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Effects of traffic calming measures in different urban areas

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Abstract

Despite of the reduction of deaths and serious injuries in roads in Spain during the last years, this reduction has not been so important in urban areas. Consequently, Traffic calming measures (TCM) have been installed in urban areas to improve mainly safety of pedestrians and cyclists. There is a wide range of existing measures, with varying success.

Most of the TCMs are focused in speed reduction, as a way of providing a safer atmosphere to urban zones. Different speed reduction percentages are obtained by each TCM according to their geometric features and emplacements in the road.

This paper compares some traffic calming measures in the cities of Bilbao, Burgos, León and Vitoria (located in the north of Spain) in order to evaluate the repeatability of their efficiency in different emplacements. The TCM selected where some of the most used in this cities. These were raised crosswalks, lane narrowing, radar speed camera signs and radar speed cameras.

The speed reduction were compared and analyzed to present some conclusions about the efficiency of each traffic calming measure.

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1. Introduction

The road fatalities in Spain reached in 1989 a maximum of 9,344 fatalities. After 25 years this situation changed reaching the lowest annual total of 1,680 people killed in 2013. The last official data provided indicate that 1,810 people were killed in road traffic accidents in 2016 (DGT, 2017a).

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Over the world, the road safety is one of the major problems. In the European Union, during 2009, more than 35,000 people died and more than 1,500,000 were injured in the European Union roads. The cost of those accidents for society was estimated on approximately 130 billion Euros (EC, 2010). Nowadays, 25,600 fatalities were record in 2016 and 26,100 during 2015 (EC, 2016 and 2017).

In Spain, during 2016, beside the 1,810 fatalities, 9,755 people were seriously injured and 130,635 were injured. In the Interurban roads, 1,291 people died, 5,050 people were seriously injured and 51,379 were injured. If we focus on the urban roads, 519 people died, 4,705 people were seriously injured and 79,256 were injured. If we look back 10 years ago, in 2007, 3082 people died outside urban roads and 741 inside urban areas. The reduction outside urban areas shows a great improvement (58%) but inside urban areas the improvements are smaller (30%) (DGT, 2008, 2017a and 2017b).

The European Commission (EC) focuses on the safety inside the urban areas in the communication of 2010 titled: Towards a European road safety area: policy orientations on road safety 2011-2020. COM (2010) 389 final. The objective nº 7 of this communication was: Protect vulnerable road users such as pedestrians, cyclist, mopeds and motorcycle riders. This also pointed the high number of fatalities and serious injured and how, in some European States, were still increasing (EC, 2010).

In Spain, during 2016, 252 pedestrians died over the total of 519 fatalities inside urban areas (DGT, 2017b). To reduce the high number of fatalities and serious injuries many countries are using the traffic calming strategies.

The Institute of Transportation Engineering in the Traffic Calming: State of the Practice (Ewing, 1999 and Lockwood, 1997) defines traffic calming as “the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior and improve conditions for non-motorized street users”.

The traffic calming strategies are designed to reduce vehicle speeds, lower the traffic volumes and increase driver alertness (Gonzalo-Orden et al, 2016; MFOM 2010). Some of these strategies and devices used are: vehicle restrictions, warning signs, gateways, speed tables, raised crosswalks, median islands, channelization islands, speed humps, rumble strips, mini-circles, roundabouts, special pavements and markings, radar clocked traffic speeds displayed to drivers, lane narrowing, horizontal shifts... (Litman, 1999; Ewing, 1999; Pau and Angius 2001; Pérez-Acebo, 2016).

As is showed in table 1, speed reduction of the motor vehicles is one of the key elements to reduce the probability of death of the pedestrians involved in an accident.

Table 1. Relationship between the speed of the vehicle and the probability of death of the pedestrian involved in an accident (Bonanomi, 1990).

Speed of collision (km/h)	80	60	40	20
Probability of death (%)	100	85	30	10

The aim of this paper is to analyze the impact of traffics calming measures on the reduction of the motor vehicles speed.

2. Methodology and case of study

Field measures were done to show the effectiveness in reducing speed of some of the traffic calming measures on various street sections of the cities of Burgos, León, Vitoria and Bilbao (situated in the North-central part of Spain). The population of this cities ranges from 130,000 to 350,000 citizens. The maximum speed allowed in the street measured was 50 km/h. In some of the traffic calmed sections the maximum speed was decreased to 30 km/h.

For this research ten representative zones were selected. The vehicle speeds on the street sections (StS) were controlled with speed radars.

28 street sections, distributed on these ten zones of the four cities, were analyzed. A basic description of these zones is given in the following lines and can be seen in figure 1. Each zone must have at least one of the traffic calming measures inside and must begin in an intersection regulated by a roundabout, a traffic light or a stop sign. In these zones it can be found:

- Intersection regulated by a roundabout, by a traffic signal and by a stop sign.
- Normal crosswalk, raised crosswalk (RCW) and crosswalk with pedestrian pushbutton traffic signal.
- Radar speed camera (RSC-50). If the car circulates in front of the camera at more than 50 km/h the owner of the car could get a speed violation fine.
- Radar speed camera sign (RSCs-50). Indicates that in the following meters there is a RSC-50.
- Lane narrowing: LN

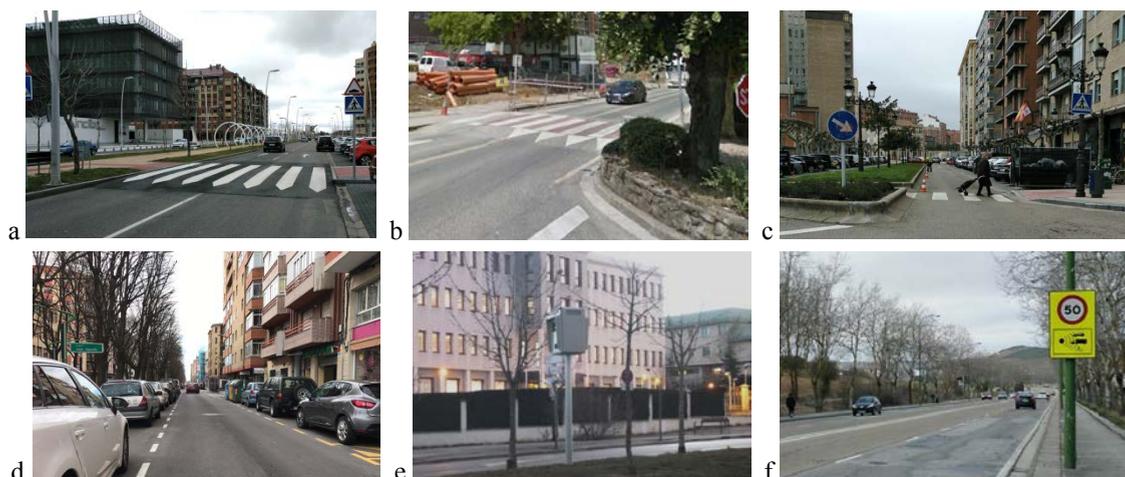


Fig. 1. Examples of: (a, b) Raised Crosswalk, (c, d) Lane narrowing, (e) Radar speed camera and (f) Radar speed camera sign.

This research will focus only in the effects of the Lane narrowing, Raises Crosswalk, Radar speed camera sign and Radar speed camera Traffic Calming Measures. Normally, measures were obtained around 100-150 m before the traffic calming measure (point 1 in each place), at the traffic calming measure (point 2) and 100-150 m after the traffic calming measure (point 3). In all selected TCMs the distance from them to the next one, both upstream and downstream, is more than 200 m, allowing drivers to develop desirable speed (Valtkus et al. 2017). Moreover, a distance between TCMs in the range from 100 to 400 m has shown no influence on the capacity of the road and spacing below 50 m showed cumulative effect (García, 2011).

2.1. Raised Crosswalks (RCW)

Various raised crosswalks (RCW) in different cities have been evaluated. In Vitoria, zone VI-A was selected, in Antonio Machado Avenue (Fig. 2.a). It has a two lane carriageway in each direction, separated with an elevated boulevard in the centre. In Bilbao, a RCW in Gernika Street was analyzed in both directions, BI-A and BI-B, respectively, in a conventional road (Fig. 2.b). This RCW represents the limit between the urban and no-urban areas, aiming to observe the effectiveness in both directions. Finally, in Leon, zone LE-A and LE-B was selected, in José Aguado Avenue. There are two lanes in each direction and a wide boulevard between them (Fig. 2.c).

In all sections, raised crosswalks have a height of 10 cm approximately, in concordance with the recommendations of the Spanish Ministry (MFOM, 2010) and above the recommendation of 30 mm for posted speed limit of 50 from Pau and Angius (2001).

2.2. Lane Narrowing (LN)

Lane narrowing effect in two different sections has been analyzed; one in Burgos (BU-A) and another one in León (LE-C) (Fig. 3).

The one in Burgos follows the Carmen Street (Fig. 3a), which is formed by a separated roadway with a traffic lane and a parking zone on the right. The whole street has been narrowed with an elevated median island. Perpendicular to Carmen Street runs Dr. José Luis Santamaría Street, which has been used as a checkpoint.

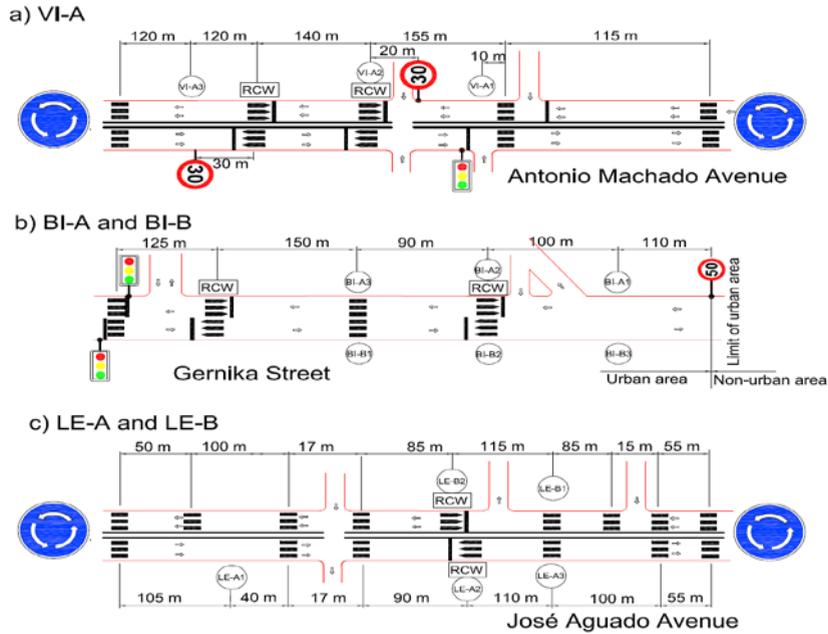


Fig. 2. Raised crosswalk analyzed, a) in Vitoria, b) in Bilbao, c) in León.

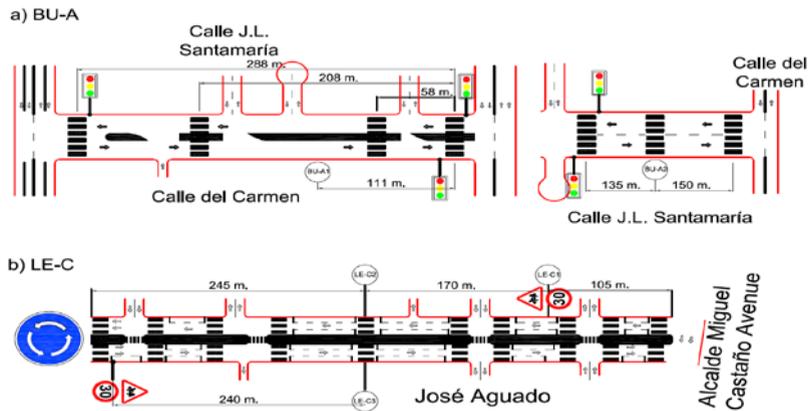


Fig. 3. Lane Narrowing analyzed in Burgos (BU-A) and León (LE-C).

In León, a section of José Aguado Avenue between Alcalde Miguel Castaño Avenue and Fernández Ladreda Avenue has been selected. This is a street section with a separated roadway and a large pedestrian median island where the narrowing has been made placing the parking area on both sides of flow direction (Fig. 3b). This area is a school zone so, in addition to the narrowing, the maximum speed has been restricted to 30 km/h.

2.3. Radar speed cameras (RSC)

Three areas with radar speed cameras were selected in Vitoria (2) and in Burgos (1). The first area in Vitoria (VI-B) is placed in Zabalgana Avenue, with two lanes in each direction and carriageways separated by a narrow median of 1 m width (Fig. 4.a). The other area in Vitoria is located in De los Huertos Avenue (VI-C), with similar characteristics to the first one (two lanes per direction and carriageways separated by a narrow median) (Fig. 4.b). The area in Burgos (BU-B) is in Cementerio Avenue (Fig. 4.c). It has four lines in a single carriageway, only separated by road horizontal signs.

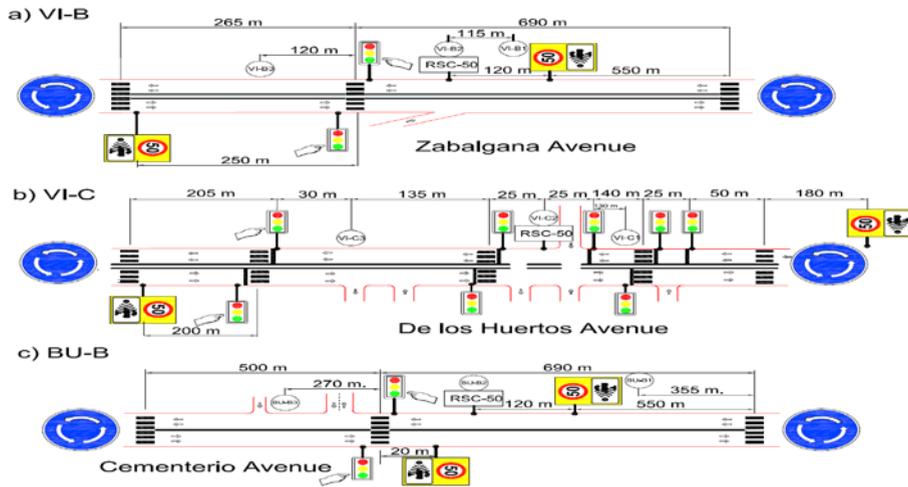


Fig. 4. Radar speed cameras analyzed, a) in Vitoria (VI-B), b) in Vitoria (VI-C) and c) in Burgos (BU-B).

3. Results and discussion

9,994 vehicles were controlled on the described street sections. Table 2 shows the speed V50 (the speed achieved or exceeded by 50 % of the vehicles), the speed V85 (the speed not reached by 85 % of vehicles or exceeded by 15 % of the vehicles) and the traffic average flows of each zone.

Table 2. Speeds and traffic flows on the controlled points

Traffic calming measure	Point of measure	Speed V50 (km/h)	Speed V85 (km/h)	Average Traffic flow (veh/h)		
Raised crosswalk	VI-A1 (Before)	49	59	2		
	VI-A2 (RWC)	34	40			
	VI-A3 (After)	52	62			
	Lane narrowing	BI-A1 (Before)	46	55	196	
		BI-A2 (RWC)	27	34		
		BI-A3 (After)	40	47		
		Radar speed camera	BI-B1 (Before)	39	48	157
			BI-B2 (RWC)	26	32	
			BI-B3 (After)	48	55	
Radar speed camera			LE-A1 (Before)	44	52	332
			LE-A2 (RWC)	36	43	
			LE-A3 (After)	44	53	
	Radar speed camera		LE-B1 (Before)	44	52	571
			LE-B2 (RWC)	35	42	
			BU-A1 (LN)	30	40	
		BU-A2 (Checkpoint)	41	51		
		LE-C1 (LN)	24	30	499	
		LE-C2 (LN)	23	29		
LE-C3 (LN)		26	32			
Radar speed camera		BU-B1 (Before)	53	63	654	
		BU-B2 (Radar)	44	48		
	BU-B3 (After)	60	73			
	Radar speed camera	VI-B1 (Before)	50	56	703	
		VI-B2 (Radar)	46	51		
		VI-B3 (After)	51	59		
		VI-C1 (Before)	48	57	287	
		VI-C2 (Radar)	45	51		
		VI-C3 (After)	44	52		

3.1. Zones with Raised Crosswalks

In the two zones of Leon (LE-A and LE-B) very similar values are measured in places situated before, at the RCW and after. A homogeneous reduction of 9-10 km/h approximately is obtained due to the presence of the calming measure from previous speed in all the range of speeds (Fig. 5.a). Obtained reduction is similar in percentage to the ones obtained in Belgrade with 7 cm speed humps, higher than with lower heights (Antic et al., 2013). However, after the raised crosswalk, previous speeds are obtained again, indicating that the presence of the TCM only implies a reduction at its point. Values from Vitoria, in zone VI-A, show that similar speed is obtained at the RCW (Table 2). However, before the RCW V50 and V85 speeds were over the speed limit and after the series of RCW even higher speeds are obtained. It indicates that after the TCM drivers tend to speed up as they think speed controlled area has finished and even more than the half of them overpass speed limit (Fig. 5.b). Finally, results from zones in Bilbao shows that RCW can be useful for indicating the limit of the urban area. When entering an urban area, remarked by the presence of a RCW, the calming measure has a memory effect on drivers and they tend to speed down as more TCMs are expected (traffic light, intersections, crosswalks, etc. (Fig. 5.c). On the contrary, when a RCW marks the end of the urban area (BI-B), drivers feel that restricted area finished, which is true in this case, and accelerate to reach usual speeds in rural roads (Fig. 5.d).

3.2. Zones with Raised Crosswalks

In Burgos, a reduction around 10 km/h between the TCM and checkpoint speeds has been observed. The LN with the construction of elevated median islands seems to help in the speed reduction (Fig. 6.a).

In León, there is no checkpoint. However, it can be seen that the LN is equally effective maintaining the memory effect through the entire zone 30, obtaining a V85 around this value (Fig. 6.b).

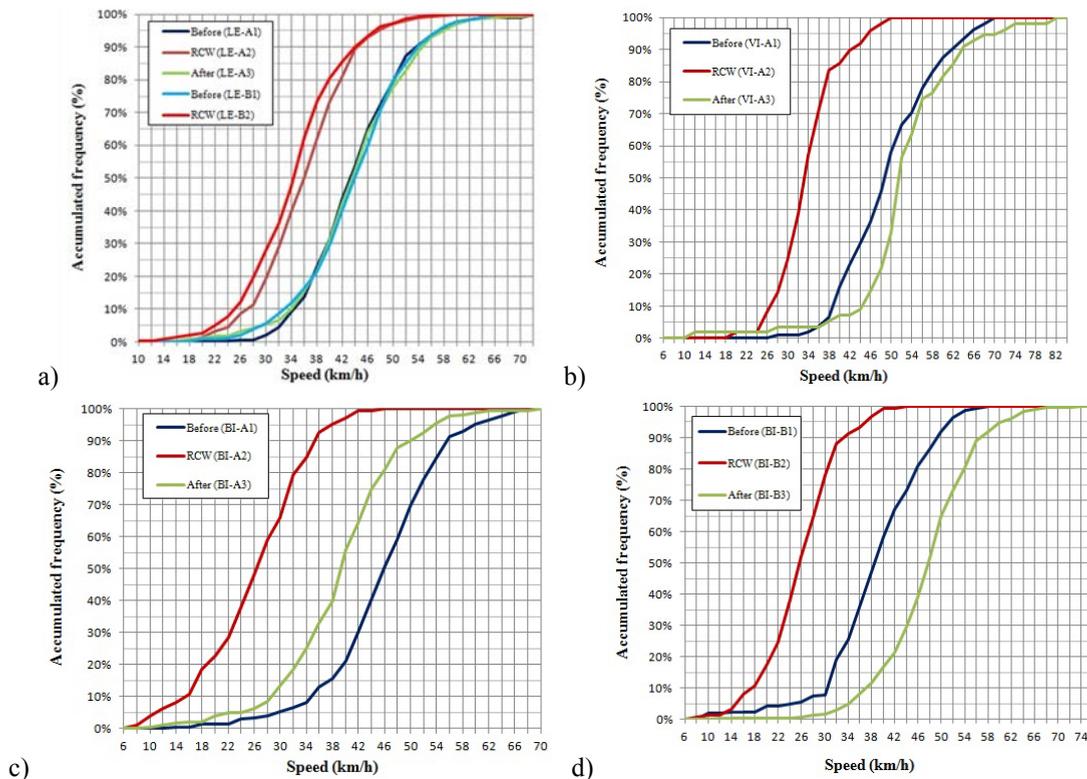


Fig. 5. Speed profiles in a) LE-A and LE-B, b) VI-A, c) BI-A and d) BI-B.

3.3. Zones with Speed Radar cameras

In Burgos, in zone BU-B, V50 and V85 values are under the speed limit at the point of the radar speed camera due to the possibility of the fine (Table 2 and Fig. 7.a). Values of V50 and V85 taken before it overpass the limit, and after it are even greater, indicating that the traffic calming measures works as a punctual measure, not providing a memory effect on drivers. Values obtained in Vitoria show similar conclusions. In zone VI-B, it can be observed that vehicles try to control their speed (but once again, more than the half of drivers overpass speed limit of 50 km/h) when approaching the radar (Fig. 7.b). At radar, most of the drivers respect the limit and when the controlled area is passed, drivers speed up since restricted area is finished. Once again, in VI-C, most of the drivers respect the speed limit at the place of the speed radar camera. Obtained values after the traffic calming measure shows a similar curve to the controlled area (Fig. 7.c). In this case, it can be a consequence of the traffic light placed after the radar. This suggests that various traffic calming measures must be implemented in order to really speed down the traffic flow.

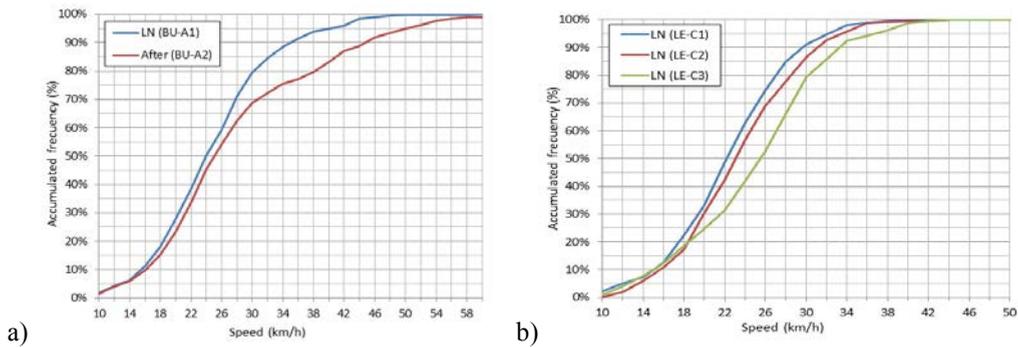


Fig. 6. Speed profiles in a) BU-A, b) LE-C

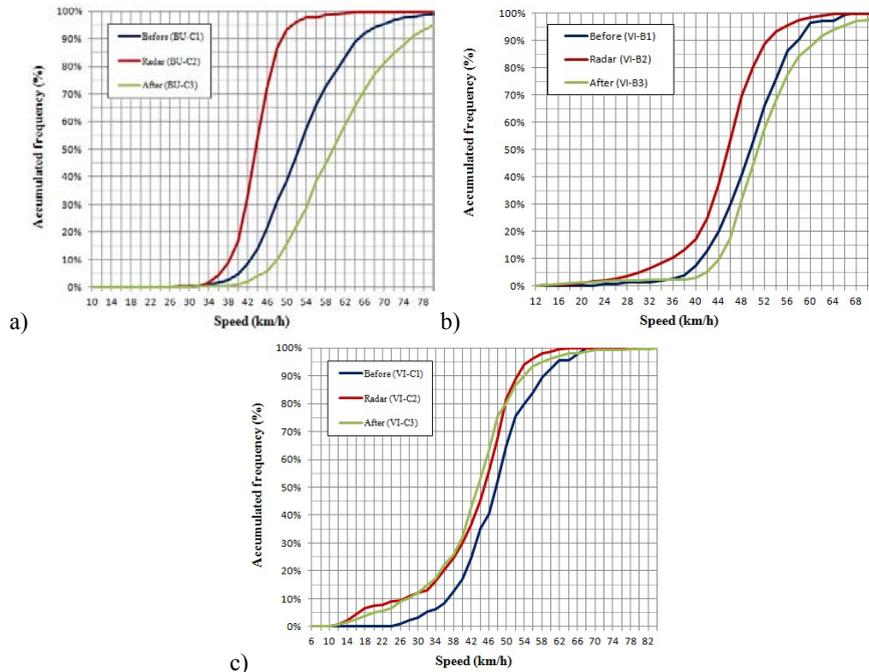


Fig. 7. Speed profiles in a) BU-B, b) VI-B and c) VI-C

4. Conclusions

Traffic calming measures are necessary in urban areas to reduce traffic speed, volumes and reduce the probability of death on pedestrians involved in fatalities. However, its effectiveness is not directly assured and it depends on where and how they are placed.

Raised crosswalks work as a punctual traffic calming measure. Motorist speed down when passing it due to the physical obstacle that it represents and after it they do not maintain the slow speed. Sometimes having passed a RCW is understood as if the controlled area was finished. However, a positive effect has been observed when situated at the border of the urban area. Drivers seem to understand that they have entered an urban area and do not maintain speeds of non-urban areas.

The line narrowing is a measure that tends to present a memory effect along its entire length. For its constitution, it is only necessary to alter the geometry of the road. This can be achieved without a high investment modifying, for example, the configuration of the parking area.

Radar speed cameras have been proved to be a punctual traffic calming measure since drivers only reduce their speed at the point of the radar. Previous speeds (V50 and V85) are controlled (but over the speed limit) but after the radar, they speed up as they feel that no more radar are placed (even hidden radars).

As traffic calming measures act punctually on vehicles' speed and do not imply a memory effect on drivers, they must be combined adequately in order to assure a traffic calmed zone in urban area.

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