Lateral Placement of Vehicles on Rural Roads

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The purpose of this paper is to present the results of various studies which have been made concerning lateral placement of vehicles on rural roads. The term "lateral placement," as it is used throughout this report, is construed to mean the position of the vehicle on the road in relation to either the right edge of the pavement or to the center-line of the road. Only two-lane roads will be considered in this report, unless otherwise specifically stated.

A thorough knowledge of the average lateral placement of vehicles is very important to the highway designer, and various studies have been made in an effort to obtain information in this field. From the standpoint of safety, we assume that the wider the pavement, within certain limits, the safer it should be; but from the standpoint of economics, it is not feasible to build highways beyond certain widths. Roads which are too narrow result in excessive maintenance of the shoulders and dangerously reduce the clearance distance of passing vehicles, and two-lane roads beyond certain widths are used as three-lane pavements by occasional drivers. Neither condition is to be desired. For these reasons, the determination of the proper width of pavement to be constructed for any particular situation has become a problem that the traffic engineer should solve.

Since 1920, there has been a steady increase of widths for newly constructed pavements. Simonson[1], in his paper, gave a diagram of this trend. In 1920, the two-lane highway was constructed with a 16-foot width. In 1925, the average width was 18 feet, increasing in 1930 to 20 feet. After 1930, differing opinions arose, with the result that in 1935, new pavements were from 22 to 24 feet in width. Since the war years, more careful consideration has been given to the proper width of roadway for any given situation, and no definite value can

[1] W. H. Simonson, "Why Roadside Development?", *Proceedings 32nd Annual Purdue Road School,* January, 1947.

be given for present new construction, because of the wide variation. The increase of widths in construction has come about from the acceptance of the fact that other factors in addition to vehicle width must be considered for proper design.

First to consider are the minimum standards specified by the Public Roads Administration. Hallett[2], in his paper before the Thirty-Second Annual Purdue Road School, gave these following P.R.A. minimum widths: Where traffic is less than 100 vehicles a day, 12-foot width is the minimum. Where traffic is from 100 to 400 vehicles a day, 20 feet is desired, but only 16 feet is required. For traffic of from 400 to 1,000 vehicles per day, 18 feet is specified and 20 feet at least is desired. State specifications must also be considered in design, and generally state requirements call for greater widths than are required by the Public Roads Administration.

The factors that influence the lateral positions of vehicles are numerous, and each must be recognized as it applies for any given condition, in order to reach a reasonable design width of pavement. These factors can be included in four general classifications: the traffic, the time of day, the driver, and the roadway.

The first classification, traffic, includes the volume, relative volume per lane, and the vehicle. Normann[3] has definitely determined that volume affects speeds, and Taragin[4] has shown that lateral placement of vehicles on the roads is influenced by volume. The term *volume,* as used here, is the number of vehicles per hour using the roadway. Taragin, taking over twenty-nine thousand readings on 18-foot pavements, showed that the distance between the left wheels and the center-line varied significantly with volume changes. At a volume of 200 vehicles per hour, the average distance of the left wheels from the center-line was 1.2 feet, while at the volume of 800 or more vehicles per hour, this average distance was increased to 1.7 feet, where it remained relatively constant. The same fact was proved again on 20-foot pavements, where, from more than sixty thousand readings, it was found that the average distance from the center-line of the left wheel varied from 1.7 feet for a volume of 200 vehicles an hour to 2.0 feet for 600 or more vehicles an hour. These results indicate that volume is one factor which influences the lateral position of the vehicle.

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[2] J. T. Hallett, "Design Standards for Federal Aid to Secondary Roads", *Proceedings 32nd Annual Purdue Road School,* January, 1946.

[3] O. K. Normann, "Highway Capacity," *Proceedings Highway Research Board,* Vol. 21, p. 379, 1941.

[4] A. Taragin, "Effect of Roadway Width on Traffic Operations—Two-Lane Roads", *Proceedings Highway Research Board,* Vol. 24, p. 292, 1944.

Another factor which influences lateral placement on two-lane roads is the relative amount of traffic in each direction. Meeting vehicles have a tendency to drive slightly farther from the pavement center-line than do free-moving vehicles. When the volume of traffic in one lane is significantly larger than the volume in the opposite lane, the traffic meeting the larger volume tends to move farther towards the outside edge of the pavement than when opposing an equal volume. It is also true that the traffic in the heavier volume will move towards the outside as the volume in that lane increases. Taragin shows this tendency in his report and Normann[5] states in his paper: ". . . it is also the rule rather than the exception that at least twice as many vehicles will be traveling in one direction as in the other on any highway, especially during periods in which the highest densities occur."

The third factor in this classification is the vehicle. Trucks and passenger cars vary considerably in body width and in tread width. Taragin used the average values of 6.0 feet for average car body width, 4.9 feet for average car tread width, 8.0 feet for average truck width, and 6.0 feet for average truck tread width. Trucks, because of the greater body width, would be expected to operate closer to the pavement edge than do the automobiles; and, without exception, Taragin's data show that the average distance for the right wheels of trucks from the edge of the pavement was less than the average distance for the right wheels of cars. The trucks must travel closer to the edge of the pavement if they are to obtain the same clearance distance with a meeting truck that is average between meeting passenger cars.

The second classification of factors is the time of day. In most studies for any given location, a variation in the lateral placement of vehicles is clearly shown between the averages of the night readings and the averages of the day readings. This difference is not great, but generally the distance of the right wheels from the pavement edge is slightly greater during the night hours than during the daytime. Since a large percentage of motor accidents occur during darkness, it seems logical for the traffic engineer to pay particular attention to night lateral placement study results.[6]

The third classification of factors influencing lateral placement is the driver. For most studies of lateral placement or speeds, the fact that people are different is acknowledged, but this factor is not usually given any consideration because it is assumed that the taking of

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[5] O. K. Normann, *loc. cit.*

[6] *Accident Facts,* National Safety Council, Inc., Chicago, Ill., 1946, p. 40.

numerous readings and the averaging of the values will cancel out the variation caused by this factor. For this reason, more than one car must be studied in determining the typical lateral placement for any given location. A factor involving the driver which might influence lateral placement and has not been adequately studied is the difference caused by the residence of the driver. From the data obtained by Taragin, a comparison may be made as to the effect of the driver's residence upon lateral placement. While no conclusions were made concerning exact differences, the evidence of data obtained in ten states shows indication that location of the driver's residence may possibly cause variation in the lateral placement of the vehicle.

The fourth classification of factors to be considered is listed under the heading of pavement. This category includes type of shoulder, width of shoulder, roadside obstacles, condition of pavement edge, condition and construction of pavement, weather as it pertains to surface conditions, and type of delineators. This particular classification will be of most interest to the traffic engineers.

First to consider is the width of shoulders. Taragin has considered varying widths in his study, and one of his conclusions is that shoulders more than four feet wide, when there are no vertical obstructions on the shoulders, do not cause any variation in the effective pavement width; however, there is no indication that shoulder widths of less than four feet have no effect on the effective width. It would be a rare circumstance which would necessitate shoulders less than four feet, but it is possible and should be considered when studying the factors affecting lateral placement.

The type of shoulder has a far more marked effect. Taragin concluded that grass and gravel shoulders have the same effect upon lateral placement, provided that both are well-maintained, but no comparison was made between the effect of well-maintained and poorly maintained shoulders. Bituminous-treated shoulders four feet or more in width increased the effective width approximately two feet for 18-foot and 20-foot pavements during daylight and slightly less at night. It was found that four percent of commercial vehicles on 18-foot pavements do encroach upon grass or gravel shoulders and that 15 percent encroach upon bituminous shoulders. This shows that commercial vehicles make use of shoulders a significant amount. On narrower two-lane roads, trucks operate very close to the pavement edge, and it is not uncommon on 18-foot roadways to see a truck leave the pavement and drive for a short distance with the right wheels on the shoulder. Over a very short period of time, this use of the shoulder, especially in wet weather, can turn the grass or gravel area into an area of ruts and mud. The result of this is that continual repair, which may involve blading and rolling as well as reseeding, must be made to the shoulders. During dry weather, use of the shoulders by rapidly-traveling vehicles causes the soil to be worn away from the pavement edge and causes a serious hazard to safety.

Obstacles on the shoulders such as signs, guardrails, headwalls, and posts have a marked effect upon lateral placement. No investigations have been reported which have studied this factor, but consideration should be made of this factor by maintenance or traffic engineers when installing markings or signs.

Tied in with shoulder type is the factor of pavement edge. Knowing that vehicles will make use of the shoulders, it is necessary that the pavement edges be maintained. From the standpoint of effect to lateral placement, the condition of the pavement edge will influence the effective width. Where the shoulders have been worn away from the pavement level or where raveling, as on some bituminous roads, has caused irregular edges, vehicles tend to operate closer to the center of the highway than they do on highways having regular pavement edges which blend into the shoulders. Lip curbs on the pavement edge also affect the effective width and Taragin learned that in daylight on a 20-foot pavement, the effective width was reduced approximately one foot by the use of lip curbs; but at night this influence was only shown by the commercial vehicles.

Condition of pavement and construction are very important factors. They include partially some of the other factors already mentioned. A pavement without longitudinal cracks or joints has less guiding influence than a road which has distinct cracks or joints. The width of the pavement has a marked effect upon the location of the vehicle with respect to the roadway edge. Taragin found in his study that on 18-foot pavements with grass or gravel shoulders, 11 percent of the commercial vehicle operators and 5 percent of the passenger car drivers failed to keep their vehicles in their own lanes. In all his data, with due consideration to the other factors, the average clearance between vehicles increased as the width of the pavement increased. For grass and gravel shoulders during daylight, the average clearance between vehicles was 3.2 feet for 18-foot roads, 4.0-4.2 feet for 20-foot roads, 4.8 feet for 22-foot roads, and 5.2 feet for 24-foot roads. His conclusions were that hazardous conditions exist for even moderate mixed traffic on pavements of less than 22 feet, but that 24-foot pavements are required to give desired clearances between commercial vehicles.

The effect of widening strips upon lateral placement as yet has not been definitely determined, but Green[7] made some experimental studies in this field. It is believed that although little actual use is made of the strips in carrying passenger traffic, the tendency is for all vehicles to travel closer to the original pavement edge, thus increasing the average clearance distance. Green reported that the addition of a 2½-foot concrete widening strip to each side of an 18-foot pavement caused an increase in the average clearance of 0.4 foot for passenger cars and 0.8 foot for trucks. At the present time, a project is under way within the Joint Highway Research Project at Purdue to determine the actual effects caused by widening strips. It is hoped that this study will prove the value of widening strips on narrow roads carrying heavy volumes of mixed traffic.

Weather, as it affects lateral placement, is most evident when the pavement is affected. Snow on shoulders cuts down average clearance because traffic shies from the covered area; and on wet pavements, center clearances are believed to be slightly greater, especially on bituminous highways, because sliding is more easily possible. The factor of weather cannot be controlled, and no definite knowledge has been obtained yet concerning the actual effect of this factor upon placement.

The last factor to be considered in this field of lateral placement is the type of delineators used. A delineator is any stripe or marker which lines traffic. Most concrete roads have a center longitudinal joint, and this joint serves to act as a center-line. Center-lines of all types have been shown to actually help keep vehicles in their correct lane. Painted center-lines have become almost universal and are very useful in channeling traffic. The most common type is either the white-painted line on a black surface or the black-painted line on a light surface. Yellow lines are used extensively to indicate no-passing zones and have been quite effective. Reflectorized center-lines have been shown to be more effective, especially at night, for channelization of the traffic than the plain painted stripe. Quimby[8] has made a study of types of delineators at the approach to a narrow bridge. He learned that with other variables remaining constant, the reflectorized center-line held traffic in its proper lane farther in the approach than did the conventional black-painted line. Oversize center-lines, some as wide as 2 feet, are now being used in experimental areas in an effort

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[7] F. H. Green, "Method of Recording Lateral Placement of Vehicles," *Proceedings Highway Research Board,* Vol. 26, 1946.

[8] W. S. Quimby, "Traffic Pattern at a Narrow Bridge," *Proceedings Highway Research Board,* Vol. 27, 1947.

to find the most effective method of obtaining adequate clearance distances and to channelize traffic. Successful use of corrugated white concrete traffic markers has been reported by the New Jersey State Highway Department[9], especially on multi-lane roads. This type of delineator might be used successfully on a two-lane pavement, especially in new construction. The method involves the pouring of a thin, wide, white concrete center-line and corrugating the concrete during the finishing process. The stripe is made flush with the pavement and presents no obstacle to crossing in passing movements. Double-painted white and black lines, and reflectorized-button center-lines have been used successfully in many instances. It may be concluded that delineators of all types aid in channelization of traffic, thus favorably affecting lateral placement, and causing an increase in the average clearance distance.

A factor frequently considered in lateral placement studies is speed. Quimby, from all data obtained for his report, showed a coefficient of correlation of -0.02, actually no correlation, between speed and lateral placement. Taragin stated that no definite relationship could be found between speed and lateral placement.

Based upon the information here presented, the following are some of the more important conclusions:

1. Volume of traffic and direction of travel greatly affect lateral placement. Increasing volumes from 200 vehicles per hour up to 800 vehicles per hour on 18-foot pavement increased the distance from the center-line by 0.5 foot. Change of volume from 200 vehicles per hour to 600 vehicles per hour on 20-foot pavement caused an increase in the distance from the center-line of 0.3 foot.

2. The critical condition of average clearances occurs when trucks meet trucks, and the relative amount of commercial traffic to use the pavement should be considered in the design.

3. Night-driving tendencies should be given more consideration than day studies of placement, because accident records show higher percentages of accidents at night for less volumes of traffic.

4. Shoulder widths increasing beyond four feet do not affect vehicle position.

5. Grass and gravel shoulders affect lateral vehicle position similarly, but a bituminous shoulder four feet or more in width along an 18-foot or 20-foot pavement increases the effective pavement width by about two feet.

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[9] "Reflector-Type Lane Dividers Effectively Channelize Highway Traffic," *Civil Engineering,* Vol. 18, No. 1, January, 1948.

6. Use of shoulders by vehicles increases as the width of pavement decreases, and bituminous shoulders are used much more than are gravel or grass shoulders by the traffic.

7. The effect on lateral placement by vertical roadside obstacles should be considered before signs, guardrails, or other roadside additions are installed.

8. Maintenance of pavement edge is necessary if maximum effective width is to be obtained. Lip curbs reduce effective width during the daytime about one foot on a 20-foot pavement, but at night affect only the placement of commercial vehicles.

9. Width of the original pavement affects greatly the lateral vehicle position. Increased widths give increased center clearance and increased pavement-edge clearance. Widths of pavement less than 22 feet are considered hazardous for even moderate volumes of mixed traffic, and 24 feet is strongly recommended for highways carrying moderate or heavy volumes of commercial traffic. A width is assumed to be adequate if vehicles, when meeting other vehicles, travel in the center of their respective lanes.

10. The value of widening strips has not been definitely ascertained, but it is believed that their use results in both increased center clearance and increased pavement-edge clearance.

11. The use of center-line delineators is very useful in channelizing traffic.

12. Speed does not generally correlate with lateral placement.