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Influence of Wider Longitudinal Road Markings on Vehicle Speeds in Two-Lane Rural Highways

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Abstract: Longitudinal road markings are a valuable aid in driving guidance. An increase in their width may influence driving and, therefore, road safety. Wider road markings generate a perception of a narrowing lane, which may induct drivers to reduce speed. The present study tries to verify if an increased width of longitudinal road markings actually helps one to drive more slowly, and consequently leads to enhanced road safety. For this purpose, three curves with reduced visibility were selected and driving speed was measured with normal and modified (wider) longitudinal road markings. The results showed a speed reduction effect of around 3.1% with wide road markings. The speed-reducing effect of wide marks was greater during weekends and with more intense traffic volume, while it was slightly attenuated by night. Finally, the calculation of some standard cases on a working day, and considering average traffic volume, gave the following speed reductions during the day and at night, respectively: for light vehicles, 2.24% and 1.96%; for heavy vehicles, 2.46% and 2.15%. In view of the results obtained, it may be said that using wide road markings can help reduce vehicle speed, thereby contributing to reduced traffic accidents and making road transport more sustainable.

Keywords: wider road markings; longitudinal pavement markings; driving speed; circulation speed; before and after road safety evaluation

1. Introduction

Some European countries use wider road markings [1]. Belgium, Denmark, Germany, and Sweden use markings up to 30 cm in width. Sweden increased the width of their longitudinal road markings to improve visibility at night, from 10 to 15 cm on the axis and from 20 to 30 cm at the edges [2]. A minimum width of 15 cm is proposed by the European Road Assessment Programme [3].

In Spain, the current width of longitudinal road markings is established by Regulation 8.2-IC [4]. Accordingly, for two-lane highways with a maximum speed equal to or less than 100 kph (two-lane rural highways), the usual widths are: 10 cm for lane separation and for edgelines (15 cm for the edgelines if the shoulder is wider than 1.5 m) and 30 cm for special lane separation. It can therefore be said that the width of longitudinal road markings on two-lane rural highways in Spain does not usually exceed 15 cm, although the norm establishes that in sections where there is a heightened possibility of conflict or risk for circulation (e.g., climbing lanes, merge and diverge segments, etc.), the recommended width is increased to 30 cm. Mark widening would be advisable as well for dangerous curves, urban crossings, intersections, and accident concentration sections.

In 2015, 69% of the 34,558 accidents with victims on Spain's interurban roadways occurred on two-lane rural highways. In addition, two-lane rural highways presented major problems of non-compliance with speed limits [5]. According to Casado-Sanz et al. [6], the severity of the drivers' injuries in this type of accident is related to low traffic volumes, higher percentages of heavy vehicles, infractions, wider lanes, and the non-existence of road markings. Road markings are known to play a key role in traffic safety, and wider road markings generate a perception of a narrowing lane, which may induce drivers to reduce speed and improve road safety. In view of the major problems of non-compliance with speed limits, and due to the fact that most accidents with victims occur on rural two-lane highways, it is worthwhile to evaluate the potential effects of implementing wider road markings for this type of roadway.

The paper is organized into the following sections: state of current research, problem statement, objectives and hypothesis, description of the study cases, data acquisition and pre-processing, methodology, results and discussion, and, finally, conclusions.

2. Literature Review

In recent decades, transportation departments, researchers, and organizations worldwide have embarked on studies of the influence of road materials and the width and type of road markings on driver visibility under diverse road and environmental conditions [1,2,7–24]. Some of these studies suggest that wider road markings may play a role in reducing accidents given certain conditions, and that accidents related to road markings (mainly running off the road and frontal crashes) are more frequent on conventional highways, especially at curves and during the night [8,9].

In 1989, Hughes et al. [9] compared the accident rate with wider and with normal markings in two-lane rural highways, obtaining different results according to the level of traffic. For high traffic levels (5000–10,000 vehicles per day) there was no reduction. However, for low traffic levels (2000–5000 vehicles per day), reductions in accident rates were found. Still, the effects of wider road edgelines do not consistently follow such a pattern. For example, Cottrell [8] collected five years of accident data (covering three years before wide edgeline installation and the two years afterward) in three two-lane rural road sections. They found no evidence that wide edgelines significantly affected the incidence of accidents. Hall [7] likewise found no significant influence in terms of the number of accidents when wider road markings were implemented.

A report by the Texas Transportation Institute [2] affirmed that most American states were using road markings wider than the minimum established by law (10 cm) for edges, lane separation, or central marks. Greater visibility was mentioned as the main reason for increasing the width of the marks. Although most of the Transport Departments involved did not assess the benefits of using wider road markings, overall satisfaction with their use was expressed, and none intended to go back to using the minimum width after that. The study specified that the use of wider edgelines was beneficial in the following situations: sections where a greater degree of road definition is needed (curves, highways with narrow or no shoulder, sections in works); places with low illumination or low contrast of road markings; and highways where older drivers are frequent, calling for greater road visibility. Further benefits of wider road markings were: improvement of long-range perception for night driving; improved stimulation of peripheral vision; and improved positioning of the vehicle in the lane and vehicle control. Davidse et al. [14] conducted a meta-analysis aimed at identifying the relationship between road markings and speed; these authors found both positive and negative effects (namely, decreases up to 5.0 kph and increases up to 10.6 kph) depending on the road, traffic, environmental, and driver characteristics.

More recently, Park et al. [25] looked at the relationship between the number of accidents on two-lane rural US highways and the width of road markings. On the highways of Kansas, they determined accident reduction mainly in daytime conditions. A similar study conducted on Michigan highways found that the positive effect of wider road markings did not change overtime. Significant accident reductions were obtained at night, with wet roadways and accidents involving only one vehicle. Finally, results obtained for the highways of Illinois indicated that an increased width of road markings produced a reduction in the number of accidents under all conditions (day, night, wet, etc.). The authors concluded that, in general, wider longitudinal markings help reduce roadway accidents.

As a proxy, the influence of wider longitudinal road markings on speed can be inferred through the effect of longitudinal speed reduction markings (LSRM). Longitudinal speed reduction markings are discontinuous longitudinal markings 30 cm wide painted next to the edgeline road markings, on the inside of the lane. Ding et al. [26] and Zhao et al. [27] studied their effect on connectors through driving simulation, obtaining the results that LSRMs could reduce vehicles' travel speed and limit drivers' willingness to increase speed, but effects depend on the radius and on the position of the vehicle along the connector.

Taking into account the few studies found on this topic, a means of exploring the impact of wider longitudinal road markings is to study the effects of the presence versus the absence of road markings. Sun et al. [28] undertook a study on the influence of the presence versus absence of edge road markings on two-lane rural highway accident rates in Louisiana. A total of 10 cases were analyzed, and the implementation of road edge markings produced two effects: vehicles circulated more centered in the lane; and accidents were reduced by 0.85% in three years. The greatest decrease in accidents occurred in run-off-road and frontal crashes, women and young people being the most benefited drivers. Meanwhile, Transport for London [29], investigated the effects of centreline removal. This study, carried out between 1997 and 2003, on three curves in two-lane rural highways (with a speed limit of 48 kph) in the United Kingdom concluded that there was a statistically significant reduction in vehicle speeds as a result of removing central markings on the carriageway.

More recently, Havránek et al. [30] conducted a study to assess how longitudinal road markings influence driving behavior. For that purpose, six curves on secondary rural roads were selected and monitored before and after application of road marking. The studied indicators were average speed and lateral position, which were collected using trajectories detected in calibrated video recordings. The results indicated that speeds decreased in both edgeline and centerline applications; regarding lateral positions, the edgelines were associated with shifting the driving trajectories towards the center of the road, and the centerlines were associated with shifting the driving trajectories towards the road edges. Babic et al. [31] investigated how the presence of traffic signaling elements affects the behavior of young drivers in night-time conditions. A driving simulator with two scenarios was used: one containing no road markings and no traffic signs, and one containing road markings and traffic signs. The results confirmed a statistically significant difference between the two scenarios in terms of driving speed and lateral position (the participants drove slower, and in a more stable manner in the scenario with road markings and traffic signs).

Although an increase in the width of the longitudinal road markings generates a perception of narrowing of the lane, the influence of road lane width in road safety is still under study. For example, Mecheri et al. [32] focused on the effects of lane width for the positioning of drivers within the lane. Their results confirmed that lane-width reduction made drivers stay closer to the road's center in most traffic situations. Yet in the absence of oncoming traffic, the narrowing gave rise to significant shifts in the distance from the lane's center to the edgeline. These results may, indirectly, be associated with traffic speed—at low speed (with dense traffic) it is easier to keep the vehicle in the center of the lane than at high speed (with low traffic). Regarding the influence of the lane width in traffic accidents, Casado-Sanz et al. [6] looked into 1064 accidents in the period 2006–2016 in two-lane rural highways in Spain, finding that the occurrence of fatal injury is greater in the wider lanes (45.80% in the lanes over 3.75 m wide, 41.40% in the lanes having a width under 3.25 m, and 32.30% in those of intermediate width).

3. Problem Statement, Objectives and Hypothesis

According to the literature review, accidents related to road markings are more frequent on conventional highways, especially at curves, and wider road markings may play a role in reducing accidents. Therefore, advancing knowledge about the effects of the width of road markings under these conditions may contribute to road safety.

Studies about how the width of road markings may influence road accidents reap diverse findings. Some affirm that wider road markings can help to decrease road accidents, while others find no relationship. The results of these studies often depend on other factors such as the characteristics of the road, traffic, vehicle, driver, brightness, etc. Very few studies analyze the influence of the width of longitudinal road markings specifically on speed.

The novel contribution of this article is that it focuses on the influence of wider longitudinal road markings (hence decreased lane width) upon the speed of circulation along curves in two-lane rural highways. It moreover aims to assess the effect of widened longitudinal marks on speed under different conditions related to the drivers themselves (habitual or not), the traffic volume, the vehicle (light or heavy), and whether it is day or night.

For the hypotheses to be validated would require: (1) An increased width of the longitudinal road markings causing a decrease in driving speed; and (2) this effect being conditioned by characteristics of the driver, the traffic, the vehicle, and daylight.

4. Study Cases

The selected curves pertain to two-lane rural highways in Andalusia (southern Spain). The curves were chosen for study mainly due to their reduced visibility. They are described below:

4.1. Curve 1 (C1) and Curve 2 (C2)

Curves C1 and C2 (Figures 1 and 2) are located on the national road N-432. This road has a lane width of 3.5 m, and the shoulders have a width of 1.5 m. C1 is a left curve (geographical coordinates: 37.376250, −3.819633). It has a radius of 230 m, and the gradient is −0.5%. The average daily traffic is 4036. C2 is a right curve (geographical coordinates: 37.373248, −3.819632). It has a radius of 400 m and the gradient is −2.6%. The average daily traffic is 4389. The maximum speed allowed is 100 kph, and the recommended speed of circulation is 80 kph for both curves; the proportion of heavy vehicles is around 7%.

Figure 1. Curve C1 with normal marks and signal hiding the radar.

Figure 2. Curve C2 with normal marks and signal hiding the radar.

4.2. Curve 3 (C3)

C3 (Figure 3) is located on the regional road A-333, and it is a right curve (geographical coordinates: 37.557542, −4.165947). It has two lanes of 3.5 m width, and shoulders of 1.0 m. The radius is 230 m, and the gradient −2.0%. The average daily traffic is 728, with 4.0% of heavy vehicles. The maximum speed allowed on this road is 90 kph, but just before the curve there is a recommendation of 70 kph.

Figure 3. Curve C3 with wider marks and signal hiding the radar.

5. Data Acquisition and Pre-Processing

For data collection, a portable traffic counter (TMS-SA model, from Icoms) was installed just before each curve. These devices use radar technology to record traffic data such as date, time, speed, and vehicle length. The measurements were taken both with normal road markings and with wider road markings. Because the radars were implemented on the reverse of traffic signs, the backside of the signals was previously painted in the same color as the radars (i.e., black). The measurement periods (during 2015) with normal road markings (10 cm for lane separation and 15 cm for edge line) and with wider road markings (30 cm both) were planned to be long enough to collect a sufficient amount of data (Table 1, columns 2 and 3).

Table 1. Radars: data acquisition and pre-processing.

	No. of Days with		No. of Registered Vehicles					
Curve (1)	**Normal Marks (2)**	**Wider Marks (3)**	**Total (4)**	**Free Flow Speed (5)**	**Normal Speed and Length (6)**	**Excluding Painting Days (7)**	**Normal Marks (8)**	**Wider Marks (9)**
C1	59	56	232,098	98,954	97,633	96,648	47,910	48,738
C2	80	167	542,154	234,660	229,989	228,956	74,688	154,268
C3	157	289	162,349	125,579	120,810	120,521	35,516	85,005

Pre-processing of the data registered by the traffic counters entailed the following steps:

- First, the influence on speed of two vehicles circulating very close after one another had to be removed, for which reason the free flow speed concept was considered. According to the Transportation Research Board [33], a minimum interval of 20 seconds between vehicles is required to guarantee free flow speed conditions. The vehicles that did not fulfill this condition were eliminated (from the total number of registered vehicles, shown in column 4 of Table 1), leaving the data shown in column 5 of Table 1.
- Next, the vehicles circulating at abnormal speeds were eliminated: data referring to vehicles traveling on the road at less than half the recommended speed (i.e., 40 kph (tractors)), or else over 160 kph were left out.
- Then, vehicles whose length was less than 2.5 m were eliminated (e.g., motorcycles). The latter two requisites resulted in the data given in column 6 of Table 1.
- Finally, the data gathered during painting days were removed, since they presented very low speed values (column 7 in Table 1).

It should be noted that the smaller decrease in the number of vehicles during the data processing process in C3 with respect to C1 and C2 is mainly due to the fact that the traffic volume in C3 is much lower than in C1 and C2. Therefore, most of the vehicles in C3 comply with the free flow speed condition, which is not true of C1 and C2. Finally, the records were classified into day or night in view of the date and local time zone definition of dawn and dusk, according to the National Oceanic and Atmospheric Administration.

6. Methodology

This study compares the speed of circulation on roadways with normal markings (before painting the wider road markings) with the speed when road markings are modified (after painting the wider road markings). First, the database was segmented according to the type of vehicle (light or heavy) and day or night, including all possible combinations.

A generalized linear model (GLM) was adjusted, using a stepwise algorithm with backward elimination to include the variables in the model. Subsequently, a Type III ANOVA was used to test whether the effect of each of the variables (and their interactions) upon speed was significant. The validity of the model as a whole was moreover tested by means of an F-test. In order to obtain the effect of the study variables on the speed of circulation, models like this were developed:

$$S = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_i X_j;\ i \neq j, \quad (1)$$

where X = (X_1, X_2, . . . , X_i) are the explanatory variables in the model, and β = ($β_0$, $β_1$, . . . , $β_k$) are the coefficient estimates.

Most of the explanatory variables are dichotomous (i.e., categorical variables with two categories) and they were coded as:

- S = speed.
- WL = 1 for wider lines, 0 for narrow lines.
- W = 1 for weekend, 0 for working day.
- N = 1 for night, 0 for day.
- HV = 1 for heavy vehicle, 0 for light vehicle.

Other variables included in the model were:

- TV = traffic volume (number of vehicles within periods of 15 minutes).
- Ci = road section. It is a variable with three categories that serves to take into account that the circulation speed may be different in each curve. C1 was taken as the reference level (thus, it was equal to 0 when referring to C1, and equal to 1 when referring to C1 or C2).

Differences in the number of observations taken on each curve, and for each type of markings (Table 1), can lead to an over- or under-representation of a certain case in the model. In order to avoid this bias, a calibration was used to adjust the number of observations. Like the weighting strategy typically used in population surveys, where a sample is adjusted to a known population, post-stratification weights were calculated for each combination of curve and type of road marking. This approach aims to ensure that all cases are equally represented in the model, and at the same time it avoids discarding observations, with the loss of information that would entail. The weights were calculated using the formula:

$$w_{\mathrm{ij}} = \frac{\tau_i}{\eta_i} \times \frac{\tau_{i,j}}{\eta_{i,j}}, \quad (2)$$

where:

- w_{ij} = the weight to apply for the observations of the curve i = {1,2,3} and the type of markings j = {1: Narrow lines, 2: Wider Lines};
- τ_i= the target proportion for the observations of the curve *i*. In seeking an equal distribution among the curves, this proportion was set to 1/3;
- η_i = the existing proportion of the *i*-curve observations over the total;
- $\tau_{i,j}$= the target proportion, within the curve *i*, for the observations with the type of markings *j*. In seeking an equal distribution among the types of markings, this proportion is set to 1/2;
- $\eta_{i,j}$ = the existing proportion, within the curve *i*, of the observations with the type of markings *j*.

Accordingly, the weights to be applied for each case are as indicated in Table 2.

Table 2. Post-stratification weights.

Curve	Narrow Lines: j = 1	Wider Lines: j = 2
C1: i = 1	w_{11} = 1.5519550	w_{11} = 1.5255890
C2: i = 2	w_{21} = 0.9955303	w_{21} = 0.4819805
C3: i = 3	w_{31} = 2.0935400	w_{31} = 0.8747034

7. Results and Discussion

Performing the ANOVA test for the joint model gave the results shown in Table 3 (significant variables and significant variable combined effects).

Table 3. Results of the joint model.

Variable	Estimate (β_k)	Std. Error	*t*-Value	Pr (>|*t*|)
(Intercept)	91.648 *	0.086	1064.831	$<2 \times 10^{-16}$
WL: Wider Lines	−2.905 *	0.075	−38.560	$<2 \times 10^{-16}$
W: Weekend	−1.105 *	0.068	−16.349	$<2 \times 10^{-16}$
N: Night	0.016	0.091	0.180	0.857
HV: Heavy Vehicle	−8.568 *	0.084	−101.913	$<2 \times 10^{-16}$
TV: Traffic Volume	−0.110 *	0.002	−47.313	$<2 \times 10^{-16}$
S: C2	4.142 *	0.045	91.267	$<2 \times 10^{-16}$
S: C3	4.324 *	0.064	67.479	$<2 \times 10^{-16}$
WL × W: (Wider Lines) × (Weekend)	0.339 *	0.085	3.979	6.92×10^{-5}
WL × N: (Wider Lines) × (Night)	0.591 *	0.088	6.728	1.72×10^{-11}
WL × TV: (Wider Lines) × (Traffic Volume)	0.031 *	0.002	13.640	$<2 \times 10^{-16}$
W × N: (Weekend) × (Night)	−0.510 *	0.095	−5.382	7.37×10^{-8}
W × HV: (Weekend) × (Heavy Vehicle)	0.595 *	0.138	4.323	1.54×10^{-5}
N × TV: (Night) × (Traffic Volume)	−0.016 *	0.003	−5.705	1.17×10^{-8}
HV × TV: (Heavy Goods Vehicle) × (Traffic Volume)	0.016 *	0.003	5.627	1.84×10^{-8}

Note: * $p < 0.01$. $R^2 = 0.111$. Adjusted $R^2 = 0.110$. Residual Std. Error = 12.222. F-Statistic = 3,939.964 *.

Therefore, the model to be considered would be:

$$\begin{gathered} S = 91.65 - 2.91 \times WL - 1.11 \times W - 8.57 \times HV - 0.11 \times TV + 4.14 \times C_2 + 4.32 \times C_3 \\ + 0.34 \times WL \times W - 0.59 \times WL \times N + 0.03 \times WL \times TV - 0.51 \times W \times N + \\ 0.60 \times W \times HV - 0.02 \times N \times TV + 0.02 \times HGV \times TV. \end{gathered} \quad (3)$$

Considering the effects of the variables one by one, Table 3 shows that:

- The circulation speed (with normal markings, on a weekday, for light vehicles, and without considering the traffic volume) is 91.65 kph for Curve C1. The circulation speed is 4.14 kph higher for C2, and 4.32 kph higher for C3. Therefore, driving speed is seen to be much higher than recommended by the vertical signaling in the three curves. Moreover, the circulation speed in C3 is higher than the maximum speed allowed.
- The isolated effect of the wide markings is that they contribute to decreasing speed by 2.91 kph.
- The widened markings reduce speed by precisely 3.18% in C1, 3.04% in C2, and 3.03% in C3.
- During weekends the speed is 1.11 kph lower, perhaps due to the presence of a greater proportion of non-habitual drivers than during the work week.
- The variable night is not found to be significant in itself, which can be explained by lower traffic volumes during this time frame (average traffic per night, 783 vehicles; average traffic per day, 2210 vehicles) and the fact that the influence of traffic on the speed of vehicles passing at nighttime is totally represented by the variable TV.
- Heavy vehicles circulate 8.57 kph more slowly than light vehicles.
- Speed decreases when traffic volume increases, by 0.11 kph multiplied by the number of vehicles (in 15 m time intervals).

As no similar studies have been found, making it impossible to compare the results obtained, it can be stated that the speed-reduction effect of the wider marks seen here is in line with the results of somewhat similar experiments about the effects of longitudinal speed reduction markings [26,27], and the consequences of implementing, or not, longitudinal road markings [29–31]. The speed-reducing effect may contribute to a reduction in the number of accidents associated with the implementation of wider longitudinal road markings [9,25,28] or the narrowing of lanes [6].

When taking into account the combined effects of the variables (i.e., interactions between them), the value 1 was assigned to variables included in the interaction, and 0 to variables not included therein. The effect of the interaction was thus derived by adding the effects of simple and combined variables, provided that all of them were included in the interaction.

According to the results obtained, and even when taking into account the combined effects, it can be said that (Table 3):

- The combination of wide road markings and weekends (S = −2.91 − 1.11 + 0.34 = −3.68) makes the vehicles circulate 0.77 kph slower than on a working day.
- At night, the speed-reducing effect of wide marks is attenuated by 0.59 kph. This lesser effect of the widened marks may have to do with the greater visibility of markings at nighttime.
- The speed-reducing effect of wide marks increases along with traffic volume (−0.11 + 0.03 = −0.08 times the traffic volume).
- On weekend nights, speed decreases slightly, by 0.52 kph (equal to −1.11 + 0.59 = −0.52).
- During weekends, heavy vehicles drive 9.08 kph slower (equal to −1.11 − 8.57 + 0.60 = −9.08)
- The speed at night decreases proportionately with traffic volume (specifically, 0.13 times the traffic volume, equal to −0.11 − 0.02 = −0.13).
- The speed of heavy vehicles is slightly reduced in conjunction with traffic volume (0.09 times, equal to −0.11 + 0.02).

Summing up, wide markings can contribute to decreasing speed by 2.91 kph. Therefore, it can be said that wider road markings have a speed-reducing effect, which may be related to the driver's perception of narrower lanes. In this study, the wider markings were associated with an average speed reduction of 3.1% on the selected curves. If the effects of the combined variables are analyzed, the effect of the wide markings increases with traffic volume and during weekend days, and decreases slightly at night.

Finally, the reduction of speed circulation after implementing the wider markings under different road conditions and vehicles was calculated. Working days and the average traffic volume during day and night were fixed. For light vehicles, the results indicate a reduction of some 2.24% during the day, and 1.96% during the night. For heavy vehicles, the daytime reduction was 2.46% and the nighttime reduction amounted to 2.15%.

8. Conclusions

In sum, a study of the influence of the width of the longitudinal road markings on the speed of circulation—an aspect scarcely addressed in the literature—was undertaken. The results establish a significant relationship between the two main variables of study (the widening of road makings leads to a reduction in circulation speed). Additionally, the influence of other variables related to the subject of study (traffic volume, type of vehicle, etc.) was highlighted. The proposed hypotheses were, in effect, validated.

Wider markings contributed to decreasing speed by 2.91 kph. Hence, it can be said that wider road markings have a speed-reducing effect, which may be related to the driver's perception of narrower lanes. Speed was reduced by 3.1% on average along the selected curves when the road markings were wider. When the combined variables and their effects are examined, the influence of wider markings is seen to increase with traffic volume and during weekend days, yet it decreases slightly at night.

Regarding the remainder of the variables, considered separately (one by one), the variable that reduces speed the most would be heavy vehicle. Other variables that have a speed-reducing effect are weekend days and traffic volume. The variable night did not prove significant. Considering interactions, speed decreases on weekend nights, during weekends for heavy vehicles, at night in proportion with traffic volume, and for heavy vehicles proportionately with traffic volume.

Finally, the calculation of some standard cases on a working day and considering average traffic volume, during day and night, gave the following speed reductions: for light vehicles, 2.24% during the day and 1.96% at night; for heavy vehicles, 2.46% during the day and 2.15% during the night.

Despite certain limitations surrounding this study, the main one clearly being that only three roads were involved, some valid conclusions can be drawn from the model developed. Altogether, the results presented here would appear to indicate that wide road markings produce a potentially beneficial speed-reducing effect in the scenarios studied, although the effect varies according to the particular variables considered. The speed-reducing effect of widened road markings may contribute to a reduction in accidents, and therefore promote the sustainability of roadway transportation. Increasing the width of markings might be implemented (as a complementary measure to vertical signaling) on dangerous road sections (curves with reduced visibility, intersections, etc.), and/or sections like the studied ones, where driving is too fast, as a first step toward enhanced road safety.

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