important a consideration in the selection of the alinement for a modern 2-lane highway as the standards for curvature, gradient, superelevation, or non-passing sight distance.

(As far as is known, there is only one State highway department that has been recording sight distances on highway plans and those shown are limited to values below 1,000 ft There are however a few other state highway departments that determine sight distances as the layout plans are prepared. Sight distances in both directions that are less than the passing sight distance for the particular design speed selected should be recorded on the plans or on accompanying charts for 2-lane rural highways to be constructed on a new alinement or when major improvements are planned It will then be possible to study the operating characteristic of the facility and determine the changes that should be made in the alinement, if any, to produce a balanced and economical design )

3 Design speeds that are more than 20 m p.h higher than the estimated possible operating speed during the fiftieth highest traffic volume in the year after construction is completed, cannot be justified when they increase the construction cost.

4 Two-lane highways, designed for speeds of 70 m p.h will not provide for operating speeds above 60 m.p h except at extremely low traffic densities.

5. Access to highways on which high operating speeds are desired must be both limited and controlled, and the grades at important intersections must be separated. Frequent intersections at grade or frequent access points will inevitably result in an unduly high proportion of slow speed vehicles.

# TRANSVERSE PLACEMENT OF VEHICLES AS RELATED TO CROSS SECTION DESIGN

By A. Taragin, *Assistant Highway Engineer, Public Roads Administration*

## SYNOPSIS

Highway engineers have long recognized the need for information relative to the transverse positions and speeds of vehicles as they are customarily driven in the normal traffic in order to determine appropriate lane widths of pavements and the influence of various highway and roadside conditions The Public Roads Administration in cooperation with a number of State Highway departments collected speed-placement data for a large number of vehicles on pavements of various surface and roadside conditions. This report is based on day and night observations of 17,000 vehicles on five sections of 18-, 20-, and 24-foot concrete pavements with grass shoulders

The results show the transverse positions and speeds of passenger cars and commercial vehicles when moving freely, when meeting other vehicles, and when engaged in passing maneuvers. The distance from the center of the pavement that free-moving passenger cars travel did not increase with a change in the surface width until a 24-ft pavement became available Drivers of commercial vehicles steadily increased their distance from the center of the road as wider pavements were made available. The free-moving passenger cars swerved to the right the greatest amount when meeting trucks and busses. The lateral movement was about 1 0 ft. for the passenger cars and 0.5 ft for the commercial vehicles.

Under the highway conditions studied the average passenger car would not travel closer than 1 9 ft. to the edge of the pavement and trucks 1 4 ft even at the expense of greatly restricted clearance between meeting vehicles An edge clearance of approximately 3 ft. was required before added pavement

**width was utilized to increase materially the clearances between meeting vehicles Results indicate that on surfaces with grass shoulders a pavement width of 20 ft is inadequate for comfortable meeting even of passenger cars**

As little as 15 years ago many 2-lane highways were still being constructed as narrow as 16 ft, and then 18-ft. pavements were common or perhaps even prevalent. Today 24-ft widths are becoming increasingly common and 13-ft. lanes to provide 26-ft widths are advocated in some areas. This trend is mainly the result of increasing sizes and speeds of vehicles and of increasing traffic volumes But how far to follow this trend is an unanswered question. Progressive highway engineers have long recognized the need for information relative to the transverse positions and speeds of vehicles as they are customarily driven in the normal traffic in order to determine appropriate lane widths of pavements and the influence of various highway and roadside conditions.

Speed-placement information for 17,000 vehicles observed on 2-lane roads has been analyzed and the results embodied in this report. This represents but a small portion of the data that have been collected by the Public Roads Administration in cooperation with a number of State highway departments, analysis of which necessarily has been delayed due to wartime conditions. Interpretation of the material has now been resumed in a small way, and this presentation is in the nature of a progress report. Although it is impossible to generalize from this limited analysis, the results do justify definite conclusions as to driver behavior under the particular conditions included.

The sections selected for analysis include five locations of 2-lane concrete roads in Illinois, as described in Table 1. All sites were on level tangent sections of rural highway where the sight distance in either direction exceeded 1,000 ft. Two pavements were 18 ft. wide, two were 20 ft. wide, and one was 24 ft. wide. In each case a black center line separated the two traffic lanes. The pavements were flanked by well maintained grass shoulders, 5 ft. wide on two of the sections, and 10 ft. wide on the others.

On all sections observations were made during daylight and on sections 1, 3, and 4, observations were also made during several hours of darkness.

The equipment used in obtaining the field data consisted of a combination speed meter and placement detector, described in detail in the April 1940 issue of *Public Roads.* With this equipment the transverse position of each vehicle on the highway and its speed were simultaneously recorded on the charts of graphic recorders. The charts moving at a uniform speed made it possible to determine the time-spacing between successive vehicles.

The speeds, transverse placements, and time spacing of each vehicle with respect to other significant vehicles on the road were compiled separately for passenger cars and commercial vehicles. Light delivery trucks and station wagons were included with the passenger cars, while busses were grouped with the commercial vehicles. Data were further segregated into the following groups representative of various positions of the vehicles in the traffic stream:

1. *Free-moving vehicles*—those that crossed the transverse placement detector at least 6 sec. after the immediately preceding vehicles traveling in the same direction, and at least 5 sec. after and 10 sec. prior to passage across the detector of any vehicles traveling in the opposing direction
2. *Meeting vehicles*—those that were spaced more than 6 seconds from a preceding vehicle traveling in the same direction and either had met or were to meet within 1.5 seconds a vehicle traveling in the opposing direction
3. *Passing vehicles*—those that were involved in overtaking and passing other vehicles traveling in the same direction and which crossed the placement detector within 1 second of the passed vehicle
4. *All other vehicles.*

Table 2 shows the traffic densities and average vehicle speeds at the five locations. In the daytime free-moving commercial vehicles traveled 6 to 10 m p h. slower than the free-moving passenger cars On the average, passenger cars traveled about 1 m.p h. slower at night than during the day, while commercial vehicles traveled slightly faster. The lower speeds on the 20-ft pavement with 5-ft. shoulders may be attributed to the fact that this section of road was closer to an urban district than the other locations.

Table 3 shows the positions of the left wheels of passenger cars and commercial vehicles. It will be noted that there are no significant differences between the values for sections with 5-ft shoulders and those of the same pavement widths with 10-ft. shoulders, presumably because there was no definite line of demarcation between the outsides of the grass shoulders and adjacent terrain. Accordingly, data for sections of the same pavement widths were combined in the subsequent analysis, regardless of the width of shoulders.

TABLE 1
DESCRIPTION OF ROADS ON WHICH OBSERVATIONS WERE MADE

| Section Number | Route Number and Location | Pavement Width | Shoulder Width | Number of Vehicles Observed | | Proportion of Commercial Vehicles | |
|---|---|---|---|---|---|---|---|
| | | | | Day | Night | Day | Night |
| | | ft | ft | | | per cent | per cent |
| 1 | US 12, 1 mile south of Volo, Ill. | 18 | 5 | 4,646 | 2,206 | 1 5 | 1.5 |
| 2 | 111 13, 5 miles S E of East St Louis, Ill. | 18 | 10 | 1,530 | — | 46 6 | — |
| 3 | US 12 & 20, 1 mile west of Oakland, Ill | 20 | 5 | 4,185 | 1,188 | 2 5 | 2 5 |
| 4 | 111.13, 6 5 miles S E of East St Louis, Ill. | 20 | 10 | 373 | 432 | 9.9 | 5 3 |
| 5 | US 67, 1 mile north of Junction with U S 40 | 24 | 10 | 2,230 | — | 19 1 | — |

TABLE 2
TRAFFIC VOLUMES AND VEHICLE SPEEDS

| Pavement Width | Shoulder Width | Hourly Volume | | Average Speed | | | |
|---|---|---|---|---|---|---|---|
| | | | | Free Moving | | All—Except Those Passing | |
| | | Range | Average | Passenger Cars | Commercial Vehicles | Passenger Cars | Commercial Vehicles |
| Day | | | | | | | |
| ft | ft | vph | vph | mph | mph | mph | mph |
| 18 | 5 | 120–1230 | 555 | 44 2 | 38 5 | 41 0 | 39 2 |
| 18 | 10 | 264–400 | 323 | 42 1 | 35 5 | 40.5 | 34 0 |
| 20 | 5 | 192–1176 | 580 | 36 6 | 34 9 | 35 2 | 33 2 |
| 20 | 10 | 282–348 | 299 | 41 3 | 31 5 | 39 7 | 30 8 |
| 24 | 10 | 210–648 | 334 | 43 4 | 36 0 | 41.7 | 35 1 |
| Night | | | | | | | |
| 18 | 5 | 348–954 | 604 | 42 3 | 44 5 | 39 6 | 39.8 |
| 20 | 5 | 126–792 | 507 | 35.6 | 35 0 | 34.7 | 32 9 |
| 20 | 10 | 160–330 | 265 | 41 9 | 36 2 | 41 1 | 36 4 |

TABLE 3
AVERAGE DISTANCE LEFT WHEELS WERE TO THE RIGHT OF CENTER LINE

| Pavement Width | Shoulder Width | Passenger Cars | | | | Commercial Vehicles | | |
|---|---|---|---|---|---|---|---|---|
| | | Free Moving | Meeting Passenger Cars | Meeting Commercial Vehicles | All Except Passing | Free Moving | Meeting Passenger Cars | All Except Passing |
| Day | | | | | | | | |
| ft | ft | ft | ft | ft | ft | ft | ft | ft |
| 18 | 5 | 1 6 | 2 3 | 2 2 | 1 8 | 1 5 | 1 8 | 1.6 |
| 18 | 10 | 1 5 | 2 1 | 2 2 | 1 7 | 1.2 | 1 6 | 1 3 |
| 20 | 5 | 1 6 | 2 4 | 2 5 | 1 9 | 1.8 | 2 4 | 1.8 |
| 20 | 10 | 1 5 | 2 3 | 2 5 | 1 9 | 1.6 | 2 4 | 2 0 |
| 24 | 10 | 2 4 | 3 1 | 3 4 | 2 7 | 2.2 | 2 7 | 2.5 |
| Night | | | | | | | | |
| 18 | 5 | 1 5 | 1.9 | 2 5 | 1 6 | 0 5 | 1 1 | 1 3 |
| 20 | 5 | 1 9 | 2 5 | 2 5 | 2 1 | 1 2 | 1 8 | 1 7 |
| 20 | 10 | 1.6 | 2.1 | 1.3 | 1 8 | 1.6 | 1 5 | 1 6 |

There was no marked difference between

the day and night average placement of passenger cars on the same pavement width. At night the tendency for commercial vehicles is to stay closer to the center of the pavement than in the daytime, especially on the narrower roads.

Under like conditions all drivers do not travel at the same distance from the center of the pavement, as illustrated by the four distributions of vehicle placements on a 20-ft. pavement shown in Figure 1. Free-moving passenger cars and free-moving trucks encroached on the left lane with the same relative frequency, yet none of the trucks was more than 1 ft. to the left of the center, while some of the passenger cars traveled as far as 3 ft to the left of the center line. There is greater variation in the transverse position for the passenger cars than for the trucks Half of the truck drivers kept the left outside rear tires of their vehicles within a 1-ft. strip of pavement (between 1 and 2 ft. to the right of the center line), whereas about 40 per cent of the passenger cars used that same narrow strip of pavement.

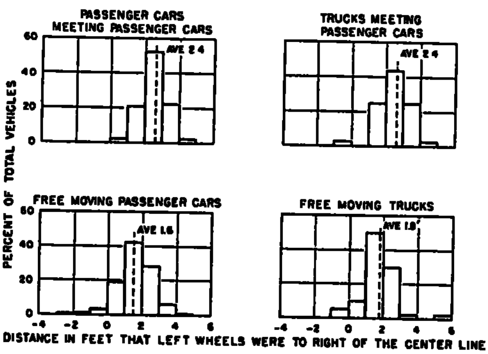


**Figure 1. Typical Distribution of Transverse Placements For Passenger Cars And Trucks on A 20-Foot Concrete Pavement During Daytime.**

Those drivers of passenger cars who used the left lane when moving freely returned entirely to their own lane when meeting vehicles traveling in the opposite direction. Otherwise the curve of frequency distribution of passenger cars meeting other passenger cars is closely similar to that of free-moving vehicles, but displaced approximately 1 ft. to the right. Some of the truck drivers who met passenger cars encroached on the wrong lane of travel, thus forcing the passenger cars they met toward the edge of the pavement.

When tread widths are added to the values shown in Figure 1, it is observed that on this 20-ft. surface none of the passenger cars used the grass shoulders. A small but significant number of trucks, however, did trespass on the shoulders, especially when meeting other vehicles.

Figure 2 shows the average positions of free-moving vehicles on 18-, 20-, and 24-ft. concrete pavements. On the right side are shown the values for passenger cars and on the left side the values for commercial vehicles. The average width of passenger-car bodies as obtained by measurements of various makes and models of cars was found to be 6.0 ft. Similarly, a width of 8 0 ft. for bodies of commercial vehicles is used in this report. The tread widths of 4 9 ft. for passenger cars and 6.0 ft. for trucks were determined from the wheel placements recorded in this study.

The analysis indicates that under the particular road and traffic conditions encountered at these sections, there is no consistent relation between the speed of the individual vehicle and its transverse position on a particular highway. Accordingly, the data for all vehicles have been grouped without regard to vehicular speed. The average speed of each vehicle type on each road section is indicated, however, in all figures.

The distances of free-moving passenger cars from the center of the pavement did not increase with a change in surface width until a 24-ft. pavement became available. On an 18-ft. surface the average driver keeps the left wheels of his car 1 6 ft. from the center of the road. On a 20-ft. surface this distance does not change, the additional width being utilized in increased distance from the pavement edge. On a 24-ft. surface, however, the distance from the center as well as from the edge is increased.

Drivers of commercial vehicles steadily increase their distance from the center of the road as wider pavements are made available. On the 18-ft. surface the left wheels of the average truck are 1.3 ft. from the center of the raodway. An increase in pavement width to 20 feet increases the distances almost equally from the center and edge of road.

Apparently, drivers judge the position of their vehicle by the distance from the center line, since this distance is about the same for both passenger cars and commercial vehicles on pavements of the same width. The narrower tread width of passenger cars naturally results in greater edge clearances than for trucks. It also appears that drivers desire a somewhat greater center clearance than they can obtain on the 18- and 20-ft sections without traveling closer than they desire to the edge.

Figure 3 shows the average positions of passenger cars when meeting other passenger cars. The speeds of these vehicles are 1 to 2 ft. is desired by passenger-car drivers. Even on the 20-ft. section desired center clearance is sacrificed in favor of added edge clearance. Additional pavement width provided by the 24-ft. surface is used by drivers to increase both the clearance between vehicles and the distance from the edge. On the 24-ft. road the distance of the right wheels from the edge of the pavement is 4.0 ft., which allows a clearance of 5 2 ft. between the bodies of the cars.

The fact that passenger cars on an 18-ft. pavement do not move farther to the right

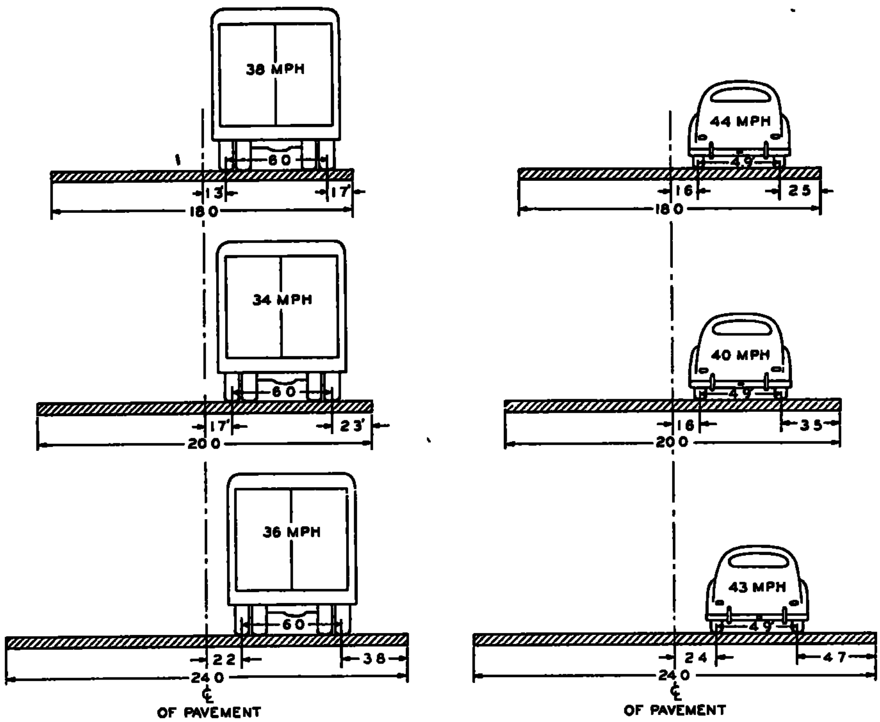


**Figure 2. Average Position Of Free Moving Vehicles on 18-, 20-, and 24-Foot Concrete Pavements During Daytime**

m.p.h. slower than the speeds of the free-moving passenger cars shown in the previous figure. The positions of passenger cars when meeting other passenger cars on an 18-ft surface are such that drivers allow a wheel track distance of 1 9 ft. from the edges of the pavement and a body clearance between vehicles of 3 4 ft When a 20-ft. pavement is provided the extra width is used almost entirely to increase the edge clearance,' again indicating that, under the prevailing particular highway and traffic conditions, a surface wider than 20 when meeting trucks (Fig. 4) than when meeting passenger cars is an indication that an 18-ft. road is entirely too narrow when there is an appreciable amount of truck traffic. The body clearance for these two types of vehicles on the 18-ft. surface was 2.3 ft, a distance considered to be inadequate especially when in some meetings the clearance was observed to be less than 1 ft. Despite this hazard, however, the average passenger-car driver refused to travel less than approximately 2 ft from the edge of the pavement.

On the section with a paved surface of 18 ft. the right wheels of the commercial vehicles were 1.4 ft. from the edge and for passenger cars this distance was 1.9 ft. The additional width provided by the 20-ft. pavement was used by the passenger cars mostly to increase the edge clearance and by trucks to increase the center clearance. On the 24-ft. surface where wider pavement was available, drivers of passenger cars as well as of trucks allowed

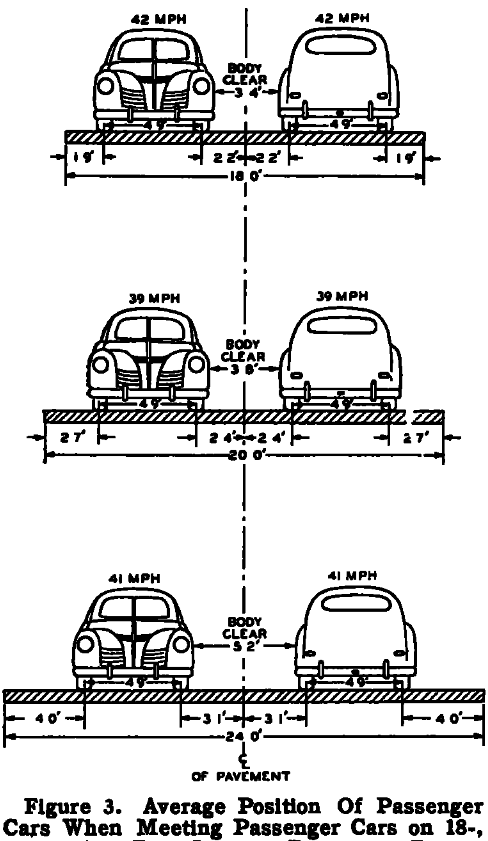


**Figure 3. Average Position Of Passenger Cars When Meeting Passenger Cars on 18-, 20-, and 24-Foot Concrete Pavements During Daytime.**

more satisfactory distances on both sides of their vehicles and maintained a clearance of 4 6 ft between the vehicle bodies.

Figure 5 shows the positions of commercial vehicles when meeting other commercial vehicles. Although truck drivers travel somewhat closer to the edge of the pavement than passenger car drivers, they also sacrifice center clearance to avoid too little edge clearance They do not travel closer than 1 4 ft. to the edge of the pavement, even though the resulting body clearance is as low as 1.2 ft. on the 18-ft. pavement. The additional width provided by the 20-ft. surface is used almost entirely in the clearance between vehicles, increasing this clearance to 3 0 ft. On the 24-ft. road, however, these commercial vehicles travel in the center of their own lanes. Ap-

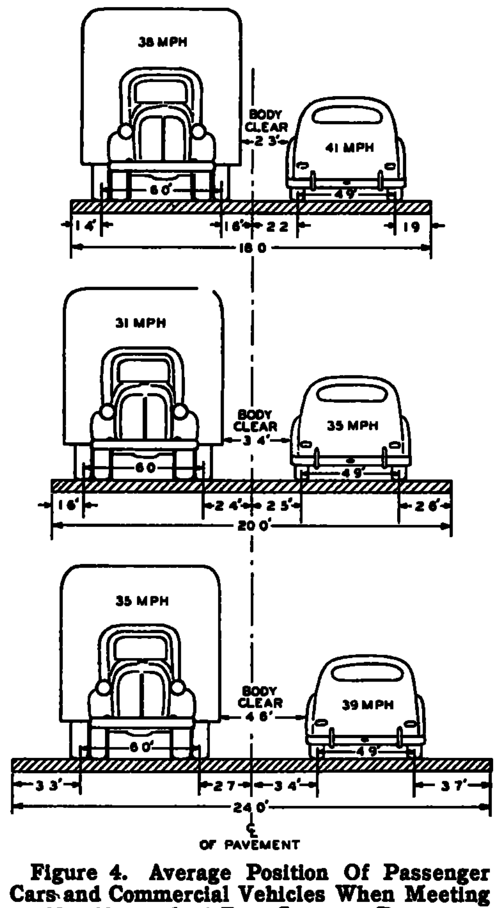


**Figure 4. Average Position Of Passenger Cars and Commercial Vehicles When Meeting on 18-, 20-, and 24-Foot Concrete Pavements During Daytime.**

parently, an edge clearance of 1 5 ft. is inadequate for trucks and busses since the extra 2-ft. width in each lane provided by the 24-ft. pavement above that of the 20-ft. pavement is utilized almost entirely in increased edge clearance Again it should be emphasized that these values cannot be assumed to apply to conditions other than those prevailing here.

The positions and speeds that the average drivers of passenger vehicles assume when overtaking and passing is shown by Figure 6. Included here are only those vehicles that passed the point of observation within 1 sec. of each other and were definitely known to be engaged in a passing maneuver. The speeds as shown are apparently related to local conditions rather than to width of road.

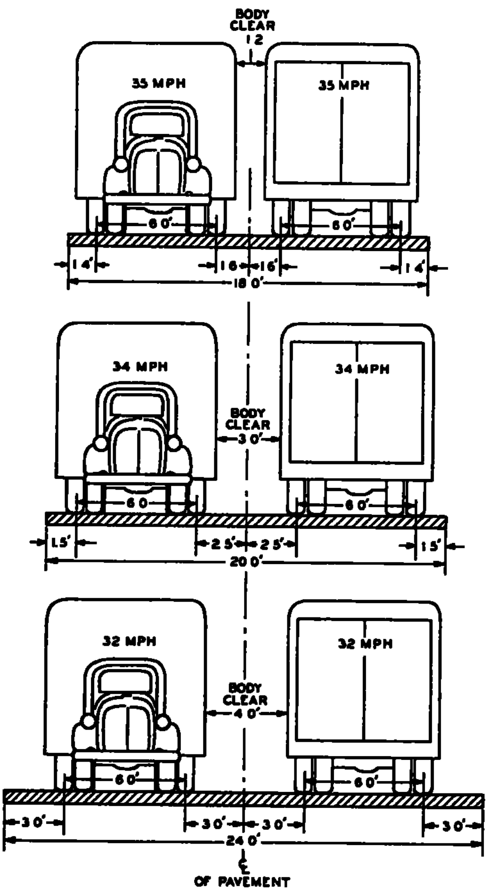


**Figure 5. Average Position Of Commercial Vehicles When Meeting Commercial Vehicles on 18-, 20-, and 24-Foot Concrete Pavements During Daytime.**

The driver of the passing vehicle gauges his transverse position by the center of the roadway and as soon as the right wheels of his vehicle are about 1½ ft. in the left lane he seems to have enough clearance for the maneuver The driver of the passed car moves his vehicle laterally to the right, as compared with his free-moving position. On both the 18-, and 20-ft pavements he keeps his vehicles about the same distance from the center. On both the 20- and 24-ft pavements he keeps the same distance from the edge, utilizing the extra width provided by the 24-ft. road to increase the body clearance to 4.8 ft.

In this presentation the relative positions of the passed and passing vehicles are shown when they were practically abreast of each other. Analysis is now under way to determine the exact transverse positions of the passed and passing vehicles during all stages of the maneuver under various traffic conditions and road characteristics. The results from this analysis will be very useful in supplementing the results of the passing-practice studies, particularly regarding the use of the left lanes on roads of various widths.

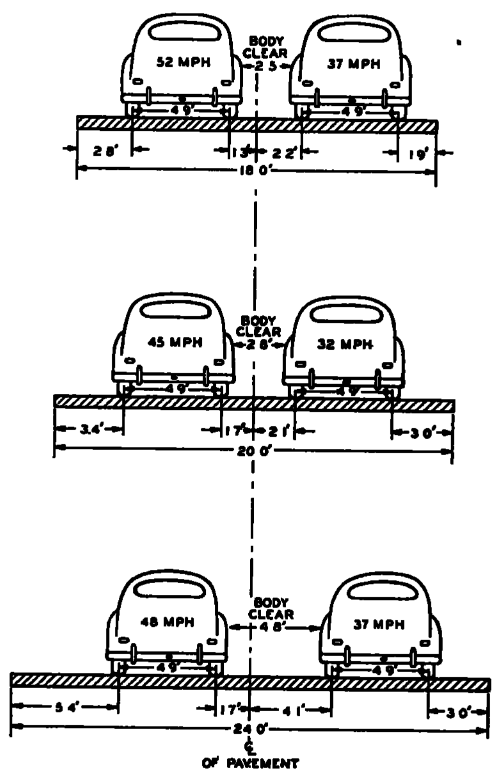


**Figure 6. Average Position Of Passenger Cars When Passing Passenger Cars on 18-, 20-, and 24-Foot Concrete Pavements During Daytime.**

Figure 7 shows the amount that free-moving vehicles moved laterally to the right when meeting other vehicles. Passenger cars meeting commercial vehicles change their position on the road to a greater degree than the trucks they meet. This is to be expected since trucks by virtue of their greater width have correspondingly less latitude for transverse movements.

Passenger cars when meeting trucks move to the right 0 6 ft. on the 18-ft. pavement and about 1.0 ft. on the wider roads. Trucks move about half as much as the passenger cars they meet. Passenger cars meeting oncoming passenger cars give way by the same distance as when meeting trucks on an 18-ft. road On the wider roads they swerve to the right about

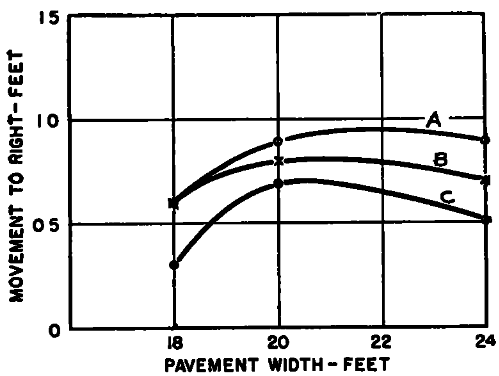


**Figure 7. Difference in Transverse Position Between Free Moving And Meeting Vehicles During Daytime.**

**A—Passenger Cars Meeting Commercial Vehicles; B—Passenger Cars Meeting Passenger Cars; C—Commercial Vehicles Meeting Passenger Cars.**

¾ ft. from their free-moving position, somewhat less than when meeting wider trucks.

The body clearances between vehicles while meeting opposing traffic are shown on Figure 8. On the roads with the three pavement widths studied it was found that the driver of a passenger car has more clearance when meeting another passenger car than when meeting a commercial vehicle, due primarily to the greater body width of the commercial vehicle. When trucks meet other trucks the clearance is about 0 5 ft less than when they meet passenger cars. The clearance between passenger cars when meeting other passenger cars is about 2 ft. greater than the clearance between trucks meeting other trucks on an 18-ft pavement, while on the wider roads the difference is only about 1 ft. The curve showing the body clearances when passenger cars and trucks meet is about midway between the other two curves.

Figure 8 indicates that if, for example, a body clearance of 4 ft. between meeting vehicles is to be maintained by the average drivers a pavement width of at least 20 ft.

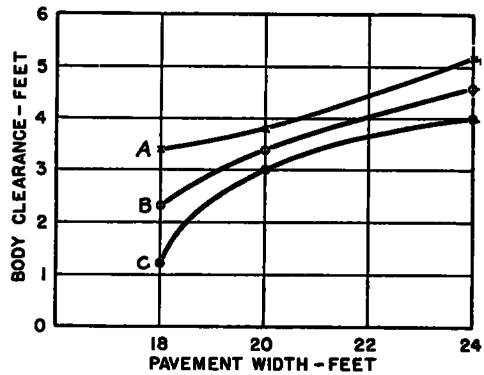


**Figure 8. Body Clearance Between Vehicles When Meeting During Daytime**

**A—Passenger Cars Meeting Passenger Cars; B—Passenger Cars and Trucks Meeting; C—Trucks Meeting Trucks.**

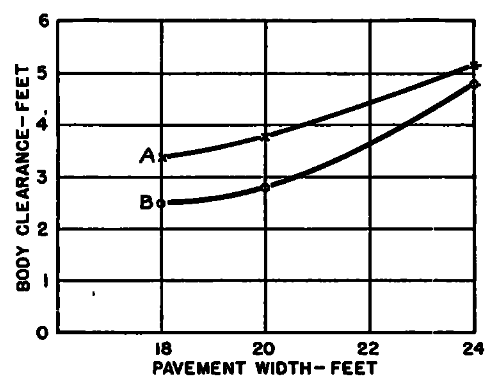


**Figure 9. Body Clearance Between Passenger Cars When Meeting And Passing During Daytime.**

**A—Passenger Cars Meeting Passenger Cars; B—Passenger Cars Passing Passenger Cars**

should be provided for traffic consisting mostly of passenger cars, a 22-ft pavement would be needed for mixed traffic and a 24-ft. pavement would be needed where truck traffic is a relatively high proportion of the total.

Figure 9 shows that drivers allow greater clearance when meeting vehicles than when passing vehicles traveling in the same direction. This difference is about 1.0 ft. on the narrower roads and 0 5 ft. on the 24-ft. pavement

CONCLUSIONS

It is important to remember that the values presented are averages for the highways selected and the conditions that were studied Some of the conclusions might have to be qualified by the results of additional analysis on roads of similar width but with other design features.

Under the conditions presented the following conclusions have been derived:

1 Trucks stay closer to the edge of the pavement than passenger cars both when meeting other vehicles and when moving freely. The greater truck body and tread width are undoubtedly factors in the lower edge clearances for trucks. It may also be attributed to the fact that truck drivers are better trained to handle their vehicles than drivers of passenger cars.

2 The path of a vehicle on a concrete road goes from one extreme when meeting opposing traffic to the other extreme when passing other vehicles in the same direction of travel. The normal position is considered to be that occupied when the vehicle is moving freely unaffected by proximity of other vehicles. The transverse shift from the free-moving to the meeting position is about 1 0 ft for passenger cars and 0 5 ft. for trucks.

3 Under the highway conditions included in this analysis (concrete pavement and good grass shoulders), the average passenger car would not travel closer than 1 9 ft. to the edge of the pavement and trucks 1 4 ft even at the expense of greatly restricted clearance between meeting vehicles An edge clearance of approximately 3 ft. is required before added pavement width will be utilized to increase materially the clearances between meeting vehicles. With these conditions a pavement width of 20 ft. is inadequate for comfortable meeting, even of passenger cars.

# CURRENT TRENDS IN THE VOLUME AND CHARACTERISTICS OF HIGHWAY TRAFFIC

By John T. Lynch

*Senior Highway Economist, Public Roads Administration*

## SYNOPSIS

The Public Roads Administration and the State highway departments are continuously collecting, analyzing, and making available to the various war agencies, through periodic bulletins, data showing fluctuations in traffic volumes and vehicle speeds. In the summers of 1942 and 1943 short surveys, which gave information concerning changes in vehicle weights and loading practices since the more extensive pre-war survey, were made in nearly all States.

The general trend in traffic volume has been downward throughout 1942 and 1943 in all sections, but to a greater degree in the East than elsewhere. In the Midwest and West traffic dropped sharply following gasoline rationing in December 1942, and then made a partial recovery. A large part of the traffic reduction has been due to a virtual elimination of summer vacational travel, and to drastic declines in Sunday and holiday travel in regions where pleasure-driving bans have been in effect.

The indicated decrease in total vehicle-mileage on main rural roads from 1940 to 1943 is about 45 percent in the East, 34 percent in the Midwest, and 31 percent in the West The indicated decrease in truck mileage from 1940 to 1943 is about 24 percent in the East, 20 percent in the Midwest, and 9 percent in the West Traffic by truck combinations, however, has increased in all regions since 1940 Average weight increases have nearly offset decreases in vehicle-mileages so that