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## **SPEED TABLE EVALUATION AND SPEED MODELING IN CROSS-TOWN ROADS**

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**ABSTRACT**

More than fifty percent of injury accidents in Spain take place in cross-town roads and urban areas. Traffic calming is an initiative to reduce the impact of traffic on local streets by lowering both number and severity of crashes. However, the implementation of traffic calming devices in Spain was not standardized in the past and no technical criteria were applied. This paper presents the methodology, results and conclusions of the analysis specifically related to speed tables as a part of the research project MODETRA.

For the research five cross-town roads with 16 speed tables were selected to analyze drivers' behavior. Speed data were collected based on a sample of more than 900 vehicles through the selected cross-town roads using GPS trackers. For each individual vehicle a continuous speed profile along the path was obtained. The analysis showed that the minimum speed was located when the vehicle left the traffic calming device and the maximum deceleration was located just before the device.

Geometric characteristics of the speed tables were measured by using a digital profilometer. A wide dispersion in the geometry can be concluded. It has been found that the speed reduction depends mainly on the separation between traffic calming devices, while the speed over the speed tables depends crucially on the entrance ramp slope, the speed table length and the distance to the previous traffic control device. Also, no statistical correlations were found between speed tables' height and speed reduction or spot speed over the speed table.

## **INTRODUCTION**

Traffic calming is an initiative to improve road safety in local areas. The practice has been implemented primarily in developed countries to reduce the frequency and severity of crashes and to improve the environment on the local area. This implies, in some cases, the decrease in traffic flow and, of course, reducing the speed of vehicles traveling through the area.

There is a wide range of traffic calming devices available to achieve the desired road segmentation; and hence, the lower speeds and safer streets. These devices include speed tables, which are flat-topped speed humps, through a prefabricated or built on site with a trapezoidal longitudinal profile. Speed tables are designed specifically to maintain a reduced speed and to allow pedestrians to walk on top.

The geometry of speed tables was not standardized in Spain until 2008. The new Spanish guidelines (1) specify the length of speed tables depending on the speed over the speed table. For example, the guidelines recommend lengths of the flat top of 4 m, slopes ranging from 4 to 10%, with ramps lengths between 1 m for 30 km/h, 1.5 m for 40 km/h and 2.5 m for 50 km/h and 10 cm height. No other heights are taken into account. On the other hand, ITE (2) recommend 6.7 meters long speed tables which includes 3.05 meters for the flat top and both ramps 1.83 meters length. The recommended height varies from 7.62 to 10.16 centimeters. According to this guideline, 6.7 meters long speed tables spaced from 91 to 152 m will provide 85<sup>th</sup> percentile operating speeds of 45 to 52 km/h, just located midway between traffic calming devices.

Other authors studied speed tables. Ewing et al. (3) presented the speed at the midpoint between two traffic calming devices, finding that the speed at this point depended on the distance between them. Comparisons of speeds before and after installation of speed tables and speed humps in different locations indicate that mean speeds were reduced from 6 to 13 km/h (4, 5, 6). However, these research were based on spot speeds rather than a continuous speed profile (3, 4, 5, 6). Barbosa et al. (7) conducted a research that first analyzed the speed profile in sections with traffic calming devices such as cushions, chicanes, speed humps and speed tables. The speed profile was taken by using 16 pneumatic sensors and a laptop computer to store the information. A multiple regression model that explained about 55% of the variation in speed was developed. The parameters considered on the study were: the distance from the previous device, the distance to the next device, the device type and the entry speed. No geometrical variations were analyzed.

On the contrary, drivers' speed selection over speed tables differs depending on the speed table length; mainly because of the change in the slope of its ramps which varies the vertical acceleration caused to the vehicles. The constructive method has to be checked in case of speed tables built in site. The method can generate changes on geometry which may affect the vehicle's operation; thus, the actual geometry of the profile should be measured.

## **OBJECTIVES**

The aim of the present research was to evaluate the influence of the speed tables on drivers' behavior depending on the geometrical characteristics of the traffic calming devices.

The main objectives of the study were: to characterize geometrically the speed tables across the selected cross-town roads; to obtain continuous speed profiles of the vehicles that circulate in the cross-town roads by using GPS trackers; and to correlate the speed in each point of the trajectory with the location, type and geometry of the traffic calming devices. Specifically, the following parameters would be analyzed: speed table geometry; speed reduction; speed over the speed tables; location of the minimum speed among the speed table; and acceleration and deceleration rates.

## **RESEARCH APPROACH**

The applied methodology included three main components: sites selection; field study and data collection; data reduction; and analysis of the results. In addition, a questionnaire was developed to assess the driver subjective perception of the traffic calming devices traveled on the cross-town road. The subjects were asked to sort the devices by comfort and speed reduction.

## Site Selection

To collect the data, 5 cross-town roads were selected according to the recommendations of a previous road safety study. The parameters taken into account were: AADT (annual average daily traffic); length of the cross-town road; and type of existing traffic calming devices. The selected towns were located in the province of Valencia: Genovés (AADT = 2600 veh/d); Quatretonda (AADT = 3240 veh/d); Llutxent (AADT = 2930 veh/d); Albalat de la Ribera (AADT = 4230 veh/d); and Chelva (AADT = 2450 veh/d).

The plan view of each cross-town road and the existing traffic calming devices is shown in Fig. 1.

The speed limit in cross-town roads was posted as 50 km/h and they presented good pavement conditions. Lane width of the selected sites varied from 3.10 to 3.25 m. Since the cross-town roads were in urban area, sidewalks at both sides of the road existed. The bicycles were allowed to circulate on the road. However, bicycle traffic volume was reduced and limited to weekends. The traffic calming devices included: roundabouts; gates; speed humps; speed tables; etc. A total of 16 speed tables were observed and analyzed.

## Data Collection

### *Speed Table Geometry*

The geometrical characteristics of the speed tables were measured by using a digital profilometer developed in the Department of Transportation. The real longitudinal profile of the devices was obtained at the point where vehicles tires passed over the speed tables. The digital profilometer gave one list of (x,y) coordinates with a precision of 1/8 of a millimeter.

The constructive method of each device was also deduced. Therefore, the vehicle behavior could be correlated to the actual speed table geometry and to the constructive method. All speed tables were constructed in site with asphalt. In all cases, the speed tables were painted red which is the common pavement marking color in Spain. Since the speed table allows the pedestrian crossing, the top flat was painted as a white zebra crossing.

### *Continuous Speed Profile*

To collect the drivers' speed, passive GPS trackers were used. The available passive GPS tracking equipment stored, every second, the time and position of the vehicle. Consequently, a continuous speed profile and accelerations profile could be deduced.

To collect the information in each cross-town road, two road controls were placed at a distance of approximately 1 km before and after the town to enable vehicles to develop the desired speed before reaching the traffic calming devices. On each end of the road segment, drivers were asked to collaborate in a road safety study. The drivers only were told that a device had to be installed over their vehicles and they were encouraged to drive as usual. Only passenger cars were taken into account. A survey was conducted at the beginning of the cross-town road to know the age, gender, number of occupants, driving experience, travel purpose, vehicle type and knowledge of the cross-town. At the end of the cross-town road, the drivers were stopped to return the device and they were asked about the comfort or discomfort feeling when passing the traffic calming devices and whether they had been influenced or not in their speed by another vehicle or pedestrian. After, a leaflet of the research was given. Another research carried out (8) used a similar methodology applied to rural roads. It was proven not to influence drivers' speed selection. Thus, drivers were not induced to reduce their usual speeds.

In each road segment a sample of more than 100 passenger cars per direction was obtained. The tests were performed during the morning period between 8:30 a.m. and 2:00 p.m., during a working day and with good weather conditions.

## Data Reduction

### *Speed Table Geometry*

Data reduction for geometric measures consisted of three steps: coordinates filtering; rotation and slopes and height calculation.

The first step was to filter the coordinate list  $(x,y)$  in order to translate the precision of 1/8 of millimeter to coordinates every 5 millimeters on the abscissa and the average  $y$  value on ordinates. After data filtering, the next step was to rotate all coordinates by multiplying each coordinate by a rotation matrix. So, the road surface was located in a horizontal plane. The last step consisted of the measurement of: maximum elevation of the coordinates; relative ramp slopes; and flat-top part. The relative ramp slope was calculated as the best linear adjustment to the ramp points. It was not used the total height and length because of the variation on the slope. Flat top part was in many cases not parallel to the terrain. The result can be seen on Fig. 2.

### *Continuous Speed Profile*

The latitude, longitude, altitude, heading, time and date, were saved at the frequency of 1 per second. After importing data from the devices, a coordinate's conversion to UTM  $(x, y)$  was done. Then, a successive data debugging process was done. Firstly, the data storage errors were found by comparison on the time stamp sequence. Secondly, a transversal positioning debugging was carried out by calculating the mean trajectory based on all vehicles data. The diverted points were discarded. After, a longitudinal positioning debugging was done by taking into account abnormal speeds, accelerations or decelerations. Finally, vehicles which had left the track were discarded. Moreover, the stopped vehicles and the conditioned by other vehicles were removed from the sample on the corresponding sections. Abnormal speed profile or trajectory and the final survey were considered during this process. Near 10 % of the initial sample was discarded due to non free-flow conditions, detour or stopping.

The time and positions of the remaining vehicles were calculated using the mean trajectory with an algorithm developed for another research (8). At a determinate space frequency, the speed and acceleration rate were obtained. The GPS accuracy was 2.5 m in absolute positioning. Successive debugging process improved the data accuracy to result in a continuous path and behavior.

Fig. 3 shows an example of 20 vehicles' observed speed profile obtained from the GPS trackers in one direction at Genovés cross-town road.

## **RESULTS AND ANALYSIS**

An analysis of the speed tables' geometry was carried out. Besides, the continuous speed profile allowed evaluating: the speed reduction on a speed table; the speed over speed tables; the minimum speed location; and the acceleration and deceleration rates. The results were statistically analyzed. The sample after removing the disturbed vehicles was 836 vehicles.

### **Speed Table Geometry**

Previous to speed data collection, the speed tables were measured. Therefore, their actual geometry was obtained. The most important characteristic was the profile since this device uses vertical acceleration to discourage speeding. The geometrical characteristics evaluated were:

- Previous traffic calming device distance (*PTCDD*)
- Next traffic calming device distance (*NTCDD*)
- Speed table length (*L*)
- Entrance ramp length (*ERL*)
- Flat top length (*FTL*)
- Exit ramp length (*ExRL*)
- Maximum height ( $H_{\max}$ )
- Terrain slope (*TS*)
- Entrance ramp slope (*ERS*)
- Exit ramp slope (*ExRS*)

In case of speed tables located at the beginning or end of the cross-town road, *PTCDD* or *NTCDD* was calculated as the distance to the previous or next curve on the road. Table 1 shows the results of the

geometry of the 16 studied speed tables. The device number corresponds to the ordinal place of the devices sequence found along the cross-town road.

It is possible to appreciate a wide dispersion on the geometry of the 16 speed tables. The lack of standardization in Spain is a plausible cause.

### Speed Reduction

The continuous speed profile for each vehicle was used to detect the maximum speed between the speed table and the previous traffic calming device. Furthermore, the minimum speed around the device could also be obtained. Speed reduction for each individual vehicle was calculated as the difference between those values. Fig. 4 shows the speed reduction in each speed table for both forward and backwards traveling direction depending on the distance to the previous traffic calming device. The 15<sup>th</sup>, 50<sup>th</sup> and 85<sup>th</sup> were obtained. It can be observed an existing relationship between speed reduction and *PTCDD*. The 85<sup>th</sup> percentile of speed reduction for the speed tables placed at the beginning of the cross-town road varies from 20 to 25 km/h, as seen in Fig. 4.

A statistical analysis of the results based on multiple regression was carried out to determinate which variables affected the speed reduction. Two possible models were found. The parameters on the first model were the entrance slope ramp and the previous traffic calming device distance. A statistically significant relationship between 85<sup>th</sup> percentile of the speed reduction,  $SR_{85}$  (km/h), and distance to the previous traffic calming device *PTCDD* (m) for a confidence level of 99% was found as shown in Table 2.

$$SR_{85} = 6.46356 + 0.951316 ERS + 0.028674 PTCDD \quad (1)$$

Where:

$SR_{85}$  = 85<sup>th</sup> percentile of speed reduction while approaching a speed table (km/h).

*ERS* = Entrance ramp slope (%).

*PTCDD* = Distance from the previous traffic calming device (m).

The model explained the 51.09% of the variability in the 85<sup>th</sup> percentile of the speed reduction. Table 2 shows the multiple regression analysis for the first model. However, the p-value of *ERS* is higher than 0.05. Therefore, the model should be simplified and a second model was constructed. The second model used as variable only *PTCDD*. Using only as explanatory variable to the speed reduction the distance from the previous traffic calming device and an exponential regression shown in equation 2, it is possible to explain 53.18% of this variation with a confidence level of 99% as shown in Table 3.

$$SR_{85} = 2.1868 \cdot PTCDD^{0.3931} \quad (2)$$

Where:

$SR_{85}$  = 85<sup>th</sup> percentile of speed reduction while approaching a speed table (km/h).

*PTCDD* = Distance from the previous traffic calming device (m).

It is possible to say that the speed reduction when approaching a speed table mainly depends on the spacing between traffic calming devices and less than the geometric characteristics of the speed table. Thus, the preferred model is the second.

An initial hypothesis could state that roundabouts may influence the speed reduction on speed tables. However, the distances between the roundabouts and the speed tables were longer enough to allow drivers to reach to their desirable speed prior the speed table (from 100 to 250 m). Furthermore, the speed reductions were calculated based on: the maximum speed between speed tables and the previous traffic calming device; and the minimum speed over speed tables. Consequently, the speed reductions were directly related to the speed tables and no effect of roundabouts was introduced on the results.

### Speed over Speed Tables

Secondly, speeds over the raised crosswalks were analyzed. Fig. 5 shows speed percentiles while driving over the speed tables depending on speed table's length and the entrance ramp slope. It has been found that the 85<sup>th</sup> percentile of speed over the speed table varied from 25 to 43 km/h.

A multiple regression analysis was carried out to determinate the relationship between the speed tables geometry and the speed over the speed table. No statistically valid model could be found using as parameters the speed table length, the entrance ramp slope, the distance from the previous traffic calming device and the speed table height. Therefore, the speed table height was removed as a variable since its p-value was the highest and the value was higher than 0.05.

Another multiple regression analysis was executed with the following variables: speed table length; entrance ramp slope; and distance from the previous traffic calming device. Equation 3 shows a multiple regression model obtained based on the speed tables' characteristics for the speed 85<sup>th</sup> percentile.

$$S_{85} = 24.5665 + 0.0202058 \cdot L - 1.12093 \cdot ERS + 0.0116383 \cdot PTCDD \quad (3)$$

Where:

$S_{85}$  = 85<sup>th</sup> percentile of speed over a speed table (km/h).

$L$  = Speed table length (cm).

$ERS$  = Entrance ramp slope (%).

$PTCDD$  = Distance from the previous traffic calming device (m).

Table 4 shows the multiple regression analysis. It was found that speed depends mainly on the entrance ramp slope and therefore depends on the length of the device and also depends on the distance from the previous traffic control device within a confidence level of 90%. It can be observed that the height was not a statistically significant variable in the model.

The multiple regression analysis results indicated that both speed table length and entrance ramp slope should be removed to simplify the model and to improve the adjusted coefficient of determination as their p-value were higher than 0.05. Therefore, a simplified model with the distance to the previous traffic calming device was elaborated. However, the simplified model had less statistical significance. Consequently, the best model to explain the operating speed over a speed table is shown in Eq. 3. The model offered an adjusted R<sup>2</sup> value of around 40, not as good as the speed reduction model. Nevertheless, the speed over the speed table had a higher dispersion on the results because the minimum speed was not majority situated over the speed table, as the analysis of the minimum speed location shows. So, the speed over the speed table highly depends on particular drivers' behavior.

Design guidelines from the United States (ITE 2007) and Spain (2008) were compared with the previous developed models. Both speed over the speed table and midway speed were obtained at a frequency of 50 meters. The first parameter was calculated by applying Eq.3; the second parameter was obtained as the sum of the speed over the speed table and the speed reduction. Therefore, the midway speed was evaluated as the sum of Eq. 2 and Eq. 3. The results are summarized on Table 5.

As seen in Table 5, the midway expected speeds calculated based on the models varies from 45.8 to 51.0 km/h that match with those given by the guidelines for the design and application of speed humps (ITE 2007) between 45 and 52 km/h. Thus, the calculated speed corresponded to the design speed on ITE. On the other hand, Spanish norm (2008) suggest three operating speed 30, 40 and 50 km/h based on the entrance ramp slope, with separations between speed tables from 50 to 150 m. However, the design speed on Spanish guidelines did not correspond with the predicted speed over the speed table except in the case that the entrance ramp slope is 4% and the spacing between devices is the lowest (50 m).

### Minimum Speed Location

The minimum speed location distribution from the 836 undisturbed vehicles sample from the 16 speed tables in both directions is shown in Fig. 6. Since individual distributions of minimum speed location belonged to the same population within a confidence level of 90%, all speed tables were used in this



analysis. As seen, the minimum speed was located after the vehicle left the traffic calming device. Less than 12% of the vehicles had its minimum speed location before the traffic control device.

### **Acceleration and Deceleration Rates**

Acceleration and deceleration rates were obtained using numeric derivatives based on the continuous speed profiles. Then, 85<sup>th</sup> percentile was calculated. Maximum 85<sup>th</sup> percentile of deceleration rate was statistically analyzed depending on the speed table geometry and the distance to the previous traffic calming device. It was found only a weak dependency between the maximum 85<sup>th</sup> percentile of deceleration rate and the entrance ramp slope. The rates for all speed tables varied from 0.87 m/s<sup>2</sup> to 2.80 m/s<sup>2</sup>; the maximum 85<sup>th</sup> percentile value of deceleration rates of all individual profiles was 1.57 m/s<sup>2</sup>. These values were considered as comfortable deceleration rates.

On the other hand, it was found that the maximum 85<sup>th</sup> percentile acceleration did not depend on any of the studied variables for a confidence level of 90%. The maximum 85<sup>th</sup> percentile value of acceleration rates for all speed tables varied from 0.92 m/s<sup>2</sup> to 1.44 m/s<sup>2</sup> while the maximum 85<sup>th</sup> percentile value of acceleration rates of all individual profiles was 1.17 m/s<sup>2</sup>. These value were also considered as comfortable acceleration rates.

Unlike the minimum speed location, it was observed that the maximum deceleration was located a few meters before the speed table, and the maximum acceleration was located nearly 20 meters after the speed table, as seen in Fig. 7.

### **CONCLUSIONS**

Traffic calming is an operational measure to improve road safety on low volume roads. The aim of traffic calming is to reduce both frequency and severity of crashes by lowering speed and/or traffic flow. Among traffic calming techniques, speed tables are highlighted. The geometry of 16 speed tables located in 5 cross-town roads of Valencia was evaluated by using a digital profilometer developed in the Department of Transportation. Given the wide dispersion of the geometrical characteristics found, it is necessary to put more emphasis on the technical criteria to implant speed tables. Moreover, the control during its construction and maintenance has to be improved.

Continuous speed profiles were obtained for a sample of more than 830 undisturbed vehicles in 5 cross-town roads. Passive GPS trackers were used with the collaboration of drivers. The speed reduction was evaluated in the 32 speed tables studied, 16 per direction. A statistical analysis was carried out to determinate with a confidence level of 99% that the speed reduction while approaching a speed table depended on the distance to the previous traffic calming device. The desired speed was unable to be reached in closer traffic calming devices. The relationship between speed table geometry and speed reduction was statistically analyzed. It is possible to say that speed reduction while approaching a speed table did not depend on the speed table's geometric characteristics within a confidence level of 90%.

The operating speed over speed tables was also calculated. It depended on: the entrance ramp slope which varied the vertical acceleration caused to the vehicles; the length of the speed table that is related to the ramps slopes; and the distance to the previous traffic control device because it affects the vehicle's initial speed. The relationship between the geometrical characteristics of speed tables and the vehicles operation was evaluated. The entrance ramp slope was found as the key factor on speed selection: the higher entrance ramp slope, the lower speed over the speed table. No statistical correlations were found between speed tables' height and the speed over the speed table or the speed reduction.

The midway operating speeds calculated based on the models exactly matched with the ones given by the guidelines for the design and application of speed humps (2) between 45 and 52 km/h; whereas for the Spanish norm (1) no such adjustment was accomplished.

The minimum speed location was found by studying the continuous speed profiles. It was located after the vehicle left the speed table since drivers tried to avoid the inconvenience suffered when the acceleration was started before leaving the device.

The maximum 85<sup>th</sup> percentile value of deceleration rates for all speed tables varied from 0.87 m/s<sup>2</sup> to 2.80 m/s<sup>2</sup>, while the maximum 85<sup>th</sup> percentile value of acceleration rates for all speed tables varied

from  $0.92 \text{ m/s}^2$  to  $1.44 \text{ m/s}^2$ . Taking into account all individual profiles, the maximum 85<sup>th</sup> percentile value of deceleration rates was  $1.57 \text{ m/s}^2$  and the maximum 85<sup>th</sup> percentile value of acceleration rates was  $1.17 \text{ m/s}^2$ . These values were considered as comfortable rates.

Finally, it is important to continue studying how the geometric characteristics of the speed tables affect to vehicles operation in order to have a better understanding of the behavior on low volume roads crossing small towns and to develop better traffic calming devices.

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**TABLE 1 Speed Table Characteristics**

ID	PTCDD (m)	NTCDD (m)	L (cm)	ERL (cm)	FTL (cm)	ExRL (cm)	Hmax (cm)	TS (%)	ERS (%)	ExRS (%)
Genovés1	60	90	724	149	414	161	8.0	0.92	3.38	4.41
Genovés 2	100	145	783	224	337	222	11.9	-0.84	4.63	4.48
Genovés 3	145	130	818	191	463	164	10.7	1.44	3.67	5.40
Llutxent 1	380	165	789	202	385	202	9.0	-5.3	3.81	4.17
Llutxent 2	165	105	808	223	345	240	9.8	-5.48	4.13	4.12
Llutxent 3	105	155	767	224	320	223	8.5	-5.50	3.19	4.13
Llutxent 4	155	450	804	215	388	201	12.9	-2.64	5.59	4.52
Quatret.1	30	115	651	151	372	129	6.1	0.98	3.56	3.59
Quatret.2	115	100	743	146	395	201	10.6	2.05	5.40	4.92
Quatret.3	100	95	676	158	292	227	10.3	1.76	6.08	4.42
Quatret.4	95	500	691	143	388	160	10.6	2.77	6.21	6.23
Albalat 1	110	100	682	152	360	170	10.5	0.20	6.75	6.00
Albalat 2	100	270	689	152	378	159	10.3	-0.54	6.54	7.26
Chelva 1	120	125	586	140	319	128	9.4	0.13	6.54	7.26
Chelva 2	125	275	637	108	364	166	8.7	0.03	6.64	5.62
Chelva 3	275	250	652	113	364	176	8.6	-4.28	4.41	5.87

**TABLE 2 Multiple Regression Analysis for Speed Reduction**

Multiple Regression Analysis					Variance Analysis					
Parameter	Estimate	standard error	t-statistic	P-value	Source	Squares Sum	LD	mean square	F-Ratio	P-Value
CONSTANT	6.46356	2.79689	2.31098	0.0281	Model	358.354	2	179.18	15.15	0.0000
<i>ERS</i>	0.951316	0.512561	1.85601	0.0736	Residue	342.955	29	11.826		
<i>PTCDD</i>	0.028674	0.005673	5.05421	0.0000	Total (Corr.)	701.309	31			
$R^2 = 51.0979\%$ ; $R^2$ (adjusted) = 47.7253 %; Standard Error of Est. = 3.4389; Average absolute error = 2.75335										

**TABLE 3 Regression Analysis for Speed Reduction**

Linear Regression Analysis for $\ln(y)=A+B\cdot\ln(x)$					Variance Analysis					
Parameter	Estimate	standard error	t-statistic	P-value	Source	Squares Sum	LD	mean square	F-Ratio	P-Value
CONSTANT	0.782516	0.338354	2.31271	0.0278	Model	1.61026	1	1.61026	34.08	0.0000
$\ln(PTCDD)$	0.393127	0.0673403	5.83791	0.0000	Residue	1.41743	30	0.0472478		
					Total (Corr.)	3.0277	31			
$R^2 = 53.1844 \%$ ; $R^2$ (adjusted) = 51.6239 %; Standard Error of Est. = 0.217366; Average absolute error = 0.171879										

**TABLE 4 Multiple Regression Analysis for 85<sup>th</sup> percentile of Speed**

Multiple Regression Analysis					Variance Analysis					
Parameter	Estimate	standard error	t-statistic	P-value	Source	Squares Sum	LD	mean square	F-Ratio	P-Value
CONSTANT	24.5665	9.6592	2.54333	0.0170	Model	236.46	3	78.8202	7.91	0.0006
<i>L</i>	0.0202058	0.010421 2	1.93892	0.0630	Residue	269.022	27	9.96376		
<i>ERS</i>	-1.12093	0.60479	-1.8534	0.0748	Total (Corr.)	505.482	30			
<i>PTCDD</i>	0.0116383	0.005391 49	2.15864	0.0399						
R <sup>2</sup> = 46.7792 %; R <sup>2</sup> (adjusted) = 40.8658 %; Standard Error of Est. = 3.15654; Average absolute error = 2.39146										

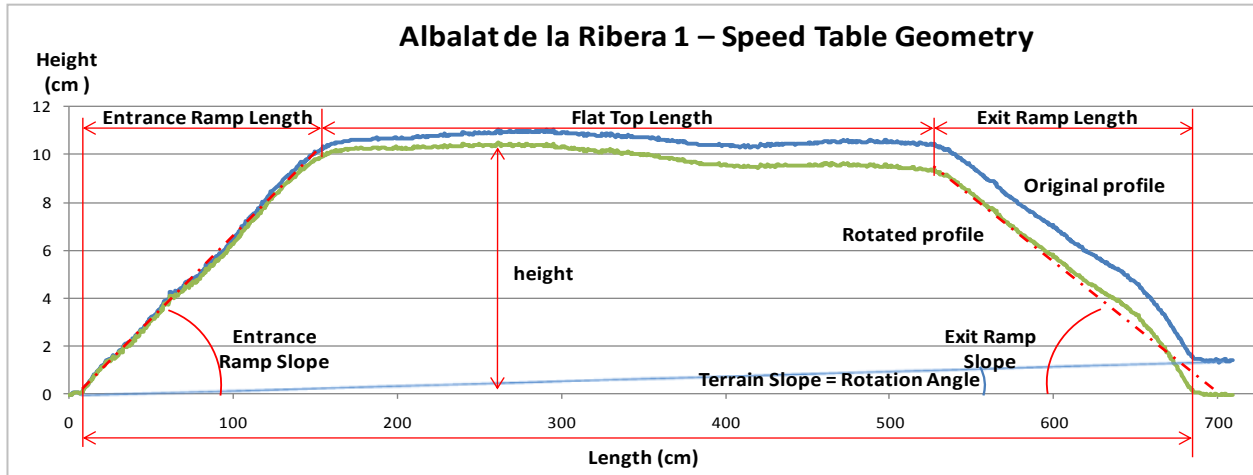
**TABLE 5 Predicted speeds based on the S<sub>85</sub> and SR<sub>85</sub> Models**

Guideline	Speed Table Type	Entrance Ramp Slope (%)	Design Speed (km/h)	Operating Speed over the Speed Table (km/h)			Midway Operating Speed (km/h)		
				Distance between traffic calming devices (m)			Distance between traffic calming devices (m)		
				50	100	150	50	100	150
USA	-	4.16	45-52	-	34.6	35.2	-	48.0	50.9
	-	5.55	45-52	-	33.0	33.6	-	46.4	49.3
Spain	A	4.00	50	38.5	39.4	40.0	49.0	52.8	55.7
	B	6.67	40	31.8	32.4	32.9	42.0	45.8	48.7
	C	10.00	30	26.1	26.6	27.5	36.2	40.0	42.9

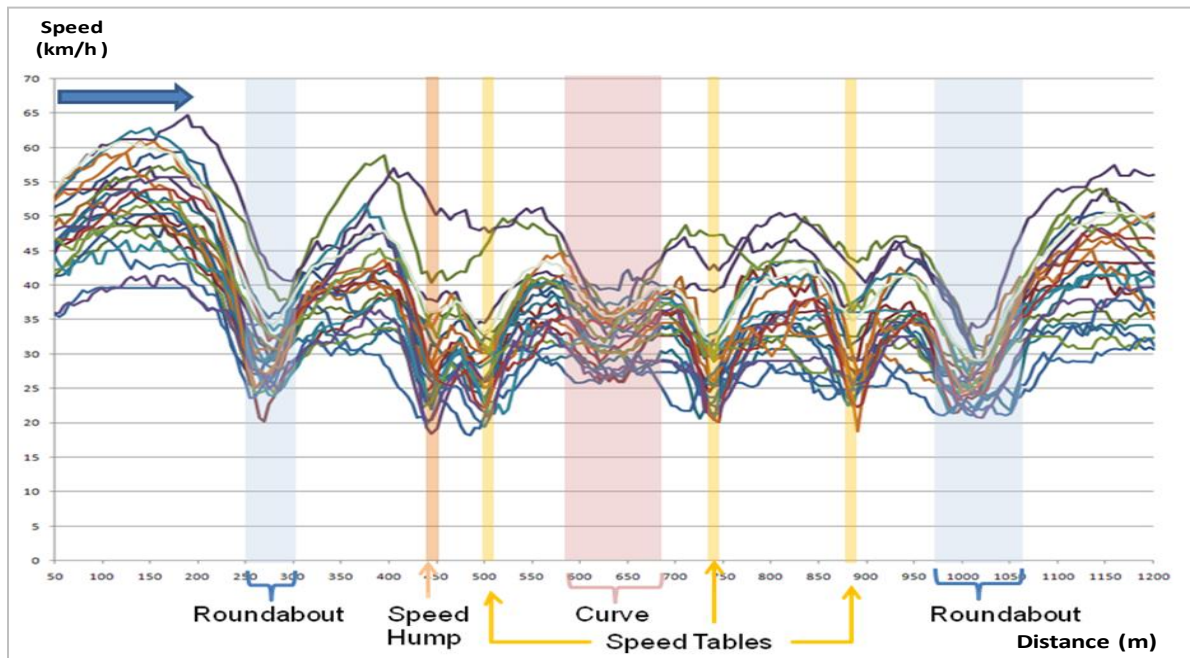




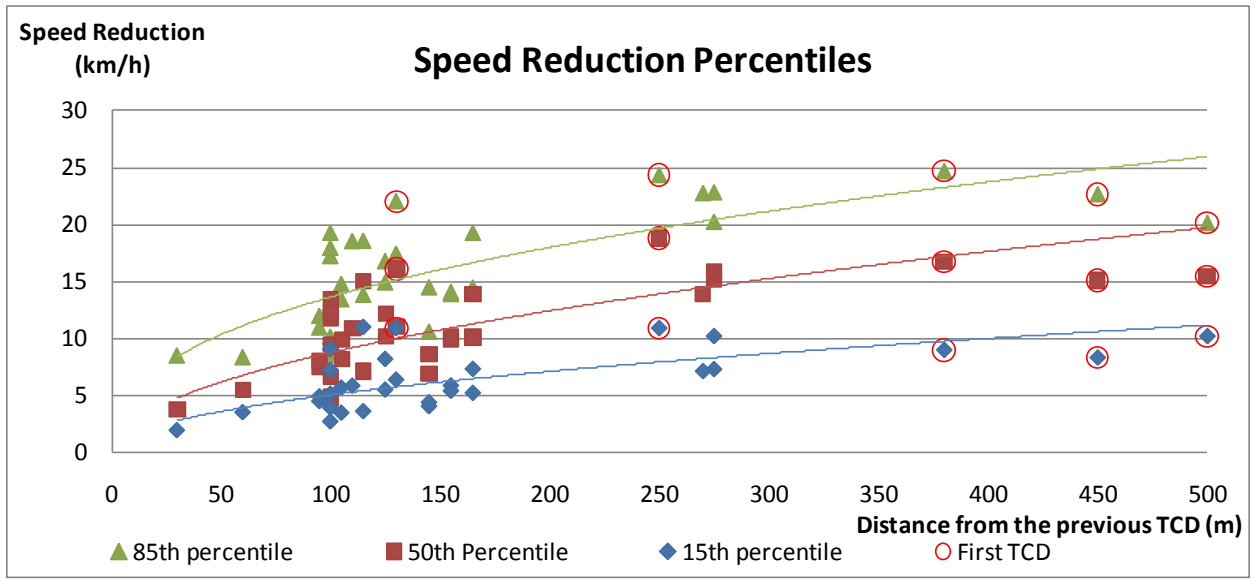
**FIGURE 1** Speed Table Location at the Selected Cross Town Roads: (a) Genovés; (b) Chelva; (c) Quatretonda; (d) Llutxent; and (e) Albalat de la Ribera.



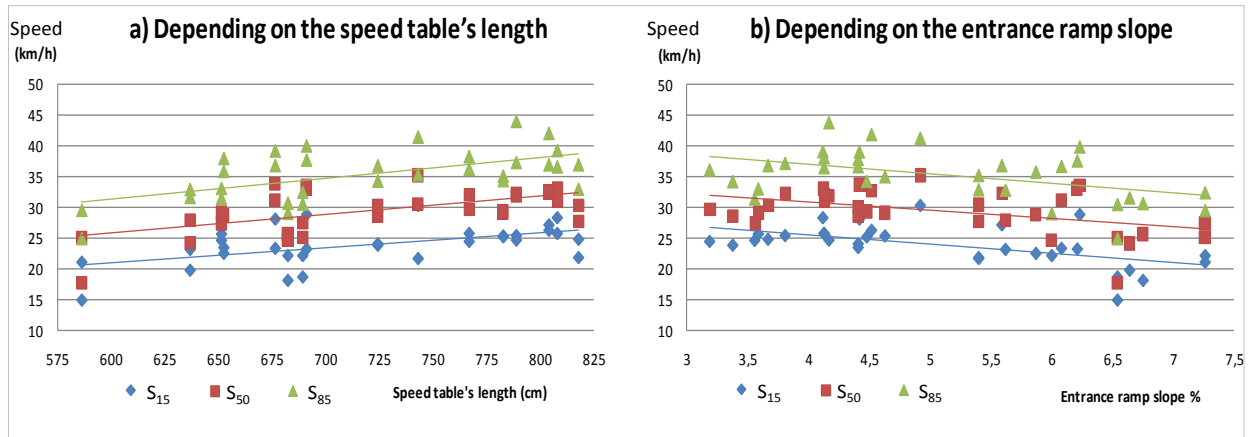
**FIGURE 2** Speed Table Geometric Characteristics.



**FIGURE 3** Speed Profile Sample at Genovés Crossing-Town Road. Direction 1.



**FIGURE 4** Speed Reduction based on the Distance from the Previous Traffic Calming Device.



**FIGURE 4 Speed Percentiles While Driving Over Speed Tables.**

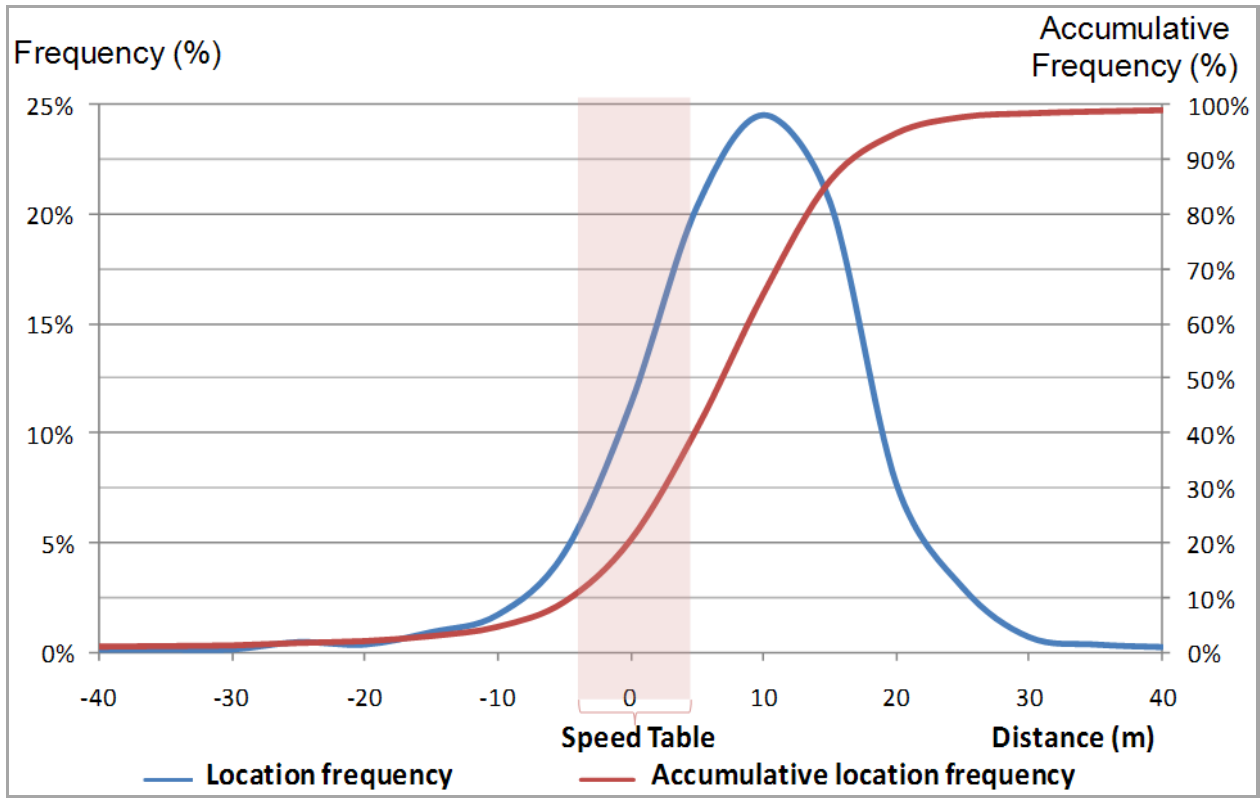
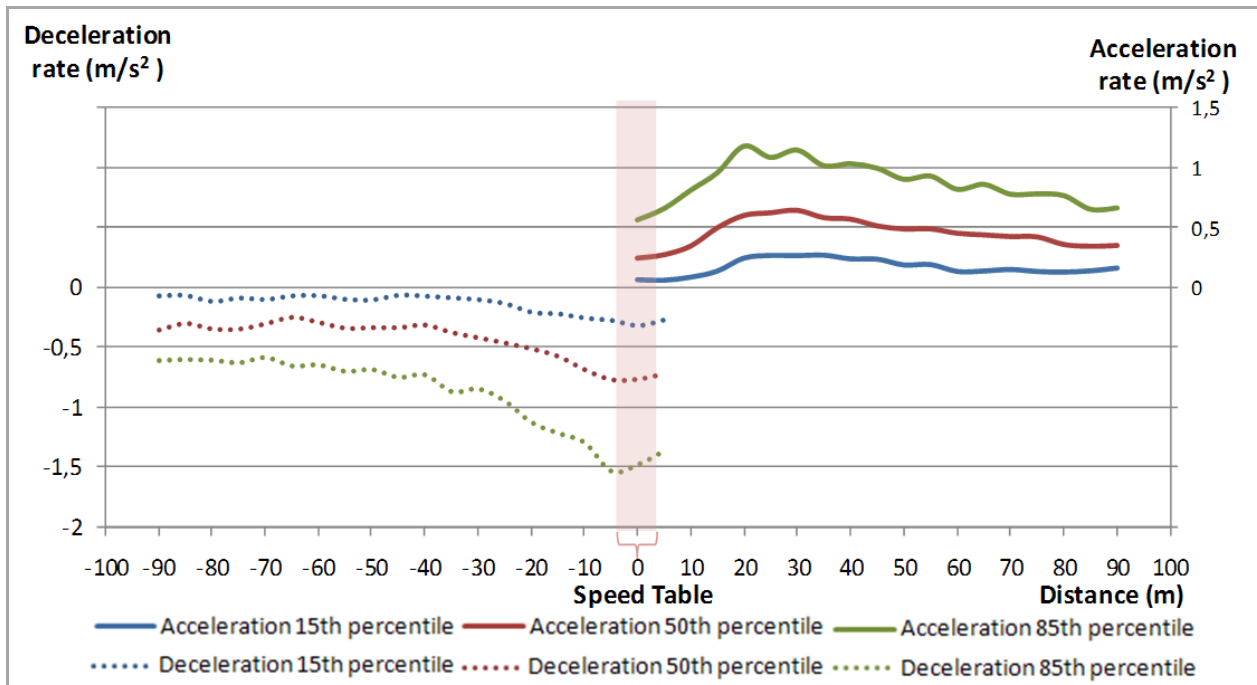


FIGURE 5 Minimum Vehicle's Speed Location Frequency.



**FIGURE 6 Acceleration and Deceleration Rates Percentiles Profiles.**