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PASSIVE PROTECTION AT RAIL-HIGHWAY GRADE CROSSINGS

INTERIM REPORT

by

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16. Abstract

Evaluation techniques were studied for use in evaluating passive protection at rail-highway grade crossings. Techniques studied were driver head movements, brake light applications, vehicle speed profiles, standard deviation of spot speeds, and motorist interviews.

Results of the pilot studies indicate that standard deviation of spot speeds and motorist interviews are the most effective evaluation techniques.

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I. SUMMARY AND CONCLUSIONS

With fourteen hundred passively controlled highway-railroad grade crossings in New Jersey and a ratio of fatalities to accidents (for train-vehicle collisions) of approximately 1:7, more effective vehicular control devices will be sought during this program.

This report summarizes the work to-date on the development and evaluation of measures to be used to test the effectiveness of passive vehicular controls which will be developed subsequently for use at rail-highway grade crossings.

Four measures were tested in three pilot studies, conducted at two sites.

a) The standard deviation of the spot speed on the crossing itself was found to be very high in relation to the variation of speed on the approach. Spot speeds at the crossing will be one measure used in our studies.

b) Head movements of motorists, looking down the tracks, was found to be virtually non-existent. This measure will not be used.

c) Brake applications on the approach to the rail crossing did not exceed 7.6% of the approach volume, even though over 60% of the motorists claim to slow down. This measure will not be used.

d) Motorist interviews are believed to be the most effective method of determining the importance of control designs. Approximately 20% of the motorist population can be reached by more effective designs, and only the motorist interview can determine if this occurs. This measure will be used in the study.

II. INTRODUCTION

Although less than 0.1 percent of motor vehicle accidents occur at highway-railroad grade crossings in the State of New Jersey, 1.8 percent of all motor vehicle fatalities occur at these crossings. These statistics indicate the seriousness of this type of collision and point to the need for more effective control designs on the approaches to railroad grade crossings.

Since 60% of the highway-railroad crossings in New Jersey are not actively controlled, special attention should be given to insure maximum effectiveness of the passive designs at these crossings.

This report covers one phase of a study on passively protected highway-railroad grade crossings. The complete study will:

a) develop evaluation techniques to be used to study the effectiveness of passive warning devices, (contained in this interim report),

b) develop experimental passive warning devices, and

c) make field installations and studies of effectiveness of the experimental devices.

Before attempting to develop a method of evaluation of passive protection devices, the desired objectives of the designs to be evaluated were defined. Three basic objectives chosen for this project are: (1) make the motorist aware that he is approaching the crossing (to make him aware of the presence of a train is beyond the scope of this kind of protection), (2) make the motorist aware that his judgment, and his judgment alone, will determine whether or not it is safe to go over the crossing, and (3) create a uniform motorist response both on the approach to and at the crossing. It is logical that the vehicle-vehicle accident potential at a crossing where there are large variations in driver reactions is greater than that at which only small variations exist.

It was with these objectives in mind that measures of effectiveness for evaluating passive protection devices were considered.

III. PROCEDURE TO EVALUATE MEASURES OF EFFECTIVENESS

Since the purpose of a control installation at a highway-railroad grade crossing is the reduction of train-vehicle accidents, without increasing vehicle-vehicle accidents, the most effective measure for the evaluation of various controls is the analysis of accident information. A tabulation of accident information, however, indicates that at any one crossing site, there may only be one accident every few years. With information as sparse as this, statistical evaluation of different controls could take decades. Hence, methods other than accident analysis have been considered in this study.

After observing motorists at several passively protected crossings, five measures of effectiveness of passive control devices were selected for consideration. These included: vehicle speed profiles, standard deviation of spot speed, motorist head movements, brake light applications and motorist interviews.

Of these, the vehicle speed profile was eliminated because it was considered impractical to obtain. A series of tape switches, pneumatic tubes, or other vehicle detection devices placed near or across the road and the related monitoring equipment would be too conspicuous to the motorist, quite possibly influencing his speed.

The remaining methods of evaluation were field tested to define and overcome possible difficulties.

STANDARD DEVIATION OF SPOT SPEEDS

The standard deviation of spot speeds at various distances from the crossing was considered to be a measure of the uniformity of driver response. A large variance in speeds would indicate a lack of uniformity in driver response to the crossing and its associated protective designs. A small variance would indicate more uniform driver response.

At two pilot sites, spot speed studies were taken at 50 foot intervals from the crossing up to 300 feet upstream. Speeds were measured using an Automatic Signal Model S-5 radar unit mounted in a vehicle parked near the crossing.

It was necessary to either mount the radar inside the car or conceal the car, because the radar, combined with a policeman pulling vehicles off the road for an interview further down the road, resembled a speed trap. Obviously this would influence vehicle speeds. Suspicions of this were confirmed when vehicles travelling in the opposite direction were spotted flashing their headlights at vehicles approaching the crossing.

HEAD MOVEMENTS

An increase in the number of motorists looking for trains would indicate an increased motorist awareness of the crossing's existence. It could be implied that the motorist who looked for a train had assumed the responsibility of insuring his own safety.

At the pilot sites, head movements were recorded by an observer inconspicuously positioned at the crossing looking upstream. The observer noted the number of drivers looking right only, left only and in both directions.

Head movements could be used on a comparative basis at the same site evaluating an existing control design to an experimental one.

BRAKE LIGHT APPLICATIONS

Motorists applying their brakes on the approach to a crossing would indicate their awareness of it. Besides frequency of brake application, the dispersion (in location from the crossing) of the application of brakes would indicate the uniformity of motorist response, among these motorists who were aware of the crossing. This procedure was also considered as a useful technique for use at night.

At a pilot site, brake light applications were recorded by an observer stationed approximately 300 feet upstream of the crossing. The point at which brakes were first applied on the approach to the crossing was noted (in 50 foot intervals). Vehicles required by law to stop at grade crossings were not included in the study.

This measure was initially tested at a smooth crossing to reduce the influence of the crossing's roughness on driver reactions. It must be noted, however, that an unfamiliar motorist who applied his brakes may have done so because he did not know whether or not the crossing was rough.

MOTORIST INTERVIEWS

The use of motorist interviews was evaluated to determine the motorists' awareness of the crossing, the source of their awareness and their subsequent action.

The interviews were taken at a point downstream from the crossing out of the approaching motorist's view. A limit of one minute's travel time, at the speed limit of the road, was chosen as the maximum distance for the interview site from the crossing. A policeman was used to pull vehicles to the side of the road for the interview.

In an effort to determine the most efficient method of conducting this survey technique, a questionnaire (Figure 1) was presented to motorists in two ways during a pilot study.

First, the motorist was handed the questionnaire and pencil and instructed to complete it himself. The interviewer only answered questions on the meaning of questions, if he was asked. In the second method, the interviewer read each question to the motorist without giving the motorist any suggestions, marking the choice closest to the driver's response or writing in a response in the "other" category.

The rationale behind the format of the questionnaire was threefold:

1) a comparison of the magnitude of motorist awareness of the crossing, using different control designs, is necessary,
2) the reason for a motorists' awareness of the crossing is essential to determine the importance of the control design, and
3) the views of the driving public were sought for control designs that may be used in further studies.

Because familiarity with the crossing and recent exposure to a crossing incident would affect a motorist's reaction, the questionnaire covered the familiarity of the motorist with the study site and his knowledge of recent events affecting highway-railroad grade crossings, in general.

NEW JERSEY DEPARTMENT OF TRANSPORTATION
RESEARCH PROGRAM ON HIGHWAY-RAILROAD GRADE CROSSINGS

1. Did you just go over a railroad crossing?________________

   IF YES

   a. Can you tell us what made you aware of it?
      ________ Signs before coming to crossing
      ________ Signs at crossing
      ________ Familiar with location
      ________ Saw tracks
      ________ Rough crossing
      ________ Other (Specify)________________

   b. What do you think would make you more aware that you were approaching this crossing?
      ________ Large signs at crossing
      ________ Large signs before coming to crossing
      ________ Several signs before coming to crossing
      ________ New shape or color to signs
      ________ Rumble strips
      ________ Other (Specify)________________

   c. Did you slow down when you approached this crossing?________

      Why did you slow down?
      ________ Rough crossing
      ________ Danger of trains
      ________ Usually slow down at railroad crossing
      ________ Other (Specify)________________

   d. Is there a bell, signal, or other warning device at this crossing which tells you that a train is coming?____________

   IF NO

   e. What do you think would make you aware that you were approaching a railroad crossing?
      ________ Large signs at crossing
      ________ Large signs before coming to crossing
      ________ Several signs before coming to crossing
      ________ New shape or color to signs
      ________ Rumble strips
      ________ Other (Specify)________________

   f. Do you think all railroad crossings have a signal, bell, or other warning device which tells you that a train is coming?________

2. How often do you drive along this section of road?
   ________ Never
   ________ Less than once a month
   ________ Several times a month

3. Have you heard anything about railroad crossings in the past few months?
   ________ No
   ________ Yes (Specify)________________

To determine to what extent motorists may be giving false information, an abbreviated motorist interview was conducted on a road that had no upstream grade crossing.

IV. SITE SELECTION

Although the selection of a site is not a primary task of this research program, soon after the start of the research it became apparent that very few sites would lend themselves to the study techniques. Considering the evaluation techniques that were to be evaluated, a site had to have the following characteristics:

a) an hourly volume (by direction) in excess of 100 vehicles, to obtain a sufficient sample size,

b) ample "cover" at the crossing and upstream of the crossing for the inconspicuous positioning of a vehicle and observer,

c) a downstream location where vehicles could be safely interviewed on the side of the road, and

d) a relatively smooth track crossing to reduce the influence that roughness would have on the motorists' actions and interview responses.

Pilot studies were conducted at two separate sites: Route 27 in Kingston and Route 70 in Medford. Both crossings have single tracks with unscheduled rail traffic volume averaging three trains per week. The passive control signing at both crossings is in good condition.

Two pilot studies were conducted at the Route 27 site: one daytime and one nighttime. Because of safety considerations, motorist interviews were not conducted during the night study. Only a daytime study was conducted at the Route 70 site.

V. RESULTS AND DISCUSSION OF PILOT STUDIES

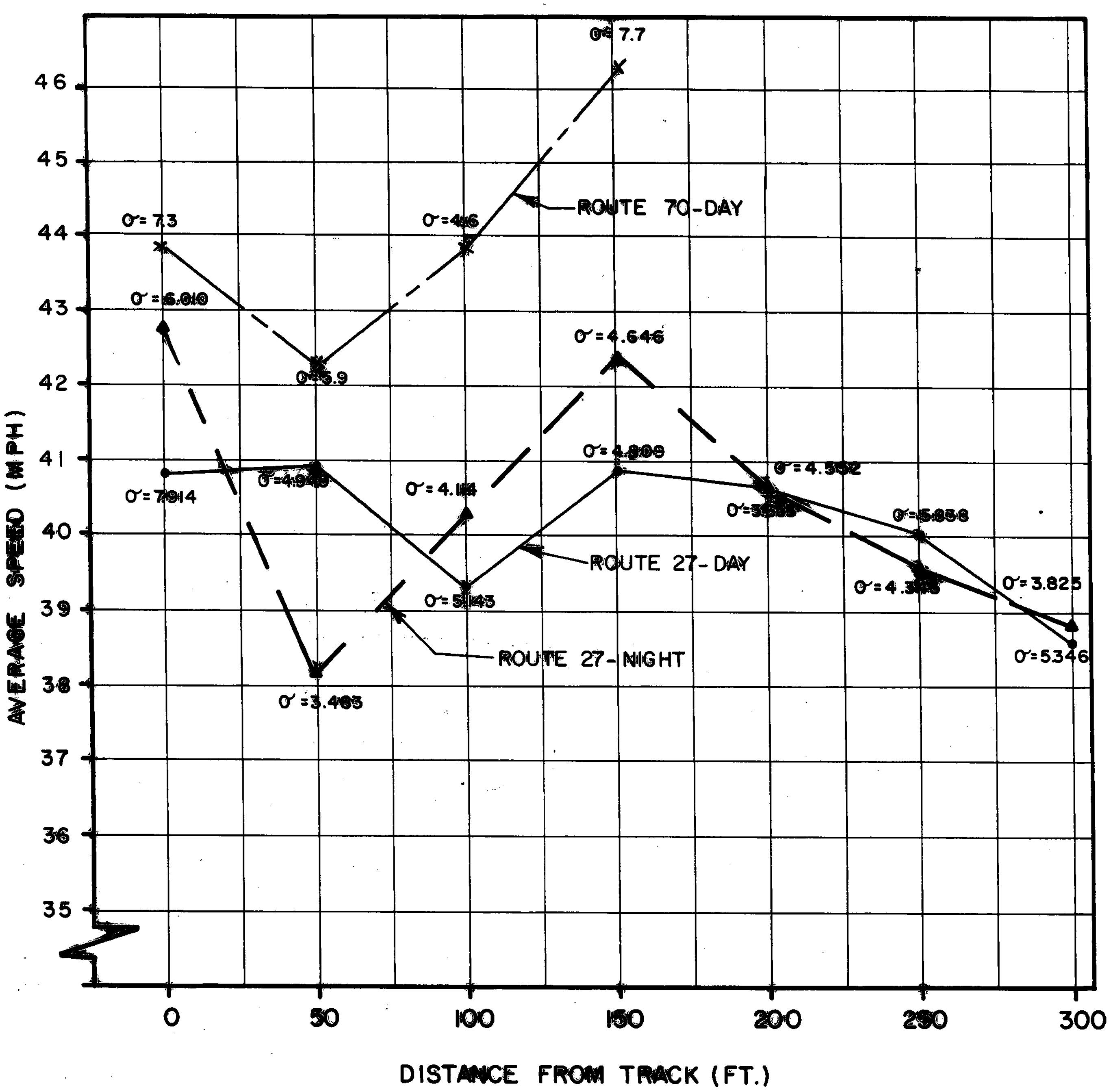
Standard Deviation of Spot Speeds

From the three studies conducted, it was found that a low point in the mean spot speed profile occurred at 50 to 100 feet upstream of the crossing (Figure 2). No inference is made from this finding since the mean speed at this point is only two to four miles per hour below other points on the approach.

The standard deviation of speeds, however, shows a very high value at the crossing itself. The assumption that deviations in speed have an influence on accident potential was enforced during all three studies, especially when vehicles were required to stop by law. Because of the resulting turbulence in the traffic flow caused by the mixture of the decelerating motorists and those of constant speed, the standard deviation is considered to be a worthwhile measure of the effectiveness of increasing the motorists' awareness of the crossing.

FIGURE 2

MEAN SPOT SPEED PROFILE



The task of determining the point on the approach for data collection of this measure has been reduced to the crossing itself, on the basis of the results of the pilot studies.

Head Movements

It was noted that less than five percent of all motorists looked in either direction on the approach to the railroad crossing at the first pilot study site. Subsequently, observations were made at several crossings with poor sight distance. Except for an occasional motorist who would glance down the tracks (while on the crossing), no one slowed and looked for trains. Obviously, it is too late to look for trains while on the crossing.

The implication that motorists who are more aware of the crossing would be cautious to the point of looking for trains could not be verified. Hence, this technique is not being considered for use as a measure of effectiveness in this study.

Brake Light Applications

Figures 3a and 3b show the frequency of brake applications by distance from the crossing for one of the pilot sites. It was found that as few as 7.6% and 3.7% of all approaching motorists applied their brakes in the daylight and night studies respectively.

The summary of the motorist interviews (Table 1 & 2) indicates that over 60% of all drivers slow down on their approach to a crossing, but only a small percentage felt it necessary to

BRAKE LIGHT APPLICATIONS – DAYLIGHT

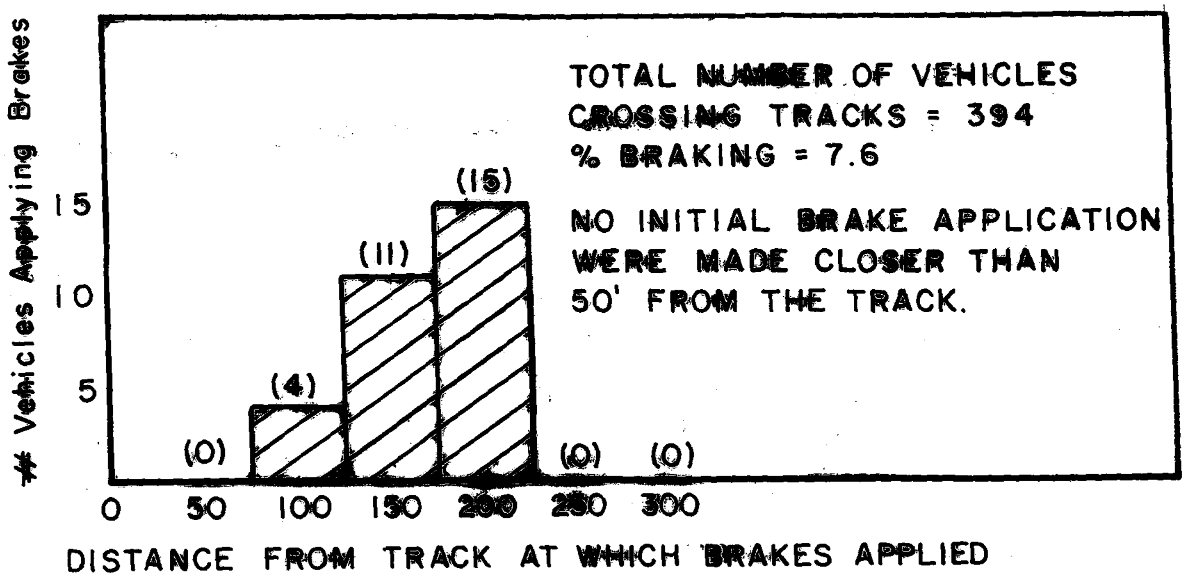


FIGURE 3A

BRAKE LIGHT APPLICATIONS – NIGHT

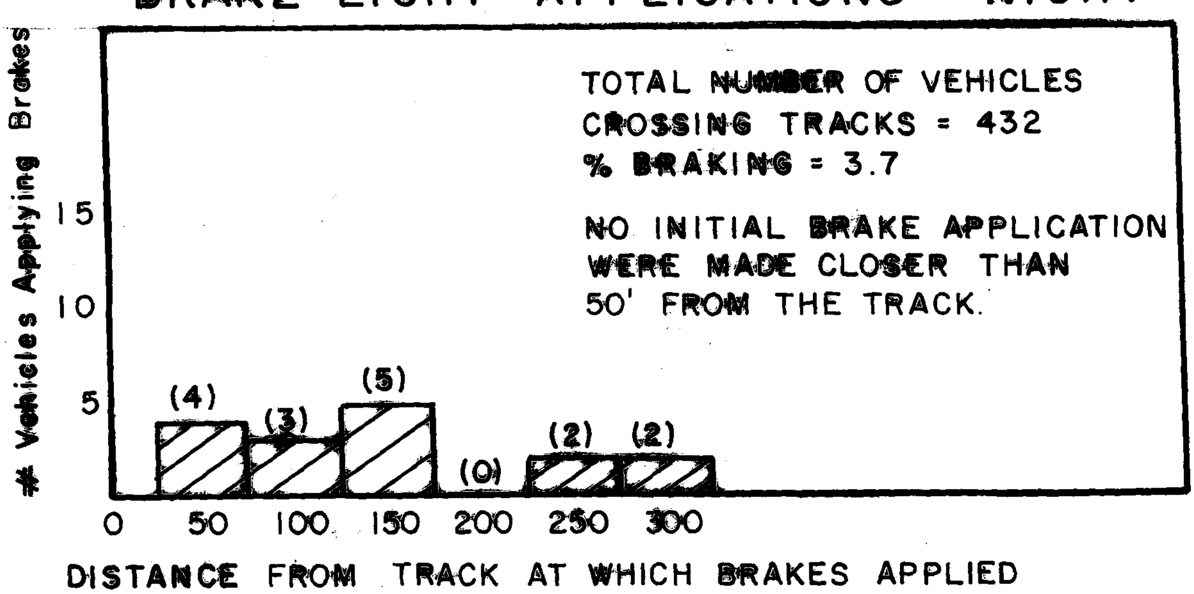


FIGURE 3B

TABLE 1

SUMMARY OF MOTORIST INTERVIEWS AT ROUTE 27 (BY PERCENT)

Question Asked		Type of Questionnaire Presentation: Motorists Interviewed	Type of Questionnaire Presentation: Motorists Filled Out Form
Percentage Aware of Crossing		90	87
Reasons for Awareness			
Signs		20	19
Familiarity		56	54
Tracks		24	27
Suggestions for Improvement			
Larger Signs		27	42
More or Different Signs		5	24
Rumble Strips		2	19
Active Control		53	5
Other		13	10
Slowed Down?	Yes	58	71
	No	42	29
Reasons for Slowing			
Rough Crossing		39	55
Danger		30	19
Habit		20	11
Other		11	15
Crossing is Active?	Yes	21	26
	No	66	49
	Don't Know	13	26
Percentage Unaware of Crossing		10	13
Suggestions for Improvement			
Larger Signs		24	30
More or Different Signs		37	20
Rumble Strips		0	50
Active Control		39	0
Other		0	0
All Crossings are Active?	Yes	100	33
	No	0	67
All Motorists			
Frequency of Travel on This Road			
Never		5	10
Less Than Once a Month		16	15
Several Times a Month		79	75
Heard About Railroad Crossings Recently	Yes	36	11
	No	64	89
Total Number of Motorists Interviewed		58	47

TABLE 2

SUMMARY OF MOTORIST INTERVIEWS AT ROUTE 70 (BY PERCENT)

Percentage Aware of Crossing		85
Reasons for Awareness		
Signs		32
Familiarity		42
Tracks		23
Other		3
Suggestions for Improvement		
Larger Signs		45
More or Different Signs		32
Rumble Strips		8
Active Control		5
Other		20
Slowed Down?	Yes	77
	No	23
Reasons for Slowing		
Rough Crossing		38
Danger		7
Habit		43
Other		12
Crossing is Active?	Yes	18
	No	73
	Don't Know	9
Percentage Unaware of Crossing		15
Suggestions for Improvement		
Larger Signs		66
More or Different Signs		8
Rumble Strips		4
Active Control		7
Other		15
All Crossings are Active?	Yes	43
	No	57
All Motorists		
Frequency of Travel on This Road		
Never		13
Less Than Once a Month		11
Several Times a Month		76
Heard About Railroad Crossings Recently		
	Yes	8
	No	92
Total Number of Motorists Interviewed		137

slow rapidly enough to apply their brakes. Although the brakes may have been applied by a motorist in an effort to be sure of stopping if a train appeared at the crossing, chances are the roughness of the crossing was as much a factor.

The discrepancy between the percentage of vehicles slowing and those applying brakes and the infrequency of the brake applications make this measure a tentative one for use in this study. If initial studies indicate an increase in application, this measure will be reconsidered for use.

Motorist Interviews

Of the two forms used for the interviews (the motorist fills out the questionnaire himself vs. an interviewer fills out the questionnaire), the latter method was found to yield faster results by about one-half minute per interview. Prior to the interviewer giving "choices" to the motorists, responses making reference to active controls were abundant. Subsequent to the choice being given to the motorist reference to active controls was drastically reduced (Tables 1 & 2). This is important because the nature of the study is geared toward passive controls.

Although from 85% to 90% of the motorists interviewed during the three studies indicated an awareness of the existence of the railroad grade crossing, approximately 20% of all the motorists were either unaware of the crossing or were not aware until they actually crossed the tracks. Assuming that "familiarity" will continue to be the primary reason for motorist awareness at railroad crossings, there is a substantial motorist population whose attention can be sought through the use of new experimental designs.

The results of the pilot study at the location where there was no upstream railroad crossing (Table 3) indicates that about ten percent of the motorists may be falsifying their reply to the question on awareness. This is assumed to be a percentage that is constant at all locations and will affect the statistics uniformly.

The motorist interview technique is probably the most conclusive means of comparing sign designs, and when combined with the standard deviation of mean speeds at the crossing, should yield a good comparison of control designs.

A secondary reason for the motorist interview was to find their views on more effective means of getting the motorists' attention on the approach to a crossing. As a result, over half of the responses indicate that signing may be the best passive control for this purpose.

TABLE 3

SUMMARY OF MOTORIST INTERVIEWS
AT SITE WITH NO RAILROAD GRADE CROSSING

Answers to Question: "Did You Just Go Over A Railroad Crossing?"	No. of Responses	Percent
Yes	14	10
Think So	2	1
Don't Remember	3	2
Don't Know	11	7
Don't Think So	3	2
No	117	78
Total	150	100

NOTE: 26% of motorists drove section of road less than once a month.