

# INTERMUNICIPAL HIGHWAY SAFETY ANALYSIS IN URBAN AREAS



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## Abstract

As a result of its location, IlhaSolteira is on the route of highway transportation of goods and has been facing some issues due to the increase of heavy vehicles in its urban areas. Considering this fact, the paper presents the study and results from a highway safety analysis in urban roads that crosses and/or surrounds IlhaSolteira city. The parameters used were flow rate, which allows to know how many vehicles use the urban road, driver’s preference (go ahead, turn left or right) and the traffic composition in order to analyze light/heavy vehicles interaction and community/heavy vehicle interaction. In both highways, the database and graphs showed up a considerable amount of pedestrian and bicycles using these urban roads, however, there is no bicycle lane or grade separation for pedestrian. Also, the survey pointed out huge lines of cars right after an MCV (multi-combined vehicle) causing congestion.

Keywords: highway safety; urban roads; light/heavy vehicles

## 1. Objective

The purpose is to analyze the safety of one major urban roads that surrounds Ilha Solteira-SP/Brazil, *Feliciano Salles da Cunha - Highway SP 310*; and one that crosses the city, *Gerson Dourado de Oliveira – Highway SP 595*. The analyze bases on the light/heavy vehicle interaction when they drive through the urban perimeter; as well as their interaction with the community. Additionally, the traffic demand should be verified based on the following parameters: flow rate, which allows to know how many vehicles use the urban road, driver's preference (go ahead, turn left or right) and the traffic composition.

## 2. Introduction

In Brazil, the majority of goods is transported by highways. In order to increase the profits, reduce time and increase the amount of goods transported per time, larger trucks have been required. Pereira Neto and Widmer (2008) state that, in Brazil, “This growth is largely due to an increase in heavy truck traffic with gross combined weights ranging from 23 and 45 t. While in 1992 these vehicles represented only 6.9% of the total fleet, in 2005 they represented 17%. Extra-heavy vehicles, with GCMs (gross combined masses) over 45t are growing gradually, and were estimated at about 4% of the fleet at the end of 2006”.

These heavy vehicles cause many impacts to the road and road users, especially close to urban areas. The traffic was not planned considering them. According to Lake at all (2002), “Three factors contribute the effect of heavy vehicles on roads: the large size of trucks; the operating capabilities of trucks that are inferior to cars; and the physical impact on nearby cars and psychological effect on the drivers of those cars”.

In this paper, heavy vehicles were divided into two categories: trucks and buses; and articulated or rigid multi-combined vehicles (MCV), such as Roads-Trains, B-Doubles and other large size vehicles. As urban areas impacts, Lake at all (2002) states: “There are two main traffic related issues associated with MCV in urban areas, namely: delays that they may cause to other vehicles and safety related impacts. These are interrelated in urban areas, as accidents involving MCV create delays, while congestion affects the probability of accidents. Other considerations of MCV in urban regions include: efficiency; contribution to the national and local economy; and environmental effects”.

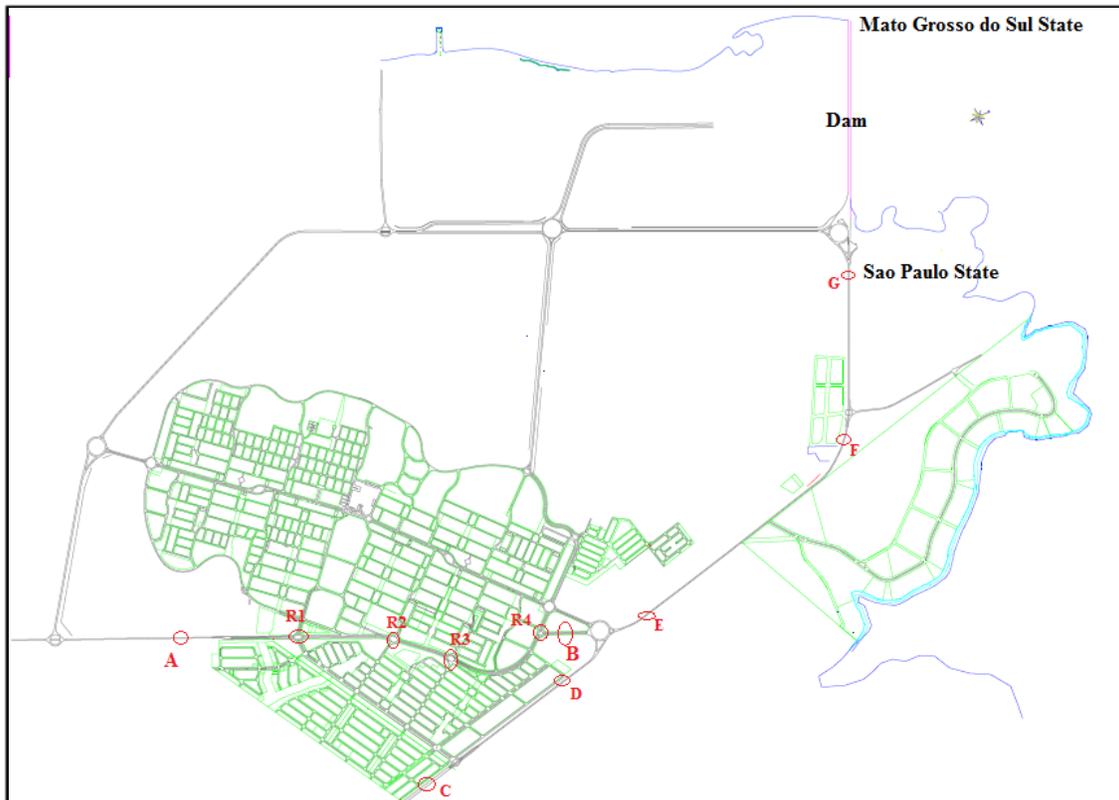
The case study, Ilha Solteira, is considered a strategic city due to its geographic location. It is located on the border between two states – Sao Paulo and Mato Grosso do Sul, the first one more industrialized and the second, agricultural. As a result of its location, Ilha Solteira is on the route of highway transportation of goods and has been facing some issues due to the increase of heavy vehicles in its urban areas.

In order to analyze the heavy vehicle impacts in Ilha Solteira urban area, the light-heavy vehicle interaction and heavy vehicle-community interaction, two major urban roads had been studied. The segments in which one was chosen based on their site characteristics: Highway SP 310 surrounds the city with a partial cloverleaf interchange and a roundabout; while Highway SP

595 crosses it and contains four roundabouts. These two factors will contribute to determine the impacts when heavy vehicles go through different site characteristics and maneuvers.

### 3. Methodology

The data collection for this project was divided in two categories. In both phases, it was assigned some points through the highways to evaluate what happened in each fragment. The data collection spots are shown in Figure 1.



**Figure 1.**Map of Ilha Solteira' urban perimeter, its main highways and assigned points to data collection.

Table 1 shows a sample of the form used to collect the necessary data. Notice that the vehicles were divided into four major categories considering their impacts in the traffic stream: light vehicles (2 tires – bicycle and motorcycle), medium vehicles (4 tires – car and SUV), heavy vehicles (6 tires – truck and bus) and multi-combined vehicles (MCV - rigid or articulated). The number of pedestrians was also considered due to the proximity of residential areas to the highway; also, in order to evaluate the safety faced to the heavy vehicle/community interaction.

**Table 1.** Sample of the form used in this research.

FORM								
Date:			Way:					
Place:			Survey taker:					
		2 tires		4tires		6 tires	+6 tires	
Hour:	Pedestrian	Bicycle	Motorcycle	Car	SUV	Truck/Bus	MCV	Notes
:00								
:01								

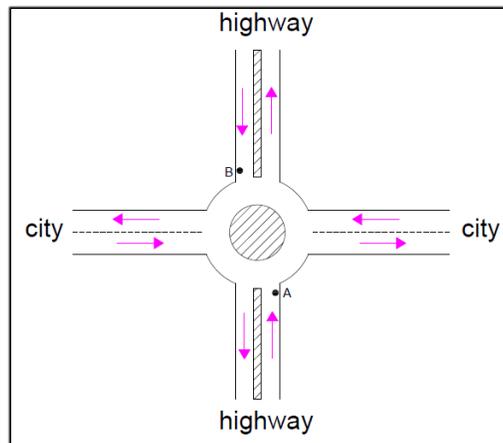
- *Highway 310*

Consists to analyze the traffic stream and its parameters. From this highway, the main parameters are vehicle types, user preferences and road use.

The survey taker took each license plate on the form (Table 1) for time intervals of 1 minute during the commercial time (7 a.m. to 6 p.m.), Monday to Friday.

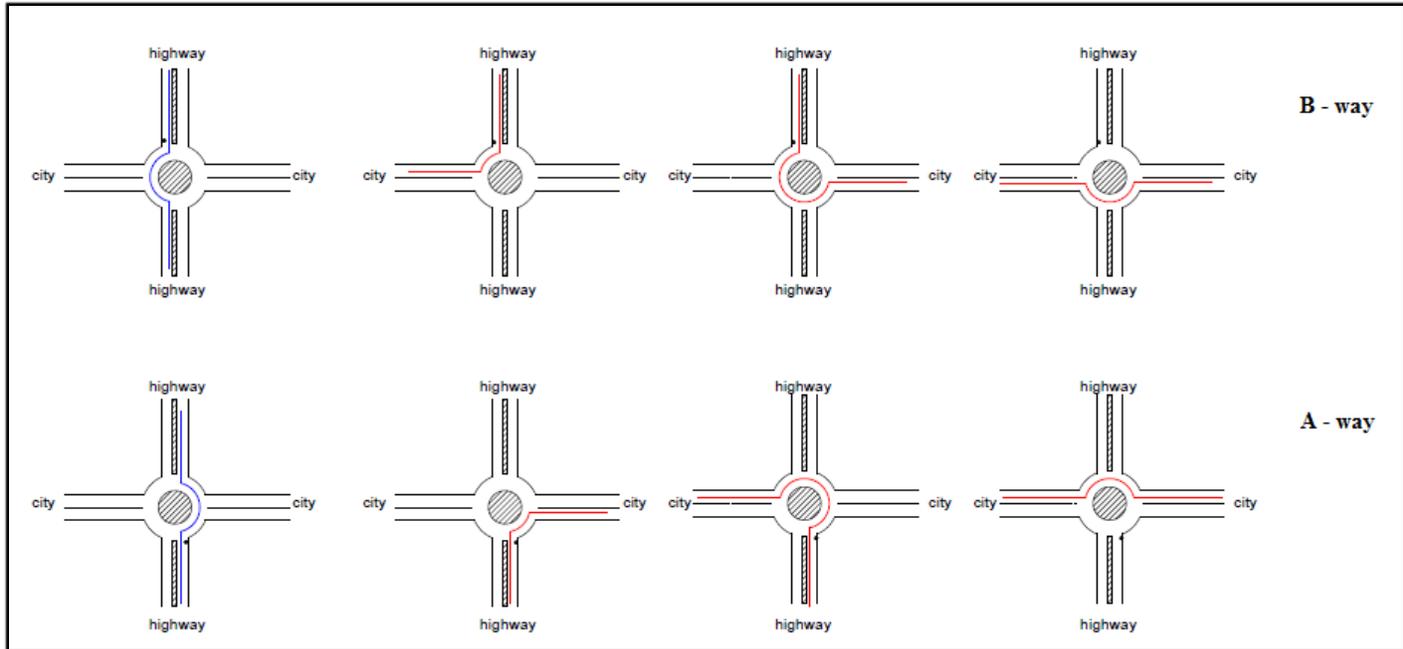
- *Highway SP 595*

On this highway, the data were collected in each roundabout in order to analyze the user preference and how the traffic impacts those who intend to go to one side to another from the city. The roundabout characteristics are shown in Figure 2.



**Figure 2.** Roundabout characteristics.

The survey taker was located at point A and B in each roundabout, as shown in Figure 2 above. For those vehicles which stayed on the highway, the color blue was assigned on the form (Table 1); or, the color red for those vehicles that were on the road and merged into the city or for those which just crossed the highway. Figure 3 illustrates all possible merges.



**Figure 3.** Possible merges in a roundabout.

A-way means the vehicles driven through point A to B and B-way the other side (see Figure 1).

Time intervals were 1 hour during the commercial time (7 a.m. to 6 p.m.), Monday to Friday.

#### 4. Results and Conclusion

##### - Highway 310

The data from the form were analyzed and based on the license plate, it was possible to illustrate the driver's preference as graphs. Each graph represents the urban road interference in the city for those drivers who enter or go away from the city, and those how just uses the urban road to go somewhere else.

Each point was assigned to permit the analyze about how many vehicles use certain engineering structures. For example, point C is located before a partial cloverleaf interchange, so the vehicle that is collected in C but not in D means it used the interchange; because there is no other way to make a sharp turn. Following the same logic, point D is located before a roundabout; point E is located before a crossroad in the city's recreational area; point F is located before a crossroad in the industrial zone and point E before the dam, at the end of the Sao Paulo state side of this highway.

Figure 4 and 5 show the average number per hour of each mean of transportation in both sides of the urban road which allows use to interpret and obtain the driver preferences, flow rate in each segment and traffic composition.

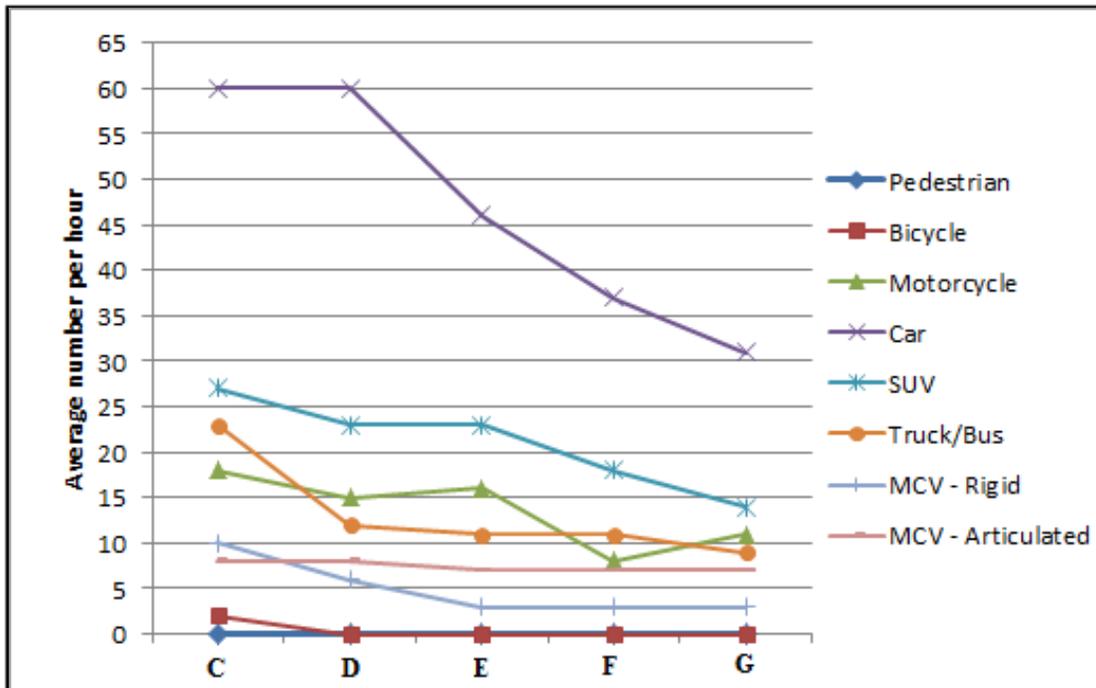


Figure 4. Average number of vehicles per hour, which pass through Highway 310 from C to G.

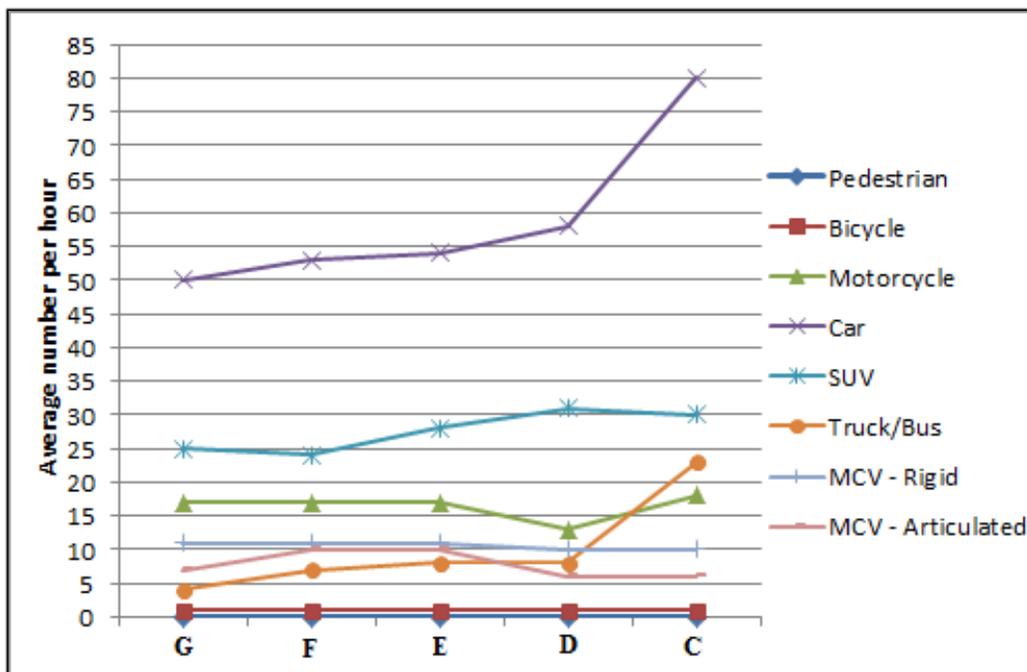


Figure 5. Average number of vehicles per hour, which pass through Highway 310 from G to C.

In order to exemplify how to read the graphs above, let's consider Figure 4, CD segment. Absence of pedestrian; 2 bicycles per hour enter in the city using the partial cloverleaf interchange; 3 motorcycles make a sharp turn on the interchange (difference between 18 motorcycle that pass through point C and 15 in point D); 60 cars just pass through this segment without making any sharp turn; 4 SUVs make the interchange, 23 pass through the segment; 11 truck/buses make a sharp turn on the interchange, 12 pass through the segment; 4 rigid MCV make a sharp turn on the interchange, 6 pass through the segment; and 8 articulated MCV just pass through this segment without making any sharp turn.

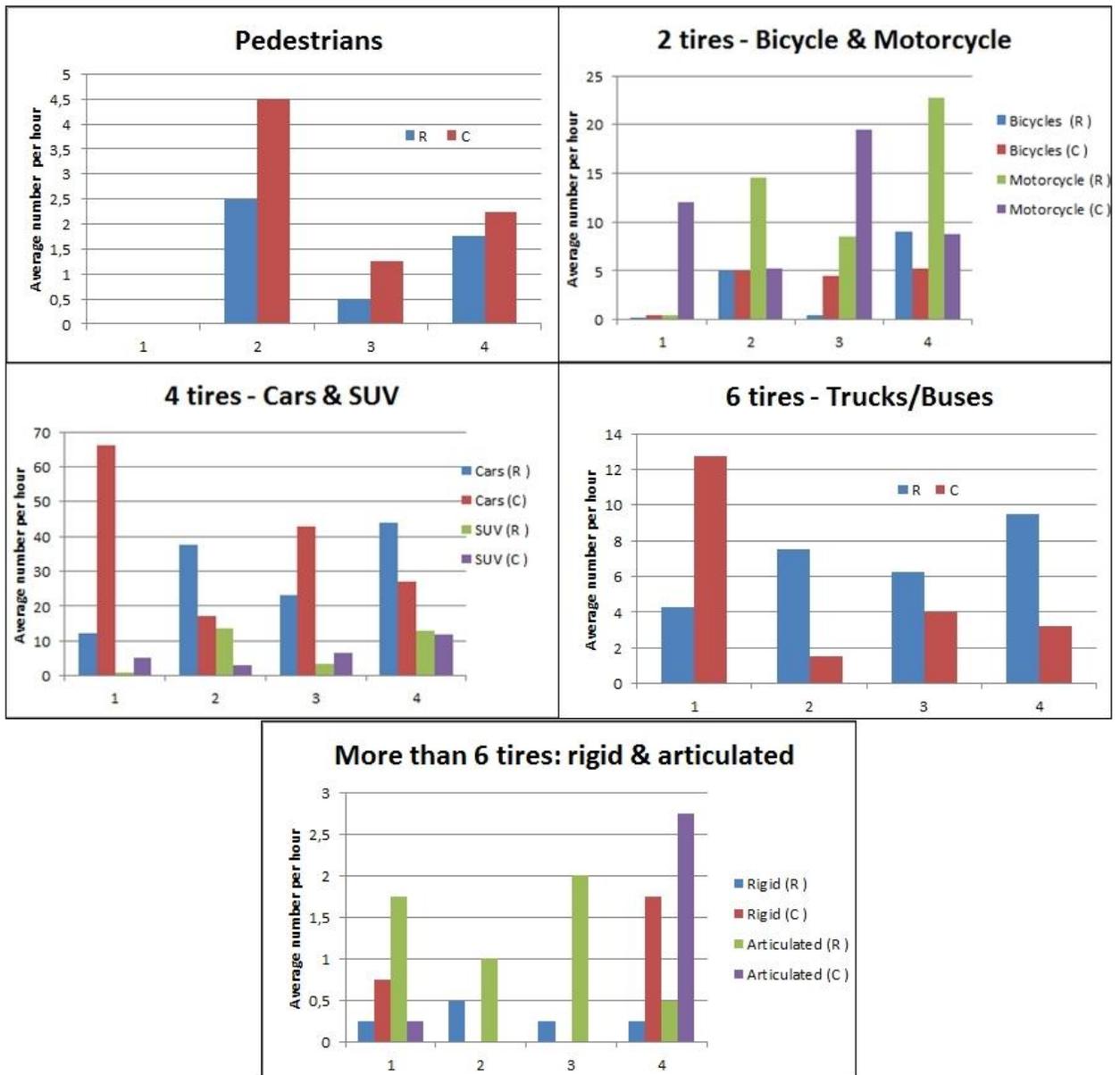
- *Highway 595*

The data from the form were analyzed and illustrated as graphs. Each graph represents the urban road interference in the city for those citizens who want to go to one side to another, considering each mean of transportation.

In all graphs, the driver preferences are indicated on the cations. The index  $R$  means the vehicle which was on the road and stayed there. The index  $C$  means those vehicles that were on the road and merged into the city or for those which just crossed the highway.

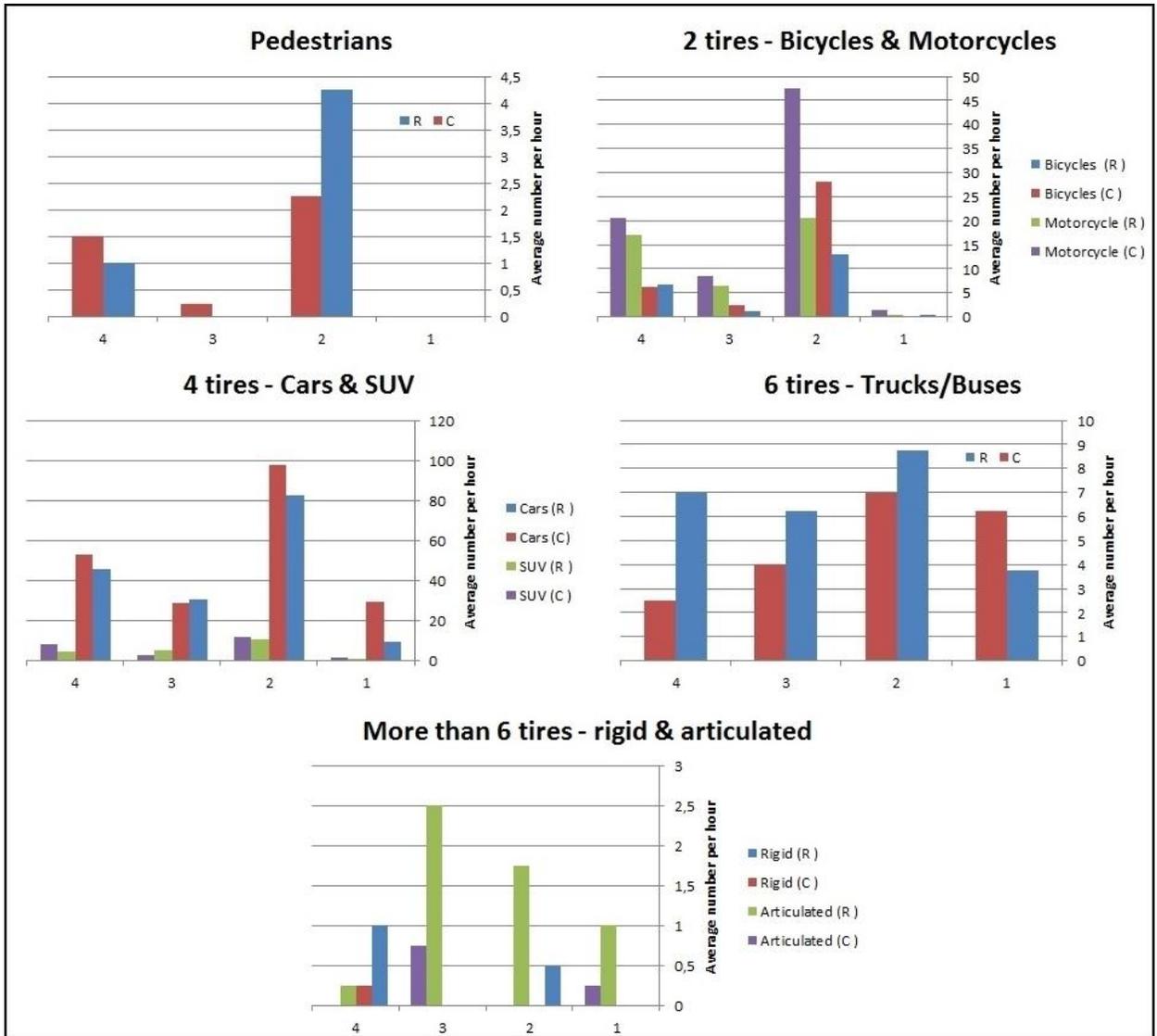
Also, we could obtain the traffic composition and flow rate from the graph.

Figure 6 shows the traffic demand parameters on the A-way (from roundabout R1 to R4, as indicated at abscissa axis).



**Figure 6.** Traffic demand parameters on the A-way.

Figure 7 illustrates the traffic demand parameters on the B-way (from roundabout R4 to R1, as indicated at abscissa axis).



**Figure 7.** Traffic demand parameters on the B-way

During data collection, the survey taker wrote some observation that may sum up to analyze light/heavy vehicle interaction. For instance, light vehicles (especially SUVs) tried to overtake heavy vehicles close to roundabout or on it; and on freeway segments too. But the major issue of heavy vehicle traffic in an urban road is the delay they cause. Huge lines of cars were collecting right after an MCV causing congestion. Another problem in both urban roads is the absence of shoulder.

In both highways, the database also showed up a considerable amount of pedestrian and bicycles using these urban roads, however, there is no bicycle lane or grade separation for pedestrian.

The next step for this research is the crash data analysis for vehicle types and vehicle maneuvers in order to evaluate better the highway safety.

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