Evaluation of an Experimental Transverse-Bar Pavement Marking Treatment on Freeway Curves

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ABSTRACT

Researchers performed a before-and-after analysis of speeds to determine the short-term and long-term effectiveness of an experimental transverse-bar pavement marking treatment at the "Plainfield Curve" on I-43/94 in Milwaukee, Wisconsin. The experimental transverse pavement marking treatment was installed in both the northbound and southbound lanes in early September 2006 and each treatment section was 1,000 feet in length. Each treatment section consisted of a series of white transverse-bar markings that were installed with decreasing spacing between successive markings giving drivers' the perception of increasing speed when driving through the section of markings, potentially causing drivers to slow down. Each individual marking was 18 inches in lateral width by 12 inches longitudinally. Speed data were collected for two weeks in late July 2006, again in September 2006 approximately one-week after the markings had been installed, and again in March 2007 approximately six-months after the markings had been installed. The researchers used analysis of variance to analyze the mean speeds for more than 43,000 5-minute intervals measured at three locations in each lane of the northbound and 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 marking treatment section with approximately 1 to 4 mph reductions in mean speed observed between the before-and-after periods (both short-term and long-term). 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.

INTRODUCTION

Various transverse pavement marking patterns have been used experimentally in the United States as a means to reduce 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 vehicles travel through the marking section at constant speeds, the decreasing spacing of the markings will give drivers the perception that they are accelerating, consequently causing them 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 Griffith and Reinhardt showed rather extensive experimentation with the transverse bar markings throughout the United States (*1*). Several different patterns, colors, sizes, and spacings had been reported for the various transverse bar installations, resulting in widely inconclusive results as to their effectiveness for speed reduction or safety improvements. Most of the studies reported some level of speed reductions after installation of the treatment, although it was inconclusive as to whether or not the observed speed reductions would be sustained over the course of time (*1*).

More recently, Katz, et al., analyzed both the short-term and long-term effects on speeds of a transverse bar treatment installed at three different 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. Speeds were measured at each of the sites 1) before installation, 2) shortly after the installation, and 3) six months after the installation. 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 reductions on at the freeway site were partially attributed to a greater percentage of unfamiliar drivers compared to the other sites (*2*).

Drakopoulos and Vergou evaluated the effect of a converging chevron treatment on speeds at a single directional freeway-to-freeway exit ramp on Interstate 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 affects attributable to the marking treatment were reported (*3*).

The research described herein describes the results of a before-and-after analysis of vehicular speeds to determine both the short-term 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-43/94 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.

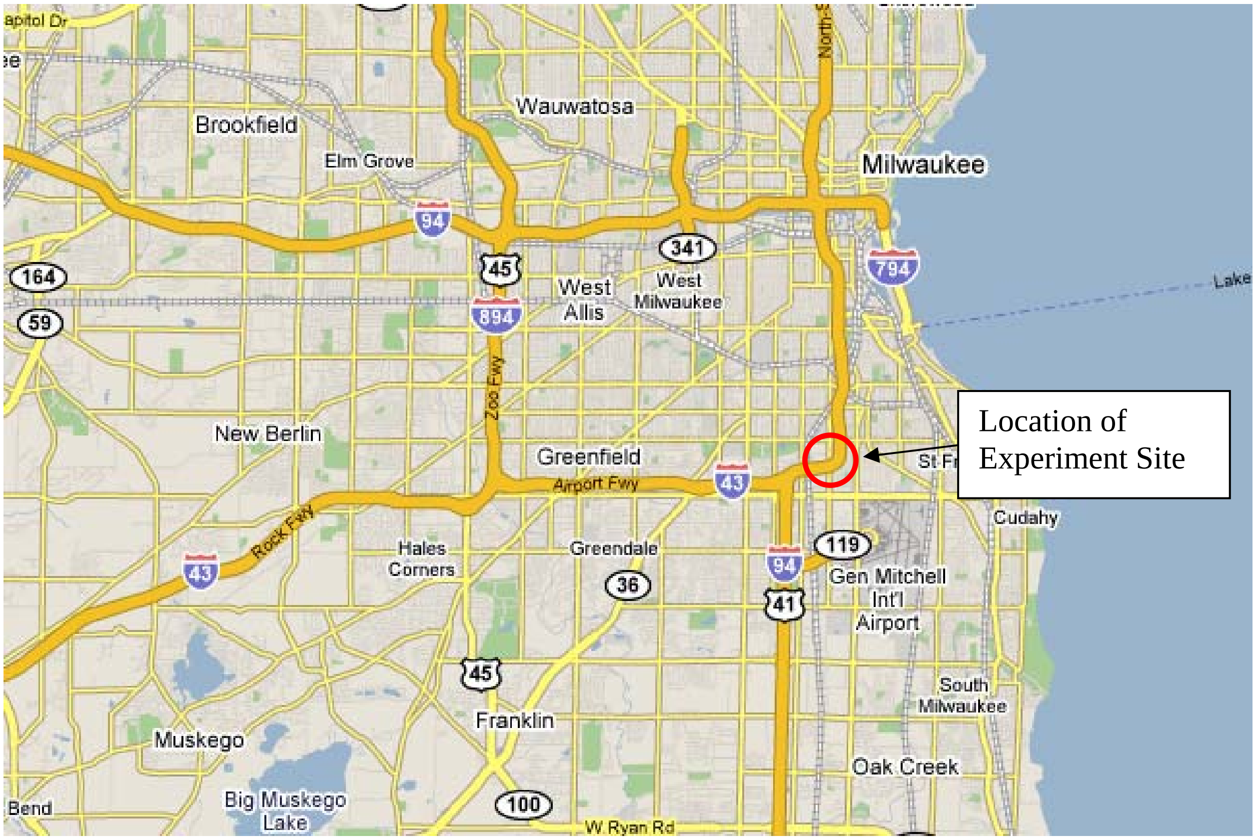

FIGURE 1. Location of experimental transverse pavement marking installation.

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 feet in length. The markings were designed and installed with decreasing spacing between successive markings within the section giving drivers' the perception of increasing speed when driving through the section of markings, potentially causing drivers to slow down. The markings were installed so that 500 feet of the treatment occurred both before and after the point of curvature (PC) of the horizontal curve. Each individual marking was a white rectangle, 18 inches in lateral width by 12 inches longitudinally. The posted curve advisory speed limit was 50 mph, and the posted speed limit upstream and downstream of the curve was also 50 mph. A photograph of the installation is shown in Figure 2.

FIGURE 2. Overhead view of experimental transverse pavement marking section (northbound).

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 in both the northbound and southbound directions. Three side-firing Wavetronix radar units were installed by Wisconsin DOT staff in both the northbound and southbound directions, which 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, median), and
- Vehicle Classification (i.e., small, medium, and large based on length).

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

- "Speed 1": 350 feet upstream of the start of the markings, which was 850 feet upstream of the curve PC and served as an upstream "control" point to allow for determination of changes in speeds between the before-and-after periods that occurred due to factors not associated with the experimental pavement marking treatment,

- "Speed 2": 600 feet downstream from the start of the markings, which was 100 feet downstream from the curve PC, and
- "Speed 3": 200 feet downstream from the end of the markings, which was 700 feet downstream from the curve PC.

"Before" data were collected from July 14th – July 28th, 2006. The pavement markings were installed between September 5th – September 8th, 2006. "Shortly-After" data were collected from September 11th – September 19th, 2006 and September 25th – October 3rd, 2006. "Long-After" data were collected from March 5th – March 14th, 2007. Note that long-term data were only available for the northbound direction due to a malfunction in the southbound data collection unit.

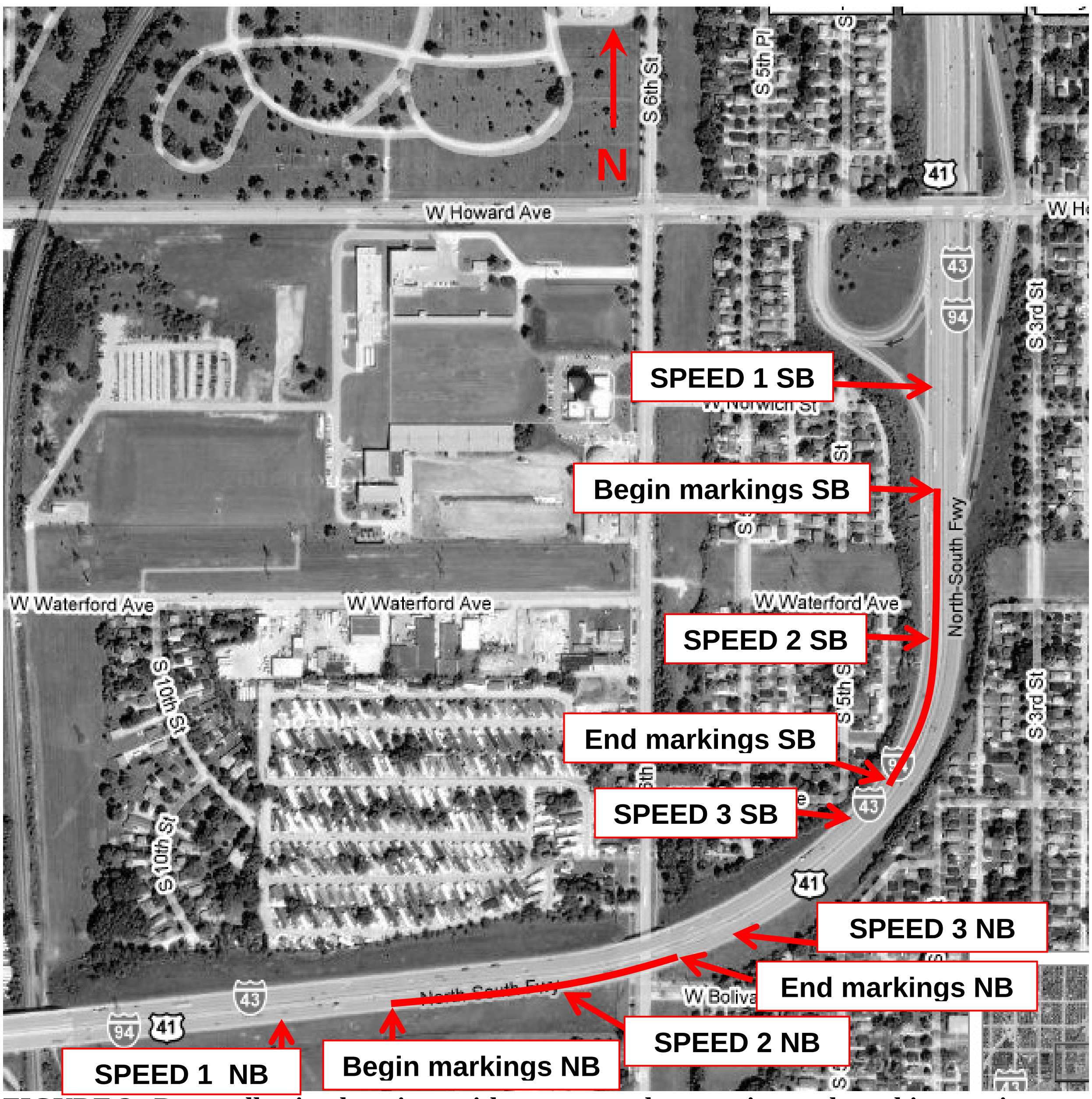

FIGURE 3. Data collection locations with respect to the experimental marking sections.

Analysis

After retrieving the data from the Wavetronix units, the data were screened and formatted for analysis. The following factors were included as independent variables (uppercase will be used throughout to designated variables used in the analysis):

- Discrete Independent Variables
  - PERIOD (Before vs. Shortly-After vs. Long-After),
  - DIRECTION (Northbound vs. Southbound),
  - DAY OF WEEK (Mon-Thurs vs. Sat-Sun),
  - LIGHT CONDITION (Daylight vs. Nighttime, based on civil twilight times obtained from United States Navy website [*4*]),
  - LANE (Shoulder vs. Middle vs. Median),
- Continuous Independent Variables (Covariates)
  - VOLUME,
  - HEAVY VEHICLE PERCENTAGE, and
  - SPEED 1 (i.e., Speed measured 350 feet upstream of the marking section).

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

- Data measured during wet, ice, or snow conditions (as indicated by archived pavement surface data from a nearby Road Weather Information System (RWIS) station [No. 101018 located at I-894/43, Hales Corners]),
- Data measured on Fridays due to the variable mix of commuter and weekend traffic, and
- Cases where average speeds were less than 35 mph for the 5-minute 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 of the 43,634 5-minute intervals (0.626 percent).

The final data set included 43,361 5-minute periods. A Full-Factorial Univariate Analysis of Variance (ANOVA) was performed using the commercially available SPSS analysis software. Two separate but identical analyses were performed using the aforementioned independent variables with the following dependent variables:

- SPEED 2 (i.e., Speed measured 600 feet into the marking section), and
- SPEED 3 (i.e., Speed measured 200 feet after the termination of the marking section).

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 marginal mean, standard deviation, and 85th percentile. Note that the estimated marginal means were reported for SPEED 1, SPEED 2, and SPEED 3, which represent the mean values statistically adjusted based on the values of the covariates (i.e., SPEED 1 [for SPEEDS 2 and 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 is shown in summary in Table 3.

TABLE 1. Traffic Volumes by DIRECTION and PERIOD

DIRECTION	PERIOD	STATISTIC	TRAFFIC VOLUME
Northbound	Before	Number of Days in Period	15
		Number of 5-minute Intervals in Period	3,933
		Average Volume per 5-minute 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-minute Intervals in Period	4,587
		Average Volume per 5-minute 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-minute Intervals in Period	2575
		Average Volume per 5-minute 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-minute Intervals in Period	4,007
		Average Volume per 5-minute 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-minute Intervals in Period	4,576
		Average Volume per 5-minute 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* (mph)	52.72	58.00	55.50
		Std. Dev. (mph)	4.65	4.00	3.59
		85th % (mph)	58	61	58
	Shortly-After	Mean* (mph)	52.67	55.21	52.95
		Std. Dev. (mph)	6.28	4.23	4.93
		85th % (mph)	59	60	58
	Long-After	Mean* (mph)	58.09	54.26	59.94
		Std. Dev. (mph)	4.71	4.65	4.47
		85th % (mph)	62	60	65
	Short-Term Change	Mean* (mph)	-0.05	-2.79**	-2.55**
		85th % (mph)	1	-1	0
	Long-Term Change	Mean* (mph)	5.37**	-3.74**	4.44**
		85th % (mph)	4	-1	7
Southbound	Before	Mean* (mph)	51.41	53.06	59.45
		Std. Dev. (mph)	4.44	4.39	3.79
		85th % (mph)	56	57	63
	Shortly-After	Mean* (mph)	52.05	52.01	54.42
		Std. Dev. (mph)	4.10	3.96	5.06
		85th % (mph)	56	56	60
	Short-Term Change	Mean* (mph)	0.64**	-1.05**	-5.03**
		85th % (mph)	0	-1	-3

*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 3 only), VOLUME, and HEAVY VEHICLE PCT.
**Change in mean was statistically significant at 95 percent confidence level as verified by Bonferroni post-hoc test.

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 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		

RESULTS

Short-Term Speed Changes

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 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.

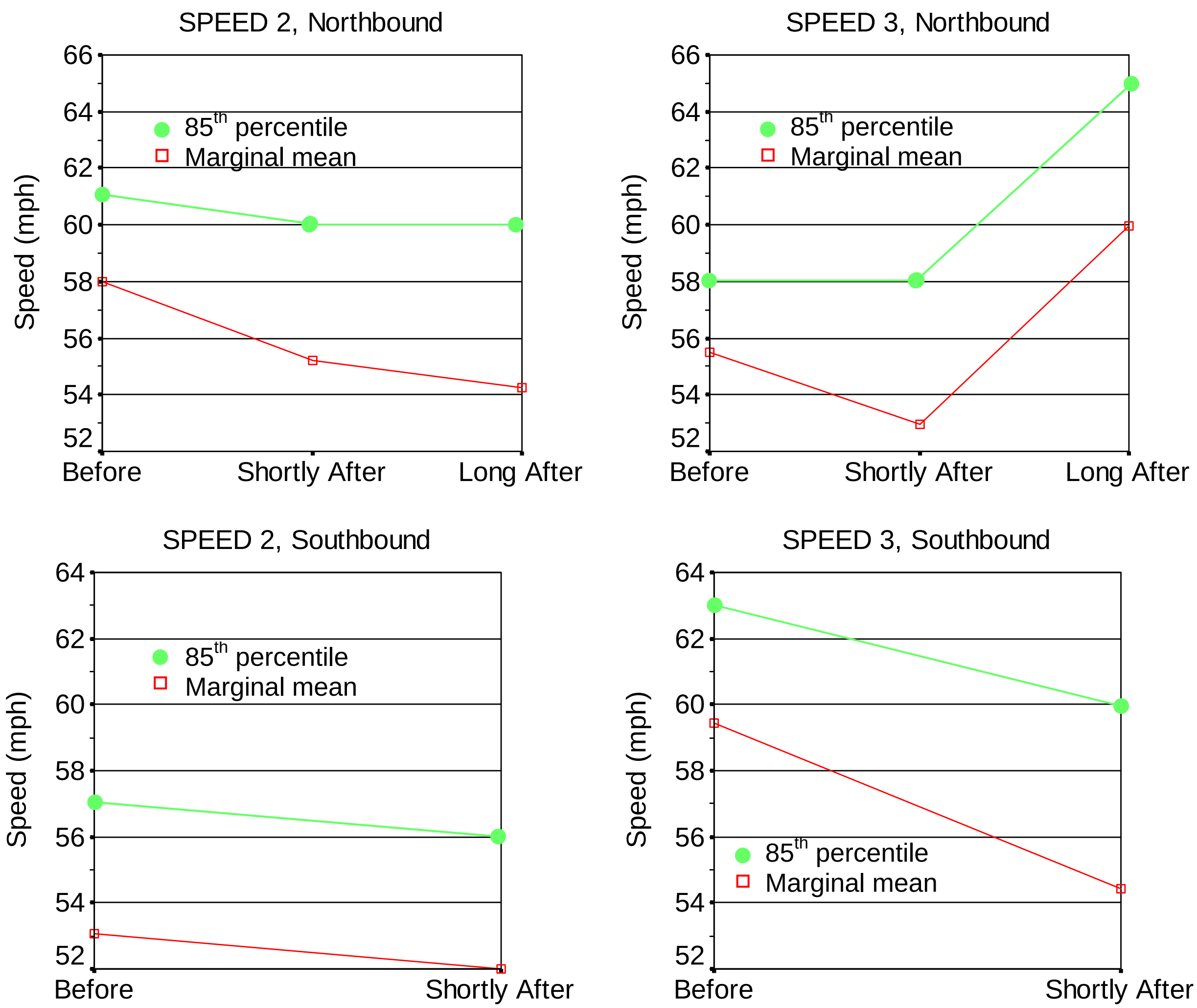

FIGURE 4. Mean and 85th percentile of SPEED 2 and SPEED 3 by PERIOD and DIRECTION.

Short-term reductions in the marginal mean speeds of approximately 2.8 mph 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 mph 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 percent confidence level.

Short-term reductions in the 85th percentile speeds were lower in magnitude compared to 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. Please note that 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 Changes

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. Recall that long-term data were only available for the northbound direction. Analysis of the data collected six-months after the marking installation for the northbound direction showed a statistically significant 3.7 mph decrease in the mean of SPEED 2 from the before period - an even greater reduction than that observed in the period shortly after the marking installation. A modest long-term decrease of 1.0 mph was observed for the 85th percentile of SPEED 2.

SPEED 3 showed much different long-term speed changes. The mean of SPEED 3 was found to increase by 4.4 mph from the before to the long-after period, which was greatly different than the 2.6 mph mean speed reduction observed at this location shortly after the installation of the markings. The increase in SPEED 3 compared to the prior data collection periods may be at least partially attributed to an overall increase in speeds in the long-after period, as evidenced by the nearly 5.4 mph increase in the mean of SPEED 1 compared to the prior periods.

Before-and-After Speed Changes 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 based on the lane of travel. The estimated marginal means for SPEED 2 and SPEED 3 stratified by lane are shown for the northbound data only in Figure 5.

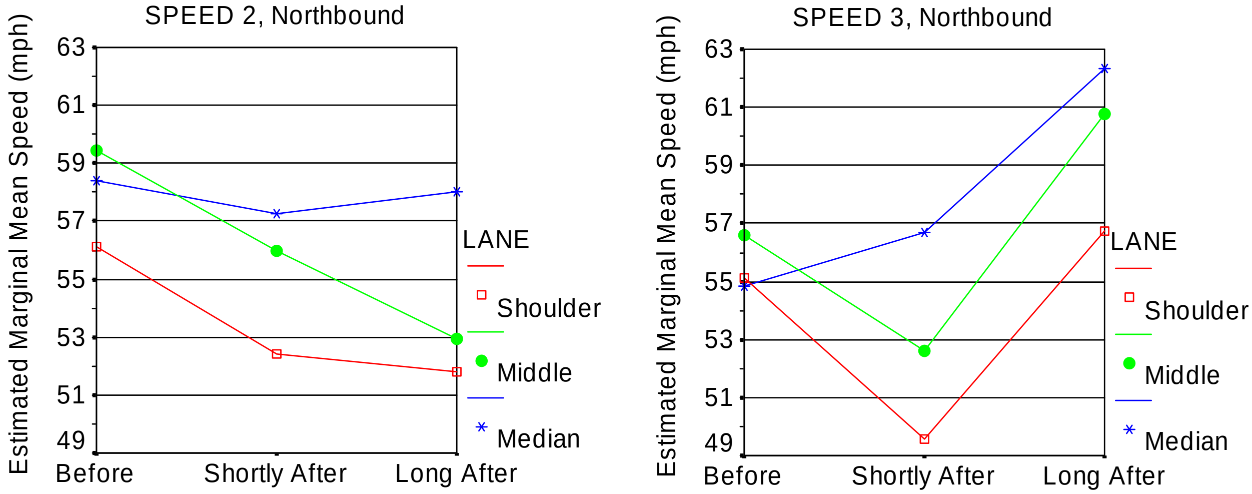

FIGURE 5. Marginal means of SPEED 2 and SPEED 3 for PERIOD*LANE (northbound only).

Figure 5 shows that, the before-and-after speeds reductions were greatest for the shoulder lane and 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 six-months after installation of the markings. Very little changes were observed for SPEED 2 for the median lane either shortly-after or long-after the markings were installed. One explanation for this observation is that faster and more aggressive drivers typically use the median lane and thus, these drivers may be less affected by speed reduction measures such as an experimental pavement marking treatment.

The short-term changes in SPEED 3 were similar to SPEED 2 with 4 to 5 mph reductions observed for the shoulder and middle lanes shortly after the markings were installed. The median lane showed a slight increase in the shortly-after period for SPEED 3. However, the long-term changes in SPEED 3 were greatly different than SPEED 2 for each lane. Each of the lanes showed a long-term increase in speeds with an approximately 2 mph increase for the shoulder lane, 4 mph increase for the middle lane, and 8 mph increase for the median lane. Again, the primary explanation for the long-term speed increases were that the overall vehicular speeds had increased in the long-term, suggested by the significant increase in SPEED 1 between the before and long-after periods.

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.

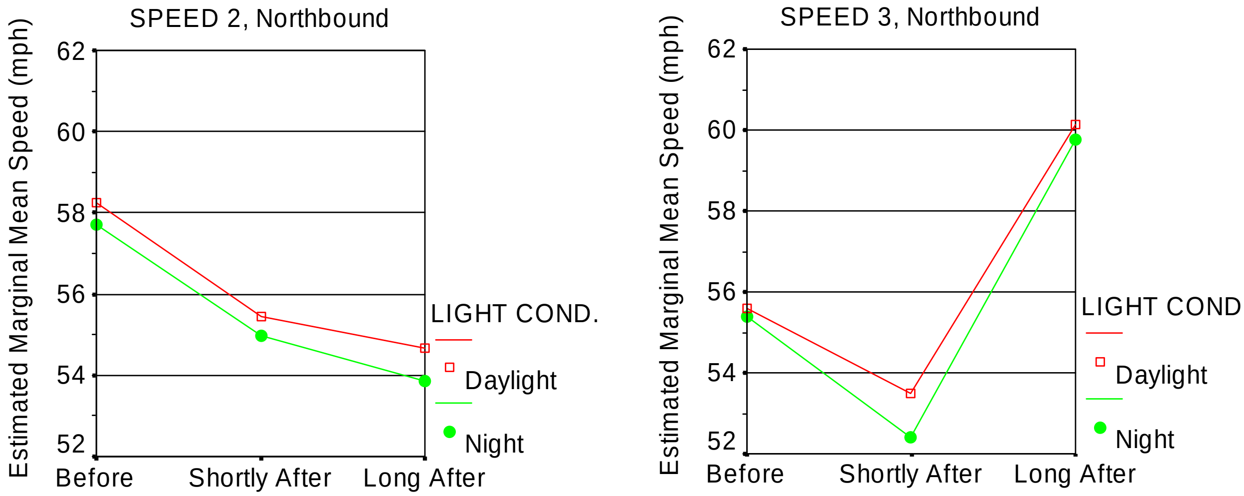

FIGURE 6. Marginal means of SPEED 2 and SPEED 3 for PERIOD*LIGHT CONDITION (northbound only).

Figure 6 shows that, the changes in mean speeds between the before-and-after periods were very 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.

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.

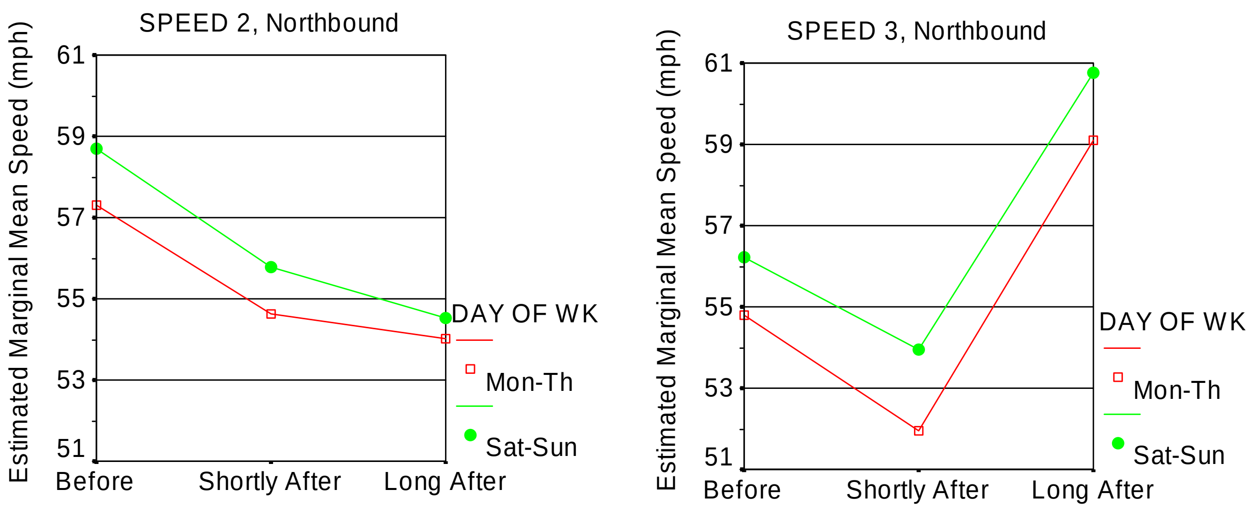

FIGURE 7. Marginal means of SPEED 2 and SPEED 3 for PERIOD*DAY OF WEEK (northbound only).

Figure 7 shows that, 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 these differences were too small to be significant from a practical point of view.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A before-and-after analysis of speeds was performed to determine the short-term and long-term effectiveness of an experimental transverse pavement marking treatment at the "Plainfield Curve" on I-43/94 in Milwaukee, Wisconsin. The researchers analyzed mean speeds for more than 43,000 5-minute intervals measured at three locations in each of the northbound and southbound directions. Speeds were measured six to eight weeks before installation of the experimental markings, one to four weeks after installation, and again six-months after installation (northbound only). An Analysis of Variance was performed to determine the short-term 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 feet 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 of approximately 2.8 mph and 2.6 mph, respectively, in the northbound direction and 1.1 mph 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 speed reductions at the SPEED 2 location were sustained in the long-term after the markings were installed. Analysis of the data collected six-months after the marking installation for the northbound direction showed a statistically significant 3.7 mph decrease in the mean of SPEED 2 from the before period - an even greater reduction than that observed in the period shortly after the marking installation. A modest long-term decrease of 1.0 mph was observed for the 85th percentile of SPEED 2. SPEED 3 showed much different long-term speed changes as the mean of SPEED 3 was found to increase by 4.4 mph from the before to the long-after period, which was at least partially attributed to an overall increase in speeds in the long-after period, as evidenced by a similar increase in SPEED 1 in the long-after period compared to the prior periods.

The speed changes between SPEED 1, SPEED 2, and SPEED 3 in the long-after period indicate that drivers responded to the markings (as suggested by the reduction in speeds between SPEED 1 and SPEED 2) and began to accelerate back to their prior speeds towards the end of the marking section (as suggested by the increase in speeds between SPEED 2 and SPEED 3). Nevertheless, the short-term speed reductions observed for SPEED 2 (located midway through the marking treatment section) were sustained between the short-term and long-term periods, suggesting that drivers were actually responding to the effect of the marking treatment and not simply due to the "novelty" associated with a new and unfamiliar traffic control treatment. Novelty effects are known to occur shortly after installation of a new traffic control device, potentially making the device appear more effective in the short-term than long-term effectiveness may suggest.

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 the researchers to conclude that the markings were considerably less effective at reducing speeds of the more aggressive drivers that typically travel in the median lane. The markings had approximately the same effect on speeds during weekdays versus 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 long-term compared to generally less-familiar weekend driving population. The markings were also found to have a similar effect on speeds during daytime versus nighttime hours, perhaps indicating similar levels of visibility of the markings when viewed during daylight conditions compared to headlights and roadway lighting at night.

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 one-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 six-months after installation when measured midway through the marking section, although speeds were shown to increase back to the upstream levels shortly after exiting the treatment 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 (i.e., curves, work zones) before conclusions can be made as to the proven long-term effectiveness of the transverse bar pavement markings as a speed reduction treatment. It does appear, however, that the treatment may be particularly appropriate for use in specific short-term speed reduction situations, such as highway work zones. Further evaluation of the treatment at other Wisconsin locations is planned.

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