THINK INDIA JOURNAL

ISSN:0971-1260
Vol-22-Issue-34-December -2019

LATERAL DISPLACEMENT OF VEHICLES ON HORIZONTAL CURVES FOR SIX LANE NATIONAL HIGHWAY

Dhrubajyoti Majumdar*, Dr R L Sharma**

*Research scholar, Dept of civil engineering, LPU Phagwara, Punjab
**Professor, Dept of civil engineering, LPU Phagwara, Punjab

Abstract

As per IRC SP087 -2013, standard right of way i.e. minimum width for 6 lane national highways in plain areas is 60 meters. The ruling design speed, as per provisions contained in IRC 38 for plain terrain, is 100 kmph and minimum design speed is 80 kmph. The geometric design of horizontal curves on national highways involve, fixation of ruling gradient, super elevation, design speed, and a minimum level of comfort to be maintained. However, it has been observed that the design speed of the vehicle gets reduced on horizontal curves because of restriction in width or right of way. Many a times, it is not possible to maintain the desired design speed on such curves for a given level of comfort. Very few studies have been conducted to ascertain the effect of width on the speed of vehicles at horizontal curves for six lane national highways. This paper examines the relationship between speed and width of horizontal curves and effect of speed on the lateral shift of vehicles. This has been demonstrated by conducting a study at horizontal curve on six lane national highway near Jalandhar city. All the data recorded were compared with theoretical calculations.

***Keywords**: Horizontal curve, Radius of curvature, Right of way, Design speed, Lateral shift, Overturning*

1. Introduction

According to IS provisions and IRC specifications the Indian National Highways are to be constructed with maximum width restricted up to 3.5 m per lane and a clearance on side obtained 0.68 m. The other constraints that affect the performance of multi-lane highways on horizontal curves are radius of curvature, super elevation, speed of the vehicle, and visibility. The road geometrics are designed to provide optimum efficiency in traffic operations with adequate safety at reasonable cost. A horizontal curve is designed to provide change in direction to the centre line of the road. The minimum radius and super elevation depend on the permissible design speed for the curve. The horizontal curves used in the alignment of the six-lane national highway maybe simple, compound, reverse or transition curves. However, in this study simple circular curves are considered for study.

The design parameters for six-lane national highway recommended by national highway authority are as follows:

- Minimum width for 6 lane national highways in plain areas is 60 meters.
- The ruling design speed, 100 kmph and minimum design speed is 80 kmph.

- The geometric design of horizontal curves on national highways involve, fixation of ruling gradient, super elevation, design speed, and a minimum level of comfort to be maintained.

This study has been undertaken to study the existing horizontal curves provided on the NH 44 (from to). the main features of the curves such as road width, ruling gradients, radius of curvature, length of the curve and speed of the vehicles are studied. The curves parameters have been collected from the data provided by the site engineer verified by concerned authorities. These parameters have been studied and compared with IRC SP 087 provisions. Further the existing condition of the road marking, cross drainage, road stability and safety features have also been studied. The off-tracking of the vehicle has been computed and then verified by actual measurements at site.As per the studies there are several factors which affects the provisions of minimum roadway width and it has also been studied that the provided width is not sufficient sometime for a vehicle to negotiate the curved path with desired speed either we have to decelerate or lateral shift of wheel of vehicle takes place.

The main objective for this study is to find out the lateral movement with respect to longitudinal speed of vehicles in six lane curved national highway near Jalandhar city also the effect of radius of curvature on speed and comfort level.

Number of studies had been carried out in the past regarding the lateral behaviour of vehicles on multilane highways. Some literature studies have been described here.

Research indicates that lateral acceleration was an inverse function of speed in curves. No difference occurs for speed below 20 mph. A robust relationship exists for speed higher than 20 mph [1]. With the decrease in velocity there is higher lateral shift of vehicle towards the right side especially during nights [2]. Another research says there is no explicit relationship exists between speed and lateral shift. Although a new term comes into consideration known as Free Space Ratio (Rf) to depict the connection between the difference in placement and lateral movement [3]. The heavy vehicle lateral appropriation estimated and found the impact of lateral placement on pavement structure a shift factor is crafted to portray speed and rutting relationship [4]. Also, it was observed drivers alter speed in curves and with this most vehicle lateral acceleration decreases at higher speeds. The extreme values set of lateral acceleration in curves decreases quadratically with speed in accordance with the experimental information obtained from vehicle driven on track [5]. A clear drop-off in lateral acceleration has been observed while increasing the speed [6]. Under mixed traffic situation a vehicle may pursue a unimodal or bimodal curve depending upon the level of slow- and fast-moving vehicles [7]. However, variable such as curve direction and horizontal curve radius was found to possess the maximum association with the change in vehicle lane [8]. vehicle that negotiate with higher speeds has larger tendency to move out or off to lane [9]. Research on vehicle heading angle by using image-based processing clearly indicates with a higher speed vehicle tends to get off from trajectory [10]. Under mixed traffic conditions an opposite connection in between the lateral and longitudinal behaviour has been found [11]. While examining the effect of lane positions, there exists a wide variety in lane explicit vehicular speed, traffic, organizations, time, progress, and gap between lateral position [12].

From the literature reviews it has been observed that changes in lateral position of vehicles depends upon various traffic parameters, such as condition of road and other geometric features of the road. By indicating geometric features for the curved roads, the lateral placement of vehicle is majorly affected by the radius of curvature and the speed of vehicle.

ISSN:0971-1260
Vol-22-Issue-34-December -2019

Although for curved roads the relationship between the speed and lateral placement is important to understand but not well understood. Numerous studies have been conducted to find the lateral movements on curves. One aspect that is not well documented for curved road negotiation is relationship of speed and lateral position.This study is performed to understand the lateral movement of vehicle for a curved road by comparing the practical data collected from site with the theoretical values calculated.

2. Data collection

For collecting the data this study includes simple methods of spreading a measuring strip along the width. Strip is marked at 30 cm interval along width of the road with markers. Material used for measurement tape is anti-crack safety waterproof fibre 30 mm tape. There are specially two methods of data collection one by manual observing and taking data directly on the site another includes taking videos for every round of vehicle passing the measuring point. Three points on the curve were selected at same distance. Readings will be collected from those three points and recording setup units will be installed at the same point.
Analysis step will include the calculation part with the data collected from experimentation and parameters provided by the authorities. Computation of lateral shift or off tracking will be done with the help ofcircular motion theory for baked curves. The computed data will be then verified with the data collected from the experimentation carried out during this study.

2.1 Data collection protocol

Data is collected during morning hours as the traffic volume is lowest at that time and desired speed achieved at low volume of traffic conditions. Collection of data is performed by maintaining the vehicle for three different speeds at 80 kph, 90 kph, and 100 kph.To carry out the study, a banked horizontal curve is selected on the national highway near Jalandhar town as shown in Fig. 1. The salient features of the site are indicated in Table 1.

Table 1. Site characteristics and parameters

Pavement Type: Flexible	Shoulder: Un paved
Length of curved stretch: 450 m	Number of lanes: 6 (divided)
Radius of curvature: 237.34 m (Inner)	Width of each lane: 3.5 m
Advisory speed: 100 kph	

ISSN:0971-1260
Vol-22-Issue-34-December -2019

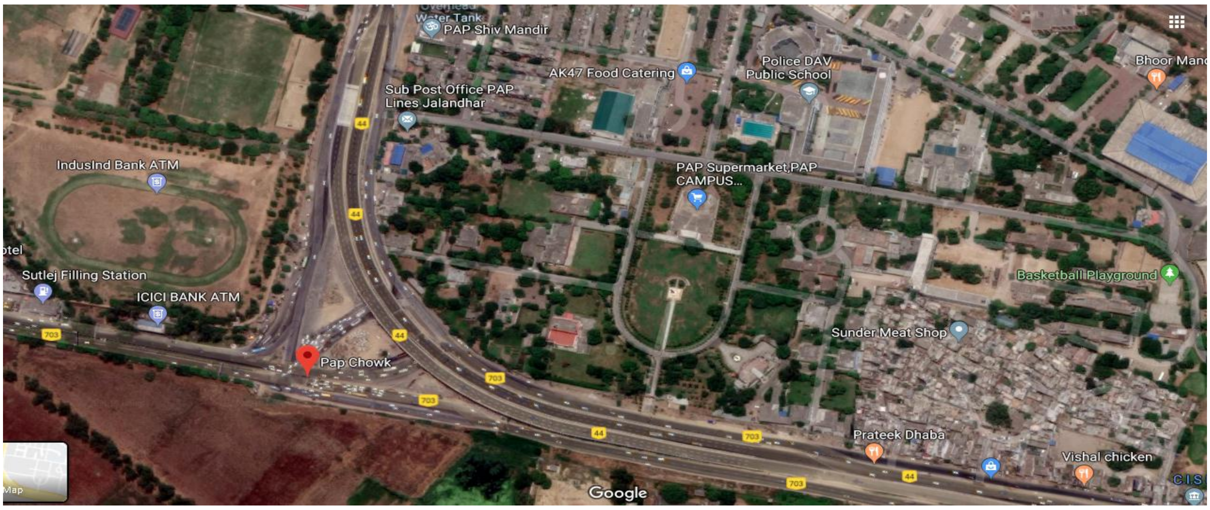


Fig 1: Site map of Flyover

All the data related to road were collected directly from the authorities at the site. The basic method for data collection from vehicle simulation was done by manual observation and videography method which helped to verify the shift of vehicle. The points from starting to end were selected at same interval and also equipped with recording units. The vehicle simulation was done for three time and shifts of vehicle from initial trajectory were being noted. The Driver was free from any influences and allowed to drive in free flow conditions.

3. Vehicular characteristics

Vehicle Make: Maruti Suzuki swift

Height of C.G from Ground	
Empty	0.682 m
With driver	0.774 m
With driver + Passengers	0.845 m
Car Height	1.53 m
Track length	1.48 m
Wheel base	2.42 m

4. Description of data and analysis

Data were collected for one direction at a time and for three different speeds. It is observed from the first point during data collection that the vehicle tires are moving towards the edge while it was entering the curve. From the second point the vehicle reaches the extreme edges of the lane and just after crossing the centre point it start moving towards the centre of the curve radius. This behaviour is found common for all three speeds. However, the values for lateral movement varies with speed.

4.1 Vehicle database descriptive statistics

Table 2: Lateral position of vehicle with different speed

ISSN:0971-1260
Vol-22-Issue-34-December -2019

Independent continuous variables	**Speed**					
	80 Kph		**90 kph**		**100 kph**	
	Inner	Outer	Inner	Outer	Inner	outer
Station A vehicle lateral distance	6.0	3.02	5.13	3.89	5.52	3.5
Station B vehicle lateral distance	7.0	2.02	6.23	2.79	6.87	2.15
Station C vehicle lateral distance	2.5	6.52	1.83	7.19	2.01	7.01

From the collected data it is observed that the values of lateral placement from inner edge keepincreasing at station B with the increase in speed but once after reaching B it starts getting low till the end C. However, the desired speed was able to maintain till the half of the curve length after that a deceleration has been seen. So, the vehicle entered with desired speed but to maintain comfort level and to avoid crashes speed reduction needs to be done. At the time when vehicle exiting the curve it again started acceleration. For the case of curve with smaller radius generally this behaviour doesn't follow.

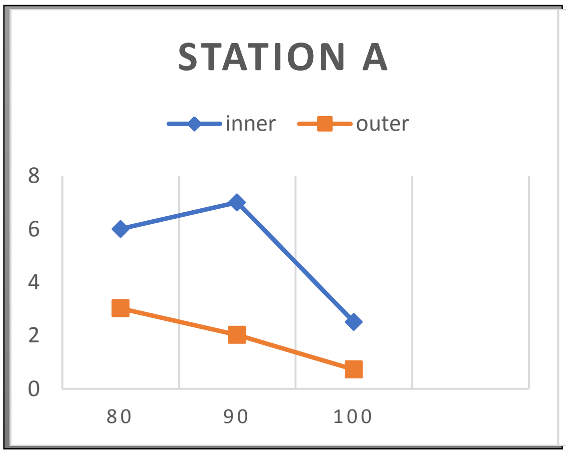


Chart 1: Data of station A

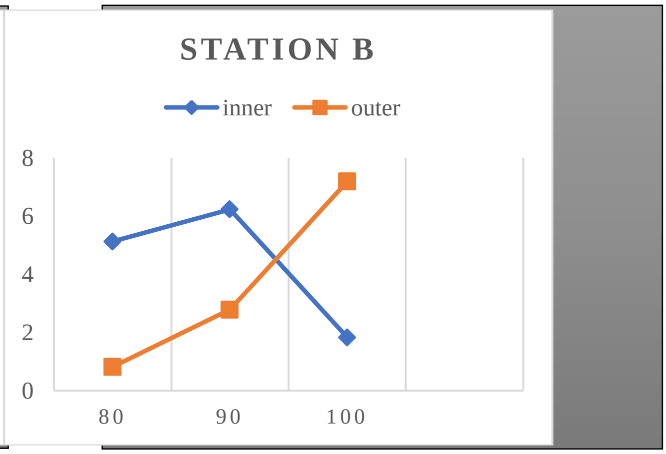
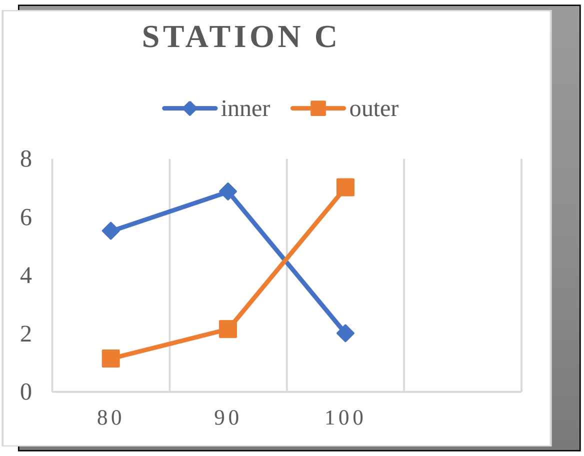


Chart 2: Data of station B



ISSN:0971-1260
Vol-22-Issue-34-December -2019

Chart 3: Data of station C

4.2 Placement of vehicle

As per the IS provisions, the ruling design speed and minimum design speed is limited up to 100 kmph and 80 kmph respectively. So, this study is performed with speed limit ranging from 80-100 kmph. Test simulation is performed in 3 different sets with different speed and it is observed that there is great difference between the distance of front wheel and edge of lane from station A to C.

Lateral acceleration of vehicle is somehow more complicated comparing to longitudinal acceleration because it happens in two-dimensional space rather than one dimensional space.Lateral acceleration around a curve is denoted by $a = \frac{v^2}{R}$ and the common unit for the same is 'g force'. Calculation of g's is done by dividing the acceleration by gravitational acceleration.

The lateral acceleration data given in Table 3 below.

Table 3: Lateral Acceleration vehicle due to centripetal acceleration

Speed (kmph)	Angular velocity (Va)	Force (f)	Lateral acceleration
80	0.8953 rpm	2041.6 N	2.0832 m/s^2
90	1.0073 rpm	2584.4 N	2.637 m/s^2
100	1.119 rpm	3189 N	3.254 m/s^2

5. Result and conclusion

This study summarizes the lateral placement study of vehicles in curved six lane national highway. Lateral placement of vehicle was collected from a single location with large radius of curvature near Jalandhar city. It was observed that while negotiating the curve the vehicle tends to move outwards the curve radius. After reaching the mid-section of the curve it starts moving towards the inner radius of the curve. However, in previous researches it is mentioned that vehicles show tendency of moving towards centre with the increase in radius. This trend is not observed during this study and from the field data, it can be concluded that the vehicle placement on curved roads varies with the radius of curvature.

ISSN:0971-1260
Vol-22-Issue-34-December -2019

6. References

1. Malcolm L. Ritchie, William K. McCoy, and William L. Welde, Study of the Relation between Forward velocity and Lateral Acceleration in Curves during Normal Driving. *Human Factors and Ergonomics Society Journal.* (1968).
2. Summala, H. and Merisalo, A. Measuring the Lateral Position of Vehicles on the Road-System and Preliminary Results. *Traffic Engineering and Control*, Vol.19, No. 7, pp. 328-330. 1978,
3. Miller, E. J. and Steuart, G. N. Vehicle Lateral Placements on Urban Roads. *Journal of Transportation Engineering*, ASCE, Vol.108, No.5, pp. 495–508, 1982.
4. Blab, R. and Litzka, J. Measurements of the Lateral Distribution of Heavy Vehicles and its Effects on the Design of Road Pavements. *Proceedings of the International Symposium on Heavy Vehicle Weights and Dimensions*, *Road Transport Technology, University of Michigan,* Ann Arbor, MI, pp. 389–395, 1995
5. Gilles Reymand and Andras Kemeny, Role of Lateral Acceleration in Curve Driving: Driver Model and experiments on Real Vehicle and Driving Simulator. *The Journal of the Human Factors and Ergonomics Society,*(2001).
6. Andrew MC Odhams and DSavid J Cole, Models of Driver Speed Choice in Curves. AVEC,(2004).
7. Dey, P.P., Chandra, S. and Gangopadhaya, S. Lateral Distribution of Mixed Traffic on Two-Lane Road. *Journal of Transportation Engineering, ASCE,* Vol. 132, No. 7, pp. 597-600,2006.
8. Brandon P. Stodart and Eric T. Donnell, Speed and Lateral Vehicle Position Models from Controlled Nighttime Driving Experiment, *Journal of Transportation Engineering*. Vol. 134, No.11,(2008).
9. Shauna Halmark, Relationship between Speed and Lateral Position on Curves. *Centre for Transportation Research and Education, Iowa State University,*(2009).
10. Jiann-Shiou Yang, Estimating of vehicle's Lateral Position via Lucas KanadeOpticle Flow Methods. *WSEAS Transaction on Systems.* Vol. 11. Issue 8,(2012).
11. G. Mahapatra, A.K. Maurya Study of vehicles lateral movement in non-lane discipline traffic stream on a straight road. *Procedia-Social and Behavioral Sciences*, 104, pp. 352-359,(2013).
12. G. Mahapatra, A.K. Maurya Study on lateral placement and speed of vehicles under mixed traffic condition. *Eastern Asia Society for Transportation Studies 2015 Conference, Cebu City*, 2015.

