



# Traffic Engineering & Highway Safety Bulletin



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Military Traffic Management Command Transportation Engineering Agency  
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## Highway Safety Driver-Aid Treatments

### Did You Know...

The most common type of fatal crash occurs when vehicles leave the roadway and strike a fixed object. Drivers often run off the road due to fatigue, impairment, and inattention.

To combat run-off-the-road crashes and reduce their severity, transportation and safety engineers use two basic strategies:

1. *Driver-aid treatments*
2. *Forgiving roadside treatments*

Use the methods in this bulletin to help drivers navigate high crash locations and avoid going out of control. A future bulletin will focus on forgiving roadside treatments. 

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### Driver-Aid Treatments

Driver-aid treatments minimize highway crashes by helping to keep the road user on the travel way. Many severe crashes occur in curves and turns due to driver fatigue or impairment.

The most common driver-aid treatments are:

- ❖ Rumble strips
- ❖ Signs
- ❖ Roadway improvements/ Intelligent Transportation Systems
- ❖ Delineators
- ❖ Object markers
- ❖ Pavement markings
- ❖ Warning beacons

### Rumble Strips

A rumble strip is a series of various type surface textures used on paved roads and shoulders that produce noise and vibration to alert road users of a traffic condition or hazard (Figure 1, Page 2).

### Application of Rumble Strips

- ❖ *Shoulder* rumble strips effectively alert drivers if they leave the travel way, thus reducing run-off-the-road crashes.
- ❖ *Centerline* rumble strips are useful in areas with undivided, two-way traffic roads where there is a history of head-on crashes.
- ❖ *Transverse*, or travel-lane rumble strips, are a useful tool for alerting motorists of an upcoming unsafe condition, such as an unexpected intersection or a tight curve.

### Related Concerns

- ❖ *Noise* – Noise is both a benefit and a concern with rumble strips. Noise serves as a benefit when it alerts motorists. However, when installed near residential areas, the noise is often



perceived as a nuisance. A solution to this concern may be to move the rumble strips further away from the travel way, reducing the likelihood of them being traveled on. However, this may also reduce their effectiveness.

- ❖ **Bicycles** – Rumble strips pose problems for bicycles. On facilities that have bicycle traffic, redesign roadway and shoulders when possible to accommodate both rumble strips and bicycles. Many states have, or are in the process of developing, bicycle-friendly rumble strips. Check out [www.fhwa.dot.gov](http://www.fhwa.dot.gov) for more information on states' rumble strip details and specifications.
- ❖ **Maintenance** – Rumble strips cause little, if any deterioration in roadway surfaces. By their design, rumble strips are self-cleaning since passing vehicles create a wind force that blows debris from the rumble strips.

### Costs vs. Benefits

- ❖ The 350+ mile Pennsylvania Turnpike system experienced a 70 percent reduction in run-off-the-road crashes after rumble strips were installed.
- ❖ California experienced an average reduction of 33 percent in run-off-the-road crashes statewide with rumble strip installation.

- ❖ The cost of milled shoulder rumble strips is about \$0.20 per foot of shoulder.
- ❖ New York State Thruway data indicate a benefit/cost ratio ranging from **66:1** to **182:1**.
- ❖ Nevada DOT calculated a benefit/cost ratio ranging from **30:1** to **60:1** for interstate rumble strips. 

**Figure 1**  
**Common Types of Rumble Strips\***

Type	Description	Comments
 <b>Milled</b>	<ul style="list-style-type: none"> <li>❖ Machine-milled</li> <li>❖ Longitudinal width of 7 inches</li> <li>❖ Transverse width of 16-17 inches</li> <li>❖ Offset 12-16 inches from travel lane</li> <li>❖ Tires drop ½ inch into groove</li> </ul>	<ul style="list-style-type: none"> <li>❖ Favorite type of most states because they are easy to install</li> <li>❖ Do not affect pavement integrity</li> <li>❖ Produce greater noise and vibration than other types of rumble strips</li> </ul>
 <b>Rolled/Formed</b>	<ul style="list-style-type: none"> <li>❖ Made by a roller with steel pipes welded to drums</li> <li>❖ 1 ¼ inches deep</li> <li>❖ 1 ½ inches wide</li> <li>❖ 8 inches between grooves</li> </ul>	<ul style="list-style-type: none"> <li>❖ Do not create the same level of noise and vibration as milled rumble strips</li> </ul>

\*The type of rumble strip and the exact dimensions vary from state to state. Contact your State Department of Transportation for further guidance.

### Signs

Signs are another effective driver-aid treatment. Examples of Warning Sign treatments for horizontal alignment changes include Turn, Curve, Reverse Turn, and Reverse Curve signs. These signs are very helpful but are commonly misused. Use the criteria in the *MUTCD* as the basis for deciding what type of sign to install. 

**Figure 2**  
**Driver-Aid Warning Signs**

Sign	Symbol	Criteria
Turn (W1-1)		Advisory speed of 30 mph or less
Curve (W1-2)		Advisory speed greater than 30 mph
Reverse Turn (W1-3)		Advisory speed of 30 mph or less and two turns in opposite directions that are separated by tangent distance of 600 feet or less
Reverse Curve (W1-4)		Advisory speed of greater than 30 mph and two curves in opposite directions that are separated by tangent distance of 600 feet or less

## Roadway Improvements and Intelligent Transportation Systems (ITS)

Roadway improvements can also be effective driver-aid treatments. Many times common improvements can yield the highest reduction in crashes.

- ❖ Realign unexpected roadway conditions
- ❖ Improve roadway drainage by improving roadway crown and superelevation
- ❖ Reconstruct deteriorated roadway surface

Intelligent Transportation Systems (ITS) have become mainstream and have greatly come down in cost. Because of their use of technology, these systems can yield reductions in crashes that other improvements cannot.

- ❖ Horizontal alignment warning systems are used to warn motorists if they are traveling too fast for the impending change in horizontal alignment.
- ❖ “RED WHEN FLASHING” signs are used to warn of red indication at nearby, traffic signal when sight distance is limited.
- ❖ Weather sensors and signs are used to provide advance warning of conditions such as black ice on a bridge.
- ❖ Collision countermeasure systems are used to warn of approaching, conflicting traffic at intersections with insufficient sight distance. 

## Delineators

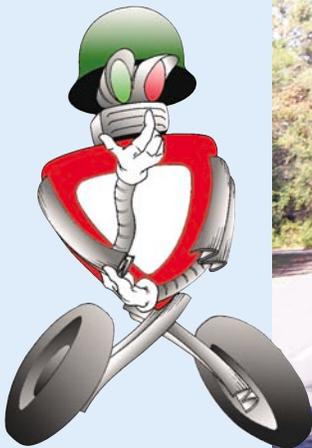
Delineators provide all-weather delineation of roadway edges and are beneficial at locations where alignment may be confusing, such as lane reductions or curves. The color of

the delineator must conform to the color of line it is supplementing.

- ❖ 30% reduction in crashes
- ❖ Benefits outweigh costs on roadways with greater than 1,000 vehicles daily 

### What's Wrong With This Photograph??

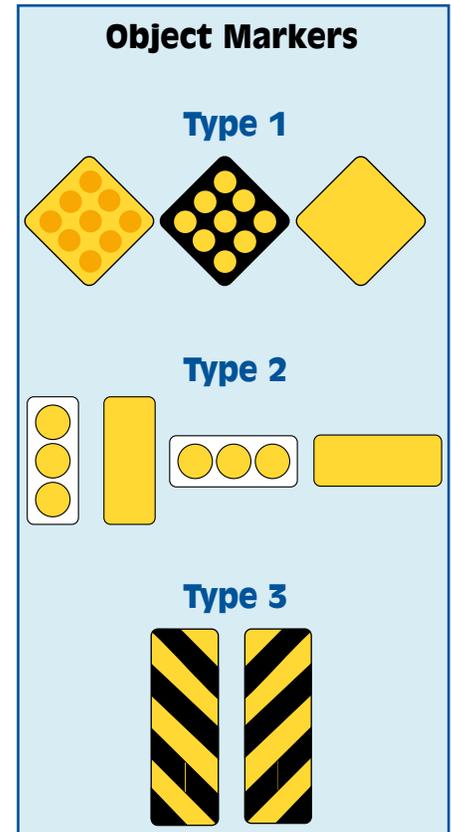
Answers on Page 5



## Object Markers

Use object markers to mark obstructions within or adjacent to the roadway.

Mark obstructions with a Type 1 or Type 3 marker. Type 3 markers have stripes sloping downward on the side traffic should pass on.

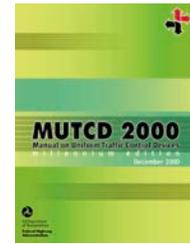


Mark roadside hazards adjacent to the roadway with Type 2 or Type 3 markers. These include underpass piers, bridge abutments, handrails and culvert headwalls. In some cases they may be used to mark roadside conditions such as narrow shoulder drop-offs, gores, small islands, and abrupt changes in roadway alignment. 

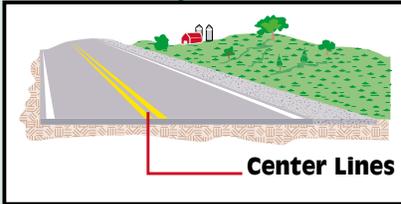
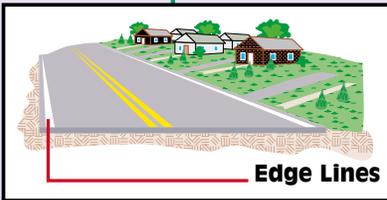
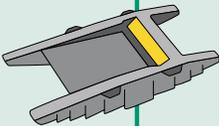
# Pavement Markings

Pavement markings make up the primary delineation and control for road users to navigate the highway system. Markings have an enormous impact on highway safety since they

regulate and guide the movement of traffic. Markings provide the best system of roadway delineation for the least cost. Cost is \$0.30 per linear feet for four inch wide solid line. 



## Warrants for Pavement Markings

Type	Purpose/ Application	National MUTCD Criteria	Benefits/Costs
<p><b>Center Lines</b></p>  <p style="text-align: center;"><b>Center Lines</b></p>	<ul style="list-style-type: none"> <li>❖ Separates traffic traveling in opposite directions</li> <li>❖ Provides delineation of separation</li> </ul>	<p><b>Standard</b></p> <ul style="list-style-type: none"> <li>❖ Mandatory for all paved urban arterials and collectors with traveled width of 20 feet or more and ADT of 6,000 or more</li> <li>❖ Mandatory on all paved two-way facilities that have three or more traffic lanes</li> </ul> <p><b>Guidance</b></p> <ul style="list-style-type: none"> <li>❖ Should be on all paved urban arterials and collectors with traveled width of 20 feet or more and ADT of 4,000 or more</li> <li>❖ Should be on all paved rural arterials and collectors with traveled width of 18 ft or more and ADT of 3,000 or more</li> <li>❖ Should be on other paved traveled ways where engineering study indicates need</li> <li>❖ Engineering judgment should be used in determining whether to place on paved traveled ways less than 16 feet because of encroaching on pavement edges, traffic being affected by parked vehicles, and traffic encroaching into opposing traffic lane</li> </ul> <p><b>Option</b></p> <ul style="list-style-type: none"> <li>❖ May be placed on two-way paved traveled ways that are 16 feet in width</li> </ul>	<ul style="list-style-type: none"> <li>❖ 30% reduction in head-on crashes</li> <li>❖ \$0.30 per linear foot for 4" wide solid line</li> </ul>
<p><b>Edge Lines</b></p>  <p style="text-align: center;"><b>Edge Lines</b></p>	<ul style="list-style-type: none"> <li>❖ Provides an edge of pavement guide for drivers</li> <li>❖ May result in lower speeds since travel lanes appear narrower</li> </ul>	<p><b>Standard</b></p> <ul style="list-style-type: none"> <li>❖ Mandatory for freeways</li> <li>❖ Mandatory for expressways</li> <li>❖ Mandatory for paved rural arterials with traveled width of 20 feet or more and ADT of 6,000 or more</li> </ul> <p><b>Guidance</b></p> <ul style="list-style-type: none"> <li>❖ Should be on all paved rural arterials and collectors with traveled width of 20 feet or more and ADT of 3,000 or more</li> <li>❖ Should be on other paved traveled ways where engineering study indicates need</li> </ul> <p><b>Option</b></p> <ul style="list-style-type: none"> <li>❖ May be placed on paved facilities that do not have centerlines</li> <li>❖ May be excluded, based on engineering judgment, for reasons such as if travel edges are delineated by curbs, parking, bicycle lanes, or other markings</li> <li>❖ May be used where edge delineation is desirable to minimize driving on paved shoulders, or on refuse areas that have lesser structural pavement strength than travel way</li> </ul>	<ul style="list-style-type: none"> <li>❖ 11 to 25% reduction in run-off-the-road crashes</li> <li>❖ \$0.30 per linear foot for 4" wide solid line</li> </ul>
<p><b>Raised Pavement Markers</b></p> 	<ul style="list-style-type: none"> <li>❖ Supplement or substitute for pavement markings</li> <li>❖ Provide travelway visibility during conditions when pavement markings are difficult to see.</li> </ul>	<p><b>Standard</b></p> <ul style="list-style-type: none"> <li>❖ Shall conform to color of markings they supplement or substitute</li> <li>❖ Shall conform to spacing requirements provided in MUTCD when substituting for centerline markings meeting above criteria</li> </ul> <p><b>Guidance</b></p> <ul style="list-style-type: none"> <li>❖ Should not substitute for right edge line markings</li> <li>❖ See MUTCD for additional guidance</li> </ul> <p><b>Option</b></p> <ul style="list-style-type: none"> <li>❖ May be placed side-by-side when substituting for wide line</li> <li>❖ See MUTCD for additional options</li> </ul>	<ul style="list-style-type: none"> <li>❖ Reduced crashes on curves by 15%</li> <li>❖ Benefits outweigh costs on roadways with more than 3,000 vehicles daily</li> <li>❖ Cost per mile for centerline delineation: Two-lane (no passing) = approx. \$3200; Two-lane (50/50 passing/no passing) = approx. \$2400; Two-lane (full passing) = approx. \$1600.</li> <li>❖ \$8 to \$32 each</li> </ul>

## Warning Beacons

Use warning beacons to call driver's attention to appropriate warning or regulatory sign or marker. Typical applications of this driver-aid treatment include:

- ❖ At obstructions in or immediately adjacent to the roadway
- ❖ As supplemental emphasis to regulatory or warning signs
- ❖ As emphasis for mid-block crosswalks
- ❖ On approaches to intersections where additional warning is required, or where special conditions exist
- ❖ As supplements to regulatory signs, except STOP, YIELD, DO NOT ENTER, and SPEED LIMIT signs. 

## MTMCTEA Can Help!

MTMCTEA highway engineers stand ready to help installations with their traffic engineering concerns—especially those involving high accident locations. We perform many types of studies with an emphasis on low-cost improvements that are immediate or short-term and yield high benefits to their implementation costs. Generally, the studies conducted include:

- ❖ Fatal crash analysis
- ❖ Safety audits
- ❖ High accident locations
- ❖ Traffic engineering
- ❖ Traffic impact (such as BRAC)
- ❖ Access roads
- ❖ Force protection
- ❖ Signal operations

## Answer From Page 3

1. An engineering study determined that an advisory speed of less than 30 mph is recommended. Replace the curve sign (W1-2) with a turn sign (W1-1).
2. Replace the centerline markings at this location with solid double yellow lines. The roadway warrants, and has, centerline markings, but the markings are worn and are broken lines.
3. The roadway warrants edge line markings, but none currently exist.
4. Although not required, consider other driver-aid



treatments at this location, such as: raised pavement markings, delineators, Chevron Alignment (W1-8) signs, or rumble strips.

## IN THE NEXT ISSUE

### Gates

- Capacity
- Security
- Design

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## Reference List

- ❖ American Association of State Highway and Transportation Officials. *Roadside Design Guide*. Washington, D.C. January 1996.
- ❖ American Association of State Highway and Transportation Officials. *The Highway Safety Design and Operations Guide*. Washington, D.C. 1997.
- ❖ Federal Highway Administration. *Manual on Uniform Traffic Control Devices*, Washington, D.C. 2000.
- ❖ [www.fhwa.dot.gov](http://www.fhwa.dot.gov)
- ❖ [www.tea.army.mil](http://www.tea.army.mil)
- ❖ [www.ite.org](http://www.ite.org)



## Training

Continuing Education	Phone	Web Site
<b>Penn State University; The Penn Transportation Institute</b>	(814) 865-4700	<a href="http://www.pti.psu.edu">www.pti.psu.edu</a>
<b>University of Maryland; Md. Transportation Technology Transfer Center</b>	(301) 403-4623	<a href="http://www.ence.umd.edu/ttcc">www.ence.umd.edu/ttcc</a>
<b>Georgia Institute of Technology</b>	(404) 385-3501	<a href="http://www.gatech.edu">www.gatech.edu</a>
<b>Northwestern University Center for Public Safety</b>	(800) 323-4011	<a href="http://www.northwestern.edu/nucps/index.htm">www.northwestern.edu/nucps/index.htm</a>
<b>Texas A&amp;M University</b>	(979) 845-3211	<a href="http://www.tamu.edu">www.tamu.edu</a>
<b>University of Washington; College of Engineering</b>	(206) 543-2100	<a href="http://www.engr.washington.edu/epp">www.engr.washington.edu/epp</a>
<b>University of California Berkeley; Institute of Transportation Studies</b>	(510) 231-9590	<a href="http://www.its.berkeley.edu/techtransfer/">www.its.berkeley.edu/techtransfer/</a>

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