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16. Abstract

This report documents procedures and results associated with the development of improved guidelines for driveway to entrance ramp spacing along freeway frontage roads. The analyses utilized in this research consisted of operational and crash/safety assessments — both of which were based upon field data specifically collected as a part of this research project and/or historical data. Several locations in the San Antonio and Austin, Texas, areas were utilized as field sites in this study.

The results of the research indicate that an adoption of new "desirable" guidelines should be pursued to accompany the current guidelines — the latter of which it is suggested be retained as "absolute minimum" spacing guidelines. The new "desirable" guidelines serve to double the distance in existing guidelines in relation to both upstream and downstream placement of driveways in relation to entrance ramps. This change specifically entails going from an absolute minimum of 100 feet to a desirable spacing of 200 feet upstream of the ramp and an absolute minimum of 50 feet to a spacing of 100 feet downstream of the ramp.

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DEVELOPMENT OF IMPROVED GUIDELINES FOR FRONTAGE ROAD DRIVEWAY ACCESS AT ENTRANCE RAMP LOCATIONS

by

Marc S. Jacobson
Assistant Research Scientist
Texas Transportation Institute

Rene Arredondo
Research Associate
Texas Transportation Institute

and

Russell H. Henk, P.E.
Associate Research Engineer
Texas Transportation Institute

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Sponsored by the
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The Texas A&M University System
College Station, Texas 77843-3135

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I. INTRODUCTION

Project 7-2927 is a three-year study that began on September 1, 1996. The objective of this project is to develop recommended spacing between an exit ramp and a downstream driveway along a frontage road as well as between frontage-road driveway access and a downstream entrance ramp. This report summarizes the research procedures and results from the study of frontage-road driveway access to downstream entrance-ramp spacing and also includes recommendations stemming from these research activities.

PROBLEM STATMENT

The Texas Department of Transportation (TxDOT) Design Division *Operations and Procedures Manual* currently prohibits the location of frontage road access within 100 feet upstream and 50 feet downstream of the intersection of travel ways (i.e., beginning of the painted gore of the entrance ramp [*1*]). The manual does not maintain a need for the use of longer distances upstream of the entrance ramp that may be desirable for high-volume entrance-ramp, driveway or frontage-road conditions. Therefore, if TxDOT is going to successfully establish and maintain safe and efficient operations for freeway ramps and frontage roads in high-volume urban areas, it should consider the development of more specific guidelines for driveway access location.

Following this brief introduction section is an overview of the general research approach and some specific procedures utilized in this study. The report presents the findings associated with each major phase of the analysis and concludes with recommendations for new guidelines regarding frontage-road access to entrance-ramp spacing. Guidelines for exit ramp to downstream frontage-road access spacing were presented in a previous report published in September 1998 (Research Report 2927-1).

II. RESEARCH APPROACH

The research approach taken by the research team can be separated into two major efforts: 1) performing a crash analysis at the entrance-ramp study sites and 2) determining the required distance for minimizing differential speeds of vehicles entering an entrance ramp. This approach allowed the research team to evaluate existing field conditions as set by the current guidelines. Recommendations were proposed for improving these guidelines to better ensure safe and efficient traffic operations in the vicinity of frontage-road entrance ramps.

The study research plan involved the following specific tasks:

Task 1: Review literature (e.g., existing guidelines),

Task 2: Identify study sites,

Task 3: Conduct field data collection and observations,

Task 4: Analyze field data,

Task 5: Analyze crash data, and

Task 6: Develop modifications to guidelines.

This report presents procedures associated with these tasks.

III. RESULTS

LITERATURE REVIEW

A literature review conducted during the exit-ramp study revealed that few studies have specifically addressed ramp-to-driveway spacing. From those studies that were reviewed, the following findings were relevant to this study:

- The major factors affecting the distance required to complete a two-sided weaving maneuver on a frontage-road are frontage-road volume and number of frontage-road lanes (*2*).
- A 1980 survey of state and local agencies revealed that existing distances between a ramp terminal and nearest access point ranged between 100 and 1500 feet (*3*).
- A 1976 study reported that general design guidelines for the Interstate Highway System suggest that access control should extend along the crossroad beyond the terminal about 100 feet or more in an urban area and about 300 feet or more in a rural area (*4*).

These aforementioned references apply specifically to the exit ramp to downstream driveway spacing issue. No references regarding driveway to entrance ramp spacing were identified in the literature review.

An additional noteworthy item identified in the literature review related to speed variability between vehicles. Past research has consistently indicated that speed differential between vehicles (as opposed to absolute speed) is the primary contributing factor to vehicle-to-vehicle collisions (*5, 6*). This phenomenon is probably best illustrated in Figure 1, which represents a conglomeration of over 30 years of research on this particular topic (*5*). As can be noted in Figure 1, crash-rate probability increases significantly with increasing speed differential. Crash probability becomes particularly high once speed differential between vehicles is greater than 10 miles per hour (mph).

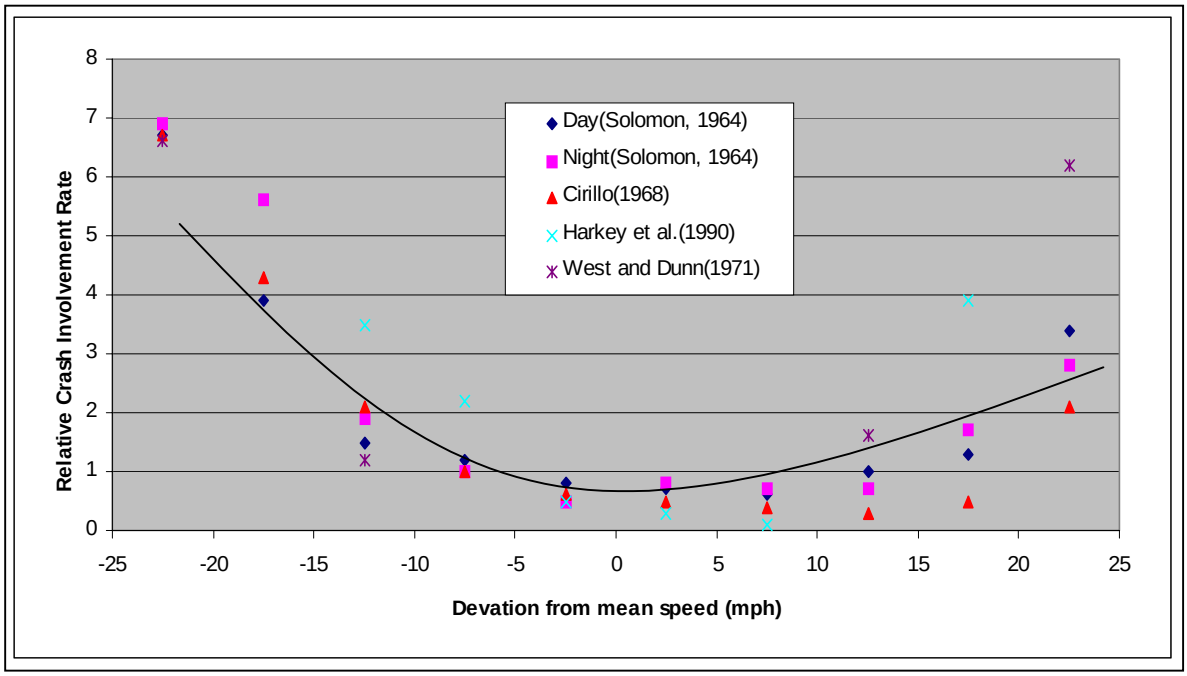


Figure 1. Crash Involvement and Overtaking Rates Relative to Average Rate and Speed.

As a result of this finding, the research conducted during this study was directed at determining adequate spacing between frontage-road access points and a downstream entrance ramp based on this target value of establishing a maximum speed differential of 10 mph. Existing guidelines of the *Operations and Procedures Manual* were accepted as the benchmark to determine if modifications to current guidelines were warranted.

FIELD STUDIES

Data Collection

Data were collected at various sites in San Antonio and Austin, Texas, to observe motorist behavior at locations with a high number of driveways upstream of an entrance ramp. These data were necessary in determining the proper spacing and distance required to safely access an entrance ramp from an upstream driveway while minimizing the effect on frontage-road vehicles.

The data-collection process began with the evaluation of numerous potential study sites within the San Antonio and Austin, Texas, highway systems. The typical study site included a

location with an entrance ramp downstream of multiple driveway-access points along the frontage road. Sites were selected specifically for the following criteria:

- driveway to entrance ramp spacing,
- frontage-road traffic volume,
- frontage-road speeds,
- minimal variability in vertical and/or horizontal curvature of roadway geometry,
- frontage- road driveway (access) density, and
- number of frontage-road lanes.

Table 1 contains a listing of the five study sites and one control site used for detailed analysis in this research study. The table describes the site location, facility name, distance from entrance ramp to nearest driveway, and frontage-road configuration.

The data-collection process included the use of video cameras for recording the origin and destination of vehicles entering the frontage road from a driveway. The research team also used video data to identify frontage-road vehicles affected by vehicles entering the frontage road from a driveway. Speed data were collected using magnetic-imaging traffic recorders (Histar counters manufactured by Nu-metrics), which were placed along the frontage-road, driveways, and entrance ramp. The recorders were also essential in determining the time of entrance for vehicles originating from the frontage-road driveways, which were then correlated with the video data.

Table 1. Description of Study Sites in San Antonio and Austin, Texas.

Site	Freeway	City	Location	Distance to Driveway feet	Frontage Rd. Configuration
1	US 281	San Antonio	Bitters	85	3-Lane w/Aux.
2	US 281	San Antonio	Thousand Oaks	50	3-Lane w/Aux.
3	US 281	San Antonio	Brook Hollow	115	3-Lane w/Aux.
4	US 183	Austin	Braker	85	3-Lane
5	IH 35	Austin	US 290	265	3-Lane
6	IH 410	San Antonio	New Valley Hi [1]	745	3-Lane

1 Location of the control site

As illustrated in Figure 2, a traffic recorder was specifically placed on the entrance ramp to determine the total traffic volume entering the freeway and also to determine the individual spot speed of all entrance ramp vehicles. The video camera was oriented in a position that would allow the research staff to determine the origin and destination of all vehicles utilizing the frontage road and entrance ramp.

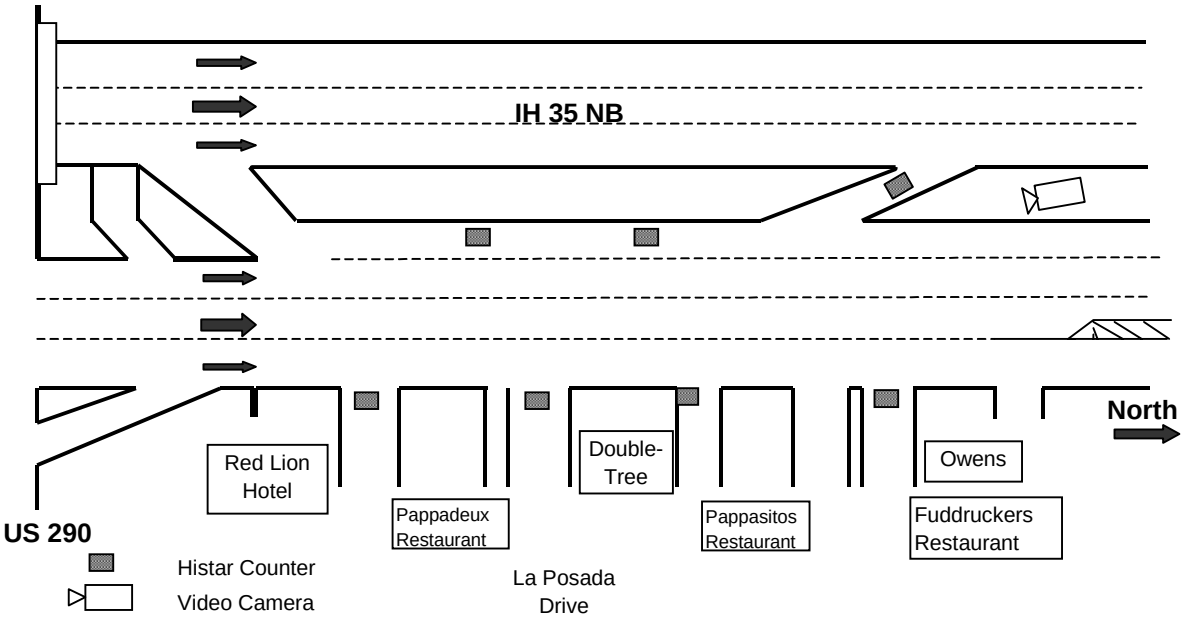


Figure 2. Typical Study Site with Data-Collection Equipment Setup.

Data Reduction

The traffic recorders were set to record in a sequential mode, which records individual vehicle data such as velocity, classification, and headway. Using this traffic-recorder data in conjunction with the video data, the researchers were able to identify each vehicle and determine its origin and destination. Using this procedure, researchers were able to calculate an entrance-ramp average speed for vehicle groups originating at different driveways along the frontage road. Figure 3 illustrates the data acquired from this data-reduction process.

The data-reduction process described was conducted at five study sites and one control site. The process involved between six to 12 hours of recorder and video data, depending on the specific site. While tracking vehicles on the frontage road, the following general information was recorded:

- origin of all vehicles using the entrance ramp,
- frontage-road vehicles impeded by driveway vehicles, and
- traffic conditions along frontage road (i.e., constrained or unconstrained).

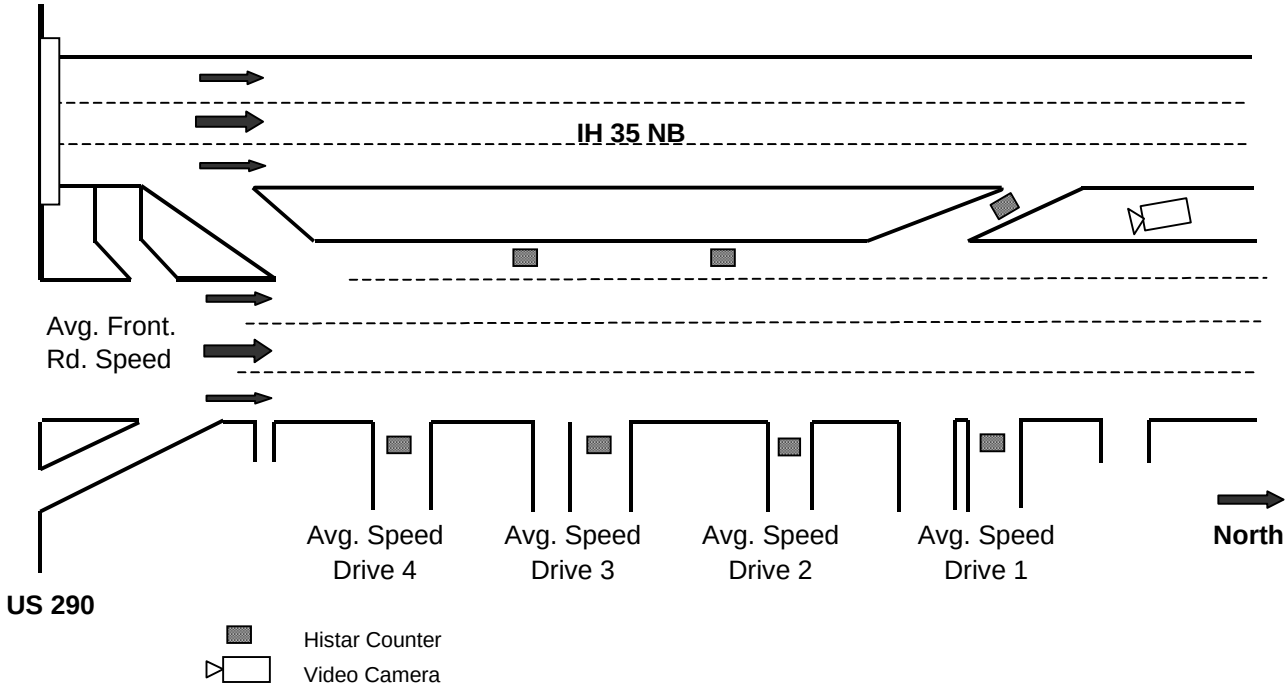


Figure 3. Entrance-Ramp Average Speeds for Vehicle-Origin Groups.

Data Analysis

The objective for conducting the data analysis was to examine the relative entrance-ramp speeds between vehicles entering from the frontage road and vehicles entering from a driveway, and then to cross-reference the speed data against driveway to entrance ramp distance(s). Due to the considerable differences in the five study sites (e.g., varying traffic volumes, number of

driveways and specific location, adjacent land use, etc.), the research team conducted the analysis using comparisons of the data in aggregate terms only (as opposed to a detailed statistical analysis).

The researchers removed from the data sample all frontage-road vehicles directly affected (i.e., impeded) by driveway vehicles entering the frontage road. This allowed for the calculation of an average speed for frontage road vehicles with free-flow conditions. The same was not needed for driveway vehicles because of the relatively low volume recorded at the driveways. The researchers also used data to evaluate the "attractiveness" or perceived safety and efficiency of driveway location based on volume of use (i.e., frequency of use given multiple driveway options). The results obtained from this data analysis were to be examined and used to evaluate the operations and the safety effectiveness of existing guidelines.

For each of the study sites, the researcher determined an average speed at the entrance ramp for vehicles originating at the frontage road and at each of the driveways along the frontage road. They then compared the entrance ramp average speed for vehicles originating at each of the driveways to the free-flow average speed of the frontage-road vehicles to determine the driveway-differential speed while entering the freeway. This analysis was used to better understand the effects on frontage-road vehicles caused by driveway vehicles entering the entrance ramp to a freeway.

OPERATIONAL ASSESSMENT

After determining the average speed at the entrance ramp for each of the driveway vehicle groups and the free-flow frontage-road vehicle group, the research team calculated a differential speed between the specific driveway upstream of the entrance ramp and the frontage road. They then tabulated these differential speeds for each of the study sites, along with the respective traffic volumes, driveway types, driveway distances to the entrance ramp, and average speed for vehicles on the entrance ramp. Table 2 contains the data for the Thousand Oaks at US 281 study site. Data for other sites examined in the analysis are included in the Appendix.

Table 2. Data for the Thousand Oaks at US 281 Study Site.

Study site:	**Thousand Oaks at US 281** **San Antonio, Texas**				
	Frontage[1]	**Driveway 1**	**Driveway 2**	**Driveway 3**	**Driveway 4**
Driveway Type	N/A	Strip Center	Strip Center	Strip Center	Strip Center
Number of Vehicles	2682	5	17	47	18
Distance (ft)	N/A	-45	50	175	410
Average Speed	51.9 [2]	42.0 [3]	33.9 [3]	38.3 [3]	45.9 [3]
Diff. Speed (mph)		**9.9**	**18.0**	**13.6**	**6.0**

[1] Frontage road characteristics across total 3-lane section

[2] Free-flow speed -- unimpeded vehicles using the entrance ramp which originated from the frontage road

[3] Speed on entrance ramp for these vehicles originating from the indicated driveway

The same table formats were used for all the study sites to understand the basic trends occurring within the frontage-road influence area. A trend between all study sites indicated a lower average differential speed as the distance between the driveway and entrance ramp increased. As Table 2 shows, Driveway 2 was the first driveway upstream of the entrance ramp (painted gore) and had an average differential speed of 18 mph. As the distance between the driveway and entrance ramp increases, the average differential speed has a tendency to decrease as well. For example, vehicles using the entrance ramp and originating from Driveway 4 (a distance of 410 feet) exhibit a speed differential of only 6 mph by comparison. Figure 4 shows a graph illustrating the increase in average speeds associated with the driveways upstream of the entrance ramp for this study site. The complete set of graphs for all study sites is located in the Appendix of this report.

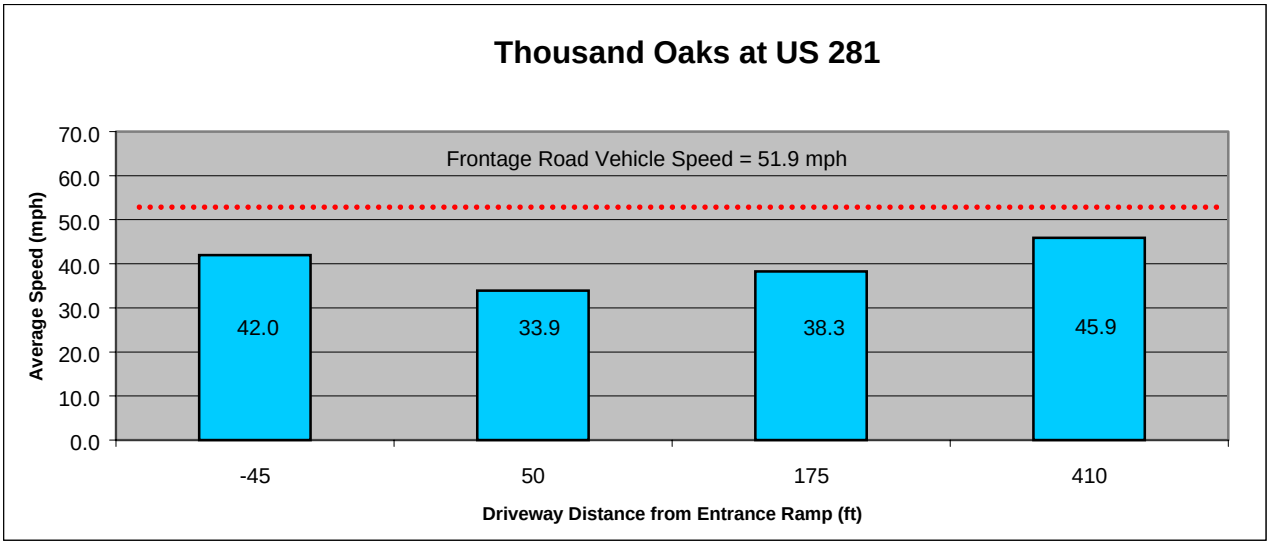


Figure 4. Average Speed for Driveways at Thousand Oaks Study Site.

Driveways located between the painted and physical gores were shown as negative distances. Speed and video data indicated that vehicles entering the entrance ramp through the painted gore were doing so at a higher rate of speed to compensate for distance. This is clearly visible for Driveway 1 of Figure 4. The nose of the painted gore was taken as the origin for measuring driveway distances, as demonstrated in the existing guidelines of TxDOT Design Division *Operations and Procedures Manual*.

The research team divided the average differential speed between the driveways and the frontage-road vehicles into distance subgroups to show the speeds for different distance groups from the entrance ramp. They then divided the distance groups into ranges, and recalculated average differential speeds for each of the ranges using the respective speed data from all sites. Table 3 shows the distance ranges with the calculated differential speeds for each group. Researchers saw the same general trend exhibited for the site presented in Table 2 and Figure 4 when they examined all sites in aggregate terms. As noted in Table 3, the speed differential for driveways located less than 100 feet from a downstream entrance ramp is unacceptably high and significantly above 10 mph. Driveway locations more than 200 feet upstream of the entrance ramp tend to produce speed differentials that are much more desirable (i.e., significantly less than 10 mph). This latter distance would double that required by the existing guidelines (Figure 5).

Table 3. Average Differential Speeds for Driveway Distance at All Study Sites.

Distance Range	Speed (mph)
< 0'	2.34
0-99'	15.00
100-199'	9.22
200-399'	5.67
400' -	2.06

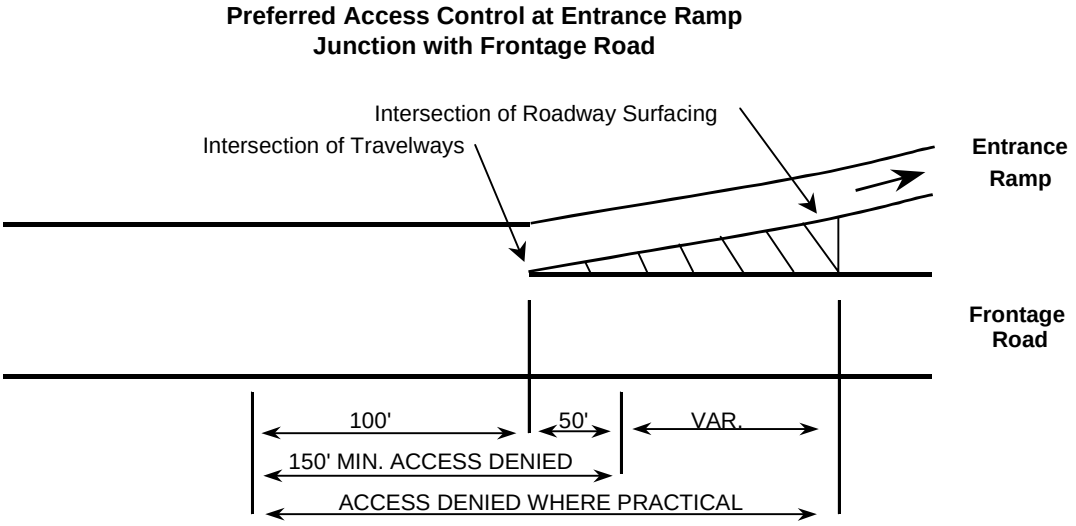


Figure 5. Current Guidelines in the TxDOT *Operations and Procedures Manual.*

DRIVEWAY "ATTRACTIVENESS"

Two of the five study sites examined in this analysis contained sets of interconnected driveways at strip-center (e.g., mini-mall) facilities. The research team also analyzed the attractiveness of the driveways at these locations, using traffic volume and distance data to evaluate motorist tendencies and behavior at driveways upstream of a freeway entrance ramp.

From observation of the total number of vehicles utilizing the driveways at these strip centers, the research teams concluded that the tendencies of the motorists are consistent. They calculated a weighted average distance from the upstream entrance ramp using the total number

of vehicles using the driveway and the driveway distances. Table 4 shows the numbers used to calculate the average distance preferred by the general motorist at the US 281 and Thousand Oaks study site.

Table 4. Strip-Center Driveway Preferences at US 281 at Thousand Oaks Study Site.

Distance Range (ft)	Distance	Number of Vehicles	Distance * Vehicles	Weighted Distance (feet)
0-100	-45	5	-225	
100-300	50	17	850	
300-500	175	47	8225	
500-	410	18	7380	
Total		87	16230	**186.55**

This location demonstrates an average of 187 feet as the preferred distance for egress from the US 281 at Thousand Oaks strip center. The research team followed the same procedures at the second location of US 281 at Brook Hollow. This site indicated an average of 241 feet as the distance for egress of the strip center. The results of this analysis show that the general tendency of motorists is to allow approximately 200 feet or more as sufficient distance between the driveway and entrance ramp to facilitate adequate weaving and acceleration distance to the target entrance ramp. Distance and traffic-volume data for both study sites are included in the Appendix.

CRASH ANALYSIS

The crash analysis performed in this study examined frontage-road accident rates in the vicinity of an entrance ramp at several of the study sites and the control site. The sites that were reviewed exhibited a variety of entrance ramp-to-driveway spacing and driveway densities. Similar to the exit-ramp study, site-selection criteria included frontage-road volume, entrance-ramp volume, number of frontage-road lanes, level of commercial development, posted speed limit, and driveway-to-ramp spacing. Figure 6 illustrates a typical crash diagram with crashes occurring within the vicinity of the driveways and entrance ramp.

The research team obtained the data used for the crash analysis from TxDOT through the Master Accident Listing. The Master Accident Listing is a standard accident information report compiled from the Texas Department of Public Safety's Traffic Accident Records merged with the TxDOT roadway information. The data analyzed covered a four-year time period from 1995 to 1998.

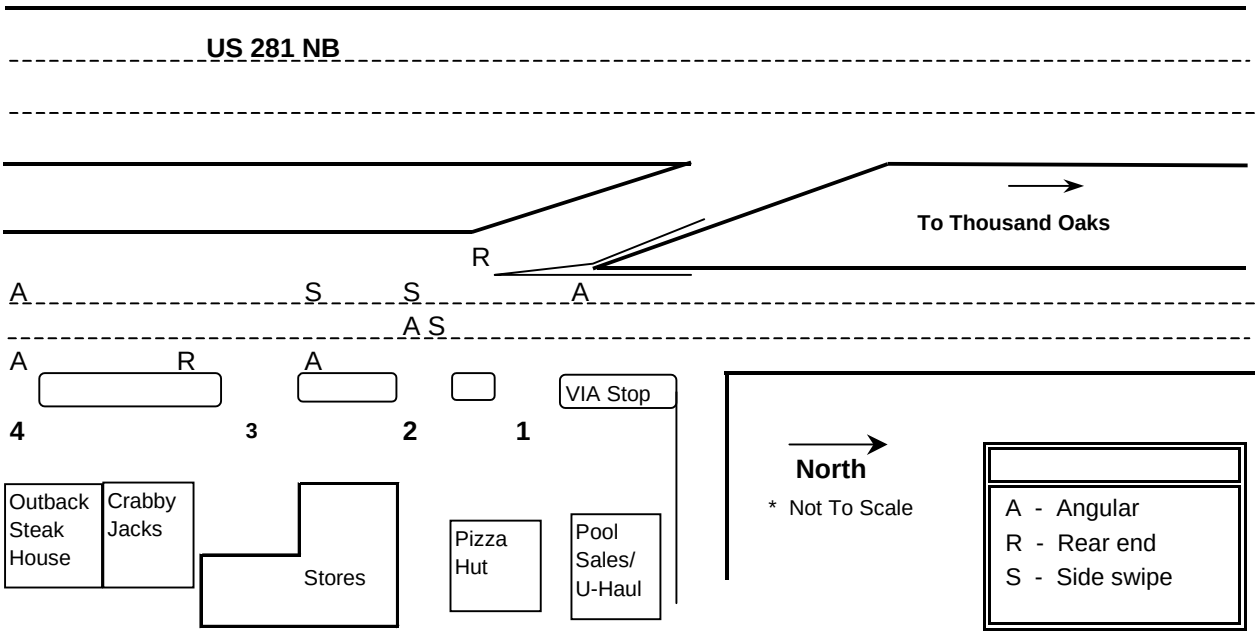


Figure 6. Crash Diagram for the US 281 at Thousand Oaks Site within Years 1995 to 1998.

Researchers summarized the crash data into a simplified crash diagram for determining the type and frequency of accidents occurring near the entrance-ramp and driveway vicinity. General observations from the crash diagrams indicated the following features to be prevalent:

- rear-end collisions near entrance to frontage road driveways,
- angular collisions near exit from driveways, and
- side swipe collision near approach to freeway entrance ramp.

The research team reviewed and analyzed the crash data to calculate an accident rate for the different study sites. They then determined the accident rate was determined by dividing the number of accidents by the average frontage-road volume (from the 1997 TxDOT Traffic

Volume Sheets) over the four-year time period. The accident rate for each site was reported as the number of accidents per million vehicles. Table 5 shows the calculated accident rates for several study sites including the number of access points along the study area and the distance of the closest driveway from the entrance ramp. As can be noted in Table 5, the crash rate increases significantly (roughly two-to-three times as frequent) for driveways located within 100 feet or less of the downstream entrance ramp – suggesting that, in addition to operational benefits, there would likely be safety-related benefits in requiring greater distance(s) between driveways and downstream entrance ramps.

Table 5. Crash Data Summary.

Location	Crash Rate (per million vehicles)[1]	Number of Access Points[2]	Closest Driveway Location (ft)[3]
Loop 410 SB, north of New Valley High[4]	0.38	4	735
Loop 1604 EB, east of Gold Canyon[4]	0.32	1	635
US 281 NB, north of Nakoma	0.96	4	75
US 281 NB, north of Brook Hollow	0.99	6+	105
US 281 SB, south of Thousand Oaks	0.66	4	50

[1] The number of crashes per million vehicles traveling the indicated frontage road section

[2] The number of access points within the immediate (<= to 1500 ft) upstream section of the entrance ramp (downstream of the nearest exit ramp)

[3] The distance from the nearest frontage road access point to the (painted) gore of the entrance ramp

[4] Control sites used for this study

IV. RECOMMENDATIONS

Using the results obtained through this research effort, the research team developed recommendations for modifying the existing guidelines. The crash analysis conducted accounts for the safety of the frontage road to entrance ramp intersection. Field studies and operational assessments indicated that the existing guidelines are consistent with absolute minimum safety and operations requirements. However, modifications of the current guidelines to create new "desirable" specifications appears to be warranted to further enhance safe and efficient travel.

MODIFICATIONS TO EXISTING GUIDELINES

As shown in Table 3, distances between the entrance ramp and the first upstream frontage road access point should be increased considerably from the current guidelines to more effectively reduce that speed differential. Current guidelines have access points denied at a minimum of 100 feet upstream and 50 feet downstream of the entrance ramp. Based on the speed differentials listed in Table 3, the research team recommended that the current guidelines be increased to 200 feet upstream and 100 feet downstream of the entrance ramp (painted gore). These recommendations are illustrated in Figure 7.

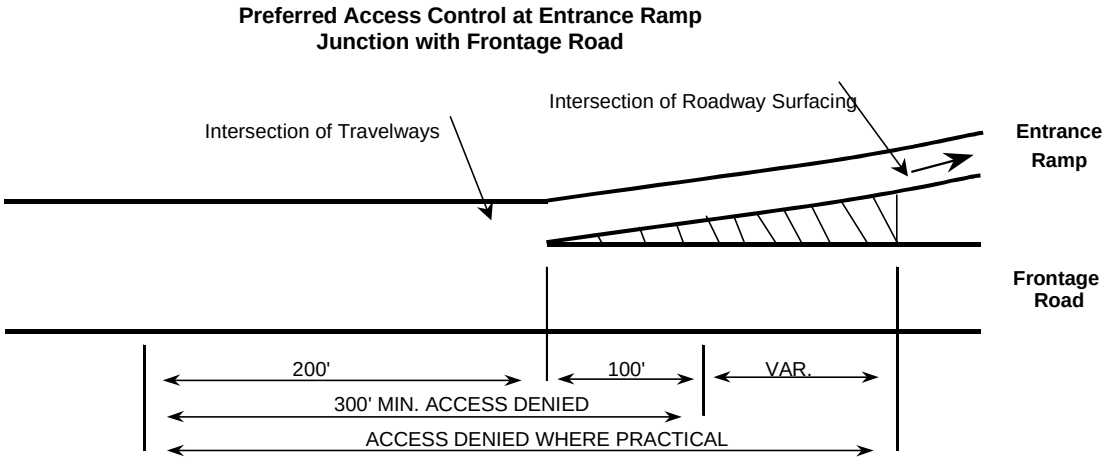


Figure 7. Recommended "Desirable" Modifications to the Current Guidelines of the TxDOT *Operations and Procedures Manual.*

The increased distance in the modified guidelines for denying access points upstream and downstream of the entrance ramp does not represent a radical departure from existing guidelines and, therefore, should not place unrealistic constraints on land development adjacent to freeways. It may be necessary to allow for limited flexibility when restricting access points near the vicinity of freeway entrance ramps. For this purpose, the existing guidelines can be retained and utilized as "absolute minimum" guidelines (Figure 8).

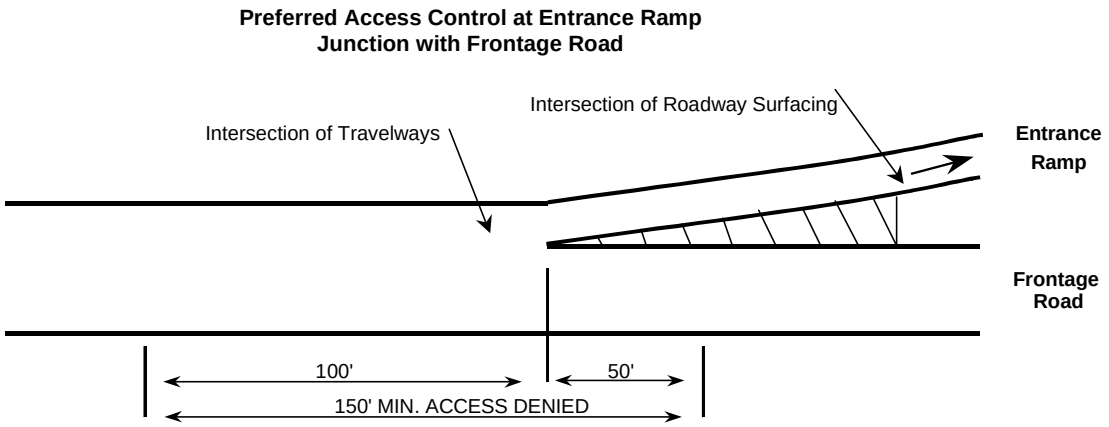


Figure 8. Absolute Minimum Guidelines for the TxDOT *Operations and Procedures Manual.*

REFERENCES

1. Operations and Procedures Manual. Part IV, Interim Metric Version. Texas Department of Transportation, Highway Design Division, Austin, TX, 1994.

2. Nowlin, L., and K. Fitzpatrick. Two-Sided Weaving Analysis on One-Way Frontage Roads. Texas Transportation Institute, Report 1939-2, Texas A&M University, College Station, TX 1996.

3. Chiu, H., E.C. Carter, and P.M. Schonfeld. State-of-the-Art Studies/Fy '87: Task 8 Intersections and Driveways near Freeway Ramps. Maryland Department of Transportation, MD 88/02, July 1987.

4. Copas, T.L., and H.A. Pennock. Design and Control of Freeway Off-Ramp Terminals. In NCHRP Synthesis of Highway Practice 35, TRB, National Research Council Washington, D.C. 1976.

5. Synthesis of Safety Research Related to Speed and Speed Limits, Publication No. FHWA-RD-98-154, March 1999.

6. Highway Safety: Factors Affecting Involvement in Vehicle Crashes. General Accounting Office (GAO), Report PEMD-95-3, March 1995.

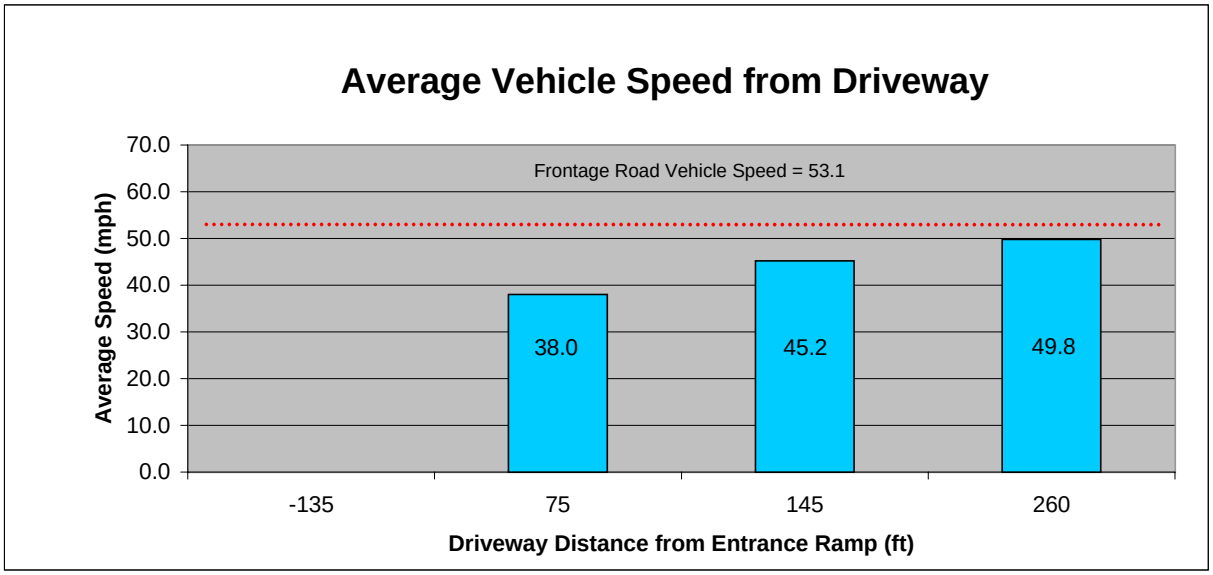
APPENDIX

Average Vehicle Speeds from Driveways at Study Sites

Figure A-1. US 281 at Bitters, San Antonio, Texas.

Location:	Bitters at US 281					
Counter:	9298					
File:	Bitters.xls, S925					
						Total
	Frontage	Driveway 1	Driveway 2	Driveway 3	Driveway 4	4
Driveway Type	4 Lane *	Restaurant	Restaurant	Drive	Conv. Store	
Vehicles	2509	0	1	76	31	2617
Distance (ft)	-	-135	75	145	260	
Speeds	53.05	0.00	38.00	45.20	49.77	

* 3 lanes plus 1 auxilary entrance ramp lane



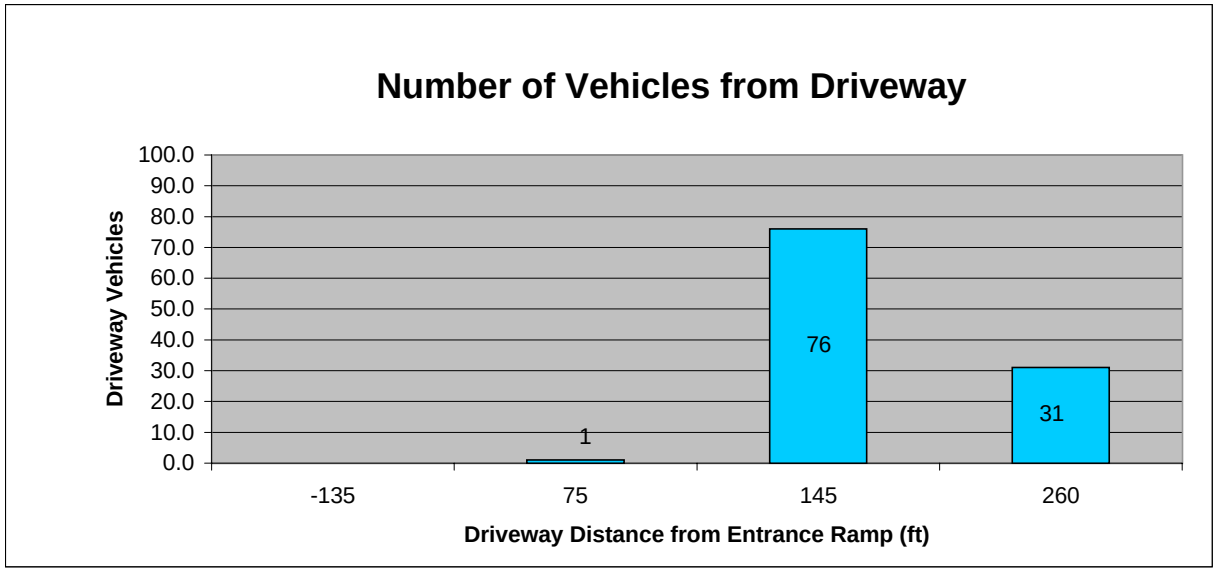
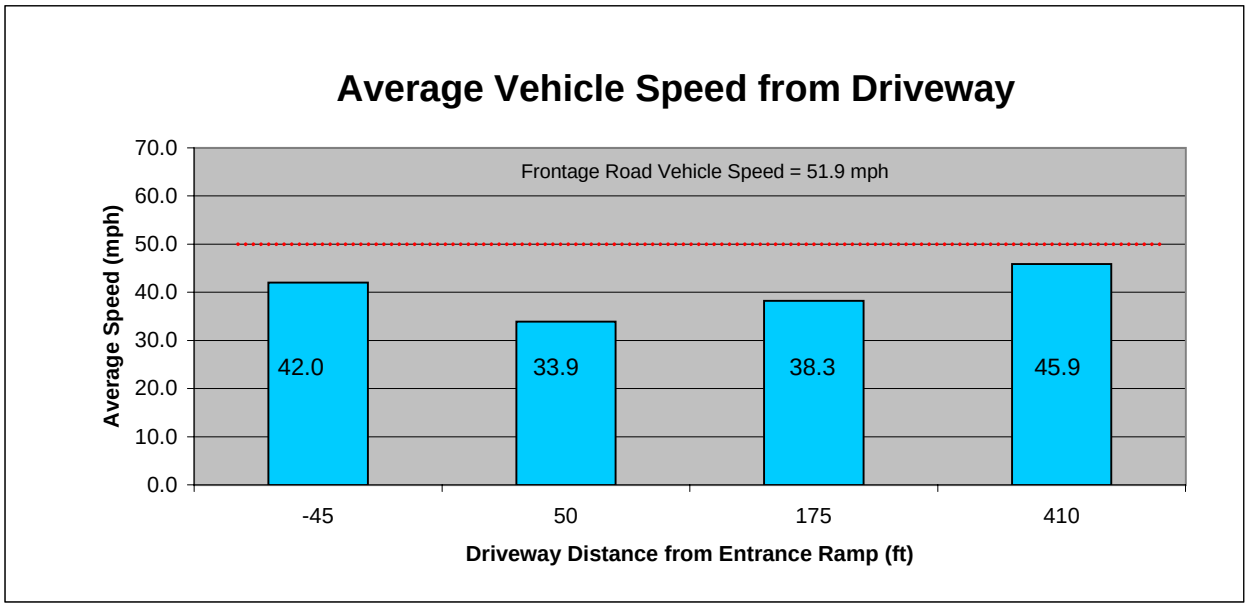


Figure A-2. US 281 at Thousand Oaks, San Antonio, Texas.

Location:	Thousand Oaks at US 281					
Counter:	1745					
File:	Thousand Oaks.xls, S859					
						Total
	Frontage	Driveway 1	Driveway 2	Driveway 3	Driveway 4	4
Driveway Type	3 Lane	Strip Center	Strip Center	Strip Center	Strip Center	
Vehicles	2682	5	17	47	18	2769
Distance (ft)	-	-45	50	175	410	
Speeds	51.93	42.00	33.88	38.26	45.89	



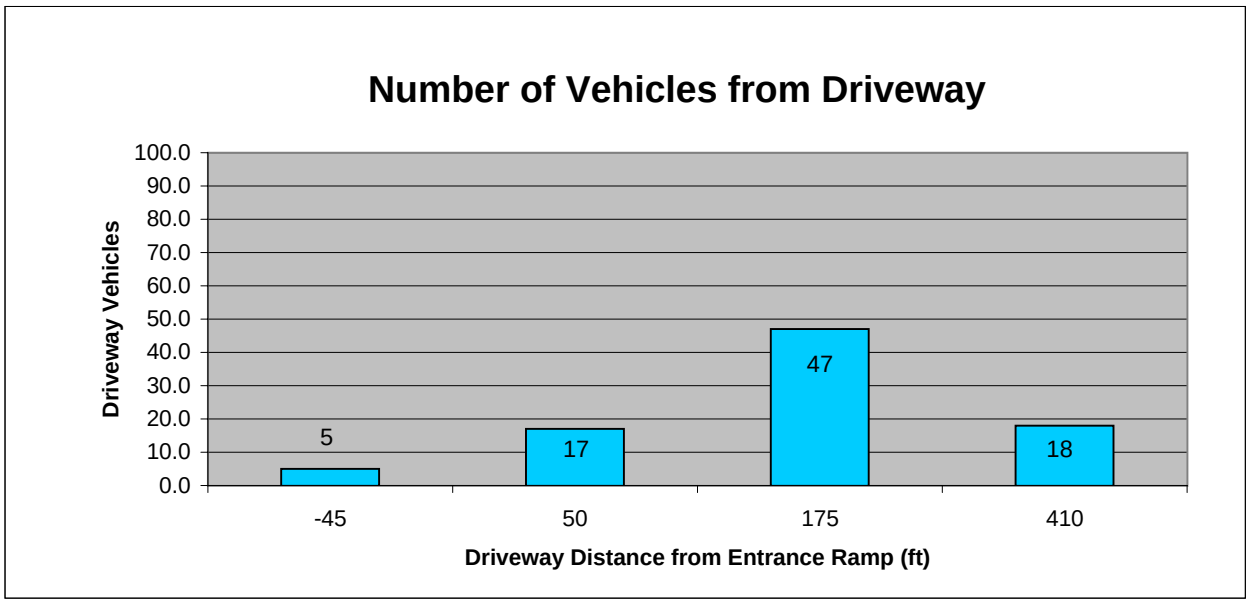
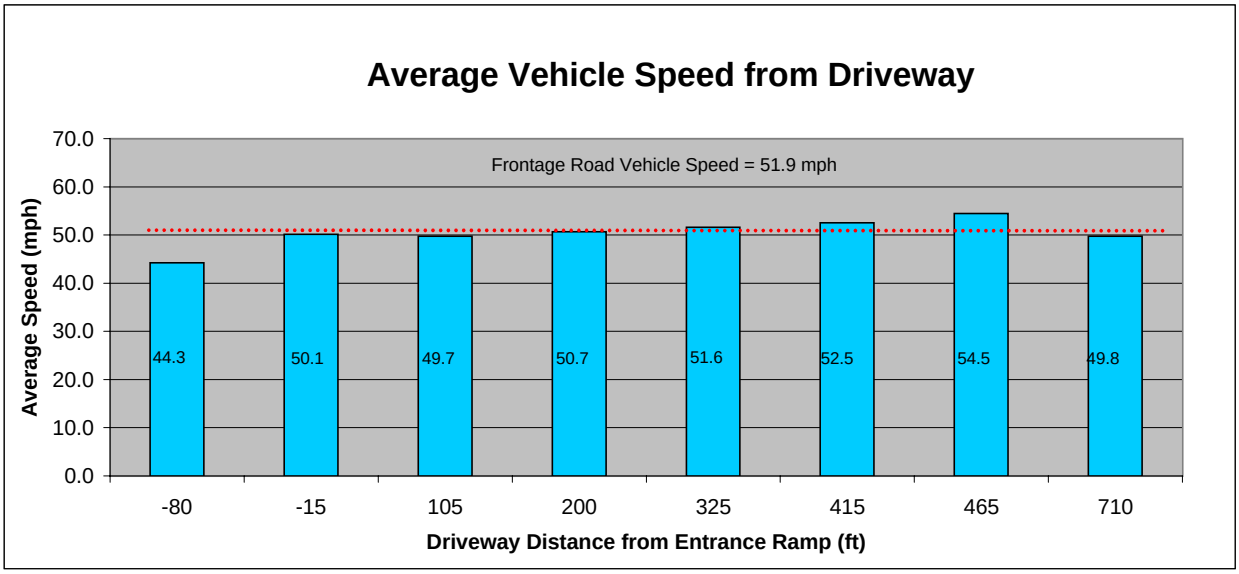


Figure A-3. US 281 at Brook Hollow, San Antonio, Texas.

Location:	Brook Hollow at US 281									
Counter:	659									
File:	Brookhollow.xls, S869									
										Total
	Frontage	Driveway 1	Driveway 2	Driveway 3	Driveway 4	Driveway 5	Driveway 6	Driveway 7	Driveway 8	8
Driveway Type	4 Lane *	Strip Center	Strip Center	Strip Center	Strip Center	Strip Center	Strip Center	Strip Center	Strip Center	
Vehicles	3682	8	137	15	225	20	13	29	69	4198
Distance (ft)	-	-80	-15	105	200	325	415	465	710	
Speeds	51.86	44.25	50.12	49.73	50.67	51.60	52.54	54.48	49.75	

* 3 lanes plus 1 auxilary entrance ramp lane



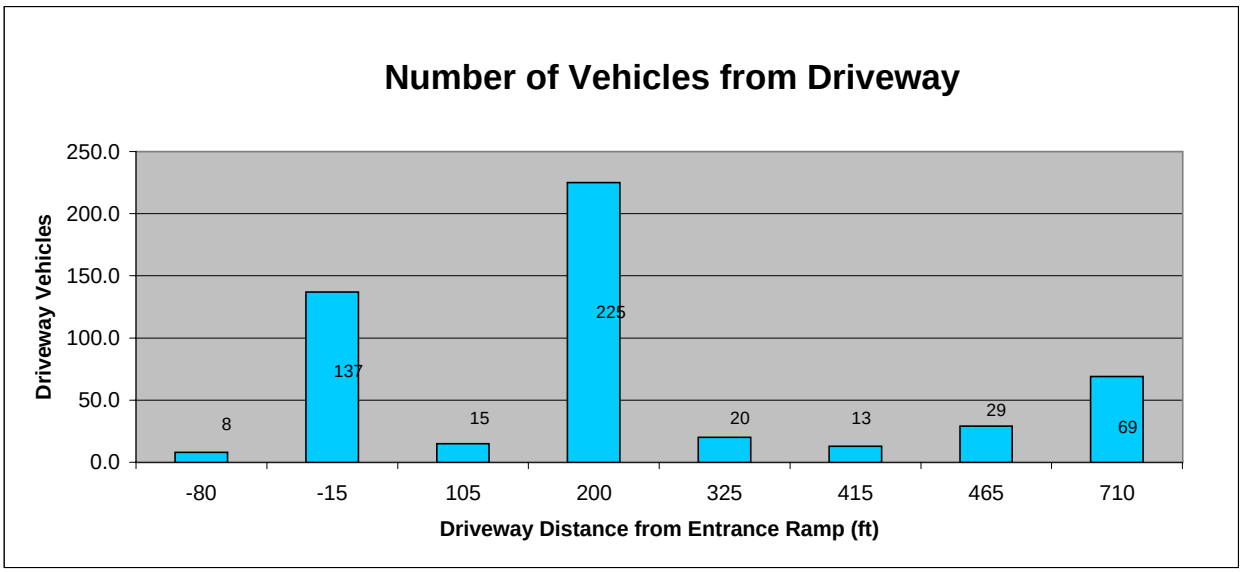
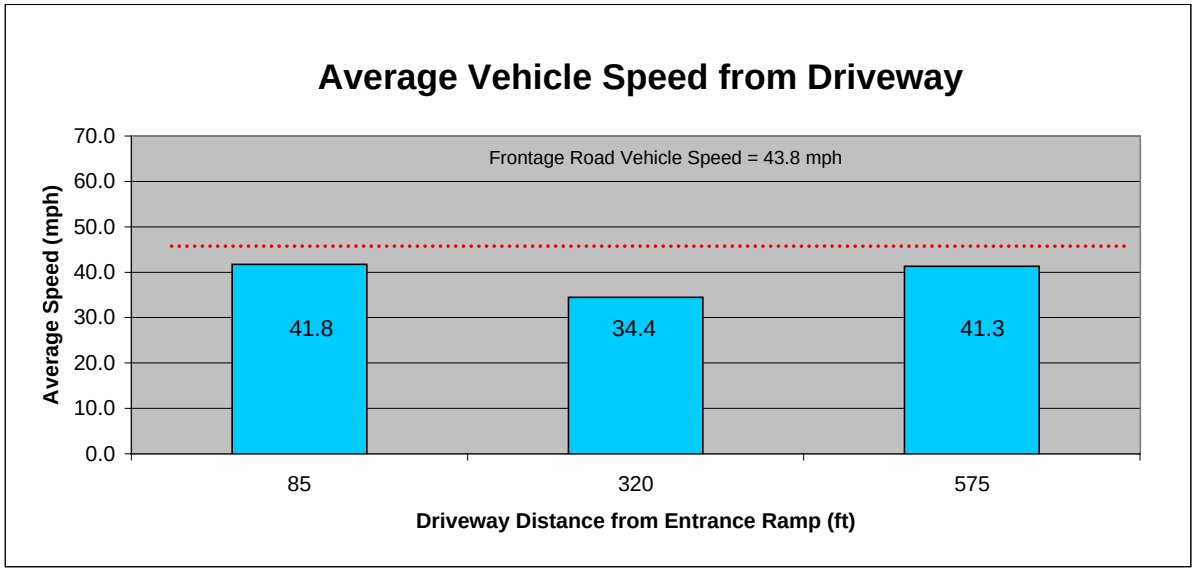


Figure A-4. US 183 at Braker Lane, Austin, Texas.

Location:	Braker Ln at US 183				
Counter:	3126				
File:	Austinhi BrakerLn.xls, 3126				
					Total
	Frontage	Driveway 1	Driveway 2	Driveway 3	3
Driveway Type	3 Lane	Restaurant	Strip Center	Strip Center	
Vehicles	3719	4	327	268	4318
Distance (ft)	-	85	320	575	
Speeds	43.76	41.75	34.44	41.34	



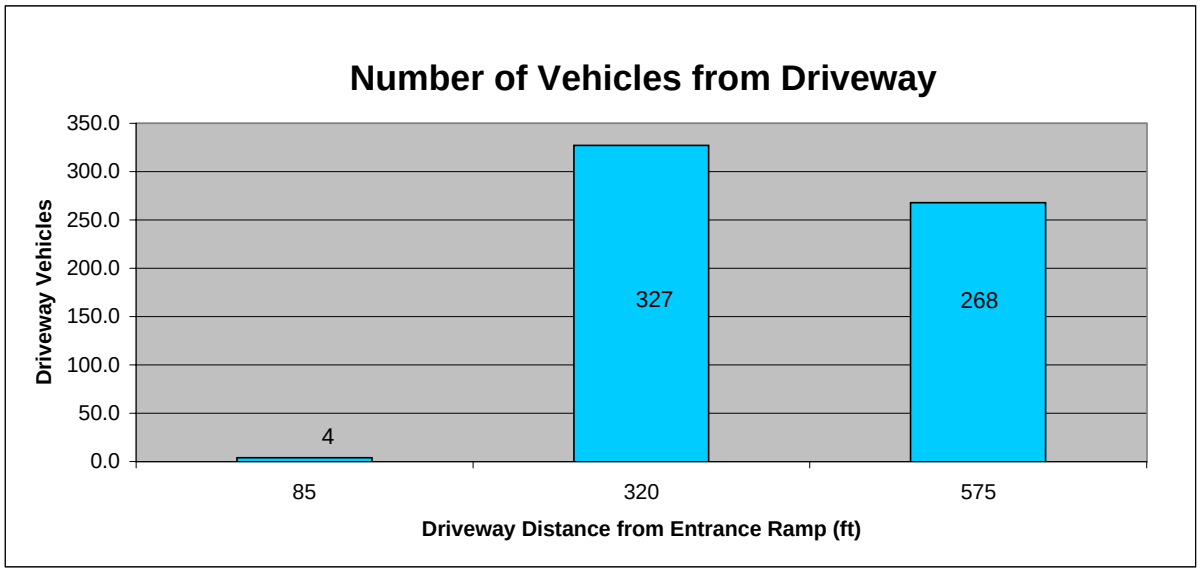
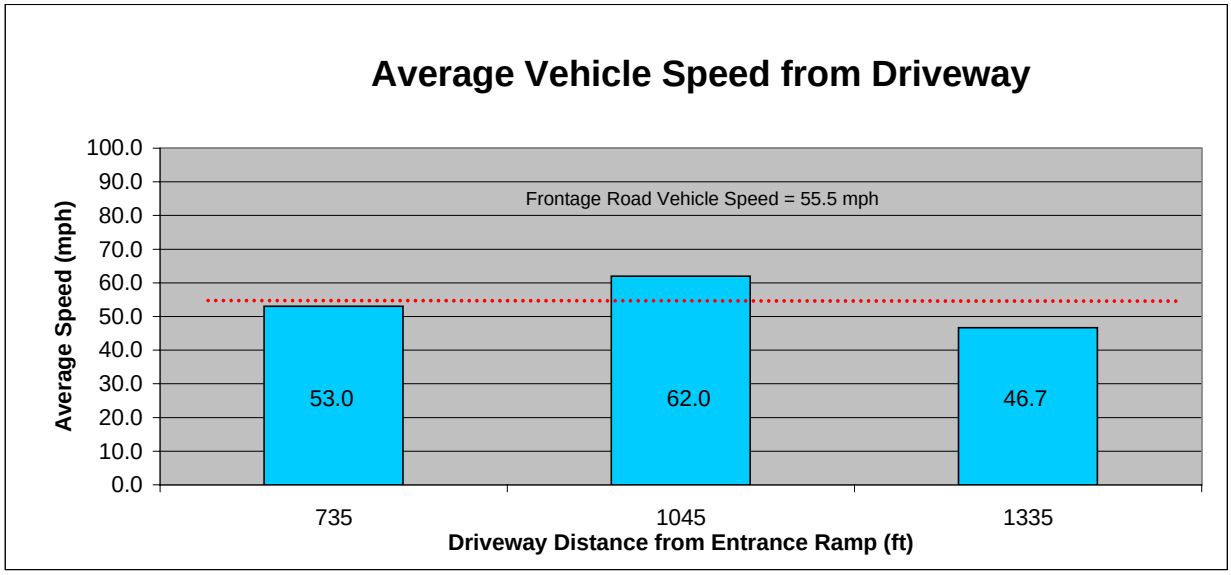


Figure A-5. Loop 410 at New Valley Hi, San Antonio, Texas.

Location: Loop 410 at New Valley Hi (CONTROL SITE)
Counter: 1080
File: Valleyhi.xls, 1080

	Frontage	Driveway 1	Driveway 2	Driveway 3	Driveway 4	Total
Driveway Type						
Vehicles	1440	1	5	3	0	1449
Distance (ft)		735	1045	1335	1640	
Speeds	55.48	53.00	62.00	46.67		



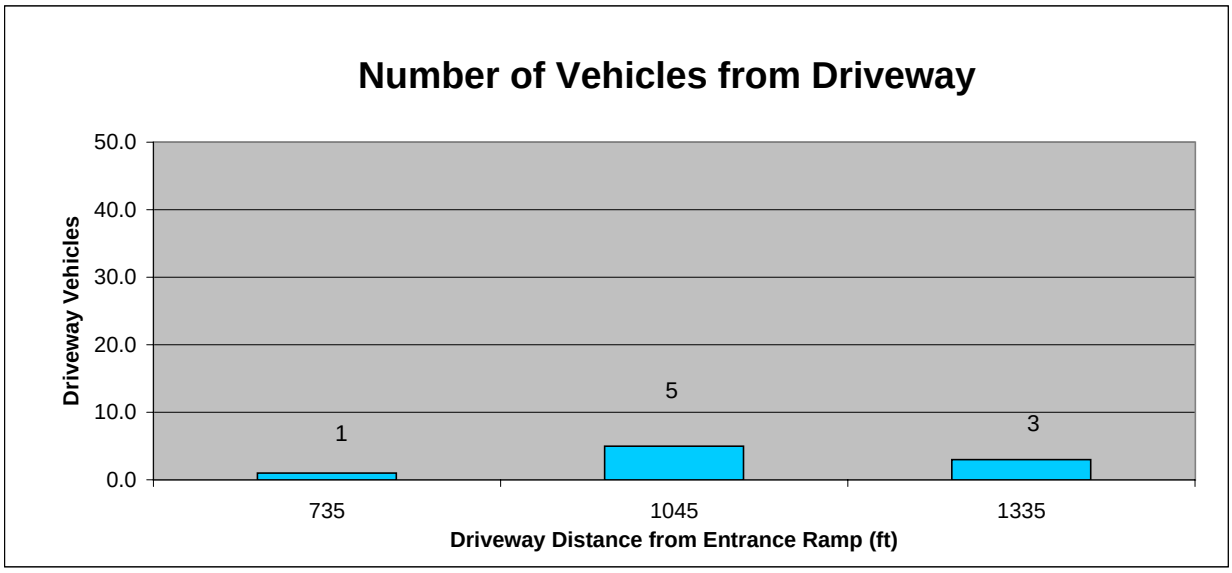


Figure A-6. US 290 at IH 35, Austin, Texas.

Location:	IH 35 at US 290					
Counter:	3125					
File:	Austin35@290.xls, 3125					
						Total
	Frontage	Driveway 1	Driveway 2	Driveway 3	Driveway 4	4
Driveway Type	4 Lane *	Lodging	Lodging	Drive	Lodging	
Vehicles	4905	110	16	264	0	5295
Distance (ft)	-	260	540	805	1075	
Speeds	47.12	43.66	43.83	46.95	none	

* 3 lanes plus 1 auxilary entrance ramp lane