Abridgment

Analysis of Exiting Vehicle Paths at Undivided Two-Way Driveways

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The results of preliminary field studies conducted at six commercial driveways to evaluate exiting vehicle paths at undivided two-way driveways are presented. Vehicle position data for several hundred exit maneuvers were collected at each driveway and analyzed. Due to the preliminary nature of the studies, no attempt was made to gather data on the volume of street traffic or information about vehicles entering the driveways. The studies suggest that encroachment by exiting traffic over the midpoint of undivided two-way driveways is fairly common, especially if the driveways have no centerline markings. They also indicate that driveway width, the type of driveway maneuver, and the presence of centerline markings greatly influence the paths taken by motorists exiting a driveway. Based on the study results, the use of centerline markings is recommended at high-volume driveways on arterial streets.

At undivided two-way driveways, the design throat width must be shared (not necessarily equally) by entering and exiting traffic. In other words, traffic waiting to exit occupies part of the driveway. Entering traffic must either use the remaining portion of the driveway or stop in the street and wait until the exiting traffic clears. Therefore, it is important to consider the "positioning" characteristics of exiting traffic in developing driveway design and control requirements. Preliminary studies (1) conducted at six commercial driveways in Bryan and College Station, Texas, were intended to

1. Determine the extent to which traffic exiting undivided two-way driveways encroaches into the portion of the driveway intended for entering traffic,
2. Investigate factors (e.g., driveway throat width and type of exiting maneuver) that may influence the positioning of exiting vehicles, and
3. Evaluate the effectiveness of centerline markings in the driveway throat in discouraging lane encroachment by exiting vehicles.

Data on exiting vehicle position were collected at each driveway by an observer as vehicles passed over a series of inconspicuous tape reference markers on the pavement. These data were obtained only when there were no entering vehicles at the driveway. Due to the limited nature of the studies, no attempt was made to gather data on the volume of street traffic or information about vehicles entering the study driveways.

In the first part of the studies, data were collected at six driveways that had no centerline markings. Two driveways in each of three width categories (narrow, intermediate, and wide) were evaluated. Both of the narrow driveways were 25 ft wide. The intermediate driveways were between 30 and 35 ft wide. The wide driveways were slightly more than 50 ft wide. In the second part of the studies, a before-and-after evaluation of a centerline marking treatment was conducted at one of the narrow driveways.

STUDY RESULTS

The studies conducted should be considered preliminary, since they evaluated exiting maneuvers at a limited number of driveways in only one geographic region. Additional field studies are needed to fully validate the results.

The results suggest that encroachment by exiting traffic over the midpoint of undivided two-way driveways is fairly common, especially if there are no centerline markings present. The percentage of encroaching traffic is greatly influenced by driveway width and the type of exit maneuver (right or left turn). The results also indicate that centerline markings at an undivided two-way driveway may significantly reduce the frequency and extent of exiting vehicle encroachments.

Undivided Two-Way Driveways with No Centerline Markings

In the first part of the studies, exiting drivers were observed encroaching over the driveway midpoint at all six driveways. These encroaching vehicles hampered or blocked entry maneuvers into the driveways in some instances.

Encroachments by right-turn exiting vehicles appeared to decrease as driveway width increased, as shown in Figure 1. On the average, 25 percent of the right-turn traffic encroached at the two narrow driveways, 12 percent at the intermediate-width driveways, and almost no traffic at the wide driveways. Encroachments by left-turn exiting vehicles showed a much different trend, as shown in Figure 2. Left-turning drivers encroached more frequently at the intermediate-width driveways and less often at the narrow and wide driveways.

Figure 3 shows the range of paths used by exiting drivers by driveway width. From Figure 3, the paths selected by left-turn and right-turn traffic were similar at the narrow driveways. At the intermediate-width and wide driveways, left-turn traffic tended to use the middle of the driveway. Right-turn traffic tended to use the right side but remained a comfortable distance from the right curb line.

Undivided Two-Way Driveways with Centerline Markings

In the second part of the studies, a before-and-

Figure 1. Effects of driveway width on encroachment by right-turn exiting vehicles.

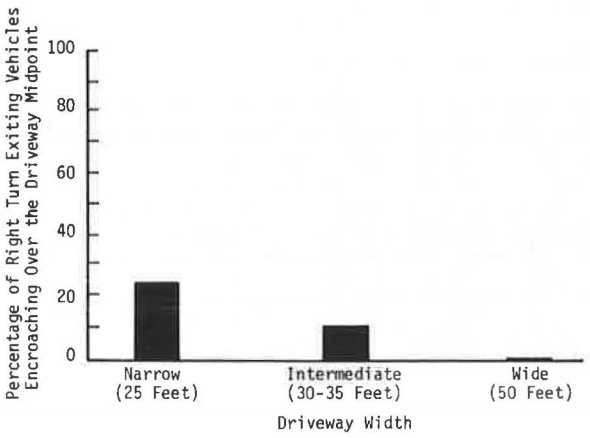


Figure 2. Effects of driveway width on encroachment by left-turn exiting vehicles.

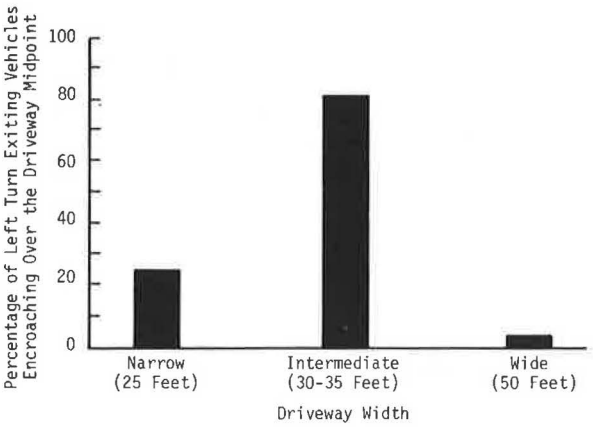
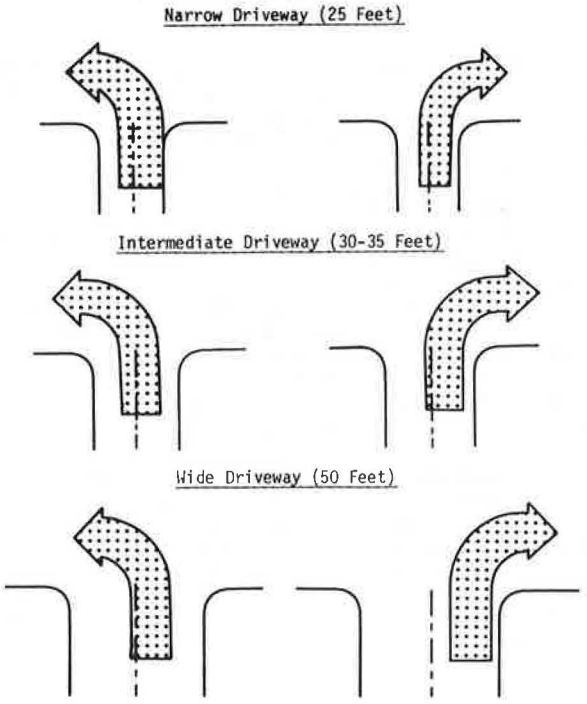


Figure 3. Paths of exiting vehicles.



after evaluation (with and without centerline markings) was conducted at one of the narrow driveways. Figure 4 shows the study driveway before and after the centerline markings were installed. The driveway had a throat width of 25 ft and a curb return radius of 15 ft.

Figure 5 shows the results of the before-and-after evaluation. The figure shows that the solid yellow centerline reduced the percentage of both left- and right-turn traffic encroaching over the driveway midpoint. Before the centerline markings were installed, about 23 percent of left-turn and 20 percent of right-turn exiting traffic encroached. After the centerline was installed, only 3 percent of the left-turn and 5 percent of the right-turn exiting traffic encroached.

The centerline markings also reduced the maximum encroachment distance, particularly for left-turn exiting traffic. The maximum encroachment by a left-turn exiting vehicle when no centerline markings were in place was 7 ft over the midpoint. When a centerline was present, the maximum encroachment was only 2 ft over the midpoint.

Figure 4. Study driveway (top) with and (bottom) without centerline markings.

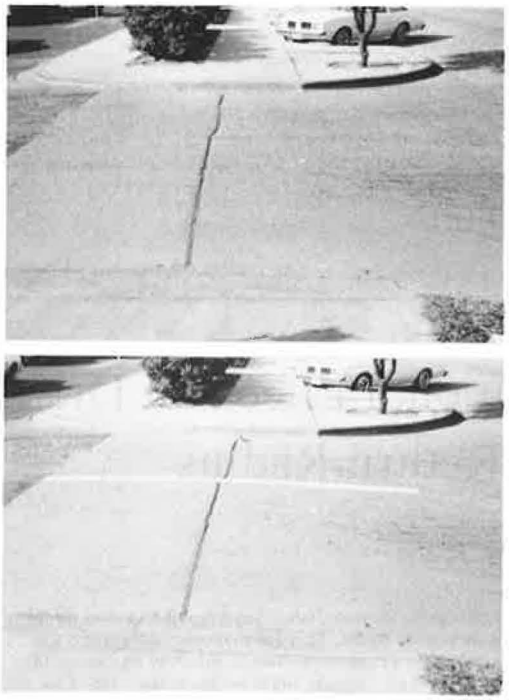
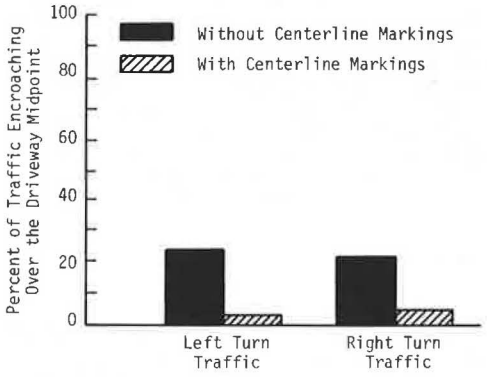


Figure 5. Effects of centerline markings on encroachment by right- and left-turn traffic.



RECOMMENDATIONS

Based on the study results, centerline markings similar to those evaluated are recommended for undivided two-way driveways where conflicts between entering and exiting traffic result from exiting vehicles using too much of the driveway width. These markings can reduce the number and extent of midpoint encroachments by exiting traffic. The centerline markings can be placed on the driveway midpoint or offset to provide additional width for entering or exiting traffic as needed. The effectiveness of an offset centerline has not been evaluated, however.

Centerlines may be most appropriate at high-volume commercial driveways on arterial streets. At these driveways, the probability of dual use (simultaneous entry and exit) is high and, when a conflict

occurs, it may have a very negative effect on traffic operations on the arterial street.

ACKNOWLEDGMENT

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REFERENCE

1. S.H. Richards. Guidelines for Driveway Design and Operation: Volume 2--Technical Report. Texas Transportation Institute, Texas A&M Univ., College Station, Rept. 5183-2, 1980.

Operational Effects of Driveway Width and Curb Return Radius

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Existing driveway design standards include independent design controls for throat width and curb return radius. They fail to recognize that these two driveway features may have an aggregate effect on driveway operation. In addition, current standards for driveway width and curb return radius are based primarily on vehicle turning capabilities and do not consider how drivers respond, in terms of speed and path, to various driveway designs. The results of proving-ground studies conducted to evaluate the effects of driveway width, curb return radius, and offset taper approach treatments on the speed and path of drivers entering and leaving driveways are presented. A total of 59 nonprofessional drivers participated in the studies. These motorists, driving an instrumented study vehicle, collectively performed more than 1400 driveway entry and exit maneuvers. Speed and path data were collected for each maneuver and were analyzed to determine the relative performance of 19 driveway design conditions. The studies revealed that current standards for driveway width and radius result in driveway designs that encourage very slow entry speeds and, in many cases, undesirable vehicle paths. Recommendations are presented, based on the study results, for driveway width and radii requirements. The studies also found that offset taper approach treatments do not have a significant effect on entry paths or speeds at driveways.

A primary objective of driveway regulation is to establish design controls for the physical features of driveways. Experience indicates that these design controls are needed to promote efficient traffic operation and safety (1,2). However, many of the design controls contained in existing state and local regulations are based more on intuition than on engineering evaluation. The actual effects of these controls on traffic operations and safety are not fully known and, because there is no documented evidence supporting them, it is sometimes difficult to justify or defend their use.

There is a particular need to determine how drivers respond (in terms of path and speed) to driveway throat width and curb return radius. Existing design controls for width and curb return radius are based primarily on vehicle turning capabilities and do not consider driver performance characteristics. In addition, existing regulations present independent design controls for these two driveway features. They do not recognize that width and curb return radius may have a combined effect on vehicle speed and path at driveways (3,4).

STUDY DESCRIPTION

A series of proving-ground studies was developed to evaluate driver response to various driveway features in terms of speed and path. The objectives of each study were as follows:

1. Study 1--Determine the effects of throat width and curb return radius (as individual design features and in combination) on the speed and path of drivers turning right into driveways,
2. Study 2--Determine the effects of exiting vehicle position on the speed and path of drivers turning right into driveways,
3. Study 3--Evaluate the effects of offset taper approach treatments on the speed and path of drivers turning right into driveways,
4. Study 4--Evaluate the effects of curb return radius on the speed and acceleration of drivers turning right out of driveways, and
5. Study 5--Evaluate the effects of unequal entry and exit curb return radii on the speed and path of drivers turning right into driveways.

In all five studies, a group of "off-the-street" motorists drove an instrumented study vehicle through a specially constructed driveway test track. The speed and path of these drivers as they entered or exited the various driveways under study were recorded. A comparative evaluation of the different driveways was then made based on the speed and path data.

Test Track

The studies were conducted at the Texas A&M University Proving Ground facility in Bryan, Texas. This facility is located at an abandoned U.S. Air Force base, and the unused airport runways provide an ideal environment for controlled driving studies.

A driveway test track, approximately 2000 ft long, was constructed on one of the runways. The study driveways were constructed by using canvas fire hoses, which were painted yellow and stuffed with wood shavings. The fire hoses provided a three-dimensional visual target and physical barrier very similar to concrete curbing and were flexible enough to use on both curved and tangent sections. In addition, the pliable hoses created no safety hazard and were easily repaired when damaged by a vehicle impact. Since the hoses were portable and did not scar the pavement, the test-track layout could be changed quickly and effectively in order to evaluate a new set of driveways.

The two test-track layouts used for the studies are shown in Figure 1. The first layout had eight