

Proven Safety Countermeasures

Enhanced Delineation and Friction for Horizontal Curves

Low-cost safety treatments vary by the severity of the curvature and the operating speed. Low-cost treatments typically include methods for warning the driver in advance of the curve, but treatments will vary by intensity of the warning. Implementing the recently published curve treatments included in the Manual on Uniform Traffic Control Devices (MUTCD) should improve curve safety over past practices by providing consistency. However, additional enhancements can be made with post-mounted delineation in the curve or an enhanced signing treatment that may include larger chevron signs with enhanced retroreflectivity. For more challenging curves, dual indicated advanced signs with constant flashing beacons may be effective. Pavement markings are also an effective communication tool to indicate the alignment change. Pavement friction is critical for changing vehicle direction and ensuring the vehicle remains in its lane. Traditional friction courses or high friction surface treatments should be considered for curves with numerous wet weather crashes or severe curves with higher operating speeds.



Background

Horizontal curves are a change in roadway alignment that creates a more demanding environment for the driver, vehicle, and pavement. The challenges associated with safe navigation of horizontal curves compound with the addition of a nighttime driving environment or inclement weather. Recent data analysis shows that 28 percent of all fatal crashes occur on horizontal curves. Furthermore, about three times as many crashes occur on curves as on tangential sections of roadways. These statistics make horizontal curves prime sites for safety improvements.

Early driver perception and appropriate reaction to changes in the roadway greatly improve the safety of the curve. Inconsistent use of warning signs has been identified as an important factor contributing to the high incidence of crashes on curves. The MUTCD was recently revised to attempt to provide a more uniform application across the United States. Other recent research on signing practices in curves has shown great potential for improving safety with low-cost options. In addition to these treatments, new technologies are being evaluated for challenging curves, such as dynamic advanced curve warning signs and dynamic sequential light-emitting diodes (LED lights) on chevrons.

There are a variety of high-friction surface treatments available. While they typically have a higher unit cost than traditional friction courses, they can often be applied at the specific curve location for a relatively low cost. Additionally, where cross-section problems such as lack of appropriate superelevation exist, this can be a low-cost alternative to address a problem in the short-term until further improvements can be made.



Crash Modification Factors are available from the FHWA Clearinghouse and present effectiveness levels for various horizontal curve treatments. For example:

- ♦ Installing chevron signs on horizontal curves on rural two-lane undivided roads can produce a 16 percent reduction in non-intersection fatal and injury crashes and a 25% reduction in nighttime, non-intersection crashes of all severity types.
- ♦ Installing new fluorescent curve signs or upgrading existing curve signs to fluorescent sheeting on rural two-lane undivided roads can result in a 12 to 38 percent reduction in non-intersection fatal and injury crashes and a 25 to 45 percent reduction in nighttime, non-intersection crashes of all severity types.
- ♦ Improving skid resistance on roadway sections with a high proportion of wet-road crashes or low friction numbers resulted in 32 percent reduction in all crashes and 65% reduction in wet road crashes in rural areas. For two-lane urban undivided roads, the reductions were 40% for all crashes and 74% for wet road crashes. While the study did not focus on horizontal curves, it is anticipated similar reductions would be expected.

Guidance

Each State with identified problems on horizontal curves should review those locations in light of the guidance provided in Section 2C.05 of the 2009 MUTCD to improve consistency within and across jurisdictions. Additionally, States should review signing practices and policies to ensure they comply with the intent of the new guidance.

Each State should also develop a process for identifying and treating problem curves. This process should consider the full range of available treatments described here and use the appropriate application for the identified problem(s), as noted in the countermeasure description above.

Key Resources

Manual on Uniform Traffic Control Devices, FHWA, 2009

<http://mutcd.fhwa.dot.gov/>

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

http://safety.fhwa.dot.gov/roadway_dept/horcurves/fhwasa07002/

Safety Evaluation of Improved Curve Delineation

<http://www.fhwa.dot.gov/publications/research/safety/09045/09045.pdf>

AASHTO Highway Safety Manual (Available for purchase from AASHTO)

<http://www.highwaysafetymanual.org/pages/default.aspx>

Crash Modification Factor (CMF) Clearinghouse [*quick search* "horizontal curve"]

<http://www.cmfclearinghouse.org>

FHWA Contacts

Office of Safety: Joseph Cheung, joseph.cheung@dot.gov, 202-366-6994

FHWA Resource Center: Frank Julian, frank.julian@dot.gov, 404-562-3689

FHWA Website: http://safety.fhwa.dot.gov/roadway_dept/horcurves/