Driver Obedience to Stop and Slow Signs

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The purpose of this study was to determine the effectiveness of standard manufactured "stop" and "slow" signs. Four of the stop signs used were of the new type (red and white, reflectorized); the remaining stop sign and the slow sign were of the old type (yellow and black enamel, non-reflectorized).

In addition to the slow sign itself, the slow sign study utilized a radar meter and a pneumatic tube speed meter.

The study showed that no combination of stop sign type or position was more effective than any other under the given conditions. However, an attempt was made to weigh the information gathered and assign definite obedience factors to the sign type-position combinations studied.

The study also showed that a slow sign placed at a location which obviously does not warrant it, is definitely ineffective. This seems to indicate that the average driver is influenced by the apparent factors involved rather than by the slow sign itself.

IN recent years much attention has been directed to the matter of materials and color combinations of stop signs. Many years back, when the problem first came up, all evidence pointed to an enameled sign with the color combination of black legend on a yellow background. One reason for this was that paints commercially available at the time had inferior qualities compared to present-day products. It was felt that the yellow chosen would be the most effective as concerned attention getting value, fading of pigment, and distance seen.

Recently, however, progress has made possible reflectorization of signs in a multitude of colors. Also, paint pigments are now available which will withstand fading tendencies, at least during the average life of a sign (2) (7).

The present trend is to a red and white reflectorized stop sign. Red was chosen due to its association with danger by the average person.

This study was undertaken in an attempt to ascertain the effectiveness of reflectorized red and white stop signs, as compared to the standard enameled yellow and black stop sign (3). In other words, the study was made to test the truth of the hypothesis that the pattern of response is essentially the same as long as a stop sign is present.

It was understood at the beginning of the study that a stop sign alone would not be the only factor influencing the decision of a driver at a stop situation. Many other factors enter the picture; however, most of them are immeasurable. Some of these are habit, present disposition of the driver, the weather, familiarity with the intersection, presence of traffic on the cross road, alertness of the driver, individual judgment, newness of the sign, and a host of others. Each of these factors could be measured only by holding all other factors constant. This alternative, however, would be entirely out of the question unless some sort of controlled laboratory tests could be arranged.

The experiment was arranged, with the realization that many other influencing factors do exist, but with the stop sign and its position as the only controlled variable. It was assumed that the other factors would be present in an equal degree throughout the study.

It is also a generally accepted fact that motorists do not like to slow down frequently when driving on rural highways, which raises the question of just how effective a "slow" sign is. This study was initiated in an attempt to ascertain to what extent motorists obey a slow sign. The investigation was constructed so as to limit the reason for slowing down only to the slow sign. This was done by erecting a slow sign where none was needed and studying the results obtained. All data for both studies were obtained in close proximity to Purdue University, Lafayette, Indiana.

STOP SIGN STUDY

Purpose and Scope

The purpose of the stop sign study was to measure driver response to a stop sign, given certain specified conditions.

An attempt was made to select locations which were similar in roadside development and topographic features; however, this proved futile, because intersections with sufficient volumes to complete the study in the limited period of time available had some sort of signal control governing them. Another factor governing location selection was that each location had to have facilities for parking the observer's car near enough to the intersection to make observation practical without being conspicuous. Because of these factors, the locations chosen were considered fixed rather than random variables in the analysis.

The first location selected was the intersection of Tippecanoe County Farm Road with US 52 By-Pass. Due to the fact that topography is flat in this area and that the buildings had been set well back from the By-Pass, sight distance was more than adequate up to 100 ft back from the intersection.

The second location selected was the intersection of Ind. 28 with Ind. 43-US 231. This intersection was "wide open;" that is, the curves at the corners had large radii, thus giving a great amount of area within the intersection proper. A dip in the road several hundred feet back from the intersection causes oncoming drivers to lose sight of the main road for a short period. This, along with vegetation growth on the northwest and southwest sides of the intersection, materially cut down the available sight distance. Also, the main road crosses Ind. 28 on a slight curve at the intersection.

Observations were made both day and night at both locations. Location I was studied during the latter part of July and the beginning of August 1955; Location II was studied during most of October and the beginning of November 1955.

Both passenger cars and trucks were included in the study. The percentage of trucks at Location I was practically negligible, whereas at Location II this percentage was rather large. Passenger cars towing trailers or other passenger cars, and farming equipment (such as tractors or tractor-drawn wagons), were excluded from the study with the idea that the mere makeup of the vehicle would influence driver reaction much more than any of the conditions set.

Pavement width at both locations was 20 ft, and in both cases the riding surface was of bituminous material.

Weather conditions were similar during the time of study; that is, observations were made only at times when the pavement was dry and the visibility good.

At both locations a gasoline station was situated on the same corner of the intersection as the stop sign under observance. With the permission of the station operators concerned the observer's vehicle was parked on the station apron, thus allowing it to be inconspicuous, yet close enough for purposes of observation.

Two sign heights were investigated to ascertain their effectiveness. The two heights chosen were 3 ft and 5 ft, measured from the pavement crown to the bottom of the sign. The first height agrees with the present Indiana standard of 42 in. measured from the pavement crown to the middle of the sign. The second height (5 ft) agrees with the National standards (1) (3).

Equipment

At the beginning of the study, it was decided that five commercial types of stop signs would be investigated. This decision was influenced by the supply on hand and the different types of stop signs available commercially. The five sign types included in the group were as follows:

Sign 1 (S_1)—Black enameled message on yellow enameled background.

Sign 2 (S_2)—Entire sign covered with a reflective sheeting composed of microscopic spherical lenses; silver message and border on red background.

Sign 3 (S_3)—Entire sign covered with smooth-surfaced reflective sheeting composed of microscopic semispherical lenses; silver message and border on red background.

Sign 4 (S_4)—Entire sign covered with semi-plastic pigmented binder, into which are embedded microscopic glass spherical lenses of two sizes; white message and border on red background.

Sign 5 (S_5)—Consists of white enameled panel and border on red enameled background; message constructed of injection-molded plastic containing microscopic lenses ground in the surface; figures covered with transparent red-colored coating on which is sprayed aluminum flake paint.

All five of the signs used were standard 24-in. signs with 8-in. characters (3).

Procedure

The method of collecting the data entailed placement of one of the stop signs within 1 ft of the existing stop sign, which was removed with the permission of the proper authorities.

The individual driver's action at the intersection was recorded under one of three possible classifications: (a) unsatisfactory stop (lowest speed attained by the driver in observing the sign greater than 5 mph); (b) stopped by traffic (either traffic already at the stop sign or traffic on the cross road); and (c) satisfactory stop (lowest speed attained by the driver in observing the sign between 0 and 5 mph).

This division of response was selected after considering the fact that at 5 mph or less the driver has his vehicle under control and is capable of making a complete stop with little difficulty, if need be. Also, the advent of the automatic shift allows the driver to come to a "rolling stop" without the necessity of shifting gears. This should not be construed to mean that a "rolling stop" is legal, it only means that in the opinion of the observer, under the conditions investigated, such a stop is safe. It is also felt that an approach speed of more than 5 mph is unsafe and, as such, unsatisfactory.

A sample of 50 vehicles was observed for each combination of sign type, sign height, and time (daylight and darkness). As each group of 50 vehicles was observed, the conditions were changed and another group of 50 vehicles observed until a total of 1,000 observations was made at each of the two locations.

STATISTICAL ANALYSIS

General

Upon completion of the sampling the field data were tabulated into a form more easily adapted to analysis. This was accomplished by using frequency distributions of the drivers making either satisfactory or unsatisfactory stops. Those drivers who were in the category of having been stopped by traffic were disregarded, because their reaction to the stop sign could not be determined with the procedure used.

Study of Variance

To determine what effect the studied conditions had on driver obedience, an analysis of variance was carried out on the sample values. These were transformed to obtain homogeneity of variance by replacing each sample value by its arc sin value (4) (8).

The results of the analysis of variance indicate that the different sign types, their positions, the time of day or a combination of any two of these had no significant effect on driver behavior at either location. However, the interaction of all three factors proves to be highly significant at both locations.

Because, in a practical sense, it would be impossible to change the sign, its position, or both every 12 hr, the frequency polygons, mentioned earlier, were summed over day and night (Fig. 1 and 2). This was done in an effort to illustrate the extent of driver obedience to a particular combination of factors during both daylight and darkness. It can be seen from these figures that certain sign types apparently stand out above the others, however, it should be remembered that the analysis shows no significant difference between sign types. Any apparent difference, therefore, should be given much thought before being accepted.

It would not do to erect a certain sign expecting a high percentage of satisfactory stops if the percentage of unsatisfactory stops is also high. Therefore, an indicator of sign acceptability is used. This indicator is called R, or the recommendation criterion. This factor has the advantage of a higher rate of increase for decreasing values of unsatisfactory stops than for increasing values of satisfactory stops. This is a good feature in that the ratios do not vary proportionately, because there is always a certain number of drivers who fall into the classification of having to stop due to existing traffic conditions.

TABLE 1

NUMBER OF SATISFACTORY AND UNSATISFACTORY STOPS (BASED ON N = 100), AND R, THE RECOMMENDATION CRITERION

Sign	Stops[a]	Position 1		Position 2	
		Loc. I	Loc. II	Loc. I	Loc. II
	S	32	56	44	67
1	U	12	14	10	11
	R	2.67	4.00	4.40	6.09
	S	47	54	35	49
2	U	18	18	20	9
	R	2.61	3.00	1.75	5.44
	S	51	55	34	64
3	U	12	18	16	11
	R	4.25	3.06	2.12	5.82
	S	44	59	50	59
4	U	13	14	17	16
	R	3.38	4.21	2.94	3.69
	S	39	53	29	60
5	U	9	8	22	10
	R	4.33	6.62	1.32	6.00

[a] S = Satisfactory stops; U = Unsatisfactory stops; R = Recommendation criterion (S/U).

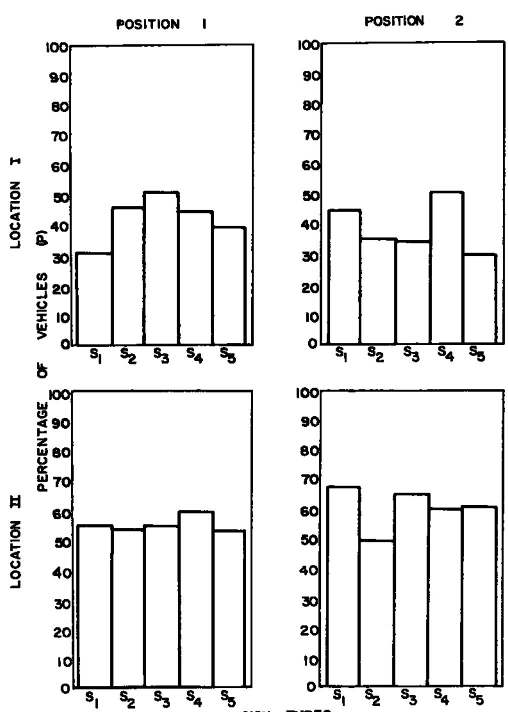


Figure 1. Frequency polygons of vehicles, summed over day and night, making satisfactory stops at each location.

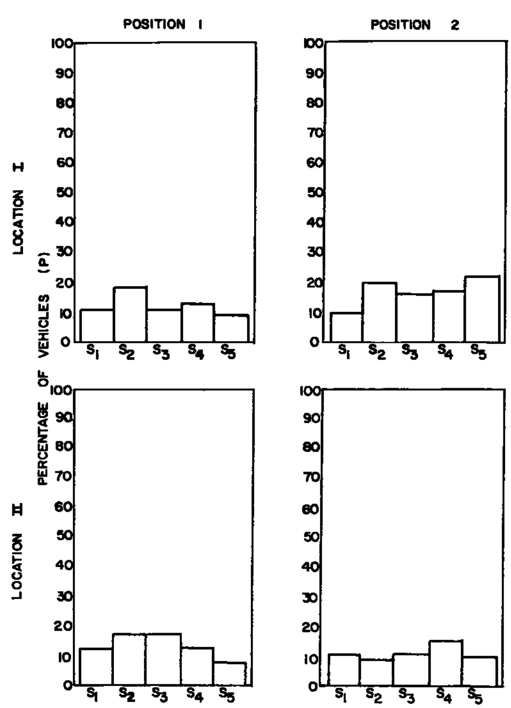


Figure 2. Frequency polygons of vehicles, summed over day and night, making satisfactory stops at each location.

Table 1 shows the number of satisfactory and unsatisfactory stops on the basis of 100 observations per sign, per position, per location. Figure 3 shows the use of the R factor for the different sign types by location and position.

CONCLUSION

It is important to remember that the stop sign analysis has been based on data collected at two particular intersections with only a few variables being controlled. Some of the ideas arrived at might have to be qualified by the results of analysis of additional intersections.

Under the conditions presented at the intersections studied, it has been concluded that, in general, no combination of stop sign and position is any more effective than another as far as driver obedience is concerned. However, it can be concluded that, using R as a criterion, sign type 1 (yellow and black nonreflective) at position 2 (5 ft high) for location I, and sign type 5 (red and white, reflectorized) at position 1 (3 ft high) for location II, exhibit the highest obedience factor for the particular location. The R value also indicates that sign type 5 is the best at position 1 for both locations, and sign type 1 is the best at position 2 for both locations.

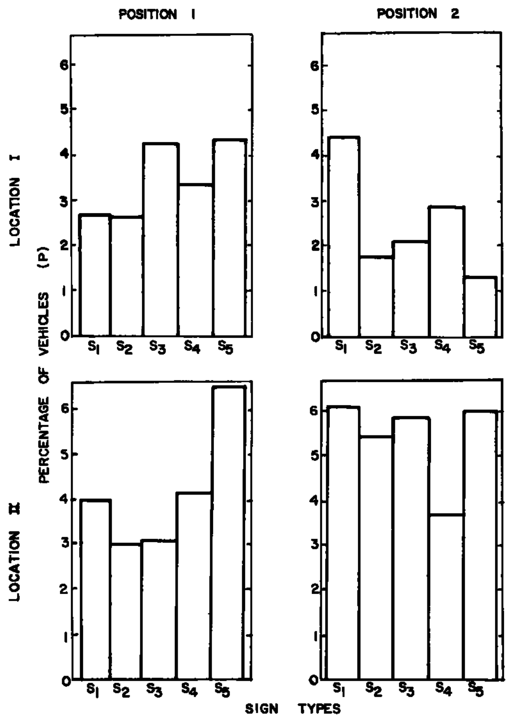


Figure 3. Recommendation criterion for sign types by position and location.

SLOW SIGN STUDY

It has been said that signs are primarily "crutches" to compensate for functional errors of design (5); however, until control of the vehicle can be taken completely away from the driver signs will be necessary. Still it is not a sound engineering or economic principle to erect signs which serve little if any value. This is not to say that no warning of danger should be given the driver, but that if the slow sign must be supplemented by a second sign stating the reason for caution, the slow sign could and should be dispensed with.

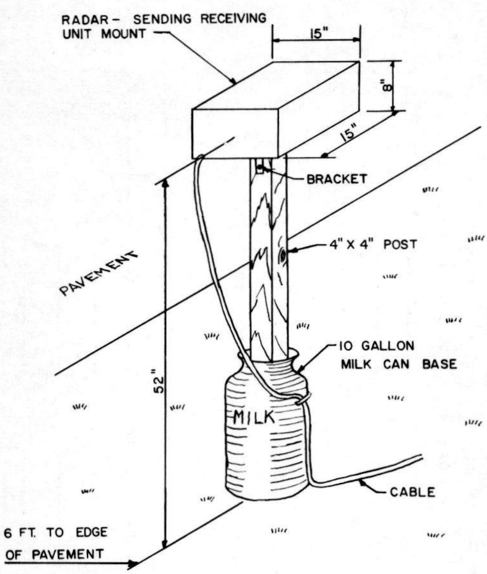
Purpose and Scope

The purpose of the slow sign study was to measure driver obedience to a standard slow sign (3).

Two locations were selected for this study. The first was approximately two miles west of the intersection of Ind. 25 and Ind. 43-US 231 on Ind. 25; the other, approximately one mile west of the intersection of Ind. 25-US 231 and US 52.

The locations selected were chosen because there was absolutely no reason for a slow sign. The topography was flat and the grade level; there were no crossings or entrances warranting lower speeds, and sight distance was much more than adequate.

It should be noted that location I was at a point where the vehicles checked had only traveled approximately 100 yards on a tangent after just having left a long sweeping curve. Location II was situated so that the vehicles checked had left a 30-mph speed zone approximately one-half mile back from the start of the check zone. It was noted in the data that a large majority of the cars checked increased their speed between the two check points at each location. This is probably due to the fact that the locations selected more or less lend themselves to be used as acceleration zones. This situation is not adverse, however, because one must realize that if the slow sign were effective, the vehicle operator would have slowed down regardless of the situation.



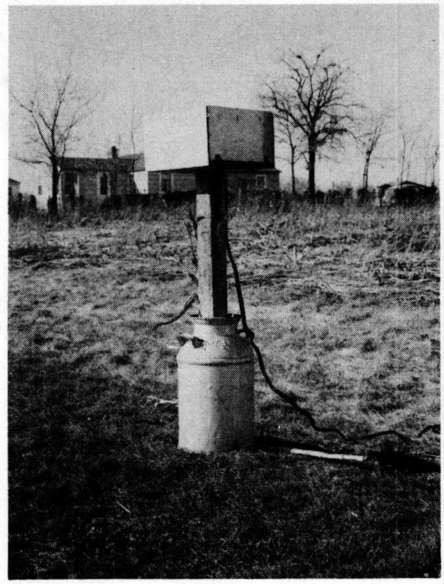


Figure 4. Radar unit in milk can mount.

Observations were made both day and night at both locations during the latter part of December 1955 and the beginning of January 1956.

Only passenger cars were included in the study; trucks, including panels, pickups, and farm vehicles, were excluded.

Weather conditions were similar during the time of study; that is, observations were made only at times when the pavement was dry, no snow was present, and visibility was good.

Speeds were taken, using a pneumatic tube speed meter, 700 ft in advance of the sign. Speeds were again taken of the same vehicles, using a commercially built radar meter, 300 ft beyond the sign.

Equipment

The equipment used in this study consisted of a standard 30-in. slow sign (black enameled message on yellow enameled background), a sign post with fasteners, a radar meter, a pneumatic tube speed meter, and a radar meter mount.

Speeds on both of the meters used can be read to the nearest 1 mph; $\pm$ 2 percent accuracy.

The radar meter mount (Fig. 4) was designed and constructed by the author. It consisted of a 10-gal. milk can, half filled with concrete to act as the base; a 4- by 4-in. wooden post, removable for easier handling, of such a length so as to bring the top of it to a distance of 4 ft above the ground; and a plywood box mounted on the top of the post by means of a heavy steel bracket. The box, made to simulate a rural mailbox, was left open at the front to allow interference-free operation of the radar unit and was equipped with a removable back for easier handling. A small opening was provided in the back to allow for the passage of the electrical cable of the radar unit.

Procedure

At the beginning of this study some concern was felt as to the effect the tubes of the pneumatic speed meter might have on the driver. To investigate this possibility, two samples of 50 passenger cars each were taken, both using the radar meter to measure the speeds. The first sample was taken without the tubes being on the road; the second was taken after the tubes had been positioned on the pavement in such a way that the speeds were taken when the driver was equidistant between the two tubes. It was found that the two average speeds thus obtained were practically identical in magnitude, thus it was decided that for purposes of this test no allowance need be made for the presence of the tubes.

After the position of the speed meter tubes was established, the slow sign was placed 700 ft from a point midway between the two tubes (Fig. 5). A distance of 700 ft was chosen because it was believed that at such a distance a driver would not be able to distinguish the slow sign and thus could not yet be influenced by it. The slow sign was placed at this point at a height of 5 ft from the middle of the sign to the ground.

The next question that had to be answered was where, in relation to the slow sign, should the radar meter be placed so as to record the lowest speeds attained by the drivers observed? Obviously this could not be at any one point; however, it was hoped that a point could be found at which the average speed of the sample would be at its lowest value.

Due to the fact that the "mailbox" mount was open at one end and the radar meter could be seen by the drivers, the meter was beamed down the road and speeds were obtained after the vehicle had passed the radar meter.

The range of the radar meter used varies between 0 and 150 ft, depending on the angle with the road at which the unit is placed. Therefore, the radar meter was placed successively at distances of 100, 200, and 300 ft beyond the slow sign, and positioned so that speeds were obtained as the vehicles passed a point 100 ft beyond the radar meter itself. In this way, the speeds of a sample of 50 passenger cars were obtained for each distance of 200, 300, and 400 ft beyond the slow sign. As the distance from the sign increased the average speed was found to increase; however, the total difference in average speed between a point 200 ft from the sign and one 400 ft from the sign was less than 2 mph. This difference in speed was not considered to be significant, but since the average speed was increasing, it was decided that speeds would be clocked at a distance of 300 ft beyond the slow sign. This placed the radar unit at a distance of 200 ft beyond the sign.

This investigation was conducted only at location I; however, the distance decided on was used at both locations.

STATISTICAL ANALYSIS

General

Upon completion of the field sampling, the collected data were tabulated in a form more conducive to analysis. This was done by subtracting the final speed from the initial speed. Therefore, a positive difference in speed indicates that the vehicle in question slowed down, whereas a negative difference indicates a speeding up.

A sample size of 50 passenger cars was used at each of the two locations for each sample taken. A t-test was then run on the collected data to ascertain whether or not this sample size was sufficient for the accuracy desired. It was found that, in each case, a sample size of 50 vehicles was more than adequate to obtain the desired results.

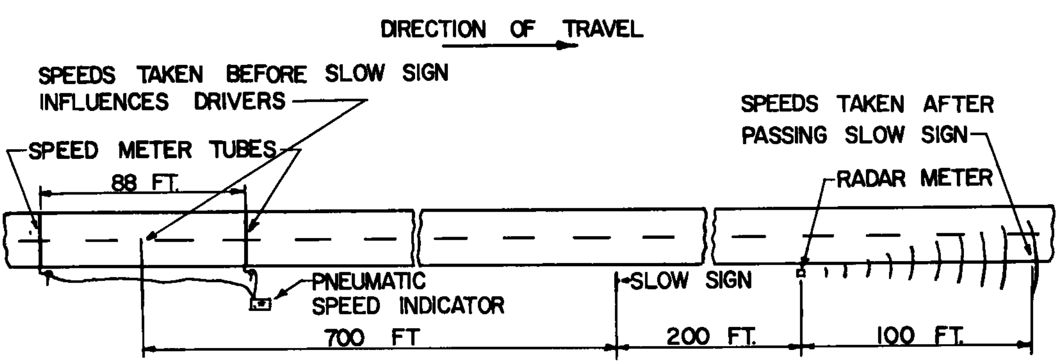


Figure 5. Diagram of slow sign set-up.

t-Test

It was decided that a one-sided t-test would be used to measure the effectiveness of the slow sign (6). It was hypothesized that a slow sign alone does influence a driver sufficiently to make him decrease his speed; that is, it is effective.

By effective, in the hypothesis, is meant that if the true mean of the speed difference (average difference for an extremely large number of drivers) was greater than zero, the slow sign would be defined as being effective. On the other hand, if the true mean of the speed difference was equal to or less than zero, the slow sign would be defined as not effective.

In this type of analysis, the error which is guarded against is the error of saying that the sign in question is not effective when in reality it is effective. With this idea in mind, the tests were designed so as to limit the probability of this error to 5 percent for each of the tests.

Table 2 gives the results of the six t-tests conducted on the collected data, plus the average speed observed for each sample. It can be seen that in four of the six cases the test indicates that the slow sign is not effective. If the slow signs were effective the probability of getting six samples, by chance, which gave four or more significances would be extremely small. Therefore, the conclusion drawn is that the slow signs are generally not effective and no further statistical work on these data is appropriate. The only conclusion which can be reached about the remaining two cases is that, even though it cannot be said, by this test, that the slow sign was not effective, the value of $\bar{d}$ is not of great enough magnitude to warrant any opposite conclusion.

This difference in significance might have come about because the drivers had a longer period of time in which to obtain their normal driving speed prior to arriving at the studied location.

Any further analysis of these data would only serve to point out how much less effective the slow sign was at one location and time of day than at another. This would be of no practical value and of little, if any, academic value.

TABLE 2

RESULTS OF t-TESTS AND AVERAGE SPEED FOR EACH SAMPLE

Sample	Sample Size	Average Speed, mph	Sample Mean	Standard Deviation	Sign Effectiveness[a]
		(a) Location I			
Day 1	50	44.3	-1.84	3.512	x
Day 2	50	46.5	-1.64	5.698	x
Night	50	47.0	-4.08	6.796	x
		Location II			
Day 1	50	44.5	+1.00	5.966	NS
Day 2	50	44.7	+0.92	5.581	NS
Night	50	45.7	-1.44	5.814	x

[a] x = Slow sign not effective; NS = Difference not significantly negative.

CONCLUSIONS

It should be noted that the slow sign analysis has been based on data collected at locations where the installation of slow signs is not warranted, and where the natural tendency of the driver is to accelerate. Therefore, with this fact in mind, the following conclusions and recommendations have been reached:

1. Slow signs are, in themselves, generally not effective.
2. Slow signs should not be used without additional signs stating the nature of the danger involved. Even then, slow signs are probably not warranted unless the need to decrease speed is extremely great.

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