Vertical Delineation

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Description

Vertical delineators are intended to warn drivers of an approaching curve while providing them with a better appreciation of the sharpness of a curve. Drivers can then select an appropriate speed before entering the curve. Delineation can also provide continuous tracking information once drivers are within the curve to help position their vehicles within the travel lane while traversing the curve.

The most common type of vertical delineation is post mounted delineators (PMDs). These devices are usually flexible or rigid posts with some amount of reflective surface mounted along the roadside to provide additional delineation (see Figure 1).

Another treatment that has been used is to provide additional delineation on chevron posts (see Figure 2).

Placement

Delineator placement and spacing of PMDs are covered in Section 3F of the 2009 edition of the *Manual on Uniform Traffic Control Devices* (MUTCD) (FHWA 2009).

A study by Chrysler and Schrock (2005) evaluated delineator spacing and color in a closed-course nighttime study with 24 drivers. The researchers found that drivers were not able to distinguish between single and double delineators or differentiate fixed versus variable spaced delineators.

In addition, drivers did not understand the difference between yellow and white delineators. Consequently, the authors suggested use of fixed spacing and elimination of single versus double delineator distinction in the MUTCD.

Cost

NCHRP Report 440 (Fitzpatrick et al. 2000) suggested that the cost of the post-mounted delineators is justified for roadways with 1,000 vehicles per day (vpd) or greater.

Effectiveness of Speed Management

No studies have been conducted in Iowa on either the speed or crash impact of post mounted delineators; however, several studies have been conducted in other areas. For example, one study was

Figure 1. Delineator posts along a curve (© PEXCO)

conducted on the effectiveness of adding additional retroreflective material to existing chevron posts.

A summary of the various studies is provided in the section below. A more detailed description of available studies is provided in the following sections.

Summary of Effectiveness for Speed Management

Carlson et al. (2004) evaluated several delineator treatments and concluded that vertical delineation of any type improves lane position at the entry and mid-point of horizontal curves.

Table 1 provides a summary of the speed effectiveness of vertical delineation treatments from various studies.

Iowa Studies on the Effictiveness of Vertical Treatmens for Speed Management

Hallmark et al. (2012) evaluated the addition of reflective material to existing chevron posts on four rural two-lane curves in Iowa (see Figure 3).

The posted speed limit varied from 50 to 55 miles per hour (mph) and the advisory speeds varied from 35 to 50 mph. Speed data were collected before and at 1 month after installation of the treatment.

As shown in Table 2, the average decrease in mean speed ranged from 0.0 to -0.8 (average of 0.4 mph). Data were only collected at one site at 12 months with an average decrease of 0.9 mph in average speed. The 85th percentile speed

Figure 2. Additional delineation on existing chevron posts (Hallmark et al. 2012)

Figure 3. Reflective treatment added to existing chevron posts (Hallmark et al. 2012)

Table 1. Speed Reduction for PMDs

Treatment	Speed Change	MPH
PMD (Vest et al. 2005)	Mean	-2.0 to 2.0
	85th percentile	-2.0 to 1.9
Full-post reflective treatment added to chevron post (Re et al. 2010)	Mean at PC	-2.2
	85th percentile at PC	-.2.2
Sequential flashing PMDs (Molino et al. 2010)	Not stated	-8.7 to -4.8
PMDs on both sides of curve (Molino et al. 2010)	Not stated	-8.0 to -4.3
PMDs on one side of curve (Molino et al. 2010)	Not stated	-6.9 to -3.6
PMDs on rural two-lane roads in Finland (Kallberg 1993)	For roadways with speed limit of 49.7 mph	-3.1
	For roadways with speed limit of 62.1 mph	No change
Full-post reflective treatment added to chevron post on rural two-land curves (Hallmark et al. 2012)	Mean at PC	-1.8 to 1.2
	85th percentile at PC	-2 to 0
	Mean at center of curve	-1.3 to 0.6
	85th percentile at center of curve	-3 to 1

Table 2: Speed Changes for Rural Curves (Hallmark et al. 2012)

	Mean speed (mph)						85th pecentile speed (mph)				
Site	Volume (vpd)	Before	1 Month	Change	12 Months	Change	Before	1 Month	Change	12 Months	Change
US 52 Average	2,280	47.2	47.2	0.0			52.0	51.5	-0.5		
Y-52 Average	1,710	53.5	53.1	-0.5	52.6	-0.9	59.3	58.8	-0.5	57.8	-1.5
221st Average	2,410	55.3	54.4	-0.8			61.0	60.3	-0.7		
IA 141 Average	830	44.3	44.1	-0.3			50.8	49.8	-1.0		
Average Over 4 Sites		50.0	49.6	-0.4			55.8	55.1	-0.7		

decreased by 0.5 to 1.0 mph (average of 0.7) at 1 month. Data were collected at 12 months for one site with a decrease of 1.5 mph.

The change in fraction of vehicles that were traveling 5, 10, 15, or 20 mph over the advisory speed limit is shown in Table 3. As noted, the average change in the fraction of vehicles traveling 5 or more mph over the advisory speed was -5 percent at 1 month after installation. Only one site had data at 12 months with no change for vehicles traveling 5 or more mph over. An average decrease of 7 percent in vehicles traveling 10 or more mph over the advisory speed occurred at 1 month with one site reporting a decrease of 3 percent for 12 months. An average 7 percent decrease in vehicles traveling 15 or more mph over the advisory speed resulted for 1 month with one site having a decrease of 8 percent for 12 months after installation. An average decrease of 2 percent occurred for vehicles traveling 20 mph over the advisory speed with a decrease of 5 percent for one site with data for 12 months.

Other U.S. Studies on the Effictiveness of Vertical Treatments for Speed Management

Vest et al. (2005) evaluated different types of warning signs to reduce speed on curves. The researchers tested sites on rural roadways with a sharp curve, history of speed-related incidents, long tangent section before the curve, no vertical grade, and no intersections, driveways, or commercial activity within the curve. They evaluated placement of post mounted delineators placed at 50-ft intervals. Change in mean speed ranged from an increase of 1.6 mph to a decrease of 1.1 mph while 85th percentile speeds increased 0.4 to 1.9 mph at the point of curvature (PC).

Within the curve, averages speeds ranged from no change to a decrease of 2 mph and from no change to a reduction of 2 mph in 85th percentile speeds.

Chrysler (2009) and Chrysler et al. (2009) assessed four types of vertical delineation including two types of PMDs (dot and full-post), standard chevrons, and chevrons with full retroreflective posts in a closed-course nighttime driving test (see Figure 4).

Twenty drivers indicated when they could judge the sharpness of the curve. The drivers were able to assess the sharpness of the curve approximately 250-ft sooner for full PMD and approximately 250-ft sooner using the chevrons with reflectorized posts than by using the baseline condition, which had only edgeline markings.

In addition, drivers were also shown photos of each treatment and asked to rank treatments by quality of delineation. The drivers ranked the chevrons with reflectorized posts the highest while full PMD came in second.

Drivers also watched video on a laptop to judge when they could perceive the sharpness of the curve. Judgment times were shortest for the chevrons with reflectorized posts for almost all situations.

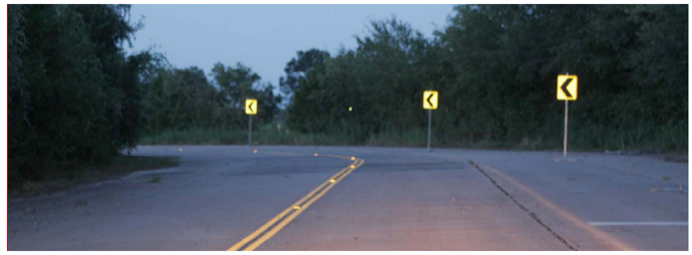
Re et al. (2010) evaluated application of chevrons and chevrons with a full-post retroreflective treatment at two curves in Texas. Both sites had paved shoulders and a posted speed limit of 70 mph during the day and 65 mph at night. One site had an advisory speed of 45 mph and the other had an advisory speed of 50 mph.

Each treatment was applied to each site and the researchers collected speed and lateral positions in the before and after data. Neither PMD showed a significant decrease in mean speed. Average speeds with the chevrons in place were 1.4 mph lower and, with the full-post chevron treatment, average speeds were 2.2 mph lower.

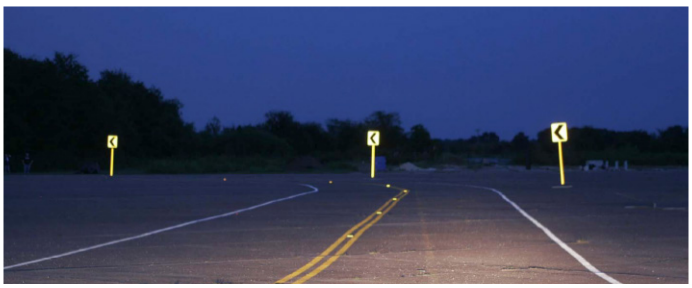
Baseline (no delineators)

Standard post reflector (dot PMD)

Full-post (full PMD)



Standard chevron (24 × 30 in)



Full-post chevron

Figure 4. Sample treatments (Chrysler 2009)

The 85th percentile speeds decreased by 1.3 mph for the scenario with only chevrons and 2.2 mph for the full-post chevrons. In most cases, the full-post chevrons reduced the percentage of vehicles exceeding 60, 65, and 70 mph. Centerline encroachments decreased by 78 percent with use of the PMDs.

Molino et al. (2010) evaluated four low-cost safety treatments on rural two-lane curves in a driving simulator with 36 participants. The test drive included a series of curves (radii of 100 or 300 feet and a deflection angle of 60 degrees) with a baseline condition (no treatments or edgelines) and four curve treatments. Drivers had to slow to negotiate all curves.

Treatments included the following:

- 4-in. edge lines
- Standard PMDs on one side of the roadway
- Standard PMDs on both sides of the roadway
- PMDs with sequential flashing light-emitting diode (LED) lights

The researchers found all PMDs were more effective in slowing drivers earlier and to a greater degree than just use of edge-line pavement markings. Acceleration was also flatter through the curve with the PMDs.

This simulator study also tested driver ability to detect curve direction and severity. The results are shown in Table 4.

As noted, drivers were able to detect curve direction and severity significantly sooner with sequential flashing PMDs than for any other treatments. Regular PMDs placed just on one side of the curve were the second most effective treatment in terms of when drivers could detect curve severity and direction.

Schumann (2000) tested lane markings (4-in.) and lane markings plus PMDs (35-in. posts with two reflective banks) placed 2-ft from the edge of the roadway. The treatments were set up along a tangent section of a test route, which was a rural two-lane roadway.

Data were collected for test drivers in an instrumented vehicle. Drivers drove the route several times with the PMDs in place and then after the PMDS were removed. The research found that PMDs can provide long-range guidance at night for drivers.

Table 4. Driver Ability to Detect Curve Direction and Severity (Molino et al. 2010)

Treatment	At Distance (ft)	
	Curve Direction	Curve Severity
None/baseline	225	53
Sequential flashing PMDs	1,288	1,127
PMDs on both sides of curve	355	95
PMDs on one side of curve	426	116
Edgelines	249	72

Table 5. CMFs for Post-Mounted Delineators

Treatment	Crash Type	CMF
Post mounted delineators (Elvik and Vaa 2004)	Serious and minor injury	1.04
Install post mounted delineators, centerlines, and edgelines (Elvik and Vaa 2004)	Serious and minor injury	0.55
Post mounted delineators on curves (US DOT 2008; Gan et al. 2005)	All crashes	0.70 to 0.80

Table 6. Crash Impacts for Post-Mounted Delineators

Countermeasures	Crashes	Change (%)
Installation of chevrons, curve warning signs, and sequential flashing beacons on curves (Montella 2009)	Total	-28.2
	Nighttime	-33.7
	Total on curves with radius ≤ 300 meters	-52.2
	Nighttime on curves with radius ≤ 300 meters	-79.0%

International Studies on Effectiveness of Vertical Delineation for Speed Management

Kallberg (1993) evaluated use of post-mounted delineators on rural two-lane roadways in Finland. During the nighttime, speeds increased after installation of the delineator on roadways with a speed limit of 49.7 mph by about 3.1 mph, but there were no significant changes in roadways with a speed limit of 62.1 mph.

Effectiveness of Crash Reduction

No studies have been conducted in Iowa to evaluate the effectiveness of vertical treatments in reducing crashes.

The following summarizes results of known national studies:

NCHRP Report 500, Volume 7: A Guide for Reducing Collisions on Horizontal Curves (Torbic et al. 2004) lists PMDs as a tried strategy based on research by Zador et al. (1987), Agent and Creasey (1986), and Jennings and Demetsky (1985), and found that, although conflicting evidence about effectiveness exists, PMDs are most likely to be effective for sharp curves.

McGee and Hanscom (2006) report on use of delineators along a curve by the Ohio DOT. The researchers reported a reduction of 15 percent in run-off-road crashes.

Montella (2009) evaluated crashes before and after installation of chevron signs, curve warning signs, and sequential flashing beacons in various combinations for 15 curves in Italy, which was compared against a reference group of 312 untreated curves using Empirical Bayes methods.

Overall, reductions of 28.2 percent were found in total crashes and 33.7 percent for nighttime crashes. The researchers found that the treatment was most effective for curves with a radius of ≤ 984-ft with a 52.2 percent reduction for all crashes and 79.0 percent for nighttime crashes. Differences were statistically significant at the 95 percent level of significance.

Table 5 provides CMFs for PMDs while Table 6 provides a summary of studies that assessed the crash impact of PMDs but did not develop CMFs.

Advantages

Low cost

Disadvantages

Maintenance costs

Resources

US DOT. *Toolbox of Countermeasures and Their Potential Effectiveness for Roadway Departure Crashes*. Report FHWA-SA-07-013. U.S. Department of Transportation, Federal Highway Administration, 2008.

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