FHWA Request to Experiment

Enhanced Delineation of Crest Vertical Curves
Through Use of
Vertical Chevron Signs

Submitted by Washington County Public Works
Stillwater, MN
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1.0 Nature of the Problem

Vertical curves present a unique challenge for driver behavior. While a driver can recognize a crest vertical curve with relative ease, the degree of vertical curvature can be impossible for a driver to assess in time for an appropriate reaction. For example, a roadway with otherwise good sight lines and a 55 mph design speed may have, due to topography constraints, a crest vertical curve which can only be safely traversed at 30 mph while maintaining the necessary stopping sight distance to other vehicles or objects in the roadway. Examples of such locations within Washington County are shown in Figures 1, 3, and 5 of this request.

Figure 1
Illustration of crest vertical curve with limited sight distance (Location #4)

Signage normally used to treat these situations may include “Hill Blocks View”, “Blind Driveway”, “Limited Sight Distance”, or other similar messages, as shown in Figure 2. However, even when accompanied by a speed advisory matched to the actual conditions by an engineering analysis, these warning signs have little effect on the prevailing speeds of through traffic. In addition, overuse of warning signs throughout the roadway network has conditioned drivers to believe that warning signs and advisory speeds can be routinely ignored.

Figure 2
Examples of available warning signs

Drivers who fail to slow to the advisory speed in these locations will normally pass through such locations without a crash. However, had there been entering traffic, a stopped vehicle, or an object in the roadway, the driver would have been unable to safely react. Drivers may recognize the hill crest, but only once they have passed the hill crest does the severity of the sight distance limitation become apparent. Before the driver can react, the hazardous location has likely been passed through without incident.

Although actual crashes might be rare, the potential for danger is real. An object in the roadway, however uncommon, would result in a collision with the object or a lane departure crash. A driver entering from a driveway within the affected area not only has insufficient sight distance to judge safe gaps in traffic, but sight distance even for mainline drivers may be below the minimum required stopping sight distance at the prevailing speeds.

A reduced speed limit would not be expected to effect a decrease in the prevailing speed, nor would a reduced speed limit normally be justified by a hazard confined to one location. While the only universally effective solution is to reconstruct the roadway to an appropriate design speed, such reconstructions are often cost-prohibitive due to the large impacts of the excavation to adjacent properties. Where full reconstruction is not a practical solution, a more effective warning device for crest vertical curves is needed.

2.0 Development of the Proposed Traffic Control Device

At one location on the Washington County system, standard chevrons installed due to a horizontal curve beyond a hillcrest have also been shown to provide visual cues to the severity of the vertical curve at the same location. The relative height of the chevrons can provide information to the driver about the rate of elevation change in the roadway. Similarly, streetlight posts, utility poles, or other traffic signs of uniform height may sometimes provide this visual cue, even if the signs are unrelated to the hazard.

Figure 3
Horizontal curve chevrons sometimes also provide vertical curve information

Unlike most other signs, chevrons for horizontal curves have been proven to provide a measureable safety benefit [1]. They can provide delineation information to drivers even where the roadway itself may not be visible due to vegetation, light conditions, or vertical curves. This request to experiment seeks to convey this same type of information to drivers for vertical curves, where horizontal curves do not exist, by using a vertically oriented chevron sign, referred to in this request as a Vertical Chevron.

By posting signs or delineators at a uniform spacing and height, the County believes that drivers will be better able to recognize the severity of the vertical curve and adjust their speed accordingly. As shown in Figure 3, standard W1-8 chevrons can provide vertical curve information to drivers; however W1-8 chevrons cannot be used where a horizontal curve does not exist. A similar effect may be obtained by using white delineators, however current

[1] Techbrief: Safety Evaluation of Improved Curve Delineation, FHWA Report – HRT-09-046, November 2009.

delineator sizes do not provide adequate visibility during daylight hours, nor do they intuitively convey that they are related to a crest curve condition.

Because of the strong similarities between the described crest curve problem and horizontal curves, Washington County proposes to use a modified version of the W1-8 chevron sign, with the chevron pointing downwards rather than to the side. By installing these signs at select locations where vertical curve design speed is substantially lower than the remainder of the roadway, we hope to obtain a reduction in prevailing speeds greater than what can be achieved with other static warning signs.

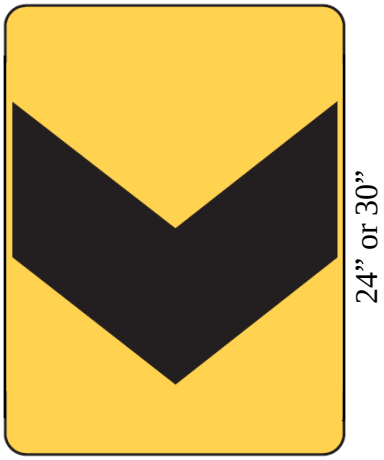

Figure 4
Proposed Vertical Chevron Design

The proposed Vertical Chevron is not currently in the Minnesota version nor the federal version of the Manual on Uniform Traffic Control Devices (MUTCD). This request proposes to use standard colors, symbols, and sizes, including maintaining the upright orientation of the sign panel, and simply rotating the chevron symbol to point downwards. Washington County is not aware of any application of such a device in any other location. The device has not yet been fabricated nor installed within the County, pending approval of this Request to Experiment.

3.0 Proposed Installation Parameters

While horizontal chevrons can provide some delineation value even when only one such sign is visible, it is generally accepted that at least two chevrons must be in view at all times as the driver approaches. This practice allows drivers to adequately perceive the depth and severity of the horizontal curve, and the County seeks to replicate this effect for severe vertical curves.

Therefore, for the proposed Vertical Chevron treatment, the County believes that at least three Vertical Chevrons must be within view at all times for the driver to adequately perceive the rate of change in the roadway grade. All Vertical Chevrons used at a given location must be of equal

size and should be equally spaced, so that the relative size of the signs can be correlated to its distance from the driver's eye. It is also important that the mounting height of each Vertical Chevron be carefully controlled so as to be at a consistent and equal height from the adjacent roadway surface. When installed in this manner, the series of Vertical Chevrons should be able to provide a visible approximation of the roadway grade for the approaching driver beyond the point where the road surface itself is visible. We hope to demonstrate that this treatment will result in a reduction in speeds by making the severity of the crest easily recognizable to drivers in advance of the condition itself.

All of the County's potential installation locations (listed later in Part 5.0) feature existing warning signs with speed advisory plaques. The proposed Vertical Chevrons would supplement these existing warning signs in the same way that W1-8 chevrons normally supplement advance warning signs for curves. The proposed Vertical Chevron signs would comply with all applicable MN MUTCD requirements for installation height, supports, and retroreflectivity.

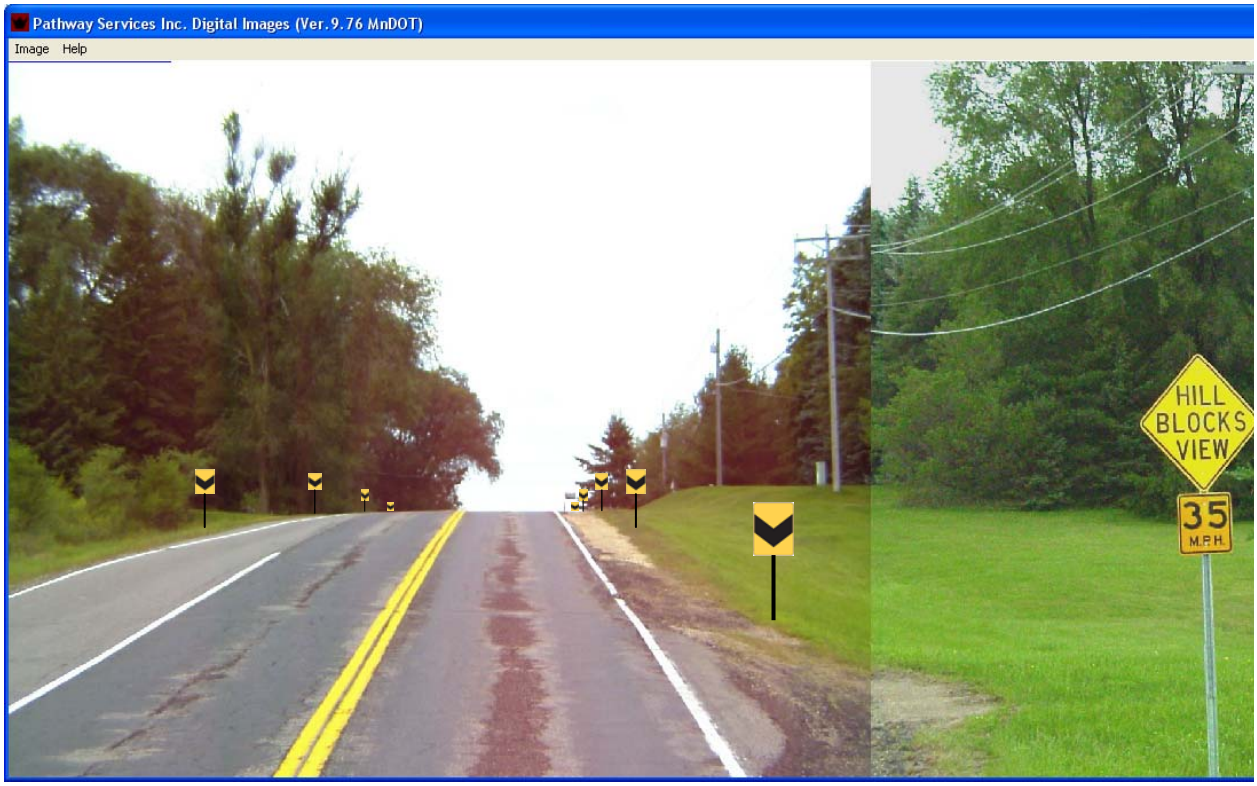

Figure 5
Digital Simulation of Proposed Installation (Location #1)

4.0 Proposed Data Collection and Evaluation

Prior to installation, the County will collect traffic speed data at three locations through the use of road tube counters or other accepted methods. Speeds will be measured at the approximate crest of the curve and at an approximately equal distance on each side of the crest. Speed data

will be differentiated by direction of travel. After installation of the Vertical Chevrons, speed data will be collected at the same locations, using the same methods, at various time periods after installation to determine both the immediate and long-term effectiveness of the Vertical Chevron treatment at reducing speeds. Speeds will also be simultaneously collected at an untreated control location with similar design characteristics, selected from the list in Part 5.0 of this submittal, to account for other factors affecting speed such as weather or fuel prices.

While the goal of the proposed device is to improve safety and reduce crashes, it will not be possible to show a statistically significant change in crash rate due to the relatively low traffic volumes and long study periods that would be needed to develop such a sample. However, if the visual cues provided by the Vertical Chevrons causes the prevailing speeds to decrease to a value which more closely matches the available stopping sight distance, it can be inferred that the safety of the roadway segment has been improved.

5.0 Proposed Time and Location(s) of the Experiment

Washington County seeks to install this experimental treatment as soon as possible in spring of 2011, if approved. Upon approval, the devices could be installed within a matter of weeks by County forces. Speed data collection would occur before installation and for up to two years after installation. Data collection would not occur continuously, but at periodic intervals to track any changes in prevailing speeds over time.

There are four crest vertical curves identified on the County's highway system as potential test locations, listed below. It has not yet been determined how many of these locations would be incorporated into the experiment and data collection efforts. However they are listed here in general order of preference.

1. County Road 74 (65th Street), east of Hadley Avenue S. in the City of Cottage Grove.
2. County State Aid Highway 17 at 69th Street North in the City of Grant.
3. County Road 74 (65th Street), west of Hadley Avenue S. in the City of Cottage Grove.
4. County Road 71 (Neal Ave) at 6th Street North in West Lakeland Township.

6.0 Patent/Copyright Statement

Washington County is not aware of any pending or current patents or copyrights precluding use of this type of traffic control device.

7.0 Required Agreements

Although this experiment is proposed to last for at least one year, data collection could continue beyond that period as well. Washington County agrees to the requirements set forth in Section 1A.10.2, Parts H and I, of the Minnesota MUTCD pertaining to removal of the proposed devices, providing progress reports, and a copy of the final results of the experiment within 2 years.