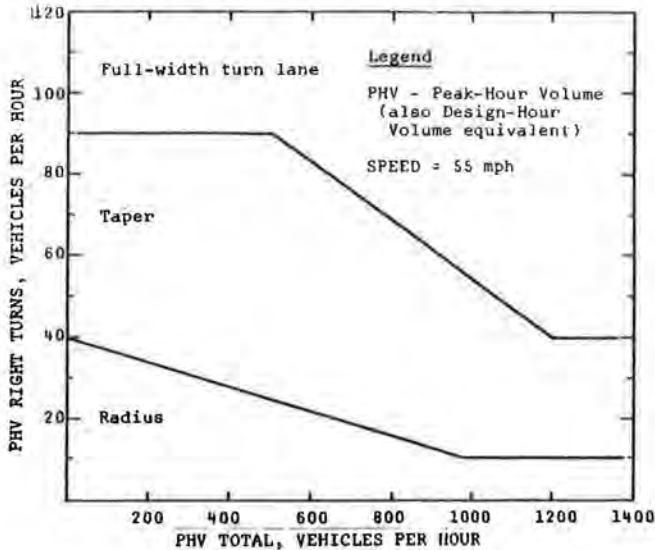


Figure 3. Guidelines for right-turn treatment: four-lane highway.



mph or less, more than 40 PHV right turns, and PHV total of less than 300, the adjusted number of PHV right turns = PHV right turns - 20.

The guidelines for four-lane highways were developed in a similar manner and are shown in Figure 3. These high-level-of-service facilities were divided highways with 55-mph speed limits.

CONCLUSIONS

Although the original intent of the study was to eliminate judgment in developing the guidelines,

this could not be done where field data were lacking. The synthesis approach placed emphasis on the field data.

The guidelines are to be used as an aid in the selection of right-turn treatments for new facilities based on forecast demand and for intersection improvements. Site-specific factors of concern that were not addressed are sight distance, grade, availability of right-of-way, and angle of turn. It is suggested that methods that reflect the special concerns be used in lieu of the guidelines for these cases. It is important that this sort of flexibility be a part of the guidelines.

ACKNOWLEDGMENT

The research reported in this paper was financed from Highway Planning and Research funds administered through the Federal Highway Administration.

The opinions, findings, and conclusions are mine and not necessarily those of the sponsoring agencies.

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Publication of this paper sponsored by Committee on Operational Effects of Geometrics.

Abridgment

Motorist Response to Selected Driveway Systems

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The results of a human-factors laboratory study conducted at a shopping mall in Bryan, Texas, to evaluate the influence of driveway layout on driveway selection by motorists are presented. The 200 licensed drivers who participated in the studies were shown one of four driveway layouts and asked a series of questions concerning use of the driveway(s) in the layout. The studies revealed that the physical layout of driveways can influence motorists' expectations and interpretation of traffic operations at the driveways. In particular, motorists will perceive that certain driveways are one-way and others are two-way, depending on the physical layout. Certain driveway layouts also imply to some motorists that particular maneuvers (such as left-turn exit or left-turn entry) are prohibited. The studies also found that individual drivers may interpret and respond to particular driveway layouts differently. Most motorists, however, are very reluctant to violate the basic premise of traffic flow in the United States—i.e., keep to the right. In terms of driveway operations, this means that motorists will tend to use driveways that they perceive to be to their right.

Much attention has been given to the design and operation of individual driveways. All states and most cities closely regulate the design and operation of individual driveways in the interest of

improved traffic safety and flow (1). In most cases, however, these regulations do not specifically address the fact that most driveways are part of a "driveway system", or a group of driveways serving the same land development (2), and, accordingly, what happens at one driveway will influence operations at all other driveways in the system. Thus, more emphasis should be given to a "systems approach" in designing and operating driveways. Unfortunately, very little is known about how particular driveway systems are perceived by motorists and how these systems perform.

HUMAN-FACTORS STUDY

A human-factors study was developed to investigate the influence of driveway system layout on driveway selection by entering and exiting motorists. The study was conducted at a regional shopping mall in Bryan, Texas (Bryan has a metropolitan area popula-

tion of approximately 100 000). Some 200 licensed drivers participated in the study. The participating drivers were younger and better educated, on the average, than drivers as a whole.

In the study, drivers were shown one of the four slides shown in Figure 1. On seeing the slide, they were asked which driveway they could and would use to perform various maneuvers (left-turn entry, right-turn exit, etc.). Note from Figure 1 that the site layout in all of the slides was identical. They all showed the same grocery store, parking lot, and street from the same perspective. The only feature that changed from slide to slide was the driveway layout.

Slide 1 in Figure 1 shows three driveways into the grocery-store parking lot. All three driveways are perpendicular to the roadway and have identical widths and curb return radii. The driveway system in slide 1 depicts a driveway configuration in which all the driveways are equally attractive to a motorist entering or leaving the parking area (except for their relative location).

Slide 2 in Figure 1 shows a dual-driveway system at the grocery store. Both of the driveways are perpendicular to the roadway and are identical in width and curb radii. This driveway system was designed to present a situation that may imply one-way operation.

Slide 3 in Figure 1 again shows a dual-driveway system; however, the driveways are not perpendicular to the roadway. Instead, they meet the street at 60° and 120° angles, respectively. This driveway system is intended to present a driveway configuration in which one-way operation may be implied and some turning maneuvers may be discouraged.

Slide 4 in Figure 1 shows a configuration similar to the one in slide 2. However, the spacing between driveways has been decreased so that the system resembles a single large driveway with a raised median in the middle to separate entering and exiting traffic.

STUDY RESULTS

The results of the human-factors studies are summarized in Table 1. Each section of the table pertains to one of the four driveway layouts evaluated (Figure 1). The table gives the percentages of subject drivers who indicated they "could use" certain driveways (question a) and "would use" a particular driveway (question b) to perform four basic driveway maneuvers. The four basic maneuvers--left-turn entry, right-turn exit, right-turn

entry, and left-turn exit--are illustrated in Figure 2.

Three-Driveway System

For the three-driveway configuration (slide 1), more than two-thirds of the drivers sampled said that they could use any of the three driveways to enter or exit the grocery-store parking lot. From the table, 70, 74, 68, and 66 percent of the drivers said that they could use driveways A, B, and C for the left-turn entry, right-turn exit, right-turn entry, and left-turn exit maneuvers, respectively. Thus, most of the drivers who participated in the study interpreted the three-driveway layout as a group of three two-way driveways.

Not all of the drivers, however, agreed with this interpretation. A significant portion of them said that only driveways B and C could be used to enter the parking area and only driveways A and B could be used to exit the parking area. These motorists, based on their responses, may have thought that driveways A and C were operating as a one-way pair (entry at driveway A and exit at driveway C) and that two-way operation was permitted at driveway B.

In response to question b, the data in the table indicate that most drivers said they would use the driveway nearest their origin when making a right-turn entry or exit maneuver. For example, 94 percent of the drivers said they would use driveway C for the right-turn entry maneuver. Driveway C is the first driveway at which a motorist would arrive if traveling to the store.

Table 1. Percentage of drivers who selected various maneuvers for each driveway layout in response to questions a and b.

Response	Driveway	Left-Turn Entry	Right-Turn Exit	Right-Turn Entry	Left-Turn Exit
Slide 1^a					
Could use driveway	A only	2	4	0	0
	B only	4	0	0	2
	C only	0	0	6	6
	A and B	6	18	0	2
	A and C	2	4	0	0
Would use driveway	B and C	16	0	26	24
	A, B, and C	70	74	68	66
	A	35	92	0	12
Would use driveway	B	41	8	6	40
	C	24	0	94	48
	Slide 2^b				
Could use driveway	A only	8	64	8	64
	B only	64	8	64	8
	A and B	28	28	28	28
Would use driveway	A	14	88	12	86
	B	86	12	88	14
Slide 3^a					
Could use driveway	A only	2	68	2	68
	B only	68	2	68	2
	A and B	30	30	30	30
Would use driveway	A	14	98	2	86
	B	86	2	98	14
Slide 4^c					
Could use driveway	A only	0	100	0	98
	B only	100	0	100	2
	A and B	0	0	0	0
Would use driveway	A	0	100	0	98
	B	100	0	100	2

^aSample size = 50.

^bSample size = 49.

^cSample size = 51.

Figure 1. Driveway systems evaluated in the study.

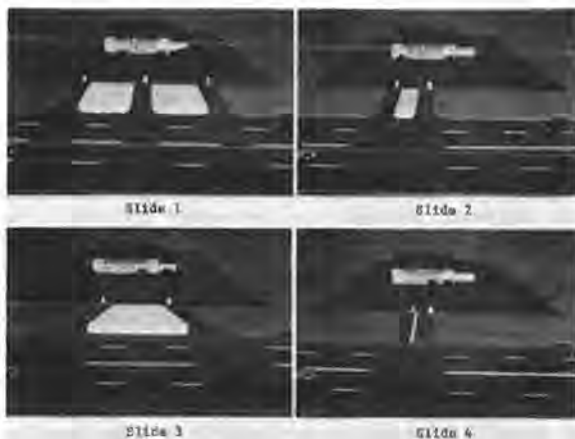
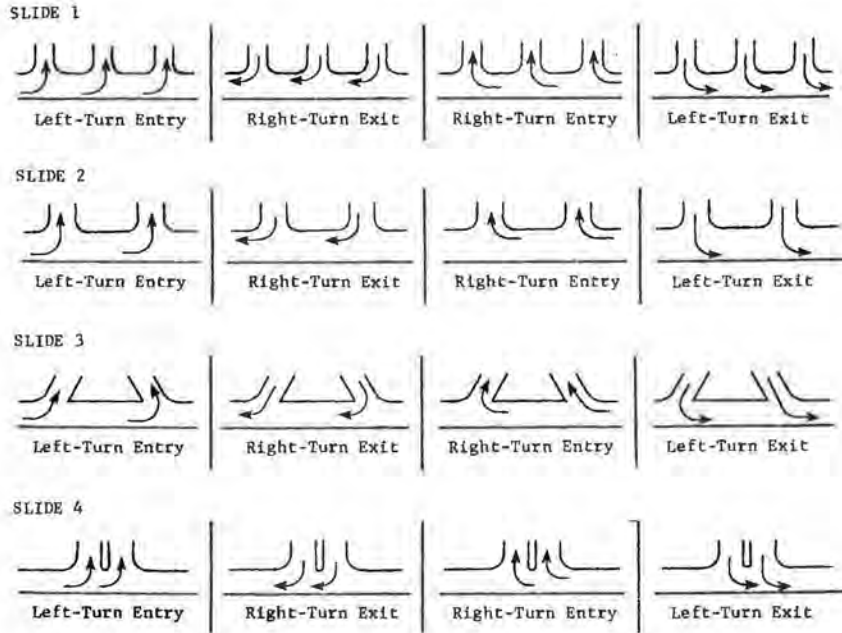


Figure 2. Basic maneuvers for four driveway layouts studied.



The consistency among the subjects in driveway selection for the right-turn entrance and exit maneuvers is attributed to two factors:

1. The drivers selected the driveway most convenient in terms of location (the driveway best positioned in terms of where they had come from or where they were going).
2. The drivers' selections were consistent with the normal one-way operation pattern (i.e., enter right and exit left).

Driveway selection trends for the left-turn maneuvers differed significantly from those observed for the right-turn maneuvers. The difference is attributed to the fact that, for left-turn maneuvers, selecting a driveway convenient in terms of location violated the normal one-way operation pattern. For example, 35 percent of the drivers said they would use driveway A, 41 percent said they would use driveway B, and 24 percent said they would use driveway C for the left-turn entry maneuver. Based on these data, it is apparent that many drivers were hesitant to challenge the one-way operational premise (keep to the right) even though there was not an obvious one-way driveway layout shown. Instead, many of the drivers opted for the middle driveway, which was generally acknowledged as a two-way driveway.

Dual-Driveway System

Sixty-four percent of the drivers associated the dual-driveway system presented in slide 2 with normal one-way driveway operation. Most of the remaining drivers (28 percent) indicated that two-way operation was permitted at both driveways. Eight percent of the drivers said that the layout implied a "reverse" one-way driveway operation--in other words, keep to the left. The operational patterns implied to motorists were consistent for the various maneuvers.

As seen in the table, driver responses to question b supported the trends observed in the question a responses. Generally speaking, almost 90 percent of the drivers said they would use the system shown

in slide 2 as a one-way driveway pair, whereas slightly more than 10 percent said they would violate the normal one-way operation pattern.

Angle Driveway System

Based on question a responses in the table, 68 percent of the drivers associated the angle driveway system in slide 3 with normal one-way driveway operation. Thirty percent said that all entry and exit maneuvers could be made at both driveways, and only 2 percent said that the layout implied a re-

Driver responses to question b support the trends observed in question a responses, which indicates that most drivers would prefer to use the driveways as a normal one-way pair. Also interesting to note from the question b responses is the fact that normal one-way operation was implied to more drivers for right-turn maneuvers than for left-turn maneuvers (98 versus 86 percent). This result is attributed to the geometric design of the driveways. For example, drivers making a left turn into driveway B must turn sharply because of the angle of the driveway and the relatively small curb return radius. Thus, some drivers were apparently discouraged from using driveway B and encouraged to use driveway A for left-turn entry maneuvers.

Divided-Driveway System

From Table 1, it is apparent that the divided-driveway layout in slide 4 strongly implied normal one-way driveway operation. Only 2 percent of the drivers (1 driver in the sample of 50) said he could and would use driveway B for the left-turn exit maneuver. All other drivers said that they would enter the parking lot by using driveway B and leave the parking lot by using driveway A.

SUMMARY

A human-factors laboratory study was conducted in Texas to evaluate the influence of driveway layout and its relation to other physical features on driveway selection by motorists. Two-hundred motor-

ists participated in these studies. The study results should be regarded as preliminary, since the study was conducted in only one part of the country and the study sample was younger and better educated than the national driving population.

Some of the more significant findings from the studies are summarized below:

1. The physical layout of driveways can influence motorists' expectations and interpretations of traffic operations. Motorists will perceive that certain driveways are one-way and others are two-way, depending on the physical layout. Certain driveway layouts also imply to some motorists that particular maneuvers (such as left-turn exit or left-turn entry) are prohibited.

2. Individual drivers may interpret and respond to a particular driveway layout differently. For example, almost all drivers agreed in their interpretation of a divided-driveway layout, but there was considerable inconsistency among drivers in interpreting and responding to a three-driveway layout.

3. Motorists' reluctance to violate the principle of one-way traffic operation (keep to the right) greatly influences their interpretation of and response to various driveway layouts.

4. Even though one-way operation was strongly implied by all of the two-driveway systems studied, not all motorists agreed with this interpretation. Therefore, it should be recognized that driveway layout alone may not provide enough information for drivers to determine with consistency the intended operation at one-way driveways. Thus, the use of effective signs and markings at these driveways is encouraged.

5. In the studies, drivers said that they would use the driveway closest to their origin (for entry maneuvers) or destination (for exit maneuvers),

provided use of that driveway did not violate the normal one-way operation pattern. If it did violate the pattern, however, many drivers said that they would use a different driveway, one whose use was consistent with the normal one-way operation pattern.

6. The angled dual-driveway system implied normal one-way operation to a slightly higher percentage of drivers than the parallel dual-driveway layout. The studies did not fully indicate that angled driveways might also discourage left-turn maneuvers.

ACKNOWLEDGMENT

The research documented here was part of a study sponsored by the Traffic Safety Section of the Texas State Department of Highways and Public Transportation and entitled "Guidelines for Driveway Design and Operation." Bobby G. Lay of the Traffic Safety Section is acknowledged for his guidance and assistance in all phases of the research study.

We would also like to acknowledge Daniel B. Fambro of the Texas Transportation Institute, who presented this paper at the Annual Meeting of the Transportation Research Board in Washington, D.C., and also provided assistance in the conceptual development of the study.

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