Lateral Vehicle Placement as Affected by Shoulder Design on Rural Idaho Highways

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During 1957, 1958, and 1959, lateral placement observations were made by the Idaho Department of Highways on bituminous-paved 2- and 4-lane rural highways having different shoulder designs. Placement data were recorded for 7,777 free-moving passenger and commercial vehicles at eight locations throughout Idaho. The study was made to evaluate the influence of shoulder design on vehicle placement. Before-and-after data were recorded to measure the effect of shoulder striping and contrasting shoulders. Effects from other factors have been kept to a minimum by rational selection of study locations. Lateral placement on the roadway was recorded from visual observations of the vehicle in relation to 1-ft markings on the pavement.

• MANY RURAL HIGHWAYS in Idaho have been constructed with full base and pavement thickness carried out to the outside edge of the shoulders. No pavement contrast, difference in surface texture, or increase in shoulder slope is provided to differentiate between the shoulders and the travel way. Two-lane rural highways, having standard total cross-section widths of 28, 34, and 40 ft, are normally constructed in this manner, as well as some 4-lane, divided sections of Interstate highways in Idaho.

There is a tendency for traffic on these sections to encroach on the shoulders, and a wide difference of opinion exists as to the desirability of this type of operation. (The term *shoulder* refers to the portion of the roadway beyond 12 ft from roadway centerline, even in the case without shoulder designation.)

Proponents of this design state that the sections without defined shoulders promote less restricted traffic operation with greater opportunity for passing.

The contrary arguments are that traffic should be restricted to the travel lanes to keep the shoulders reserved for emergency use. Furthermore, as traffic volumes increase and become more complex, additional controls such as shoulder definition are necessary to obtain orderly and safe flow characteristics.

It was felt that a more solid foundation of facts was needed before this type of design could be analyzed further. For this reason, the Traffic Section of the Idaho Department of Highways decided to make a study of lateral vehicle placement.

Previously, extensive lateral placement studies were made by the Bureau of Public Roads and the State highway departments of Arizona, California, Colorado, Idaho, New Mexico, Oregon, Texas, Utah, and Washington in 1955. The data were summarized and reported by Taragin (HRB Bull. 170, pp. 54-76; 1958).

This report contains valuable information and has been of help in planning the work of the Highway Department. However, because information was desired pertaining to specific sections of Idaho highways, it was decided to undertake additional studies.

In planning this study, it was decided that placement information should be obtained on the controversial sections. This would then give data on shoulder encroachment also. Further, it was important to measure the effect on lateral placement of different shoulder defining means, such as shoulder striping and shoulder contrast. It was felt that this could best be done by collecting before-and-after data. Observations were made prior to installation of shoulder stripes and again after they had been installed. This before-and-after procedure was used whenever possible.

Because no information was available regarding travel path pattern on 4-lane Interstate sections, such sections were also studied. Altogether 7,777 single observations were made at eight rural locations.

Table 1 gives the number and type of observations at each study location.

CLASSIFICATION OF DATA

For the purpose of this study the term *free-moving vehicles* applies to vehicles that passed the study site when there was no opposing traffic in the adjacent lane or no vehicles following closely behind. These vehicles were considered uninfluenced by other traffic as to their choice of lateral position on the roadway. After a briefing of the observers to assure consistency in their judgment, it was left to them to estimate when a free-moving condition existed.

To compare the lateral placement patterns for different vehicle types, the vehicles observed were separated into two main groups. At some study locations, these groups were divided into two secondary groups.

1. *Passenger vehicles.* This classification included passenger cars, pickups, panels, and other automobiles having comparable size and operating characteristics.
   a. Local passenger vehicles. This group included all passenger vehicles carrying Idaho license plates.
   b. Foreign passenger vehicles. This group included all passenger vehicles with license plates from other States or countries.
2. *Commercial vehicles.* This classification included trucks, buses, and all vehicles with dual wheels.
   a. Single-unit trucks.
   b. Semi-unit trucks.

RECORDING PROCEDURES

Visual observations of the lateral position of the vehicles in relation to

TABLE 1
NUMBER AND TYPE OF OBSERVATIONS

Study Location No.	No. of Lanes	Passenger Vehicles		Commercial Vehicles		Total Vehicles
		Before	After	Before	After	
1	2	985	446	213	96	1,740
2	2	365	—	87	—	452
3	2	409	174	75	62	720
4	2	439	146	82	31	698
5	2	350	107	75	22	554
6	4	819	—	260	—	1,079
7	4	—	1,328	—	369	1,697
8	4	641	—	196	—	837
Total						7,777

markings on the pavement were recorded for this study. The markings consisted of 1-ft long and 1-in. wide pieces of tape nailed to the pavement at 1-ft intervals measured from the roadway centerline. Every 5-ft mark was indicated with a contrasting color. By watching the center of the right front wheel of the approaching vehicles, the observers were then able to determine the vehicle placement. The observers were located outside the shoulder approximately 120 ft beyond the markings, depending on field conditions at the study location. The observer was concealed as much as possible from the vehicle operators normal line of vision, so as not to disturb the normal lateral placement pattern.

CHARACTERISTICS OF STUDY LOCATIONS

Previous studies have indicated that lateral placement is affected by interaction of many factors. Some of these factors (such as operating speeds, vehicle dimensions, and traffic volumes) can be related to the driver and his vehicle. Other factors (such as grade and curvature, shoulder treatment and width, striping, curb and gutter characteristics, roadside conditions, and illumination) are related to the condition of the highway facilities.

Because the purpose of this study was to examine the influence of some of these factors on vehicle lateral placement, effort was made to eliminate the effect of unwanted factors through rational selection of study locations. The study sites were located as far as practical on straight and level sections away from intersections, bridges, and other lateral restrictions. All sections studied were located in rural areas having no influence from roadside development. No pedestrian traffic existed at or near the study sites. All observations were made during daylight hours. Posted speeds at all study locations were 60 mph during daylight hours. A summary of study location characteristics is given in Tables 2 and 3.

Study Location 1

Observations at this location were made on US 20-26 (Mile Post 46.6) between Star Junction and Eagle Junction. This is a 2-lane section having 12-ft travel lanes with 8-ft shoulders. The roadway surface consisted of a bituminous plant mix pavement continuous across the travel lanes and the shoulders. Placement data were initially recorded August 27, 1957 (Fig. 1) Further data were taken on July 14, 1958, after the installation of a solid, white, reflectorized, 2-in. wide shoulder stripe 17.0 ft from the roadway centerline (Fig. 2). The 1958 ADT for this section was 4,200 vehicles.

Study Location 2

This 2-lane section having 12-ft travel lanes with 8-ft shoulders is on US 20-26 (Mile Post 41.8) between Star Junction and Caldwell. Some surface color and texture contrast between the travel way and the shoulders existed at this location. The travel way was surfaced with a bituminous plant mix pavement, and a bituminous surface treatment had been applied to the shoulders. There was no shoulder stripe installed. Observations were made September 12, 1957 (Fig. 3). The recorded 1958 ADT for this section was 4,200 vehicles.

Study Location 3

These data were recorded on Idaho 15 (Mile Post 64.5) south of Cascade. This is a 2-lane section consisting of 12-ft travel lanes with 5-ft shoulders. A bituminous plant mix pavement continuous across the travel lanes and

TABLE 2

CLASSIFICATION OF TWO-LANE STUDY LOCATIONS

Study Location No.	Fig. No.	Study Location	ADT 1958 (vehicles)	Date of Study		Traffic Lanes		Shoulders			Shoulder Stripe Location	
				Before	After	Width (ft)	Surface	Width (ft)	Surface	Contrast	Before	After
1	1, 2	US 20-26 M.P. 46.6	4,200	8-27-57	7-14-58	12	Bit. plant mix	8	Bit. plant mix	None	None	17 ft from centerline
2	3	US 20-26 M.P. 41.8	4,200	9-12-57		12	Bit. plant mix	8	Bit. surface treatment	Some surface and texture contrast	None	None
3	4	SH 15 M.P. 64.5	850	8-29-57 9-5-57	10-10-57	12	Bit. plant mix	5	Bit. plant mix	None	None	15 ft from centerline
4	5	SH 72 M.P. 41.5	1,850	9-13-57	7-15-58	12	Bit. plant mix	4	2-ft bit. plant mix and 2 ft of gravel	Contrast between gravel and plant mix	None	13.5 ft from centerline
5	6, 7	US 30 M.P. 28.3	3,000	9-4-57	7-14-58	12	Bit. plant mix	3	gravel	Contrast	None	11.5 ft from centerline

TABLE 3

CLASSIFICATION OF FOUR-LANE INTERSTATE STUDY LOCATIONS

Study Location No.	Fig. No.	Study Location	ADT 1959 (vehicles)	Date of Study	Traffic Lanes		Shoulders				Median (ft depressed)	Other Characteristics
					Width (ft)	Surface	Width (ft)		Surface	Contrast		
							Right	Left				
6	8	I-80N Station: 1855+00	4,200	9-17-59 9-23-59	12	Light chip seal	10	4	Bit. plant mix	Color and surface texture contrast	78	
7	9, 10	I-80N Station: 1809+00	4,200	10-30-59 11-18-59 12-14-59	12	Light chip seal	10	4	Bit. plant mix	Color and surface texture contrast	78	After installation of sign: Do Not Travel on Paved Shoulder
8	11	I-15W Station: 1033+00	3,600	10-7-59 10-8-59	12	5/8-in. chip seal	10	4	5/8-in. chip seal	None	78	

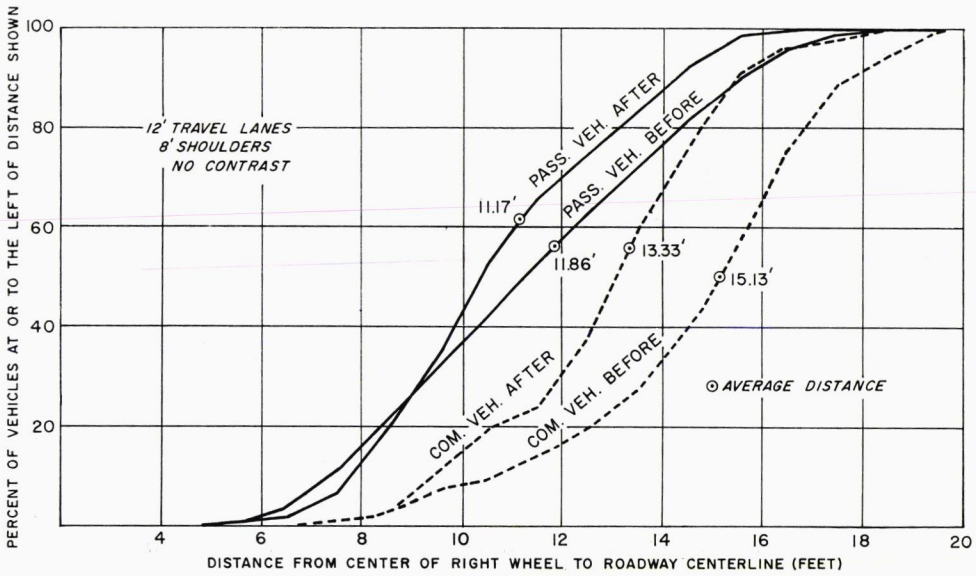

Figure 1. Position of free-moving vehicles before and after installation of shoulder stripes at Study Location 1.

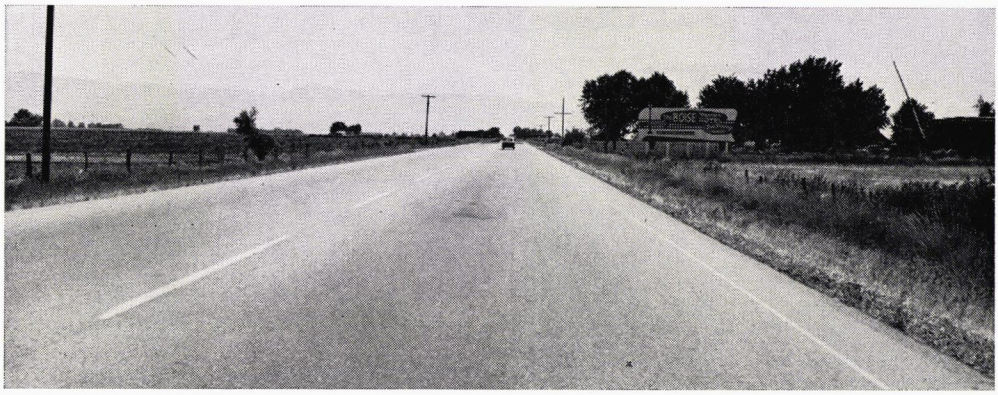

Figure 2. Study Location 1.

the shoulders provided no shoulder contrast. Before data were recorded August 29 and September 5, 1957 (Fig. 4). After data were recorded October 10, 1957 after the installation of a 2-in., solid, reflectorized, white shoulder stripe located 15.0 ft from the roadway centerline. The recorded 1958 ADT for this section was 850 vehicles.

Study Location 4

This study site was located on Idaho 72 (Mile Post 41.5) between Karcher Junction and Marsing. This is a 2-lane section having 12-ft lanes and 4-ft shoulders. The pavement on the travel lanes was a bituminous plant mix type. The 4.0-ft wide shoulder consisted of 2.0 ft of bituminous plant

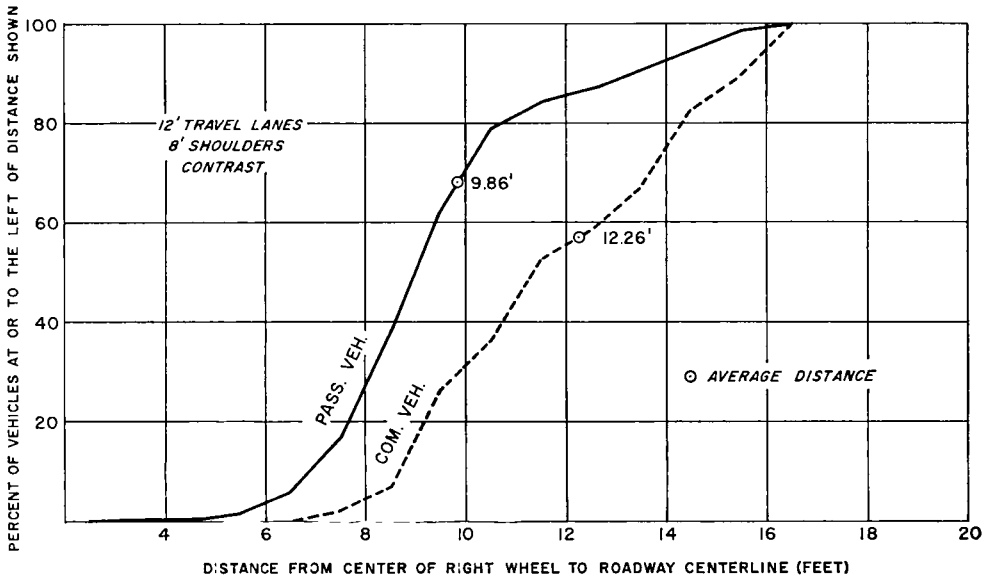

Figure 3. Position of free-moving vehicles at Study Location 2.

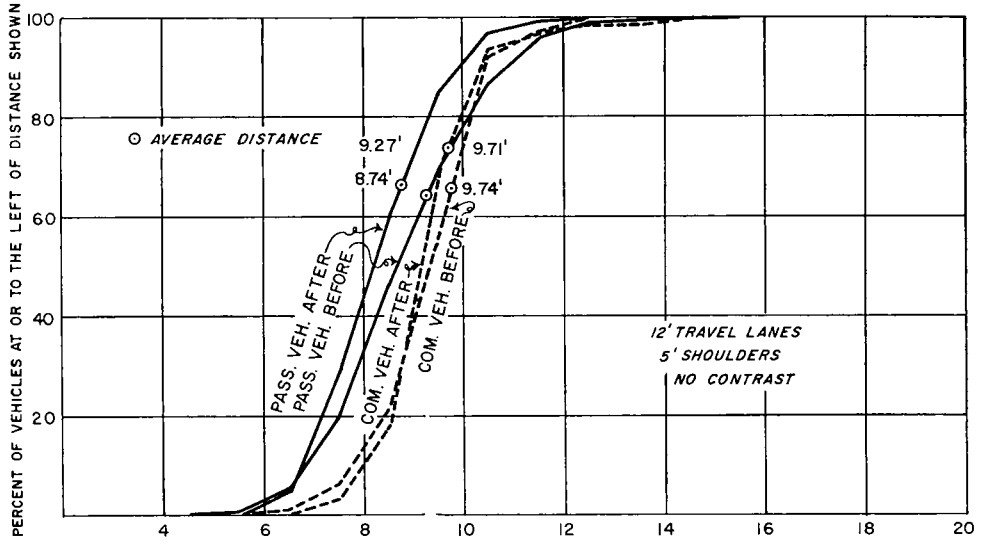

Figure 4. Position of free-moving vehicles before and after installation of shoulder stripes at Study Location 3.

mix and 2.0 ft of gravel, thereby providing a texture and color contrast between the outer 2.0 ft of the shoulder and the rest of the cross-section. Before observations were taken September 13, 1957 (Fig. 5). Later a 2-in., solid, reflectorized, white shoulder stripe was installed 13.5 ft from the roadway centerline, and after data recorded July 15, 1958. The recorded

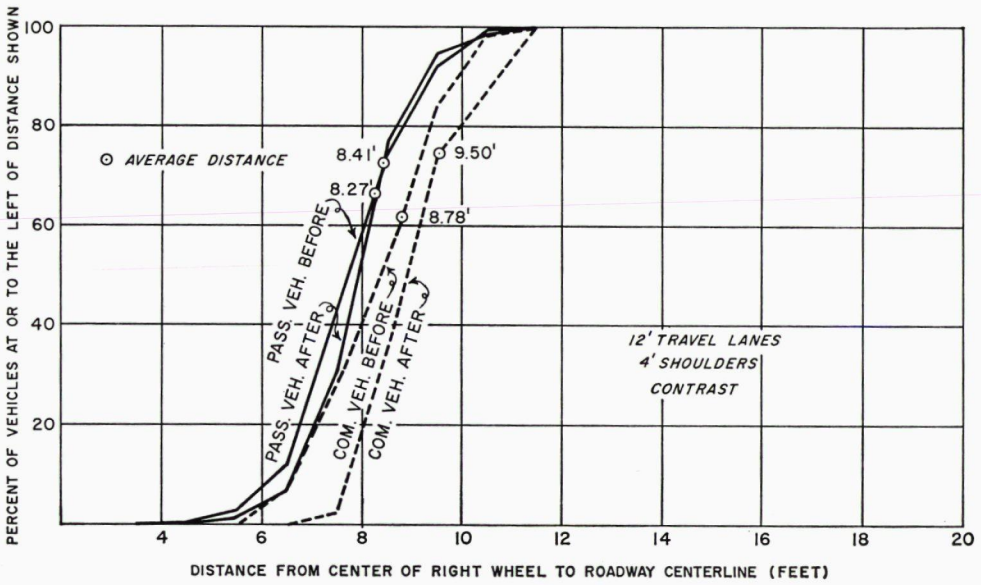

Figure 5. Position of free-moving vehicles before and after installation of shoulder stripes at Study Location 4.

1958 ADT for this section was 1,850 vehicles.

Study Location 5

Observations were also made on US 30 (Mile Post 28.3) between the Idaho 44 Junction and Sand Hollow Creek. This is a 2-lane section with 12-ft lanes and 3-ft shoulders. Shoulder contrast through the use of bituminous plant mix travel lanes and gravel shoulders was very noticeable (Fig. 6). Initial observations were made September 4, 1957 (Fig. 7). Data were also recorded July 15, 1958, after the application of a 2-in., solid, reflectorized, white shoulder stripe

Figure 6. Study Location 5.

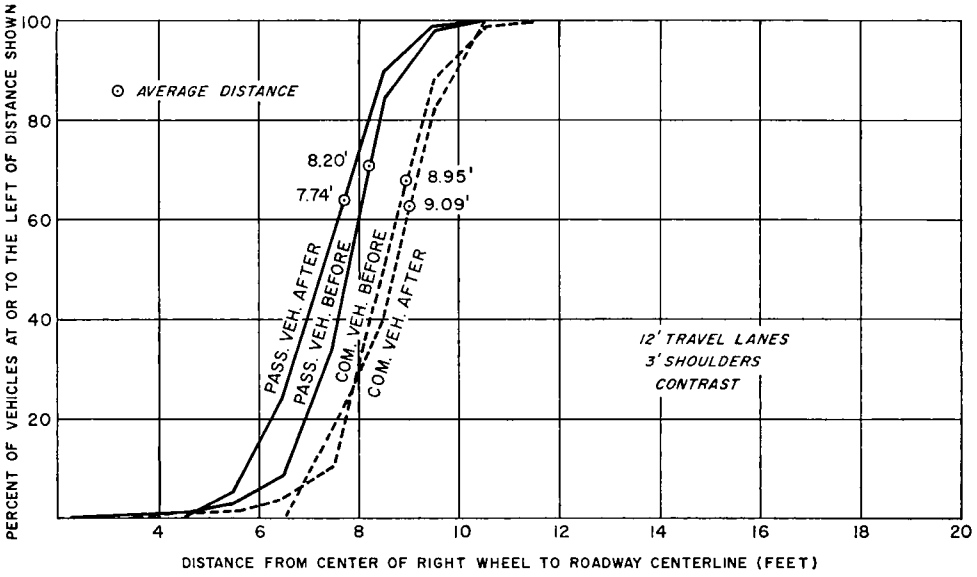

Figure 7. Position of free-moving vehicles before and after installation of shoulder stripes at Study Location 5.

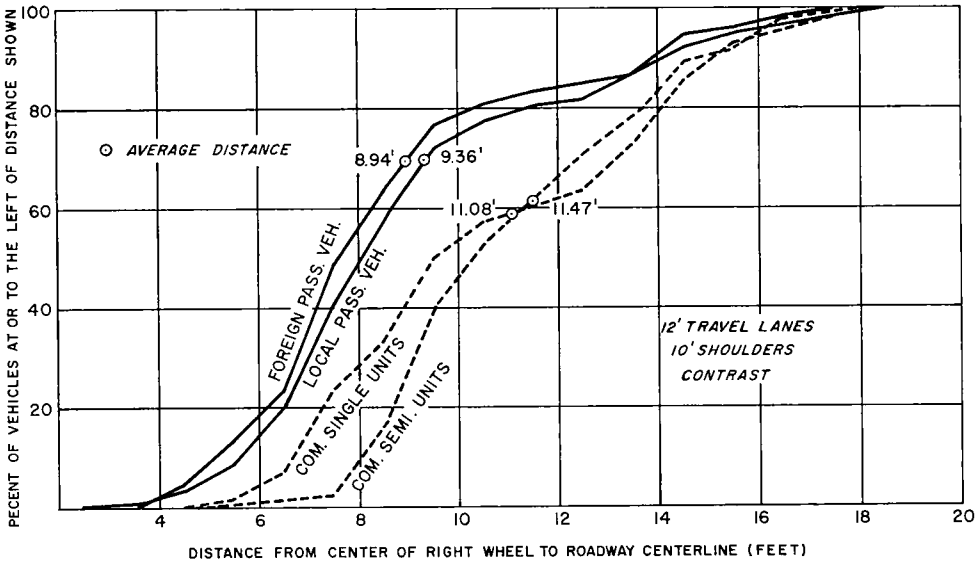

Figure 8. Position of free-moving vehicles before installation of signs at Study Location 6.

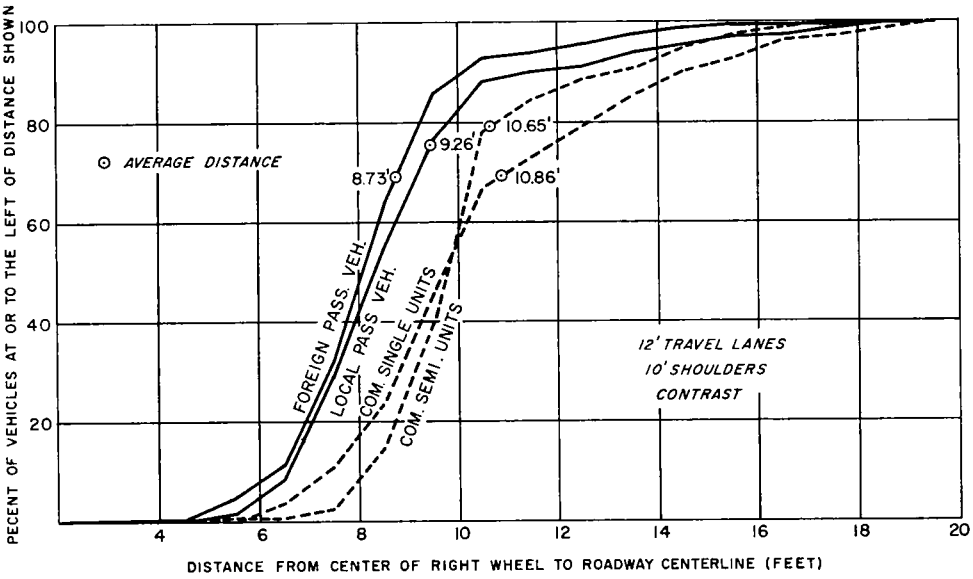

Figure 9. Position of free-moving vehicles two days after installation of sign at Study Location 7.

located 11.5 ft from the roadway centerline. The recorded 1958 ADT was 3,000 vehicles for this section.

Study Location 6

Observations were also made on Interstate 80N (Station 1855+00) west of Mountain Home. This is a 4-lane section having a 78-ft depressed median, 12-ft travel lanes, 10-ft outside shoulders, and 4-ft inside shoulders. The travel lanes were surfaced with a ⅝-in. chip seal and the shoulders were of bituminous plant mix, thereby providing some color and texture contrast between the shoulders and travel lanes. The two travel lanes serving one direction of traffic were separated by a 4-in., white, reflectorized, broken lane stripe (Fig. 8). No shoulder stripes were applied. The recorded 1959 ADT was 4,200 vehicles.

Study Location 7

This study site was also on Interstate 80N at approximately the same location (Mile Post 1809+00) as Study Location 6. This location, therefore, has the same characteristics as Study Location 6. Observations were made at it October 30, 1959, two days after installation of signs reading "Do Not Travel On Paved Shoulder" (Fig. 9). The signs, measuring 3.0 by 4.0 ft were installed at approximate 2-mi intervals, 8.0 ft outside the right-hand shoulder.

Data were also recorded at this location November 18, 1959, three weeks after the installation of the signs and on December 14, 1959, seven weeks after installation of the signs (Fig. 10). Because no significant difference was noticed between these recordings, the observations are shown combined in Figure 9.

Study Location 8

Observations were also made on Interstate 15W (Station 1033+00) located adjacent to the community of American Falls. This is also a 4-lane Interstate section having a 78-ft de-

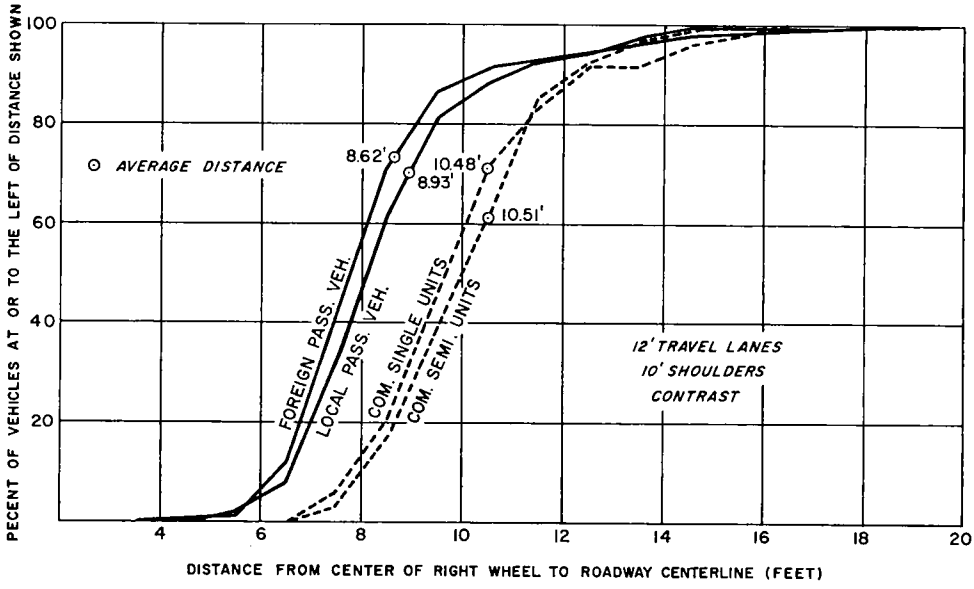

Figure 10. Position of free-moving vehicles three to seven weeks after installation of signs at Study Location 7.

pressed median, 12-ft travel lanes, 10-ft outside shoulders, and 4-ft inside shoulders. A $\frac{5}{8}$-in. chip seal had been placed covering both travel lanes and shoulders leaving no shoulder contrast. The two travel lanes serving one direction of traffic were separated with a 4-in., white, reflectorized, broken lane line. There were no lines to mark the shoulders. The observations were made October 7 and 8, 1959 (Fig. 11). The recorded 1959 ADT was 3,600 vehicles.

LATERAL PLACEMENT

Shoulder Width

Comparison of traffic on a section having 8-ft shoulders with no shoulder contrast or striping (Study Location 1) with traffic on a section having 5-ft shoulders also with no contrast or striping (Study Location 3) shows a difference in lateral vehicle placement. The average passenger vehicle placement distance from the centerline was 11.86 ft on the section having 8-ft shoulders and 9.27 ft on the section having 5-ft shoulders. This comparison shows an average placement shift towards the center of the roadway of 2.59 ft for a difference in shoulder width of 3.00 ft. At the same time the average commercial vehicle placement shifted from 15.13 ft on the section having 8-ft shoulders to 9.74 ft on the section having 5-ft shoulders, a distance of 5.39 ft.

A comparison of average vehicle placement on the section having 4-ft shoulders (Study Location 4) to the section with 5-ft shoulders (Study Location 3) shows that the average passenger vehicle lateral placement moved in towards the center of the roadway from 9.27 to 8.27 ft, a distance of 1.00 ft. For commercial traffic, the lateral shift was 0.96 ft from 9.74 to 8.78 ft. The lateral shift detected between a 5-ft shoulder and a 4-ft shoulder, however, may have also been affected by some shoulder contrast existing for the 4-ft shoulder

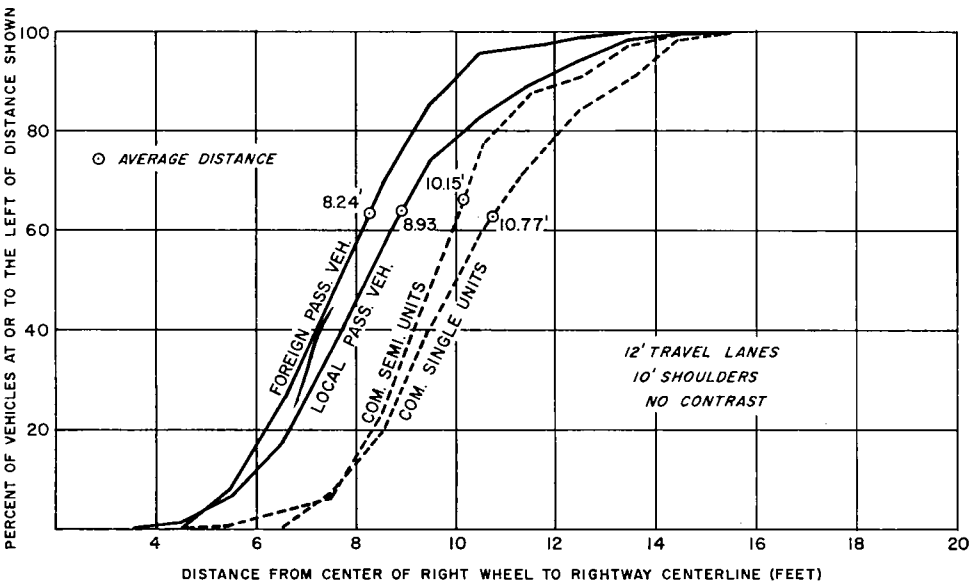

Figure 11. Position of free-moving vehicles at Study Location 8.

while no contrast existed for the 5-ft shoulder.

A further reduction in shoulder width of 1.00 ft from a 4-ft shoulder (Study Location 4) to a 3-ft shoulder (Study Location 5) shows no significant change in lateral placement either for passenger or commercial traffic.

Edge Striping

One of the reasons for making this study was to investigate the effect of shoulder striping on the vehicle placement. Data recorded before and after installation of a 2-in., solid, white reflectorized, shoulder stripe on 2-lane sections having different shoulder widths, show a change in the average travel path both for passenger vehicles and commercial vehicles.

Observations after installation of a shoulder stripe 17 ft from the roadway centerline (Study Location 1) show a move of 0.69 ft for the average passenger vehicle and 1.80 ft for the average commercial vehicles towards the roadway centerline. In this case, there was no contrast between the shoulder surface and the travel lane surface. An analysis of the curves in Figure 1 shows that this change was not caused by a change in travel of the portion of traffic traveling closest to the roadway centerline, but rather by a change in travel of the traffic that before was traveling close to the shoulder or even encroaching on the shoulder. Comparing passenger and commercial traffic, a two to three-times greater lateral shift was found for commercial traffic.

The same trends were observed on a section with 12-ft lanes and 5-ft shoulders before and after installation of a shoulder stripe 15 ft from the roadway centerline (Study Location 3). However, the differences between the before and the after averages are less. The lateral shift toward the roadway centerline was 0.53 ft for the average passenger vehicle and 0.03 ft for the average commercial vehicle. On the section with 12-ft lanes and

4-ft shoulders having some color and texture contrast (Study Location 4), no significant difference in placement was found for passenger vehicles after installing a shoulder line 13.5 ft from the roadway centerline. The average travel path for commercial traffic, however, was closer to the shoulder after installation of the shoulder stripe. This is contrary to what is found at other study locations and may possibly be explained by the probable insufficient sample size at this location. Observations for the narrowest shoulder studied (Study Location 5) showed a move of the average travel path for passenger vehicles towards the roadway centerline after installation of a shoulder stripe 11.5 ft from the centerline. No significant difference was observed for commercial traffic.

A comparison of the observations for the four different shoulder widths studied indicates that shoulder striping has greater effect on the lateral placement of both passenger and commercial vehicles on the wider sections. On the section with 8-ft shoulders, there was a 0.69-ft lateral shift towards the roadway centerline for the average passenger vehicle after installation of shoulder stripes. On the 5-ft shoulder the lateral shift was 0.53 ft and even less on the sections with 4- and 3-ft shoulders.

Passenger Traffic vs Commercial Traffic

Observations from all eight study locations show that the average passenger vehicle travels with its right front wheel closer to the roadway centerline than does the average commercial vehicle. The greatest difference between the average position of the right front wheel for passenger and commercial vehicles was found on sections with wide shoulders such as on the 4-lane Interstate sections having 10-ft wide right-hand shoulders (Figs. 8, 9, and 11) and on the 2-lane section with 8-ft wide shoulders (Figs. 1 and 3). Less difference was found on other 2-lane sections having 5-, 4-, and 3-ft shoulders (Figs. 4, 5, and 7).

A comparison of passenger and commercial traffic with respect to travel path is not complete without considering the difference in front wheel gauge (center-to-center of tires) for these two vehicle groups. Using 5.5 ft as an average value for front wheel center-to-center distance for passenger vehicles and 7.0 ft for commercial vehicles, a conversion from position of the right wheel to position of vehicle center can be made. These conversions are shown by the curves in Figure 12. The center of the average observed passenger vehicle on a 4-lane Interstate section having 10-ft outside shoulders (Study Location 6) was 6.69 ft from the roadway centerline. The center of the average observed commercial vehicle was 7.80 ft from the roadway centerline or 1.11 ft closer to the shoulder than the average passenger vehicle. On a 2-lane section having 8-ft shoulders (Study Location 2), the corresponding figures were 7.11 ft for passenger vehicles and 8.78 ft for commercial vehicles, the difference being 1.67 ft. Observations on other 2-lane sections with 5-, 4-, and 3-ft shoulders show the same tendency for passenger vehicles to travel closer to the centerline than commercial vehicles.

Foreign vs Local Traffic

For all observations made on the 4-lane Interstate locations (Study Locations 6 through 8), the data for passenger vehicles were grouped in foreign and local traffic.

Recordings for all three study groups show that foreign passenger vehicles traveled closer to the roadway centerline than did local passenger vehicles. The differences between local and foreign passenger traffic in average position of the right

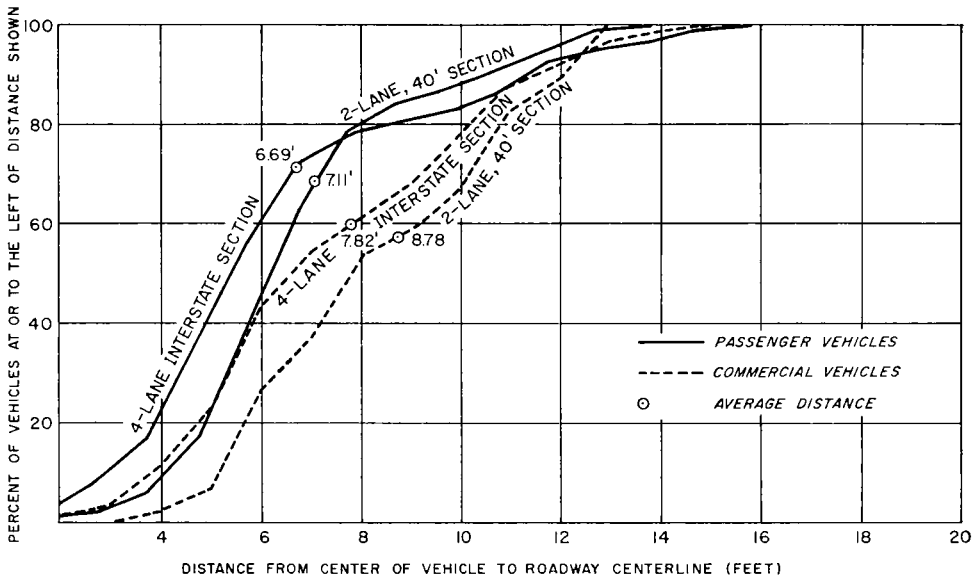

Figure 12. Comparison of vehicle placement for passenger and commercial vehicles on 2- and 4-lane sections, Study Locations 2 and 6.

front wheel range from a high of 0.69 ft to a low of 0.31 ft for the different study locations. Unfortunately, no reason for this tendency can be detected from the collected data.

Signing

Traffic was observed at Study Location 7 before and after installation of signs with the legend "Do Not Travel On Paved Shoulder." These 3- by 4-ft signs, placed 8 ft outside the right shoulder, were spaced 2 mi apart. Observations were made before, 2 days after, and 3 to 7 weeks after installation of the signs. Graphs have been prepared from the recorded data (Fig. 13).

The curves indicate the signing was somewhat effective. The average position of the right front wheel for passenger vehicle was 9.44 ft from the roadway centerline before signing. The average position was recorded as 9.10 ft two days after signing and 8.89 ft three to seven weeks after signing. The corresponding averages for commercial vehicles were 11.30 ft before, 10.73 ft 2 days after, and 10.50 ft three to seven weeks after signing.

Shoulder Contrast

Traffic observations on 40-ft sections with 12-ft travel lanes and 8-ft shoulders were made of Study Locations 1 and 2. No contrast between travel lanes and shoulders existed at Study Location 1; however, both surface texture and color contrast existed at Study Location 2. Comparing the data for Study Location 1 before installation of shoulder stripe with Study Location 2 (Figs. 1 and 3), traffic traveled closer to the roadway centerline at Study Location 2 having shoulder contrast.

Without shoulder contrast (Study Location 1) the average position of the right front wheel was 11.86 ft from the roadway centerline for passenger vehicles and 15.13 ft from the centerline for commercial vehicles. With shoulder contrast (Study Loca-

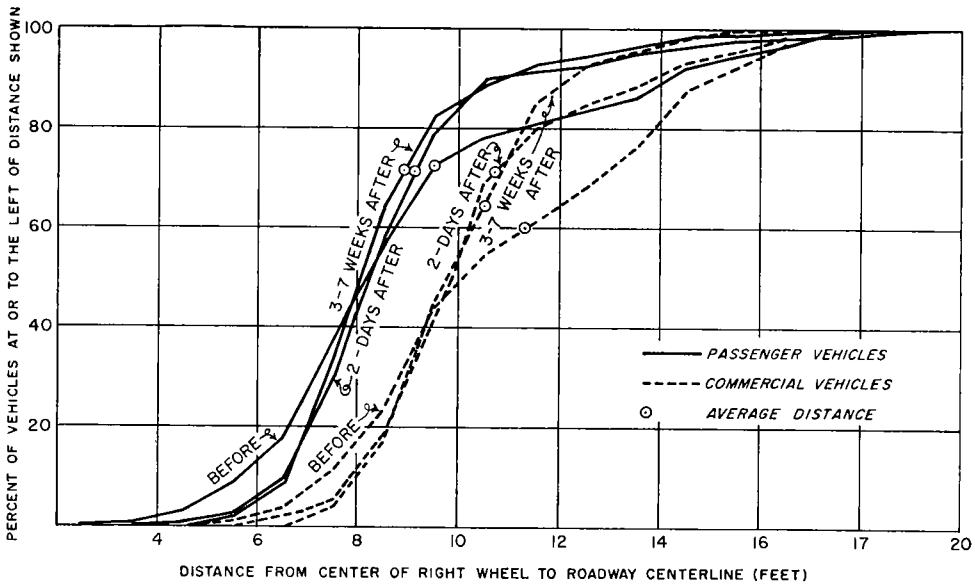

Figure 13. Effect of signing on vehicle placement (Figs. 8, 9, and 10 combined).

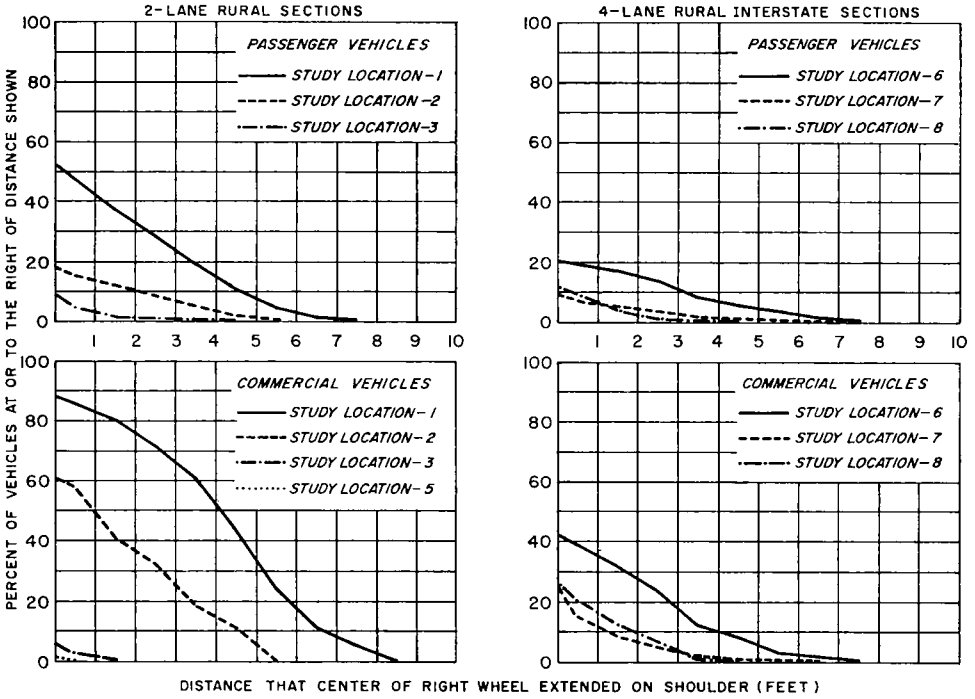

Figure 14. Shoulder encroachment on 2- and 4-lane sections with no shoulder stripes.

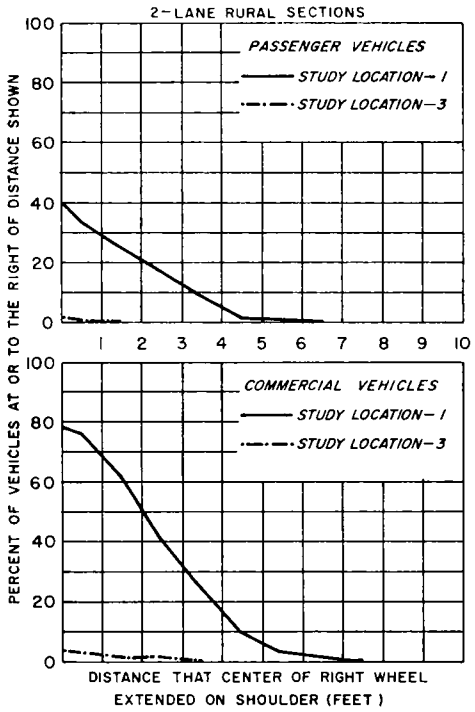

Figure 15. Shoulder encroachment on 2-lane sections with shoulder stripes.

tion 2) these average values decreased to 9.86 ft for passenger vehicles and 12.26 ft for commercial vehicles. This shows that the average path of the observed vehicles was approximately 2 ft closer to the roadway centerline when some surface texture and color contrast existed between the travel lane and shoulder.

Recordings at Study Locations 6 and 8 contain similar data for 4 Interstate sections. Study Location 6 has 10-ft outside shoulders having both color and surface texture contrast created by a light chip seal on the travel lanes and a bituminous plant mix on the shoulders. Study Location 8 has 10-ft outside shoulders having no color or surface texture contrast differentiating the shoulders from the travel lanes.

Traffic observations at these locations indicate that the average position of both passenger and commercial vehicles is approximately ½ ft closer to the roadway centerline on the section having shoulder contrast (Study Location 6).

From the shape of the ogives, the lateral shift towards the centerline is not so much from a change in travel for the portion of the vehicles traveling closest to the centerline, but rather by a lateral shift in position of the vehicles that before were traveling close to or even encroaching on the shoulders.

SHOULDER ENCROACHMENT

Any factor causing a change in the amount of shoulder encroachment on a section of a highway will also affect the average lateral placement of traveling vehicles on the highway. However, it cannot be reasoned that a factor found to affect the average lateral placement will necessarily change the amount of shoulder encroachment.

Figures 14 and 15 show observed shoulder encroachment on 2- and 4-lane sections with and without shoulder striping. It is found that commercial vehicles generally encroach on the shoulders more than do passenger vehicles on the wider road sections. Approximately 50 percent of the passenger vehicles and about 90 percent of the commercial vehicles (Fig. 14) traveled with the right wheels on the shoulder on a 40-ft section without shoulder contrast and without shoulder striping (Study Location 1). These percentages were reduced to 40 percent for passenger traffic and 80 percent for commercial traffic after the installation of a 2-in., solid, white, reflectorized, shoulder stripe (Fig. 14). Observations on narrow roadways show the same trend. On the 34-ft section (Study Location 3), approximately 5 percent of the passenger traffic and 10 percent of the commercial traffic encroached on shoulders having no

contrast or striping. Application of a shoulder stripe reduced the encroachment to about 2 percent for passenger traffic and eliminated encroachment of commercial vehicles.

Generally, more shoulder encroachment was observed on the wider sections. Though over 50 percent of the passenger vehicles encroached on the 8-ft shoulders of the 40-ft section at Study Location 1, only 10 percent encroachment was found under similar conditions on the 5-ft shoulder of the 34-ft section at Study Location 3, and no encroachment at all for the 30-ft section at Study Location 5. Also, more encroachment by commercial traffic was observed on the wide sections than on the narrow sections. After installation of the 2-in., solid, white, reflectorized, shoulder stripe, it was found that, although 40 percent of the passenger traffic encroached on the shoulder on the 40-ft section (Study Location 1), less than 2 percent encroachment was found on the 34-ft section (Study Location 3) and no encroachment observed on the 30-ft section (Study Location 5). The same trends were detected for commercial traffic after installation of shoulder stripes.

Shoulder encroachment was less on 2-lane sections where some color or texture contrast between the shoulder and the travel lanes existed. Over 50 percent encroachment was observed for passenger traffic on the 2-lane, 40-ft section having no shoulder contrast (Study Location 1), and less than 20 percent encroachment was found on a similar section with shoulder contrast (Study Location 2). For commercial traffic the corresponding percentages are approximately 90 and 60 percent.

An opposite trend, however, was observed on the 4-lane Interstate sections. At Study Location 6, having surface and color contrast, a passenger vehicle encroachment of 20 percent was observed, while at Study Location 9 having no shoulder contrast, a 10 percent encroachment was observed. This same pattern was noticed for commercial traffic on the same sections. Unfortunately, the observations do not give any indication as to the reason for this trend.

TENDENCY TO TRAVEL IN THE SAME TRACKS

The average slope of the ogives plotted from the observations indicate the closeness with which the data group around the average value; in other words, the tendency of the drivers to travel in the same wheel tracks.

A measure for the slope of the curves is obtained by examining the distance between the upper and the lower quintile. These values are given in Table 4.

Data in Table 4 indicate that on the section with an 8-ft shoulder (Study Location 1), the observed passenger traffic between the quintiles traveled with the right front wheel on

TABLE 4

OBSERVED QUINTILES ON SECTIONS WITH DIFFERENT SHOULDER WIDTHS

Study Location No.	Figure No.	Shoulder Width (ft)	Lower Quintile	Upper Quintile	Distance Between Upper and Lower Quintile (ft)
1	1	8	8.4	14.4	6.0
3	4	5	7.5	10.1	2.6
4	5	4	6.8	8.8	2.0
5	7	3	6.9	8.4	1.5

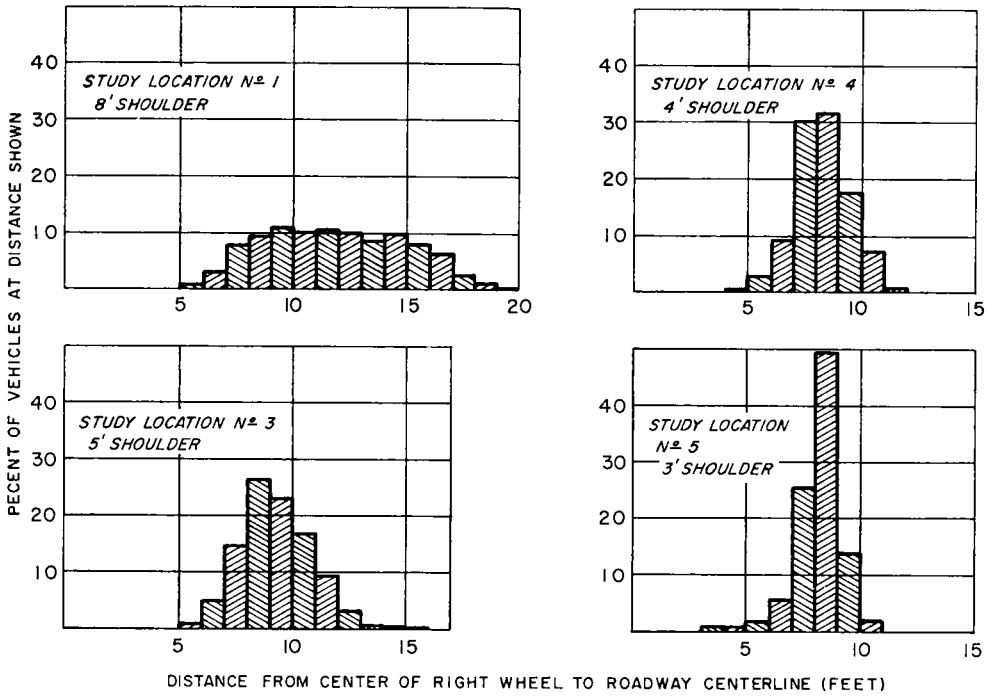

Figure 16. Distribution of wheel tracks for passenger vehicles on 2-lane sections.

a 6.0-ft wide area located between 8.4 and 14.4 ft from the roadway centerline. On the section with a 5-ft shoulder (Study Location 3) a 2.6-ft wide area was chosen located between 7.5 and 10.1 ft from the centerline. On the sections with narrower shoulders (Study Locations 4 and 5) even more restricted areas were chosen for the right front wheel. A study of the observations for commercial vehicles shows the same trend.

Figure 16 shows the distribution of the wheel tracks for the right front wheel of passenger vehicles. At Study Location 1 these wheel tracks of the vehicles between the quintiles covered 58 percent of the total roadway width including the shoulders. On the section with 5-ft shoulders (Study Location 3) the same wheel tracks covered 31 percent of the total roadway width. With a 4-ft shoulder (Study Location 4) 25 percent was covered and with 3-ft shoulder the percentage was 20 percent.

SUMMARY OF FINDINGS

1. The width of the shoulder influenced the lateral placement of vehicles. Both passenger and commercial vehicles traveled closer to the roadway centerline on sections with narrow shoulders than on sections with wide shoulders.

2. Both passenger and commercial vehicles traveled closer to the roadway centerline after the installation of 2-in., white, solid, reflectorized shoulder stripes. The greatest lateral shift was observed on commercial vehicles on sections having the widest shoulders.

3. Passenger vehicles traveled with the center of the vehicle closer to the roadway centerline than did commercial vehicles.

4. Vehicles with out-of-state licenses traveled closer to the roadway centerline than did vehicles with Idaho licenses.

5. The installation of signs with the legend "Do Not Travel On Paved Shoulder" tended to shift the average lateral placement towards the roadway centerline.

6. On sections with contrasting shoulders, the average travel path was located closer to the roadway centerline than on sections with no shoulder contrast. This effect held for both passenger and commercial traffic on both 2- and 4-lane study locations. Affected the most by the use of contrasting shoulders were those vehicles that with no contrast would travel closest to the shoulder edge.

7. More shoulder encroachment was observed from commercial than from passenger vehicles, and more encroachment was found on the sections with wide shoulders. The use of shoulder striping reduced the amount of encroachment. Less shoulder encroachment was observed on 2-lane sections with contrasting shoulders than on sections without shoulder contrast.

8. The narrower the roadway, the greater was the tendency for drivers of passenger vehicles to travel in the same wheel tracks.