Abridgment

Effects of Reduced Speed Limits in Rapidly Developing Urban Fringe Areas

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Speed zoning on the basis of the 85th percentile speed in rapidly developing urban fringe areas usually results in the posting of 55 mph speed limits. Although these areas have some urban-like characteristics, no differentiation in speed limits is made between highways in these areas and those in rural locations. Speed zoning below the 85th percentile may be beneficial to drivers in rapidly developing areas, indicating that the area requires additional attention and caution. Presented in this paper are the results of field studies conducted at six urban fringe highway sites in Texas where speed limits were currently 55 mph and rapid urban development was occurring. Speed zones of 45 mph were installed at these sites even though the 85th percentile speed did not warrant the lower speed zones. Spot speed, speed profile, and accident data were collected before and after the speed zones were implemented. No significant changes occurred in speeds, speed distributions, or speed-changing activity at the sites. Likewise, accident rates remained unchanged. It appears that the lower speed zones were not effective in improving safety at these sites.

In recent years, several sections of highways on the fringes of many major cities in Texas have been experiencing rapid urban development. The driving environment on these highways has become more complex as traffic volumes increased, adjacent commercial and residential dwelling units were constructed, and new and additional forms of traffic control were installed during a short period of time. At many locations, accidents and accident rates have increased significantly. As a result of the high speeds still present on these highways, many of the accidents have been quite severe.

Current speed zoning procedures *(1)*, which rely primarily on the 85th percentile speed of traffic on a facility, may not be adequate for these rapidly developing urban fringe areas. Even though the areas develop some urban characteristics, the 85th percentile speed usually indicates that a speed limit of 55 mph be posted, identical to that posted in rural areas. In effect, no distinction in speed limits is made between highway sections in a rural area and highway sections undergoing rapid development in urban fringe areas.

Speed zoning procedures might be improved by allowing a speed limit to be posted below the 85th percentile speed in these rapidly developing urban fringe areas. This action may signal to motorists that the driving environment is more complex and that additional attention and caution is needed. To test this hypothesis, the Texas Transportation Institute has conducted a study sponsored by the Texas State Department of Highways and Public Transportation to examine the effect of implementing speed limits below the 85th percentile speed on highways in rapidly developing urban fringe areas.

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STUDY METHOD

Before-and-after speed and accident data were collected to evaluate the effectiveness of implementing speed zones below the 85th percentile speed. Six study sites on two-lane and four-lane undivided highways were identified where (a) rapid urban development was occurring in urban fringe areas that had been primarily rural in nature, and (b) 55 mph speed limits were still posted. Characteristics of study sites are given in Table 1. Speed and accident data were collected at each site after which the speed limits were reduced to 45 mph. Speed and accident data were collected again after the speed limits were lowered. The two sets of data were then analyzed and compared.

Speed limits of 45 mph were selected for study because it was believed that 50 mph limits would not present the same sense of urbanization to motorists, whereas zones of 40 mph or below would be too inconsistent with existing speeds on the facility and would immediately be dismissed by drivers as unreasonable and unrealistic. Also, the study was designed to investigate only the effects of reduced speed limits on traffic speeds and accidents. Consequently, attempts were made to maintain law enforcement at a constant level during the study, and no public notice was given of the speed limit reductions. Although the effects of additional enforcement or public notification of the speed limit reduction would have been of interest, determining them was beyond the scope of this study.

Data Collection and Reduction

Spot speed data were collected at three locations placed one-fourth, one-half, and three-fourths of the way through each study site. In each direction at each location, speeds of 125 free-flowing vehicles were obtained by using a speed radar gun from within a vehicle parking in as inconspicuous a position as possible. Free-flow vehicles were defined as vehicles having at least a 5 sec headway between them and the vehicle directly in front of them. Consequently, both isolated vehicles (those with no other vehicles nearby) and vehicles at the head of platoons were eligible for sampling. An attempt was made to sample isolated vehicles and lead vehicles in platoons in proportion to their relative frequencies at the sites. At the four-lane study sites, an attempt was also made to sample from each lane in

TABLE 1 SUMMARY OF STUDY SITE CHARACTERISTICS

Site	Location	Length (mi.)	Cross-Section	Development		1983 AADT	Accidents/MVM 1983
				Degree	Type		
1	Houston	2.3	2-lane, 2-way	Low	Residential	14,100	3.9
2	Houston	3.1	2-lane, 2-way	Low	Residential	10,700	1.2
3	Houston	3.9	4-lane, Undivided	Moderate	Residential	30,400	0.9
4	Houston	3.3	4-lane, Undivided	High	Commercial, Residential	29,000	4.7
5	Austin	2.0	4-lane, Undivided	Moderate	Commercial, Residential	25,000	8.2
6	Ft. Worth	2.3	4-lane, Undivided	Low	Commercial, Residential	11,500	3.7

AADT = Annual Average Daily Traffic

MVM = Million-Vehicle-Miles

proportion to the volumes of traffic on each. Care was taken not to choose data collection locations near intersections, major driveways, or other features that may affect normal driving speeds. Before-and-after data were collected at the same locations to ensure that locational differences did not affect the study results. Several statistics of interest were computed from the spot speed data including

1. Average speed,
2. The 85th percentile speed,
3. Proportion of recorded speeds exceeding 60 mph,
4. Standard deviation of speeds, and
5. Skewness index of the distribution of speeds.

Selection of these statistics were based on documented relationships between vehicle speeds and accident severity and frequency. Because accident severity appears directly linked to vehicle speed *(2, 3)*, the average speeds, 85th percentile speeds, and the proportion of vehicles exceeding 60 mph were used to measure overall changes in speeds and the number of high-speed drivers at the study sites. In contrast to accident severity, accident frequency appears less dependent on absolute speeds than on either the variability of speeds *(4)* or the shape of the speed distribution *(5, 6)*. Consequently, the standard deviation of speeds, as well as the skewness index of the speed distribution, were computed from the data collected.

In addition to spot speeds, speed profile data were also collected at the sites. A car-following technique was used with an instrumented vehicle to obtain measurements of speed every 500 ft through the sites. Twenty vehicles selected at random were followed through each direction of travel at each site. A measure of speed-changing activity was computed from the profile data, based on the acceleration noise concept originally introduced by Jones and Potts *(7)*, and successfully used by others *(8)* for describing the quality of traffic flow in quantitative terms. Acceleration noise is defined as the standard deviation of the accelerations and decelerations of an individual vehicle as it travels over a particular section of road. This value represents the disturbance of the vehicle's speed from a uniform speed and provides a measure of the frequency and degree of speed changes for that vehicle.

Accident data from the Master Accident File maintained by the Texas Department of Public Safety were obtained for the 1-year period before installation of the 45 mph speed zones at the study sites. The zones were left in place for 1 year, at which time the accident data for that year were also obtained from the Master Accident File. Because the study sites were located in urban fringe areas of ongoing development, significant changes in traffic volumes occurred over the 2-year study period, as observed from Table 2. Therefore, accident rates (accidents per million vehicle miles) were computed at each site for both total and severe (fatal and injury) accidents.

TABLE 2 CHANGES IN TRAFFIC VOLUMES

Site	Traffic Volumes (AADT)		
	Before	After	Change
1	14,000	16,200	+16%
2	10,300	10,600	+3%
3	33,000	35,000	+6%
4	22,000	19,800	-10%
5	27,000	31,000	+15%
6	16,800	18,000	+7%

One aspect of speed control proven to have a dramatic effect on vehicle speed is the degree of law enforcement *(9, 10)* at a location. The law enforcement agencies responsible for patroling and speed-ticketing at the various study sites were requested to maintain the same level of enforcement efforts throughout the study. Although all agencies did agree to main-

tain their current efforts, objective data (such as the number of speeding tickets given during the before and after time periods) were not available to check to determine if enforcement levels remained constant. Also, this lack of information prevented a comparison of relative levels of enforcement between sites.

RESULTS

Effect on Speeds

Overall, the installation of 45 mph speed limits at the study sites in rapidly developing urban fringe areas had little effect on vehicle speeds. A summary of the average speeds, 85th percentile speeds, and the proportion of drivers exceeding 60 mph are given in Table 3. These results are for the middle data collection location at the study sites. Results for the other two locations where spot speed data were taken are included in the Appendix. Although slight location-to-location variation did exist at the sites, the overall changes between the before-and-after speed data were similar at all locations. As can be seen in Table 3, Site 5 experienced a 4 to 6 mph reduction in the average and 85th percentile speeds. Likewise, the proportion of drivers exceeding 60 mph dropped 6 to 10 percent. However, the remaining sites did not experience similar reductions in speeds; speeds actually rose slightly at Site 3. It does not appear that the lower speed zones were consistently effective in reducing vehicle speeds at these sites to any significant degree. It is possible that the reduction in speeds at Site 5 were the result of a relatively higher level of law enforcement as compared to the other sites, but this fact is not known for certain because the information about law enforcement efforts at the sites was not available.

Examination of the standard deviation, skewness index, and acceleration noise statistics also suggests that the lower speed zones had little or no effect on the speed distribution or speed-changing activity at the study sites. The data in Table 4 illustrate how these statistics generally did not change between the before-and-after speed data collected at the sites.

Effect on Accidents

A comparison of accident rates at the six sites is given in Table 5. Although two sites did experience a reduction in accidents, the overall evaluation generally showed no change in accident

TABLE 3 EFFECT OF 45 mph SPEED ZONES ON VEHICLE SPEEDS

Site	Average Speed (mph)			85th Percentile Speed (mph)			Proportion of Drivers Exceeding 60 mph (%)		
	Before	After	Change	Before	After	Change	Before	After	Change
1									
EB	47.3	47.0	-0.3	53	52	-1	0	0	0
WB	47.8	48.3	+0.5	54	53	-1	1	8	+7*
2									
EB	53.2	52.3	-0.9	61	58	-3	21	9	-12*
WB	53.2	52.8	-0.4	59	59	0	14	15	+1
3									
EB	48.5	52.3	+3.8*	59	57	+3	1	6	+5*
WB	49.2	49.9	+0.7	54	54	0	6	3	-3
4									
NB	42.9	43.4	+0.5	49	49	0	1	15	+14*
SB	44.8	43.6	-1.2	50	48	-2	1	12	+11*
5									
NB	53.1	47.2	-6.1*	58	53	-5	11	1	-10*
SB	51.1	46.9	-4.2*	56	52	-4	7	1	-6*
6									
NB	52.9	51.9	-1.0	59	57	-2	11	9	-2
SB	54.2	49.9	-3.3*	59	56	-3	12	6	-6

*Statistically Significant Change from Before Condition (Level of Confidence = 95%)

TABLE 4 EFFECT OF 45 mph SPEED ZONES ON THE DISTRIBUTION OF SPEEDS AND SPEED-CHANGING ACTIVITY

Site	Standard Deviation (mph)			Skewness Index[a]		Acceleration Noise (ft/sec^2)		
	Before	After	Change	Before	After	Before	After	Change
1								
EB	5.2	5.1	-0.1	1.0	1.0	1.1	1.0	-0.1
WB	5.2	4.9	-0.3	1.0	1.0	1.3	1.0	-0.3*
2								
EB	7.3	6.4	-0.9	0.9	1.0	-0.9	0.9	0.0
WB	5.6	6.1	+0.5	0.9	1.1	0.7	0.6	-0.1
3								
EB	4.8	4.7	-0.1	0.9	0.9	1.2	0.9	-0.3*
WB	5.8	5.1	-0.7	1.1	0.8	1.3	1.1	-0.2*
4								
NB	6.3	6.3	0.0	1.0	0.9	1.1	1.2	+0.1
SB	5.3	6.0	+0.7	1.0	0.9	1.1	1.1	0.0
5								
NB	5.9	5.5	-0.4	0.9	0.9	1.1	1.3	+0.2
SB	6.0	5.3	-0.7	0.9	0.9	1.3	0.9	-0.3*
6								
NB	5.8	6.1	+0.3	1.1	1.0	1.0	0.9	-0.1
SB	4.8	5.6	+0.8	0.9	0.9	0.7	0.8	+0.1

*Statistically Significant Change from Before Condition (Level of Confidence = 95%)

[a]Skewness Index was computed as $\frac{2(\text{93rd \%-tile} - \text{50th \%-tile speeds})}{(\text{93rd \%-tile} - \text{7th \%-tile speeds})}$

rates. Similarly, severe accidents did not appear to be reduced; Sites 2 and 6 posted increases in the frequency of these accidents. Only Site 3 was found to have a substantial reduction in its severe accident rate. Curiously, this was also the site at which speeds increased after the 45 mph speed zones were installed. As only 1 year of after accident data were available, and because accidents in themselves are rare events, the changes in accident rates that occurred were most likely the result of random fluctuation regression-to-the-mean, rather than a reduction in the posted speed limit.

SUMMARY OF FINDINGS

The effect of reducing speed limits below the 85th percentile speed of traffic at locations in rapidly developing urban fringe areas has been examined in this study. Overall, a reduction in the speed limits from 55 to 45 mph at the six study sites had no conclusive effect on absolute speeds, speed distributions, or speed-changing activity. Likewise, the lower limits were not effective in reducing the frequency or the severity of accidents occurring at the study sites. It is not known whether motorists did not notice the reduced speed limits, or whether drivers saw but chose to disregard or ignore the lower limits. Whatever the reason, the lower speed limits in rapidly developing urban fringe areas did not persuade motorists to drive more carefully.

These results parallel those of past research efforts *(11)* that have attempted to influence drivers to operate their vehicles at a "safer" speed by posting lower speed limits. As this and previous studies have revealed, reduced speed limits apparently do not alter, to any significant degree, perceptions of accident risk, the potential of receiving a speeding ticket, or any of the other factors that drivers are assumed to consider when selecting the speed at which they travel.

The study results show that traffic safety and operations were not improved in rapidly developing urban fringe areas solely by posting a speed limit below the 85th percentile speed. As stated previously, this study was unable to consider the effects of

TABLE 5 COMPARISON OF ACCIDENT RATES

Site	Rate Before	Rate After	Change (%)
Total Accidents			
1	4.08	2.57	−37[a]
2	1.11	1.08	−3
3	2.02	1.22	−40[a]
4	7.32	9.14	+25
5	7.10	7.03	−1
6	2.41	3.04	+26
Severe (Fatal and Injury) Accidents			
1	1.53	1.47	−4
2	0.26	0.58	+125
3	0.83	0.46	−44
4	2.98	2.98	NR
5	3.15	2.79	−11
6	0.92	1.66	+80[a]

NOTE: Accidents per million vehicle-miles. NC = No change in accident rates.

[a]Significant change in accident rate based on Poisson comparison of means test (level of confidence = 95 percent).

increased law enforcement or public notification at the speed limit reduction, or both, on speed and accidents. Additional research to examine the effect of these factors should be considered, with special emphasis on whether the costs of implementing these factors are justified through reduced accident costs and improved traffic operations on highways in rapidly developing urban fringe areas.

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APPENDIX

TABLE A-1 EFFECT OF 45 mph SPEED ZONES ON VEHICLE SPEEDS, LOCATION 1

Site	Average Speed (mph) Before	After	Change	85th Percentile Speed (mph) Before	After	Change	Proportion of Drivers Exceeding 60 mph (%) Before	After	Change
1									
EB	47.7	45.9	-1.8*	51	52	+1	2	1	-1
WB	49.1	45.5	-3.6*	54	52	-2	3	0	-3
2									
EB	55.2	53.8	-1.4	61	60	-1	24	20	-4
WB	55.1	54.1	-1.0	60	60	0	18	17	-1
3									
EB	46.8	48.9	+2.1**	53	53	0	1	2	+1
WB	47.6	50.0	+2.5**	53	56	+3	3	5	+2
4									
NB	53.2	50.2	-3.0	59	56	-3	15	9	-6*
SB	52.3	50.5	-1.8	58	58	0	11	9	-2
5									
NB	51.5	48.3	-3.2*	57	53	-4	9	2	-7*
SB	51.0	46.8	-4.2*	56	52	-4	6	0	-6*
6									
NB	49.1	47.3	-1.8*	56	52	-4	3	3	-1
SB	49.7	47.4	-2.2*	55	54	-1	3	1	-2

**Statistically Significant Increase from Before Condition (Level of Confidence = 95%)

*Statistically Significant Decrease from Before Condition (Level of Confidence = 95%)

TABLE A-2 EFFECT OF 45 mph SPEED ZONES ON THE DISTRIBUTION OF SPEEDS, LOCATION 1

Site	Standard Deviation (mph) Before	After	Change	Skewness Index Before	After
1					
EB	6.2	4.8	-1.4*	0.9	0.9
WB	6.3	5.0	-1.3*	1.1	1.0
2					
EB	5.9	6.2	+0.3	0.8	0.7
WB	5.4	6.0	+0.6	1.1	1.0
3					
EB	6.2	4.3	-1.9*	1.0	0.8
WB	6.1	5.6	-0.5	0.9	1.1
4					
NB	5.7	5.7	0.0	1.1	1.2
SB	6.2	6.8	+0.6	0.8	1.0
5					
NB	5.7	5.2	-0.5	1.1	0.8
SB	6.0	5.5	-0.5	0.9	0.9
6					
NB	6.8	4.8	-2.0*	0.8	0.9
SB	6.0	6.0	0.0	0.9	1.0

**Statistically Significant Increase from Before Condition (Level of Confidence = 95%)

*Statistically Significant Decrease from Before Condition (Level of Confidence = 95%)

TABLE A-3 EFFECT OF 45 mph SPEED ZONES ON VEHICLE SPEEDS, LOCATION 3

Site	Average Speed (mph)			85th Percentile Speed (mph)			Proportion of Drivers Exceeding 60 mph (%)		
	Before	After	Change	Before	After	Change	Before	After	Change
1									
EB	41.3	44.8	+3.5**	47	50	+3	0	0	0
WB	44.3	45.2	+0.9	50	50	0	0	0	0
2									
EB	52.7	50.0	-2.7*	58	56	-2	10	1	-9*
WB	50.2	51.6	+1.4	55	58	+3	8	10	2
3									
EB	53.5	51.9	-1.6*	59	57	-2	14	2	-12*
WB	52.0	54.1	+2.1**	57	60	+3	7	17	+10**
4									
NB	47.1	48.4	+1.3	54	54	0	2	2	0
SB	46.3	48.4	+2.0**	52	54	+2	3	6	+3
5									
NB	54.4	48.6	-5.8*	60	54	-6	16	2	-14*
SB	49.5	48.1	-1.4	55	54	-1	6	3	-3
6									
NB	50.4	48.3	-2.1*	55	53	-2	4	2	-2
SB	53.2	49.4	-3.9*	59	54	-5	14	5	-9*

**Statistically Significant Increase from Before Condition (Level of Confidence = 95%)

*Statistically Significant Decrease from Before Condition (Level of Confidence = 95%)

TABLE A-4 EFFECT OF 45 mph SPEED ZONES ON THE DISTRIBUTION OF SPEEDS, LOCATION 3

Site	Standard Deviation (mph) Before	After	Change	Skewness Index Before	After
1					
EB	5.1	5.3	+0.2	0.8	1.3
WB	5.7	4.6	-1.1*	1.0	0.9
2					
EB	6.3	5.1	-1.2*	0.8	1.1
WB	4.7	6.9	+2.2**	1.0	0.9
3					
EB	5.8	4.5	-1.3*	1.1	0.9
WB	5.7	6.2	+0.5	0.9	1.0
4					
NB	5.9	5.1	-0.8	1.1	1.1
SB	6.4	6.1	-0.3	0.8	1.0
5					
NB	5.4	5.7	+0.3	0.8	0.9
SB	6.2	6.3	+0.1	0.9	1.0
6					
NB	4.9	4.7	-0.2	0.9	0.9
SB	5.9	4.9	-1.0*	1.0	1.0

**Statistically Significant Increase from Before Condition (Level of Confidence = 95%)

*Statistically Significant Decrease from Before Condition (Level of Confidence = 95%)