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# A simulator approach to study the effect of spiral curves on driver's behavior for two-lane rural highway

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**Abstract.** Many studies based on spot locations have been conducted to improve highway design consistency to reduce accident rates. Traffic accidents had a strong relationship with environmental sustainability in terms of emissions and natural resources consumption. This study based on driving a simulator can produce continuous drivers' behavior profiles to facilitate analyzing the behavior on various curves' scenarios (with/without spiral). This paper studied the effect of the spiral transition curves on drivers' behaviors in terms of speed and lateral position with changing geometric features of horizontal curves at the two-lane rural highway. Seventy-two participants were selected to ride on 48 different curves. Curves of experimental track had 4 radii, 3 deflection angles, 2 directions and with/without spiral. Drivers' speed behavior studied at five specific locations at every curve, and 3 segments at studying the lateral position. Effect of spiral studied according to 3 approaches; changing radius, deflection angle, and direction of the curve. Briefly, spiral had significant in small radii curves and sharp deflection angles by increasing the average speed at curves and reduced tangent-to-curve speed reduction. Also, spiral decreased the lateral displacement at approach tangent and during the curve.

## 1. Introduction

There are many previous studies based on simulator that have examined what affects a driver's behavior to reduce accidents. The simulators can design all types of roads (urban and rural), as well as the environment surrounding the road. It also has been widely used especially when new cities are building. Simulator allows designers to study more than scenario when building roads (in terms of the location of the road, the number of lanes, and the direction of travel) and the effect of each design on the traffic consistency. The majority of the studies based on simulator were about the intersections and how is the cycle time of the signals affect on traffic, then designer chose the most appropriate design that reduces the waiting time in the signals and gives more flow to the traffic. Thus, this reduces emissions from the cars waited in the signals, which improves the sustainability of the environment. However, this study focused on the behavior of drivers on rural roads, as it is the most dangerous type of roads in terms of the percentage of fatal accidents that occur [1]. Speed and lateral position of vehicles are the most significant contributing factors on traffic accidents. Many studies found that most accidents were occurred on horizontal curves rather than on tangent straight lines [2], where drivers may underestimate their speed at approach tangent and enter the curve at an unsafe speed. Drivers' errors associated with horizontal curves appear as a result of three interrelated problems: lack of driver attention, misperception of the appropriate speed of the curve's curvature, and bad lateral positioning in the lane along the curve [3]. Two-lane highways are one of the most dangerous road types, because



of the high possibility of face-to-face or run-out of road accidents. Road safety has a strong relationship with environmental sustainability in many ways. One of the most influential factors that affected environmental sustainability is CO<sub>2</sub> emissions from stuck vehicles in the traffic congestion bottleneck resulted from bad highway design accidents [4]. Besides, natural resources are heavily consumed to recreate and repair the accident-damaged parts. On the other hand, one of the main factors that affect driving safety on highways is the speed consistency among roadway successive elements. For this reason, estimating the speed reduction between the tangent and circular curve is necessary to evaluate the consistency for highway design [5]. Therefore, roads should be designed to provide driving consistency between successive road segments.

Driving simulators allow researchers to experiment in controlled conditions and a safe environment. Simulator also collecting reliable data and explaining interactions between drivers and the road environment [6]. Measuring driver's behavior in the real-world would produce data with the highest validity, but observations in the real world make it very difficult to control in the surrounding environment. The simulator has advantages as a cost-effective studying tool to test different features of road design, without any risk on the drivers, and provide a safe environment to drivers during the test [7]. Simulator had another advantage in terms of environmental sustainability; participants rode a simulator instead of instrumented vehicles that prevent CO<sub>2</sub> emissions due to real driving. In this study, the 72 participants rode on a 35 km path with overall more than 2500 km. According to the *European Commission*, the average emissions for a passenger car are about 130g CO<sub>2</sub>/km [8]. Many previous studies have verified that the studies based on driving a simulator were valid. A previous study conducted to compare the speed and lateral position of the drivers in the simulated tunnel and the speed and lateral position of the drivers in the real tunnel using an equipped vehicle [9]. Fortunately, many validation studies show that drivers have similar speed performances in driving simulators compared to those measured in the real-world [10],[11].

## 2. Methodology

### 2.1. Participants

Seventy-two participants held a driving license selected to represent the actual proportions of drivers in terms of age and gender. After that participants filtered based on their answers to a physical questionnaire. So, nine participants who had motion sickness from simulator were eliminated from this experiment. Sixty-three participants, 44 men, and 19 women, whose ages ranged from 22 to 71 years (mean = 36.7, standard deviation = 13) completed the experiment.

### 2.2. Experimental Road

The road of the experiment is consisting of groups of straight lines, horizontal curves and spiral curves -half of the curves had a spiral-. Straight-line tangents with 600m length located between all curves. This length is enough for drivers to reach a free-flow speed before curves. Curves on the experimental path had different geometric characteristics; *i) radii* were 125, 200, 400 and 800m; *ii) deflection angles* 20°, 40°, and 60°. *iii) right and left* direction and *iv) with/without spiral*. With 4×3×2×2 combination we got 48 different curves. The simulated road consisted of a two-lane rural highway with a lane width of 3.50 m and a shoulder width of 1.25 m. Cross slopes were designed according to the Italian geometric design standards.

### 2.3. Apparatus

French Software *Scanners* from *OKTAL* company were used to provide a flexible and efficient simulation. The dynamics of the interactive vehicle is modeled by the software CarSim. Built-in Scanners and Studios are updated at a frequency of 500Hz. The recorded data relating to all of the driver's control input (steering wheel angle, racing pedals, gear, etc.), those of the vehicle (speed, engine speed, position, etc.) and those related to autonomous vehicles and those useful to define the behavior concerning other vehicles and the road infrastructure.

The simulator cockpit is a half of a real Citroën C2, equipped with a dashboard, standard driver controls (speedometer, fuel level, indicators, actual gear, etc.), two adjustable seats in addition to side and central mirrors. The gearbox can be sequential or automatic. All control interfaces provide a realistic response. The pedals are provided with dynamic force feedback and the torque at the wheel is reproduced with high accuracy by a servo-motor directly connected to the steering column. The cab is mounted on a hexapod with six electric actuators able to guarantee six degrees of freedom (translation in X, Y, and Z, yaw, pitch, and roll).

Three-dimensional images are projected onto three flat screens (4x3 meters), surrounding the simulator cockpit. The video system provides a forward field of view of 180°x50° and a resolution for a single front screen of 1400x1050 pixels. The mirrors have been replaced by three 6.5 " LCD monitors, as shown in Figure 1. An infrared video camera and a microphone installed in the cockpit allow the researchers to communicate with the participants, to check their psychophysical status and control their behavior while driving.

Finally, all stimuli, internal and external, provided to the occupants of the cockpit are accurately reproduced to ensure the feeling of being in a real vehicle and to perform a real driving task. The quality of audio and video (refresh rate of 60 images per second) systems helps make the driving experience as realistic and complete as possible [12].



**Figure 1.** Cockpit of the VERA driving simulator

#### *2.4. Experimental procedure*

After the participants fill the forms of medical inspections questionnaire. They were accompanied to drive the simulator. Each participant had about 10 minutes to get used to the vehicle controls (warm-up phase). The test essentially consists of driving the simulator in different scenarios on the country road. The participants must drive as the natural way as possible. During the various phases of the experiment, an investigator will always be in audio-video contact with the driver, to provide all the comments and information necessary for the trial.

### **3. Data Analysis**

Data were collected with a frequency rate equal to 20 Hz and were interpolated every 5 m in Excel sheets. Each curve had two speared sheets, one for speed and another for lateral position. Every speared sheet had data from 600 m before the curve to 600 m after curve every 5 m. Experimental rout had four different radii of curves and three different deflection angles with two directions (right and left). We got 24 curves without a spiral and the other 24 curves with a spiral. Forty-eight different speared sheets created for each curve for speed and another 48 sheets to lateral position. Table A shown in appendix A presents the average speed results at every studied location. The comparison conducted between curves without spiral and similar curves but with a spiral transition curve. Because of a huge data set, the average of drivers' speeds studied on curves the same geometric features- same radius, same deflection angle and same length- [13]. The same concept considered studying the drivers' lateral position.

### 3.1. Speed Data Analysis

Speed profile created for every curve, the most studies previous that assumed that the speed is constant on the circular curves and varies in the spiral transitions and on the tangents were wrong. Since this study was based on continuous speed measurements, studied drivers' speed became allowable at each location selected. In this study, the transition spiral curve effect studied at five specific locations as following; **1)** 150m before PC, **2)** point of curvature, **3)** mid curve, **4)** point of tangency and **5)** 150 m after PT; for curves without spiral. On the other hand, the five locations for curves with spiral were: **1)** 150m before the middle of entrance spiral, **2)** middle of entrance spiral, **3)** mid curve, **4)** middle of exit spiral and **5)** 150m after the middle of exit spiral. Five points were exactly in the same place in the two cases, to study the pure effect of the spiral transition curve because of the half-length of spiral created on the tangent and the other half on the circular curve.

### 3.2. Lateral position Data Analysis

Lateral position (lateral displacement) is a lateral distance between the centerline of the traveling lane and the center of gravity for the vehicle. Driving vehicle (Citroën C2) had 1.70 m width, so if the lateral displacement exceeds 0.90 m that's mean the vehicle violates lane boundary. Lateral position considered positive (+ve) when the drivers move to the roadway axis (near to opposite flow direction) and negative (-ve) when drivers move far away from the roadway axis (near to road shoulder). To studying the effect of the spiral on drivers' lateral position, the average of absolute lateral displacement was taken for each curve studied at 3 segments (approach tangent, curve, and departure tangent). At approach tangent, the average lateral displacement was taken from 150 m before the curve to the beginning of the curve. At the curve segment, the average lateral displacement was taken from the curve start to curve end. At departure tangent, the average is taken through 150 m after the curve ends.

## 4. Result and Discussions

The spiral transition curve effect on drivers' behaviors [speed and *lateral position* (LP)] studied according to 3 approaches. The three approaches were changing curves' a) radii, b) deflection angles and c) direction. At each approach, there was only one variable radius, deflection angle, and direction respectively. The two other variables were command with different values of the studied variable. This methodology followed to eliminate the effect of the other variables to find the pure effect of the spiral transition curves on drivers' speed and speed reduction.

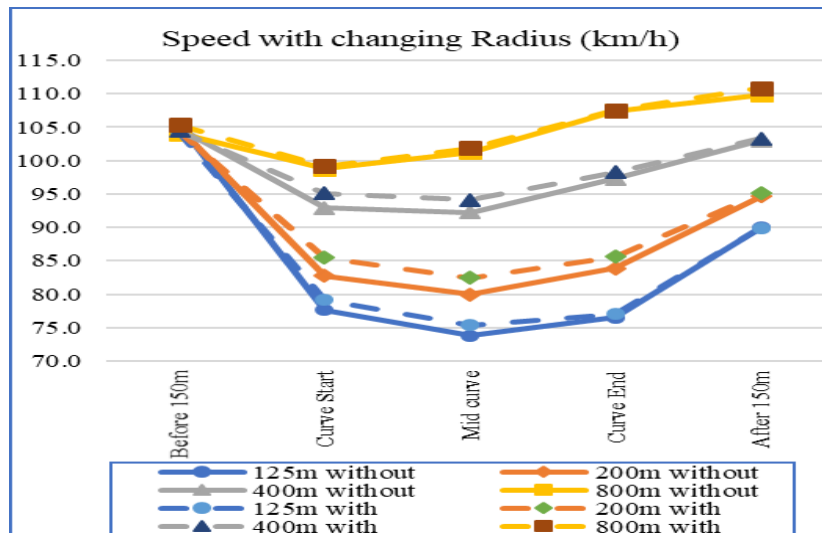
### 4.1. Effect of changing curves' radii:

Curve radius had the most significant effect on drivers' behaviors. Small radius curves had much lower speed than large radii curves had. Also, the average absolute lateral displacement was higher in sharp curves with small radii as shown in figure 2 and table 1. Figure 2 shows 4 pairs of speed profile, each pair represent radius. Each pair had 2 profiles of speed one with and another without spiral. According to LP analysis. table 1 shows two rows for each radius. The first row represents AALD (*average of absolute lateral displacement*) in cm, and the second row represents SELDR (*Spiral Effect on Lateral Displacement Reduction*) in %.

#### 4.1.1. Effect of the spiral with changing curves' radii on speed:

At 150 m before the curve's start, the speed on all curves was approximately the same because there was no indication for the next curve. There was no effect of curves' radius on the speed. At the curve start, the difference in speeds due to changing radii was significant. The speed was much lower than the approach tangent. One can observe that the speed on curves with a small radius much lower than curves with a large radius. Also, the speed was higher in the case of curves with spiral. In the middle of the curve, the speed has the lowest value amongst the whole curve for all curves except curves with an 800 m radius which had the lowest speed at the curve's start. Also, the speed variance due to different radii was the highest and speed at curves with spiral was higher. At the end of the curve, speed started increasing again but not at the same rate, i.e. small radii curves had a higher acceleration rate. The

speed on sharp curves still lower than the speed on wide curves. Besides, the speed on curves with spiral still higher than the speed on the other curves without spiral. Finally, after 150 m of the curve’s end speed continues increasing at different rates, and the speed variance between curves with/without spiral became very insignificant.



**Figure 2.** Effect of Transition Curve Existence on Driver Speed for Different Curve Radii

On the other hand, the effect of the spiral curve at the first location was small but gradually started to be significant. Towards the end, the effect went back to be insignificant again. The spiral transition curve had a significant effect on speed reduction, especially in sharp curves. Speed reduction decreased from 31.7 to 28.9 km/h at the curve with 125m with a 9% improvement in speed reduction. At curves with a 200 m radius, the speed reduction decreased from 24.8 to 21.9 km/h with an 11% improvement in speed reduction. Curves with 400 m radius had the highest improvement in speed reduction with 18%, where the speed reduction decreased from 12.6 to 10.3 km/h. On the other hand, the spiral had a negative effect on speed reduction at curves with 800m by increasing speed reduction by 1 km/h. In conclusions spiral appearance had a noticed effect at sharp curves and a slight effect in wide curves. From the perspective of the studied locations, speed found, as shown in Figure 2. Curves with spiral effect had a higher speed than curves without spiral.

4.1.2. Effect of the spiral with changing curves’ radii on Lateral position

Drivers had a higher *lateral displacement* (LD) in sharp curves than wide curves. At approach tangent the lateral displacement the maximum value, where drivers prepared to enter the curve comfortably. LD relatively decreased at the circular curve. LD reached the lowest value at departure tangent. The spiral transition curve had a positive effect in decreasing the lateral displacement at approach tangent and curve but had a negative effect at the departure tangent as shown in Table 1.

**Table 1.** Effect of Changing Curve’s Radius on (*Average Absolute Lateral Displacement*) in (cm) and the (*Spiral effect in Lateral Displacement Reduction* in (%))

Radius (m)		Approach Tangent		Curve		Departure Tangent	
		without spiral	with spiral	without spiral	with spiral	without spiral	with spiral
125	AALD (cm)	48.60	45.35	42.41	40.97	27.04	34.99
	SELDR		-7%		-3%		29%

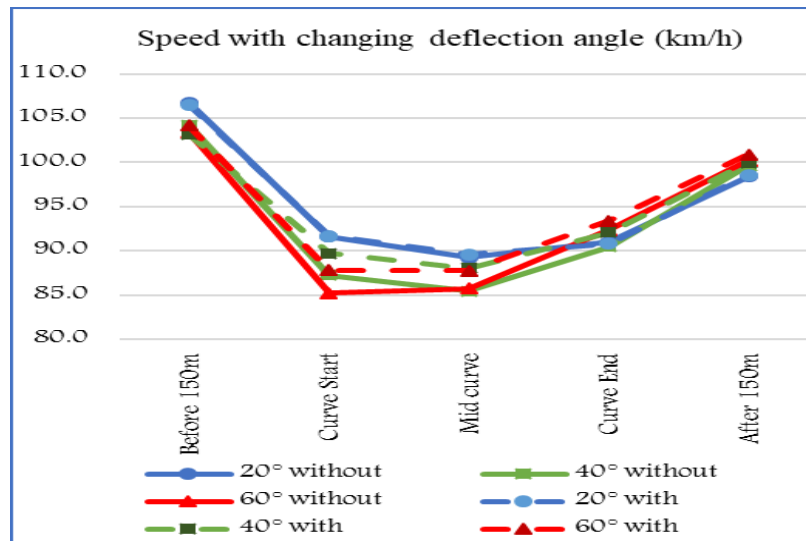
Radius (m)		Approach Tangent		Curve		Departure Tangent	
		without spiral	with spiral	without spiral	with spiral	without spiral	with spiral
	(%)						
200	AALD (cm)	49.81	47.37	32.52	30.38	28.33	30.95
	SELDR (%)		-5%		-7%		9%
400	AALD (cm)	35.65	33.85	31.95	29.90	26.21	29.39
	SELDR (%)		-5%		-6%		12%
800	AALD (cm)	32.57	29.68	25.58	25.24	23.91	24.84
	SELDR (%)		-9%		-1%		4%

#### 4.2. Effect of changing curves' deflection angle:

Deflection angles had a significant effect on drivers' speed, especially at the curve's start as shown in Figure 3. On the other hand, deflection angles did not affect AALD as shown in Table 2.

##### 4.2.1. Effect of the spiral with changing curves' deflection angles on speed:

At 150m before the curve's start, the speed for 20° deflection angle curves was the highest, and for 40° and 60° deflection angles were approximately the same. The effect of spiral curves before horizontal curves was impalpable for all different deflection angles. At the curve's start, the speed significantly decreased, the speed at curves with a 60° deflection angle was the lowest. The effect of the spiral was clear at 40° and 60° deflection angles but it was unnoticeable at a 20° deflection angle. It was also found that the lowest speed for 60° deflection angle curves occurred at the curve's start. In the middle of the curve, speed for 20° and 40° deflection angles reached the lowest, but in 60° deflection angle speed was backed to increase again. The effect of the spiral was clearer at 40° than 60° deflection angle, and still very slight in the 20° deflection angle. After that, the speed was backed to increase for all different deflection angles curves but at different rates. Acceleration varied from highest to lowest at 60°, 40°, and 20°, respectively. At the curve end, the effect of varied deflection angles going to disappear again. The effect of the spiral transition curve decreased at the curve end to be unnoticeable. At 150m after the curve, drivers on curves with a huge deflection angles were faster than those curves with a small deflection angle with a tiny difference, where no effect of the spiral for all curves there.



**Figure 3.** Effect of Transition Curve Existence on Driver Speed for Different Curve Deflection Angles

The spiral transition curve had a significant effect on speed reduction for curves with 40° and 60° deflection angles, but at 20° deflection angle curves spiral had a slight effect. Speed reduction decreased by less than 1 km/h for 20° deflection angle curves. While curve with a 40° deflection angle had the most significant effect of the spiral with a 19% improvement in speed reduction followed by a 10% improvement for 60° deflection angle curves. The speed reduction decreased from 18.7 to 15.1 km/h and from 18.2 to 16.4 km/h for curves with 40° and 60° deflection angles, respectively. Spiral transition had a noticeable effect in sharper deflection angles as shown in Figure 3.

4.2.2. Effect of the spiral with changing curves’ deflection angles on lateral position:

The spiral transition curve also had a positive effect in decreasing LD at approach tangent and curve, and negative effect at departure tangent as shown in Table 2. Sharper deflection angle had a significant SELDR at approach tangent, but middle def. angle was the most significant at the curve.

**Table 2.** Effect of Changing Curve’s Deflection Angle on (*Average Absolute Lateral Displacement*) in (cm) and the (*Spiral effect in Lateral Displacement Reduction* in (%))

Deflection Angle (°)		Approach Tangent		Curve		Departure Tangent	
		without spiral	with spiral	without spiral	with spiral	without spiral	with spiral
20 °	AALD (cm)	41.06	39.03	31.96	31.56	26.16	32.28
	SELDR (%)		-5%		-1%		23%
40 °	AALD (cm)	41.05	39.11	33.87	30.13	26.64	27.03
	SELDR (%)		-5%		-11%		1%
60 °	AALD (cm)	42.86	39.05	33.52	33.18	26.32	30.82
	SELDR (%)		-9%		-1%		17%



#### 4.3. Effect of changing curves' direction:

Curve direction had a slight effect on speed before and at curve entrance. On the other hand, the spiral transition curve appearance had a noticeable effect during a horizontal curve. Curve's direction had the most significant effect on drivers' LP as shown in figure 4 and Figure 4 shows a sample of the LP profile for a certain curve. Red profiles for left curves and green for right. Solid profile for curves without spiral and dotted for curves with spiral.

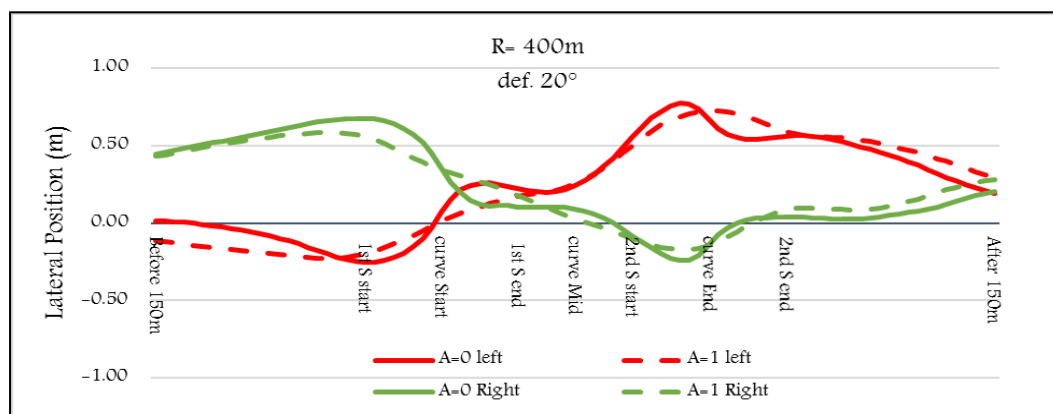
##### 4.3.1. Effect of the spiral with changing curves' direction on speed:

At 150 m before the curves, all curves –right/left and with/without spiral- had approximately the same speed. The effect of curve direction and spiral appearance was unnoticeable. At the curve's start, speed significantly decreased with the same deceleration rate in two directions. The speed on curves with spiral -Right/Left- was slightly higher than that on the curves without. Curve directions did not affect the speed at the curve's start. In the middle of the curve, speed on the right curves was higher than those of the left curves. The spiral still had a clear difference in speed in the two directions with the same effect. At the end of the curve, speed returned to increase again, but speed on the right curves was still higher than these left curves. The effect of the spiral curves on speed is going to disappear and direction effect going to increase. After 150 m of the curve end, the effect on the spiral disappeared but the effect of direction still appeared. Besides, the speed on the right curves was slightly higher.

Spiral had no effect on drivers' speed on approach and departure tangents. The effect of the spiral transition curve was significant along a horizontal curve. Spiral decreased the speed reduction from 19 to 16.5 km/h with a 13% improvement for left curves, while the speed reduction decreased from 17 to 15.9 km/h by 6% for the right curves.

##### 4.3.2. Effect of the spiral with changing curves' direction on lateral position:

Curve's direction had the most effectiveness of the drivers' LP as shown in Figure 5. At approach tangent, left curves had a small displacement with a negative effect of the spiral, i.e. spiral increased the lateral displacement. In right curves the LD was huge, and the effect of the spiral was significantly positive. Vice versa at curve, left curves had a large LD and right curves had a small LD. The SELDR was positive for both directions along curves. As usual spiral had a negative effect at departure tangent.



**Figure 4.** Lateral Position Profile in (m) for curves with 400 m radius and 20° deflection angle

**Table 3.** Effect of Changing Curve on (*Average Absolute Lateral Displacement*) in (cm) and the (*Spiral effect in Lateral Displacement Reduction* in (%))

Direction		Approach Tangent		Curve		Departure Tangent	
		without spiral	with spiral	without spiral	with spiral	without spiral	with spiral
Left	AALD (cm)	19.36	20.14	49.64	48.65	39.55	44.17
	SELDR (%)		4%		-2%		12%
Right	AALD (cm)	63.96	57.98	16.59	15.91	13.19	15.91
	SELDR (%)		-9%		-4%		21%

## 5. Conclusions

Studying drivers' behaviour by using a driving simulator had many advantages from different ways. Simulator providing a safe and controllable environment to study. Although the current research deals with driver's behavior in rural regions, simulator's software can be developed to cope with the urban driver interaction with the surrounding. In other words, traffic signals, pedestrian interaction, a temporary delay, traffic jam, variety in density and flow can be simulated and tested by drivers to find general trends in response and hence effect on safety can be evaluated. Researchers can use a simulator to study many alternatives to provide an adequate road design, which is one of the main factors affected by road safety. Improving highway consistency decrease an accidents rate, which leads to a decrease in CO<sub>2</sub> emissions resulted from vehicles stuck in accidents traffic jam. Besides, a simulator saves the emissions resulted from driving studying vehicles. In this study, seventy-two participants driving a simulator to study the effect of spiral transition curves on the two-lane rural highway on drivers' speed behavior. Drivers' behaviors were average speed at horizontal curves and speed reduction from tangent to curve. Continuous speed profiles were created for drivers at each tested roadway. A comparison conducted between curves with/without spiral to evaluate the role of a spiral transition curve on drivers' speed. Five specific locations along each tested curve was selected to compare the speed on curves with spirals to curves without spiral. Curve radius had the most significant effect on drivers' speed. Speed had a positive relationship with the curve radius. Deflection angles had a noticeable effect, especially at the curve's start. The direction of the curve did not affect drivers' speed until the middle of the curve. For all curves at every approach, it has been shown that the speed on curves with spiral was higher than curves without a spiral along the curve. Spiral also improved the speed reduction from tangent to the curve. The effect of spiral increased with decreasing curve radius and/or increasing deflection angles. Spiral approximately had no effect of large radius 800 m and small deflection angle 20°. At studying the drivers' lateral position, it was found that the curve radius had a significant effect with an inverse relationship between radius and lateral displacement. Lateral displacement was higher at approach tangent than curve. Deflection angles approximately did not affect drivers' LP. The most affected factor on LP was curve direction. After studying drivers' LP, it was found that all drivers followed correcting behavior to cross the curves. In conclusion, the spiral transition curve had a positive effect on decreasing speed reduction in addition to decreasing the lateral vehicle displacement. Consequently, the transitional curve has an indirect positive impact on the environment, as it allows drivers to maintain their speed in better manner, because the deceleration and acceleration of vehicles are among the most affecting fuel consumption. Also, reducing accidents leads to conserving natural resources that are used to remake the damaged parts. Regarding collecting overall digital response to this kind of research. It is believed that highway driving simulators can play a valuable rate of generating data. This can be analyzed properly and thus develop a sort of spatial

prediction of driver's response related to various regions. In other words, depending on certain region characteristics of highway alignments, a kind of spatial map response can be eventually developed.

## 6. Appendices

### Appendix A. Average Speed at 5 Studied Locations for All Curves

Radius (m)	Def. Angle (°)	150 m Before Curve Start				Curve Start				Curve Middle			
		Without		With		Without spiral		With spiral		Without spiral		With spiral	
		L	R	L	R	L	R	L	R	L	R	L	R
125	20	106.3	111.0	85.3	88.0	82.6	85.4	79.1	79.9	82.4	83.3	105.8	112.0
	40	104.1	102.8	77.3	72.9	70.3	67.7	76.3	72.7	79.6	77.1	101.2	98.8
	60	102.1	106.6	67.7	74.7	66.3	70.3	68.9	75.5	74.7	77.8	102.4	105.6
200	20	107.6	105.9	87.1	86.3	83.6	83.8	86.7	86.3	90.1	88.1	107.5	103.1
	40	104.4	102.6	80.5	82.7	75.8	79.5	81.6	81.4	86.0	84.2	102.6	102.9
	60	104.9	103.4	82.1	77.8	77.4	79.9	78.9	79.8	84.2	80.4	105.5	104.8
400	20	104.2	110.7	93.7	94.8	92.4	91.7	92.6	97.0	94.7	98.9	104.3	109.2
400	40	104.7	105.0	91.7	92.3	92.5	91.3	93.1	95.0	93.1	97.2	105.0	103.7
	60	103.0	101.4	92.6	92.5	93.9	91.6	96.1	90.8	94.6	92.3	104.1	100.2
800	20	104.3	104.0	99.9	97.9	99.1	95.3	101.3	93.7	101.0	94.9	107.4	102.9
	40	102.2	107.8	97.6	103.1	100.4	106.1	101.8	102.5	98.2	102.3	103.9	107.3
	60	103.2	102.7	98.6	95.7	105.3	101.5	109.6	102.2	102.7	96.0	108.6	102.1

Radius (m)	Def. Angle (°)	Curve End				150 m Before Curve Start			
		Without spiral		With spiral		Without spiral		With spiral	
		L	R	L	R	L	R	L	R
125	20	81.0	84.4	90.2	93.0	90.2	93.0	90.8	91.3
	40	72.3	70.7	88.5	88.0	88.5	88.0	88.5	89.0
	60	73.7	77.0	87.9	92.0	87.9	92.0	88.3	91.7
200	20	83.8	85.1	93.8	95.0	93.8	95.0	95.3	93.5
	40	80.4	84.5	93.3	95.6	93.3	95.6	95.4	96.4
	60	83.5	85.9	94.1	96.0	94.1	96.0	94.2	95.8
400	20	95.0	94.4	101.4	102.2	101.4	102.2	100.1	104.1
	40	98.2	96.7	104.3	101.8	104.3	101.8	104.2	102.7
	60	102.0	97.5	106.9	101.6	106.9	101.6	107.3	101.5
800	20	103.8	100.3	107.4	104.0	107.4	104.0	110.5	102.9
	40	108.5	112.6	110.1	115.0	110.1	115.0	110.7	112.7
	60	111.2	108.0	112.5	110.2	112.5	110.2	117.3	110.9

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