as indicates in (Figure 2).

The following results only presented the results from points 1 and 4. which are higher flow rotary access points that cause Traffic jams at peak times, these points are located on BR – 010 classified as the main or expressed arterial route.

3.3.1 Relationship of current geometry to current vehicle flow

Table 5 shows the current box and ride measurements as well as the number of lanes per lane and the current volume of vehicles. The values presented are the highest flow roads where it gives access to the kneecap intersection in the BR-010. The following results indicate that in the current situation the measures of the do not meet the current flow (Table 2) and not even compared to road classification no (Table 3).

POINTS CRITICIS	VEHICLE VOLUMES	WIDTH FROM THE BOX	N° OF TRACKS	WIDTH OF RIDES
PONTO 1	1605 veíc/h	10,65m	3	0,48
PONTO 4	1341veíc/h	6,80m	2	1,55

Table 5 - Current Situation

3.3.2 Relationship of current geometry to estimated vehicle flow for 2027

(Table 6) relates the estimated vehicle flow for the year 2027 to the current situation of the intersection access roads indicating the their inefficiency to meet future demand according to (Table 2).

POINTS CRITICIS	VEHICLE VOLUMES	WIDTH FROM THE BOX	N° OF TRACKS	WIDTH OF RIDES
PONTO 1	3451 veíc/h	10,65m	3	0,48
PONTO 4	2884 veíc/h	6,80m	2	1,55

Table 6 - Future Situation with Current Geometry

3.3.3 Geometry Ratio Required to Meet Current and Future Flow

According to the studies by Fajersztajn (2012) the widths of the boxes, the width of the rides and the number

of current lanes do not meet the needs or even of the current flow relating (Table 2) to (Table 5) and neither by (Table 3), thus (Table 7) presents necessary for the intersection access roads considering measures that meet the current situation and another decade.

POINTS CRITICIS	FLOW CURRENT	FLOW FUTURE	WIDTH FROM THE BOX	N° OF TRACKS	WIDTH OF RIDES
PONTO 1	1605 veíc/h	3451 veíc/h	>12m	≥4	2 - 3m
PONTO 4	1341veíc/h	2884 veíc/h	>12m	≥4	2 - 3m

Table 7 - Future Situation with Updated Geometries

IV. FINAL CONSIDERATIONS

The analyzes reported in this work served to verify the importance of the traffic studies that allowed the identification of the current flow and made possible a future estimation and with it the assimilation to the common problems already in the current situation due to deficiencies in the road network.

Conflict identification occurred through on-site surveys intersection such as major congestion at peak times, this being what drew the most attention to this study, since they provoke driver stress and anxiety even reaching the level of accidents serious.

When analyzing the intersecting roads, the most critical points were reported, or that is, the ones with the highest flows, so the study turned only to these points where the need for superior measurements was verified both in the boxes of the highways as in number of lanes and sizes of rides so it is suggested to future work that adequacy projects are carried out on the roads in conflict.

In the classification of a road, vehicle flows, speed maximum and its geometry if it is not possible at all to perform a adequacy in conflict roads, speed studies are suggested allowed on the roads, seeking to decrease the flow just as it was done in São Paulo in 2015 when the maximum permitted speed was reduced to 50km / h on the local avenue Tietê local track, where before the top speed allowed was 70km / h.

In this context the understanding of road concepts applied to traffic challenges ensures the maintenance and improvement of warranties citizens' rights through safe, economical and efficient transport.

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