TEXAS TRANSPORTATION INSTITUTE
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Project Summary Report 0-4052-S

Project 0-4052: Guidelines for the Use and Spacing of Delineators and Chevrons

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PROJECT SUMMARY REPORT

Research Recommendations for Delineator and Chevron Applications

This research effort focused on the investigation of methods to simplify horizontal curve delineation treatments without jeopardizing safety (see Figure 1). The specific objectives of the research were to simplify delineator and Chevron spacing along horizontal curves, determine a radius above which a horizontal curve on a freeway or expressway may be delineated as a tangent, and explore whether there is any visibility benefit in using double delineators versus single delineators.

Figure 1. Effective Use of Curve Delineation Increases Safety.

What We Did . . .

Researchers first conducted a short survey of state transportation agencies to identify curve delineation practices used in the remaining 49 states that may differ from the *Manual on Uniform Traffic Control Devices* (MUTCD) or Texas Department of Transportation (TxDOT) policy. The survey had four questions.

The first question was aimed at determining whether agencies that use retroreflective raised pavement markers (RRPMs) on their freeways and expressways delineate gentle curves on these limited access facilities as tangents, and if so, at what point they make this distinction. This question was important because the current language in the MUTCD implies that all curves on freeways and expressways require post-mounted delineators, regardless of the radius.

The next question of the survey was aimed at determining whether there is a real need to distinguish between single and double delineators for various applications.

The third question of the survey was designed to reveal the difficulty in applying the delineator spacing criteria as shown in the MUTCD. The MUTCD spacing table is based on the curve radius or degree of curve. While this may be adequate for roadway design engineers, it is not convenient for field personnel who typically do not have easy access to this information or have a way to measure it in the field. Additionally, the MUTCD provides guidelines for variable delineator spacing on the approach and departure to horizontal curves. The states were asked if they practiced this guidance.

The fourth and final question of the survey focused on Chevron spacing in horizontal curves. The question determined if there are states using more objective spacing criteria than MUTCD's guidance of having at least two delineators in view at a time.

In addition to the survey, the research team identified and tested methods for field personnel to safely and efficiently space delineators and Chevrons in horizontal curves. The research identified nine methods and through extensive testing and validating ultimately recommended two methods for TxDOT's consideration.

The research team visited 58 horizontal curves around the state to assess the current state-of-the-practice in terms of curve delineation and how it complied with TxDOT's standards and

Figure 2. Ball Bank Indicators.

Figure 3. Radiusmeter.

policies. During these visits, the researchers also compared three different ball bank indicators (BBIs) (see Figure 2).

The researchers studied how Chevron spacing in horizontal curves impacts approach speeds and speeds in the curves. This research was conducted on the open road with cooperation from the TxDOT Bryan and Waco district offices.

Finally, the researchers performed a battery of delineator visibility tests at the Texas A&M University Riverside campus. These tests included the evaluation of driver perception of curve severity as a function of radius, delineator size, and approach delineator spacing. The tests also included an assessment of how well drivers understand delineator color and how the size and color of the delineator affect driver detection distances.

What We Found . . .

A total of 34 states responded to the survey. Of particular significance was the finding that 63 percent of the states delineate gentle curves on expressways and freeways as tangent sections. The cutoff curve radii criteria for this decision ranged from 2865 ft to 14000 ft, with an average of 6400 ft. The survey also revealed that most states still use the radius-dependent delineator spacing in the MUTCD but they simplify the approach and departure delineator spacing to the horizontal curves. Even though most states still use the radius-dependent spacing table for delineation, there were no innovative solutions suggested for determining radius in the field. Some states are still using the chord method.

Of the 58 horizontal curves with delineators, we found that on average the delineator spacing was about that recommended by MUTCD, but there were large variances indicating lack of consistency. Furthermore, there was no strong relationship found between radius and delineator spacing or radius and Chevron spacing. This effort also revealed that if delineators are used on approach and departure tangents to horizontal curves (a rather uncommon event), usually only one is used and it is typically spaced at the same spacing as used in the curve.

Of the 58 horizontal curves with Chevrons, we found that the use of Chevrons in horizontal curves appeared to start and end at the transition point between the curve and the tangent (either the approach or departure tangent). This effort also revealed that curves are not often delineated with Chevrons in accordance with TxDOT guidelines, and large differences were found from district to district.

There were no systematic differences found in three BBI devices. However, results from the use of the BBI devices were cause for concern. Overall, only 29 percent of advisory speed values were considered to be set appropriately (when using all three BBI devices). The score increased to approximately 47 percent when at least one BBI measurement agreed with the speed advisory plaque setting. There also appeared to be inconsistent setting of the advisory speed plaque from district to district. In other words, when the advisory speed values that were set in the field did not match the researchers' values, some districts tended to be higher in nearly all the cases while other districts appeared to be lower in nearly all the cases.

After testing nine different methods field personnel could use to set delineator and Chevron spacing in the field, the researchers ultimately recommended two methods. The first is the advisory speed method, which is simple to use but has more error. Using this method, the field personnel simply look up the advisory speed value of the curve in a table to determine the appropriate spacing. The accuracy of the technique relies on an accurate advisory speed value setting and, as discussed above, the advisory speed values across the state are not set consistently. The second method uses a global position satellite device (named the Radiusmeter in this project) developed at TTI by the research team. This device is highly accurate and easy to use but requires an initial investment of $400 to $500. The Radiusmeter produces an immediate radius value after traversing a horizontal curve at highway speed in any type of vehicle (see Figure 3).

As mentioned, the researchers also performed a field study to determine drivers' responses to an increased number of Chevrons. More than two Chevrons within driver view provided small benefits in terms of decreased speeds entering and traversing horizontal curves. For instance, at the point of curvature, the researchers observed a decrease of about 3 mph in average speeds after the number of Chevrons in the curve was increased. They also found that the speeds at night were particularly lower after the Chevron numbers were increased.

During the nighttime visibility study at Texas A&M University Riverside campus, the researchers determined that drivers cannot distinguish between single and double delineators and they cannot distinguish between variable spacing and fixed spacing on approaches to horizontal curves. The researchers also discovered that drivers do not understand the difference between yellow and white delineators.

Table 1. Spacing Criteria for Field Personnel.

Advisory Speed Value (mph)	Delineator Spacing in Curve (ft)	Chevron Spacing in Curve (ft)
15	35	40
20	40	80
25	50	80
30	55	80
35	60	120
40	70	120
45	75	160
50	85	160
55	100	160
60	110	200
65	130	200

NOTE: Approach and departure delineation on horizontal curves should be spaced at twice the curve spacings shown above using 3 delineators or 1 Chevron.

Table 2. Radius-Based Spacing Recommendations.

Degree of Curve	Radius (ft)	Delineator Spacing in Curve (ft)	Chevron Spacing in Curve (ft)
1	5730	225	400
2	2865	160	280
3	1910	130	200
4	1433	110	200
5	1146	100	160
6	955	90	160
7	819	85	160
8	716	75	160
9	637	75	120
10	573	70	120
11	521	65	120
12	478	60	120
13	441	60	120
14	409	55	80
15	382	55	80
16	358	55	80
19	302	50	80
23	249	40	80
29	198	35	40
38	151	30	40
57	101	20	40

NOTE: Approach and departure delineation on horizontal curves should be spaced at twice the curve spacings shown above using 3 delineators or 1 Chevron.

The Researchers Recommend . . .

For spacing delineators and Chevrons in curves, TxDOT's policies and standards should include Table 1 for field personnel. This table enables field personnel to easily determine an appropriate spacing for delineators or Chevrons using the advisory speed. It recommends a simpler procedure for spacing delineators on the approach and departure to horizontal curves. A note of caution should be included with this table so that the advisory speed value is double-checked for accuracy. For ultimate accuracy, however, the researchers recommend that the Radiusmeter be used to determine the radius and spacing be selected using the MUTCD criteria or values shown in Table 2.

For spacing delineators and Chevrons in curves, TxDOT's policies and standards should include Table 2 for engineers. This table enables engineers to easily determine appropriate spacing for delineators or Chevrons based on the radii of the curves in the design plans. Like Table 1, it recommends a simpler procedure for spacing delineators on the approach and departure to horizontal curves. Furthermore, it includes a cutoff for delineation of curves at one degree of curvature. Table 2 could be used by field personnel if they knew the radius or had a device such as the Radiusmeter to measure the radius.

The final recommendation is that TxDOT send a letter to the Federal Highway Administration requesting the MUTCD be modified to incorporate the research findings described in the report. Implementation of these findings will simplify horizontal curve delineation and thereby increase consistency without compromising safety. A letter was drafted by the research team and included in the final report (0-4052-1).

For More Details . . .

The research is documented in the following report:

0-4052-1, *Simplifying Delineator and Chevron Applications for Horizontal Curves*

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TxDOT Implementation Status
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This research project investigated methods for determining the spacing of delineators and chevrons along horizontal curves without compromising safety. One product was required for this project: recommended guidelines for delineator and chevron spacing on horizontal curves based on some criteria other than the radius of the curve. This product can be implemented for immediate use by field personnel and engineers as a means of measuring delineator and chevron spacing in horizontal curves. If approved by the Federal Highway Administration, it is recommended that the measures adopted in this product be included in the next edition of the national *Manual on Uniform Traffic Control Devices*.

For more information, contact Mr. Wade Odell, P.E., RTI Research Engineer, at (512) 465-7403 or e-mail wodell@dot.state.tx.us.

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