

Red Colored Pavement

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A before-and-after study was performed on a ramp ending with a stop sign and at the ramp's intersection with a one-way roadway. Speeds and lags for both day and night conditions were measured before and after the ramp was paved red. Four pneumatic tubes were placed on the ramp at various distances from the stop line. Ramp traffic was registered on a 20-pen recorder. Speeds were computed using the difference in time and the distances between tubes. Average speeds were determined for points 100, 200, and 318 ft from the stop line.

Ramp traffic stopping and ramp and highway traffic crossing the intersection were manually recorded using a 20-pen recorder. Average accepted and rejected lags were computed. Before and after measurements were compared: the daytime speeds were significantly lower after the ramp was paved red, but for nighttime speeds and daytime and nighttime lags, there were no significant differences.

•THE motorists on today's highways are called upon to assimilate vast amounts of information about the ever-changing traffic stream around them. They must digest and react to a multitude of traffic-control devices within a relatively short period of time.

Over the past 25 to 30 years, various experimental sections of colored pavement have been examined in an effort to determine their potential as an aid to better driver performance and highway safety. However, very little controlled research has been reported, and that which has, did not lead to conclusive results.

Initial attempts at producing colored pavement resulted in some unsatisfactory results. A principal source of complaint was color fading, and early applications suffered from an insufficient amount of pigments.

Although colored pavement studies to date have not proven or disproven, for the matter, its effectiveness as an aid to better driving performance and safety, other studies dealing with the use of color as a means of conveying information indicate that color coding is a significant means of conveying information to the motorist (1,2).

In order to evaluate on a limited basis the potential of colored pavement as an aid to driver performance and safety, the New Jersey Department of Transportation has installed a section of red colored pavement to be used in conjunction with stop signs. The study will evaluate (a) the performance of materials used to produce a colored surface, and (b) various driver characteristics related to the use of colored pavement. The first portion of this study, the materials evaluation, will not be discussed in this report as the test section of highway has not been in operation a sufficient period of time to adequately conduct such an evaluation. It is anticipated that the materials evaluation will evaluate such physical characteristics as (a) color uniformity, saturation, and retention; (b) visibility and reflectance; (c) skid resistance properties; and (d) reaction to chemicals, among other factors. The Prismo Safety Corporation applied red-coated spheres to this section of colored pavement, and the results of their tests of reflectivity and sphere retention will be covered in the materials evaluation.

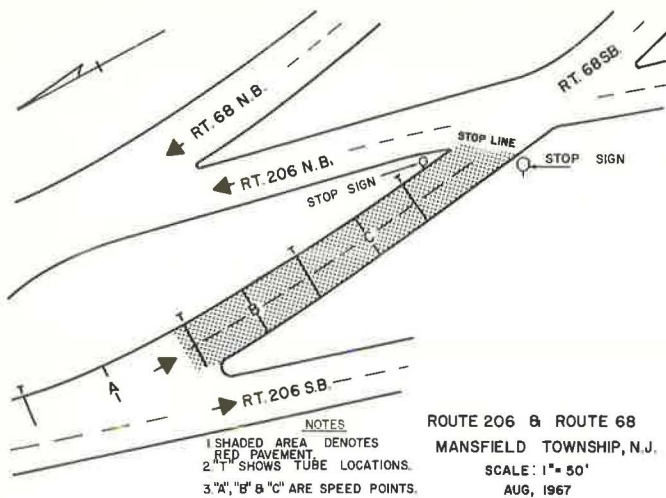


Figure 1. Red pavement site plan.

As previously stated, the color selected for evaluation was red and was used in conjunction with a stop condition. This is in accordance with a recommended use of the color red by the special committee on color of the National Joint Committee on Uniform Traffic Control Devices.

The color red in highway practices is accepted to mean "stop" or "do not" (2). There was some apprehension as to what the motorist's reaction would be to this red colored pavement. Would he think there was a stop condition ahead and react accordingly, or would he feel that it meant "do not enter" and cause him to react accordingly? This

was an important question at this location because it was at a ramp-type location where the color red could have conveyed either meaning. However, since to our knowledge it has not stopped anyone from entering the ramp, it did not convey the meaning of "do not enter."

The purpose of this portion of the study is to evaluate the effects of red colored pavement on various aspects of driver behavior at a ramp location ending in a stop condition.

DESCRIPTION OF SITE

The section of highway selected for the study was the intersection of US 206 and NJ 68 in Mansfield Township, Burlington County, New Jersey (Figs. 1 and 2). A 280-ft section of the Route 206 southbound ramp (between US 206 southbound lanes and US 206 northbound lanes) was paved with $\frac{3}{4}$ -in. red asphalt (see shading) on June 22, 1967. Prior to this, the ramp was concrete. This ramp leads to a stop condition at the northbound lanes of US 206 and connects into NJ 68 eastbound (on the east side of the northbound lanes of US 206). The terrain is flat and open, with no sight-distance restrictions. The speed limit on US 206 is 55 mph in both directions. There are two oversize (44 by 44 in.) internally illuminated (neon tubing) flashing stop signs at the end of the ramp (Fig. 3). The ramp is illuminated by two 4,000 lumen incandescent overhead lights spaced



Figure 2. Study site.

170 ft apart on the right-hand side of the ramp. Two 4,000 lumen incandescent overhead lights located on US 206 also contribute illumination to the ramp.

The AADT on US 206 south, at the entrance to the ramp, is 7,500 veh/day, with approximately 54 percent, or 4,050 veh/day using the ramp. The AADT on US 206 north is 3,500 veh/day at the ramp crossing with US 206 north. The ramp consists of two 16-ft lanes bordered by mountable concrete curbs. White solid edge-marking lines were in place next to the concrete curb and a white skip-line separated the two lanes. A white stop line was at the location of the stop signs at the east end of the ramp. The same markings were replaced after the red pavement was installed.

Although accidents are not reported in this report due to insufficient time to evaluate them after the pavement was laid, they did play a role in the selection of the location as a study section. A before-and-after accident analysis will be conducted after sufficient time has elapsed to adequately conduct such a study.

From January 1, 1963, to December 31, 1965, 31 accidents occurred—three fatal, killing five persons, and eleven injury accidents, injuring 44 persons. Twenty-two of the accidents were right angle and seven were rear-end. All rear-end accidents occurred on the ramp.



Figure 3. Stop condition.

STUDY PROCEDURE

One of the major reasons for adding color to the road surface is that the color should alert the motorist to an impending special condition. In this case, the red color was to alert the motorist to an impending stop condition. In an attempt to evaluate this, two characteristics were measured: (a) the speeds of vehicles (passenger cars or vehicles with four tires) approaching the stop signs before and after the installation of the red pavement at various points to be discussed later, and (b) the number of vehicles disregarding the stop signs before and after the installation of the red pavement. A third characteristic was also measured that was felt could be affected by the red pavement. This was the acceptance of lags by vehicles crossing US 206 north from the ramp. It was felt that the red pavement might alert the motorist to a hazardous condition and cause him to be more cautious to conditions at the intersection, thereby perhaps choosing to accept longer lags. A lag, for the purpose of this study, is the time interval between the arrival of a vehicle at the stop sign on the ramp and the arrival of the first vehicle on US 206 at the center of the intersection of the ramp and US 206 north. A lag will also be referred to as a time interval between the arrival of a vehicle at the center of the intersection of US 206 north and the arrival of the next vehicle on US 206 north at the same location when a vehicle is waiting on the ramp to cross US 206 north. To insure an adequate, consistent sample, only lags for cars that are first in line on the ramp will be tabulated. (Lags for queued vehicles will not be tabulated.)

Speed Measurements

Speeds were measured by use of pneumatic tubes stretched across the ramp at distances of 50, 150, 250, and 386 ft from the stop line and connected to a 20-pen recorder. The speed data were collected during both day and night conditions; only vehicles which stopped for the stop sign were recorded. Because speeds recorded are average speeds over a measured distance, they are plotted at the midpoints between the tubes at which the speeds were determined; i.e., the speeds are plotted at distances of 100,

TABLE 1
SPEED DATA COLLECTION TIMES

Date	Day or Night	Hours	Sample Size
(a) Before			
5/4/67	Day	4:00 p. m. - 6:30 p. m.	286
5/4/67	Night	8:30 p. m. - 10:30 p. m.	297
(b) After			
7/27/67	Day	3:45 p. m. - 7:00 p. m.	603
7/27/67	Night	8:45 p. m. - 10:15 p. m.	402

the ramp, and (c) a ramp vehicle crossing the intersection. The sample data recorded on the recorder are shown in Figure 4. Referring to this Figure, line 1 shows a blip for the arrival of a vehicle on US 206, line 2 shows a blip for the arrival of a vehicle on the ramp, and line 3 shows the crossing of a vehicle on US 206. Distance R in Figure 4 is a time lag rejected, while distance A is the time lag accepted by the vehicle on the ramp to cross US 206 north. Lag data were taken before and after the installation of the red pavement (Table 2).

Vehicles Disregarding Stop Sign

The number of vehicles which passed through the stop sign, making no attempt to slow or stop, was recorded during the same time periods as the collection of lag data.

ANALYSIS AND RESULTS

Speeds Before and After

The speed data were analyzed statistically by utilizing the standard test for testing significant differences in means. The formula utilized for this test is

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}}$$

where

\bar{X}_1 and \bar{X}_2 = the mean speeds for before and after;

N_1 and N_2 = the sample sizes for before and after; and

S_1 and S_2 = the standard deviations of the speeds before and after.

The level of significance used in the test was the 90 percent level of significance. If the t-value obtained in the test

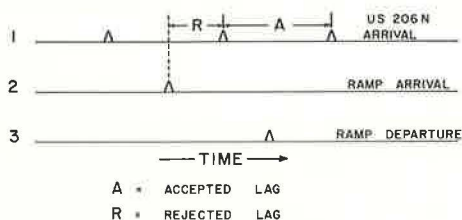


Figure 4. Recorder tape.

200, and 318 ft from the stop line (Fig. 1). Before and after speed data were taken as given in Table 1. The weather was clear and dry during all data collection periods.

Lag Measurements

The measurements of lag acceptance and rejection were made by utilizing a telegraph key connected to a 20-pen recorder. The recorded data were (a) a vehicle arriving at the center of the intersection of US 206 and the ramp on US 206, (b) a vehicle arriving at the stop line on

TABLE 2
LAG DATA COLLECTION TIMES

Date	Day or Night	Hours	Sample Size*
(a) Before			
11/4/66	Day	1:30 p. m. - 3:00 p. m.	86
11/9/66	Night	6:30 p. m. - 8:00 p. m.	44
(b) After			
7/31/67	Day	1:40 p. m. - 3:10 p. m.	124
8/1/67	Night	8:45 p. m. - 10:15 p. m.	47

* For cars which are first in line only.

is greater than the t-value for the 90 percent level (1.65) of significance, then there is assumed to be a significant difference in the results at this level of significance.

As stated previously, the speeds were obtained at distances of 100, 200, and 318 ft from the stop line. Table 3 shows the speeds before and after at each point and for day and night conditions. This is also shown in Figures 5 and 6.

It can be seen (Fig. 5) that at all three points where the speeds were recorded for the day conditions, the after average speeds were less than the corresponding before speeds. Although the average speeds after were less by only approximately 1 mph, they were significantly different at the 90 percent level of confidence at points A and B. At point C there was no significant difference in the average speeds before and after.

At the same three points (Fig. 6) during night conditions, the average speed during the after portion was also less than the before average speed. However, at none of the three points were the average speeds significantly different at the 90 percent level for before and after.

TABLE 3
BEFORE AND AFTER SPEED DATA

Site	Distance From Stop Sign (ft)	Mean Speed (mph)		Significant Difference
		Before	After	
(a) Day				
A	318	38.7	37.6	Yes
B	200	32.1	31.5	Yes
C	100	24.1	23.9	No
(b) Night				
A	318	37.4	37.1	No
B	200	31.5	31.2	No
C	100	23.9	23.6	No

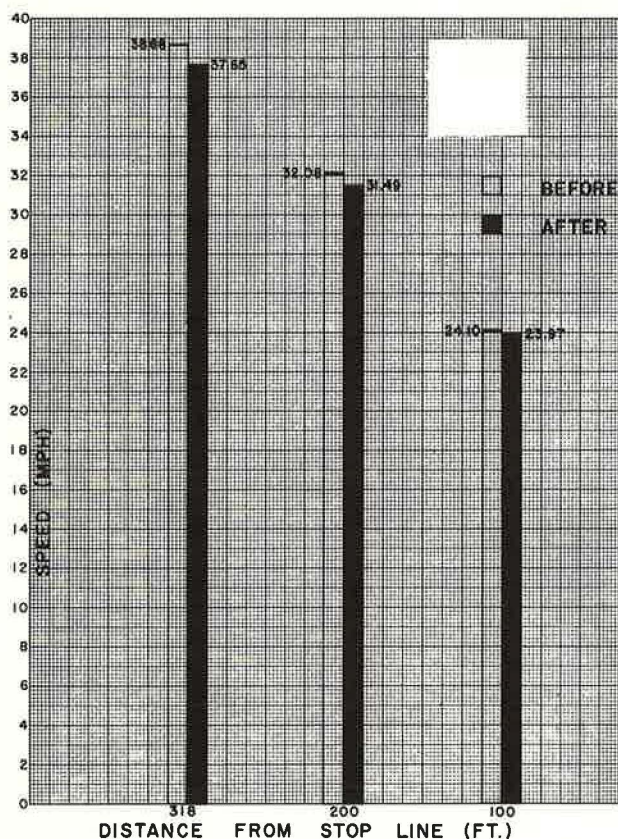


Figure 5. Speeds, day.

A second test, the "F" test was used to check for a significant difference in the variance of the before and after speeds. The formula utilized for this test is

$$F = \frac{S_1^2}{S_2^2}$$

where

S_1^2 = variance of before speed data, and

S_2^2 = variance of after speed data.

The 90 percent level of significance was used in this test also.

At points A and C there is a significant difference in the variability of the before and after speeds for day conditions. At point A, the variance before is greater than the after variance, whereas at point C, the reverse is true. At point B there is no difference at the 90 percent level of significance. The colored pavement may have the effect of causing speeds to be grouped closer around the mean at point A, whereas it appears that the reverse occurred at point C. It would appear more desirable to have the speeds grouped closer around the mean, as at point A, than to have a larger variation, as at point C.

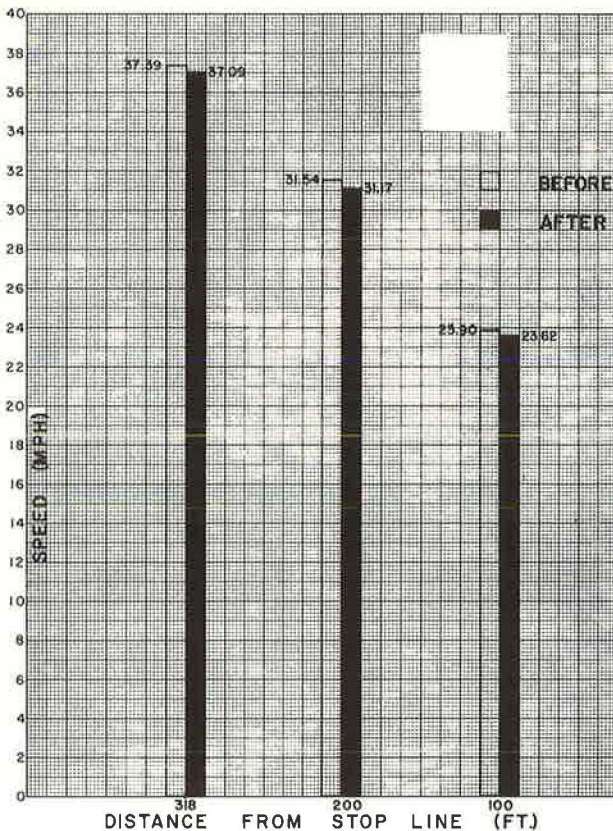


Figure 6. Speeds, night.

speeds should not have been affected by the red pavement and, statistically, they were not.

Lag Acceptance and Rejection

Vehicles accepting or rejecting lags of from 0.5 to 15.0 seconds were analyzed to determine the mean lag accepted and the mean lag rejected for both before and after conditions. The 15-second maximum lag was used because no vehicle rejected a lag over 15 seconds.

During the before and after period for day conditions, the average lag accepted was 10.52 and 10.72 seconds respectively. A test for significant differences in means at the 90 percent level of confidence indicated that there was no significant difference between the average lag accepted before and after the installation of the red pavement. The average lags rejected for the same conditions were 3.70 seconds before and 3.97 seconds after. Here, also, there was no significant difference in the two average values before and after (Table 4). It does not appear that the red colored pavement has any effect on causing the driver to be more cautious and perhaps accept a longer lag.

For night conditions before and after, the average lags accepted were 11.28 and 11.05 seconds respectively (Table 5). Here again, the test for significant differences in means indicates that there was no significant difference between the average lag accepted at night before or after the installation of the red pavement. The average lag rejected at night before was 4.49 seconds, and after it was 4.51 seconds. There was no significant difference at night in the average lag rejected before and after the instal-

For night conditions, there was a significant difference at the 90 percent level at point A, as there was for day conditions. However, there was no significant difference at points B and C. The after variance was again less than the before variance.

The fact that the mean speeds are not significantly different for before and after conditions during hours of darkness appears to support the opinions of our engineers who have driven the section during both day and night conditions. The red pavement is certainly visible during day conditions, but appears to black out at night. The red color does not appear to be discernible, thereby logically indicating that the red pavement should have no effect on changing speeds in the area.

Although the average speeds were only slightly less during the after period for day conditions, it is possible that the red pavement alerted the motorist to the impending stop-hazardous condition, which thereby contributed to the reduction in the average approach speeds. For night conditions, since it appears at least visually that the red pavement was not distinguishable, the average

TABLE 4
LAG DISTRIBUTIONS, DAY

Midpoint Value (sec)	Accepted		Rejected	
	Before	After	Before	After
0.25	0	0	8	11
0.75	0	0	13	21
1.25	0	0	9	28
1.75	0	0	13	16
2.25	0	0	18	15
2.75	0	0	17	15
3.25	0	0	9	29
3.75	0	0	14	12
4.25	1	0	7	12
4.75	0	0	6	6
5.25	0	0	4	18
5.75	1	4	8	11
6.25	1	2	4	10
6.75	4	4	6	11
7.25	4	7	11	5
7.75	9	3	3	2
8.25	5	7	3	4
8.75	5	11	2	2
9.25	6	3	0	5
9.75	2	9	1	2
10.25	2	9	0	2
10.75	7	8	1	3
11.25	3	9	0	3
11.75	7	8	0	3
12.25	6	5	0	0
12.75	4	2	0	1
13.25	6	8	0	1
13.75	2	9	0	0
14.25	5	6	1	0
14.75	6	10	0	0
Total	86	124	158	248
Over 15.00	157	190	0	2
Mean	10.52	10.72	3.70	3.97
Std. Dev.	2.65	2.57	2.53	2.90

Note: Means are computed using values of 15.00 seconds or less.

TABLE 5
LAG DISTRIBUTIONS, NIGHT

Midpoint Value (sec)	Accepted		Rejected	
	Before	After	Before	After
0.25	0	0	4	10
0.75	0	0	8	12
1.25	0	0	9	8
1.75	0	0	6	20
2.25	0	0	6	8
2.75	0	0	4	9
3.25	0	0	4	7
3.75	0	1	7	14
4.25	0	0	8	12
4.75	0	1	5	6
5.25	0	0	5	5
5.75	0	0	3	13
6.25	0	0	3	7
6.75	0	1	3	7
7.25	0	2	5	7
7.75	1	0	4	4
8.25	0	3	2	2
8.75	3	3	4	7
9.25	3	1	4	2
9.75	5	4	0	1
10.25	6	3	1	1
10.75	3	3	2	4
11.25	2	3	0	2
11.75	4	0	0	2
12.25	6	6	2	0
12.75	3	3	0	1
13.25	4	3	0	3
13.75	1	4	0	0
14.25	0	3	0	0
14.75	3	3	0	0
Total	44	47	99	174
Over 15.00	164	216	1	0
Mean	11.28	11.05	4.49	4.51
Std. Dev.	1.77	2.65	3.05	3.19

Note: Means are computed using values of 15.00 seconds or less.

lation of the red pavement. Here again, it does not appear that the red colored pavement had any effect on causing the driver to be more cautious and perhaps accept a longer lag.

Disregard of Stop Sign

Under day conditions before the pavement was installed, eight out of 282 vehicles observed passed through the stop sign without making any attempt to slow or stop. After the installation, three vehicles out of 351 observed passed without stopping. For night conditions, two out of 252 observed passed before as compared with one out of the 311 observed after. A test for significant difference in proportions, also at the 90 percent level, indicates that there is no significant difference in the passing before and after for day or night conditions.

CONCLUSIONS

No definite conclusions can be drawn from this study concerning the overall effectiveness of the use of red colored pavement, particularly since it deals with only one location. However, it is felt that this study gives some insight into the effect of the red colored pavement on approach speeds and lag acceptance and rejection. At this site, it appears that the red pavement may have a significant effect on causing the average approach speed at two of the three study points to be significantly less for day conditions. It also may have an effect on the variation of speeds at two of the study points, although the variation was less at one point after and greater at the other. It could be argued

that the difference in average speeds was too small to be appreciable logically; however, it was appreciable statistically at the 90 percent level of significance. For night conditions, there was no change in the average before and after speeds statistically; since the red color was not discernible at night, this appears logical.

The red pavement apparently had no effect on the average lag accepted or rejected after the installation of the pavement as compared with before the installation for both day and night conditions.

Generally, it appears that the red colored pavement caused little, if any, change in the parameters studied. However, two major categories are yet to be studied, namely, the materials evaluation and the accident analysis.

Also, it must be kept in mind that the use of colored pavement to convey a definite meaning to the motoring public is new and little, if any, attempt has been made to educate the public as to its use or meaning. Although this location was given wide newspaper and TV coverage, it is doubtful that the majority of motorists passing through the location accept the red color to mean that a "stop" or "hazardous" condition is impending. Perhaps the better measure will be the accident evaluation.

Although the results of this study show little, if any, change in the parameters studied after the installation of the red pavement, it is not meant to infer that colored pavement cannot be an effective traffic control device. It is felt that colored pavement has the same potential to convey messages through its use of color as traffic signs. However, some means of educating the motoring public to the meanings of the various colors when used in pavements must be devised. Then the results of studies to evaluate its effectiveness will perhaps be more meaningful and give a better insight into its actual potential as a traffic control device.

REFERENCES

1. Birren, Faber. Safety on Highways. Amer. Jour. Opthal., Series 3, Vol. 43, 1957.
2. Robinson, C. C. Color in Traffic Control. Traffic Engineering Mag., May 1967.