Effectiveness of Experimental Transverse-Bar Pavement Marking as Speed-Reduction Treatment on Freeway Curves

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Researchers performed a before-and-after analysis of speeds to determine the short- and long-term effectiveness of an experimental transverse-bar pavement marking treatment at the Plainfield curve on I-43–I-94 in Milwaukee, Wisconsin. The experimental transverse pavement marking treatment was installed in all lanes for each of the northbound and southbound directions of the curve in early September 2006. Each section of the pavement marking treatment was 1,000 ft long. The treatment sections consisted of a series of white transverse-bar markings installed with continuously decreasing spacing between successive markings, giving drivers the perception of increasing speed, potentially causing them to slow down. Each individual marking was 18 in. in lateral width by 12 in. longitudinally. Speed data were collected for 2 weeks in late July 2006; again in September 2006, approximately 1 week after the markings had been installed; and again in March 2007, approximately 6 months after the markings had been installed (northbound only). The researchers used analysis of variance to analyze the mean speeds for more than 43,000 intervals of 5 min each measured at three locations in each lane of the northbound and the southbound directions. The results of the analysis suggest that the experimental transverse pavement marking treatment was effective at reducing curve speeds, especially shortly after installation. The marking treatment showed the greatest effects on speeds midway through the treatment section with approximately 1- to 4-mph reductions in mean speed observed between the before and the after periods. A lane-by-lane analysis showed that the marking treatment was most effective at reducing speeds in the shoulder and middle lanes, while speeds in the median lane were relatively unaffected.

Several transverse pavement marking patterns have been used experimentally in the United States as a means of reducing vehicular speeds by creating the illusion to drivers that they are accelerating. This illusion can be generated by placing either transverse bars or chevrons on the pavement at increasingly closer spacings. As drivers travel through the marking section at constant speeds, the decreasing spacing of the markings gives the perception of acceleration, consequently causing drivers to slow down. These types of pavement marking treatments have been installed at horizontal curves, roundabouts, intersections, bridges, and work zones.

A 1995 review of current practice by Griffin and Reinhardt showed rather extensive experimentation with transverse-bar markings throughout the United States (*1*). Several patterns, colors, sizes, and spacings had been reported for the various transverse-bar installations, with widely inconclusive results on their effectiveness for speed reduction or safety improvements. Most of the studies reported some level of speed reduction after installation of the treatment, although they were inconclusive about whether the observed speed reductions would be sustained over the course of time.

More recently, Katz et al. analyzed both the short- and long-term effects on speeds of a transverse-bar treatment installed at three horizontal curves (*2*). The three sites included a freeway-to-freeway exit ramp in New York, a two-lane rural arterial in Mississippi, and a two-lane rural local highway in Texas. The results showed a long-term decrease in speeds at each of the sites, although the magnitude of the decrease varied by site. The freeway exit ramp saw a long-term mean speed reduction of 3.9 mph, while smaller speed reductions were observed at the rural arterial and local highway. The greater speed reduction at the freeway site was partially attributed to a greater percentage of unfamiliar drivers there compared with the other sites.

Drakopoulos and Vergou evaluated the effect of a converging-chevron treatment on speeds at a single-direction freeway-to-freeway exit ramp on I-94 in Milwaukee, Wisconsin (*3*). A before-and-after analysis showed reductions in the mean and 85th-percentile speeds of 15 and 17 mph after the installation of the chevron markings. These changes were highly significant, both statistically and practically, considering that the after data were collected 18 months after installation of the markings and that the comparison site did not show considerable changes in speeds during the same period. No adverse effects attributable to the marking treatment were reported.

TREATMENT LOCATION AND DESCRIPTION

This paper describes the results of a before-and-after analysis of vehicular speeds to determine both the short- and long-term effectiveness of an experimental transverse-bar pavement marking treatment when used on a curved section of freeway. The Plainfield curve on I-43–I-94 in Milwaukee, Wisconsin, was selected as the site for installation of the experimental pavement marking in both the northbound and southbound directions. The pavement marking treatment was intended to serve as a low-cost interim safety countermeasure before future realignment construction. The location of the pavement marking installation is shown in Figure 1.

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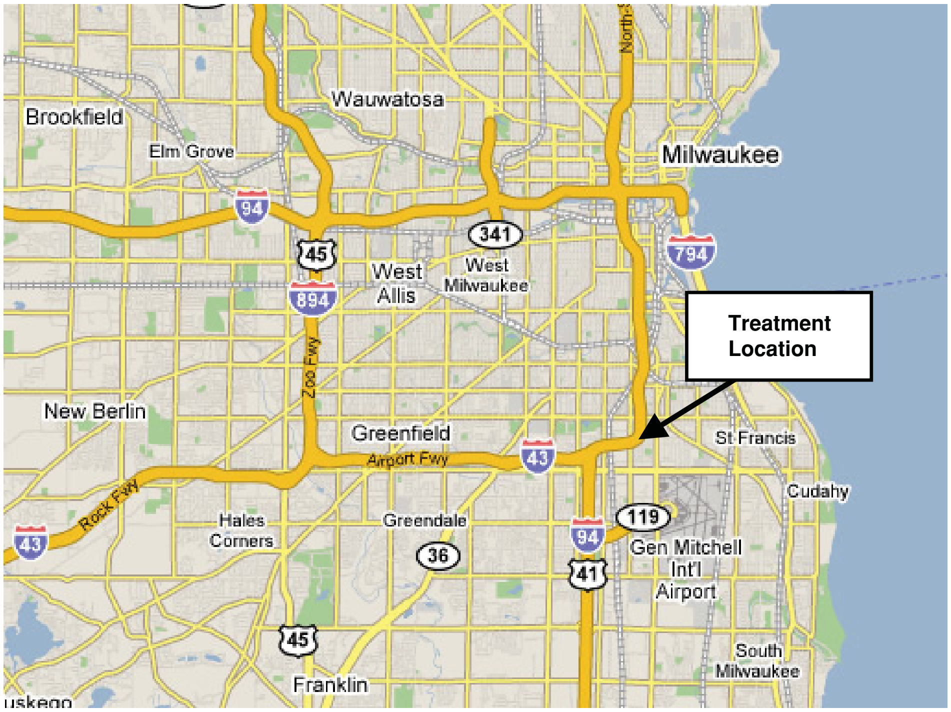

FIGURE 1 Location of experimental transverse pavement marking treatment section.

The experimental transverse pavement marking treatment was installed in both the northbound and southbound lanes at the Plainfield curve in early September 2006. Each treatment section was 1,000 ft long. The markings were installed so that 500 ft of the treatment occurred both before and after the point of curvature (PC) on the horizontal curve. Each individual marking was a white rectangle, 18 in. in lateral width by 12 in. longitudinally. The posted curve advisory speed limit was 50 mph, and the posted speed limit immediately upstream and downstream of the curve was also 50 mph, although the typical speed limit along rural sections of I-94 and I-43 in Wisconsin was 65 mph.

The marking sections were designed and installed with continuously decreasing spacing between successive markings, giving drivers the perception of increasing speed, potentially causing them to slow down. The spacing between successive markings was designed to slow drivers from 65 to 50 mph over the initial 500 ft of the treatment by using a constant frequency of 4 bars/s to provide the illusion of acceleration. Thus, initial spacing between successive markings was 24 ft, while spacing at 500 ft and beyond was 19 ft. Photographs of the section with the pavement marking treatment are shown in Figure 2.

FIGURE 2 Experimental transverse pavement marking treatment.

METHODOLOGY

Data Collection

Speed, volume, occupancy, and vehicle type percentages were measured before and after installation of the markings at three locations throughout the curve (labeled SPEED 1, SPEED 2, and SPEED 3) in both the northbound and southbound directions. Three side-firing Wavetronix radar units were installed by Wisconsin Department of Transportation (DOT) staff in both the northbound and southbound directions and were used to collect the necessary data. The radar units were used to measure and record the following data for each passing vehicle in the particular direction of study:

- Speed,
- Date,
- Time,
- Lane (shoulder, middle, or median), and
- Vehicle classification (i.e., small, medium, or large, based on length).

For data storage purposes, the radar units were programmed to bin the data into 5-min intervals. Thus, the following data were stored for each 5-min period: average speed; total volume in each lane; and percentage of small, medium, and large vehicles. The approximate locations of the northbound and southbound data collection stations are shown in the site diagram in Figure 3 and included the following:

- SPEED 1, which was 350 ft upstream from the start of the marking treatment and 850 ft upstream of the curve PC. This location served as an upstream control point to allow for determination of changes in speeds between the before and the after periods that occurred due to factors not associated with the experimental pavement marking treatment;
- SPEED 2, which was 600 ft downstream from the start of the markings and 100 ft downstream from the curve PC; and
- SPEED 3, which was 200 ft downstream from the end of the markings and 700 ft downstream from the curve PC.

Before data were collected from July 14 to July 28, 2006. The pavement markings were installed between September 5 to September 8, 2006. The shortly-after data were collected from September 11 to September 19, 2006, and September 25 to October 3, 2006. The long-after data were collected from March 5 to March 14, 2007. Long-term data were measured only at the Speed 1 and the Speed 2 stations in the northbound direction due to malfunctions in the other data collection units at the time the data were collected.

Analysis

After being collected from the Wavetronix units, the data were screened and formatted for analysis. The following variables were included in the analysis (with uppercase designating variables):

- Discrete independent variables
  – PERIOD (before versus shortly-after versus long-after),

FIGURE 3 Data collection locations with respect to the experimental marking sections.

– DIRECTION (northbound versus southbound),
– DAY OF WEEK (Monday to Thursday versus Saturday and Sunday),
– LIGHT CONDITION [daylight versus nighttime, based on civil twilight times obtained from U.S. Navy website (*4*)], and
– LANE (shoulder versus middle versus median);
- Continuous independent variables (covariates):
– VOLUME,
– HEAVY VEHICLE PERCENTAGE, and
– SPEED 1 (i.e., speed measured 350 ft upstream from the start of the marking section); and
- Dependent variables:
– SPEED 2 (i.e., speed measured 600 ft downstream from the start of the marking section) and
– SPEED 3 (i.e., speed measured 200 ft downstream from the end of the marking section).

The primary measures of effectiveness were the changes in both SPEED 2 and SPEED 3 between the before and the shortly-after periods. To determine any long-term speed reduction benefit provided by the markings, changes between the before and the long-after periods were also included as measures of effectiveness, although these data were only available for SPEED 2 in the northbound direction.

Certain data were excluded from the analysis because it was believed that they may potentially bias the results, including the following:

- Data measured during wet, icy, or snowy conditions [as indicated by archived pavement surface data from a nearby Road Weather Information System station (No. 101018 located at I-894–I-43, Hales Corners, Wisconsin)];
- Data measured on Fridays, due to the variable mix of commuter and weekend traffic; and
- Cases in which average speeds were less than 35 mph for the 5-min interval, due to the likelihood of congestion being present at speeds below 35 mph, thereby masking any effects of the pavement marking treatment. These cases accounted for only 273 (0.626%) of the 43,634 intervals of 5 min.

The final data set included 43,361 periods of 5 min. A full-factorial univariate analysis of variance (ANOVA) was performed with the commercially available SPSS analysis software. The initial ANOVA showed DIRECTION to be the strongest factor. As a result, subsequent ANOVA were performed separately for each travel direction. Table 1 displays the traffic volume characteristics for each direction and period. Table 2 displays the descriptive statistics for the speed data split by DIRECTION and PERIOD, including the estimated

TABLE 1 Traffic Volumes by DIRECTION and PERIOD

Direction	Period	Statistic	Traffic Volume
Northbound	Before	Number of days in period	15
		Number of 5-min intervals in period	3,933
		Average volume per 5-min interval	219
		Average daily traffic volume	63,072
		Total traffic volume during period	874,866
		Percent of total traffic volume used in analysis (excludes Fridays, wet data, speeds <35mph)	80.5
	Shortly after	Number of days in period	18
		Number of 5-min intervals in period	4,587
		Average volume per 5-min interval	158
		Average daily traffic volume	45,531
		Total traffic volume during period	725,770
		Percent of total traffic volume used in analysis (excludes Fridays, wet data, speeds <35mph)	64.4
	Long after	Number of days in period	9
		Number of 5-min intervals in period	2,575
		Average volume per 5-min interval	201
		Average daily traffic volume	57,948
		Total traffic volume during period	518,148
		Percent of total traffic volume used in analysis (excludes Fridays, wet data, speeds <35mph)	64.4
Southbound	Before	Number of days in period	15
		Number of 5-min intervals in period	4,007
		Average volume per 5-min interval	164
		Average daily traffic volume	47,001
		Total traffic volume during period	655,628
		Percent of total traffic volume used in analysis (excludes Fridays, wet data, speeds <35mph)	82.7
	Shortly after	Number of days in period	18
		Number of 5-min intervals in period	4,576
		Average volume per 5-min interval	155
		Average daily traffic volume	44,670
		Total traffic volume during period	709,948
		Percent of total traffic volume used in analysis (excludes Fridays, wet data, speeds <35mph)	67.8

TABLE 2 Descriptive Statistics for SPEED 1, SPEED 2, SPEED 3 by DIRECTION and PERIOD

Direction	Period	Statistic	SPEED 1	SPEED 2	SPEED 3
Northbound	Before	Mean[a] (mph)	52.72	58.00	55.50
		Std. dev. (mph)	4.65	4.00	3.59
		85th % (mph)	58	61	58
	Shortly after	Mean[a] (mph)	52.67	55.21	52.95
		Std. dev. (mph)	6.28	4.23	4.93
		85th % (mph)	59	60	58
	Long after	Mean[a] (mph)	58.09	54.26	—
		Std. dev. (mph)	4.71	4.65	—
		85th % (mph)	62	60	—
	Short-term change (shortly after minus before)	Mean[a] (mph)	–0.05	–2.79[b]	–2.55[b]
		85th % (mph)	1	–1	0
	Long-term change (long after minus before)	Mean[a] (mph)	5.37[b]	–3.74[b]	—
		85th % (mph)	4	–1	—
Southbound	Before	Mean[a] (mph)	51.41	53.06	59.45
		Std. dev. (mph)	4.44	4.39	3.79
		85th % (mph)	56	57	63
	Shortly after	Mean[a] (mph)	52.05	52.01	54.42
		Std. dev. (mph)	4.10	3.96	5.06
		85th % (mph)	56	56	60
	Short-term change (shortly after minus before)	Mean[a] (mph)	0.64[b]	–1.05[b]	–5.03[b]
		85th % (mph)	0	–1	–3

[a]Marginal means were reported for SPEED 1, SPEED 2, and SPEED 3. The marginal means represented values statistically adjusted in the ANOVA based on the values of SPEED 1 (SPEED 2 and SPEED 3 only), VOLUME, and HEAVY VEHICLE PCT.
[b]Change in mean was statistically significant at 95% confidence level as verified by Bonferroni post-hoc test.

marginal mean, standard deviation, and 85th percentile. The estimated marginal means were reported for SPEED 1, SPEED 2, and SPEED 3, which represent the mean values statistically adjusted on the basis of the values of the covariates [i.e., SPEED 1 (for SPEED 2 and SPEED 3), VOLUME, and HEAVY VEHICLE PERCENTAGE]. Thus, marginal means provide a statistically normalized representation of the changes in mean speed between the various data collection periods. The results of the ANOVA for northbound data only are shown in summary in Table 3.

RESULTS

Short-Term Speed Reductions

Table 2 shows that short-term reductions in the mean and 85th-percentile speeds were observed after the installation of the marking sections in both the northbound and the southbound directions. The marginal means and 85th-percentile speeds for SPEED 2 and SPEED 3 split by PERIOD and DIRECTION are shown in Figure 4.

Short-term reductions in the marginal mean speeds of approximately 2.8 and 2.6 mph were observed in the northbound direction for SPEED 2 (i.e., midway through the marking treatment section) and SPEED 3 (i.e., shortly after termination of the marking treatment section), respectively. Short-term speed reductions of 1.1 and 5.0 mph were observed in the southbound direction for SPEED 2 and SPEED 3, respectively. The ANOVA results confirmed that these short-term speed reductions were statistically significant at a 95% confidence level.

Short-term reductions in the 85th-percentile speeds were lower in magnitude than the mean speeds. Northbound traffic showed 0.0 to 1.0-mph short-term reductions in the 85th-percentile speed, while 1.0- to 3.0-mph short-term reductions were observed for southbound traffic. Changes in the 85th-percentile speeds were not statistically analyzed because well-accepted statistical methods for testing differences between percentiles do not exist. No considerable changes were observed between the data collection periods for standard deviation of speed.

Long-Term Speed Reductions

The results in Table 2 and Figure 4 also show that the speed reductions were sustained in the long term after the markings were installed. Again, long-term data were available only for the northbound direction at the SPEED 1 and SPEED 2 data collection stations. Analysis of the data collected 6 months after the marking installation for the northbound direction showed an incremental 0.9-mph decrease in the mean of SPEED 2 from the Shortly-After period, which equates to a 3.7-mph decrease in speed between the Before and Long-After periods. The 85th percentile of northbound SPEED 2 remained unchanged between the Shortly-After and the Long-After periods.

Before-and-After Speed Reductions by Lane

The ANOVA results shown in Table 3 also confirm the presence of significant interaction effects between several of the categorical variables. Of particular interest to this study were the interactions of the variable PERIOD with other factors, which would indicate that the pavement marking treatment may have caused drivers to respond differently under different situations. For example, the effectiveness of the marking treatment was found to vary strongly on the basis of the lane of travel. The estimated marginal means for

TABLE 3 Results of Full-Factorial ANOVA for SPEED 2 and SPEED 3 (Northbound)

Source	Type III Sum of Squares	df	*F*	Sig.
Dependent Variable: Speed 2 (mph) $R^2 = 0.558$				
Corrected model	259,508.8	38	798.6	0.000
Intercept	336,507.6	1	39,349.9	0.000
VOLUME	2,428.6	1	284.0	0.000
SPEED 1	12,652.3	1	1,479.5	0.000
HEAVY VEHICLE%	17,374.5	1	2,031.7	0.000
LANE	47,212.7	2	2,760.4	0.000
LIGHT CONDITION	945.1	1	110.5	0.000
DAY OF WEEK	3,812.0	1	445.8	0.000
PERIOD	44,084.5	2	2,577.5	0.000
LANE * LIGHT COND	43.9	2	2.6	0.077
LANE * DAY OF WEEK	2,840.3	2	166.1	0.000
LIGHT COND * DAY OF WEEK	33.1	1	3.9	0.049
LANE * LIGHT COND * DAY OF WEEK	33.4	2	2.0	0.142
LANE * PERIOD	17,841.1	4	521.6	0.000
LIGHT COND * PERIOD	80.0	2	4.7	0.009
LANE * LIGHT COND * PERIOD	263.6	4	7.7	0.000
DAY OF THE WEEK * PERIOD	493.4	2	28.9	0.000
LANe * DAY OF WEEK * PERIOD	977.9	4	28.6	0.000
LIGHT COND * DAY OF WK * PERIOD	359.7	2	21.0	0.000
LN * LGHT COND * DAY OF WK * PER	15.2	4	0.4	0.777
Error	205,727.6	24,057		
Total	76,177,532.0	24,096		
Dependent Variable: Speed 3 (mph) $R^2 = 0.653$				
Corrected model	394,753.7	38	1,189.6	0.000
Intercept	344,579.2	1	39,458.3	0.000
VOLUME	1,479.0	1	169.4	0.000
SPEED 1	11,341.8	1	1,298.8	0.000
HEAVY VEHICLE %	17,225.9	1	1,972.6	0.000
LANE	42,928.6	2	2,457.9	0.000
LIGHT CONDITION	781.0	1	89.4	0.000
DAY OF WEEK	10,696.3	1	1,224.8	0.000
PERIOD	100,374.4	2	5,747.0	0.000
LANE * LIGHT COND	56.7	2	3.2	0.039
LANE * DAY OF WEEK	2,422.4	2	138.7	0.000
LIGHT COND * DAY OF WEEK	30.0	1	3.4	0.064
LANE * LIGHT COND * DAY OF WEEK	7.9	2	0.5	0.635
LANE * PERIOD	43,315.6	4	1,240.0	0.000
LIGHT COND * PERIOD	866.2	2	49.6	0.000
LANE * LIGHT COND * PERIOD	303.7	4	8.7	0.000
DAY OF WEEK * PERIOD	350.3	2	20.1	0.000
LANE * DAY OF WEEK * PERIOD	76.8	4	2.2	0.067
LIGHT COND * DAY OF WK * PERIOD	244.1	2	14.0	0.000
LN * LGHT COND * DAY OF WK * PER	13.0	4	0.4	0.829
Error	210,083.8	24,057		
Total	74,043,073.0	24,096		

SPEED 2 and SPEED 3 stratified by LANE are shown in Figure 5 only for northbound data.

Figure 5 shows that the before-and-after speeds reductions were greatest for the shoulder lane and the middle lane. Short-term speed reductions in the shoulder and middle lanes were approximately 3 to 4 mph for SPEED 2. The before-and-after speed reductions for SPEED 2 were sustained for the shoulder lane and were reduced even further for the middle lane 6 months after installation of the markings. Very little change was observed for SPEED 2 for the median lane for either the Shortly-After or Long-After period from installation of the markings. One explanation for this observation is that faster and more aggressive drivers typically use the median lane. Thus, these drivers may be less affected by speed reduction measures like an experimental pavement marking treatment. The short-term changes in SPEED 3 were similar to those observed in SPEED 2, with reductions of 4 to 5 mph observed for the shoulder and middle lanes for the Shortly-After period from installation of the markings. The median lane showed a slight increase in the Shortly-After period for SPEED 3.

Before–After Speed Changes by Light Condition

Figure 6 displays the interaction effects of the variables PERIOD and LIGHT CONDITION on SPEED 2 and SPEED 3. Figure 6 shows that the changes in mean speeds between the before and the after periods were similar for both daylight and nighttime conditions for both SPEED 2 and SPEED 3, as evidenced by the relatively parallel lines in each graph. Although the interactions between LIGHT CONDITION and PERIOD on SPEED 2 and SPEED 3 were found to be statistically significant, these differences were too small to be significant from a practical point of view.

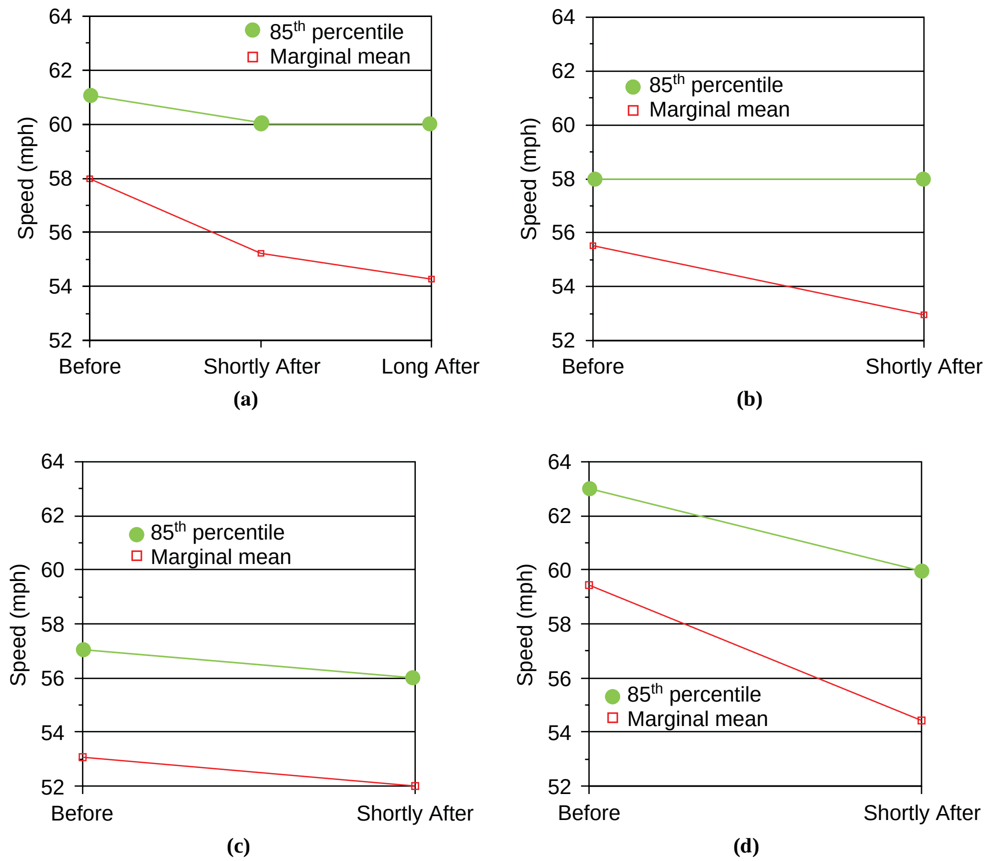

FIGURE 4 Mean and 85th percentile of SPEED 2 and SPEED 3 by PERIOD and DIRECTION: (*a*) SPEED 2, northbound; (*b*) SPEED 3, northbound; (*c*) SPEED 2, southbound; and (*d*) SPEED 3, southbound.

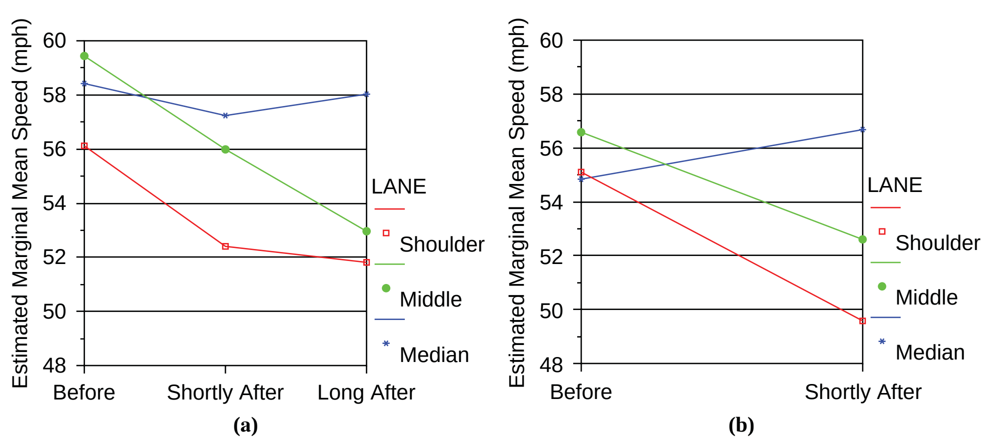

FIGURE 5 Marginal means of (*a*) SPEED 2 and (*b*) SPEED 3 for PERIOD * LANE (northbound only).

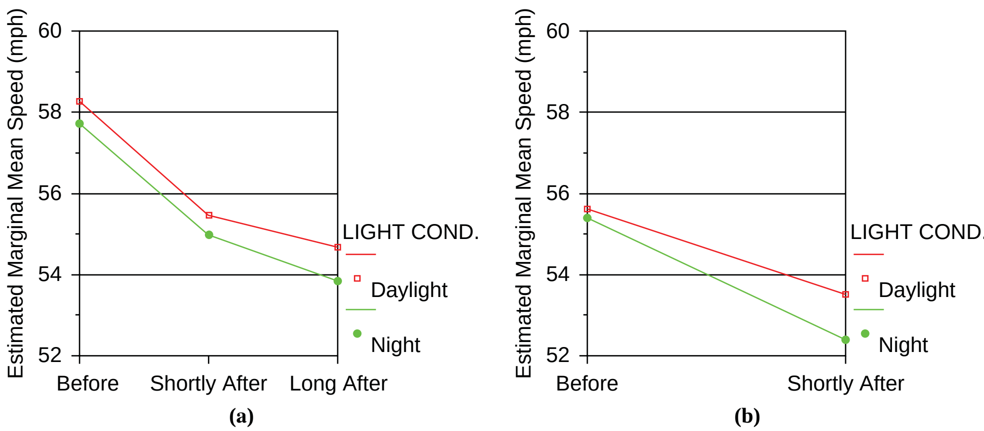

FIGURE 6 Marginal means of (*a*) SPEED 2 and (*b*) SPEED 3 for PERIOD * LIGHT CONDITION (northbound only).

Before–After Speed Changes by Day of Week

Figure 7 displays the interaction effects of the variables PERIOD and DAY OF WEEK on SPEED 2 and SPEED 3. As Figure 7 shows, the before–after mean speed reductions were similar for both weekdays and weekends at both the SPEED 2 and SPEED 3 locations, as evidenced by the relatively parallel lines in each graph. The interactions between DAY OF WEEK and PERIOD on SPEED 2 and SPEED 3 were found to be statistically significant, although, similarly to other two-way interactions, these differences were too small to be significant from a practical point of view.

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

A before-and-after analysis of speeds was performed to determine the short- and long-term effectiveness of an experimental transverse pavement marking treatment at the Plainfield curve on I-43–I-94 in Milwaukee, Wisconsin. The researchers analyzed mean speeds for more than 43,000 intervals of 5 min measured at three locations in each of the northbound and southbound directions. Speeds were measured 6 to 8 weeks before installation of the experimental markings, 1 to 4 weeks after installation, and again 6 months after installation (northbound only). An analysis of variance was performed to determine the short- and long-term effects of the pavement marking treatment on the means of both SPEED 2 (i.e., speeds measured midway into the marking section) and SPEED 3 (i.e., speeds measured 200 ft after the termination of the marking section).

The analysis showed statistically significant short-term reductions in the mean speeds for SPEED 2 and SPEED 3 after installation of the marking treatment of approximately 2.8 and 2.6 mph, respectively, in the northbound direction and 1.1 and 5.0 mph, respectively, in the southbound direction. Reductions in the 85th-percentile speeds were lower in magnitude, with 0.0- to 1.0-mph reductions in SPEED 2 and SPEED 3, respectively, observed for northbound traffic and 1.0- to 3.0-mph reductions observed for southbound traffic. No considerable changes were observed between the data collection periods for standard deviation of speed.

The results also showed that the short-term speed reductions at the northbound SPEED 2 location were sustained in the long term after the markings were installed. Analysis of the data collected 6 months after the marking installation for the northbound direction showed an incremental 0.9-mph decrease in the mean of SPEED 2 from the Shortly-After period, which equated to a 3.7-mph decrease between the Before and the Long-After periods. These results suggest that

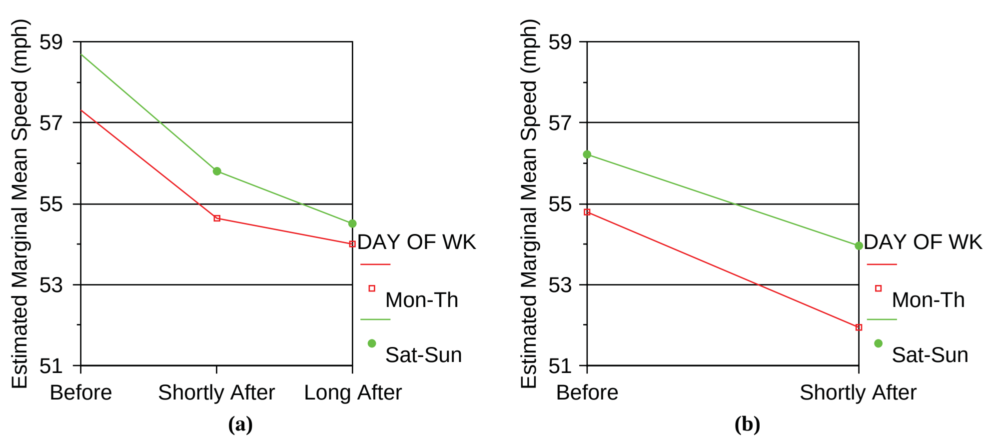

FIGURE 7 Marginal means of (*a*) SPEED 2 and (*b*) SPEED 3 for PERIOD * DAY OF WEEK (northbound only).

drivers were actually responding to the effect of the marking treatment and not simply to the novelty associated with a new and unfamiliar traffic control treatment. The 85th percentile of northbound SPEED 2 remained unchanged between the Shortly-After and the Long-After periods.

Lane-by-lane statistical analysis showed that the greatest before-and-after speed reductions occurred in the shoulder and middle lanes, while only slight and inconsistent effects on speed were observed for the median lane. This led researchers to conclude that the markings were considerably less effective at reducing speeds of the more-aggressive drivers who typically travel in the median lane. The markings had approximately the same effect on speeds during weekdays and weekends, perhaps suggesting that the generally familiar weekday driving population (i.e., commuters) will react similarly to the markings in both the short term and the long term compared with the generally less-familiar weekend driving population. The markings were also found to have a similar effect on speeds during daytime and nighttime hours, perhaps indicating similar levels of visibility of the markings when viewed during daylight conditions and at night with headlights and roadway lighting.

In conclusion, the results of the analysis suggest that the experimental pavement marking treatment was effective at reducing curve speeds, especially in the short term (i.e., less than 1 month after installation). The markings showed the greatest short-term effects on vehicles in the shoulder and middle lanes, with 3- to 5-mph reductions in the mean speeds observed both midway through and shortly after exiting the experimental-marking section. Before–after speed reductions were sustained 6 months after installation at the northbound location when measured midway through the marking section.

The findings reported here were in relatively good agreement with the findings of other recent research of similar transverse-bar pavement marking treatments used at curves (*1, 2*). Furthermore, no adverse safety effects associated with the transverse markings were observed. Nevertheless, the researchers recommend further evaluation of these treatments in various scenarios (e.g., curves and work zones) before conclusions can be drawn about the proven long-term effectiveness of the transverse-bar pavement markings as a speed reduction treatment. It appears, however, that the treatment may be particularly appropriate for use in specific short-term speed reduction situations, such as highway work zones.

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