
Topic: Safety Improvements (Low cost signs, markings & road edge enhancements)

What Safety Improvements are discussed?

This summary provides an overview of a variety of low cost improvement strategies that could be considered as a part of the safety project development efforts focused on reducing the number of single vehicle crashes along rural highways. Specific improvements range from enhanced pavement markings to installing dynamic messaging signs on curves or blind intersections.

Fundamental Safety Improvements

- Edge and Centerline Markings
 - Longitudinal lane striping provides a continuous stream of information presented to the driver and is a relatively inexpensive safety improvement that can easily be deployed. The most commonly used widths are 4 and 6 inches. According to the Manual on Uniform Traffic Control Devices (MUTCD), all roads with 3 or more lanes are required to have centerline markings whereas requirements for 2-lane roads can be subject to different road classifications, ADTs, traveled way width and surrounding area types. For example, urban collectors and arterials with 20 feet or greater of traveled way width and an ADT of 6,000 vehicles per day (vpd) or greater are required to have centerline markings. Centerline markings are recommended for urban roads with an ADT of 4,000 vpd or greater, and markings are recommended for rural roads with an ADT of 3,000 vpd or greater and 18 feet of traveled way. *Any* type of 2-lane roads in any location with any amount of vehicle traffic can be subject to consideration of installing centerline as well as edge line markings. For more information see the “Enhanced Edge Lines” literature review.
- Horizontal Alignment Signs and Advisory Speed Plaques
 - For a single curve, the MUTCD provides four different types of signs:
 - Turn (W1-1)
 - Curve (W1-2)
 - Hairpin Curve (W1-11)
 - 270-degree Loop (W1-15)
 - For a section of road with multiple curves, the MUTCD provide three signs:
 - Reverse Turn (W1-3)
 - Reverse Curve (W1-4)
 - Winding Road (W1-5)
 - All these signs are intended to be placed in advance of any type of curve where permitted. The placement distance in advance of the curve is dependent upon the posted or 85th percentile speed.
 - The advisory speed plaque (W13-1) is a sign placed in conjunction with any of the advance curve warning signs. This sign advises drivers to maneuver through the curve(s) at the advised speed to reduce the potential risk of a crash.

- It is not uncommon to see speed plaques and turn warning signs used together. It is up to the agency's engineering judgement to decide whether to use the signs simultaneously. Another variation of the configuration is permitted in which the advisory speed is placed on the same sign (W1-1a or W1-2a). These signs are intended to be used as a supplement, not a replacement for the advance horizontal alignment sign and advisory speed plaque.
- **Chevron & Delineators**
 - Chevron alignment signs (W1-8) are intended to guide drivers through a change in horizontal alignment. These signs vary in size and the larger it becomes, there is a general relationship to a higher degree of emphasis for drivers that are approaching the curve. The amount of space required between chevrons within the curve is based on the speed limit and the spacing of chevrons on the approach or departure is typically twice as much as the interior spacing.
 - Delineators are another, even more common, form of showing change in horizontal alignment. These devices are placed above the road surface and are circular or rectangular with a minimum 3-inch dimension. The MUTCD requires that the color of the delineators are to match the adjacent edge line.

Enhanced Safety Improvements

- **Dynamic Signing & Flashing Beacons**
 - Dynamic signing, specifically on a curve, is a safety improvement that has variable performance throughout the United States. Dynamic curve signing is intended to alert approaching vehicles to take the curve with caution. These signs may also include mounted flashing lights and are actuated when the device detects an oncoming vehicle.
 - Flashing beacons have a wide variety of applications. Some applications include use for pedestrian enhancements at crosswalks, mounting on stop signs or even attached to curve advisory signs. The addition of flashing beacons to curve warning signs is a heightened way to gain driver's attention. One of the largest effects agencies who have deployed flashing beacons have experienced is that vehicle speeds can be greatly reduced depending upon the characteristics of the location.
- **Raised Pavement Markings (RPMs) & Profile Thermoplastic Markings**
 - Other longitudinal delineation features may consist of raised pavement markings (RPMs). RPMs may either be reflective or non-reflective. Reflective RPMs have been used in areas where snowfall occurs as well as on curvilinear sections.
 - Thermoplastic markings are used to create a raised profile, longitudinally or perpendicularly to the traveled way, so that when vehicles pass over them, the markings create a tactile sensation that alerts drivers. These markings also enhance pavement visibility and are typically utilized in warmer climates as snow plowing would destroy the markings. A few agencies have used this treatment with positive results, but there are no firm evaluations.

Other Safety Improvements

- **The Safety Edge**
 - The Safety Edge is a pavement edge safety treatment that replaces the sharp drop off with a 30 degree wedge of bituminous or concrete material. This wedge assists drivers

who drift off of the highway to regain control and return to the surface safely. The crash modification factor (CMF) for this safety improvement ranges from 0.845 to 1.002 for all crash types. Additionally, the Safety Edge also reduces the amount of erosion and general maintenance associated with gravel shoulders. Best practice is to maintain a flush edge so that no drop-offs exist. The flush edge and the lack of a vertical drop-off also eliminates tire scrubbing or tire wear on the pavement edge as well, once again reducing maintenance costs.

- **Roadside Shoulder Improvements**

- Shoulders are necessary for providing emergency storage of disabled vehicles, enforcement and maintenance activities, extra maneuverability to motorists to avoid crashes, improved bicycle accommodations, clear recovery areas, improved stopping sight distance on horizontal curves and increased capacity by increasing driver comfort. Roads with curb and gutter shoulders also store and carry water during storms. The following table provides ranges for paved shoulders on varying types of roadways.

Type of Roadway	Rural [feet]	Urban [feet]
Freeway	4 – 12	4 – 12
Ramps (1-lane)	1 – 10	1 – 10
Arterial	2 – 8	2 – 8
Collector	2 – 8	2 – 8
Local	2 – 8	–

- There is a correlation between shoulder width and CMFs specifically on 2-lane highways. Wider shoulders have larger safety benefits resulting in larger reductions in crashes and lower CMFs. The shoulder doesn't have to be paved but it has to be usable. The width of the usable shoulder is the total length in which a vehicle can traverse in order to perform an emergency maneuver. This measured distance is from the edge of the traveled way to the shoulder slope and paved shoulders are included in this distance where applicable.

- **Rumble Strips**

- Rumble strips can either be placed on the edge line of the pavement or offset from the pavement marking if there is a paved shoulder. Centerline rumble strips typically have the centerline painted over them and are suggested to reduce the risk of lane wandering and head-on crashes. Edge or shoulder rumble strips are suggested to reduce the risk of run-off-road crashes. Additionally, St. Louis County and other agencies who use edge line rumble strips with the pavement marking painted on top have commonly observed increased retroreflectivity as well as an increased lifespan of the pavement markings which could reduce maintenance costs.
- Transverse rumble strips have typically been used on approaches to rural intersections or even in areas with high pedestrian volumes. Temporary transverse rumble strips have also been used in advance of construction zones to alert drivers of a potential change in the traveled way. For more information see "Transverse Rumble Strip" literature review.

- Clear Zone Maintenance
 - Efforts to improve the safety performance of roadway features beyond the road's edge are usually considered as a part of reconstruction due to the typically high implementation costs. However, funding constraints have forced many highway agencies to adopt very long reconstruction cycles (more than 50 years). As a result consideration is now being given to addressing clear zone violations involving trees (33% of Minnesota road departure crashes) and ditches (34%) as part of the safety program. The Crash Modification Factor Clearinghouse website identifies crash reductions between 20% and 40% when increasing clear zone widths by 15 to 30 feet.

References

FHWA. 2006. *Low-Cost Treatments for Horizontal Curves*. (FHWA-SA-07-002)

FHWA. 2007. *Mitigation Strategies for Design Exceptions – Shoulder Widths*. (FHWA-SA-07-011)

FHWA. 2008. *The Safety Edge – A Pavement Edge Drop-Off Treatment*. (FHWA-SA-10-034)