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*THE EFFECT ON SPEED OF SPEED LIMIT
SIGNS ON SUBURBAN ARTERIAL STREETS*

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by

*C.M. ELMBERG
H.L. MICHAEL*

Technical Paper

THE EFFECT OF SPEED OF SPEED LIMIT SIGNS
ON SUBURBAN ARTERIAL STREETS

TO: K. B. Woods, Director January 25, 1961
Joint Highway Research Project

FROM: H. L. Michael, Assistant Director File: 8-4-19
Joint Highway Research Project Project: C-36-173

Attached is a technical paper titled "The Effect of Speed of Speed Limit Signs on Suburban Arterial Streets" by C. M. Elmsberg and H. L. Michael. This paper was presented at the Annual Meeting of the Highway Research Board in January 1961.

The material presented in the paper has been previously submitted to the Advisory Board in more detailed form. It was prepared in the attached summary form for publication and dissemination.

The technical paper is presented to the Board for the record and for approval for publication by the Highway Research Board.

Respectfully submitted,

Harold L. Michael
Harold L. Michael, Secretary

HLM:kmc

Attachment

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ON SUBURBAN ARTERIAL STREETS

by

Curt M. Elmberg, Traffic Engineer, KM Consulting Engineers, SWEDEN

and

Harold L. Michael, Assistant Director, Joint Highway Research Project
Purdue University

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INTRODUCTION

For years philosophers have argued that speed, per se, is not destructive. The elliptical path traveled by the earth with a speed exceeding 66,000 miles per hour in its annual trip around the sun is actually a highly advanced freeway. There are, however, as yet, no appreciable conflicts or frictions along this freeway in terms of crossroads or other vehicles.

To a mathematician, physicist, or astronomer speed may simply mean the ratio of distance to time; to a traffic engineer speed means nothing, but in conjunction with terms such as mean speed, speed percentiles, speed zones, and other measurements it has significant connotations.

Man always has strived and always will strive for attaining faster and faster speeds on the land, on the sea, and in the air. The problem, therefore, is not only to develop vehicles which are able to travel at high speeds but also to develop additional devices which will assist man to safely and efficiently control and utilize the speeds attained. One respected traffic engineer has stated the same thing this way (1)*: "Speed is one of the great essential benefits which make highway transportation indispensable in modern America. It must be provided for and protected".

What speed is safe? Drastically expressed, the only safe speed is zero mile per hour (2, 3), for accidents occur at all speeds. However, higher speeds do increase the chances of exposure to situations and the rapidity at which these develop may reduce the ability of a driver to react

* Numbers in parentheses refer to the list of references at the end of this paper.

properly and may lead to more accidents. It also is generally true that speed is a factor in the severity of an accident (4).

Ever since the early growth in the use of motor vehicles, special attention has been given the problem of safe speed. In 1925 Dickinson and Marvin (5) defined safe speed as "such that a driver will be able to stop his vehicle within the distance ahead that is certain to be free from any obstruction". This is certainly still true today. What is then a good driver? Johnston (6) defines him as "one who starting on a journey regardless of the roadway, weather, vehicle, or traffic arrives at his destination without having any trouble himself or without causing anyone else any trouble". Is this a driver who always drives at a safe speed? A research study in Pennsylvania (7) revealed that the speeds of the drivers with accident records were only slightly higher than those for the drivers without accident records.

Yet, speed is often advocated as the greatest contributing cause to accidents. Thorough studies, however, have indicated that this may not be entirely true. A study in Minnesota of 40,000 accidents (2) in which data as to vehicle speeds were stated showed that if every accident in which speed was the only violation could have been prevented the number of accidents would have been reduced less than 10 percent, and if all accidents could have been prevented in which speed was the primary cause of the accident the reduction in number of accidents would not have been much greater. Actually nearly 75 percent of the accidents involved some violation other than a speed violation. In 1955 the Chicago Park District ascribed speed as the principal cause of only 9 percent of automobile accidents (8).

It is not surprising, therefore, that speed control is one of the most difficult and controversial problems of traffic operations. Criteria for establishing speed zones do not have the degree of acceptability as have such other traffic controls as no passing zones or traffic signals. Speed control is difficult because variations in driving behavior between individuals complicate the establishment of adequate, reasonable, and uniform warrants based on objective speed surveys. Speed control is controversial because of the divergence of opinion among engineers, enforcement officers, the motorists, and the people living along the highway as to the proper speed and the appropriate methods for controlling speeds.

Speed control, however, is important because properly done it may facilitate movement at uniform speed and thereby contribute to improved capacity and safety. It may also assist the motorist in selecting speeds that are safe and that permit him to obtain the maximum utility, economy, and convenience from his vehicle and the road. Speed zoning has therefore developed and is defined as the establishment of safe and reasonable speed limits, based upon engineering study, for sections of street or highway where any general state-wide legislative speed limits do not fit the road and traffic conditions (9). Speed limits for such speed zones are established for favorable weather and traffic conditions with further reduction due to inclement conditions still regarded as the responsibility of the driver.

Approaching an urban area, speed zones generally begin in the fringe area, usually termed the suburban, in which roadside development of all kinds

such as residences, filling stations, drive-in-theaters, cafes, trailer courts, et cetera may occur. This transition zone between rural and urban development is also often the transition zone for speed limits. Should this be a series of speed limit signs, gradually limiting the speed from the state-wide limit in the rural area to the limit used in the urban area? What warrants should be used and where should signs be placed? Is the type of roadside development in this area a factor to be considered in signing the area? The answers to these questions were the results wanted from the research project which the authors conducted and the results of which are the subject of this paper.

STUDY LOCATIONS

Five locations, listed in Table 1 and shown in Figure 1, were selected as study sites. These locations generally met the following pre-set requirements:

1. The highway was straight and level so that the motorist could easily perceive the change from rural to suburban to urban area.
2. Posted speed limits if any, were not overly restrictive, and the limits were placed in reasonable decreasing order when approaching from the rural area.
3. No signals, stop signs or warning signs which might have an adverse effect upon the speed pattern were present.
4. The roadside development was predominately of one type - residential, commercial, or industrial - on each section.

One of the five locations, referred to as location A, was chosen for a comprehensive speed limit signing study due to the fact that the highway had been recently reconstructed from a two lane facility to a four lane one and no speed limits had as yet been posted.

This highway in the rural area is a four lane divided facility with a 30 foot wide grass median which narrows to a 5-foot concrete median as it enters the city limits (Figure 2). The lane width is 12 feet. On one side of the highway are golf courses, on the other, some development which is not closely situated to the highway. The effect of this development upon speed was subsequently found to be negligible. The highway inside the city has four undivided lanes, each 12 foot wide, and runs through a highly

developed residential area with development literally to the curb (Figure 3). The test section of this highway was approximately 9,000 feet long with 3,800 feet of this distance primarily undeveloped or lightly developed and 5,200 feet highly developed as an urban residential area. The reconstruction of this highway was completed in the fall of 1958. From that date until June 1959 no speed zoning was in effect. Speed surveys were extensively performed during this period of time, especially in the inbound direction. At seven sites a radar speed meter was secretly concealed and used to measure the speed of free moving passenger vehicles. Vehicles were also classified into local and non-local vehicles with a local vehicle being one registered in the county where the road was located. This was done because it was felt that local vehicles being familiar with the environment might be less sensitive to changes in posted speed limits than non-local vehicles. The effect of speed limits during day and night hours was also separately analyzed.

For more than half a year this highway operated without posted speed limits and it was under these conditions that speed distributions for week-day operation were first obtained at the seven sites. It was from this comprehensive data that speed limits along the highway were determined and put into effect. The numerical values for the speed limits and their locations along the highway coincided as practically as possible with the 85th percentile speed found under no-sign conditions. Signs placed on the section included speed zone ahead and 50, 40, 35 and 30 mph speed limits. Only one sign at a time was posted starting with the higher speed limit,

and the effect on the entire section was studied for several weeks before a new sign was added. This procedure continued until the complete signing plan which is shown in Table 2 had been completed.

Locations B, C, D, and E, the other four locations of this study, are similar in that they are the transition sections from rural to urban of major highways. Each of these locations was speed zoned prior to the study by the State Highway Department so as to reduce vehicle speeds from the 65 mph rural limit to a 30 mph urban limit. Location B is characterized by little development along it with none on one side of the highway due to a paralleling and nearby river. The development along Location C was almost entirely residential, that along Location D was primarily commercial and that along Location E primarily industrial.

Speeds at Locations B, C, D, and E were taken at preselected sites throughout the suburban area in sufficient quantity to present a clear picture of the speed pattern for inbound vehicles in this zone. Speeds were taken in such a manner that the motorists were not aware that they were being checked. This was accomplished by concealing all personnel and the radar meter from the motorists view.

All speeds were taken at all locations under non-peak volume conditions and for all sites this was when volume was less than the capacity of the road section. Speeds were taken of only passenger cars. Enforcement during the period of the study was not increased or decreased. Local authorities were requested to provide normal enforcement at the study locations.

ANALYSIS OF SPEED PARAMETERS

The field data were analyzed to yield values of speed parameters for each station at each site by speed limit in effect at that station, residence of vehicle, and time of study (day or night). The parameters calculated were a measure of two characteristics of the speed distribution: the magnitude and the dispersion. The parameters of magnitude obtained were the mean speed, the median (or 50th percentile) speed, and the 15th and 85th percentile speed; those of dispersion were the variance (or square of the standard deviation), the speed differential, and the pace.

These parameters were then analyzed by statistical methods to determine if differences in parameter values were significant for the different conditions and the source of such variation.

Location A

The effect of speed limit signs on speed in a suburban area as found in the comprehensive study at Location A is typically illustrated by the effect on the 85th percentile speed in Figures 4 to 7. These figures are for local vehicles, non-local vehicles, day, and night conditions, respectively, and for the after condition are with all of the signs of the speed limit plan (See Table 2) in place.

The 85th percentile speeds of local vehicles were slightly higher after posting speed limit signs than they were before (Figure 4). The increase is slight, however, and may be because of the removal of the uncertainty of some local motorists as to whether a lower speed limit, which had existed on the road before its reconstruction, still was in

effect even though no signs were present. On the other hand, non-local drivers appeared to change their speeds very little after the posting of the limits (See Figure 5). Although there were some slight mathematical differences between the before and after 85th percentile speeds in the respective cases shown there were no statistically significant differences at a five percent significance level.

Another important result is that the absence of speed limit signs in the developed area did not result in an abnormal speed pattern in this area. Speeds were approximately the same with and without speed limit signs which represented the 85th percentile speed.

Analysis of the other parameters - average speed, 15th and 50th percentile speed, and the 10 mph pace - also revealed that in general they were not affected by the placing of speed limit signs. Speed were, at some locations, significantly lower at night than during the day but only by a small amount. Local vehicles were found to travel significantly slower than non-local vehicles but again by only a small amount and only at some stations.

After all the speed limit signs had been posted and this phase of the study completed, the one 35 mph sign was replaced with a 30 mph sign and speeds again were observed. This provided data for four conditions of posted speed limit at this one location, no posted limit, 40 mph, 35 mph, and 30 mph. The effect on the various parameters is shown in Table 3.

Although the results at this one site cannot be classed as conclusive, the results indicate the small changes which one can expect in speed parameters by speed zoning.

The 85th percentile speed, for example, was found to be virtually the same for the posted 40, 35 and 30 mph limits; in other words, the numerical value on the speed limit sign did not have any effect on this parameter at this site. The lower speed limit sign did give a larger percentage in the pace but the pace occurred at a higher range. The possibility of efficient enforcement should also be noted. It must be characterized as impossible to apprehend more than one third of the drivers because of speeding 5 mph over the speed limit; in fact, reputable enforcement officials have stated that apprehension of more than one percent of the drivers would be difficult.

Location B

This location exhibited specific characteristics because of the absence of extensive development along the highway. Although 65 miles per hour was permitted the 85th percentile speed was 55.9 miles per hour in the non-zoned area and 54.0 miles per hour at the "Speed Zone Ahead" sign during the day. The 50 mile per hour speed zone, about three miles long, revealed a reduction of the 85th percentile speed from 53.3 miles per hour at the beginning of the speed zone to 50.6 miles per hour at the end of the same zone. During the night, vehicles reduced their speed considerably more within the 50 mile per hour zone than during the day. The absence of illumination along the road, the increased darkness due to the dense and nearby vegetation at this location, or the non-existence of development may explain this large difference. Furthermore, non-local vehicles reduced their speed substantially more at night than local vehicles who obviously were more familiar with the road.

Locations C, D, and E

Speeds at sites on these three locations, each one displaying a predominant type of development, were statistically tested against each other in order to determine whether or not there was any significant differences in speed pattern by type of development. The result, revealed significant differences in speed due to most of the factors studied, including significant interactions. The results indicated that type of development may significantly effect actual speeds but the factors which could have effected the speed were so many that it was not possible to come to definite conclusions regarding this effect or to place any quantitative values on it. It was again found, however, that non-local vehicles at all locations and for all sign conditions traveled noticeably faster than local vehicles. It was also found that night driving speeds generally were significantly lower than day speeds at the 5 percent level but by different amounts and the differences were not always significant. Little relationship between the posted speed limit and the 85th percentile speed at that point was noted at any of the locations.

CONCLUSIONS AND RECOMMENDATIONS

This study revealed that drivers, in general, do not drive according to posted speed limit signs. Most of them select a speed which they consider proper, reasonable, and safe for conditions prevalent, regardless of regulations. Moreover, it was shown that when speed limits are determined from the 85th percentile speed, traveled speeds are not materially affected.

The fear that the establishment of a speed limit which appears relatively high to some will create a new speed pattern with faster speeds appears to have no foundation.

Most drivers will obey a posted speed limit if, and only if, the sign is properly posted and the numerical limit is reasonable. Such signing also permits realistic enforcement of speed limits, and the use of speed limits as an enforcement tool appears to be, in the absence of having an effect on speed, a primary use of speed zoning, at least until better respect for speed limit signs has again been established with the motorists.

The study of the effect of roadside development on speed did not produce conclusive results, but the many significant differences noted in the speeds indicated a strong possibility that there is a significant effect on speed by type of development.

It was also clearly evident that the relationship between speed and roadside development is extremely complex. More detailed studies of this effect would be extremely valuable.

ADDITIONAL REMARKS

For an American observer it may be of interest to learn a little about the speed problem in Europe. After a period of speed zoning at the beginning of the era of motor vehicles, most of the countries in Europe abolished speed limits entirely, in the urban area as well as in the rural. With the rapid increase in motor travel in the late 50's, it became evident to many that free speed could no longer be permitted in urban areas. Country after country adopted speed limits for urban areas.

The effect of these urban speed limits has been studied and the results were presented at the 5th International Traffic Engineering Study Week in Nice, France, in September 1960.

The introduction of urban speed limits in recent years in Europe did result in a reduction in accidents and in travel speed. The European driver appears to obey posted speed limit signs. This is probably due to the fact that the average running speed in Europe is lower than in the United States and in the fact that posted speed limits do not differ very far from this speed. Another very important reason for better obedience is the fining system which is used in some countries. The fines vary according to the income of the offender. Violating a speed limit can, therefore, be very costly.

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TABLE 1
SPEED STUDY LOCATIONS

Location	Urban Area	Highway	Direction from which Vehicles Approach the Urban Area	Direction of Study	ADT
A	West Lafayette	U. S. 52	North	Southbound & Northbound	4600-5500
B	West Lafayette	Ind. 43	North	Southbound	2800-4300
C	Logansport	U. S. 35	South	Northbound	3500-4100
D	Peru	U. S. 31	North	Southbound	4100-4300
E	Wabash	U. S. 24	East	Westbound	4300-4500

TABLE 2
SPEED SIGNING PLAN AT LOCATION A

<u>Area</u>	<u>Speed Sign Installed</u>
Rural	65 mph, state limit
Approach to urban	Speed Zone Ahead
Residential Development	Begin 50
Increasing in Intensity	Begin 40
	40
	40
	Begin 35
	Begin 30

TABLE 3

SPEED PARAMETERS FOR PASSENGER CARS AT ONE SITE
WITH DIFFERENT POSTED SPEED LIMITS

<u>Speed Parameter</u>	<u>Speed Limit Posted</u>			
	<u>None</u>	<u>40 mph</u>	<u>35 mph</u>	<u>30 mph</u>
Mean Speed (mph)	31.99	33.48	33.91	34.31
85th Percentile Speed (mph)	37.38	38.44	38.42	38.49
Speed Differential (mph)	9.77	9.83	9.09	8.47
10 mph Pace	26-35	28-37	28-37	30-39
Percent in Pace	73.0	72.8	74.6	78.9
Standard Deviation (mph)	4.65	4.83	4.70	4.26
Percent of Vehicles exceeding the speed limit by 5 mph or more	0	1.6	10.1	37.8

STUDY LOCATIONS

FIGURE 1

VIEW AT LOCATION A

Little Development - 50 mph zone

FIGURE 2

VIEW AT LOCATION A

Residential Development - 40 mph zone

FIGURE 3

85TH PERCENTILE SPEED BEFORE AND AFTER
POSTING OF SPEED LIMITS
(LOCAL VEHICLES)

**85TH PERCENTILE SPEED BEFORE AND AFTER
POSTING OF SPEED LIMITS
(NON-LOCAL VEHICLES)**

85TH PERCENTILE SPEED BEFORE AND AFTER
POSTING OF SPEED LIMITS
(DAY CONDITION)

FIGURE 6

85TH PERCENTILE SPEED BEFORE AND AFTER
POSTING OF SPEED LIMITS
(NIGHT CONDITION)