

# Horizontal Curve Safety

*Horizontal curves are changes in the alignment or direction of the road, as opposed to vertical curves, which are a change in the slope.*

In 2008, more than 27 percent of fatal crashes occurred at horizontal curves; the vast majority (over 80 percent) were roadway departures.<sup>1</sup>

Due to the predominance of horizontal curves on typical rural roads, a higher percentage of fatal curve-related crashes occur on rural roads,<sup>2</sup> particularly on two-lane roadways in rural areas. Fatality rates on rural roads are typically more than twice the rate than on urban roads, because of a number of infrastructure and non-infrastructure related issues.<sup>3</sup>



Source: Oregon DOT

## Minnesota Local Curve Safety Enhancement Program Example

In an 11-county region in southern Minnesota, local highway agencies reduced highway fatalities by implementing a Curve Safety Enhancement Program. By analyzing 20 years of crash data and then overlaying the crash data on a GIS layer, horizontal curve safety was found to be a primary crash concern. Thirty-two percent of crashes occurred on horizontal curves (composed of less than 10 percent of the highway system in the region) and 47 percent of severe roadway departure crashes occurred on horizontal curves.

Minnesota DOT district engineers provided training and assistance in horizontal curve safety to local agencies within the 11-county region. County engineers inventoried and updated all existing curve signs and advisories. They also implemented an aggressive program for removal of roadside obstructions and enlisted the assistance of maintenance drivers in identifying obstructions. The Safety Edge was specified for on all pavement projects. As a result, highway fatalities in the 11-county region dropped from an average of three a year in 2002-2004, to 0.3 fatalities per year in 2005-2007.

## Countermeasures

Most roadway departure countermeasures are effective when applied specifically at horizontal curves. Agencies should base selection of countermeasure strategies on sound engineering study or judgment. Some factors to consider include speed limit compliance, geometric features of the curve, sight distance, and traffic volume.

- **Basic Treatments:** The devices considered “basic” treatments for horizontal curves are found in the Manual on Uniform Traffic Control Devices (MUTCD). They include pavement markings (centerline and edge line) and signage.
  - » **Centerlines:** When an agency identifies a curved section as a potential safety problem, and the road segment does not have a centerline, this should be the first, minimal treatment applied. However, engineering judgment is required on the placement of centerline markings on narrow travel ways (less than 16 feet wide) because of the potential for traffic encroaching on the pavement edges and into the opposing lane, plus the presence of parked

1 RDs and Curves\_2005-2008, received from FHWA Office of Safety, July 2010.

2 NHTSA Traffic Facts 2007 Data, Rural/Urban Comparison - DOT HS 810 996.

3 Implementing the High Risk Rural Roads Program, FHWA-SA-10-012, Federal Highway Administration, March 2010.

vehicles. With low traffic volume and/or when the pavement is less than 16 feet wide, consider using post delineators, chevrons, or curve warning signs.

- » **Edge Lines:** Edge line pavement markings provide a visual reference to help prevent drivers from drifting off the roadway. While it is not necessary to have a centerline to add an edge line, applying white edge lines without a yellow centerline on a narrow road may be misunderstood as a one-way roadway. Standard edge line width is 4 to 6 inches. Some agencies use a wide edge line (8 to 12 inches) on the curved section to provide a stronger visual cue to drivers.
- » **Signage:** Use of signs, or sign combinations, is based on engineering judgment.

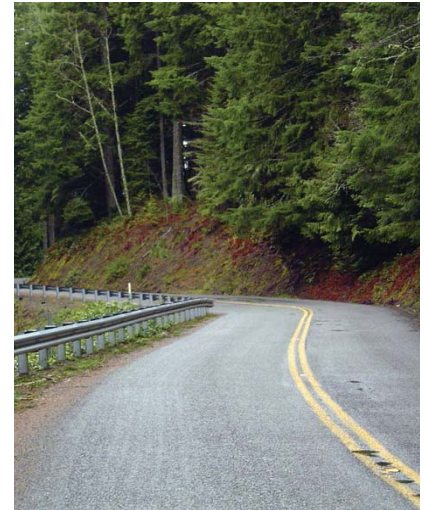
- **Enhanced Basic Treatments:** Most basic devices can be visibly enhanced by techniques that include increasing device size; placing identical signs or devices on both sides of the roadway; using basic devices with high retroreflectivity and fluorescence; flashing beacons; profile thermoplastic markings; and raised pavement markers.

- **Other Traffic Control Device Treatments**

- » **Reflectors or panels of retroreflective sheeting** can be a highly effective treatment for delineating curves, especially at nighttime. Strips of sheeting are shaped to provide linear delineation of concrete barriers or metal guardrail to alert drivers of approaching curves. Installing reflectorized tape or other delineation device to trees, utility poles, and other roadside obstructions is a low-cost way to reduce the crash hazard from fixed objects.
- » **Dynamic curve warning systems** activate when vehicles approach the curve at high speed. Typically these systems combine a speed measuring device (such as loop detectors or radar) with a flashing beacon and a variable message sign. Because these systems have a much greater effect on high-speed drivers than a static curve warning sign, agencies should consider their use in high-crash locations where less expensive countermeasures have failed. In California, installation of these devices resulted in a 44 percent reduction in crashes in the first year and 39 percent in the second year.
- » **Pavement markings in advance of horizontal curves** provide supplementary warning information, and also can be considered at curve locations where signs have proved ineffective.

- **Rumble Strips:** Rumble strips produce noise and vibration to alert drivers to potentially hazardous situations. They can be installed on horizontal curves longitudinally with the centerline; with the edge line or on the shoulder; or transversely across the full lane in advance of the curve.

- **Minor Roadway Improvements:** Shoulder drop-off elimination (the Safety Edge), paved shoulder treatments, shoulder widening, wider clear zones, and skid-resistance pavement surface treatments can also reduce crash potential at curves.



Source: FHWA

## For More Information

Low-Cost Treatments for Horizontal Curve Safety FHWA, December 2006. FHWA-SA-07-002.

[http://safety.fhwa.dot.gov/roadway\\_dept/horicurves/fhwasa07002/](http://safety.fhwa.dot.gov/roadway_dept/horicurves/fhwasa07002/)

A Guide for Reducing Collisions on Horizontal Curves NCHRP Report 500, Vol. 7, 2004.

<http://www.trb.org/Main/Public/Blurbs/154782.aspx>

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