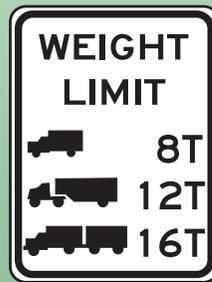


Iowa Traffic Control Devices and Pavement Markings:

A Manual for Cities and Counties



*Sponsored by the
Iowa Highway Research Board
Project TR-441*

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Iowa Department of Transportation.

CTRE's mission is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, and reliability while improving the learning environment of student, faculty, and staff in transportation-related fields.

Iowa Traffic Control Devices and Pavement Markings: A Manual for Cities and Counties

April 2001

Sponsored by the Iowa Department of Transportation
and the Iowa Highway Research Board
Iowa DOT Project TR-441

Developed by
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Acknowledgments

The development of this manual grew out of a desire by Iowa's local transportation agencies for a convenient, easy-to-use, "one-stop" guide for using traffic control devices and pavement markings on city and county roadways. While the concept seems straightforward, moving from concept to reality required the dedicated involvement of dozens of professionals and organizations across the state for more than a year. The Center for Transportation Research and Education (CTRE) is indebted to everyone whose assistance and support contributed to the product you have before you.

Perhaps most important, the Iowa Highway Research Board (IHRB) recognized the value of this project for Iowans. The board funded development, publication, and distribution of the manual (TR-441), provided valuable feedback on an initial draft, and helped address potential liability issues. Other important input was provided by transportation staff from many of Iowa's cities and counties who answered a survey about their current practices and needs for information regarding the use of traffic control devices and pavement markings. (Detailed results of that survey can be found in a related research report: *Development of a Traffic Control Devices and Pavement Markings Manual for Iowa's Cities and Counties with a Survey of Common Practices: Final Report.*)

In addition to input provided by the IHRB and survey respondents, the authors of this manual drew heavily on similar manuals from other states, including Kansas, South Dakota, and Texas, and from earlier documents produced by the Iowa State Highway Commission and the Iowa Department of Transportation. These documents helped the authors determine appropriate categories of information for Iowa's new manual and provided many sample illustrations that have been recreated for this manual.

The authors wish to express their sincere thanks to members of the project's advisory committee, listed below. As peers of the manual's primary audiences, committee members provided invaluable expertise and advice. But they did much more. This was truly a working committee, and through several hands-on meetings, e-mail communications, and telephone calls, committee members actively participated in planning, writing, and editing many sections of this manual.

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Finally, the authors want to thank Traffic and Parking Control Company (TAPCO), which provided electronic files for many sign graphics that were ultimately recreated for this manual. One original TAPCO graphic, R4-7, is found on page E1.2.

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Section A

Introduction

A:
Introduction

Introduction

Iowa Traffic Control Devices and Pavement Markings: A Manual for Cities and Counties has been developed to provide state and local transportation agencies with suggestions and examples related to traffic control devices and pavement markings. Both rural and urban applications are included.

The primary source of information for this document is the *Manual on Uniform Traffic Control Devices (MUTCD)*, but many additional references have also been used. A complete listing of these is included in the appendix to this manual, and the reader is invited to consult these references for more in-depth information.

The contents of this manual are not intended to represent standard practice or to imply legal requirements for installation in any particular manner. This document should be used as a supplement to the *MUTCD*, not as a substitute for any requirements contained therein. Engineering judgement should be applied to all decisions regarding traffic control devices and pavement markings.

All references to the *MUTCD* in this manual apply to the millennium edition. The reader should be aware that many millennium revisions are allowed phase-in periods by the Federal Highway Administration (FHWA), ranging from two to ten years. These extended compliance periods should be considered when making decisions regarding traffic control devices and pavement markings. A new addition to the *MUTCD*, Part 5, "Traffic Control Devices for Low-Volume Roads," also contains valuable recommendations for signing and marking low-volume roads.

This manual is presented in an easy to use three-ring format. Topics included in the complete guide manual may not apply to all jurisdictions and can easily be removed or modified as desired. Desired millennium *MUTCD* sections may be added for quick reference using the divider at the end of this document. Contents may also be available on CD-ROM in the future.

The *MUTCD* can be found at <http://mutcd.fhwa.dot.gov/>.

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Operating Statement

Research and experience have demonstrated that increasing the *amount* of traffic control does not necessarily increase drivers' compliance with those controls. Rather, drivers tend to comply most often (and thereby increase traffic safety) with traffic control efforts that are *consistent* and *reasonable*.

Transportation agencies are advised, therefore, to adopt a policy that establishes a systematic, systemwide approach to traffic control, based on the advice of qualified engineers. (Documenting the agency's compliance with such a policy is also valuable, particularly with legal liability issues.)

A suggested operating policy for transportation agencies would state: "Decisions regarding establishment of traffic control in specific situations will be based on the precepts of the *Manual on Uniform Traffic Control Devices* and engineering studies considering factors such as traffic speed, volumes, sight restrictions, and crash history."

The source for this suggested operating policy is the video *Traffic Control—What Works* available from the Minnesota Local Road Research Board and the Minnesota Department of Transportation.

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Section B

Quick Reference

B: Quick
Reference

Quick Reference

Minimum suggested channelizing device and sign spacing in work zones

Traffic Speed (mph)	Taper Length Each 12 Ft Lane ¹	Device Spacing		Sign Spacing Advance of Taper & Between Signs
		Taper	Tangent	
25	125	25	50	100
30	180	30	60	150
35	245	35	70	250
40	320	40	80	350
45	540	45	90	400
50	600	50	100	450
55 (non-freeway)	660	55	110	500

¹Does not apply to flagger tapers.

A guide for advance warning sign placement distances

Posted Speed (MPH)	Condition A (High Judgement Needed)	General Warning Signs					
		Condition B (Stop)	Condition C (Deceleration to Advisory Speed)				
			0	10	20	30	40
20	175	-	-	-	-	-	-
25	250	-	100	-	-	-	-
30	325	100	150	100	-	-	-
35	400	150	200	175	-	-	-
40	475	225	275	250	175	-	-
45	550	300	350	300	250	-	-
50	625	375	425	400	325	225	-
55	700	450	500	475	400	300	-
60	775	550	575	550	500	400	300
65	850	650	650	625	575	500	375

Please refer to Section 2C.05 of the *MUTCD* and "Warning Sign Placement" (C18) in this manual for more information.

Speed conversions between mph¹ and kph²

mph to kph											
mph	20	25	30	35	40	45	50	55	60	65	70
kph	32	40	48	56	64	72	80	89	97	105	113
kph to mph											
kph	30	35	40	50	60	70	80	90	100	110	120
mph	19	22	25	31	37	44	50	56	62	68	75

¹mph = miles per hour.

²kph = kilometers per hour.

1 mph = 1.466 fps (feet per second); 1 fps = 0.6818 mph.

1 mph = 0.6215 kph; 1 kph = 1.609 mph.

Sign sheeting material

Engineering Grade	Minimal retroreflectivity and life
High Intensity	Medium retroreflectivity and life
Diamond Grade	Maximum retroreflectivity and life; also available in fluorescent colors

Phone numbers and websites

American Traffic Safety Services Association (ATSSA)	
	www.atssa.com
CTRE	1-515-294-8103 www.ctre.iastate.edu
FHWA	www.fhwa.dot.gov
Iowa DOT	www.dot.state.ia.us
Iowa DOT Weather	www.weatherview.dot.state.ia.us
International Municipal Signal Association (IMSA)	
	www.imsasafety.org
Iowa One Call	1-800-292-8989
Iowa State Patrol	1-800-525-5555
Institute of Transportation Engineers (ITE)	
	www.ite.org
MUTCD	mutcd.fhwa.dot.gov
State Traffic Engineer	1-515-239-1513

Background sign color code

Black	Regulatory
White	Regulatory
Yellow	General warning
Red	Stop or prohibition
Blue	Motorist services, guidance, and evacuation route
Green	Movements permitted, direction guidance
Brown	Recreational and cultural interest guidance
Orange	Temporary traffic control
Fluorescent	
Yellow-Green	Schools, pedestrians, and bicycles

Uniform utility color code

Red	Electric power lines, cables, or conduits
Yellow	Gas or gaseous materials; oil or petroleum materials; steam
Orange	Alarm lines, cables or conduits; communication lines, cables, or conduits
Blue	Irrigation lines; slurry lines; water lines
Green	Drain lines; sewers

Standard colors for pavement markings

Yellow	Separates opposing traffic in an adjacent lane or to mark a left-hand edge line on multilane roadways
White	Used to separate traffic on multilane roadways moving in the same direction, for turning lanes, right-hand edge markings, and most symbols
Blue	Disabled parking areas
Red	Restricted use

Miscellaneous measure

Engineer's Chain	100 ft.
Surveyor's Chain	66 ft.
Rod	16.5 ft.
Link	7.92 in.

Length unit conversions¹

	Inches	Feet	Yard	Rod	Mile	Millimeter	Centimeter	Meter	Kilometer
Inches	-	0.0833	0.0277	0.00505	1.578x10 ⁻⁵	25.4	2.54	0.0254	2.54 x 10 ⁻⁵
Feet	12	-	0.3333	0.0606	1.893x10 ⁻⁴	304.8	30.48	0.3048	3.048 x 10 ⁻⁴
Yard	36	3	-	0.1818	5.682x10 ⁻⁴	914.44	91.44	0.9144	9.144 x 10 ⁻⁴
Rod	198	16.5	5.5	-	0.00312	5029.2	502.92	5.0292	0.00502
Mile	63,360	5,280	1760	320	-	1.609x10 ⁶	1.609x10 ⁵	1609.34	1.60934
Millimeter	0.03937	0.00328	0.00109	1.987x10 ⁻⁴	6.214x10 ⁻⁷	-	0.1	0.001	1.0x10 ⁻⁶
Centimeter	0.3937	0.0328	0.01093	0.00198	6.214x10 ⁻⁶	10	-	0.01	1.0x10 ⁻⁵
Meter	39.37	3.28	1.0936	0.19883	6.214x10 ⁻⁴	1,000	100	-	0.001
Kilometer	3.937x10 ⁴	3,280.84	1,093.61	198.84	0.62137	1.0X10 ⁶	1.0X10 ⁵	1,000	-

¹For conversions from the vertical dimensions, multiply. From the horizontal dimensions, divide.

Important publications

Manual on Uniform Traffic Control Devices.

FHWA standard publication on signing, pavement markings, traffic signals, roadway construction zones, rail crossings, etc.

A Policy on Geometric Design of Highways.

American Association of State Highway and Transportation Officials (AASHTO) publication on roadway design; commonly known as the “green book”

Roadside Design Guide.

AASHTO manual of roadside design; design slopes, clear zones, barriers and sign support standards

Traffic Engineering Handbook.

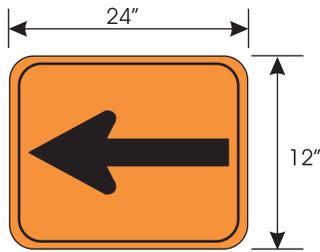
ITE handbook on traffic engineering; information on traffic studies, traffic signals, roadway lighting, signing, pavement markings, roadway geometrics, etc.

Manual of Transportation Engineering Studies.

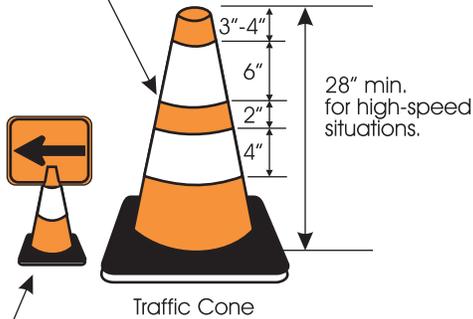
ITE in-depth manual on traffic studies, analyzing accidents, street parking, traffic flow, etc.

Cones

Cones are available in many sizes from 12 to 36 inches in height. Roadways with speeds greater than 40 mph should only use cones 28 inches or taller. Cones are sold in different weights and should be heavy enough to withstand local winds and the drafts created by semi-trucks. Cones should also include reflectorized bands for night visibility. Refer to Section 6F.55 of the *MUTCD* for more information.

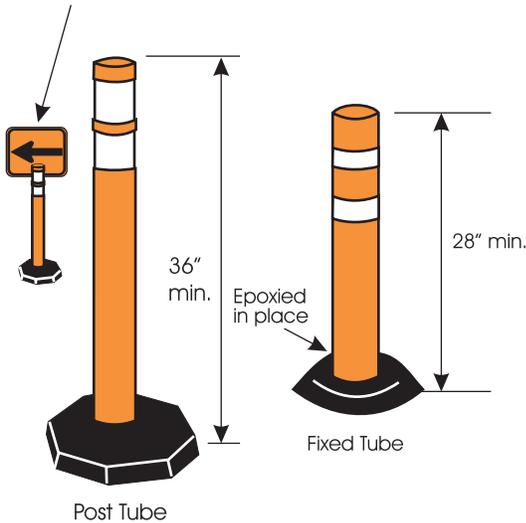


Reflective cone sleeve
(sunset to sunrise only)



Traffic Cone

Supplemental directional or warning signs may be mounted on cones and other devices subject to agency approval.*



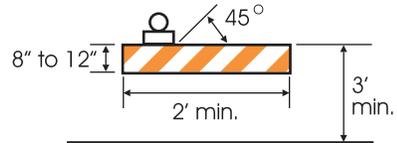
Post Tube

Fixed Tube

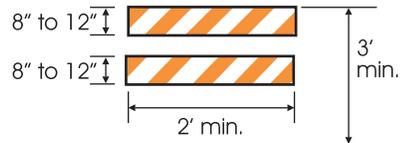
* These supplemental signs have not been given a Uniform Sign Code number.

Channelizing devices (temporary use)

Warning Light
(Optional on all barricade types)

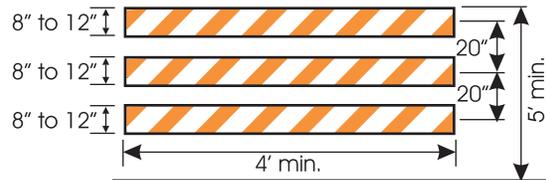


Type I Barricade



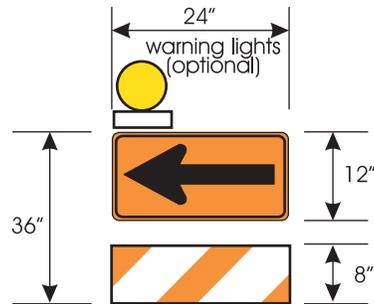
Type II Barricade

Note: Barricades shall have a minimum of 270 square inches of retroreflective area facing traffic when used on freeways, expressways, and other high-speed highways.



Type III Barricade

Typical barricades (temporary use)



Direction indicator barricade

Barricade characteristics

Type	I	II	III
Width of Rail	8" min. 12" max.	8" min. 12" max.	8" min. 12" max.
Length of Rail	2' min	2' min.	4' max.
Width of Stripes ¹	6"	6"	6"
Number of ReflectORIZED Rail Faces	2	4	3

¹ For rails less than 3 feet long, 4-inch wide stripes may be used.

Section C

Signs

C: Signs

Signs

As defined by Section 1A.01 of the *MUTCD*, “the purpose of traffic control devices, as well as principles for their use, is to promote highway safety and efficiency by providing for the orderly movement of all road users on streets and highways throughout the nation...Traffic control devices notify road users of regulations and provide warning and guidance needed for the safe, uniform, and efficient operation of all elements of the traffic stream.”

Signs are a principal means for regulating, warning, and guiding traffic. However, to be effective, signing must meet these *MUTCD* requirements:

- fulfill a need
- command attention of drivers
- convey a clear and simple meaning
- command respect of road users
- provide adequate time for proper response

To meet these requirements, due consideration must be given to the following elements with regard to signs:

- *Design*—color, shape, size, lettering, retroreflectivity, and legibility.
- *Placement*—sign location in relation to motorists and the subject to which the message applies.
- *Operation*—consistent service by the sign in meeting traffic needs.
- *Maintenance*—adequate attention to assure the sign remains visible and functional.
- *Uniformity*—consistent appearance and application to achieve consistent driver perception and response.

These topics will be discussed throughout this manual to demonstrate the importance of understanding and applying *MUTCD* concepts and requirements to achieve maximum benefits for users of our public transportation system.

Sign Types

Signs can be divided into three basic types, as defined by the *MUTCD*:

- *Regulatory*—advise road users of laws, regulations, or legal requirements. Regulatory signs require official action to be enforceable.
- *Warning*—alert drivers of conditions that could be hazardous on or adjacent to the roadway.
- *Guide*—provide directional and navigational information. An important element of the guidance system is street name signs. These signs may not always receive sufficient consideration and are further discussed in the article “Guide Signs” (C7) in this manual.

Two additional groups can be added to these major types:

- *Motorist Information*—provide drivers with information about services, businesses, attractions, and facilities near the roadway.
- *Emergency Management*—control, direct, and guide traffic in response to an emergency.

Visibility

To meet basic *MUTCD* requirements and provide maximum effectiveness for road users, information presented on signs, whether legend or symbols, must be legible and understandable. Traffic speed, weather and light conditions, sight distance, and driver age directly affect the legibility and clarity of a sign message. To address these factors, sign design must consider overall sign dimensions, lettering size, color, contrast, and retroreflectivity. For effective use, signs must be positioned relative to the driver’s cone of vision and located in a position that allows adequate response time.

Sections 2B.03, 2C.04, and 5A.03 of the *MUTCD* provide minimum dimensions for regulatory and warning signs, but some flexibility is allowed with guide signs in consideration of message variability. The Federal Highway

Administration's *Standard Highway Signs* provides basic design guidelines and requirements for most signs used on public roadways. For uniformity and effectiveness, it is important to follow the precepts in these reference documents. Please refer to Part 2, "Signs," and Part 5, "Traffic Control Devices for Low-Volume Roads," in the the *MUTCD* for recommendations on sign size.

Consider these recommendations, from Section 2A.14 of the *MUTCD*, when determining the size and layout of all signs:

- use one inch of letter or symbol height for each 40 feet of anticipated daytime viewing distance and 30 feet for nighttime viewing
- the space above and below the message should equal one-half of the message height
- use this same minimum spacing between lines of the message
- allow adequate spacing from the ends of message lines to sign borders
- if these recommendations cannot be met with common sign dimensions, use a larger sign, regardless of type

These recommendations will have more positive effects on visibility at night than during daylight viewing, particularly with high-performance sign sheeting. If adequate sign dimensions and/or lettering size and spacing are not used in sign design, legibility at night will be adversely affected.

These design factors can be as important as sheeting type and retroreflectivity in providing readable sign messages during reduced light conditions. The introduction of fluorescent colors in recent years has enhanced the performance of signing in the twilight hours and heavily overcast conditions. Fluorescent colors are more effective than standard colors in these lighting conditions.

The effectiveness of sign visibility can be verified through periodic inspections, both day and night. These activities are discussed elsewhere in this manual.

Sign Sheeting

Irregular locations for sign installations, such as left-hand placements, overhead, and high or extended lateral mountings, may result in less projected light reaching the sign face during night conditions. For example, a right-hand mounted sign may receive about 100% of projected light from vehicle headlights, while a similar sign on the left side of the roadway may receive only about 25% of light from the same source. This discrepancy occurs because vehicle headlights are usually pointed downward and to the right.

Signs mounted in these nonstandard locations, such as No Passing pennants and some rural street name signs, may need a higher performance sheeting for adequate visibility at night.

Sheeting material is available in both standard and fluorescent colors. Fluorescent colors improve visibility during certain daylight hours. Sign colors with different meanings have been adopted to promote consistent understanding by drivers. The following table, from Section 1A.12 of the *MUTCD*, lists available sign colors and the purpose of each.

Sign color and purpose

Yellow	General warning
Red	Stop or prohibition
Blue	Motorist services guidance and evacuation route
Green	Indicated movements permitted, direction guidance
Brown	Recreational and cultural interest guidance
Orange	Temporary traffic control
Black	Regulation
White	Regulation
Fluorescent	
Yellow-Green	School zones, pedestrian, and bicycles
Purple	Unassigned
Light Blue	Unassigned
Coral	Unassigned

Several types of sign sheeting are available, including:

1. *ASTM Type I*—medium retroreflective sheeting, also known as “engineering grade”; featuring enclosed lens glass bead sheeting
2. *ASTM Type II*—medium-high intensity retroreflective sheeting, known as “super engineering grade”; also featuring enclosed lens glass beads
3. *ASTM Type III*—high intensity, retroreflective sheeting, known as “high intensity”; typically two layers with encapsulated glass beads
4. *ASTM Type IV*—high intensity, typically unmetalized microprismatic retroreflective element material; also known as “high performance”
5. *ASTM Type V*—metalized microprismatic material, known as “super high intensity”
6. *ASTM Type VI*—vinyl-backed microprismatic material; known as “elastomeric high intensity”; used for many roll-up sign designs as well as highly visible apparel
7. *ASTM Type VII (Iowa)*—microprismatic, very high intensity, retroreflective sheeting, known as “diamond grade” or “high performance”

Specifications for these sheetings are described in ASTM D 4956-95, which has also been adopted by the FHWA and many agencies. All of these sheetings, with the exception of Type VI, can be obtained with pressure sensitive, heat-activated backings for easy application.

With more expensive sheeting and capabilities of computerized cutting of letters, there may be incentive to use a technique called “nesting,” by which many more letters can be cut from a given dimension of sheeting by rotating individual letters to fit more closely. While this technique may seem more efficient, caution should be used with certain sheeting types. Some microprismatic sheetings may not provide consistent luminance for desired night visibility when letters are rotated prior to cutting. Agencies that manufacture signs should be aware of this concern and discuss the potential effects of rotation on luminance characteristics of specific sheeting with vendors prior to using this process.

Cost, performance, and service life vary with each of these sheeting types. For instance, Type III sheeting is about four times brighter and costs about three times as much as Type I, with a service life of up to twenty years, compared to an estimated seven years with Type I. By contrast, Type VII sheeting can cost up to four times that of Type I, but provide from six to fourteen times the brightness. Service life for Type VII may be up to twenty years. These factors must all be considered when selecting the most appropriate sheeting type for the performance desired.

Starting with a higher performance sheeting will result in more visibility over a greater period of time, thus meeting minimum retroreflectivity requirements longer. Brighter sign messages also permit agencies more latitude in placement locations, as visibility will remain satisfactory even at wider viewing angles. For instance, high-intensity sheeting retains good legibility from a 30 degree viewing angle at night. With some Type VII sheeting, this satisfactory viewing angle increases to 60 degrees. This may be particularly important with No Passing pennants and certain street name signs. Life-cycle costing should always be considered in these decisions. Always be sure to check product warranty, shelf life, and retroreflectivity with the vendor prior to making purchase decisions. The following is a list of sign sheeting vendors:

3M Corporation - Traffic Control Materials Division

3M Center Bldg. 225-5S-08
St. Paul, MN 55144-1000
(800) 553-1380
www.3M.com/tcm

Nippon Carbide Industries (USA), Inc.

3136 E. Victoria St.
Rancho Dominguez, CA 90221
(800) 821-4264

Avery Dennison

250 Chester St.
Painesville, OH 44077
(800) 435-8088

American Decal & Manufacturing Company

4100 W. Fullerton Ave.
 Chicago, IL 60639
 (773) 489-4700
 reflective@americandecal.com

Stimsonite Corporation

Purchased by Avery Dennison
 7542 N. Natchez Ave.
 Niles, IL 60648
 (847) 647-7717
 www.stimsonite.com

Reflexite North America

1001 4th St.
 Sacramento, CA 95819
 (916) 739-6903

Nazdar Company

8501 Hedge Lane Terrace
 Shawnee, KS 66227
 (800) 767-9942

The table below presents information for various sheeting types.

Common sign sheeting materials

Sheeting Material	Possible Use	Advantages	Disadvantages
Painted	Commercial/home use only, not intended for roadways	Very inexpensive	Short life
Nonreflective	School zones, work zones only in operation during daylight hours	Minimal expense	Limited uses
Enclosed Lens (Engineer Grade)	Low-speed work zones, speed limits, no parking zones, areas that require little reflectivity	Lowest initial cost	Shorter life
Encapsulated Lens (High Intensity)	Warning signs, keep right, stop, speed limits on arterials, no passing zones, signal ahead, areas that require very good reflectivity	High reflectivity, good life	Moderate initial cost
Prismatic (Diamond Grade)	Interstate work zones, street name signs, warning signs, areas where hazards or high speeds exist during dark hours	Extremely high reflectivity, long life	High initial cost

Sign Substrate

The substrate or backing is the material that gives rigidity to signs. Various materials are available for this purpose, including steel, aluminum, wood, plastics, and fiber glass, each with particular features. The table below lists various materials that can be used for sign substrates.

After considering the features of substrate materials, an agency may wish to select different types for various applications or simply use the same material for all signs. Most agencies use aluminum for a majority of signs and other materials in special situations. Some rural agencies use steel substrate for most sign applications. As with sheeting, substrate materials

selected should be the most cost-effective over the anticipated service life. Practicality can also be a consideration. Sign trucks or storage shelves designed for aluminum signs can be overstressed with the greater weight of steel or wood.

For local fabrication, substrates can be purchased in various precut forms. Large agencies may purchase material in rolls or large sheets and cut shapes in-house. Smaller jurisdictions may obtain substrate material precut, especially with odd-shaped signs such as Stop, No Passing, Railroad Crossing, and School Crossing signs. Prepunched holes are advisable since these are usually cleaner than drilled holes.

Sign substrate materials

Material	Advantage(s)	Disadvantage(s)	Possible Applications
Steel	Very strong, resistant to gunshots, moderate initial cost	Heavy material, tends to rust, little scrap value	Rural roadways, park areas, parking lots
Aluminum	Moderately strong, long life, cost-effective, high scrap value, low weight	Susceptible to gunshots, high initial investment	General roadway signage, overhead signs on freeways or signal mast arms, street name signs
Wood	Moderately strong, moderate life, comes in large sizes, medium weight	Can warp and delaminate	Large temporary signs, information signs, specialty signs
Plastics	Low weight, moderately strong, low initial cost, no corrosion	Brittle in cold weather, poor rigidity when thin, ultraviolet light degradation, sheeting material may not adhere to some types	Parking lots, temporary signs, indoor signage, areas around water
Fiber Glass	Medium weight, no corrosion, good rigidity	Must handle with gloves, brittle in cold weather, can delaminate	Parking lots, temporary signs, indoor signage, areas around water

Substrates can also be obtained in various thicknesses. A small increase in substrate thickness can have a significant effect on cost while adding little to the service life of signs. Typical thickness of street signs, for instance, is 0.080 inches. Larger signs or those exposed to high wind loadings may be increased in thickness to 0.100 inches for added rigidity. The mounting system used for signs can affect the substrate decision as well (one-post vs. two-post, strap mounting, etc.). These design elements need to be considered using life-cycle costing along with other sign features.

Orientation of Signs

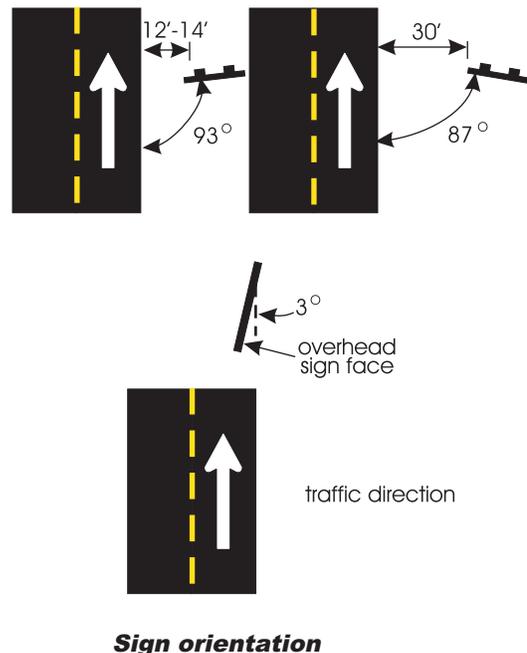
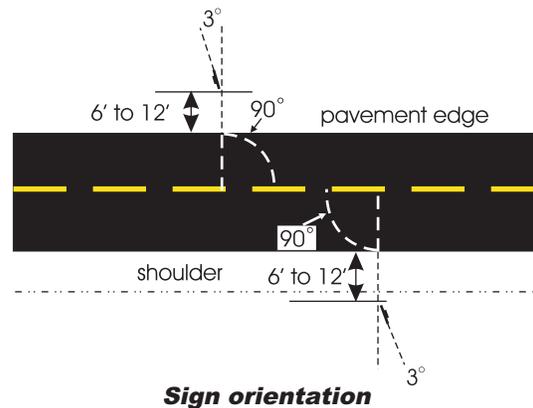
While adequate attention is usually paid to proper mounting height and location of signs, another important factor concerning night sign visibility is sometimes overlooked. This factor is the orientation of the sign face in relation to approaching traffic.

Normally signs should be installed at approximately right angles to approaching vehicles, but to minimize the effects of headlight glare, rotation of the sign face slightly away from the roadway is recommended. All sign sheeting has a glossy surface that can act as a mirror, making the message illegible. This action is even more important for signs with higher intensity sheeting. Section 2A.21 of the *MUTCD* recommends turning signs to avoid a mirror reflection for approaching traffic. For signs located near the roadway (less than 30 feet), the sign face should be turned about 3 degrees away from approaching traffic. A rotation of 3 degrees toward the road for signs installed farther than 30 feet from the roadway is suggested. For each additional 10 feet of offset, 1 degree less rotation is recommended.

On curved alignments, the angle of orientation should be determined from the direct line of approaching vehicles, not from the edge of the

road. For instance, small signs should be aligned approximately perpendicular to approaching vehicles when at a distance of about 250 feet from the sign. Overhead mounted signs should be rotated approximately 3 degrees upward to reduce potential glare and accumulation of dirt, snow, etc. Signs located on grades may be tilted from vertical to improve the viewing angle.

Please refer to the following illustrations for more information.



Warranties

Vendors furnish warranties in many forms and degree of detail. Some can be quite complex and difficult to understand. It is important to read all sign warranties carefully and question the vendor if unsure of details.

Consider the following questions pertaining to warranties:

- Is the specific performance level for sheeting stated or does the warranty simply describe the product as retroreflective?
- Is the color level specified?
- If failures occur, how are settlements made?
- Are materials, substrate, labor, etc. all covered?

Some warranties may not address these points adequately. It is important for jurisdictions to insist on detailed warranties to protect their investment in traffic control devices.

Recycling

Damaged and/or worn signs can be recycled at a considerable cost savings over replacement signs. In many cases, bent signs can be straightened. Old sheeting can be removed by grinding or water blast, although chemical removal is no longer an approved process in most areas due to environmental concerns. Caution must be used when grinding old sheeting from thin aluminum blanks. Sheeting removal by grinding 0.080-inch aluminum blanks more than once can result in signs with inadequate rigidity.

Placing new sheeting directly over old facing is generally not recommended by many manufacturers. Standard adhesives are designed for use with metals or wood and may not perform satisfactorily against the top film of old sheeting. Plastic substrates may pose particular problems with sheeting replacement. Both the plastic and adhesive must be compatible to perform well. Be sure to check any planned refacing practice with a sheeting manufacturer prior to undertaking the process.

Children at Play Signs

As described in Section 2C.02 of the *MUTCD*, the purpose of warning signs is to inform drivers of a condition they are likely to encounter consistently. The use of Playground signs (W15-1) alerts drivers to locations where children can be expected. This sign should be used only in advance of a location adjacent to the roadway designated for children's play, creating the potential for a high concentration of children.



W15-1

Warning signs should be uniformly designed and used; generally, symbol message signs are recommended. Children at Play and variations such as Slow—Children, Watch Children, and Caution—Children signs are not consistent and may confuse drivers. The *MUTCD* does not recommend the use of these nonuniform signs.

Special warning signs, such as those described, or similar warnings, such as Deaf Child, intend to warn drivers and reduce vehicle speeds. However, many studies have shown that vehicle speeds are primarily determined by roadway conditions and environment, not signing.

Overuse of these signs or placement in non-warranted situations may cause drivers to ignore the intended message. More positive means of speed control in neighborhoods may be accomplished with traffic calming measures described in the article “Traffic Calming Measures” (G9) in this manual.

Some jurisdictions have developed guidelines for the installation of special warning signs, such as the Deaf Child sign. These guidelines usually require medical certification of hearing loss and include a maximum age stipulation—perhaps 10 to 12 years of age—assuming that this signing will no longer be necessary once the child reaches that age. This stipulation also assures that signing will be removed once the need has passed. These guidelines also generally restrict the use of Deaf Child signs to non-access restricted roadways.

More pertinent information on this topic can be found in the appendix.

Commercial Developments

Traffic-volume generation from commercial developments, such as shopping centers, large manufacturing plants, and even suburban or rural subdivisions can be significant, particularly at peak hours. Appropriate planning for access and impacts on public roads and streets is very important to reduce potential congestion and safety concerns.

An area that may be overlooked in this process is the establishment and maintenance of proper traffic control at entrance locations from these developments to public roadways. Section 321.321 of the Code of Iowa requires that drivers stop or yield at the entrance to a through highway but does not provide specific requirements for signing or other traffic control. Since entrances to these developments are predominantly under private control, placement of signing, specifically Stop signs, is generally not considered to be the responsibility of road agencies, although Code Section 321.345 does grant this authority. Installation of traffic control signs and devices in private developments often results in substandard and nonuniform sign size

and shape. This can be a particular concern when Stop signs are not furnished and placed in compliance with *MUTCD* requirements.

Section 1A.07 of the *MUTCD* focuses on this subject by recommending that states adopt provisions of the Uniform Vehicle Code, Section 15-117: “No person shall install or maintain in any area of private property used by the public, any sign, signal, marking or other device intended to regulate, warn, or guide traffic unless it conforms with the State manual and specifications adopted under Section 15-104.” Section 321.259 of the Iowa Code also addresses this issue.

Considering applicable Code provisions, *MUTCD* recommendations for uniformity of design, application, driver respect, and compliance with established traffic control, it is suggested that commercial developers be advised and encouraged to follow standard accepted practice for traffic control devices either informally or through a permitting process.

Crossings

The *MUTCD* now recommends the same sign (W11-1 or W11-2) for use both as an advance warning device and at the actual crossing location. Section 2C.37 describes the use of these signs and requires the use of a supplemental downward pointing arrow (W16-7P) at the crossing location if a crosswalk is not delineated with pavement markings.



W11-2 and W16-7p

Curves and Hills

Changes in horizontal and vertical alignment can surprise drivers; therefore, proper advance warning is recommended. Several types of signs and other devices are available for use, but selecting the most appropriate traffic control for each situation should be based on engineering study and good judgement. Some of the factors to consider in selecting signing include the operating speed of the roadway, past experience (including crash history), geometrics of the roadway, and classification of the road section.

Signs and Devices

Section 2C.06 of the *MUTCD* states that engineering judgement should be used to determine whether a Curve or Turn sign should be used, but these suggestions will provide guidance.

Turn Sign (W1-1). The Turn sign can be used where engineering studies have shown the recommended operating speed to be 30 mph or less, and this speed is less than or equal to the speed limit established by law or regulation for that area. Recommendations for determining operating speeds are contained in the article “Speed Limits” (H3) in this manual.



W1-1R



W1-1L

Curve Sign (W1-2). The Curve sign may be used where engineering studies have shown recommended operating speeds greater than 30 mph and equal to or less than the speed limit

established by law or regulation for that area. For curves with a degree of curvature less than 3 degrees, use of curve signing is optional.



W1-2R



W1-2L

Reverse Turn Sign (W1-3). The Reverse Turn sign is intended for use where two turns or a turn followed by a curve in opposite directions are located less than 600 feet apart. If the first turn is to the right, a Right Reverse Turn sign (W1-3R) should be used. If the first turn is to the left, a Left Reverse Turn sign (W1-3L) is appropriate. If more than 600 feet exists between the end of the first curve and the beginning of the second, the appropriate single curve sign should be used before each curve.



W1-3R



W1-3L

Reverse Curve Sign (W1-4). Reverse Curve signs are intended for use where two curves in opposite directions are located less than 600 feet apart. If the first curve is to the right, a Right Reverse Curve sign (W1-4R) should be used. If the first curve is to the left, use a Left Reverse Curve sign (W1-4L).



W1-4R



W1-4L

Winding Road Sign (W1-5). Winding Road signs are intended for use where three or more turns or curves are separated by distances of less than 600 feet each. This sign should be erected an appropriate distance in advance of the first turn or curve. If the first turn or curve is to the right, a Right Winding Road sign (W1-5R) should be used. If the first turn or curve is to the left, a Left Winding Road sign (W1-5L) should be used.



W1-5R



W1-5L

Where three or more turns or curves are located over a distance of one mile or more, then a supplemental plaque (W7-3a) may be installed below the Winding Road sign.



W7-3a

Advisory Speed Plate (W13-1). The Advisory Speed plate is intended to supplement and provide additional information with warning signs, such as turn and curve signs. The advisory speed plate is not an enforceable speed limit but is provided as guidance for drivers. The plate is used to recommend a safe operating speed and is not intended to be used alone. This sign is a minimum of 18 inches square and should be mounted on the same post assembly as the warning sign. When engineering judgement indicates a need for this sign, recommended speed on the plate should be determined by engineering study and shown in multiples of 5 mph. Because surface characteristics or other conditions may change over time, locations with advisory speed plates should be checked periodically to determine if the recommended speed should be adjusted. Advisory speed determination is covered elsewhere in this manual.



W13-1

A new sign combining horizontal alignment and advisory speed (W1-9) has been added in Section 2C.07 of the *MUTCD*. This sign is intended to be installed at the beginning of a turn or curve to warn motorists. This sign is to be used to supplement the advance warning signs (W1-1 or W1-2).



W1-9

Another sign option is discussed in Section 2C.33 of the *MUTCD*. The Curve Speed sign (W13-5) can be used beyond the beginning of a curve to supplement other horizontal alignment signing where drivers need to be advised of the recommended curve speed.



W13-5

Large Arrow Sign (W1-6). The Large Arrow sign is intended to provide notice of an abrupt change in the direction of travel. This sign should not be used in situations where a change in direction is not necessary. When a Large Arrow sign is used, it should be located on the outside of a turn or curve in line with and at right angles to approaching traffic. For desired effectiveness, Large Arrow signs should be visible for a sufficient distance to allow appropriate reaction by drivers; 500 feet of visibility is suggested. Both day and night trial observations to determine proper position may be necessary.



W1-6

Chevron Alignment Sign (W1-8). Where changes in horizontal alignment warrant, Chevron Alignment signs may be used as an alternate or supplement to standard delineators or Large

Arrow signs. These signs are a minimum of 18 inches vertical by 12 inches horizontal, but larger sizes may be recommended by engineering study or good judgement. When used, Chevron Alignment signs should be installed along the outside of a turn or curve in line with and at right angles to approaching traffic. Chevrons should be spaced so motorists will have at least two in view at all times until the roadway alignment no longer requires the need for the signs. The Iowa DOT recommends a minimum of three to four visible chevrons within a 12 degree cone of vision for drivers. For desired effectiveness, chevrons should be visible for a sufficient distance to allow appropriate reaction by drivers; 500 feet of visibility is suggested. Both day and night trial observations should be performed to determine final positioning.



W1-8

According to the Kansas Department of Transportation, the procedure for spacing chevrons is as follows (refer to the diagram on the following page):

1. Determine the beginning and ending points of installation.
2. Determine the distance (X) between the beginning and ending points along the curve. (See the figure "Placement of chevron signs on curves" on the following page.)
3. Determine the spacing value (Sc) from the following table using the given curve radius (R).
4. Determine the number of spaces (N):
$$N = X/Sc$$
5. Round the number of spaces (N) to a reasonable whole number (Nr).

6. Determine the actual spacing distance (S_a) between the chevrons:

$$S_a = X/Nr$$
7. Use $(N+1)$ markers spaced at intervals a distance of S_a apart, and $2(N+1)$ chevron signs so the signs will be visible on both sides of the curve.

If it is necessary to have warning or regulatory signs preceding curve points A and B in the top diagram, they should be located using the following procedure. (Refer to the diagram, "Placement of warning or regulatory signs at beginning of a curve," shown below.)

From a point P that is 300 feet in advance of the curve and 4 feet to the right of the center line,

view the angle ϕ between the sign at point A and the sign to the left of point A (A_1) (or the sign to the right of point B in the top diagram). Place the sign on a line from point P at approximately the same angle ϕ to the right of point A (or to the left of point B) and at a location on that line with a distance of S_a (actual spacing distance) to the right of point A (or the left of point B). Point C on "Placement of warning or regulatory signs at beginning of a curve" is the suitable location for the sign using this procedure.

Please note that special curve situations will arise in which a combination of vertical and horizontal curvature will require additional consideration by the engineer.

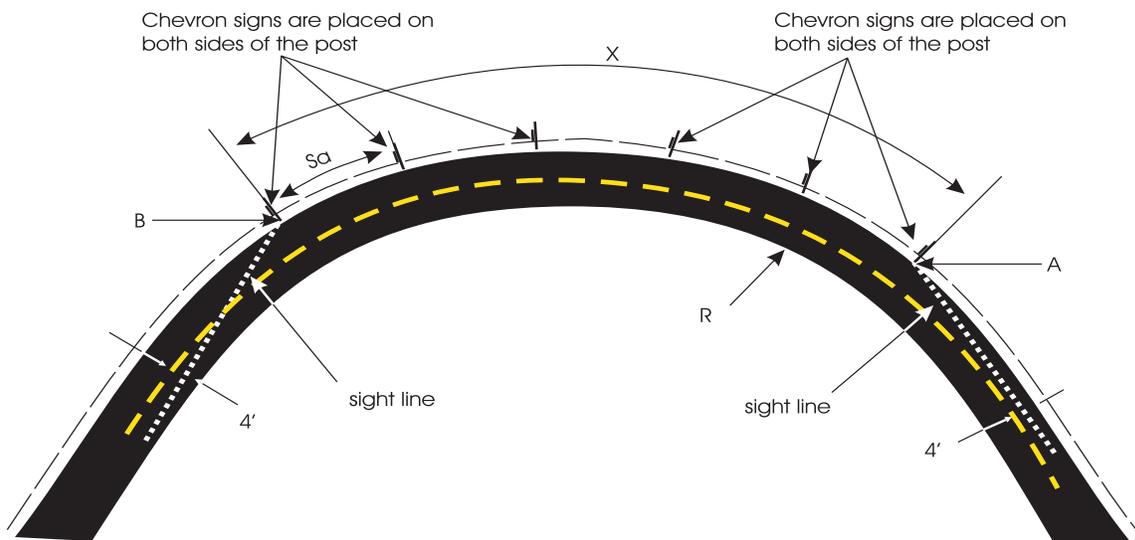
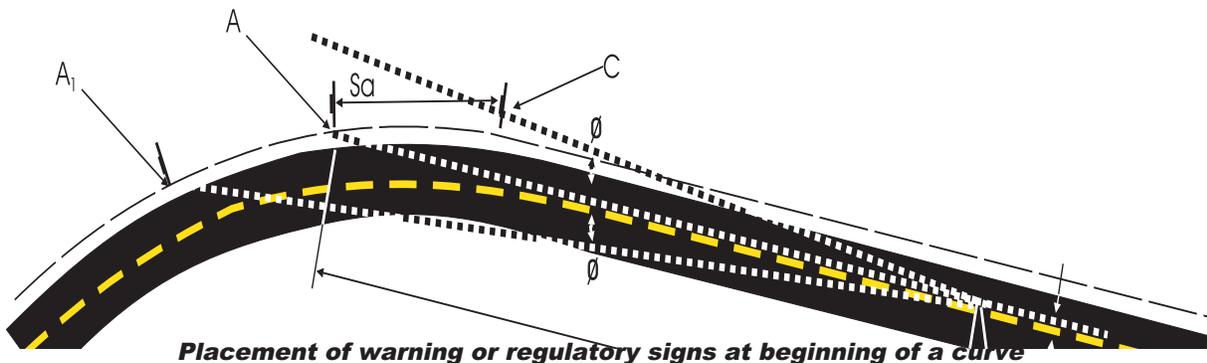


Figure XX Diagram to Illustrate Placing of Chevron Signs on Curves.

Placement of chevron signs on curves

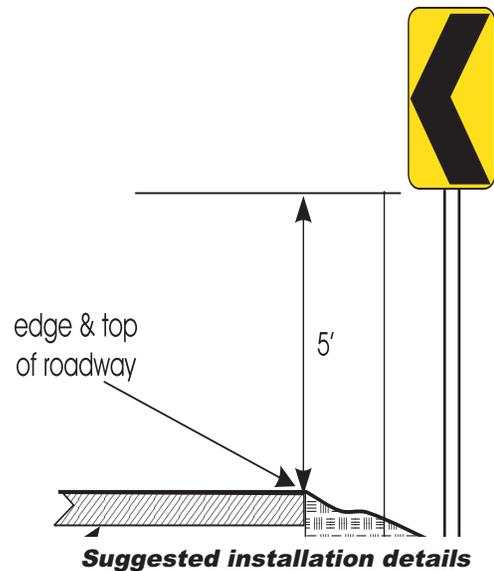
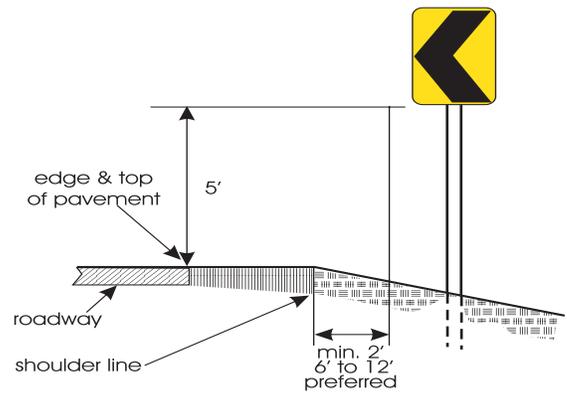


The following table is based on the equation $S = 4.5 \sqrt{R - 50}$. The S values have been adjusted to provide the incremental values shown in the chart. The S values (S_c) are intended as guides. Chevron alignment sign spacing should be uniform throughout a given installation; therefore, adjustments in the chart values may be made. Also, see discussion of edge lines under "Pavement Markings" (D1) in this manual.

Suggested spacing for Chevron signs

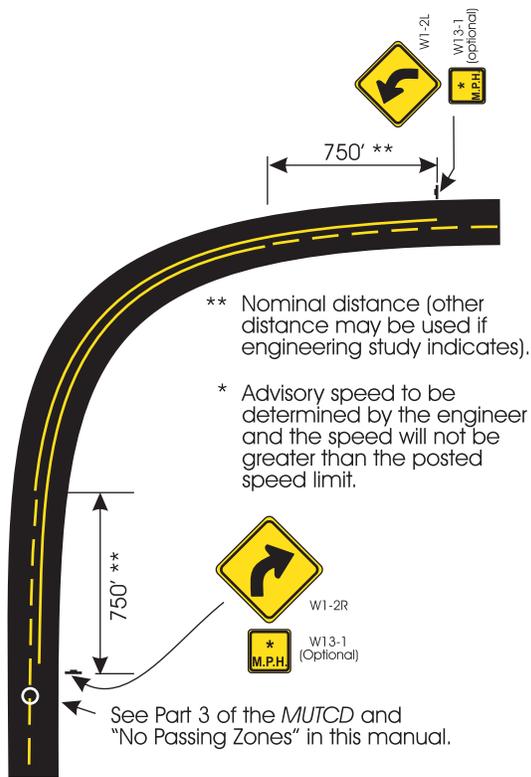
Design Speed (0.08)	Degree (D)	Radius (R)	Spacing Distance (S _c)
Max Super)			
60 mph	1°00'	5730'	200'
60 mph	2°00'	2865'	200'
60 mph	3°00'	1910'	200'
60 mph	4°00'	1432'	150'
50 mph	5°00'	1146'	150'
50 mph	6°00'	955'	125'
50 mph	7°00'	819'	125'
40 mph	8°00'	716'	125'
40 mph	9°00'	637'	100'
40 mph	10°00'	573'	100'
40 mph	11°00'	521'	100'
40 mph	12°00'	477'	100'
30 mph	13°00'	441'	100'
30 mph	14°00'	409'	75'
30 mph	15°00'	382'	75'
30 mph	16°00'	358'	75'
30 mph	17°00'	337'	75'
30 mph	18°00'	318'	75'
30 mph	19°00'	302'	75'
30 mph	20°00'	286'	75'

Suggested Installation Details

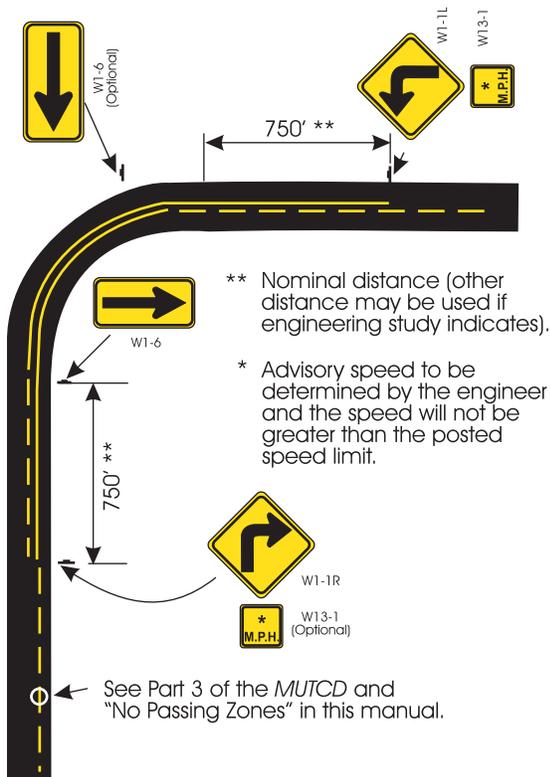


Maximum lateral installation up to 12 feet from traveled way.

Note: Chevrons should be installed on break-away sign posts if within clear zone.



Suggested signing and pavement marking on a curve with safe driving speed over 30 mph



Suggested signing and pavement marking on a turn with safe driving speed 30 mph or less

Hill Sign (W7-1 to W7-5). The Hill sign (W7-1 and W7-1A) is intended for use in advance of a downgrade where the length, percent of grade, horizontal curvature, and other physical features require special caution by motorists, particularly motor carriers. Several other signs and supplemental plates in this series are also available to mark these situations as needed. A Hill plate (W7-5) can be used as a supplement to W11 series signs to warn special users such as bicycle riders. Downgrades such as the following may merit Hill (W7-1) and Grade (W7-3) warning signs:

- 5% grade in excess of 3000 feet in length
- 6% grade in excess of 2000 feet in length
- 7% grade in excess of 1000 feet in length
- 8% grade in excess of 750 feet in length
- 9% grade in excess of 500 feet in length

Crash histories and field observations may also warrant installation of these signs.



W7-1



W7-1a



W7-3



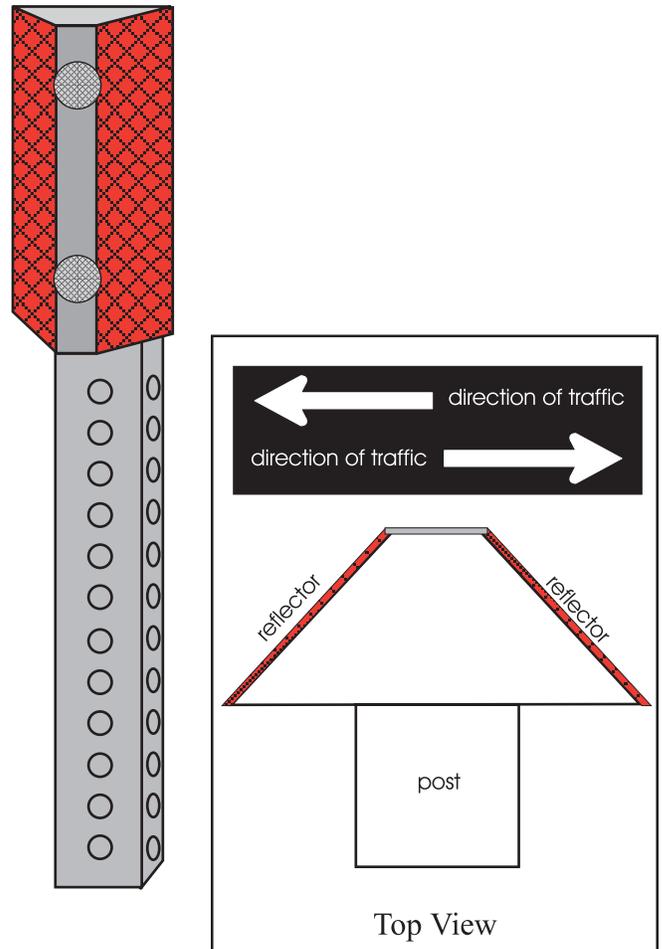
W7-5

Deer Crossing Signs

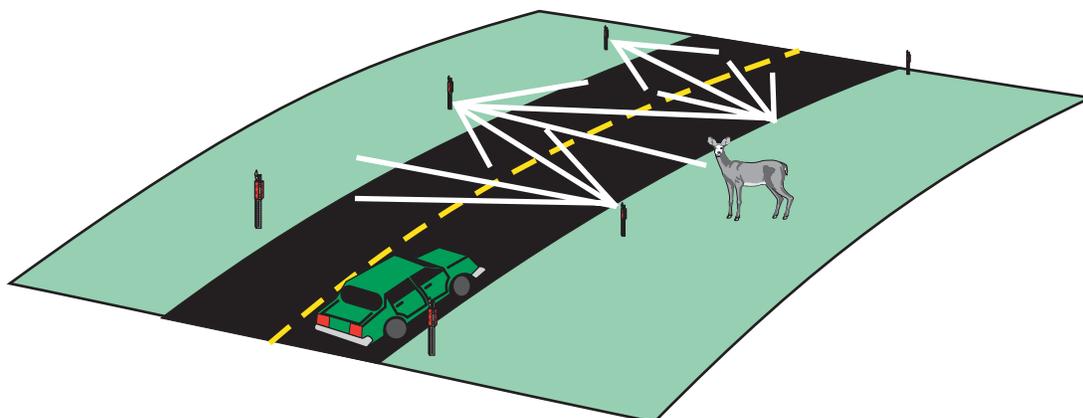
Animals on the road are a major cause of crashes in rural Iowa and are becoming more frequent in urban locations. Crashes involving deer can result in significant property damage or serious injury to drivers and passengers. The installation of warning signs for deer crossings should be considered carefully, since occurrence of deer on the roadway is occasional and overuse of deer warning signs leads to general disregard of the signs by the driving public.

Special reflectors to alert deer of night traffic have been developed, marketed, and deployed along roads in some areas in Iowa. However, results from the use of these devices have been inconclusive. Consequently, to warn of areas where deer are most likely to be encountered, it is recommended that criteria be established for warranting appropriate warning signs. These criteria could include good documentation of locations where vehicle crashes involving deer have occurred. The Accident Location and Analysis System (ALAS) for crash history, as well as local records of struck deer removal, can be valuable. Review of data for a three-to-five year period is suggested.

Travel speed of vehicles also should be considered. For example, some jurisdictions only



Deer reflector (top and side view)



Use of deer reflectors

provide signing where speed is in excess of 45 miles per hour or in topography where sight distance is occasionally limited by roadside obstructions or vertical and/or horizontal curvature. Using these data and geometric characteristics as reference, consultation initially with the Iowa Department of Natural Resources (DNR) local conservation officer or area game warden and then with the DNR wildlife research supervisor may result in a recommendation from that agency for placement of deer crossing signs to warn drivers of a particular area of concern.

Section 2C.37 of the *MUTCD* describes the use of specific crossing signs, including the Deer Crossing Symbol sign (W11-3). In addition, a supplemental plaque, Deer Crossing (W11-3p) can be used. To advise drivers of a more precise location where encounters with deer are likely, it is suggested to use a supplemental plaque, such as Ahead or Next X Miles.

It is suggested that areas signed for deer crossing be reviewed occasionally to verify the continued need for signs. However, unless major factors of

habitat use or road configuration change, the removal of these signs may not be appropriate. Any anticipated change in signing should be reviewed with DNR representatives.



W11-3



W11-3p



Supplemental plaque

Guide Signs

The *MUTCD* contains significant discussion of guide signs, Chapter 2D. Compared to regulatory and warning signs, the information presented on guide signs tends to be considered of less importance. The value of guide signs to road users is reflected in the priority of response for maintenance, especially in emergencies, where guide signs rank behind regulatory and most warning signs. However, directional and navigational advice is valuable to motorists and inadequate presentation can result in confusion and driving errors. This fact, together with the large investment that guide signs can entail, should merit appropriate concern for the design, placement, and maintenance of guide signs.

The *MUTCD* includes several types of guide signs for conventional roads and streets in Chapter 2D, such as route markers, destination and distance signs, trailblazing, service signs, street name signs, and numerous miscellaneous signs. Design standards and recommendations are presented in the *MUTCD* for features such as color, sign size, retroreflectivity, location, amount of legend, and lettering size, style, and spacing. This information should be reviewed carefully when making decisions about guide sign design. *Standard Alphabet for Highway Signs and Pavement Markings* and *Standard Highway Signs* are two publications also recommended for reference. Both are available from the Federal Highway Administration.

Route Markers

The State of Iowa adopted a standardized marking system for local rural roads many years ago, with recommended lettering and numbering for any routes on which counties desire to establish marking. Revisions to this system can be initiated in individual counties by following the procedures described in Instructional Memorandum

4.01 issued by the Local Systems Department of the Iowa Department of Transportation. In general, Iowa counties place and maintain route marking signs on the farm-to-market system; however, some counties mark paved roads only. The location and frequency of route markers should be studied appropriately to meet the needs of the user. Although installation of route markers at every intersection may not be necessary, placement where a confusing decision is presented to the driver is recommended. County route signs have a distinctive shape, with a blue background and yellow lettering. The *MUTCD* recommends a minimum sign size of 18 inches by 18 inches for two digit markings and 24 inches by 24 inches for three digits. Even larger sizes can be obtained, if desired.

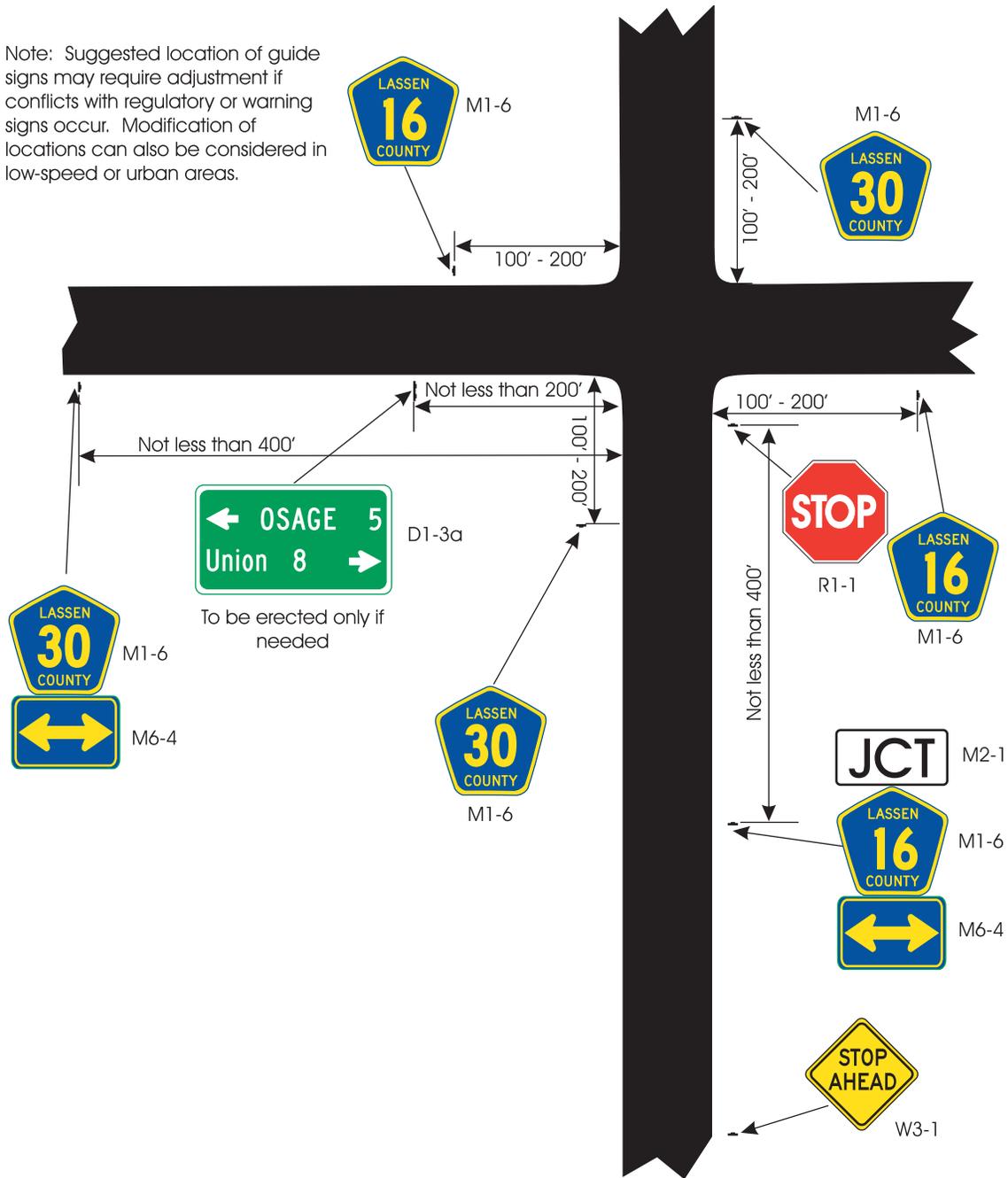
When establishing a route marking system, local agencies must consider Iowa Code Section 306.41, which requires a designated detour for all temporary closures exceeding 48 hours on marked routes.

Additional information on route marking can be found in “A Proposal for a Uniform County Route Marker Program on a National Scale,” available from the National Association of Counties.



M1-6

Note: Suggested location of guide signs may require adjustment if conflicts with regulatory or warning signs occur. Modification of locations can also be considered in low-speed or urban areas.



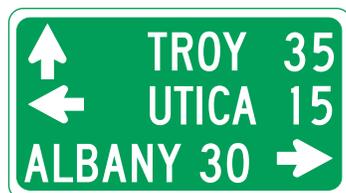
Suggested layout of guide signs at an intersection of two rural roads

Destination and Distance Signing

Local agencies can use destination and distance guide signing in many specific situations where this information is valuable and necessary to advise unfamiliar motorists. Sections 2D.33 through 2D.37 of the *MUTCD* describe applications for these particular types of guide signs, discussing such issues as message presentation, sign size, colors, and location. Of particular interest may be the *MUTCD* recommendations for limiting the number of destinations listed and the amount of legend as covered in Section 2D.07.



D1-1



D1-3a

Trailblazing

Although not used extensively in local applications, trailblazing signing can be effective in directing unfamiliar drivers to desired routes where confusing circumstances are encountered. This may be particularly true in some urban situations. Primarily, trailblazing consists of constructing an assembly consisting of a “To” auxiliary sign above the route sign and a directional arrow below the sign on a single post. These signs should be placed in a location where maximum visibility is assured. More information on this topic is presented in Section 2D.32 of the *MUTCD*.

Miscellaneous Guide Signs

Chapter 2D of the *MUTCD* also includes discussion of an extensive list of additional and auxiliary signs that can be used to enhance the primary message presented on a guide sign. Supplemental signing includes directional arrows, To, End, Junction, cardinal directions, and many miscellaneous messages. These signs have a standard size of 24 inches by 12 inches in general, but some devices such as arrows and Junction signs should be 21 inches by 15 inches for desired visibility. In addition, the *MUTCD* contains detailed discussion and guidance on various other guide sign topics that may be of interest to local agencies, such as auxiliary signs, assemblies for route, junction, advance turns, and directional signing, reference posts, trails, and general information signs.

Street Name Signs

The *MUTCD* describes recommended attributes for street name signs in Section 2D.38.

Street name signs must be retroreflectorized or properly illuminated, and a green background with white lettering is recommended.

Lettering Specifications. Recent action by the Federal Highway Administration has increased minimum requirements for lettering size to 6 inches for uppercase letters and 4.5 inches for lowercase letters for street name signs on roadways with speeds over 25 mph. The type of road or street may be designated with minimum 3-inch lettering.

Lower speed local roads can install street name signs with minimum 4-inch letters, if desired. However, there is another consideration with lower speed streets. These facilities may be congested allowing motorists less time to observe and interpret sign messages. A larger copy for easier recognition may be justified for this reason.

Spacing Specifications. Requirements for larger lettering and retroreflectorization were made in recognition of driver needs, particularly those of aging drivers. However, larger letters alone may not entirely meet those needs. Appropriately-sized sign blanks and borders are also very important. Please refer to the suggestions contained in the “Signs” (C1) article in this manual regarding spacing of the sign message.

A rule of thumb for determining letter spacing is as follows (stroke width is the width of the leg of a given letter):

- For straight to straight legs, such as “N” to “N”, use two-stroke width spacing.
- For straight to curved legs, such as “N” to “O”, use one-and-one-half stroke spacing.
- For curved to curved legs, such as “O” to “O”, use one-stroke spacing.

Software providing recommended letter spacing is available.

Reduction in legibility, especially at night, may result from condensed lettering. With high-performance sheeting, this consideration is even more important.

Use of high-performance sheeting for street name signs is desirable because of *MUTCD* requirements and the location at which signs are commonly installed. When using these highly reflective products, particularly ASTM Type VII (Iowa), adequate sign-blank dimensions relative to legend are most important for night visibility. Signs with high-performance sheeting, but of inadequate overall size relative to legend, will not be legible when viewed with vehicle headlights. When making an investment in high-quality materials and modern design, it is equally important that the resultant product provide satisfactory service to the public.

Installation Suggestions. Installing multiple street signs at the same level, especially on utility poles, to save mounting straps can result in obstructed visibility from at least two directions, as one sign will block the other. If possible, mountings at different elevations should be used.

Consistent placement locations for street name signs throughout a jurisdiction should also be sought. When drivers become accustomed to a similar location for street name signs at every intersection, less confusion and searching for guidance will result. All signs, including street name signs, should be reviewed for visibility from every approach direction after installation. In addition, if only one set of street name signs is used per intersection, those signs will be in a disadvantaged location for approximately 50 percent of all drivers at that intersection, both city and rural.

General Suggestions. Unusual lettering styles, special symbols, extra-long street names, and nonstandard colors to emphasize uniqueness of a particular community can present visibility problems for street name signs. Always remember that street name signs have a valuable purpose and require adherence to *MUTCD* standards. Close reference to the Federal Highway Administration’s *Standard Highway Signs* is recommended for lettering and other design details.

More importantly, street name signs must be visible and legible to all roadway users in order to justify the large investment of public funds. For this reason all signs, and perhaps especially street name signs, should be properly designed and specified, carefully inspected upon receipt under day and night viewing conditions, and appropriately maintained after installation.

An established contact and dialog with local planning and zoning agencies can help your community avoid some of these problems. In addition, if a new subdivision suggests using long street names, an example of the resulting size of the sign using recommended lettering size and spacing can be quite helpful in discouraging this practice.

Signs used to mark rural residences and structures for emergency response (911 signs) also merit appropriate consideration. A consistent numbering system beginning at the west and south county lines should be used with sequential numbering from each section line. With this method, even if an individual sign is missing, locations can still be found relatively quickly.

Since these signs are mounted by private owners in many instances, it is important to include instructions on mounting height, perhaps 4 to 5 feet, and location where visibility and recognition are maximized. These signs should be mounted on individual posts, be visible from all approach directions, and use high-performance sheeting for necessary nighttime legibility. Suggested lettering size and spacing, colors and retroreflectivity are discussed earlier in this article and also under “Signs” in this manual.

Potential emergency responders should be consulted and advised of the design, numbering system, and location of these signs. Confusion and difficulty in locating a residence during an emergency response should be avoided or at least minimized. Occasional cleaning, especially if located on gravel roads, may be advisable.

Intersections

Increasing traffic volumes and changes in character, existing terrain and roadway geometrics, crash experience, and public concern are some reasons to consider adopting higher levels of traffic control at intersections.

Very low volume intersections with adequate sight distance require comparably little sign and marking control. No control at all is acceptable at many intersections with these characteristics. However, as conditions change, added measures of traffic control might be required to maintain public safety. The following are a few intersection traffic control options to address traffic operation and safety needs:

- Use no control
- Install Yield signs at minor approaches with Yield Ahead signs as needed.
- Install Stop signs at minor approaches with Stop Ahead signs as needed.
- Add flags to Stop signs.*
- Increase size of Stop signs to 48 or 60 inches.
- Add flashing beacons to Stop signs.
- Install Stop signs and Stop Ahead signs on both sides of the approach road.
- Install rumble strips if approach road is paved.
- Establish an all-way stop at the intersection, if warranted.
- Install roadway lighting.
- Consider signalization, if warranted.

These steps should not be considered as necessarily sequential nor all-inclusive, but rather as options to include in an engineering study if upgrading of intersection traffic control is desirable.

Some jurisdictions effectively use various intersection warning signs (W2-1 through W2-6) to indicate the presence of an intersection and the possibility of conflicting traffic. Several options are available for consideration, and reference to *MUTCD* Section 2C.34 is recommended prior to selection and installation.



W2-1

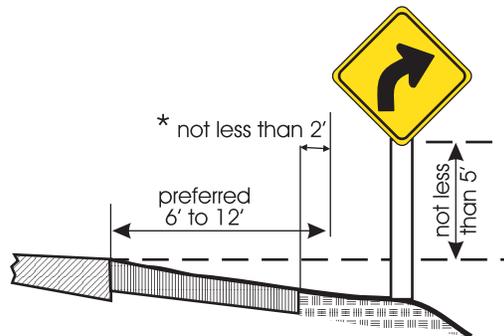


W2-2

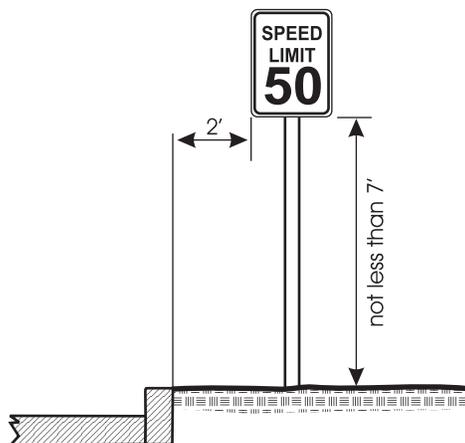
* The *MUTCD* does not address the use of flags to enhance sign visibility. It is suggested that the advice of the Iowa DOT state traffic engineer be sought prior to pursuing this option.

Location and Height of Signs

Chapter 2A of the *MUTCD* suggests that signs be placed as far as practical from the traveled way so as not to pose a potential hazard for vehicles that run off the road. Under normal conditions, this distance is recommended to be 6 to 12 feet in rural areas and 2 feet behind curbs in urban locations, as shown in the following illustrations.



Roadside sign (rural)

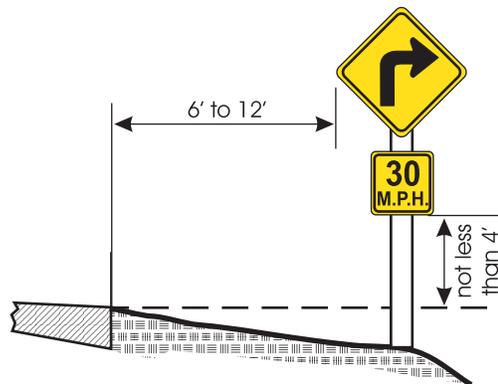


Roadside sign (business or residence district)

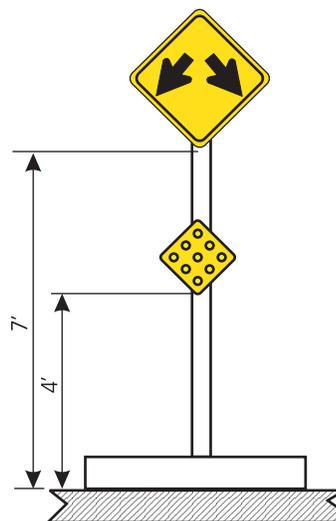
Less offset is permissible when conditions do not allow the recommended clearance, such as narrow right of way or steep fore slopes*. On very low volume rural roads (less than 200 vehicles per day [vpd]), offsets of as little as 2 feet from the traveled way may be used. A 1-foot clearance behind curbs in urban areas is permissible where narrow right of way restricts sidewalk and pole placement. Any sign within

clear zone limits in rural areas must have breakaway supports or be properly shielded. More discussion on this can be found in the article “Sign Posts and Supports” (C14) in this manual.

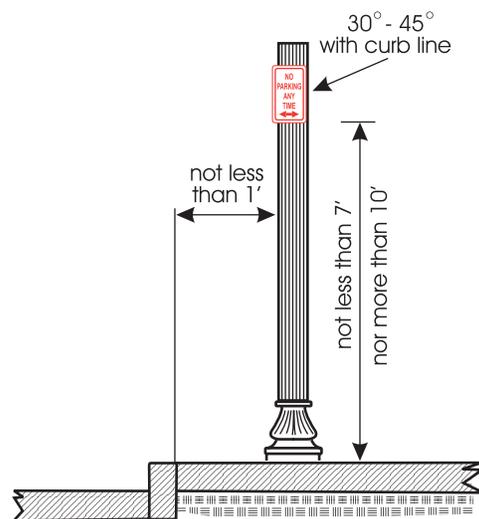
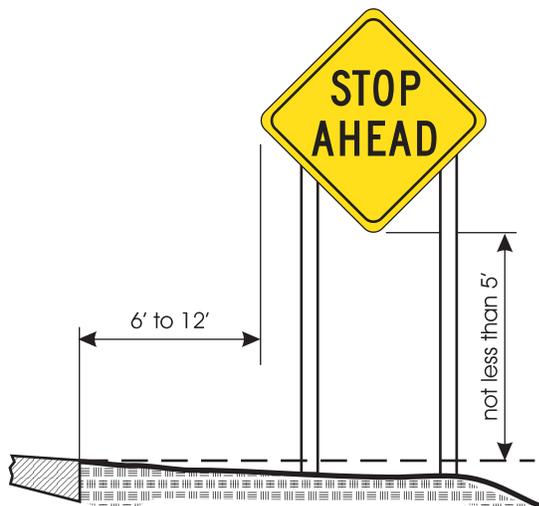
Signs in rural areas should be mounted with a minimum vertical clearance of 5 feet from the bottom of the sign to the top of the pavement or road surface. This height increases to 7 feet minimum in urban areas where parked vehicles and pedestrian concerns require additional clearance for visibility. Any supplemental plates may be mounted below the primary sign at a height 1 foot less than these recommendations. See the following illustrations for more information.



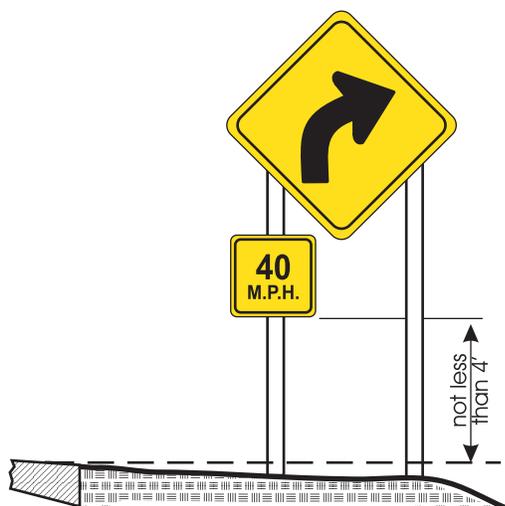
Warning sign with advisory speed plate (rural)



Warning sign on island in the line of traffic

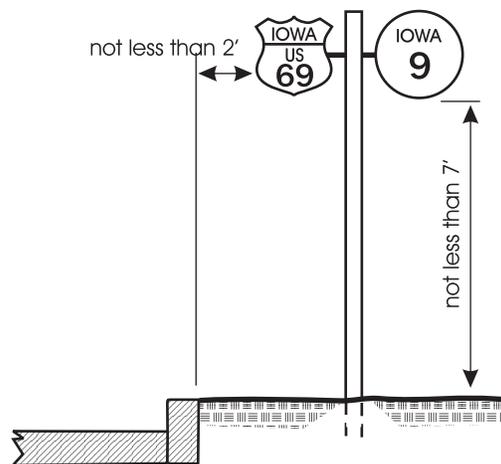


**Parking sign (business or residential district)
(restricted right of way)**

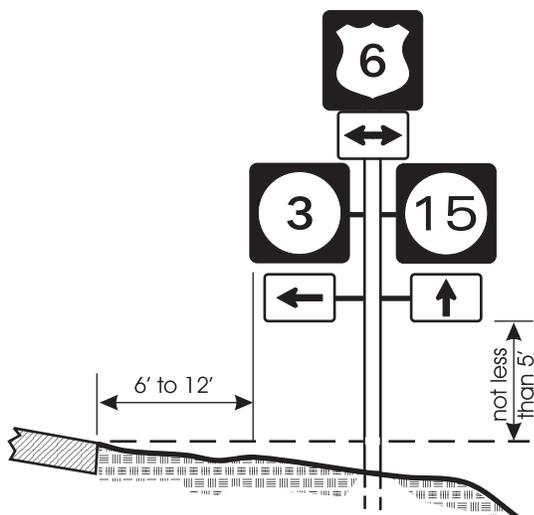


With Advisory Plate

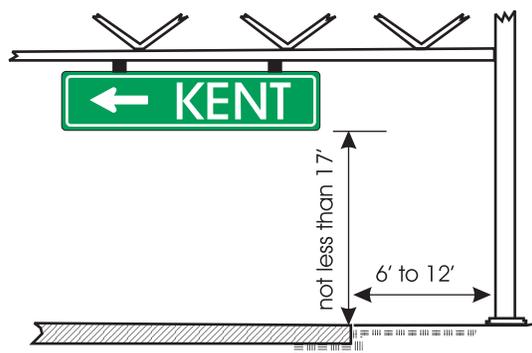
**Height and location of two-post roadside signs
(rural)**



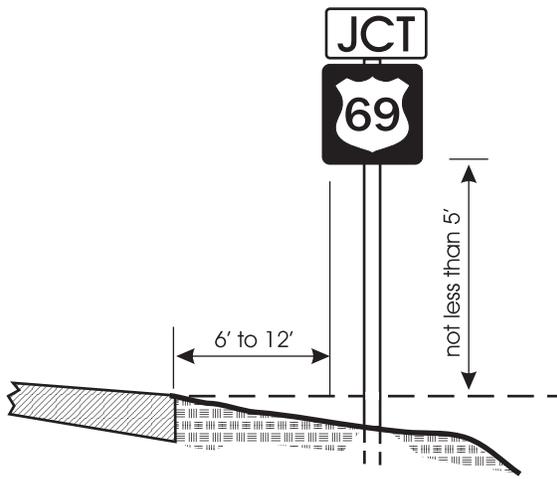
Route markers (business or residence district)



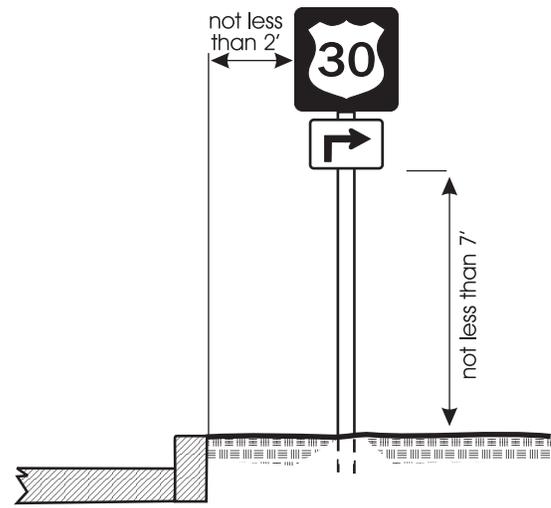
Directional marking (rural)



Overhead destination sign mounting



Junction (rural)



Turn marking (business or residence district)

Low-Water Stream Crossings

As an alternative to replacing deficient structures on low-traffic roads, low-water stream crossings (LWSC) are sometimes selected as a cost-effective alternative. When this option is used, proper regulatory and warning signs should be installed.

Flood Area Ahead Sign. The Flood Area Ahead sign is a diamond-shaped warning sign and is yellow with black lettering and border. The standard size is 30 inches by 30 inches. This sign would usually be installed about 750 feet in advance of the low-water crossing or at the last turnaround location for vehicles, whichever is greater. If the location of the low-water crossing is not readily visible from approximately 1,000 feet, use of a supplemental distance advisory plate mounted below the Flood Area Ahead sign may be considered. An advisory speed plate may also be considered if the recommended crossing speed is less than the speed limit established by law or regulation for the approach roadway. If an advisory distance plate is used with the Flood Area Ahead sign, a speed advisory plate can be mounted under the next sign, Impassable During High Water. Neither supplemental plate should be used alone.



30" x 30"

Impassable During High Water Sign. The Impassable During High Water sign is diamond-shaped and yellow with black lettering and border. The standard size is 30 inches by 30 inches. This sign is normally installed about 450 feet in advance of the low-water crossing.



30" x 30"

Do Not Enter When Flooded Sign. The Do Not Enter When Flooded sign consists of a 24-inch by 30-inch rectangular sign with black lettering and border on a white background. Since this is a regulatory sign, installation and enforcement requires an appropriate resolution by the board of supervisors or city council. This sign should be installed about 200 feet from the actual low-water crossing.



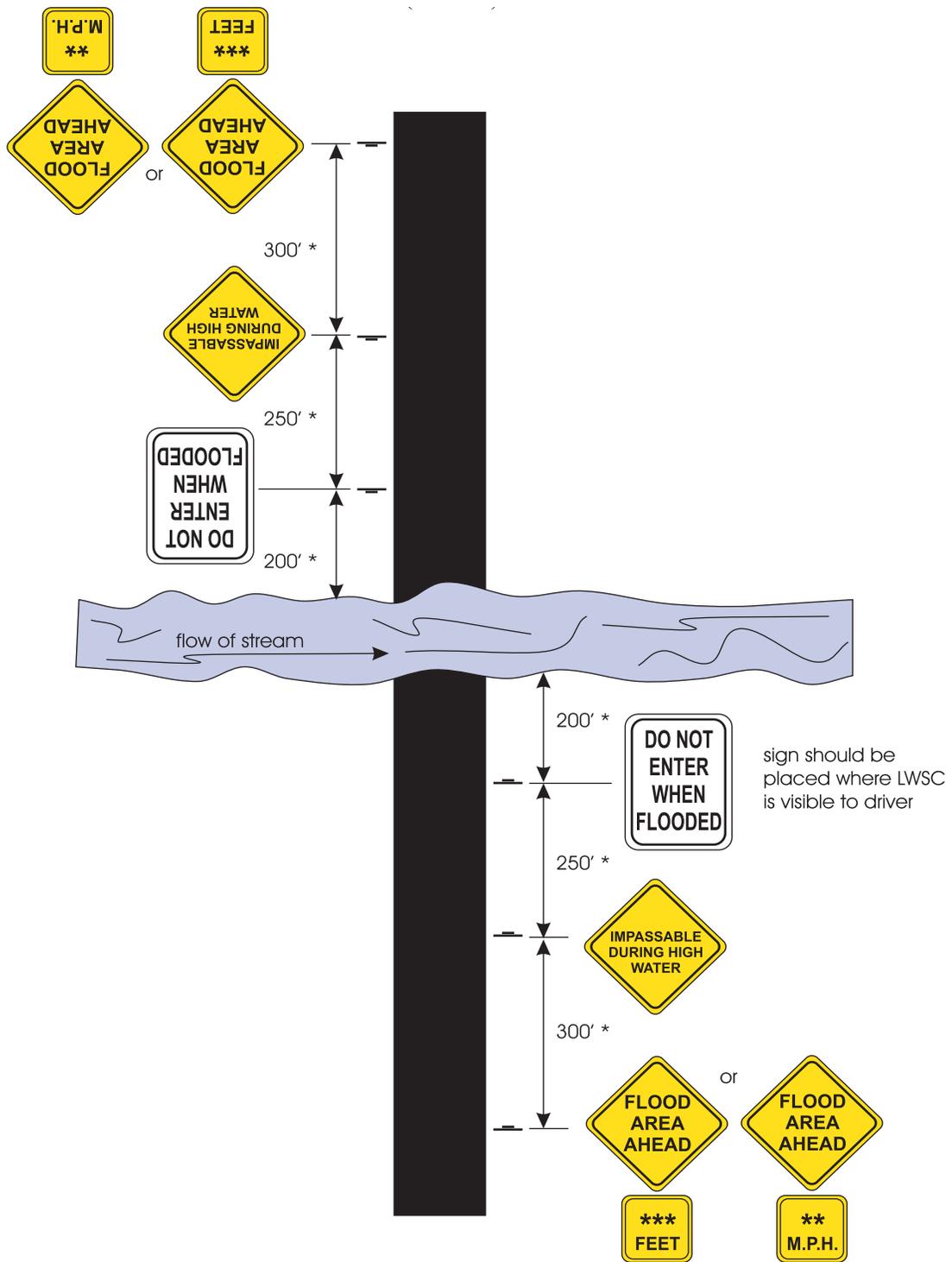
24" x 30"

In addition to these recommended signs, the following suggestions should be considered in establishing low-water crossings:

- Use only on low-volume, unpaved roads.
- Do not use on roads that serve occupied dwellings where no alternate emergency access is available.
- Perform timely maintenance of signs and roadway, particularly after flooding.

Additional information can be obtained from the Iowa DOT Office of Local Systems.

The following illustration shows a suggested typical layout for signing of a low water crossing in Iowa.



* Nominal distance (other distance may be used if engineering study indicates).

Typical signing of low water stream crossing (LWSC)

Narrow Bridges and Culverts

Bridges and culverts that are narrower than the approach roadway present a potential conflict for drivers and should be considered for appropriate warning signing and marking. Traffic control devices and markings that provide positive guidance with sufficient information to direct motorists through existing obstructions may be appropriate. Sections 2C.13 through 2C.15 and Part 3 of the *MUTCD* contain several signs and markings that warn of narrowing roadway conditions.

A Narrow Bridge sign (W5-2 or W5-2a) is intended for use in advance of a bridge or culvert that has a clear two-way roadway width of 16 to 18 feet or any structure with a roadway clearance less than the approach pavement. Use of object markers, delineators, and pavement markings can provide additional guidance.



W5-2



W5-2a

A One Lane Bridge sign (W5-3) is intended for use on two-way roadways in advance of bridges and culverts with one of these features:

- a clear roadway width of less than 16 feet
- a clear roadway width of less than 18 feet where significant commercial vehicle use exists (approximately 10% of total volume)
- an approach roadway alignment that results in poor visibility to structures with clear roadway width of less than 18 feet

Additional guidance for drivers can be provided with object markers, delineators, and pavement markings.



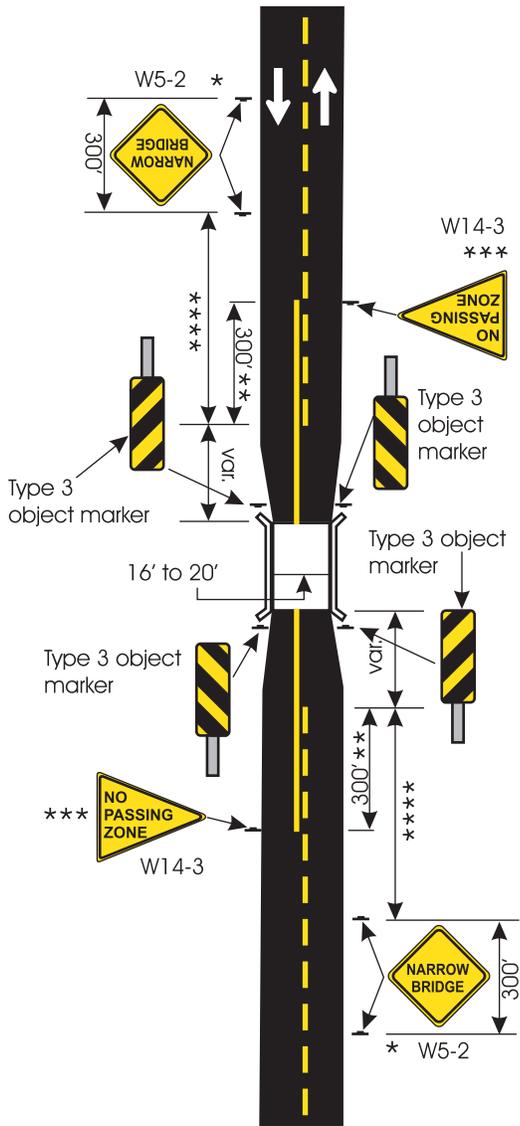
W5-3

A Road Narrows sign (W5-1) is intended for use in advance of a situation where a roadway narrows abruptly to a width that would not permit two cars to pass safely without reducing speed. Use of object markers and delineators can provide additional guidance for motorists.

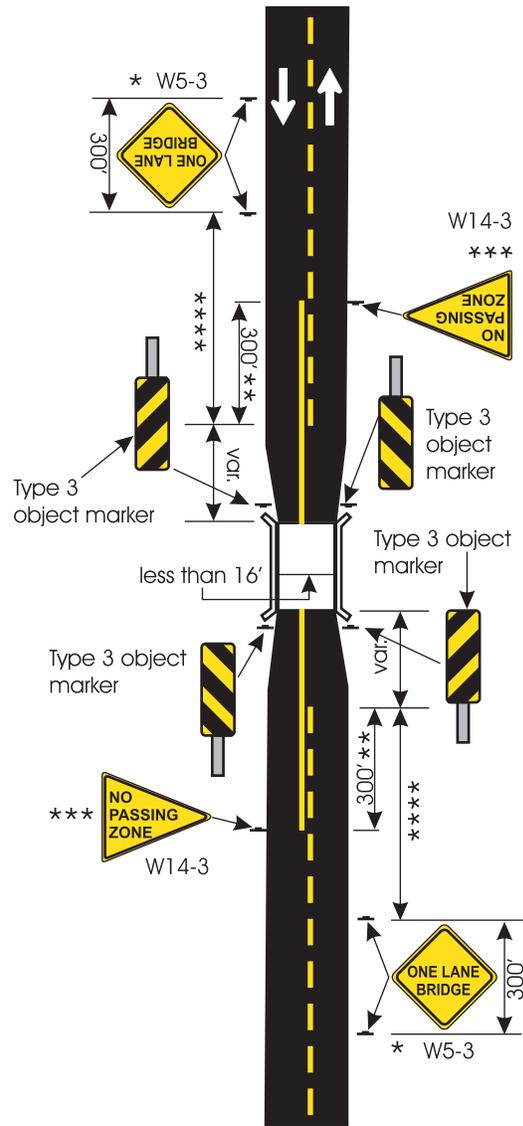


W5-1

The following illustrations suggest layouts for signing and marking of narrow and one-way bridges or culverts.



Narrow bridges (16' to 20')



One-lane bridges (less than 16')

Typical signing and marking with Type 3 object markers on all four corners

Note: Inside edge of object marker shall be mounted flush with inside edge of hub guards or bridge rail.

* If horizontal or vertical alignment warrants, an additional sign may be erected at the 300-foot distance shown.

** Nominal distance—other distance may be

used if engineering study indicates.

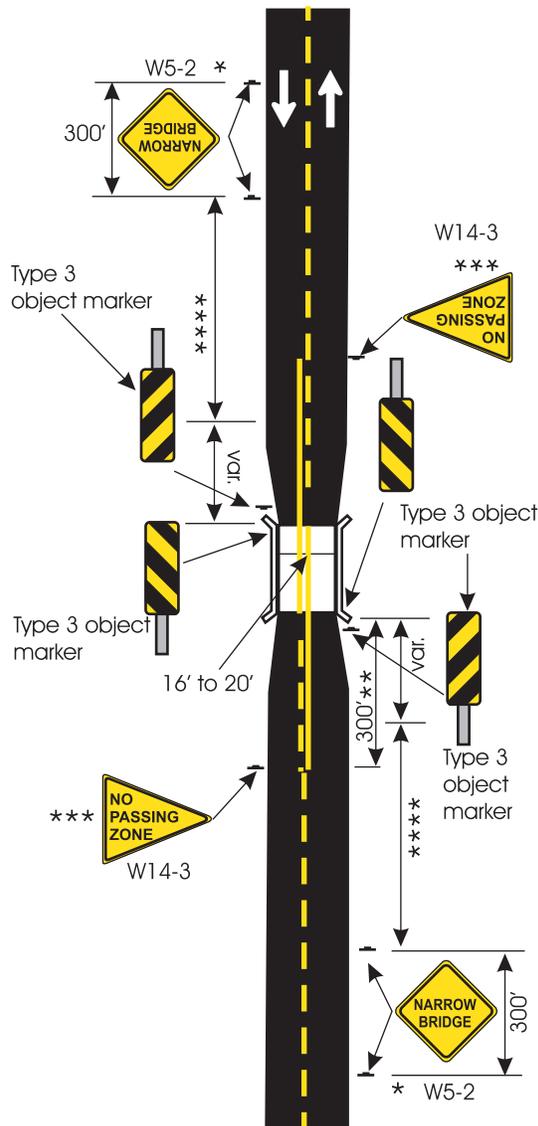
*** No Passing Zone sign suggested on paved roads.

**** Use PIEV distance—other distance may be used if engineering study warrants. (PIEV distance is defined in the article "Warning Sign Placement" (C18) in this manual.)

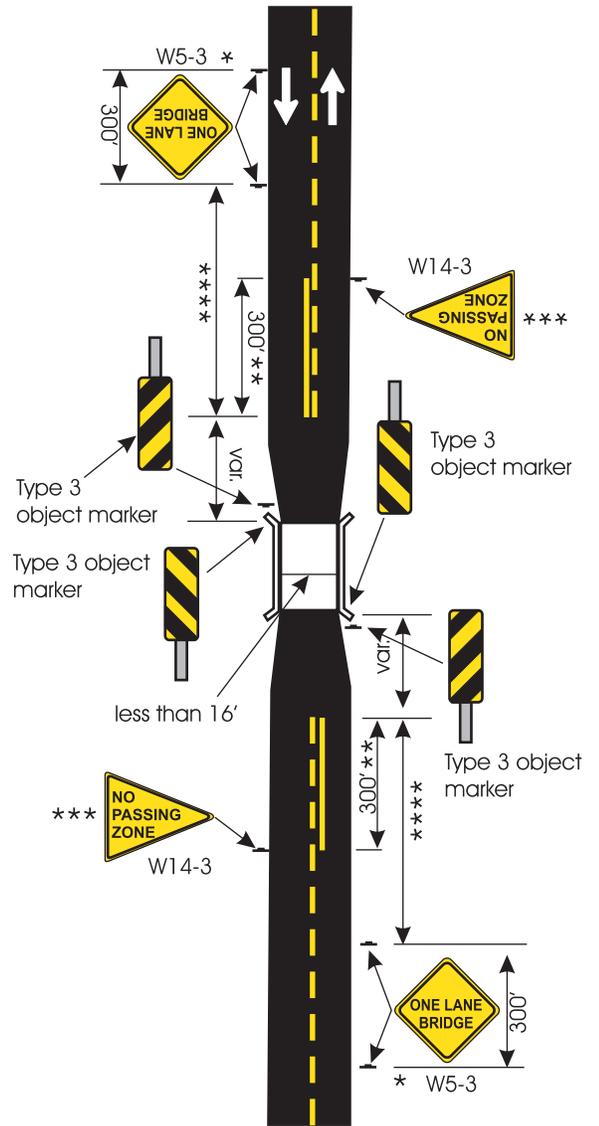
In rural areas, increased numbers of wide farm equipment can present a challenge in maintaining signs and markers. Here are a few suggestions that can be used in these situations:

- Place Type 3 object markers, back to back, on the right side only of each approach as shown in the following illustrations. This may permit wide equipment to “wiggle through.”

- Reduce the height of object markers to permit wide equipment to pass over, but be sure not to lower the markers below the height of the obstruction. Frequent removal of vegetation and other debris may be needed to maintain visibility. Jurisdictions using this option should properly document the reason for the practice.
- Use flexible supports for object markers to reduce permanent displacement when impacted.



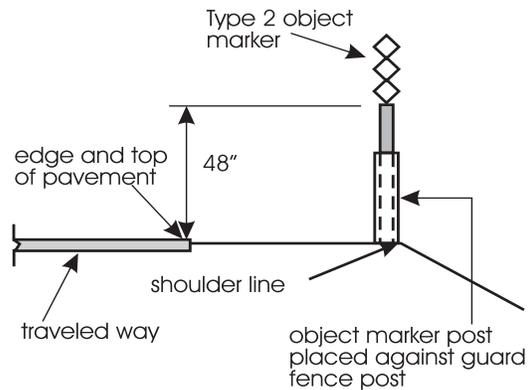
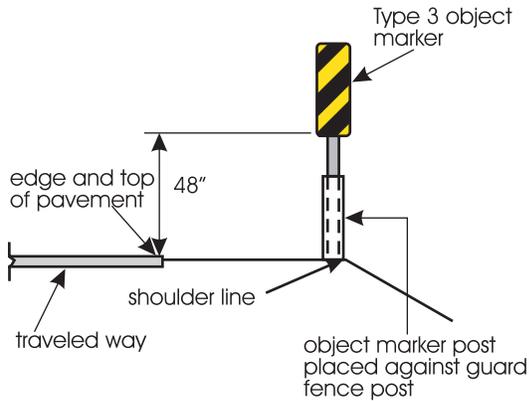
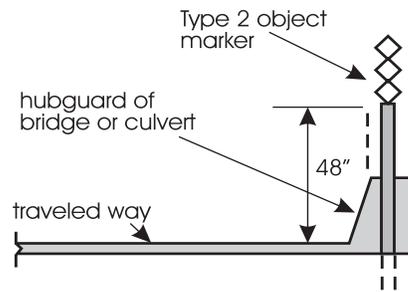
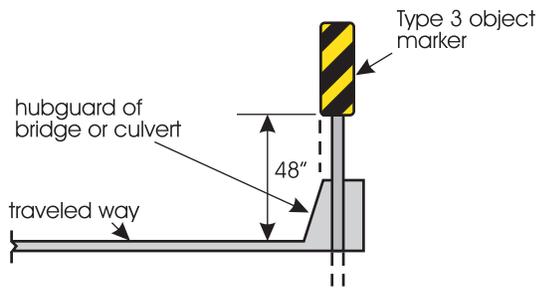
Narrow bridge (16' to 20')



One-lane bridge (less than 16')

Typical signing and marking for the “wiggle-through” option

*See notes on previous page.



Typical mounting of Type 3 object marker

Typical mounting of Type 2 object marker

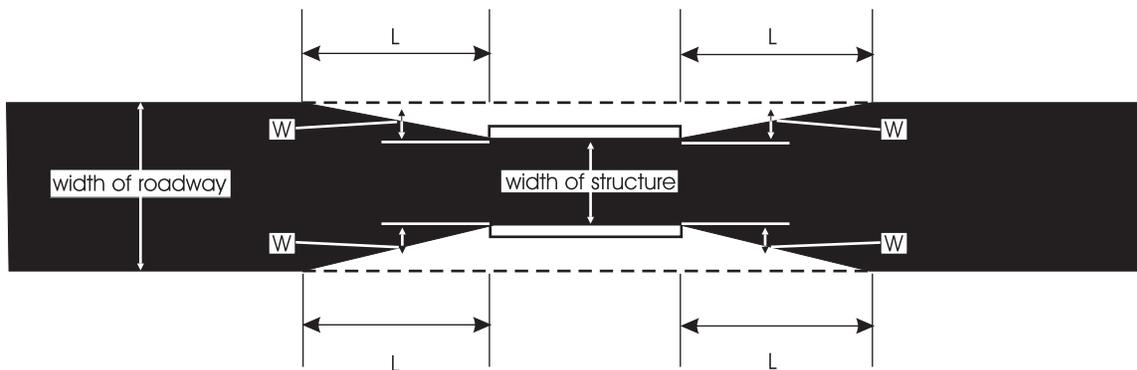
Tapering Recommendations

A tapered pavement or roadway edge may be used to guide the driver away from hazardous obstacles such as bridge abutments, dropoffs, culverts, or other objects that narrow the driving width.

Minimum recommended taper lengths (L) are shown in the table at right and the figure below.

Minimum taper lengths

W (ft)	Operating Speed		
	Less than 30 mph	30-40 mph	Over 40 mph
2 or less	30'	50'	100'
3	45'	75'	150'
4	60'	100'	200'
5	75'	125'	250'
6	90'	150'	300'



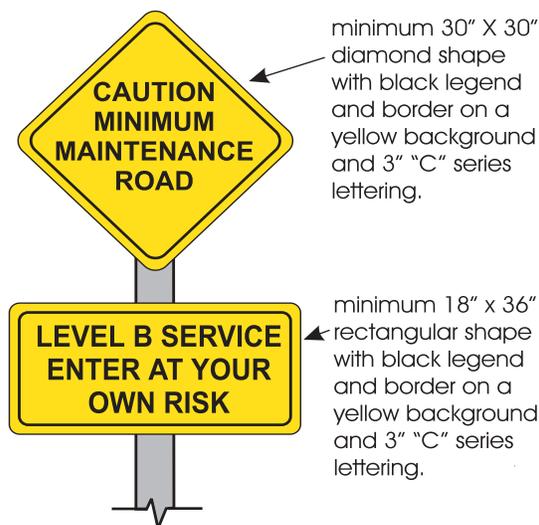
Taper details

Reduced Maintenance Level Roads

Section 309.57 of the Iowa Code provides counties with options to establish reduced maintenance levels on little-used area service roads using a system of three service levels:

1. Area Service A—maintained in conformity with applicable statutes.
2. Area Service B—maintained at a lower level with standards determined by county ordinance.
3. Area Service C—maintained to a minimum level as determined by the county; restricted access.

Area Service B roads must be established by ordinance or resolution. Appropriate warning signs must be erected and maintained by the county at all access points from other public roads. An example of the appropriate warning sign is shown in the following illustration.



Signs required at all access points of Level B roads

Area Service C roads must also be established by ordinance or resolution upon petition by all land owners adjacent to the road. Roads that are designated as Area Service C shall have appropriate warning and regulatory signs erected and maintained by the county, and access shall be restricted by means of a gate or other barrier. An example of recommended signing is shown in the following illustration.



Signs required at all access points of Level C roads

For additional information, please refer to Iowa Code Section 309.57 and the County Engineers Instructional Memorandum 2.22.

In addition, situations may be encountered where it is desirable to advise the public that maintenance responsibilities of a local jurisdiction have terminated. Roadways occasionally continue onto private property beyond public control and appropriate signing to advise unfamiliar drivers may be considered. Failure to warn motorists could result in liability exposure to local governments.

Local jurisdictions may also wish to advise drivers of a change in maintenance responsibilities from city to county or vice versa. County or City Maintenance Ends signs, such as that shown on the following page, have been developed to advise the public of a termination in maintenance responsibilities along a roadway.

Appropriate advance warning of this situation at the last turnaround point should also be considered, such as an End County or City Maintenance sign with X Feet advisory plate mounted as a supplementary sign.

The actual end of county (city) maintenance should be marked to guide drivers and help them avoid accidental trespass on private property. An appropriate advisory plate should be placed beneath the County or City Maintenance Ends sign. Examples include Private Lane, Road Closed, or Private Property.



minimum 30" x 30"



minimum 24" x 18"

End of maintenance sign with advisory plate

School Bus Stop Ahead Signs

Section 7B.10 of the *MUTCD* describes the use of School Bus Stop Ahead signs and recommends that these signs be used only in advance of locations where a school bus stops to pick up or discharge passengers and is not visible for a distance of 500 feet by approaching traffic from either direction. The *MUTCD* also implies that these signs should only be installed where terrain and roadway features limit sight distance for approaching vehicles and the bus stop cannot be relocated to a more visible location. The warning sign used for this purpose is the 30-inch by 30-inch School Bus Stop Ahead (S3-1). Larger signs may be used in special situations where more emphasis is needed. Some agencies have modified this sign to indicate the distance to the actual stop, such as “500 Feet” in lieu of “Ahead.”



S3-1



Permissible

Suggested Response to Installation Requests

1. Confirm with the school district the need for the signs and the use of the location as a school bus stop. The highway authority may want to set up a complaint process, utilizing school transportation and administrative employees as a first point of contact for complaints and requests for signing.

2. Review the location carefully to ascertain that minimum conditions are met. If the conditions are met, install the sign per *MUTCD* guidelines.
3. In lieu of accepting the *MUTCD* minimum 500-foot visibility requirement, in some instances it may be advisable to further study the location to determine and compare available sight distance with stopping sight distance. If stopping sight distance exceeds available sight distance, warning signs may be justified.

Available Sight Distance (ASD) can be determined with an assumed driver's eye height of 3.50 feet and a target height of 4.0 feet. The target represents approximately one-half the height of a school bus, including flashing lights. By positioning the target at the point of bus stop, the available sight distance can be determined.

Stopping Sight Distance (SSD) can be determined using the data and procedures in the latest edition of AASHTO's *Policy on Geometric Design of Highways and Streets*.

For traffic approaching the front of the bus stop, 10 feet should be anticipated for a pedestrian crosswalk plus 25 additional feet for clear zone.

For traffic approaching the rear of the bus stop, 35 feet should be anticipated for the length of the bus plus 25 additional feet for clear zone.

Suggested Warning Sign Applications

When approaching from the front, if ASD plus 10 feet plus 25 feet equals or is less than SSD, a sign is warranted.

When approaching from the rear, if ASD plus 35 feet plus 25 feet equals or is less than SSD, a sign is warranted.

If the need for a School Bus Stop Ahead sign is concluded, it is recommended that installation be made approximately 500 feet in advance of the point where one half of the stopped bus is visible.

As with all warning signs, School Bus Stop Ahead signs should only be placed when warranted by previously described conditions. Overuse of these signs or installation in unnecessary locations will reduce the overall effectiveness of the warning and result in the tendency for drivers to ignore the message.

Sign Maintenance

Discuss sign maintenance needs with the school district. A formal or informal agreement ad-

ressing school bus stop signing may be established with the school district. It may be worthwhile to assign responsibility to the school for monitoring the continuing need for signing by students and advising road authorities when such warning is no longer needed. The determination of continual need for signing may require annual communication from the highway authority to the school superintendent or transportation director. Unnecessary signs should be removed promptly.

The appendix contains a sample letter and policy for local agency use in negotiating agreements with school districts for installation of these signs.

Sign Posts and Supports

To address various signing needs and agency preferences, several types of supports are available. Small signs (less than 50 square feet) are commonly supported with either wood or steel posts. When available and with permission, small signs also can be mounted on existing utility or roadway light poles. Larger signs (greater than 50 square feet) may be mounted on specially designed steel or aluminum structures such as trusses, bridges, or cantilevered supports.

Small Sign Supports

Small sign supports most generally are either wood or steel. Wood posts are available in standard sizes of 4x4, 4x6, and larger. Box beams of laminated plywood are available to support larger signs. Major types of steel sign posts for small signs include U-channel, round pipes, and square tube.

Posts for small signs are installed by direct driving, drilling and backfilling, or setting in a concrete foundation. In soft or sandy soils, use

of soil-bearing plates or concrete footings may be required to hold the sign in a stable position.

All sign supports located within the clear zone* of the road or street must meet acceptable breakaway standards. Small sign steel supports described above and 4x4 wood posts generally meet breakaway standards when installed in “normal soil” conditions and may be used within the clear zone without barrier protection. When soil-bearing plates or special foundations are needed in sandy or marshy soils, it is advised that you consult with the Department of Transportation or Federal Highway Administration . Breakaway criteria adopted by the FHWA assume a 7-foot path width for vehicles. (It is assumed that all posts less than 7 feet apart would be impacted simultaneously.) The table “Common sign posts,” on the following page, lists the number of posts of various types and sizes that can be installed within a 7-foot width and still meet breakaway requirements.

* Clear zone is an unobstructed area adjacent to the traveled way that is provided to enable an errant driver to return to the road or stop without potential for a serious crash. Criteria for determining clear zone width are contained in AASHTO’s *Roadside Design Guide*.

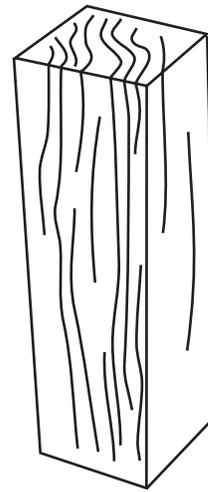
Common Sign Posts¹	
Description	Maximum in 7-foot path
Wood Posts, Southern Yellow Pine²	
4" x 4", direct burial	2
4" x 4" with two 1" holes, in 24" diameter, 30" deep concrete foundation	2
4" x 6" with two 1.5" holes, direct burial	2
4" x 6" in 18" diameter, 30" deep concrete foundation	1
4" x 6" with two 1.5" holes, in 24" diameter, 30" deep concrete foundation	2
6" x 6" with two 2" holes, in 24" diameter, 30" deep concrete foundation	1
6" x 8" with two 3" holes, in 24" diameter, 30" deep concrete foundation	1
U-Channel, 80 ksi Steel (Marion Steel)	
3-ppf and less, direct burial	2
3-ppf and less with 6" splice and two grade 9 bolts and spacers on 4" centers	3
4-ppf and less with 6" splice and two grade 9 bolts and spacers on 4" centers	2
Steel Square Tube, 33 ksi (Unistrut Corp.)	
1.75" square in a 2" square 12-gauge (Ga.) anchor	3
2.0" square and smaller, 12-gauge post in the next larger size anchor	2
2.5" square and smaller, 10-gauge post in the next larger size anchor	1
2.5" square and smaller, 10-gauge post with triangular slip base	3
Steel Square Tube, A570, 12 or 14 gauge (Allied Tube)	
2" square and smaller 14 gauge in a 12-gauge anchor	2
2.25" square 14-gauge post in a 12-gauge anchor	1
Slip Base	
S7 x 15.3 steel posts, inclined slip base, and concrete foundation	1
8" x 4" x 3/16" thick steel tube, inclined slip base, and concrete foundation	1
W6 x 12 steel post, omni-direction slip base, and concrete foundation	1
Breakaway Couplings (Transpo Industries, Inc.)	
45-ppf and less, and a weight of 600 pounds below the hinges	1
18-ppf and less, and a total weight of 600 pounds below the hinges	2

¹ In "standard" soil or in concrete as noted. Contact the manufacturer for other soil types and for installation details.

² Holes in wooden posts are drilled on the center line of the sides of the posts, perpendicular to the direction of adjacent traffic at heights of 4 and 18 inches above the ground. See the illustration "Typical breakaway modification for wood sign posts" on page C14.5.

Source: Arthur Breneman

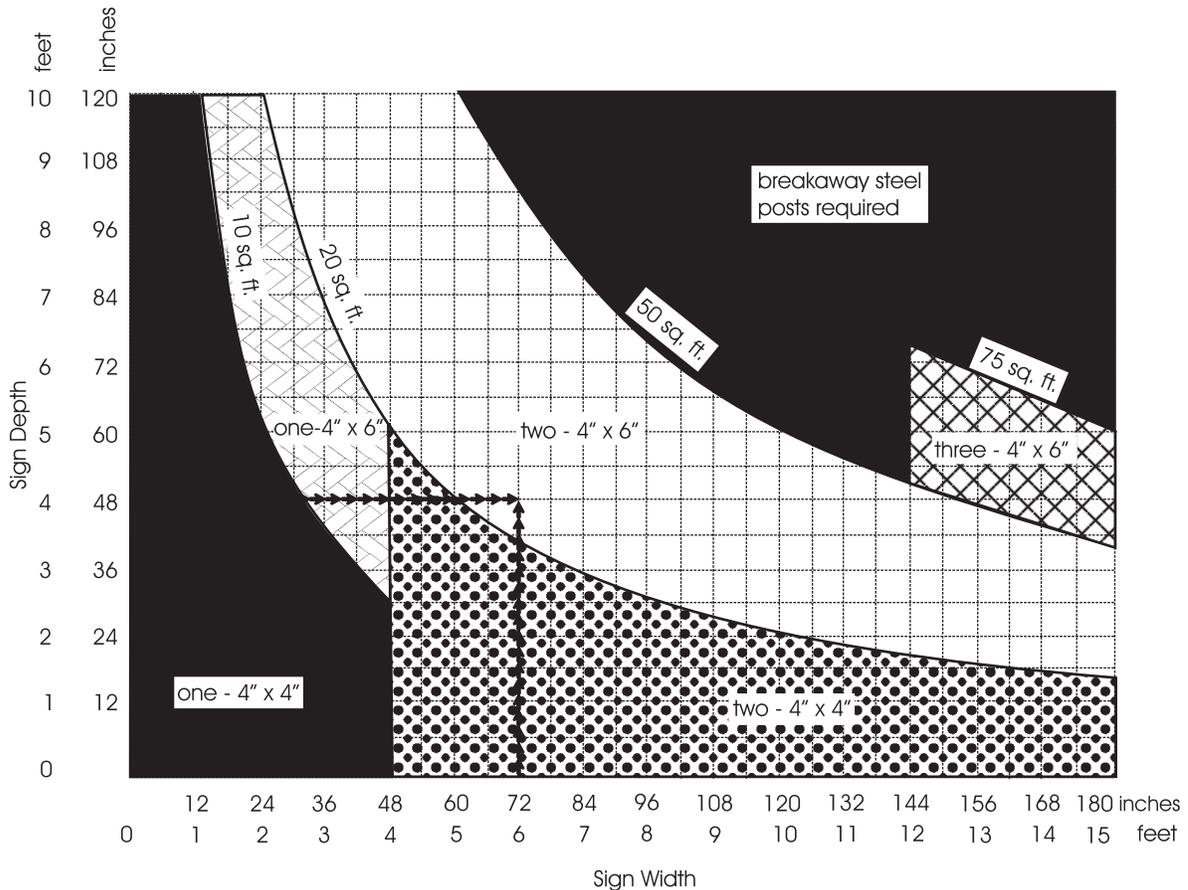
Wood Posts. Wood posts are most commonly 4x4, available in lengths from 10 to 14 feet and 4x6, usually in lengths of 16 to 24 feet. The length of the post is dictated by elevation of the selected location in relation to road surface and desired embedment (usually recommended at approximately 4 feet). To select the proper size and number of wood posts for a given sign, refer to the diagram, "Determination of sign post size and number," at the bottom of this page.



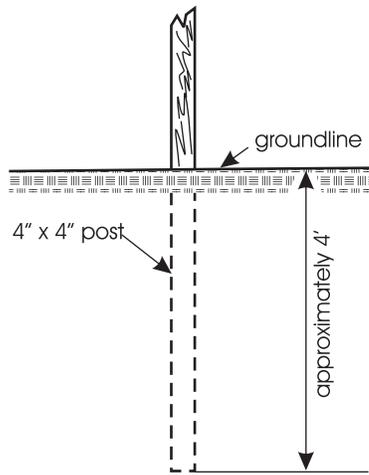
Wood post

In addition, these dimensions can be used as a guide to select the size and number of wood posts:

<u>Sign Area</u>	<u>Post Number and Size</u>
less than 10 sq. feet	one or two 4x4s
10-20 sq. feet	one 4x6 or two 4x4s
20-50 sq. feet	two 4x6s
50-75 sq. feet	three 4x6s or steel
greater than 75 sq. feet	steel posts

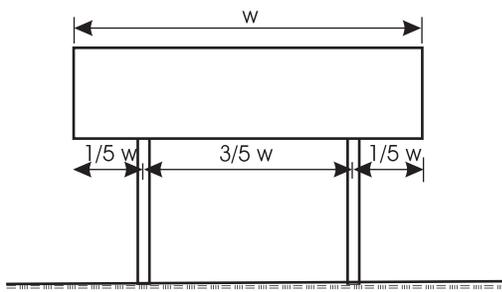


Determination of sign post size and number

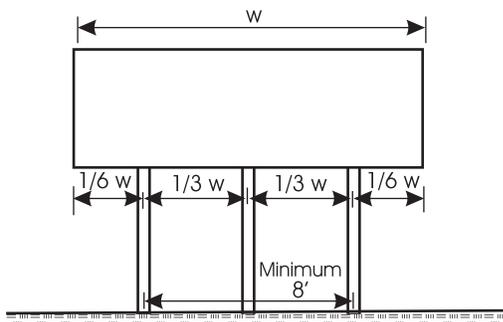


Suggested sign post installation

For stability considerations, a maximum width of 4 feet is recommended for signs to be mounted on a single post. The recommended minimum sign width for a three-post assembly is 12 feet to avoid having two posts within the path of an errant vehicle. Refer to the following diagrams for suggested two- and three-post mounting configurations.

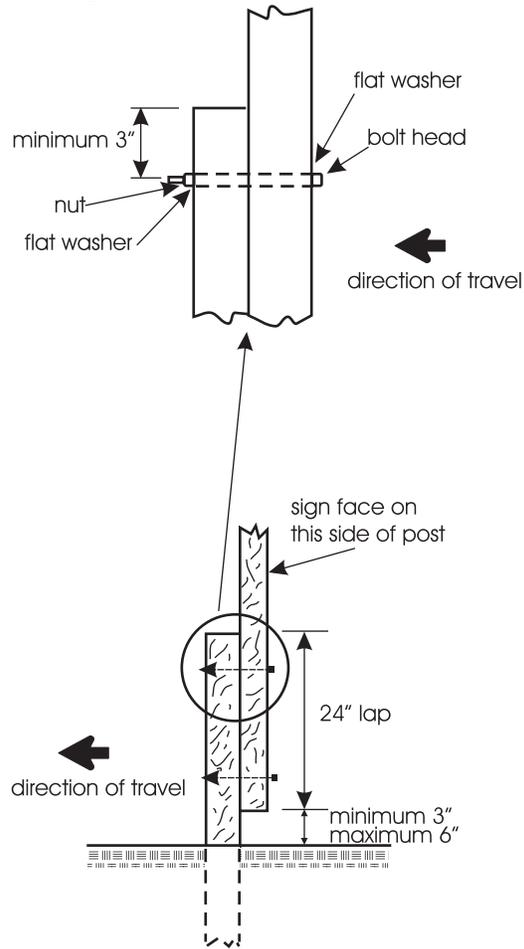


Typical two-post assembly



Typical three-post assembly

In special situations, wood posts may need to be spliced. Refer to the following diagram, “Post Splicing Details,” for splicing detail suggestions. Splices should be made just above the groundline to allow breakaway features to function properly. No part of the splice should be below ground elevation.



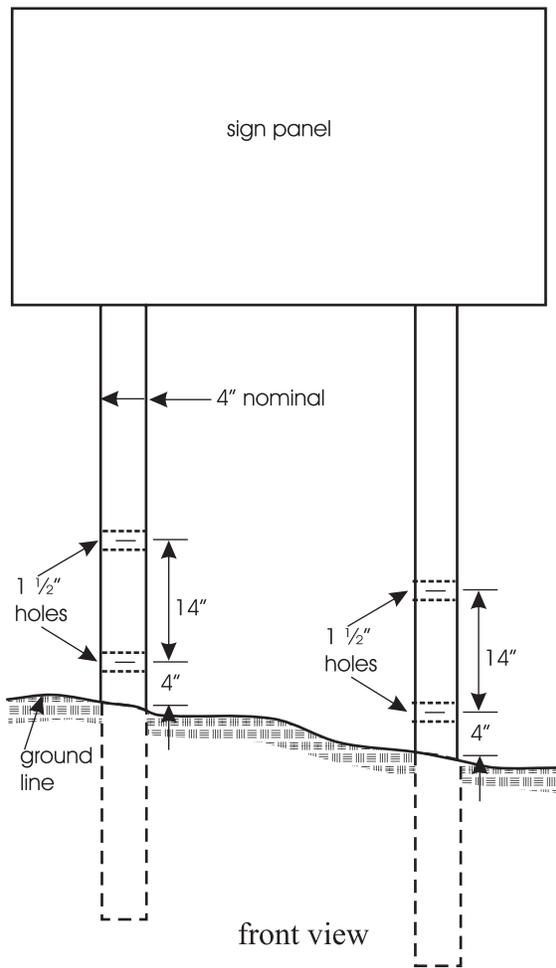
Post-splicing details

Notes:

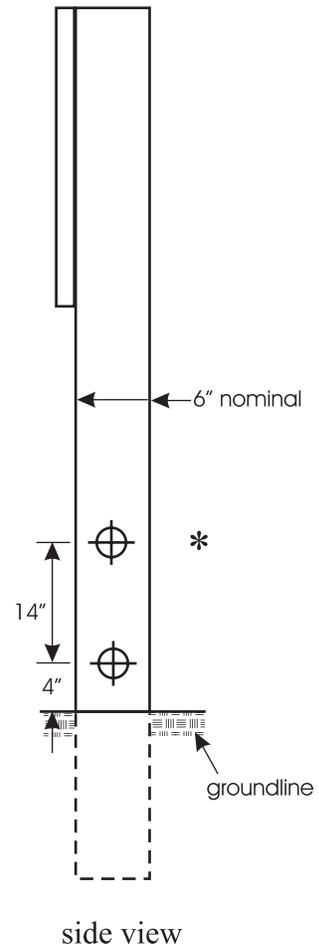
Posts for smaller signs with less than 10 square feet of area should be installed with approximately 4 feet below the ground surface. For larger signs and longer post lengths, the portion below the ground surface should be a minimum of 5 feet. Post holes should be backfilled with suitable soil tamped in place. In cases where the soil is unsuitable, crushed rock or crushed concrete should be used. Care should be taken in the process to see that the posts are plumb, insofar as possible, at all times. If properly placed, posts should remain firmly in position without needing further attention.

All wood posts 4x6 or larger must be modified to meet breakaway requirements if located within the clear zone. This modification can be achieved by drilling two holes near the bottom of the post as shown in the following figure.

All wood posts for permanent mounting should be pressure-treated for maximum service life.



Typical modification for wood sign posts



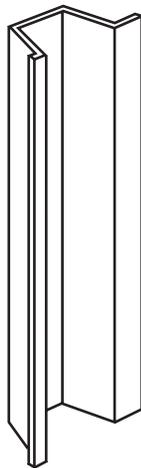
* Hole size for larger posts:
 6" x 6" - 2" diameter
 6" x 8" - 3" diameter

**Typical breakaway modification
 for wood sign posts
 (4 in. x 6 in.)**

Note:
 All 4x6 inch posts shall be modified by having two 1 1/2 inch diameter holes drilled perpendicular to the roadway center line.

Steel Posts. Steel posts for small signs are available in U-channel, round pipe, and square tube form.

U-channel posts are preferred in many cities because of the light weight, direct-driving feature, and low initial cost. U-channels generally exhibit lower loading capacities than other steel designs and do not permit signs to be mounted at right angles on a common post. Signs on U-channel posts may vibrate in the wind, causing rotation or loosening from the ground support. Use of soil-bearing plates may be necessary to stabilize some signs. These posts also can be installed back-to-back for greater stability. The posts may be spliced for more efficient use. A major manufacturer of U-channel posts is Marion Steel.

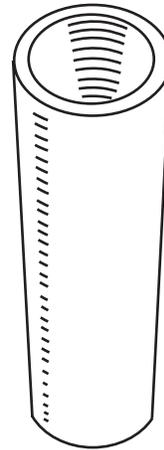


Steel U-channel post

The following posts are recommended for various sign dimensions:

<u>Sign Size</u>	<u>Post Weight</u>
18" x 24"	2 lbs./ft
30" x 30"	3 lbs./ft
36" x 48"	2 posts at 2 lbs./ft

Round pipes and newer, modified shapes have been used successfully for small sign supports in many jurisdictions. These pipes are also light and can be driven directly or placed in concrete footings. A threaded coupling also can be used as a breakaway feature and a more efficient replacement. Round pipes are somewhat more stable than U-channel posts and permit sign mounting at any angle.

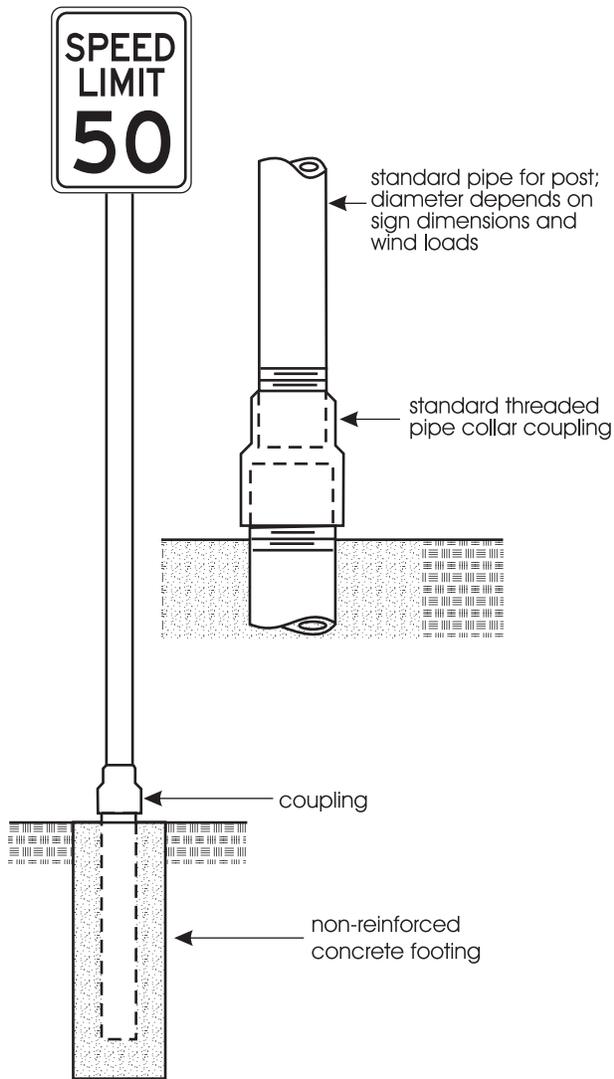


Steel pipe post

Standard galvanized, schedule 40 steel pipe is often specified. Steel posts can be driven directly into the ground to a depth of at least 3.5 feet. However, these posts may not meet current breakaway standards, and this feature should be considered before installation. Steel plates attached to the posts add stability in windy conditions. Recommended post sizes follow:

<u>Sign Size</u>	<u>Post Size</u>
30" x 30"	2" I.D.
36" x 48"	2.5" I.D.

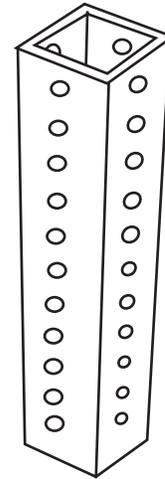
S-Square Tube Products of Commerce City, Colorado, is one manufacturer of this type of post. An example of round pipe supports and the threaded coupling breakaway feature can be seen on the following page.



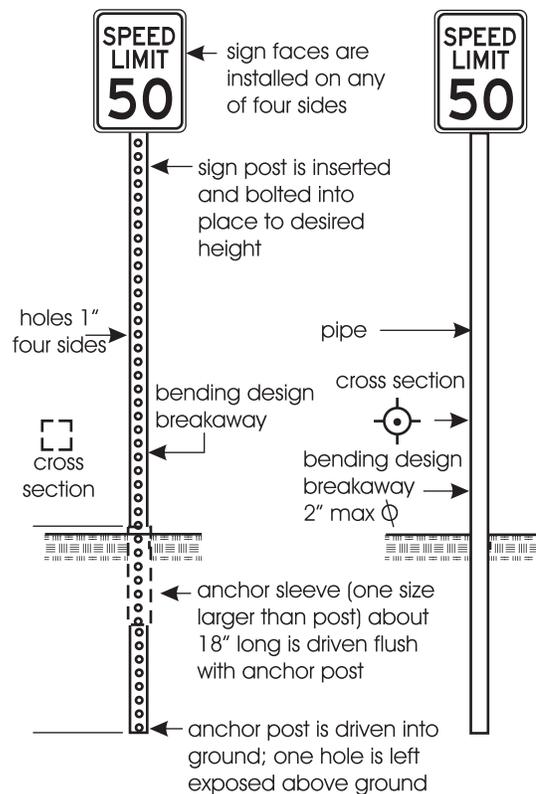
Round pipe sign support system and threaded coupling breakaway feature (inset)

Square tube posts for small sign supports are becoming more popular in both rural and urban applications. Typically, these posts are furnished with mounting holes prepunched at 1-inch spacings. Common sizes range from 1 1/2 inches to 2 1/2 inches in either 12 or 14 gauge. These supports can be driven directly or installed in a larger-sized anchor post, which makes replacement much easier. Advantages of square tube posts include flexible mounting and use options, increased strength compared to U-channel posts, option to mount on any side, and simple replacement. Damaged posts also can be recycled efficiently. Furthermore, special hard-

ware is available to increase flexibility. However, the cost of square tube posts is generally higher than U-channel. Whenever installing patented support systems, users should refer to manufacturer instructions.



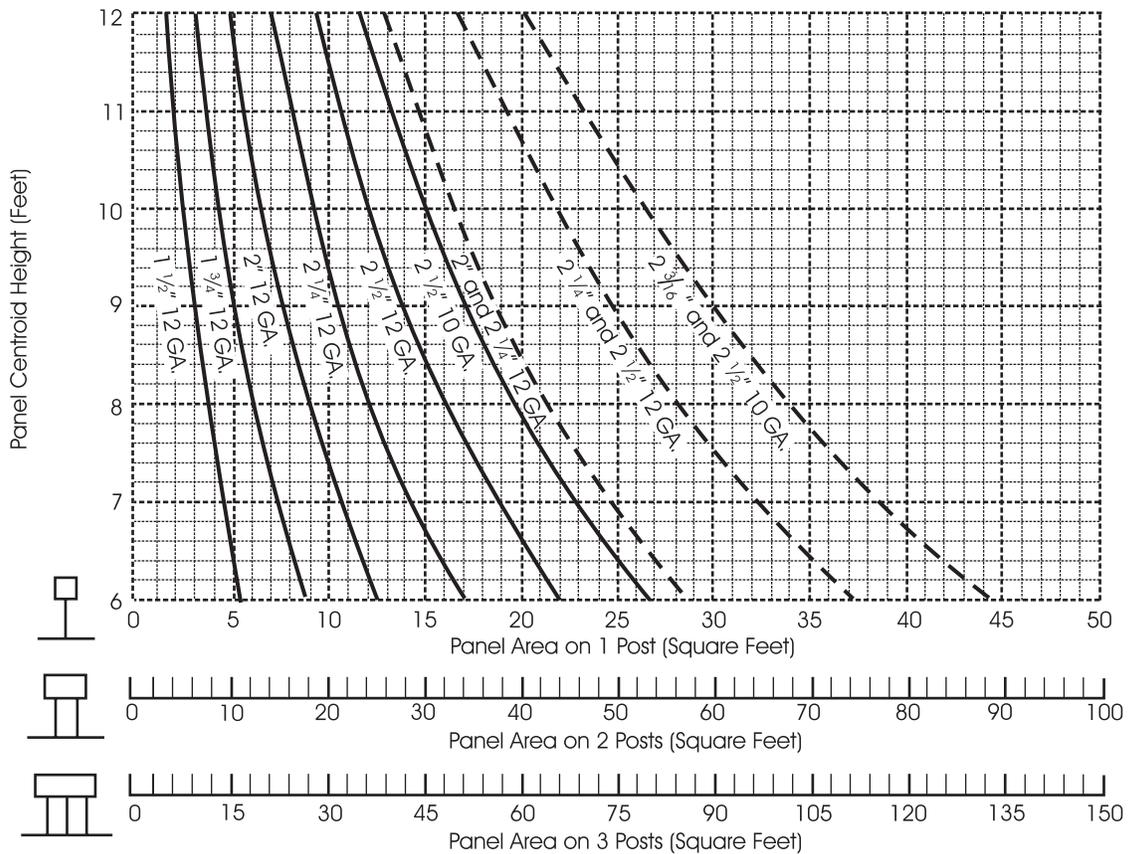
Square steel tube



Sign support systems

The following figures and tables provide guidance in selecting post size for various sign dimensions. Additional information is available

from vendors. Major manufacturers of square tube posts include Unistrut, S-Square Tube Products, and Western Highway Products.

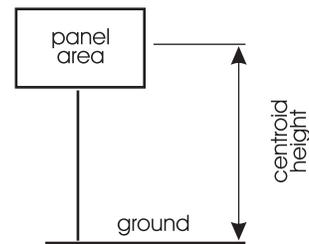


At intersection of panel area and centroid height on the chart, select post size from the line to the immediate right of the point.

Slip bases are required on the following:

- all posts with two sizes telescoped
- two-post supports 2 1/4" and larger
- all three-post supports

Lines plotted using design information in AASHTO specifications for supports for highway signs.



Telespar sign post chart (70 mph wind speed) for square tube posts

Source: Unistrut.

12-gauge perforated square posts¹

Sign Size (inches) Width x Height	Height to Bottom of Sign (feet)					
	5	6	7	8	9	10
12 x 12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
12 x 18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
12 x 24	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4
12 x 30	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4
12 x 36	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4
12 x 48	1 1/2	1 3/4	1 3/4	1 3/4	2	2
18 x 12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
18 x 18	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4
18 x 24	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4
18 x 30	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4	2
18 x 36	1 1/2	1 3/4	1 3/4	2	2	2
18 x 48	1 3/4	2	2	2	2 1/4	2 1/4
24 x 12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
24 x 18	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4
24 x 24	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4	2
24 x 30	1 1/2	1 3/4	1 3/4	2	2	2
24 x 36	1 3/4	1 3/4	2	2	2 1/4	2 1/4
24 x 48	2	2	2 1/4	2 1/4	2 1/2	2 1/2
30 x 12	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4
30 x 18	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4	2
30 x 24	1 1/2	1 3/4	1 3/4	1 3/4	2	2
30 x 30	1 3/4	1 3/4	2	2	2	2 1/4
30 x 36	1 3/4	2	2	2 1/4	2 1/4	2 1/2
30 x 48	2	2 1/4	2 1/4	2 1/2	2 1/2	A
36 x 12	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4
36 x 18	1 1/2	1 3/4	1 3/4	1 3/4	2	2
36 x 24	1 3/4	1 3/4	2	2	2	2 1/4
36 x 30	1 3/4	2	2	2 1/4	2 1/4	2 1/4
36 x 36	2	2	2 1/4	2 1/4	2 1/2	2 1/2
36 x 48	2 1/4	2 1/4	2 1/2	A	A	B
42 x 12	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4
42 x 18	1 1/2	1 3/4	1 3/4	2	2	2
42 x 24	1 3/4	2	2	2	2 1/4	2 1/4
42 x 30	2	2	2 1/4	2 1/4	2 1/2	1 1/2
42 x 36	2	2 1/4	2 1/4	2 1/2	2 1/2	A
42 x 48	2 1/4	2 1/2	A	A	B	C
48 x 12	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4	2
48 x 18	1 3/4	1 3/4	1 3/4	2	2	2 1/4
48 x 24	1 3/4	2	2	2 1/4	2 1/4	2 1/2
48 x 30	2	2 1/4	2 1/4	2 1/2	2 1/2	A
48 x 36	2 1/4	2 1/4	2 1/2	2 1/2	A	A
48 x 48	2 1/2	2 1/2	A	B	C	C

Note: All posts are 12 gauge, except as noted below.

A – 2 1/2 square tube, 10 gauge perforated.

B – combine 2 and 2 1/4 tubes, 12 gauge with slip base.

C – Combine 2 1/4 and 2 1/2 tubes, 12 gauge with slip base.

D – Combine 2 3/16 and 2 1/2 tubes. 10 gauge with slip base.

Design specification: Standard specification for structural supports for highway signs, luminaires, and traffic signals.

¹Single posts; wind speed 70 mph.

Source: Unistrut.

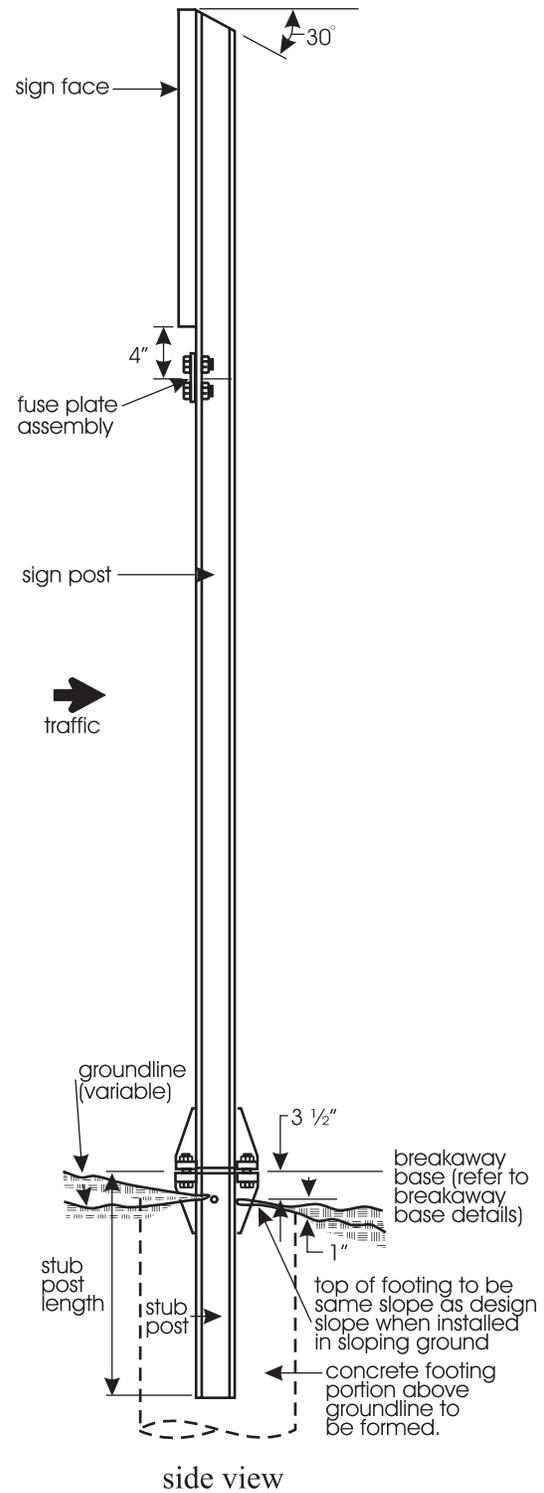
Additional Small Sign Considerations. To save installation and material costs and to minimize sidewalk obstruction, consider alternate mounting on existing supports such as utility poles, roadway light poles, and signal poles. Overhead span wires may also be appropriate in special situations. When considering alternate mounting, bear in mind that permission from the pole owner is needed, and visibility to motorists should be paramount.

Any sign support system should be durable and structurally adequate to endure wind and ice loadings. Also look for characteristics such as relatively low material and maintenance costs, ease of installation and replacement, availability, crashworthiness, and visual aesthetics.

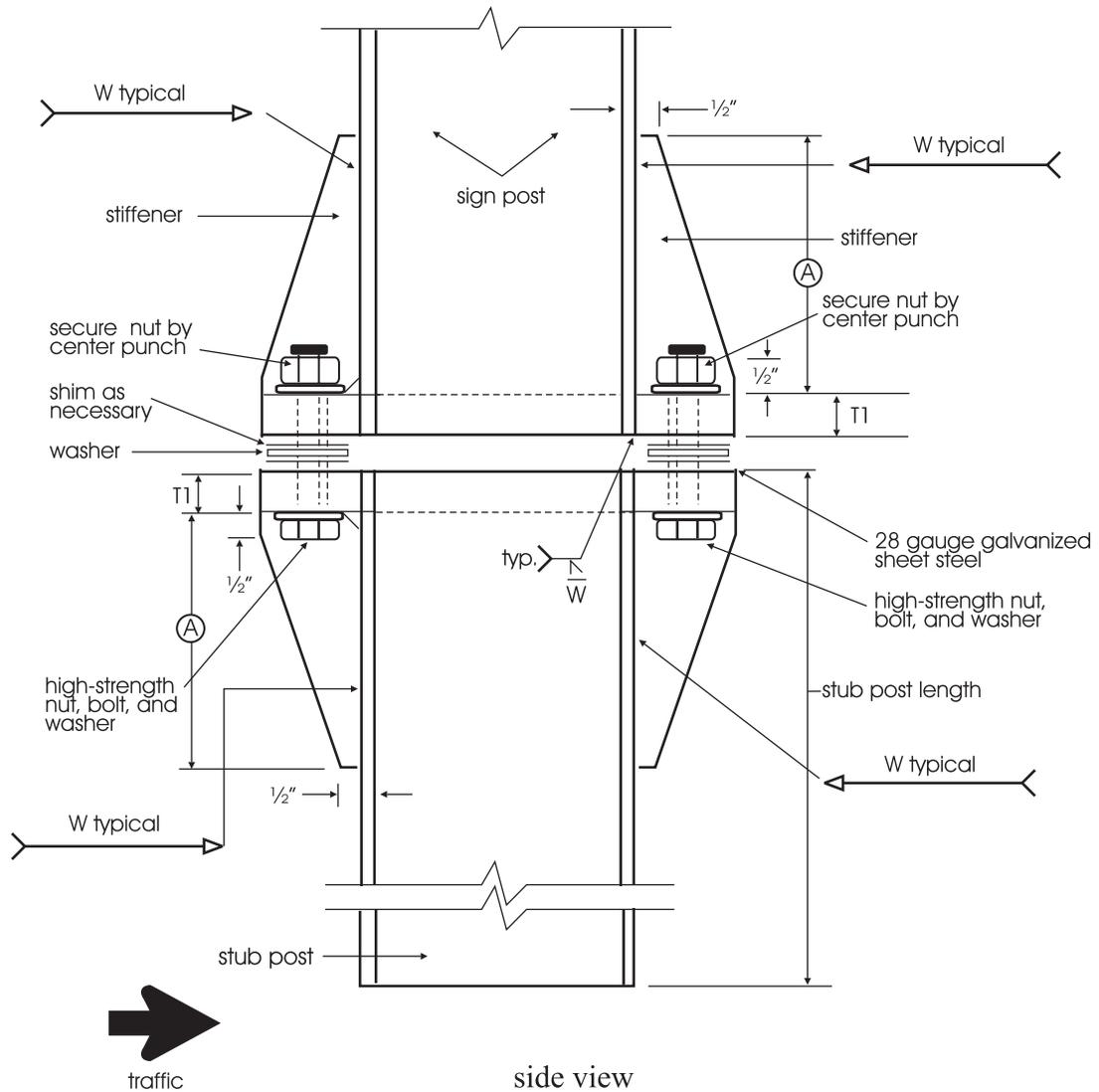
Large Sign Supports

Large signs (greater than approximately 50 square feet) are commonly supported with steel or aluminum posts fabricated from w-beams or s-sections and usually have several unique features. When located within the clear zone (see page C14.1 for a definition of clear zone), special breakaway designs must be used. The following figure illustrates a typical design for a large sign support. Additional advice and design information can be obtained from the Iowa Department of Transportation.

Other types of supports commonly used for large signs include cantilever and sign bridge overhead structures. Materials used for these structures include tapered steel tube, single steel tube and truss construction. Aluminum is another popular construction material.



Typical sign installation



(W) welds shall be continuous fillet welds and of a depth equal to the thickness of the flange for the post unless otherwise specified

Breakaway Base Data				
Post Size	Bolt Size and Torque	(A)	(T)	(W)
W 6 x 9 W 6 x 12 W 6 x 15 W 8 x 18	$\frac{5}{8}$ " dia. x $2 \frac{3}{4}$ " Torque = $37 \frac{1}{2}$ ' lbs.	5"	$\frac{3}{4}$ "	$\frac{1}{4}$ "
W 8 x 21 W 10 x 22 W 10 x 26 W 12 x 26	$\frac{3}{4}$ " dia. x $3 \frac{1}{2}$ " Torque = $62 \frac{1}{2}$ ' lbs.	6"	1"	$\frac{5}{16}$ "

Breakaway base details

Stop and Yield Signs

Sections 2B.04 through 2B.07 of the *MUTCD* describe Stop signs (R1-1), including applications and placement. Use of Stop signs is recommended for specific situations primarily involving high speeds, high traffic volumes, restricted views, and crash history.

In addition, the *MUTCD* discusses a few situations where Stop signs should not be used. The *MUTCD* also advises that less restrictive measures of traffic control be considered where a full stop is not required at all times.



R1-1

MUTCD Sections 2B.08 through 2B.10 describe Yield signs (R1-2) along with applications and placement of these signs. This description includes locations and situations where Yield signs can be effectively installed. Primary factors to be considered when judging the appropriateness of Yield sign usage include traffic volumes, volume split, speeds, visibility, and crash history.

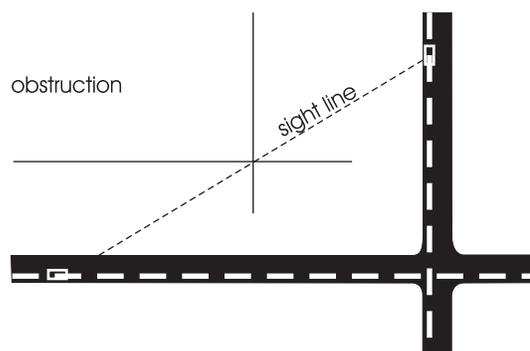


R1-2

Visibility and approach speed are important factors when selecting the most appropriate control for a given intersection. A sight triangle can aid in the analysis of these factors.

A minimum sight triangle will allow a sufficiently unobstructed sight distance along all

approaches to an intersection, including across the corners, to allow approaching drivers to take necessary action—stop, slow, or accelerate—to avoid collision. Any object in the sight triangle high enough to restrict visibility (3 feet) should be removed or lowered, if possible. These objects could include cut slopes, vegetation, growing crops, or parked vehicles. An in-depth discussion of sight triangles can be found in AASHTO's *A Policy of Geometric Design of Highways and Streets*, 1990.



Sight triangle

When an approach to an intersection is not controlled by Stop signs, motorists should be able to see a potential hazard early enough to take appropriate action. The average driver requires an estimated minimum of three seconds to perceive and react to a hazard. The following table lists the distance a vehicle will travel in three seconds at various speeds.

**Distance traveled by a vehicle in 3 seconds
(not stopping distance)**

Speed (mph)	Distance (feet)
10	45
15	70
20	90
25	110
30	130
35	155
40	180
50	220
60	260

The *MUTCD* advocates the use of Stop signs only when warranted. In many situations with lower volume roads and streets, Yield signs or no control may be the most appropriate choice.

Overuse of Stop signs will result in additional delay for drivers, disruption in traffic flow, increased fuel consumption and consequent pollution, and possible noncompliance by motorists. Some studies have found that Stop sign installation will not effectively reduce speeds and should not be used for this purpose. Alternate methods of controlling speeds, such as traffic calming, are described elsewhere in this manual.

Many studies have been made of the effects of Stop versus Yield control at intersections. One such reference is *Guidelines for Converting Stop to Yield Control at Intersections*, National Cooperative Highway Research Program (NCHRP) Report 320, published in October 1989.

If Yield signs are to be used for intersection control, the following suggestions should be considered prior to installation. These suggestions are general guidelines only, not specific requirements. A detailed engineering study may be needed to review specific situations.

For rural roads:

1. The average daily traffic (ADT) on the through road should not exceed 400 vehicles per day.
2. The sight distance on the minor roadway

should be sufficient to permit an approaching vehicle traveling at the posted or operating speed to stop before reaching the major road intersection.

For urban streets:

1. The major street has been designated as a through street with control along a substantial length that grants or implies right-of-way by using traffic.
2. The average daily traffic should be less than 1,500 vehicles per day on the major street and less than 600 vehicles per day on the minor street.
3. The intersection should most likely be a residential street intersection with a speed limit of 25 mph or lower.
4. No more than two crashes involving vehicles on the minor street have occurred over the past three years.

Local agencies can develop criteria to best meet specific needs. Yield signs can be a logical alternative to Stop sign control, but Sections 2B.09 and 5B.02 of the *MUTCD* should be consulted for application criteria.

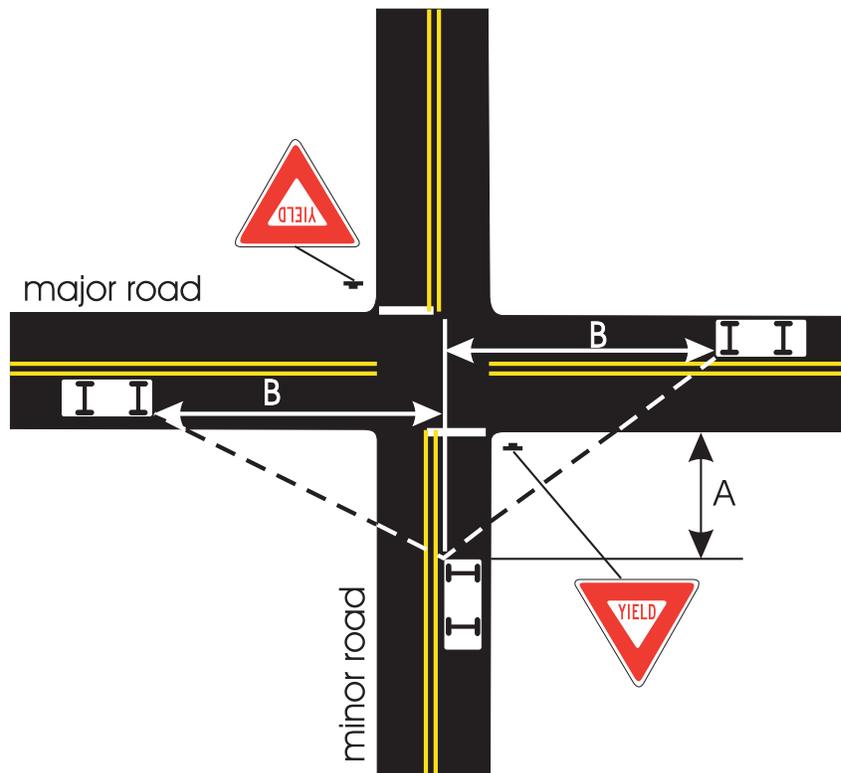
If Stop or Yield sign visibility is restricted for approaching vehicles, use of Stop Ahead or Yield Ahead signs as described in *MUTCD* Section 2C.26 should be considered.

The following illustration and table can be used to determine sight distance warrants for Yield sign installation.

Suggested minimum corner sight triangle for Yield sign control use

Minor Road		Sight Distance, <i>B</i>, along Major Road for Various Speeds								
Speed (mph)	Distance <i>A</i> (ft)	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph
10	45	130	155	180	205	230	255	280	305	330
15	75	145	175	200	230	260	285	315	345	375
20	110	160	195	225	255	290	320	355	385	415
25	150	180	215	250	285	320	355	390	425	460
30	200	-	235	270	310	350	390	425	465	505
35	250	-	-	295	340	380	420	465	505	550
40	315	-	-	-	365	410	455	500	545	590
45	385	-	-	-	-	440	490	540	585	635
50	465	-	-	-	-	-	525	575	630	680

Note: Refer to the illustration “Minimum corner sight triangle for Yield sign control use” below.



Minimum corner sight triangle for Yield sign control use

“T” and “Y” Intersections

“T” intersections, especially in rural locations, may be unexpected by motorists and require appropriate warning signs. Sections 2C.09 and 2C.34 of the *MUTCD* describe Large Arrow signs (W1-6 and W1-7). These signs are horizontal and rectangular in shape with a yellow background, black symbol, and a standard 48 inch x 24 inch size. The large arrow (W1-6) warns of a sharp change in alignment for approaching drivers and is most commonly used on pronounced horizontal alignment changes. Please see the article “Curves and Hills” (C5) in this manual for description of this application.

The double-head arrow sign (W1-7) is effective in marking the terminus of “T” intersections. In addition, Section 2C.34 the *MUTCD* describes the “T” Symbol sign (W2-4), which can be used in advance of specific “T” intersections. This sign and other similar intersection warning signs (W2-1 through W2-6) should generally not be used on an approach where traffic is required to stop, nor where the intersection is channelized, nor where junction signing or advance-turn arrows are present. The following figures illustrate suggested signing for “T” intersections.



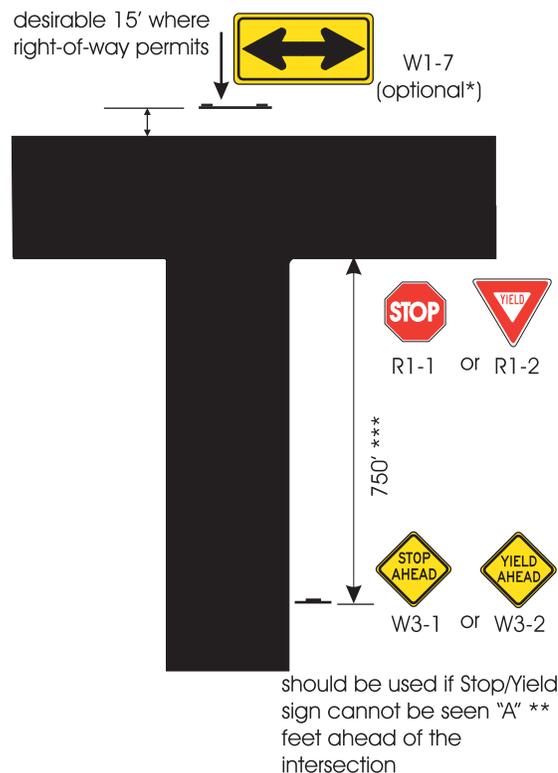
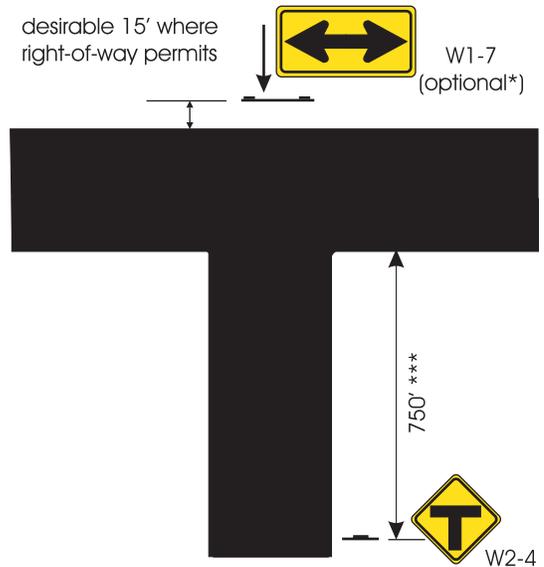
W1-7

* large double-headed arrow W1-7 may be used when added emphasis is needed or desired

**

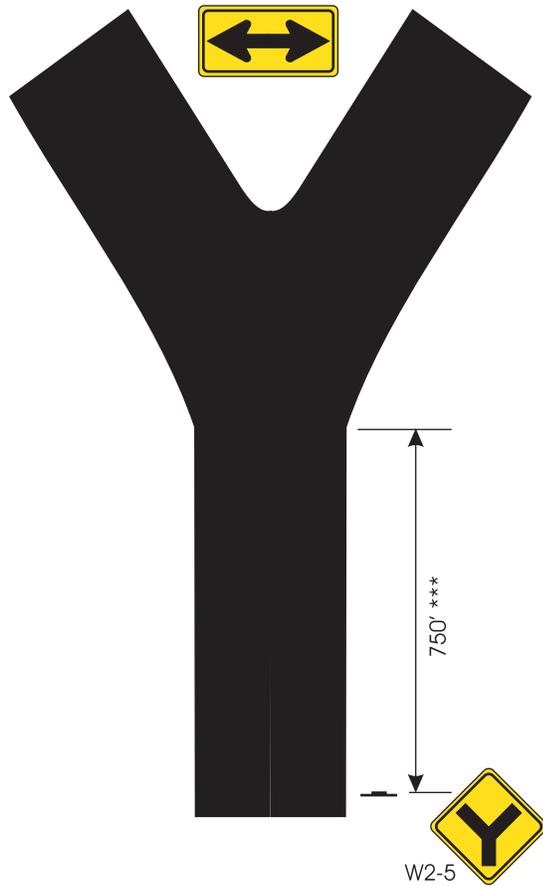
Operating Speed	Distance “A” (feet)
30	100
40	225
45	300
50	375
55	450

*** nominal distance (other distance may be used if engineering study indicates)



Typical signing for “T” intersections

The *MUTCD* also describes the use of the “Y” Symbol sign (W2-5), which can be used in advance of a “Y” intersection. Use of the large arrow sign with double head (W1-7) also can be used in the fork of the “Y” directly in line with approaching traffic.



*** Nominal distance (other distance may be used if engineering study indicates).

Typical signing for “Y” intersections

Unofficial and Unauthorized Signs

MUTCD and Iowa Code Stipulations

Section 1A.08 of the *MUTCD* (“Authority for Placement of Traffic Control Devices”) states the following:

“Traffic control devices, advertisements, announcements, and other signs or messages within the highway right-of-way shall be placed only as authorized by a public authority or the official having jurisdiction, for the purpose of regulating, warning, or guiding traffic ... Any unauthorized traffic control device or other sign or message placed on the highway right-of-way by a private organization or individual constitutes a public nuisance and should be removed. All unofficial or nonessential traffic control devices, or other signs or messages should be removed.”

Furthermore, the Code of Iowa, Section 321.259 (“Unauthorized Signs, Signals, or Markings”) states the following:

“No person shall place, maintain, or display upon or in view of any highway, any sign, signal, marking, or device which purports to be or is an imitation of or resembles an official parking sign, curb, of other marking, traffic control device or railroad sign or signal, or which attempts to direct the movement of traffic, or which hides from view or interferes with the effectiveness of any official traffic control device or any railroad sign or signal, if such sign, signal, marking, or device has not been authorized by the department and local authorities with reference to streets and highways under their jurisdiction and no person shall place or maintain, nor any public authority permit upon any highway, any traffic sign or signal bearing thereon any commercial advertising. This shall not be deemed to prohibit the erection upon private property adjacent to highways of signs

giving useful directional information of a type that cannot be mistaken for official signs.

Every such prohibited sign, signal, or marking is hereby declared to be a public nuisance and the authority having jurisdiction over the highway is hereby empowered to remove the same or cause it to be removed without notice.”

Considering these provisions and requirements unofficial and/or unauthorized signs, and other traffic control devices or markings within public right-of-way should be removed or caused to be removed as soon as possible.

Political Signs

Section 306C.22 of the Iowa Code contains provisions specifically addressed to a class of signs described as political signs and regulates the size and duration of these signs. Political signs may be erected and maintained on private property, provided the property owner agrees and the sign conforms to general provisions contained in the Code for other advertising devices.

A sample county political sign policy is included in the appendix. Advice of legal counsel and close adherence to local ordinances is advised.

Section 306.23 of the Iowa Code describes conditions in which special event signs may be erected on private property. Specific requirements for placement, size, location, and duration are included in this code section.

For more advice on this topic, contact Advertising Management, Office of Traffic and Safety, Iowa Department of Transportation, Ames, Iowa, 515-239-1296.

Please refer to the appendix of this manual for additional information.

Warning Sign Placement

Warning signs should be placed to allow adequate time for a driver to perceive, identify, decide, and perform any necessary maneuver. The total time required to perceive and react to a situation is referred to in the *MUTCD* as perception, identification, emotion, and volition, or PIEV time. PIEV time can vary from about 2 seconds for general warning signs to as much as 10 seconds where higher driver judgement is required. Please refer to Section 2C.05 of the *MUTCD* for more details.

The following table suggests minimum warning sign placement locations that may be used for three conditions:

- Condition A—high driver judgement required. Typical situations are merges, lane reductions, and narrow bridges, usually on high-volume, high-speed roads.
- Condition B—stop condition. Drivers may be required to come to a complete stop such as signalized or stop-controlled intersections, crossroads, and pedestrian or school crossings.
- Condition C—deceleration condition. Drivers may be required to reduce speed to make the proper maneuver, such as a curve, turn, dip, or low clearance.

The above information should be considered minimum requirements and engineering judgement must be exercised with these applications.

In some locations, a supplemental advisory plate with distance noted may be used where an

intermediate side road exists between the sign and the condition. This will avoid confusion for the driver about the location to which the warning pertains.

Other miscellaneous warning signs not related to a specific location, such as Rough Road (W8-8) and Soft Shoulder (W8-4), may be installed in the most appropriate location available. Minimum spacing between warning signs with different messages should normally be based on PIEV times for driver comprehension and reaction.



W8-8



W8-4

Some advance warning sign locations are fixed points, such as speed limit changes, no passing zones, etc.; but reasonable flexibility is allowed in the location of many other warning signs. When deciding location for these signs, be sure to consider surrounding terrain and visibility constraints.

Cut sections or narrow right of way may restrict desired height and lateral displacement of sign placement. Obstructions, such as trees, buildings, utility poles, bridge piers, and other signs, may hamper visibility. Existing driveways, side roads, and other features may also affect sign placement. In general, always increase warning sign placement distance when obstacles to the ideal location are encountered.

If signs are mounted back to back, care should be taken to assure the shape or outline of either sign is not obscured.

The effectiveness of any warning sign placement should be reviewed periodically, both day and night.

A guide for advanced warning sign placement distance (in feet)¹

Posted or 85 th Percentile Speed (mph)	Condition A High Judgement Needed ²	General Warning Signs						
		Condition B Stop Condition ³	Condition C—Deceleration Condition to Listed Advisory Speed (mph) (desired speed condition) ⁴					
			0	10	20	30	40	50
20	175	5	5	-	-	-	-	-
25	250	5	100	5	-	-	-	-
30	325	100	150	100	-	-	-	-
35	400	150	200	175	5	-	-	-
40	475	225	275	250	175	-	-	-
45	550	300	350	300	250	5	-	-
50	625	375	425	400	325	225	-	-
55	700	450	500	475	400	300	5	-
60	775	550	575	550	500	400	300	-
65	850	650	650	625	575	500	375	-

Notes:

¹ The distances are adjusted for a sign legibility distance of 175 ft, which is the appropriate legibility distance for a 5-in. Series D word legend. The distances may be adjusted by deducting another 100 ft if symbol signs are used. Adjustments may be made for grades if appropriate.

² Typical conditions are locations where the road user must use extra time to adjust speed and change lanes in heavy traffic because of a complex driving situation. Typical signs are Merge, Right Lane Ends, etc. The distances are determined by providing the driver a PIEV time of 6.7 to 10.0 seconds plus 4.5 seconds for vehicle maneuvers minus the legibility distance of 175 ft for the appropriate sign.

³ Typical condition is the warning of a potential stop situation. Typical signs are Stop Ahead,

Yield Ahead, or Signal Ahead. The distances are based on the 1990 AASHTO policy for stopping sight distance (page 120) providing a PIEV time of 2.5 seconds and friction factor of 0.30 to 0.40 minus the sign legibility distance of 175 ft.

⁴ Typical conditions are locations where the road user must decrease speed to maneuver through the warned condition. Typical signs are Turn, Curve, or Cross Road. The distance is determined by providing a 1.6 second PIEV time (1990 AASHTO, page 119) a vehicle deceleration rate of 10 ft/second² minus the sign legibility distance of 175 ft.

⁵ No suggested minimum distances are provided for these speeds, as placement location is dependent on site conditions and other signing to provide an adequate advance warning for the driver.

Source: MUTCD.

Section D

Pavement Markings

D: Pavement
Markings

Pavement Markings

Pavement markings can be a very cost-effective roadway improvement in terms of reducing crashes and providing guidance to drivers, especially at night. Part 3 of the *MUTCD* defines the purpose of markings: to regulate and guide traffic movements and promote safety. Markings can be used to supplement other regulatory and warning devices or used alone to provide results that cannot be obtained with other devices without diverting attention from the roadway.

Pavement markings, like other traffic control devices, should be easily recognized and understood, well-maintained, and used only in consistent applications, including design, color, and placement location.

Roadway markings can be yellow, white, red, or blue. Section 3A.04 of the *MUTCD* describes where each of these colors may be used. In addition, black may be used on lighter pavement to supplement the standard colors. A black outline can be quite effective in improving the visibility of markings in some instances.

Roadway markings can be classified as longitudinal lines, transverse markings, or words and symbols. These markings can provide positive guidance by defining limits of safe travel, such as center lines, lane lines, edge lines, crosswalks, or stop bars. Markings can also be used for negative guidance, advising drivers where not to travel, such as no passing zones, gore areas, or painted medians and islands. Word messages and symbols on the pavement include directional arrows, speed limits, and approach warnings such as Stop Ahead, and Pedestrian X-ing.

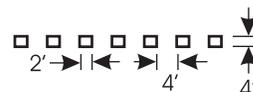
Street markings can be used to designate parking spaces, and painted curbs can be used to supplement parking restriction signing.

Sections 3A.05 and 3A.06 of the *MUTCD* list several principles or concepts for longitudinal lines:

- Yellow lines designate separation of traffic lanes flowing in opposite directions or can be used to mark the left edge of one-way roadways.
- White lines delineate the separation of traffic flows in the same direction or can be used to mark the right edge of pavements.
- Red markings are used to delineate roadways that shall not be entered or used.
- Broken lines are permissive.
- Solid lines are restrictive.
- Dotted lines indicate guidance.
- The width of line indicates degree of emphasis.
- Double lines indicate maximum emphasis or restriction.
- Blue markings designate parking for persons with disabilities.

The *MUTCD* further recommends widths and patterns for longitudinal pavement lines, generally as follows:

- Normal line width is 4 to 6 inches (wider lines may improve visibility).
- A wide line should be at least twice the width of a normal line.
- Double lines are two normal-width lines separated by a discernible space.
- Broken lines consist of segments and gaps, usually with a ratio of one to three. For rural highways, this ratio is generally 10-foot lines to 30-foot gaps.
- Dotted lines are formed by short segments, normally 2 feet in length and 4 feet apart. Width of a dotted line should be at least equal to the width of the line being extended.



Dotted line (white)

Materials

Pavement marking materials can be divided into two common types, nondurable, primarily paints, and durable, which include epoxy, thermoplastics, poly urea, poly urethane, tapes, and raised pavement markings. Each marking material type has specific characteristics that must be considered in the selection process, including service-life expectancy, color quality, retroreflectivity, special application methods, and of course, initial cost. Because service life and retained retroreflectivity are key elements for agency consideration, these factors should be included in life-cycle analysis to determine the most cost-effective material for each type of application.

Nondurable Markings. Nondurable markings (paints) can be further categorized by solvent, method of application, and drying time. Historically, traffic paints have been available with a variety of solvents, including alkyd resin (oil), rubber, modified alkyd (oleoresin), and waterborne. Due to environmental concerns, solvent-based paint has now been largely replaced by waterborne or water-based paints. Methods of application for paints can be either hot or cold.

Drying time is another type of classification. While application method, ambient temperature, and chemical composition can affect drying time, several categories can be specified. These include conventional (several minutes to several hours), fast dry (2 to 7 minutes), quick dry (30 seconds to 2 minutes), and instant (30 seconds or less).

Durable Markings. Epoxies are two-component materials that generally provide longer service life than paints. Application usually requires specific surface preparation, such as shot or sandblasting and a relatively long cure time (up to 45 minutes depending on ambient conditions). Both fast-set and slow-set formulations are available, but performance of fast-set epoxy can be unsatisfactory with certain pavement types.

Poly urea and poly urethane are also two-component materials that can provide fast drying times with good durability. Both materials require specialized application equipment but can be placed at temperatures as low as 32 degrees Fahrenheit, which can be advantageous for late season work.

Thermoplastics are solid at ambient temperatures and must be melted for application. These materials can be furnished in two forms: solid blocks and granulated mixture. Thermoplastics do not contain solvents. This type of material will provide extended service life, with extruded application generally outperforming spray placement. Loss of material may occur from snow-removal operations. Reapplication over existing markings may be accomplished with little surface preparation, although material buildup must be considered.

Tapes are available in several performance levels and types, both permanent and temporary. Tape markings can be applied to existing pavement, rolled into hot surfaces, or placed in prepared grooves. Wet reflective tape is also available in permanent or temporary applications. This material can provide good visibility, even when fully submerged in water. Proper surface preparation is especially critical to achieve maximum performance from tape markings. At the end of useful life, tape markings should be removed prior to application of new material. Generally, this is accomplished by grinding. While the initial cost of some tapes is high compared to other markings, extended service life can make this material a cost-effective consideration.

The following table provides cost and service life information for several pavement marking materials.

Cost and service life of marking materials

Marking Material	Expected Service Life (in years)¹	Cost²
Traffic Paint	1/2 to 1	\$0.10/ft
Epoxies	2 to 3	\$0.60/ft
Poly Ureas and Urethanes	2 to 5	\$0.85/ft
Thermoplastics	5 to 7 ³	\$0.90/ft
Tapes	2 to 7 ³	\$1–4.00/ft
Wet Reflective Tape	2 to 4	\$1–2/ft

¹ Service life can vary with traffic and weather conditions

² Cost based on averages, will vary based on quantities, locations, placement factors, etc.

³ Night visibility may deteriorate earlier.

Special Marking Products and Procedures

Concern for maintenance of minimum retroreflectivity standards and visibility in wet weather conditions has resulted in increased interest in new products and methods.

Raised pavement markers (RPMs) have been used for many years to improve nighttime

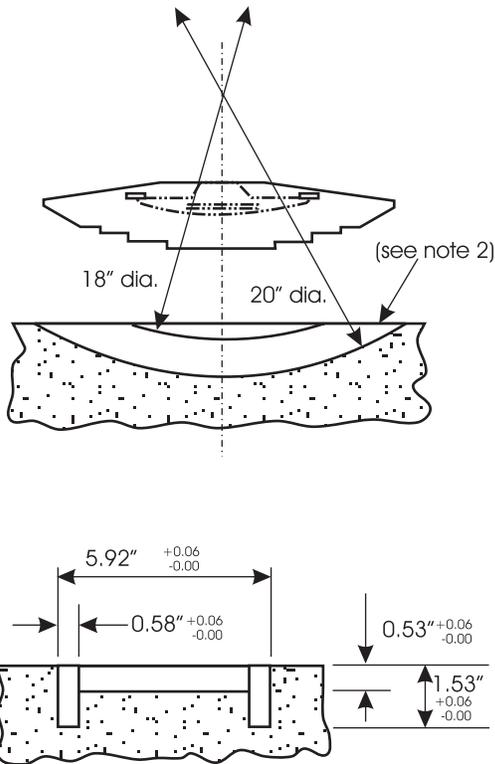
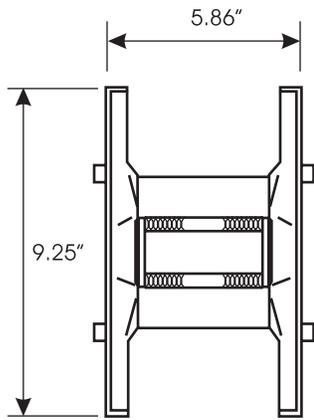
visibility in needed locations. RPMs have not been accepted for general use in many northern states due to high initial cost and susceptibility to damage from snowplow activity. However with care in design and installation, RPMs can be an effective means of guidance for vehicles at night. The following suggestions are included for RPM usage:

- RPM color must be the same as the marking they supplement or replace.
- Retroreflective or internally illuminated RPMs can replace markings of other types.
- The pattern of RPMs should simulate the pattern of replaced markings.
- Normal spacing for RPMs should be determined based on the standard length of the broken line segment.
- Where it is desired to alert motorists to a change in road alignment, this spacing may be reduced.

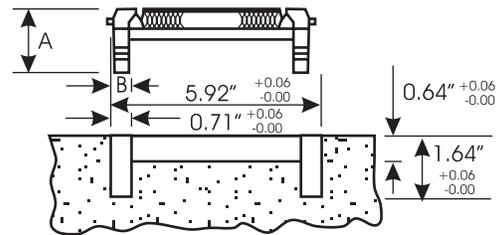
Raised pavement markers can also be used effectively in certain temporary work zone applications.

Refer to Sections 3B.11 through 3B.14 of the *MUTCD* for more information on raised pavement markers.

The illustrations on the following pages depict typical raised pavement marker applications.



optional for conventional type



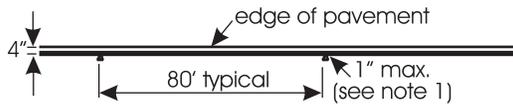
	Conventional Type	Low-Profile Type
A	1.74"	1.69"
B	0.46"	0.59"

Notes:

1. Center-line raised pavement markers shall be placed between the two painted lines. Markers installed along an edge line or channelizing line shall be placed so that the casting is not more than 1 inch from the near edge of the line. Markers installed along a lane line or dashed yellow center line shall be placed between and in line with the dashes. Markers shall not be placed over lines except where the lines deviate visibly from their correct alignment, and then, only with the approval of the engineer.
2. To facilitate the cutting of the two parallel slots and intervening concave surface simultaneously, it is recommended that an arbor and saw blades assembly be used. For additional details and tolerances of the casting and arbor-saw assembly, contact the casting manufacturer.

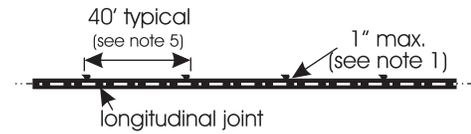
Casting and saw cut details for raised pavement markers

Source: Ohio Department of Transportation.



Edge Line

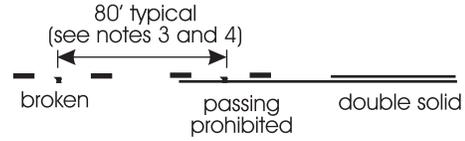
one way (white) with right edge line and
one way (yellow) with left edge line or
two way (yellow both sides)



Channelizing Line
two way (white)

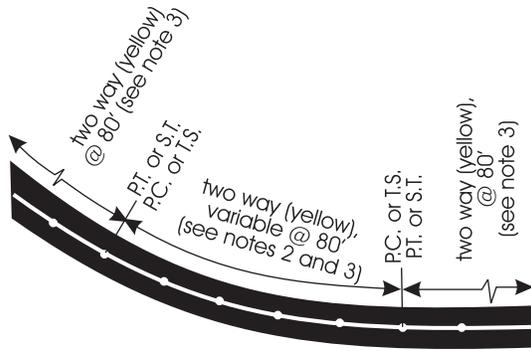


Lane Line
one way (white)



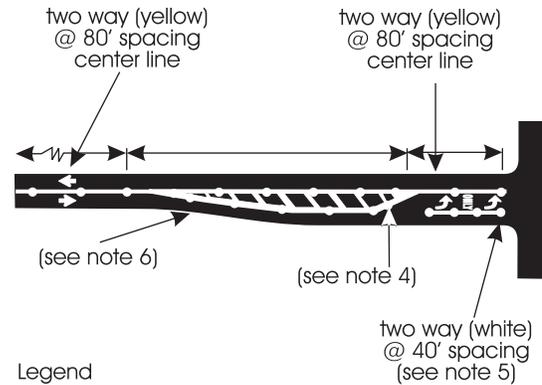
Center Line
two way (yellow)

Typical raised pavement marker placement with longitudinal pavement markings



Legend
■ reflectors

RPM details for horizontal curve

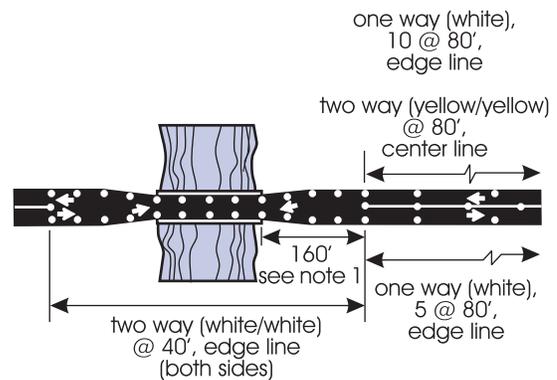


Legend
■ reflectors

RPM details for approach with left turn lane

Notes:

1. For one-lane bridges, painted center line and center-line markers may be omitted 160 feet on each side and across the bridge.
2. For horizontal curves of 5 degrees or greater, the spacing of the center-line markers shall be reduced to 40 feet between P.C. and P.T.
3. For horizontal curves of 10 degrees or greater, the spacing of the center line markers may be reduced to 20 feet between P.C. and P.T. When using 20-foot spacing, 12 raised pavement markers at 40-foot spacing shall be installed on each end of the 20-foot spacing.
4. A minimum of three equally spaced, raised pavement markers shall be installed on the back taper.
5. When a channelizing line is less than 80 feet long, one raised pavement marker shall be



RPM details for one-lane bridge

6. Raised pavement markers shall not be placed on edge lines on a through approach.

Source: Ohio Department of Transportation.

Specifications and application rates for placing pavement marking lines

	Broken Center Line	Broken Lane Line	Double Center Line	No Passing Zone Line	Right Edge Line	Left Edge Line
Color	Yellow	White	Yellow	Yellow	White	Yellow
Width	4"	4"	two at 4"	4"	4"	4"
Pounds of Beads per Gallon of Paint¹	8	6	8	8	6	8
Wet Film Thickness (mils)	11	11	11	11	11	11
Gallons of Paint per Mile¹	3.02	3.02	24.14	12.07	12.07	12.07
Feet per Gallon of Paint	1748	1748	219	437	437	437
Gallons of Paint per Minute²	0.60 ³	0.60 ³	4.40 ⁴	2.42	2.42	2.42

- ¹ Maximum retained retroreflectivity may be achieved with a bead rate of 10 lbs/gal and paint rate of 15 gal/mile for single, solid 4-inch lines.
- ² Based on a uniform travel rate of 12 mph, or 1,056 feet per minute.
- ³ Rate of application when 10-foot segments of broken line are being placed.
- ⁴ Rate of application for placing double lines simultaneously.

Other methods to improve nighttime and wet weather visibility include recessed pavement markings, which involves grooving a strip of appropriate dimensions in the pavement surface followed by installation of a high-performance, retroreflective traffic tape. This method and others of similar technique are costly initially but have demonstrated excellent service life characteristics.

Special pavement markings, such as those described, can be especially cost-effective in high traffic urban areas, such as intersections, where maintenance of desired visibility is difficult.

Application Recommendations

To achieve desired performance and service life from pavement markings, regardless of material used, proper application techniques should be followed. Each marking type has specific

preparation and application requirements that should be adhered to for quality results.

Paints. Water-based paint is the most common type of pavement marking material used in jurisdictions today. Before applying this, or any other type of markings, proper cleaning of the road surface is required. Generally, brooming to remove dirt, concrete curing compound, vegetation, and debris will result in a sufficiently clean surface. However, washing of the surface may be needed in some instances. It is imperative that clean, dry pavement conditions exist during painting operations. Spotting of line locations can then be completed. The table above contains suggested application rates for both paint and retroreflective beads. Whether these markings are placed by local crews or contract, the rates and wet film thickness in the table above can be used to ensure proper application.

Suggested operating speed for trucks applying paint is 12 mph or 1,056 feet per minute. Newer equipment can allow painting at higher speeds, but the quality of product should not be sacrificed for faster application rates. Studies have shown that retained retroreflectivity will be reduced significantly at application rates over 17.5 mph.

Most painting of traffic lines is accomplished to renew existing markings, with the old lines still visible. For best results and professional appearance, adequate care should be exercised to match the old markings as much as possible. This may be particularly challenging with broken or skip lines but is well worth the effort. If existing lines are to be revised, the old markings should be completely removed. Common removal methods include water blasting, sandblasting, burning, and grinding.

Equipment used for paint application should be properly designed and maintained for best results. Heat exchangers can be used to decrease paint viscosity for easier spraying, especially on cool, humid days. However, paint should not be heated over 120 degrees Fahrenheit. Paint flow meters should be used to monitor delivery rates and assure compliance with intended application standards.

Other Materials. For other pavement marking materials, follow manufacturer recommendations closely, especially for surface preparation, ambient temperature restrictions, and application techniques. Expensive durable markings, such as thermoplastics, epoxy, and tapes can fail prematurely if manufacturer requirements are neglected.

Whenever applying pavement markings on streets and roads open to public travel, it is important to use proper traffic control procedures. Refer to Part 6 of the *MUTCD* and “Temporary Traffic Control During Operations” (K1) in this manual for suggested work zone traffic control.

Many factors can affect service life of pavement markings. Some of these include pavement type and surface condition, volume and composition of traffic, season and temperature at application time, thickness of markings, and snow removal damage. But key factors in satisfactory performance of all types of marking material are proper surface preparation and application techniques.

Contract Bidding and Administration

The Iowa Department of Transportation is an excellent source of information on bidding, specifications, and approved contractors and materials. Consult with the appropriate offices of the Iowa DOT to obtain advice and information.

All contracts should include specific performance requirements, including beginning and ending dates and number of working days allowed. Appropriate penalties should be included to protect local agencies from incomplete and unsatisfactory work. If removal of existing markings is necessary, be sure to clearly state this in the contract documents. When proprietary or special durable materials are contracted, bidders should be properly qualified to accomplish the work. Contractor certification by the material vendor may be desirable as a qualification prior to bidding. Testing and/or certification of materials should also be expected. If a warranty is desired, this should also be included in the contract stipulations. Knowledgeable and experienced inspectors are a valuable asset in achieving high-quality results from pavement marking contracts.

Some states are successfully using multi-year, performance-based specifications for pavement marking placement. This procedure may become more commonplace in the future. However, the quality and completeness of contract specifications along with good inspection are key to achieving desired results and avoiding disagreements over performance.

Warranties

For best results, follow manufacturer recommendations closely, especially when specifying high-performance pavement marking materials. Whether material placement is accomplished by agency staff or contractor, procedures should be adequately monitored to assure specifications are met. Review vendor warranties carefully to ascertain whether materials purchased will meet expected results. If failures occur, how will a settlement be made? Will the vendor replace at no cost to the agency? What initial retroreflectivity should be expected? How long will minimum values be retained? All vendors do not offer detailed warranties for products, but local jurisdictions should request verification that expected results will be met.

Applications of Pavement and Curb Markings

Center Lines. For two-lane, two-way roads, center lines consist of:

- normal, broken yellow lines where passing is permitted.
- a normal, broken yellow line and parallel solid yellow line where passing is permitted in one direction.
- double, solid yellow lines where passing is prohibited in both directions.

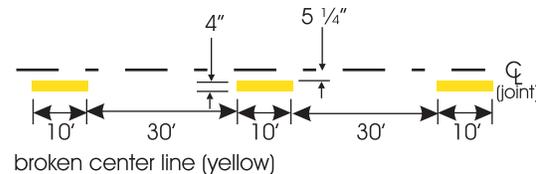
Section 3B.01 of the *MUTCD* recommends use of center lines on paved rural arterials and collectors with a width of 18 feet or greater and traffic volumes exceeding 3000 ADT. Rural roads not meeting these minimum characteristics can also be considered for center-line application when warranted by an engineering study and judgement. Where continuous center-line

markings are not used on low-volume rural roads, short sections may be marked at specific locations such as hills, curves, bridges, etc. to designate the position of opposing traffic. Where center lines are placed, no passing zone lines should also be used where minimum passing sight distances do not exist, at lane reduction transitions, and at approaches to obstructions that must be passed on the right.

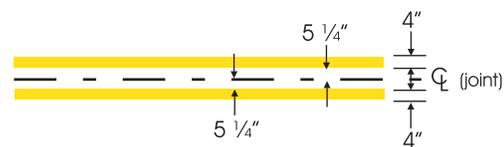
For urban arterials and collectors, the *MUTCD* recommends center lines be placed where roadways are 20 feet or greater in width and traffic volumes meet or exceed 4,000 ADT.

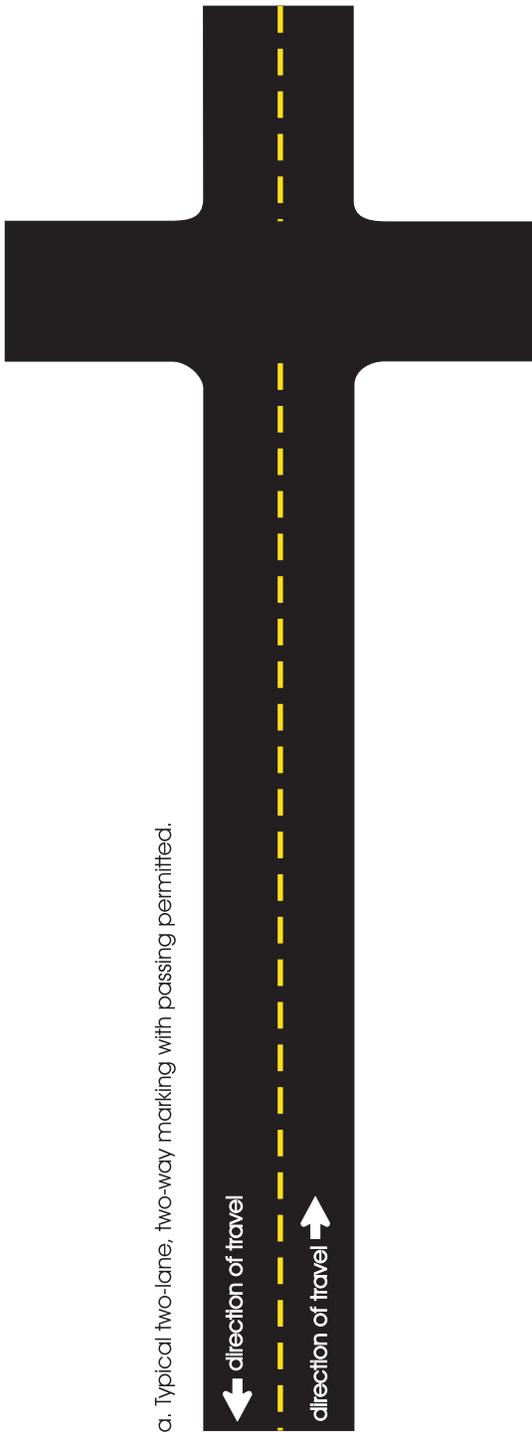
On traveled ways less than 16 feet in width, an engineering study should be used to determine whether center-line markings should be placed.

Typical two-lane, two-way road applications are shown in the following illustrations and those on the following page:

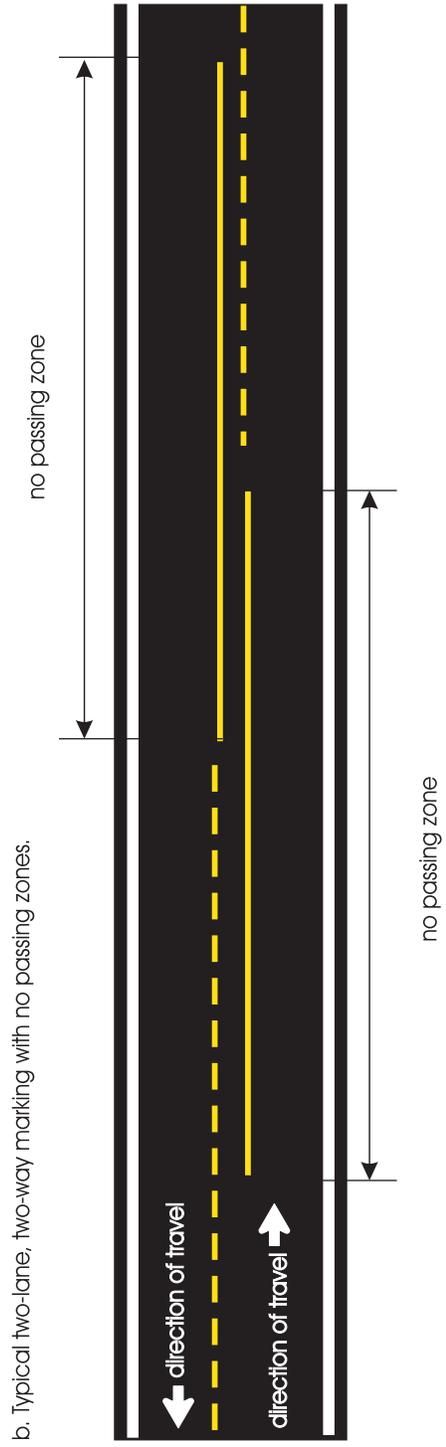


Broken center line (yellow)





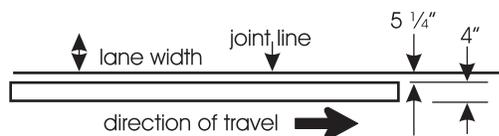
a. Typical two-lane, two-way marking with passing permitted.



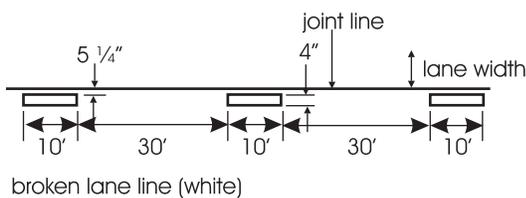
b. Typical two-lane, two-way marking with no passing zones.

Typical two-lane, two-way marking applications

Lane Lines. Chapter 3B of the *MUTCD* recommends lane lines be used on roadways with two or more adjacent traffic lanes with the same direction of travel and at congested locations where the roadway will accommodate more traffic lanes with lane lines than without. Lane lines, when used, are to delineate the separation of traffic traveling in the same direction. These lines are white in color, normally 4 inches in width, and consist of either broken or solid lines. Broken lines indicate lane changing is permitted with appropriate care and solid lines are used to discourage lane changing. Double solid lines are used where crossing lanes is prohibited.



Solid lane line (white)



Broken lane line (white)

No Passing Zones. Requirements and application for no passing lines is described in the “No Passing Zones” section of this manual and in Section 3B.02 of the *MUTCD*.

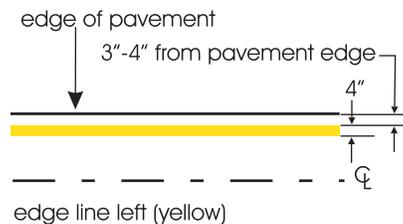
Edge Lines. Edge lines are used to delineate the edges of the traveled way on paved roadways. These markings have unique value as visual reference guides for drivers at night and under adverse weather conditions. When these lines are used, they should not be continued through intersections but should be continued across driveways. Edge lines are normally 4 inches in width and white in color on two-lane, two-way roads and streets. Edge lines should be placed on these streets and highways per Section 3B.07 of the *MUTCD*:

- Rural arterials and collectors with a width of 20 feet or more and an ADT of 3,000 vpd or

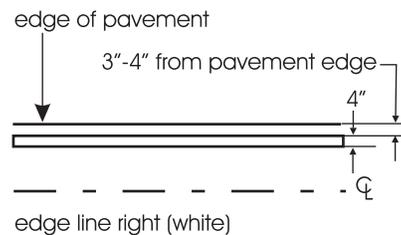
greater, where the edge is not delineated with curbs or other markings.

- Other low-volume roads or locations where engineering study or judgement indicates need.

On low-volume rural roads, edge-line markings may be used at specific locations, such as horizontal curves, narrow bridges or pavement width reductions, curvilinear alignment, or other locations where needed, based on engineering judgement or study. Edge-line markings may also be used where restricting traffic from shoulders or other areas with less structural strength than adjacent pavement is desirable. Edge-line markings can be used with or without center-line markings. Edge lines should not be placed where engineering study or judgement indicates that safety may be adversely affected.



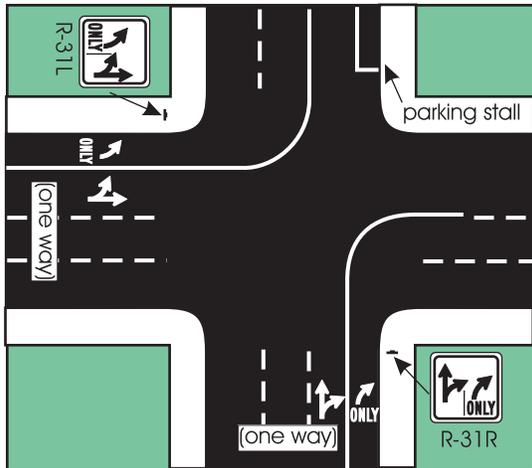
Left edge line, one way (yellow)



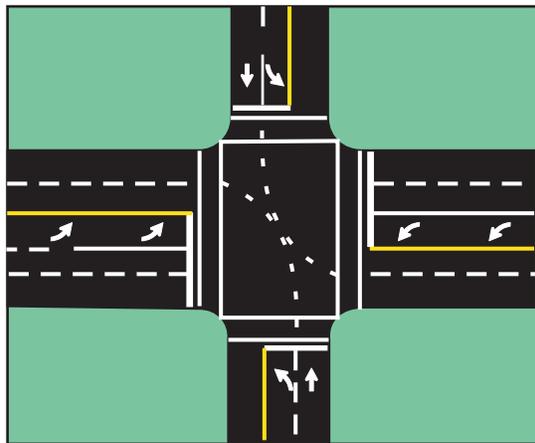
Right edge line (white)

Pavement Marking Extensions through Intersections. Geometric conditions, such as skewed alignments, multiple turn lanes, complex designs, or crash history may warrant a need to consider extension of longitudinal pavement markings through certain intersections. These markings, which can be either center lines or lane lines, may provide additional control and guidance for motorists. The *MUTCD* recommends such extensions be the same color and at least the same width as the line being extended. Dotted or solid lines can be used for extensions

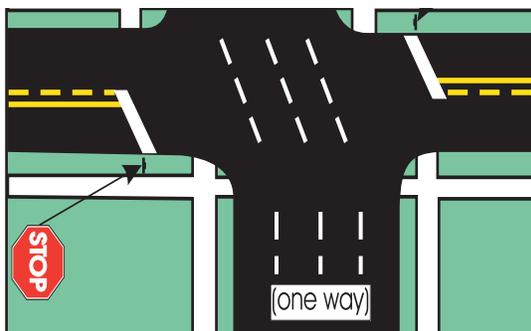
with greater width or raised pavement markers utilized for additional emphasis. The following diagrams illustrate several options for pavement marking extensions through intersections.



Solid double turn lane lines



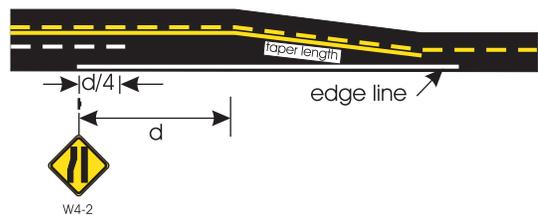
Dotted line markings to extend longitudinal lane line markings



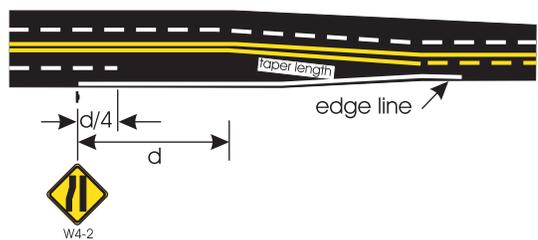
Offset lines continued through the intersection

Lane-Reduction Transition Markings. On roads with pavement markings, Section 3B.09 of the *MUTCD* requires that lane-reduction markings be used to guide traffic where pavement width changes to a lesser number of lanes. On two-way roadways, no passing markings shall be used to prohibit passing in the direction of convergence and continue through the transition area. The *MUTCD* describes transition length computations. The following illustrations show recommended signing and markings for several situations.

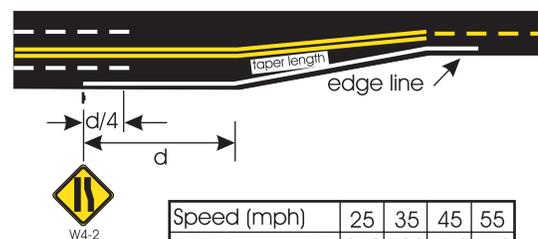
a. from 3 lanes to 2 lanes



b. from 4 lanes to 3 lanes



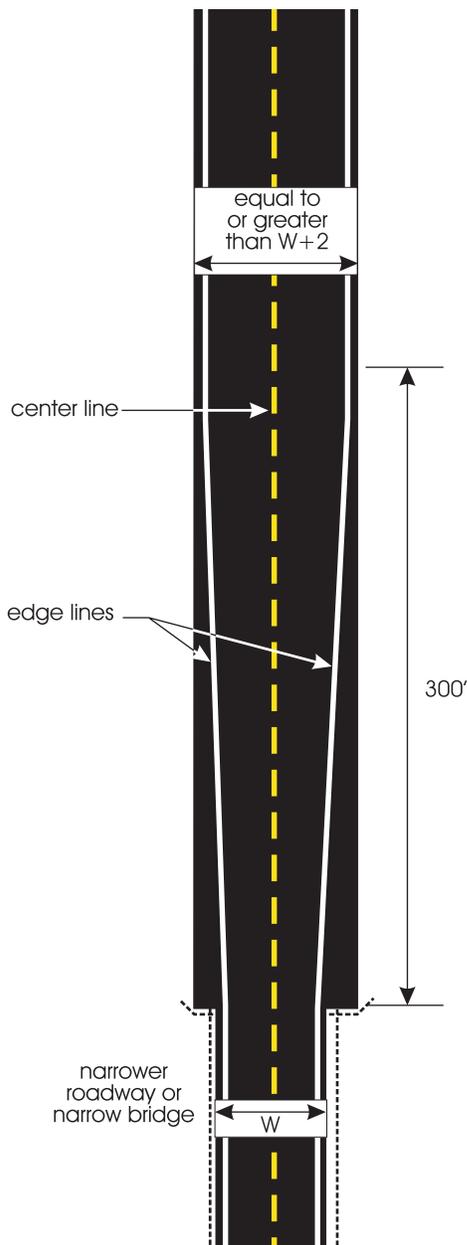
c. from 4 lanes to 2 lanes



Speed (mph)	25	35	45	55
"d" Distance (ft)	250	400	550	750

Pavement markings and signing for transitions in lanes

In addition, where a narrow bridge or abrupt narrowing of pavement width occurs, it is suggested that edge transition lines be added for traffic guidance. The Iowa Department of Transportation's *Manual on Pavement Marking Program* recommends a transition length (taper) of 300 feet. Refer to the following illustration for suggested edge-line placement.



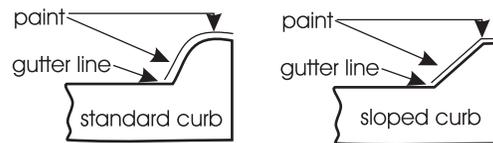
Edge-line transition at abrupt changes in pavement width or approaches to narrow bridges

Curb Markings. Curb markings, when used, are most often intended for delineation or to reinforce parking restrictions. When used for delineation, curb markings should follow the general principles of markings in Chapter 3A of the *MUTCD*. Colors for those markings would generally be either retroreflective yellow or white, depending on roadway design.

When used for no parking restrictions, curb markings may be used as a supplement to regulatory signing, especially where curbs can be obliterated by snow, ice, or debris. When signs are not used, it is suggested that a legible word marking be stenciled on the curb, such as “No Parking.” Because yellow and white colors are routinely used for delineation, Section 3B.21 of the *MUTCD* allows local authorities to prescribe special colors as a supplement to standard signing for parking regulations. Other colors, such as blue (to designate handicap parking), are also permitted by the *MUTCD*.

Some jurisdictions have established guidelines for parking restrictions at intersections primarily based on sight limitations for approaching traffic. These restrictions can vary from a minimum of 10 feet from an established crosswalk for minor street approaches to 30 feet from crosswalks at signalized intersections.

All curb markings can be costly and labor intensive to apply and maintain; therefore, placement should be carefully studied prior to initial installation.

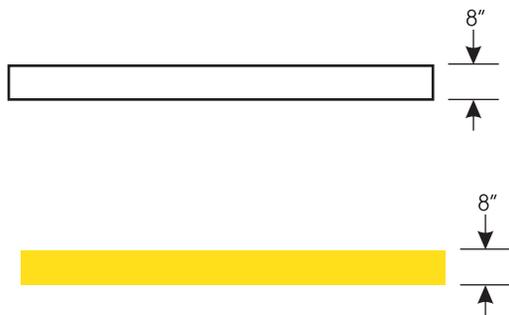


paint 12" width for 6" standard curb,
paint 14" width for 6" sloped curb.

Curb markings (yellow or white)

Channelizing Markings. Channelizing markings consist of minimum 8-inch wide or double solid lines. They can be yellow when used to separate traffic traveling in opposite directions or white for traffic moving in the same direction. A common use of channelizing markings is to guide traffic at entrance and exit ramps of interchanges. However, these markings can also provide valuable guidance assistance to motorists when an obstruction occurs in the middle of a roadway, such as bridge piers or refuge and median islands. Additional emphasis can be

obtained by crosshatching the triangle-shaped island area with the same color markings as the channelizing lines. Section 3B.10 of the *MUTCD* further describes requirements and application of channelizing markings.



Channelizing markings (white and yellow)

Transverse Markings. Transverse pavement markings include stop bars, crosswalks, speed measurement markings, and miscellaneous lines such as parking space markings. Section 3B.15 of the *MUTCD* requires these markings to be white in color.

Stop bars are solid white lines, 12 to 24 inches in width, that extend across all approach lanes. These lines can be used in conjunction with Stop signs or traffic signals where indication of vehicle stopping location is important for pedestrian safety, where crossings exist, or for motorist safety, such as at signalized railroad crossings.

Stop bars can be used in rural or urban locations and with or without crosswalk markings. When used, stop bars should normally be placed 4 feet in advance of and parallel to marked crosswalks. Where crosswalks are not marked, stop lines should be placed at the desired vehicle stopping point, but not more than 30 feet nor less than 4 feet from the intersecting roadway.

When used at Stop sign locations, stop bars should be placed in line with the Stop sign. However, if the sign cannot be located at this point, the stop line should be placed at the

recommended stopping point. Placement location for stop bars should always consider motorists' vision of crossroad traffic from the stopped position. Also consider whether growing crops may restrict vision at certain times of the year. Drivers should be able to adequately view approaching traffic from the stop-bar position or this marking will not be effective.



Stop bar (white)

Crosswalks. Crosswalks are used to guide pedestrians across intersections and roadways by defining the most appropriate crossing path. These markings also warn motorists of pedestrian crossing points. Crosswalks can be installed at intersections controlled by traffic signals or Stop signs and noncontrolled intersections. When used in nonintersection applications, these markings will legally establish the crosswalk.

Section 3B.17 of the *MUTCD* requires that crosswalks consist of solid white lines marking both edges of the crosswalk. Furthermore, these lines shall not be less than 6 inches nor more than 24 inches in width and should not be placed less than 6 feet apart. It is also recommended that crosswalk lines extend entirely across the paved roadway to discourage diagonal pedestrian travel where this movement is not intended.

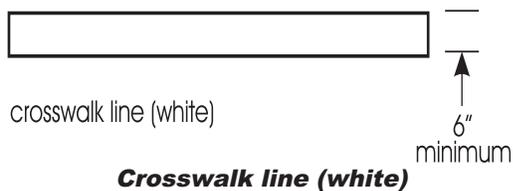
For additional visibility, the area of the crosswalk may be marked with white diagonal lines. Increased durability can be gained by using white longitudinal lines placed perpendicular to the crosswalk. These lines may be 6 feet long, approximately 12 to 24 inches in width and spaced 12 to 60 inches apart. Spacing the markings to avoid wheel paths will reduce wear.

Placement of crosswalks is encouraged by the *MUTCD* at intersections where substantial

conflicts exist between vehicles and pedestrians. Marked crosswalks are also suggested at points of pedestrian concentration, such as loading islands, midblock crossings, and locations where a proper crossing may be difficult to identify. However, the *MUTCD* recommends that crosswalk markings not be installed indiscriminately. Engineering studies should be performed prior to placement, particularly away from locations controlled by signals or Stop signs. Factors to be considered in studies include school zones, shopping areas, pedestrian and vehicle volumes, traffic speeds, sight distance, and various physical features of the roadway. The type and age of pedestrians are also important factors to consider.

At nonintersection locations, appropriate warning signs and parking restrictions are necessary since pedestrian crossings may be unexpected.

A typical crosswalk line and several options for marking crosswalks are shown in the following figures.

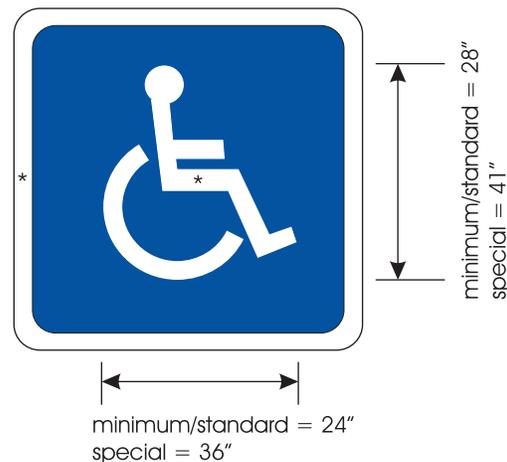


*Spacing of lines selected to avoid wheel path.
Typical crosswalks

For discussion of supplemental crosswalk identification devices, please refer to the article "Movable Stop Signs for School Zones" (G6) in this manual.

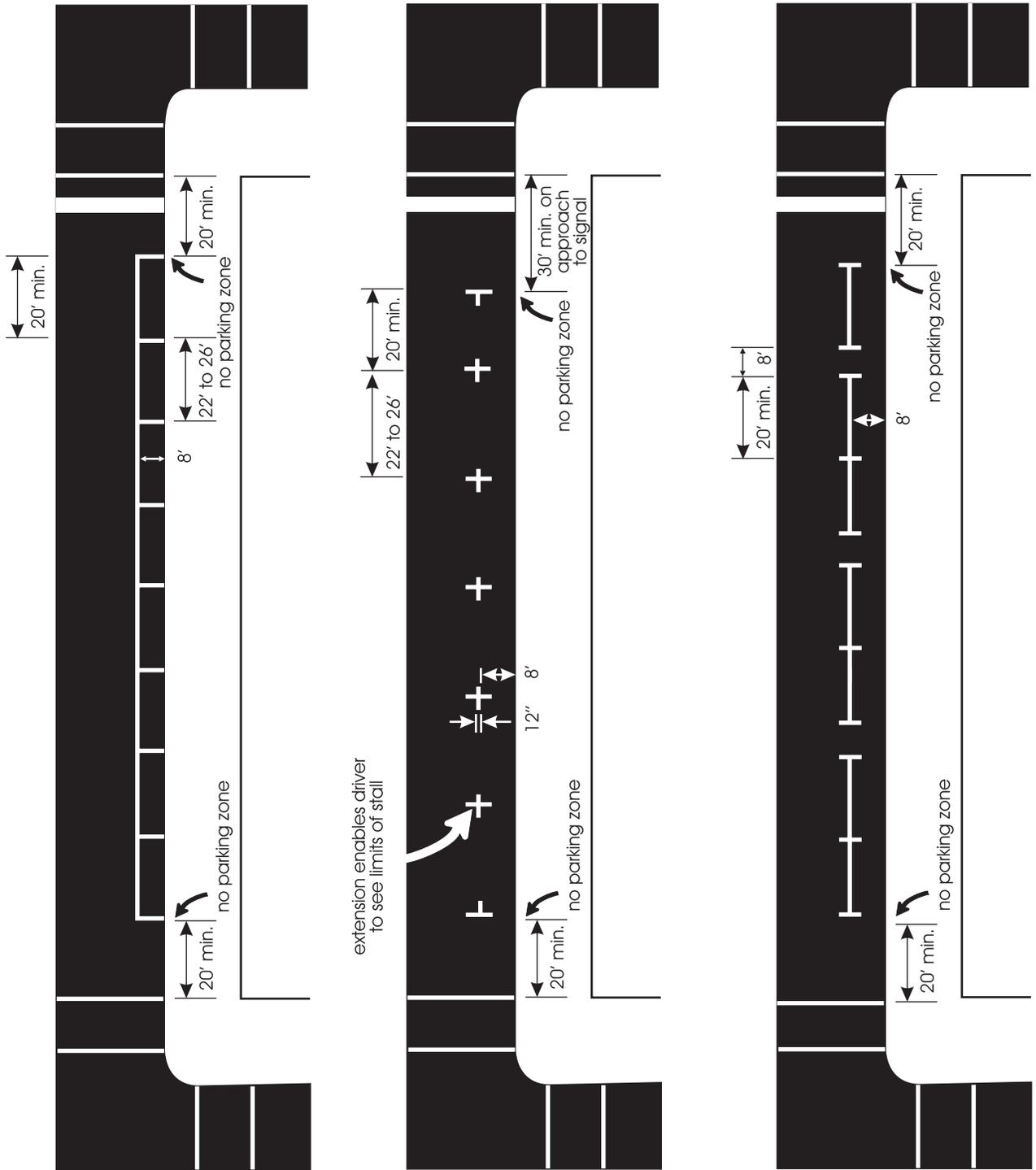
Parking Spaces. The marking of parking spaces will encourage more efficient use of available parking along public streets. Markings can also be used to prevent encroachment at fire hydrants, bus stops, loading zones, intersection approaches, and other locations where parking restrictions are established. Please refer to Section 3B.18 of the *MUTCD* for more detailed information. Typical parking spaces are shown in the figures on the following page.

Parking-space markings are always white, with the exception that blue may be used to designate parking for persons with disabilities. The International Symbol of Access (ISA) marking can be used in each space reserved for that purpose. A blue background with white border may supplement the wheelchair symbol as shown in the following figure.



* stroke width
minimum/standard = 3"
special = 4"

**International Symbol of Access
parking-space marking**



Suggested parking-space markings

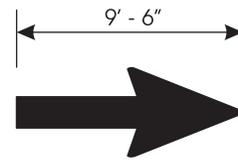
Words and Symbols. Words and symbols can be placed on the pavement surface to provide guidance, warning, or regulation for traffic. Symbols are preferred over word messages. Section 3B.19 of the *MUTCD* requires these markings to be white in color. The design should comply with the FHWA's *Standard Alphabet for Highway Signs and Pavement Markings*. Use of these markings has been found to reduce crashes in mandatory turn lanes and at approaches to stop and yield-controlled intersections. Typical words and symbols include the following:

- Regulatory—Stop, Yield, Right or Left Turn Only, arrows, or speed limitations
- Warning—Stop Ahead, Yield Ahead, Signal Ahead, and School, Pedestrian, or RR X-ing
- Guide—various route designations or street names

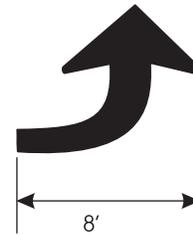
For maximum effectiveness, the following recommendations are listed for word and symbol markings:

- Large letters and numerals should be a minimum of 6 feet in height. Larger lettering and symbols improve visibility.
- No more than three lines of information should be presented at one location.
- If more than one line of message is included, the first word should be nearest approaching drivers.
- Spacing between words or symbols should be at least four times the height of those characters for low speed roads, but never more than ten times that height.
- Words and symbols should cover no more than one lane width, except for School markings, which may extend over two lanes.
- For mandatory turn lanes, lane-use arrows and the word “only” should be used. In addition, standard signing as described in Part 2 of the *MUTCD* should be installed.
- The word “stop” must not be used unless accompanied by a stop line and Stop sign. This message is also not appropriate unless all vehicles are required to comply at all times.
- Use of nonstandard word messages and markings should be avoided.

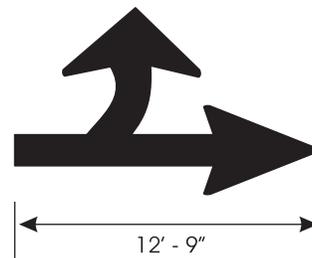
The following figures illustrate several typical word and symbol markings.



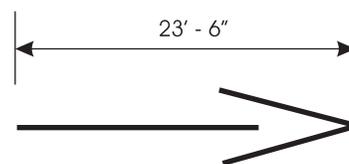
Through lane-use arrow



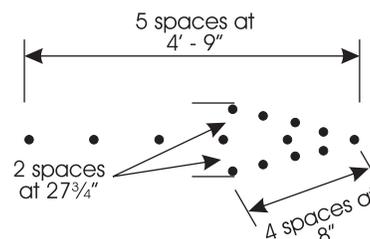
Turn lane-use arrow



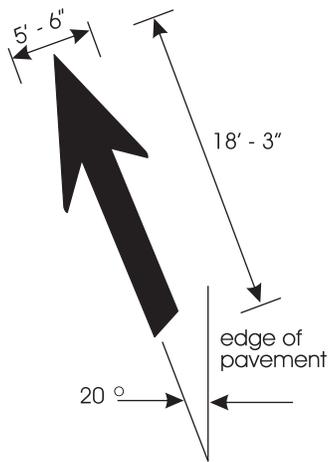
Turn and through lane-use arrow



Wrong way arrow

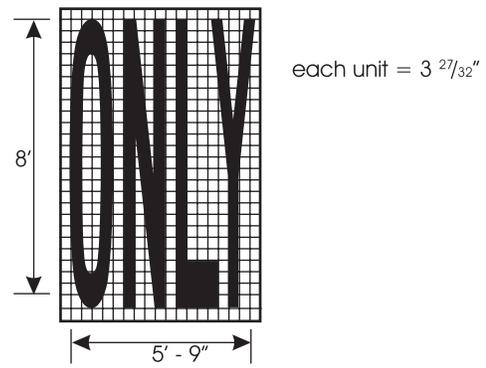


Wrong way arrow

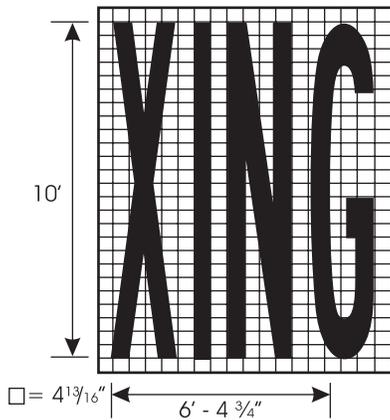


Lane-reduction arrow

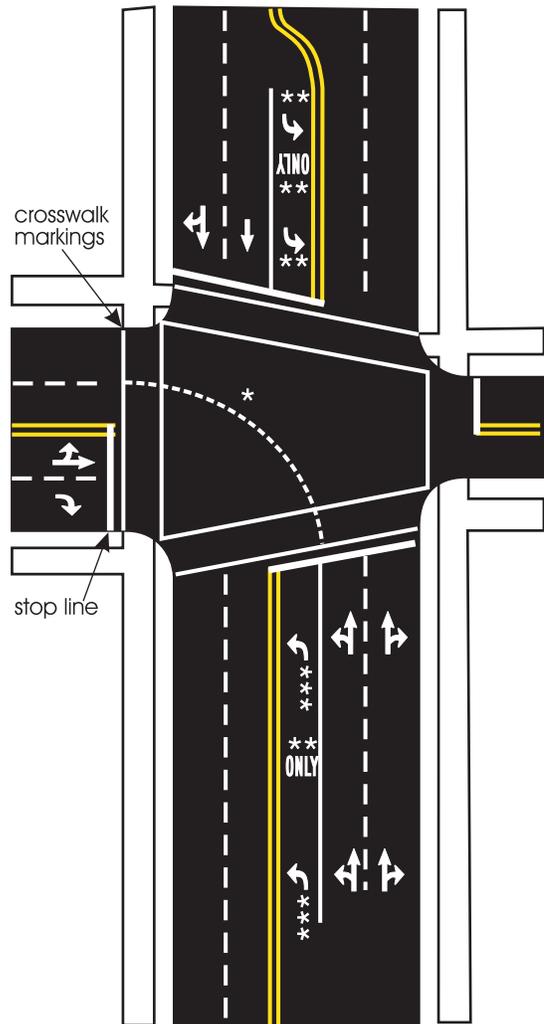
The markings shown here are standard sizes for normal installation. Sizes may be reduced approximately one-third for low-speed urban condition. Larger sizes may be needed for freeways, above average speeds, and other critical locations. A narrow elongated arrow design is optional. For proper proportion, see *Standard Alphabet of Highway Signs and Pavement Markings* (FHWA).



"Only" marking

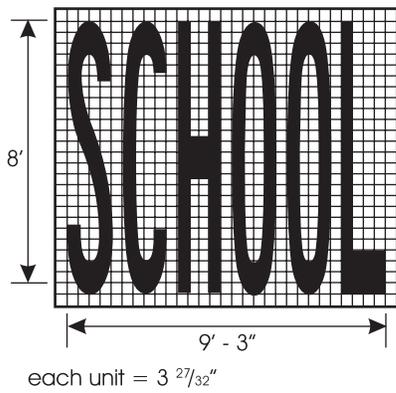


"XING" marking

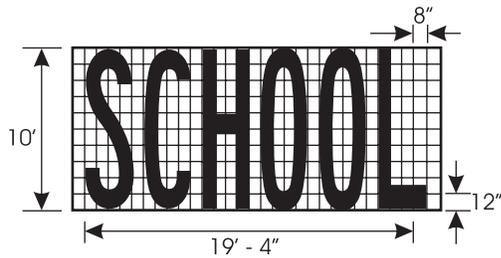


- * Line extension may be solid or dotted line.
- ** Optional.
- *** Required where through lane becomes mandatory turn lane.

Typical lane-use control word and symbol markings



"School" marking, one-lane approach



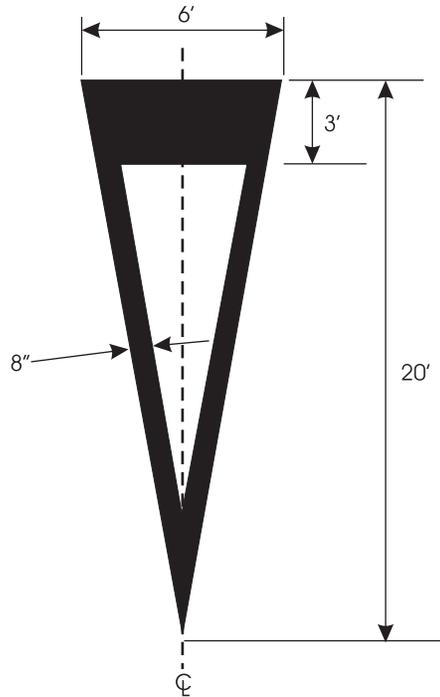
"School" marking, two-lane approach

New Symbols. The millennium edition of the *MUTCD* contains several additional symbols and markings, such as

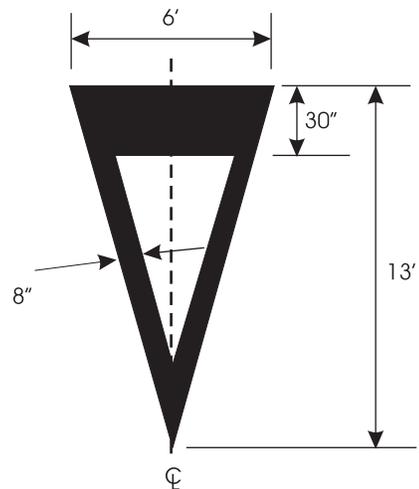
- Yield Ahead symbols
- markings for roundabouts and other circular intersections
- advance warning markings for speed humps and tables

Examples of these markings are shown in the following figures.

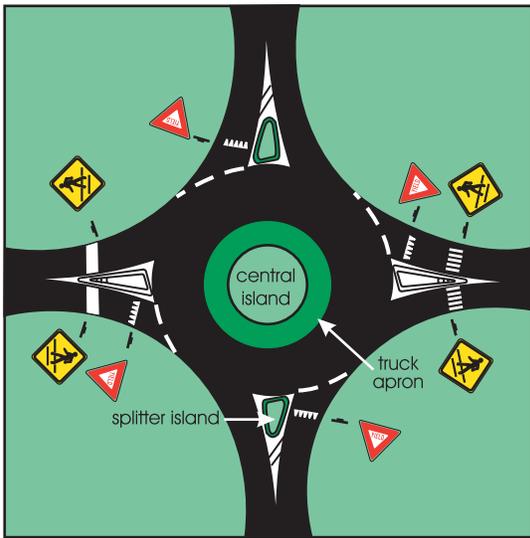
posted or statutory speed limit \geq 45 mph



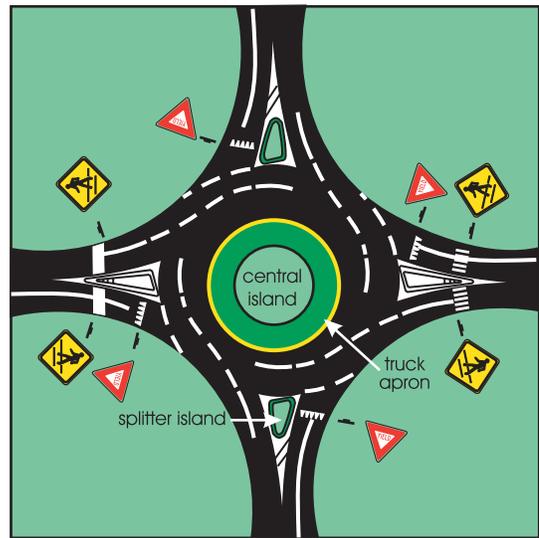
posted or statutory speed limit < 45 mph



Typical yield ahead triangle symbols



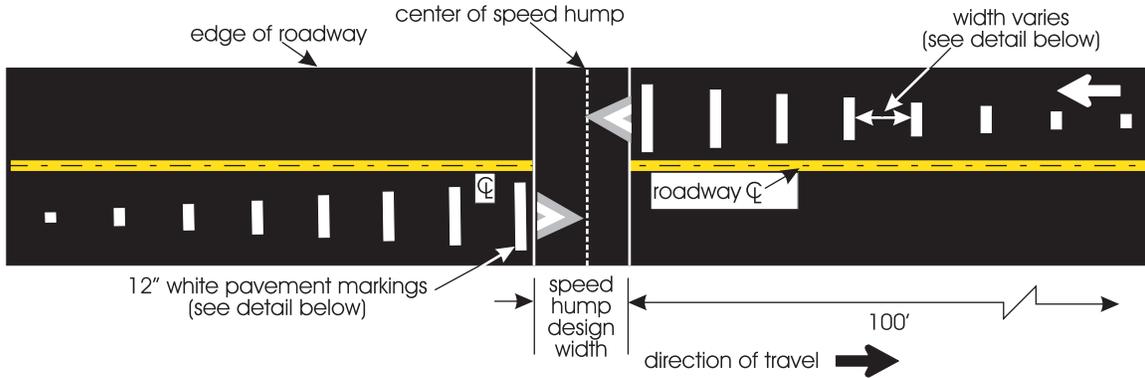
**Typical markings for roundabouts,
one lane**



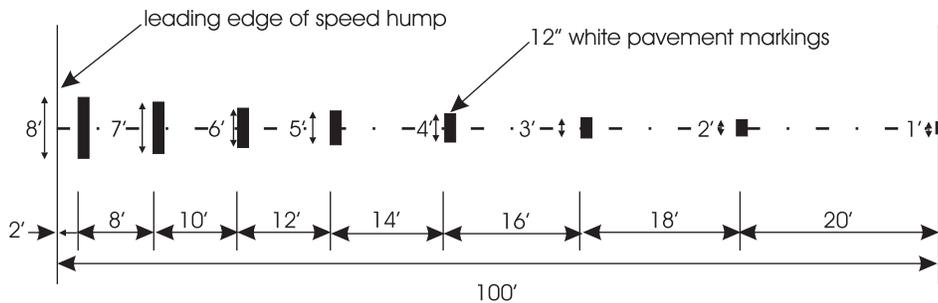
**Typical markings for roundabouts,
two lanes**

As an option, advance pavement wording such as “bump” or “hump” may be used prior to a speed hump, either alone or in conjunction with advance speed hump markings.

Section 2C.22 of the *MUTCD* describes the use of a Speed Hump sign (W17-1) to warn of these vertical deflections.



Advance warning markings for speed humps



Detail of advance warning for speed humps

Section E

Object Markers

E: Object
Markers

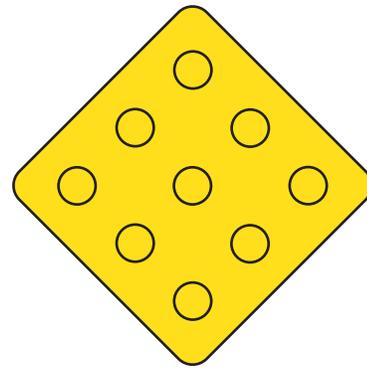
Object Markers

Chapter 3C of the *MUTCD* describes the use of object markers to warn of obstructions within or adjacent to the roadway. When used, these devices should consist of an arrangement of one or more of the following designs:

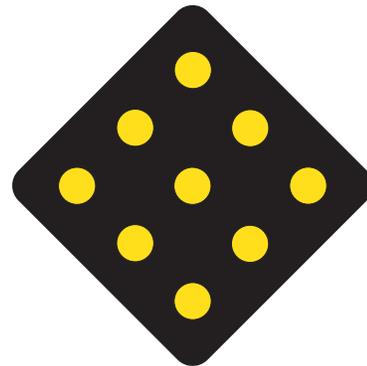
- **Type 1**—Either a marker consisting of nine yellow retroreflectors, each with a minimum dimension of 3 inches, mounted symmetrically on a yellow or black diamond panel 18 inches or more on each side, or a yellow retroreflective diamond panel of the same dimensions.
- **Type 2**—Either a marker consisting of three yellow retroreflectors, each with a minimum dimension of 3 inches, arranged either horizontally or vertically, or an all-yellow retroreflective panel at least 6 inches x 12 inches in dimension.
- **Type 3**—A striped marker, 12 inches x 36 inches, consisting of a vertical rectangle with alternating black and retroreflective yellow stripes sloping downward at an angle of 45 degrees to the side of the obstruction on which traffic is to pass. The minimum width of the yellow stripe is 3 inches. The appearance may be better if the black stripe is wider than the yellow.

The mounting height to the bottom of the markers should normally be 4 feet above the surface of the nearest traffic lane for marking obstructions 8 feet or less from the shoulder or curb, and 4 feet above ground surface for marking objects greater than 8 feet from the shoulder or curb.

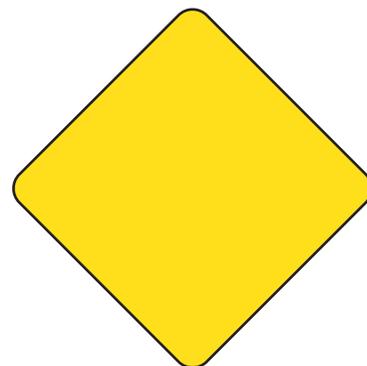
When object markers are used for a hazardous object that requires a lower or higher mounting, the vertical mounting height may vary according to need but should be documented.



18"x18"

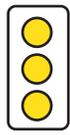


18"x18"



18"x18"

Typical Type 1 object markers



6" x 12"



6" x 12"



12" X 6"



12" X 6"

Typical Type 2 object markers

Obstructions located within the roadway shall be marked with either Type 1 or Type 3 markers. Additional emphasis can be provided on larger surfaces by painting the face of the obstruction with diagonal stripes in a design similar to Type 3 object markers. In lieu of object markers, appropriate signs, such as the Keep Right sign (R4-7) and the Double Arrow sign (W12-1) can be used, as described in Sections 2B.28 and 2C.18 of the *MUTCD*. Appropriate pavement markings, as described in Chapter 3B of the *MUTCD*, should be used to mark the approach to the obstruction.



OM-3L
12" x 36"



OM-3R
12" x 36"

Typical Type 3 object markers

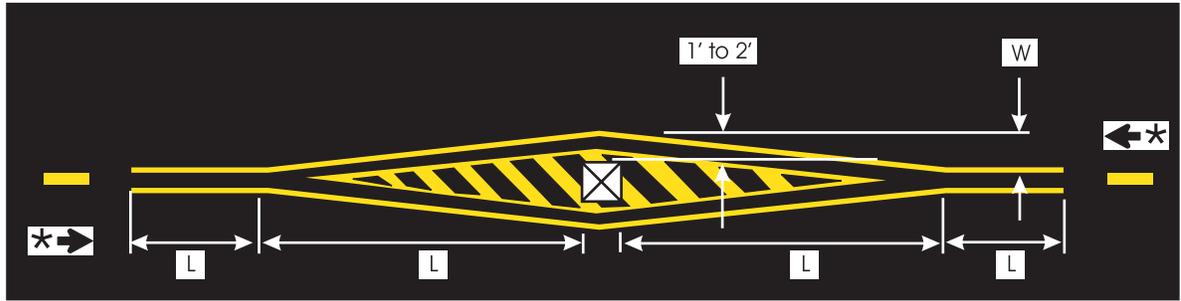


R4-7

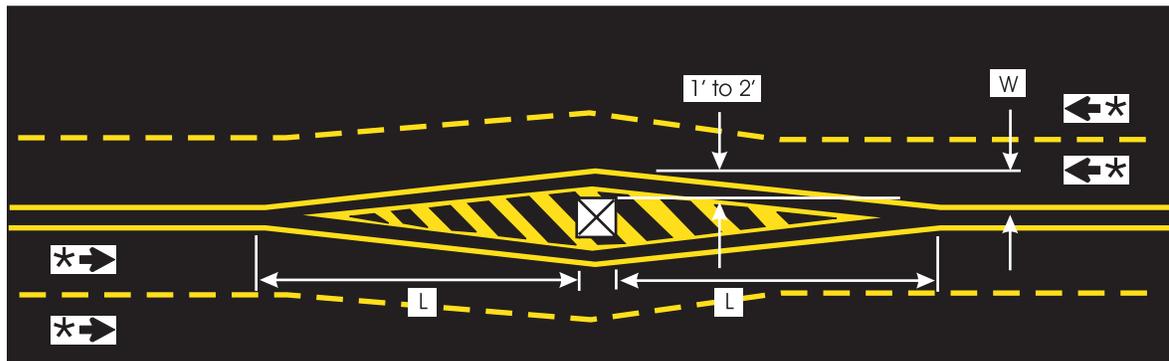


W12-1

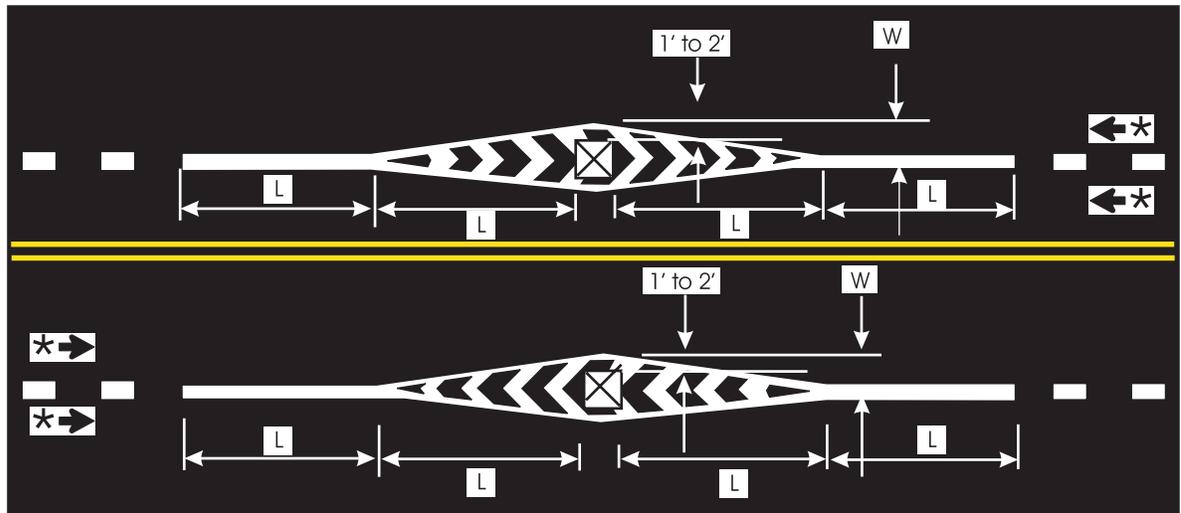
a. center of two-lane road



b. center of four-lane road



c. traffic passing both sides of obstruction



* Direction of travel.

Typical approach markings for obstructions in the roadway

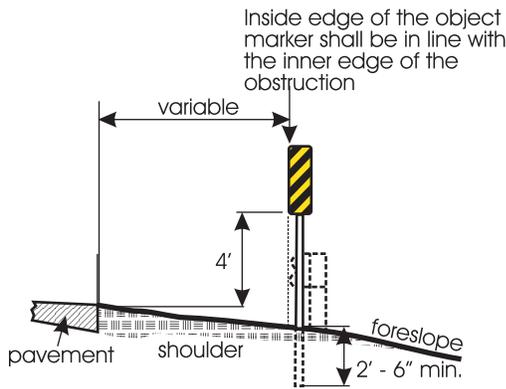
For speeds 45 or more, $L = S \times W$
 For speeds 40 or less, $L = WS^2/60$

Minimum length of $L = 100$ feet in urban areas
 $L = 200$ feet in rural areas

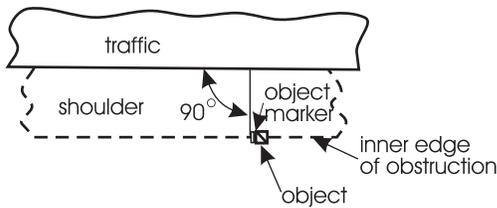
$S = 85$ th percentile speed in miles per hour
 $W =$ Offset distance in feet

Length "L" should be extended as required by sight distance conditions.

Objects not actually in the road, but close to the edge of the traveled way, may need to be marked. Such obstructions include overpass piers, bridge abutments, handrails, and culvert headwalls. Other physical conditions such as narrow shoulders, dropoffs, islands, gores, and abrupt changes in alignment are potentially hazardous to traffic that leaves the travelled way. Type 2 or 3 object markers can be used to mark these locations, with the inside edge of the marker in line with the inside edge of the obstruction (examples of these applications are presented in the article entitled “Narrow Bridges and Culverts” (C11) in this manual). Standard warning signs, as described in Chapter 2C of the *MUTCD*, also should be used where applicable.



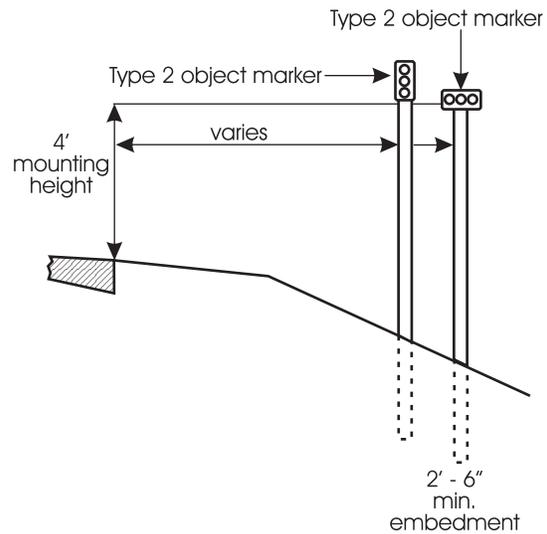
Typical installation of Type 3 object marker



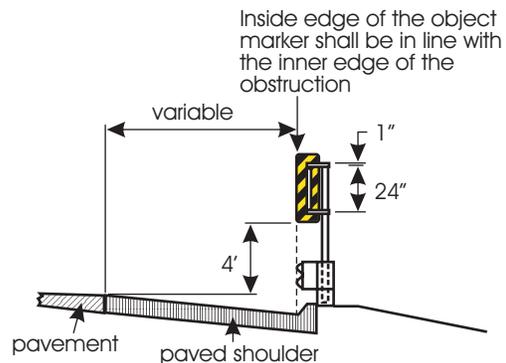
Object marker should be installed normal to direction of roadway traffic

Typical installation

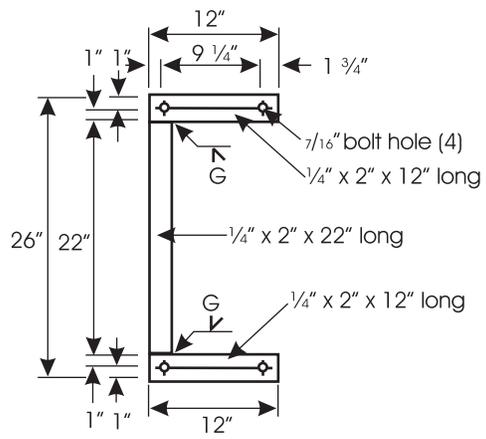
End-of-Roadway markers are intended to be used at the termination of a road or street where no alternate path for vehicles exists. These markers consist of nine red retroreflectors, each with a 3-inch minimum dimension mounted symmetrically on an 18-inch red or black diamond panel, or simply an 18-inch retroreflective diamond-shaped red panel. Be sure that the minimum mounting height of these markers is 4 feet. Proper advance warning signs should also be used. These devices are further discussed in the article “End of Road or Street” (G2) in this manual.



Installation details and mounting height of Type 2 object markers



Typical offset installation of Type 3 object marker



Typical offset bracket

Section F

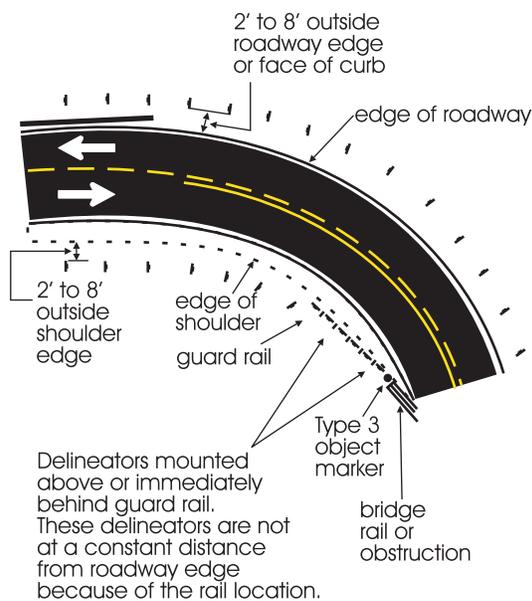
Delineators

F:
Delineators

Delineators

Road delineators are light reflecting devices mounted along the side of a roadway in series primarily to guide traffic through alignment changes. These devices can be used to supplement other signs and devices where additional guidance for traffic is desirable. The color of delineators shall be the same as the color of edge lines described in Sections 3B.01 and 3B.04 of the *MUTCD*. Delineator design and requirements are found in Chapter 3D of the *MUTCD*. Delineators should be mounted 4 feet above the

roadway and placed 2 to 8 feet outside the shoulder or road edge. Distance from the road edge and between devices should remain constant unless existing obstructions or road features prohibit this placement. Several delineators should always be visible simultaneously to motorists. Trial observations should be made at night to determine effectiveness of delineators after installation. A typical delineation layout and a table listing suggested spacing are shown in the following figures.



Typical delineation layout

Suggested spacing for highway delineators on horizontal curves

Radius of Curve (feet)	Spacing on Curve (feet)
50	20
150	30
200	35
250	40
300	50
400	55
500	65
600	70
700	75
800	80
900	85
1000	90

Distance in feet (rounded to the nearest 5 feet).

Section G

Additional Situations

G: Additional
Situations

Bicycle Paths and Lanes

The use of bicycles for recreation, exercise, and general transportation has continued to increase both on and off public roadways. In Iowa, except where specifically prohibited, bicycles are permitted to share roads and streets with motorized vehicles. Wide variation in bicycle rider abilities and experience, slower operating speeds, and reduced visibility contribute to the challenge of providing effective signing and pavement markings for both bicycle riders and drivers who encounter bicycle traffic.

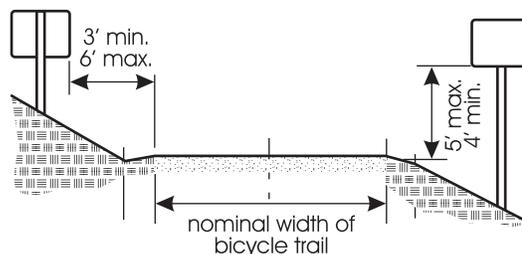
The *MUTCD* includes an entire section, Part 9, to address traffic controls for bicycle facilities in addition to references in Parts 2 and 3. Part 9 identifies several types of bicycle use facilities: bikeway, bicycle path, preferential bicycle lane, shared roadway and/or path, and designated bicycle route. Some of these are exclusive for bicycle usage; others are shared-use facilities. The *MUTCD* explains signing and marking needs for each type .

Exclusive Bicycle Facilities

Part 9 of the *MUTCD* describes required traffic control for exclusive bicycle facilities, including bicycle paths on which motorized vehicle travel is prohibited.

Signing and markings on bike paths are generally very similar to requirements for other roadways in design and application requirements including colors, lettering, symbols, retroreflectorization, and shape. Reduced sizes, in recognition of slower travel speeds and lessened right of way width, are allowed. Mounting height and lateral placement may also be reduced on exclusive bicycle facilities.

Signs. Signs are used to serve three basic purposes: regulating bicycle usage, warning of unexpected conditions, and directing riders along established routes. Overuse of signs is not recommended.



Bicycle sign placement on a trail

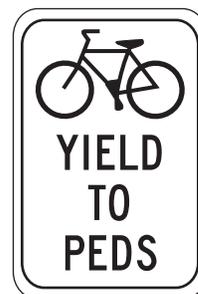
Some typical regulatory signs include Motor Vehicle Prohibition sign (R5-3) and Bicycle Restriction signs (R9-5 and R9-6). Stop (R1-1) and Yield (R1-2) signs can also be used where needed. Shared Sidewalk signs (R9-7) are suggested where bicycles and pedestrians use the same facility.



R5-3



R9-5



R9-6



R9-7



M1-8

Warning signs include the Hazardous Condition sign (W8-10), used where trail conditions could cause the rider to lose control—such as slick pavement or bridge decks, wet trail surface, or rough surface. These conditions can be further explained through the use of supplemental plaques.



W8-10 and Slippery When Wet supplemental plaque



M1-9



M4-11



M4-12

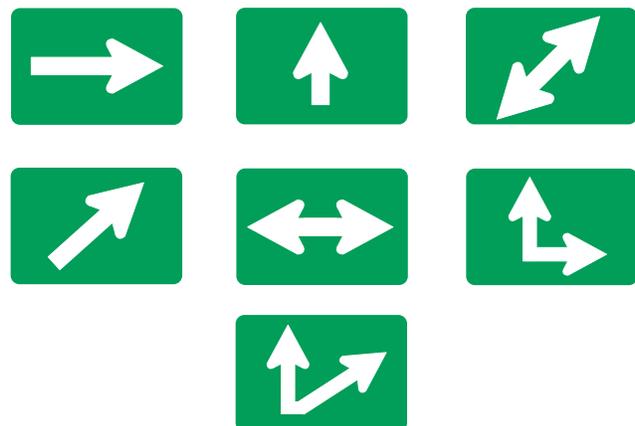


M4-13

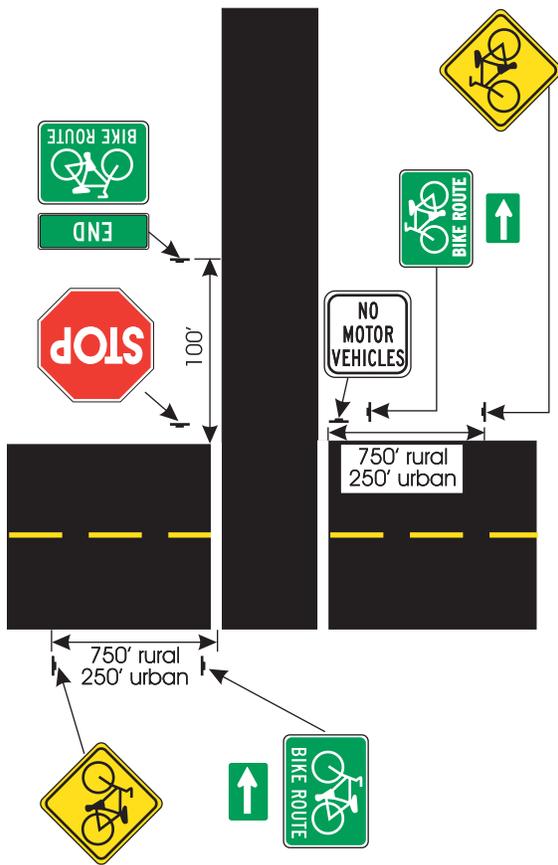
Guide signs used on bicycle trails include Bicycle Route signs (D11-1) and Bicycle Route markers (M1-8 and M1-9). These signs are green and retroreflectorized white and are placed at frequent intervals to keep riders informed of any changes in route direction. Several supplemental plaques—including Begin, End, To, and arrow designations (M7-1 through M7-7)—and specific destinations can also be effectively used.



D11-1



M7-1 through M7-7



Typical signing for beginning and ending of bicycle trail

Pavement Markings. Pavement markings can also be used effectively on exclusive bicycle facilities.

A 4-inch wide yellow center line stripe can be used to separate opposite directions of travel—broken where sight distance permits passing and solid elsewhere. This practice can be especially beneficial with heavy bicycle volumes, on curves with restricted sight distance, and on unlighted paths where nighttime riding is anticipated.

White edge lines are also beneficial where evening or night riding is expected. Even though bicycles are not equipped with strong headlights, the added visibility of retroreflectorized pavement markings can help the rider to navigate.

Shared-Use Facilities

Facilities where bicycles and motorized vehicles use the same traveled way include bikeways, designated bicycle lanes, and shared roadways. Traffic control devices on shared-use facilities must be observed by both bicycle riders and motorized vehicle operators; thus the *MUTCD* requirements for design and application described in Parts 2 and 3 are applicable.

Signs. As with exclusive bicycle facilities, signs used in shared-use facilities can be identified in three groups: regulatory, warning, and guide. Guide signing for shared-use facilities are similar to those described earlier, but dimensions should be increased to improve recognition by motorists.

Typical regulatory signs used on shared streets and roads include the Bicycle Prohibition sign (R5-6), Designated Lane signs (R3-16 and R3-17), and No Parking signs (R7-9).



R5-6



R3-16



R3-17



R7-9

The Hazardous Condition sign (W8-10) and the Hill sign (W7-1 or W7-5) are a typical warning signs on shared-use roadways where long, steep downgrades are encountered.

A Share the Road plaque (W16-1) can be used to supplement a Bicycle Crossing sign (W11-1) to advise motorists to be alert for slower moving bicycle traffic.



W7-5



W11-1 and W16-1

Bicycle Crossing Warning signs (W11-1), when installed at the actual crossing location, require the supplemental downward pointing arrow (W16-7). See Section 9B.15 of the *MUTCD* for more information.

The Bicycle Crossing sign (W11-1) is also used on roadways in advance of a designated bicycle crossing. The *MUTCD* recommends placement of these signs approximately 750 feet in advance of a crossing in rural areas with high speeds and approximately 250 feet in advance of a crossing in lower speed urban locations. When crossings occur at controlled intersections, use of this signing may not be needed. The fluorescent yellow-green color may be used for this sign.



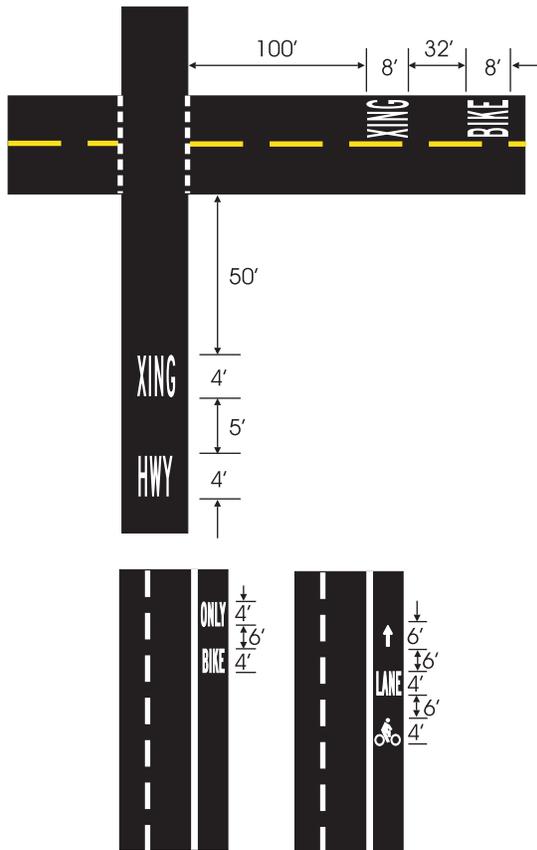
W11-1 and W16-7



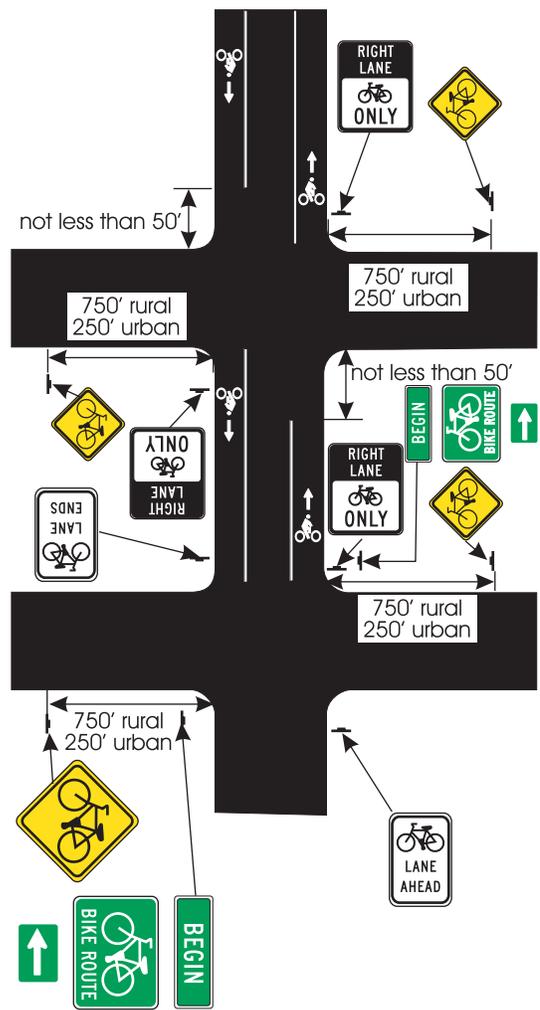
**W11-1 and W16-7
(fluorescent yellow-green)**

Pavement Markings. The use of pavement markings on roadways with designated bicycle lanes is especially important. These markings indicate a delineation of lanes for motorized vehicles and bicycle traffic, provide advance information about turning and crossing maneuvers, and can assist the bicycle rider by indicating proper travel paths.

Specific design and application recommendations for pavement markings on bicycle lanes are included in Part 9 of the *MUTCD*. These recommendations include 6-inch wide white lane lines, preferential lane symbols, word messages, and bicycle symbols. Examples of these uses are illustrated in the following figures.



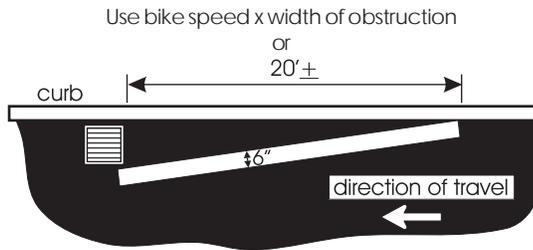
Word and symbol pavement markings for bicycle facilities



Typical signing for beginning and ending of designated bicycle lane

Refer to Part 9 of the *MUTCD* for appropriate signing recommendations.

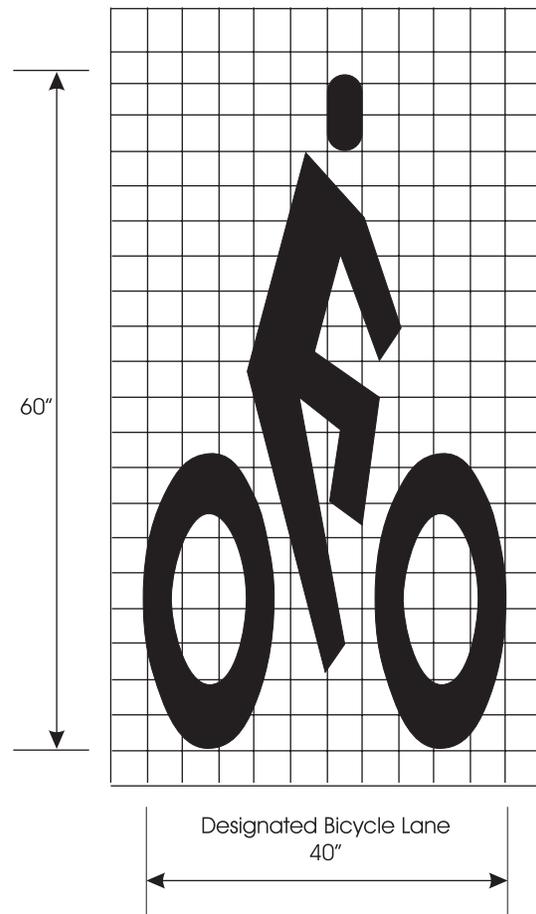
Where a storm drain or intake in the roadway cannot be avoided or modified for safe bicycle travel, the special pavement markings illustrated below can be used effectively.



Typical marking in advance of drainage hazard

Retroreflectorized object markers—Types 1, 2, or 3, as described in Chapter 3C of the *MUTCD*—can be installed at locations where objects or obstructions that could be hazardous to bicyclists are adjacent to the trail. Objects or obstructions might include utility poles, trees, and railroad tracks.

The following is the suggested bicycle pavement marking symbol for use in preferential bicycle lanes. The color of this marking should be white. A template is available from American Sten-Cyl of Mahwah, New Jersey, through LaFarge Road Marking of Omaha, Nebraska.



Suggested bicycle pavement marking for use in preferential bicycle lanes
(Template directions should be adjusted to meet requirements)

End of Road or Street

When a public road or street terminates and no alternate vehicular path exists, installation of appropriate signing, markers, and barricades may be considered. In addition, more positive control such as chain-link fencing or a guardrail may be added if a physical condition such as a stream or deep excavations exists just beyond the point of closure. Advance warning signs such as Dead End (W14-1), No Outlet (W14-2), or Not a Through Street (W14-1a) may be considered. If used, these signs should be mounted at a location where it is possible for vehicles to turn around.

For urban closures, rural closures on low-speed roads, and rural subdivision streets where placement of a sign will not interfere with property access, end-of-roadway markers, as described in Section 3C.04 of the *MUTCD*, should be used. The recommended mounting height is 4 feet. The number of devices used is dependent on the street width. If the road terminates at a gated entrance, the signs may be bolted or otherwise secured to a gate or fence. Refer to the following illustrations for typical layout suggestions.



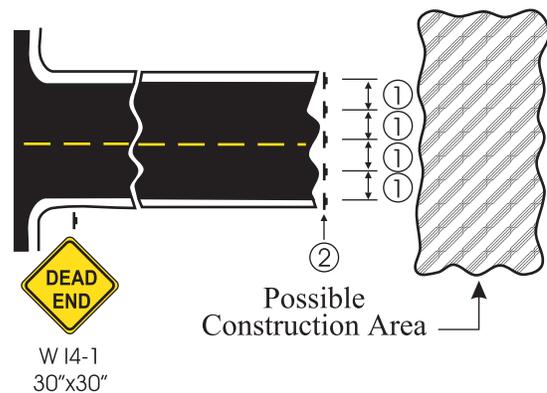
W14-1



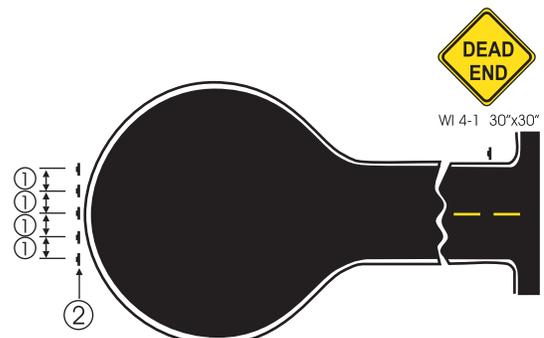
W14-1a



W14-2

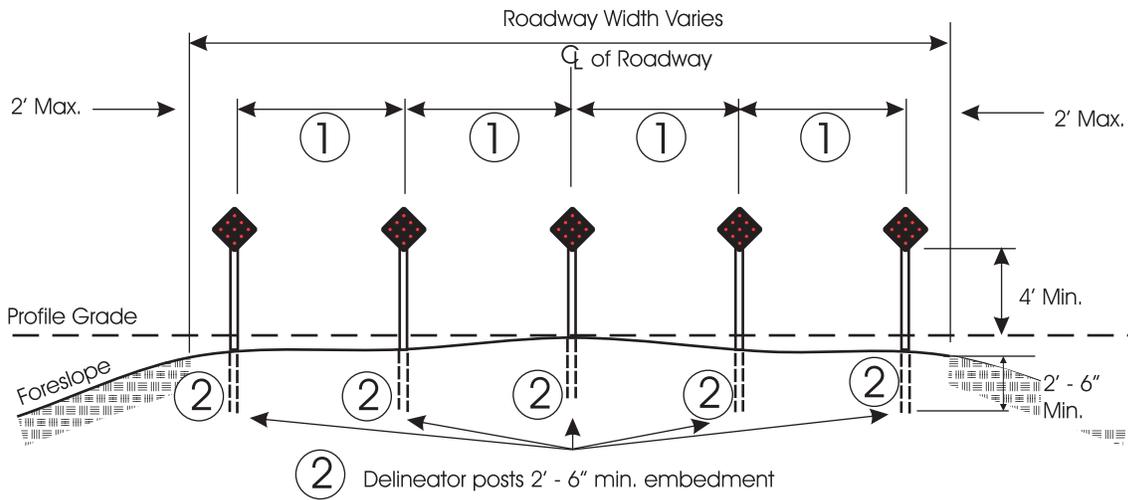


Dead end without cul-de-sac



Dead end with cul-de-sac

- ① Evenly spaced (min. 6', max. 8') as directed by the engineer
- ② Delineator posts, 2'- 6" min. embedment



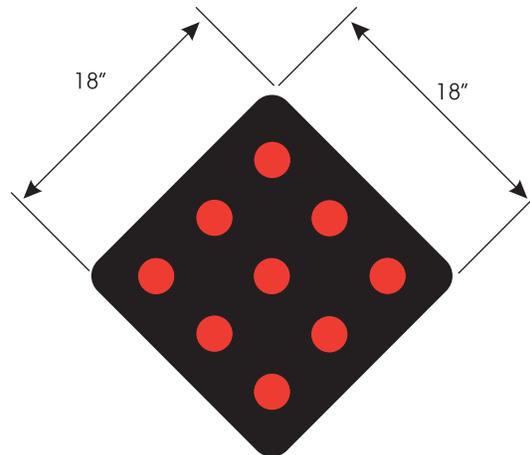
Approach View

(1) Evenly spaced (min. 6', max. 8') as directed by the engineer

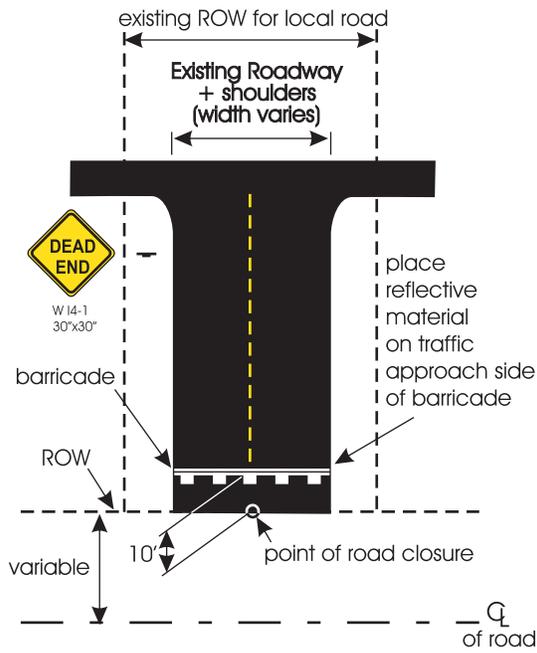
(2) Delineator posts, 2'- 6" min. embedment

General Notes:

This road closure layout is intended for dead-end streets in urban or other residential areas. Additional positive closure, such as a chain-link fence or guardrail, should be considered to supplement these symbols when a condition such as a natural stream or deep excavation exists. See *MUTCD* Chapter 3C for details of red reflectorized buttons on a black or red background sign.



Permanent road closure (urban)

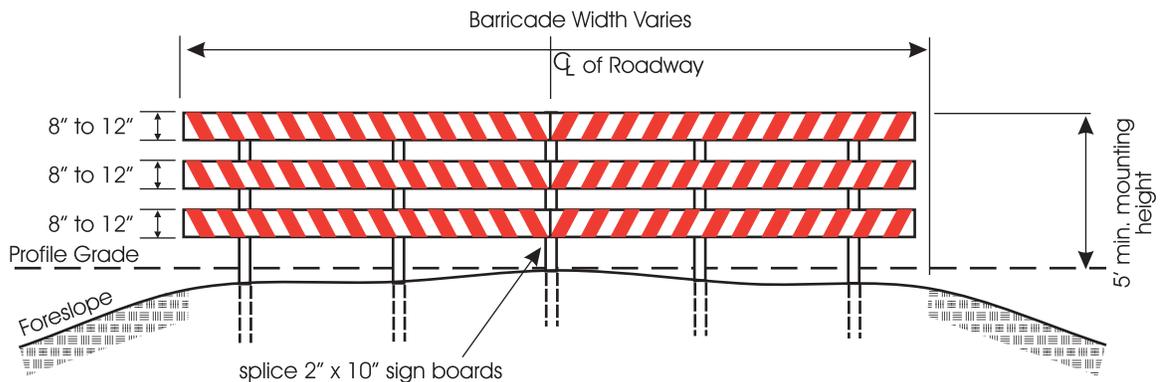


ROW = right of way

Typical installation

For rural situations, Section 3F.01 of the *MUTCD* describes barricades that may be used to advise of the closure. A Type III barricade with design similar to that described in Section 6F.60 of the *MUTCD* is recommended, but the colors are red and white. Retroreflective sheeting should be used, with the striping downward toward the center of the closed roadway. Barricading should extend completely across the closed road and shoulders. Refer to the following illustrations for typical layout recommendations.

In addition, existing roads may be dropped from county maintenance but not obliterated in some rural areas. Official road closure and vacation proceedings or in some cases, city annexations, may result in former roads becoming city streets, private lanes, or driveways. In some cases, gates may be placed at this point. County Maintenance Ends signs may be placed in lieu of or in supplement to these gates to note the end of the county road. Please see the article “Reduced Maintenance Level Roads” (C12) for illustrations of these signs.



Typical Approach View
(Type III barricade)

Permanent road closure (rural)

Flashing Beacons

Flashing beacons can supplement other traffic control devices where additional emphasis and warning for drivers is desired. It is commonly concluded that flashing beacons will result in a reduction of vehicle speeds, but some studies have found that this assumption is not always true. Appropriate investigation of each location should be undertaken prior to installation to avoid overuse and loss of effectiveness. Type, design, and use of these devices are fully described in Chapter 4K of the *MUTCD*.

Common uses of flashing beacons include the following:

- hazard identification, such as obstructions in or near the roadway, midblock crosswalks, intersections where additional warning is needed, and as a supplement to certain warning and regulatory signs
- speed limit, either fixed or variable
- intersection control
- Stop sign supplement

Hazard Identification Beacon

Beacons used for hazard identification should only be used as a supplement to other appropriate warning or regulatory signs and devices. Except for school speed limit signs, beacons should not be included within the border of the sign or device.

When used at intersections, beacons should not face conflicting vehicle movements.

Warning beacons are yellow in color, with a minimum 8-inch diameter visible face. If a single warning beacon is used to identify a roadway hazard, it should be mounted between 8 and 12 feet above the ground. If the beacon is suspended over the roadway, mounting height should be between 15 and 19 feet. Two beacons, each a minimum of 8 inches, aligned either horizontally or vertically and flashing alternately, can be used for added emphasis.

Speed Limit Sign Beacon

Flashing beacons used with speed limit signs can consist of two yellow lenses, each with a single yellow lens with a minimum 8-inch visible diameter. When two lenses are used, they would normally be mounted with a vertical alignment and flashed alternately. When used to emphasize a variable speed limit, the beacon should only be flashing when a reduced speed limit is in effect. Except for school speed limit signs, flashing beacons should not be mounted within the border of the signs.



Example school speed limit sign

Intersection Control Beacon

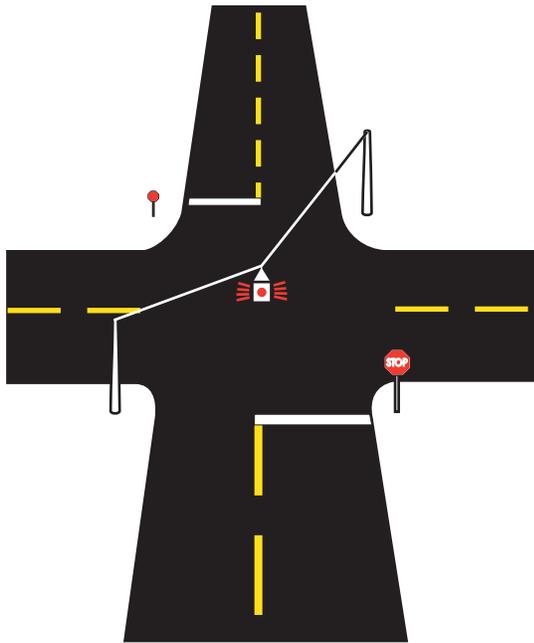
Flashing beacons for intersection control may be used at locations where traffic volumes or physical conditions do not warrant traffic signals but crash history indicates a possible hazard. These beacons consist of one or more circular yellow or red lenses, each with a minimum of 8 inches of visible diameter. They should be used only at intersections to control two or more

directions of travel. Application of intersection control beacons should be limited to the following:

- yellow on one route (normally the major) and red for the remaining approaches
- red for all approaches, if a multiway stop is warranted

A Stop sign should be used on any approach with a red flashing beacon.

Intersection control beacons are generally suspended over the roadway, but pedestal mounting is acceptable under appropriate conditions (refer to recommended mounting heights described previously under the heading “Hazard Identification Beacon”). When a pedestal mount is used, the pedestal should not be located in the roadway unless within the confines of a traffic or pedestrian island. An example of an intersection control beacon is shown below.



Typical intersection control beacon installation

Stop Sign Beacon

Beacons emphasizing Stop signs consist of one or more sections of a standard traffic signal face with a circular flashing red lens. Flashing beacons should be mounted 12 to 24 inches above the top of a Stop sign. When a single lens is used, it should have an 8-inch or 12-inch diameter lens. If two lenses are used, each should have a minimum 8-inch diameter. If aligned vertically, the two beacons should be flashed alternately, but if mounted horizontally, flashing should be simultaneous to avoid confusion with railroad signals.

Flashing beacons and mountings should generally comply with design requirements for traffic signals, including the following:

- Have a minimum visible diameter of 8 inches.
- Be visible for a minimum distance of 1/4 mile when flashing under normal weather conditions.
- Ensure that red and yellow lens colors comply with ITE vehicle traffic control signal head requirements.

Beacons should be flashed at a rate of 50 to 60 times per minute, with the illumination time between one-half and two-thirds of the total cycle length. Flashing beacons should be monitored for excessive glare at night and an automatic dimming device used if needed.

Highway/Rail Crossings

Part 8 of the *MUTCD* details the recommendations for appropriate traffic control at railroad grade crossings on public streets and roads. Volumes of traffic on both rail and road facilities, location, terrain, and roadway surface are some of the factors that may affect the type and extent of signs and markings to adequately protect public safety at these crossings.

Highway/rail grade crossing controls can be grouped into two general classes: passive and active. Passive controls include signs, pavement markings, and crossing illumination. Active controls include flashing lights and gates. In this manual, only passive controls will be described in detail.

Signs

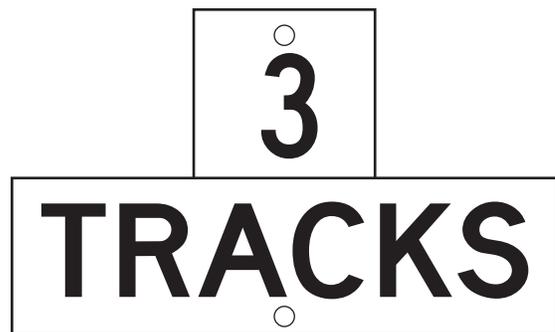
Railroad Crossing Sign (Crossbuck). The railroad crossing sign (R15-1), commonly referred to as a “crossbuck,” is a regulatory device composed of white reflectorized sheeting with “Railroad Crossing” in black lettering. The accompanying supplemental sign (R15-2) can be used to denote the number of tracks at the crossing, if there are two or more. Placement and maintenance of these signs are normally a responsibility of the railroad company, but transportation agencies may want to advise the company of any deteriorating sign conditions.

Where physically possible and when visible to approaching traffic, the Railroad Crossing sign should be installed on the right side of the approach roadway to the crossing. Where engineering study indicates restricted approach sight distance or unfavorable road geometry, crossbuck signs can be mounted back-to-back or otherwise located, so that two faces are displayed to that approach.

For the future, Section 8B.02 requires that white retroreflective material, minimum of 2 inches wide, be placed along the back of both blades of R15-1 signs and on the front and back of support posts.



R15-1



R15-2

Railroad Advance Warning Signs. A Railroad Advance Warning sign (W10-1) should be used on each approach roadway to grade crossings, except in the following situations:

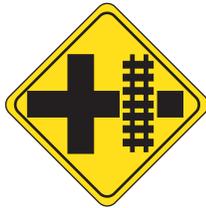
- on low-volume, low-speed roadways crossing minor spurs or other tracks that are infrequently used or flagged by train crews
- in business districts where active highway/rail crossing traffic control devices are in use



W10-1

Be sure to place these signs in accordance with Chapter 2A and Table 2C-4 in Section 2C.05 of the *MUTCD*. In residential or business locations where very low speeds are prevalent, minimum placement distances of 100 feet from the crossing may be appropriate.

Railroad Advance Warning signs (*W10-2*, *W10-3*, and *W10-4*) are intended for approach roadways that parallel the railroad to warn turning drivers that they will encounter a highway/rail grade crossing soon after making the turn. Placement location for these signs, described in Table 2C-4 in the *MUTCD*, is measured from the roadway intersection. Examples of these warning signs are shown below.



W10-2



W10-3



W10-4

Stop and Yield Signs. Stop (R1-1) or Yield (R1-2) signs at highway/rail grade crossings may be used at the discretion of the road authority and should be limited to those locations where warranted by engineering study. According to Section 8B.07 of the *MUTCD*, factors for consideration may include

- substantial train traffic (two or more trains per day)
- no automatic signal
- low-volume roadway traffic
- limited visibility of oncoming trains by approaching road vehicles
- character and significance of crash history,
- an interim measure until active traffic control devices are installed



R1-1



R1-2

When used, Stop or Yield signs may be installed on the crossbuck post or located on a separate support at a point where vehicles are to stop and with a clear view down the tracks. In accordance with *MUTCD* Chapters 2B and 2C, as well as “Stop and Yield Signs” (C15) in this manual, Stop Ahead (W3-1 or W3-1a) or Yield Ahead (W3-2 or W3-2a) may also be required.



W3-1



W3-1a



W3-2



W3-2a

Many other signs are described in Part 8 of the *MUTCD* for use in appropriate situations and the user should refer to this resource for additional information and warrants for use. These signs include the following:

- Exempt (R15-3)
- Do Not Stop on Tracks (R8-8)
- Tracks out of Service (R8-9)
- Low Ground Clearance Sign (W10-5)
- Trains May Exceed X mph(W10-8)
- No Train Horn (W10-9)

Note that many of these signs are regulatory and require official action for installation and enforcement.



R15-3



R8-8



R8-9



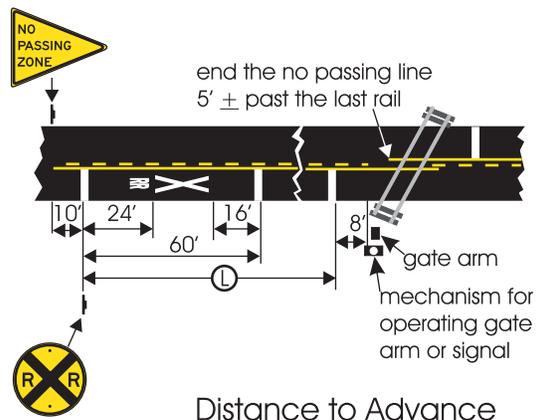
W10-5



W10-8



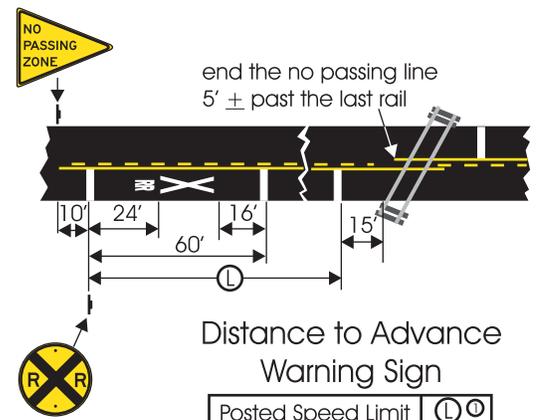
W10-9



Distance to Advance Warning Sign

Posted Speed Limit	(L) (O)
30 mph	325'
35 mph	400'
40 mph	475'
45 mph	550'
50 mph	625'
55 mph	700'

Standard pavement markings for a grade crossing with gates or signals



Distance to Advance Warning Sign

Posted Speed Limit	(L) (O)
30 mph	325'
35 mph	400'
40 mph	475'
45 mph	550'
50 mph	625'
55 mph	700'

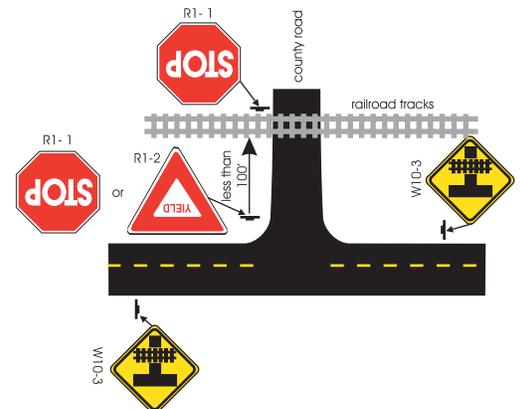
Standard pavement markings for a grade crossing without gates or signals

All transverse markings shall be 24 inches wide.

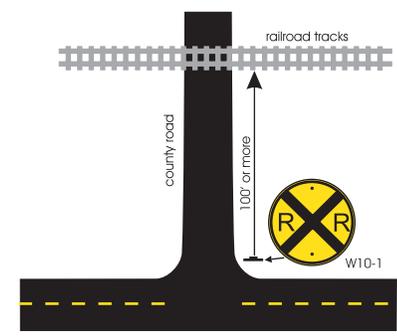
On multilane roads, the transverse markings shall extend across all approach lanes, and individual RR and X symbols shall be used in each approach.

① Minimum distance may be increased to fit conditions at individual crossings and interpolated for speeds not shown.

Refer to Section 8B.16 of the *MUTCD* for more details on pavement markings.



Restricted road sight distance



Advance stop and warning for parallel railroad grade crossing

Although both total incidents and casualties at railroad/highway crossings have declined nationally in recent years, some jurisdictions continue to experience signal and crossing violations by drivers. Several innovations have been developed and marketed recently to address this behavior.

A majority of new safety devices and technologies involve physical barriers that prevent or inhibit vehicles from driving around down crossing arms. These devices typically include median barriers consisting of mountable, prefabricated islands with retroreflectorized yellow and black paddle-type delineators or tubular markers mounted thereon. Other effective devices include four quadrant gates and other proprietary systems. For detailed description of four-quadrant gates, see Section 8D.05 of the *MUTCD*.

These innovations may be considered in specific situations where positive barriers are warranted to enhance public safety.

Additional Information and Upgrading Programs

The Iowa Department of Transportation administers a program for upgrading of traffic control at railroad/highway grade crossings with funding through the Federal Highway Administration, entitled Federal-Aid Section 130 Railroad/Highway Safety Program.

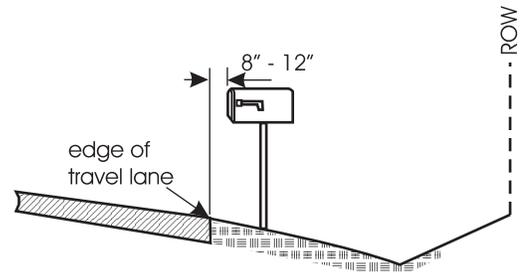
Using a hazard formula as described in Chapter 812 of the Iowa Administrative Code and an Exposure Index as developed by the Iowa DOT, qualifying crossing locations can receive funding for needed upgrades of existing traffic control. More information is available in Iowa DOT PPM 500.09.

Mailboxes in Roadway Right of Way

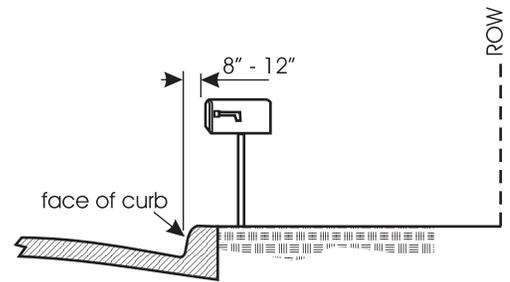
Since mailboxes are normally located within the “clear zone” (defined in “Sign Posts and Supports” [C14]) of the traveled way, crashworthy characteristics of mailboxes and supports are a concern. Also, mailboxes’ close proximity to the roadway often results in damage by maintenance equipment. The following information suggests design and placement of mailboxes and supports.

Placement Recommendations

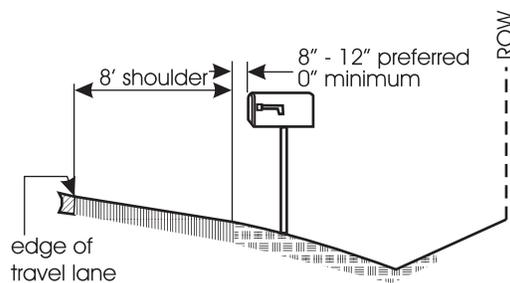
Lateral installation of mailboxes must offer the mail carrier easy access to the box from the delivery vehicle as well as necessary clearance from the traveled way. The following illustrations provide suggested installation locations relative to several road and street situations. (All proposed mailbox placements should be reviewed with the local post office prior to actual installation.)*



Lateral placement with no shoulder or turnout

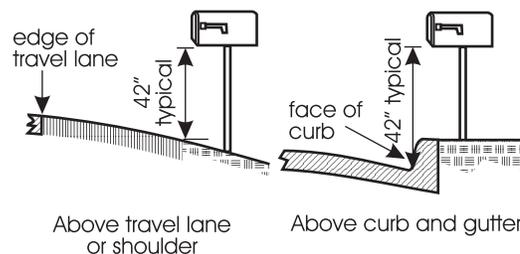


Lateral placement with curb and gutter



Lateral placement with shoulder or turnout

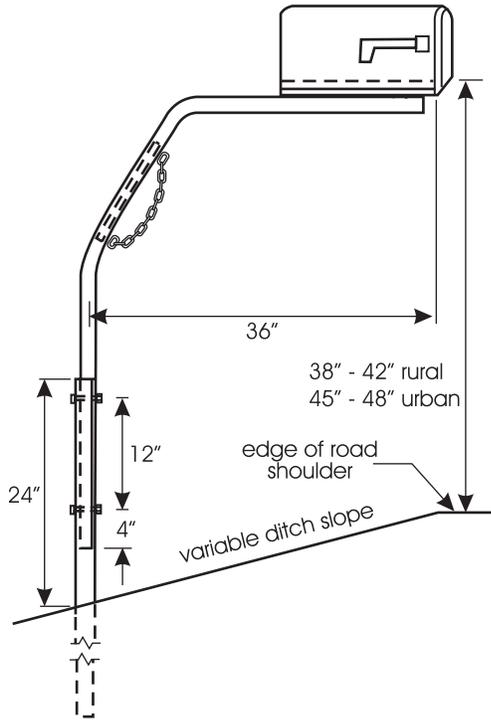
The height of mailboxes is governed by the United States Postal Service, which recommends an installation height of 42 to 48 inches, again for convenient access by the mail carrier.



Height of the mailbox

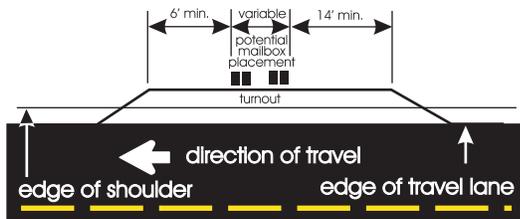
*Note: In consideration of uniformity and crashworthy features, some agencies have established programs to furnish and install approved design supports if property owners provide the mailbox.

One particular support design has been used effectively in some areas to reduce damage from snow plows and other maintenance equipment. This post provides a cantilever support, which places the vertical post section several additional feet from the traveled way. An example of this design is shown below.



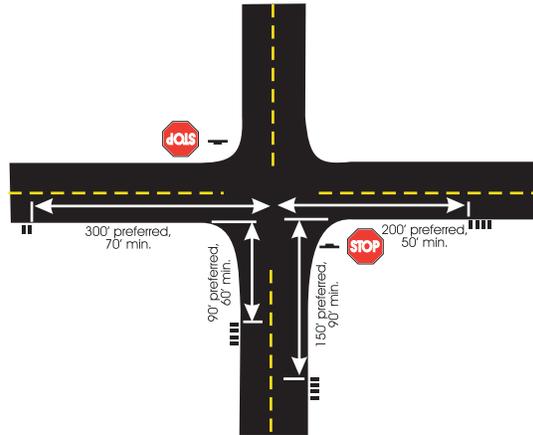
Mailbox support (steel pipe and sign post)

Mail delivery can be made safer and more convenient through the use of turnouts. These designs can be most effective where multiple mailboxes are present requiring the carrier to spend a considerable length of time in one location. An example of a suggested turnout design is shown in the following figure.

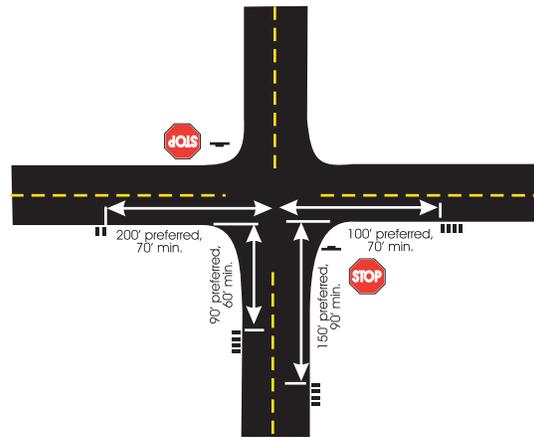


Longitudinal placement for turnout

Mailbox installations near intersections also should be studied for the potential safety of road users and mail carriers as well as convenience of the home owner. Suggested locations for mailbox installations are shown in the following figures.



Mailbox placement at rural intersections where through road speed limit \geq 55 mph

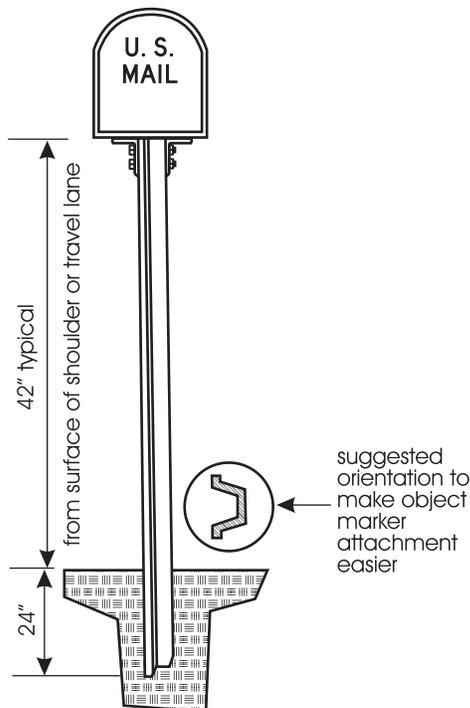


Mailbox placement at intersections where through road speed limit $<$ 55 mph

Mailbox Supports

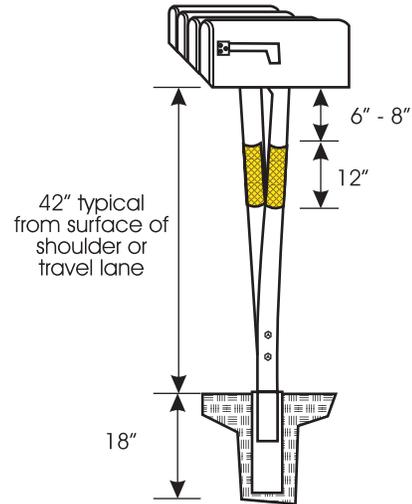
Supports or posts for mailboxes are of two general types: single support and multiple support. Although many existing mailboxes are supported on wood posts or by other means, crash testing has indicated that light metal or plastic are the best materials for meeting crash-worthy recommendations.

Support for a single mailbox can be provided by a channel post or a 2 to 2-1/2-inch thin wall steel pipe. Two small mailboxes can be mounted on a single support with the use of a proper adapter plate. Single supported mailboxes should not be placed closer than 2 feet apart, with a maximum of two single supports grouped together to avoid the “ramp effect” on vehicle impact. American Association of State and Highway Transportation Officials (AASHTO) guidelines recommend a spacing of 3/4 the mounting height. The following shows a suggested single mailbox support.

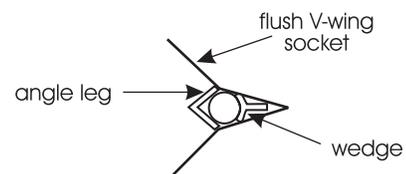
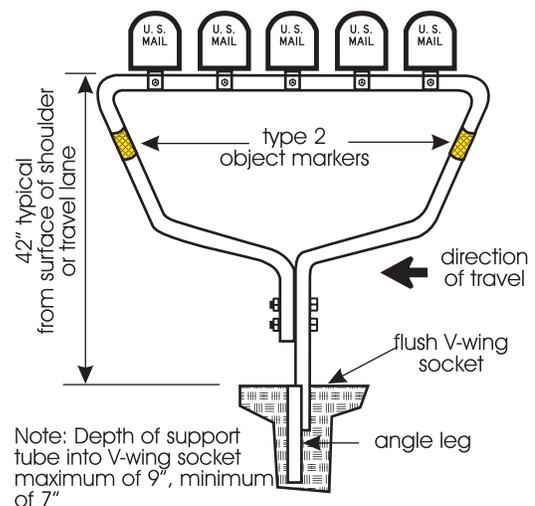


Installation of single mailbox support

Depending on the size of the mailboxes, up to five individual boxes can be installed on multiple support, commonly referred to as a “coat hanger” design. Adjacent multiple supports should not be placed closer than 4 feet, with no limit on the number of adjacent groups. The following figures show recommended multiple support design.



Installation of multiple mailbox support

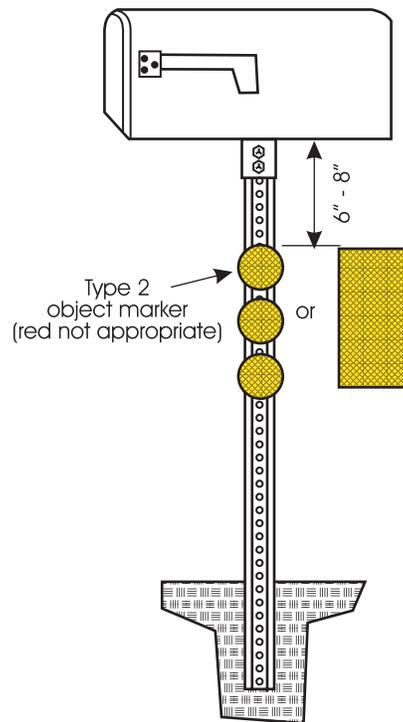


Installation of multiple mailbox support

These designs have been implemented in Texas. The Texas Department of Transportation and AASHTO's *A Guide for Erecting Mailboxes on Highways*, published in 1994, can provide more detailed information on design and experience.

Object Markers for Mailboxes

Use of proper object markers can provide increased visibility of mailbox installations at night. On two-lane, two-way roads and streets, consideration should be given to placing markers on both sides of the mailbox. A Type 2 object marker is the recommended device for this purpose. Use of a 12-inch strip of reflective sheeting on the upright portion of multiple supports also can be effective. This sheeting should be either yellow or white. Red is not an approved color for this application.



Example of reflective object markers for mailbox support

Movable Stop Signs for School Zones

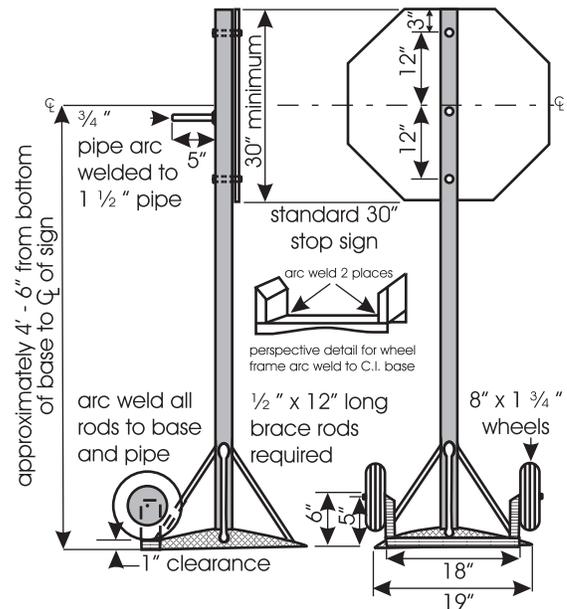
Section 2B.05 of the *MUTCD* states that portable or part-time Stop signs shall not be used except for emergency and temporary traffic control purposes. However, Section 321.249 of the Iowa Code allows use of movable Stop signs in locally established school zones. Alternatives to movable signs, such as permanent Stop signs (when warranted) or the use of adult crossing guards, should be seriously considered.

Although movable Stop signs are not recommended for general use, these devices have been employed for many years in school zones across Iowa. As with other traffic control devices, judgement and prudence should be exercised with this practice, and guidelines should be followed in those instances where movable Stop signs cannot be eliminated or avoided.

These items should be considered in establishing criteria for movable stop sign use:

1. Establish a school zone as required by Iowa Code Section 321.249. This action would be taken by the governing authority, whether city or county.
2. Develop conditions for use; an agreement with the school board may be advisable detailing hours of use, responsibilities for placement and removal, and maintenance of signs and markings.
3. Consider use of trained crossing guards to supplement the signs.
4. Require removal when crossing is not in use. It is important that stop control not be employed when unnecessary throughout the day.

5. Use standard design for signs and pavement markings. The following illustration depicts one of the recommended designs.
6. Review the performance of the system on a periodic basis.



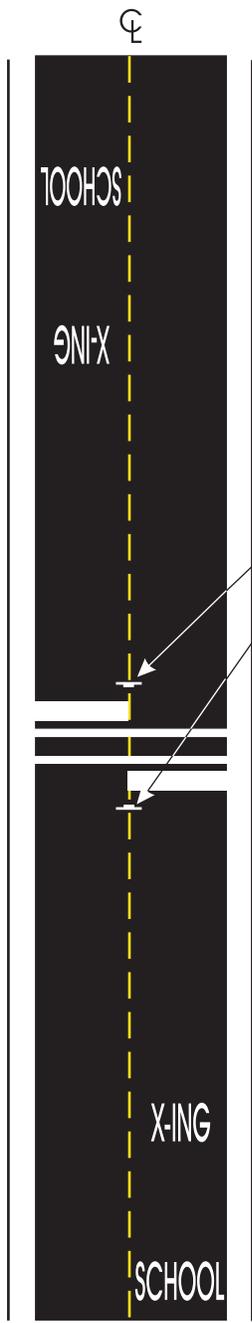
Approximate weight, cast-iron (C.I.) base : 40 pounds.
Wheel frame to be constructed of three pieces of 1" x 2" channel iron.

The 16" member cut to fit contour of base.

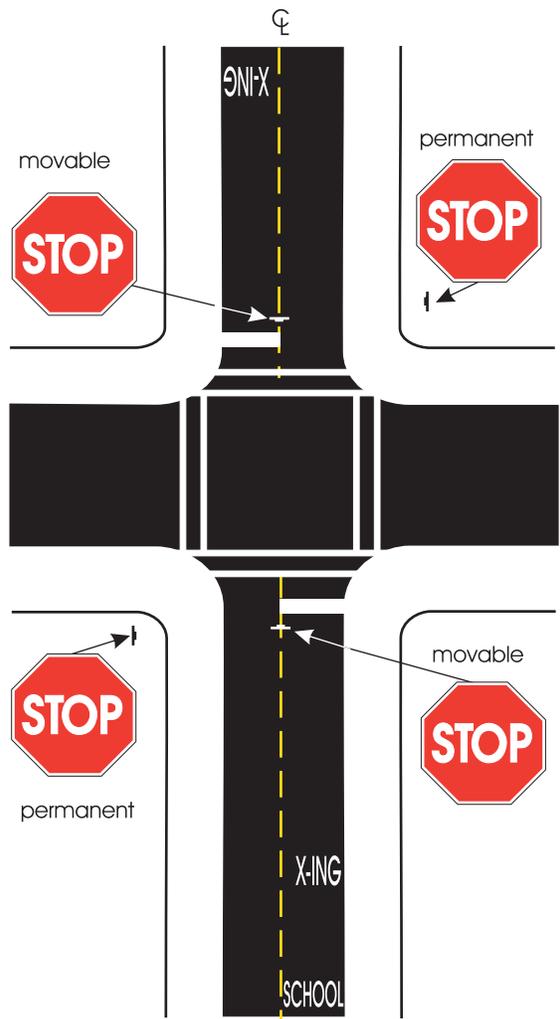
Material required:

- 1-30" standard stop sign: 1 pc. $\frac{3}{4}$ " pipe 5" long;
- 1 pc. $1\frac{1}{2}$ " pipe 5'-4" long; 2 $\frac{3}{8}$ " x $\frac{1}{2}$ " long bolts with nuts;
- 4 pcs. $\frac{1}{2}$ " x 12" long rods; 1 pc. 1" x 2" x 1' - 4" long and 2 pcs. 1" x 2" x 5" channel iron;
- two-8" x 1 $\frac{3}{4}$ " wheels with axles to suit; 1 cast-iron base, 1' - 7" diameter.

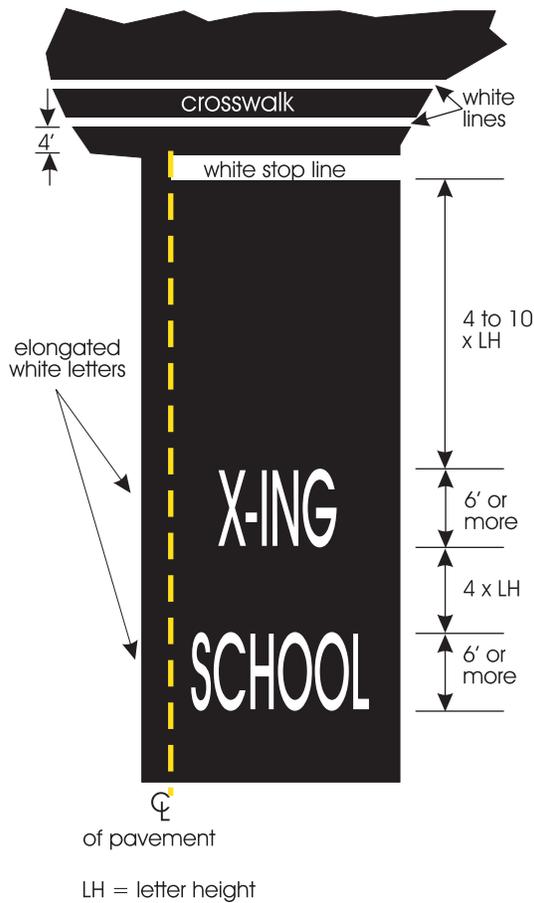
**Suggested details for movable stop signs
(other support designs also available)**



**Suggested location of movable Stop signs
Mid-block**



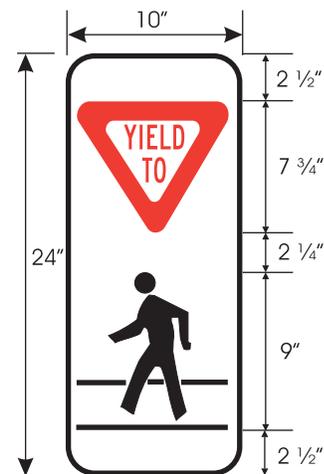
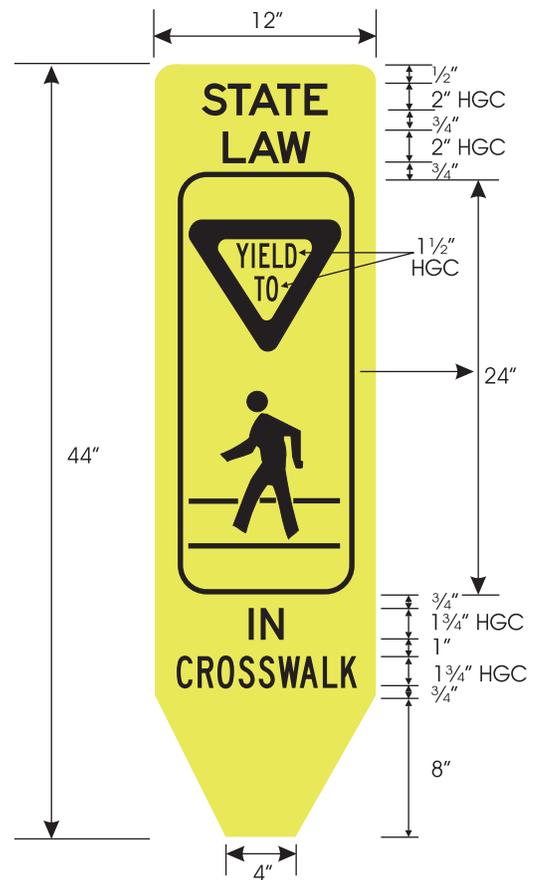
**Suggested location of movable Stop signs
Intersection**



Details for pavement markings

Alternate devices have been developed and adopted in other states to enhance driver awareness of pedestrian crosswalks. The state of New Hampshire, for example, has approved the use of a device as shown here for temporary use on the center line of roads adjacent to crosswalks.

These devices are available with either fixed or movable bases, constructed of recycled rubber and plastic, and have been tested for crashworthy characteristics. The sign panels for these devices are available in fluorescent yellow-green or conventional colors. Local jurisdictions may want to consider use of these devices in lieu of movable Stop signs.



Supplemental crosswalk identification devices

Rumble Strips

Driver noncompliance with stop signs can be a serious concern. Several methods can be used to improve visibility, recognition, and compliance at stop sign controlled intersections. One of those methods is rumble strips in advance of the intersection.

While these installations have been in use for many years and several studies have examined where the most effective use of rumble strips can be made, no conclusive information exists that would indicate when to install these devices. Engineering judgement should be exercised when selecting rumble strips as a safety enhancement.

These points should be considered in deciding the use of rumble strips:

1. *Crash History.* The number of crashes and whether these were related to a failure to stop are important considerations.
2. *Opinions of Others.* Law enforcement, county or city attorney, Iowa DOT local maintenance staff, and citizens can provide valuable information, experience, and support.
3. *Other Safety Measures, Existing or Proposed.* Other methods of raising driver awareness such as larger or double Stop and Stop Ahead signs and advance warning signs, flashing beacons, or even lighting all can be considered.
4. *Proximity of Existing Homes.* Noise from vehicles passing over rumble strips can be an irritation to nearby residents. This factor should not necessarily be a reason for

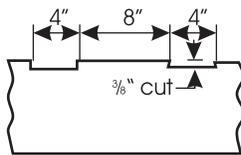
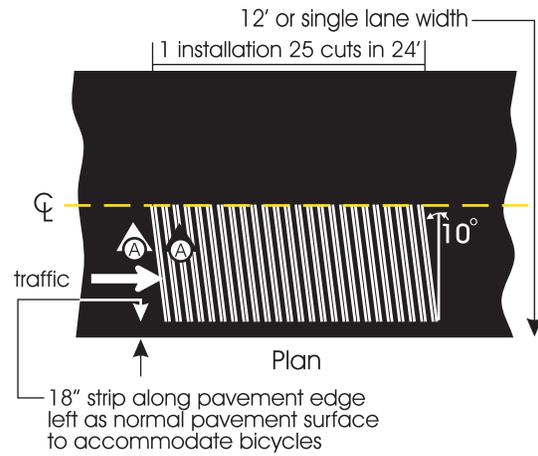
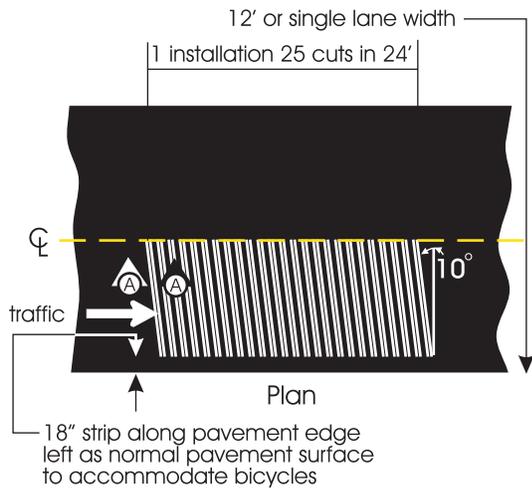
eliminating rumble strips. Consideration should be given to nonstandard spacing to minimize noise near a home.

5. *Intersection Location.* A hill and/or curves in advance of a stop intersection may require additional warning, which rumble strips can provide.
6. *Traffic Conditions.* Volume, speed, and number of commercial vehicles should be taken into account.
7. *Pavement Type.* Stability of rumble strips in some flexible pavements may be less than desirable. Consideration should be given to placing portland cement concrete (PCC) patches with rumble strips in flexible pavements.

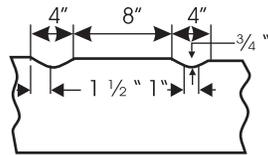
Rumble strips have also been used in some situations other than stop intersections, such as sharp curves, but these applications are rare.

Use of rumble strips can be effective in alerting drivers of stop signs, but installation should be carefully studied in advance. Rumble strips, like signs, are traffic control devices and, as such, create liability concerns for local governments. While no warrants exist to indicate when rumble strips are appropriate, once installed the local jurisdiction will assume a duty to maintain strips properly as provided in Iowa Code Section 668.10(1).

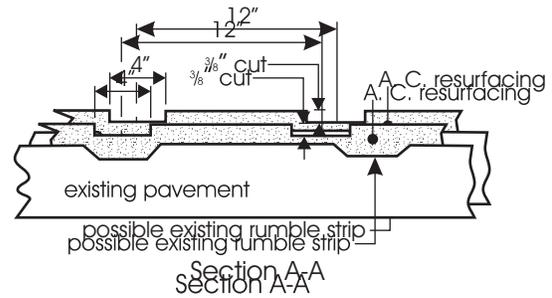
The illustrations on the following page depict suggested design and layout for rumble strips.



Section A-A
rumble strip cut in new PCC or ACC pavement

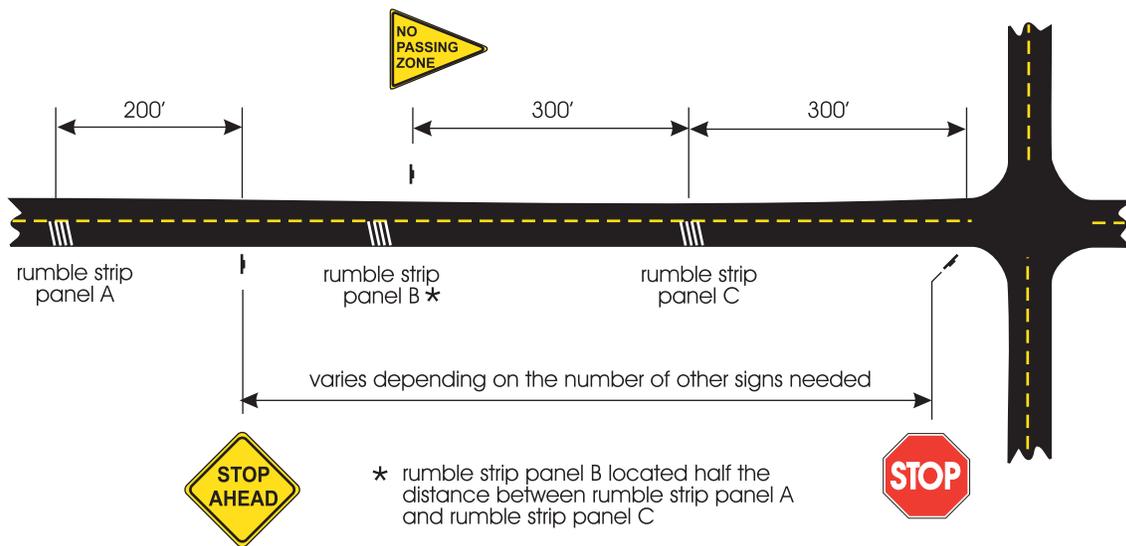


Section A-A
rumble strip placed in plastic PCC concrete



Suggested rumble strip panel in resurfacing

Suggested rumble strip panel in new pavement



Typical rumble strip panel location and signing

Snowmobiles

Section 321G of the Code of Iowa allows the operation of snowmobiles within highway right of way under certain conditions and stipulations, and snowmobile trails are common in the northern half of the state. To provide uniform response and administration for trail establishment, operation, and maintenance, road agencies should adopt a policy to govern authorization and usage of public highway right of way for this purpose. The appendix includes a sample snowmobile policy and permit application.

Transverse crossings of public roads by established snowmobile trails should be undertaken by mutual consent of the trail sponsor and road authority after appropriate analysis of road and trail users' safety. Crossings should be kept to a minimum to avoid potential conflicts by motor vehicles and snowmobiles.

Warning signs for trails include the Snowmobile sign (W11-6) and the Snowmobile Crossing sign (W11-6AX). The supplemental plaque (W11-6P) can also be used for additional emphasis in advance of crossings. Since crossing use by snowmobiles is seasonal, these signs should be removed or covered when not needed.

Signing along the established trail is usually the responsibility of trail users. However, uniform signing should be used, and signs can be obtained from the Department of Natural Resources. Only these uniform signs should be permitted within the public right of way.



W11-6



W11-6AX



W11-6P

Signs may be installed to mark trails, identify hazards, and establish any desired operating controls. These signs should not be permitted to be placed on or attached to an official highway sign or other traffic control device but should be installed independently on supports near the right of way line. "Danger" warning signs, however, may be placed near the potential hazard. It is also not recommended to place trail signs within the clear zone (defined on page C14.1 of this manual) or within roadway slope limits.



Stop Sign

PURPOSE: to be used along trails prior to a road crossing
SIZE: 12"x12" - 9"x9"
BACKGROUND COLOR: red
BORDER AND LEGEND: silver



Dead End Private Trail

PURPOSE: to indicate a limited use trail or designate a restricted area
SIZE: 12"x12" - 9"x9"
BACKGROUND COLOR: silver with red ball
BORDER AND LEGEND: silver



Permissive

PURPOSE: to indicate snowmobile trails and other areas where snowmobiling is permitted
SIZE: 12"x12" - 9"x9"
BACKGROUND COLOR: silver
LEGEND: green circle, black snowmobile symbol



Restrictive

PURPOSE: to indicate areas where snowmobiling is not permitted
SIZE: 12"x12" - 9"x9"
BACKGROUND COLOR: silver
LEGEND: red circle, black snowmobile symbol

Regulatory signs

Trail Intersection

PURPOSE: to indicate an intersection in the trail
SIZE: 12"x12" - 9"x9"
BACKGROUND COLOR: orange with black border
LEGEND: black 2"x11" vertical and 2" x 5 1/2" diagonal



Danger

PURPOSE: to indicate an area of danger on the snowmobile trail
SIZE: 12"x12" - 9"x9"
BACKGROUND COLOR: yellow
LEGEND: black



Warning signs

Trail Blazer

PURPOSE: to reassure the user he is on the trail
SIZE: 5" x 7" - 6" x 6"
BACKGROUND COLOR: orange with black border



Directional Blazer

PURPOSE: to indicate changes in trail direction
SIZE: 9 1/4" x 12" - 9" x 9"
BACKGROUND COLOR: orange with black border
LEGEND: black 5 1/4" directional arrow



Informational signs

Other issues to consider with snowmobile trails can include temporary structures and maintenance operations such as "grooming." These points should be addressed in an agency's policy and included in a preuse agreement or permit with the trail sponsor. Actual dates of permitted use may be included in the permit or agreement stipulations, but in any regard, removal of all trail signs and temporary structures should be undertaken when trail use ceases.

For more information and recommendations on establishment of snowmobile trails, please refer to the Iowa Department of Transportation and Iowa Department of Natural Resources (DNR).

Traffic Calming Measures

Too much speed and too many vehicles are common complaints in many urban communities. To address these public concerns, many jurisdictions are tempted to adopt apparently easy solutions, such as lowering speed limits and/or installing Stop signs. However, without consistent and increased enforcement, speed limits lower than the 85th percentile are ineffective and not recommended. Installation of Stop signs without proper warrants is never recommended. Traffic calming offers an alternative solution.

Traffic calming is defined by the Institute of Traffic Engineers as “the combination of mainly physical measures to reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users.”

The concept of traffic calming involves physical alterations to a road or street, which cause or invite motorists to decrease driving speed and pay increased attention to the driving task. Some results include reduced speeds and volumes, reduced collision severity, reduced need for extraordinary law enforcement, improved safety for pedestrians and bicyclists, and improved access for all modes of traffic.

The cost of traffic calming measures can vary from a few thousand dollars for closures, speed humps, and bulb-outs to \$50,000 or more for extensive roundabout designs.

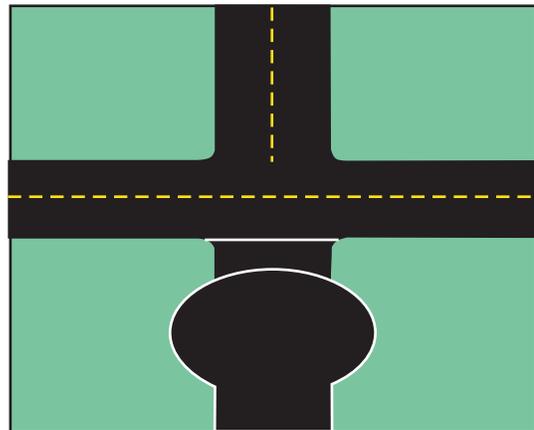
Parts 2 and 3 of the *MUTCD* include recommendations for the signing and marking of certain traffic calming measures. This resource should be consulted for appropriate traffic control. Chapter 2C contains description of new signs for traffic calming use, such as Speed Hump (W17-1) and Circular Intersection (W2-6).

When considering implementation of any traffic calming initiatives, it is recommended to seek appropriate public input and support. Temporary measures such as removable curbs and islands can be used to gauge public reaction and support for any permanent implementation under consideration.

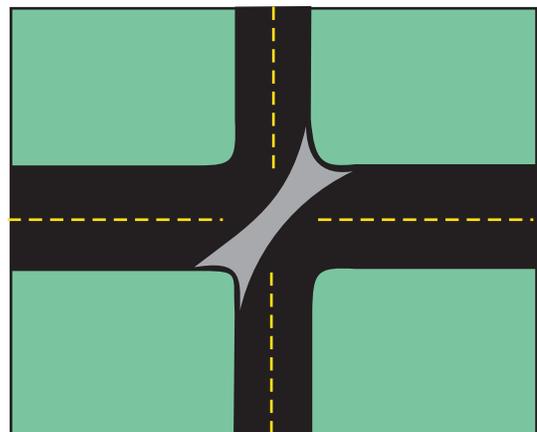
Common traffic calming measures include the following practices.

Closures, Diversions, and Semi-Diversions

These steps would have an obvious effect on reducing traffic volume on a given road or street, but effects to adjacent routes must also be considered.



Street closure (cul-de-sac)



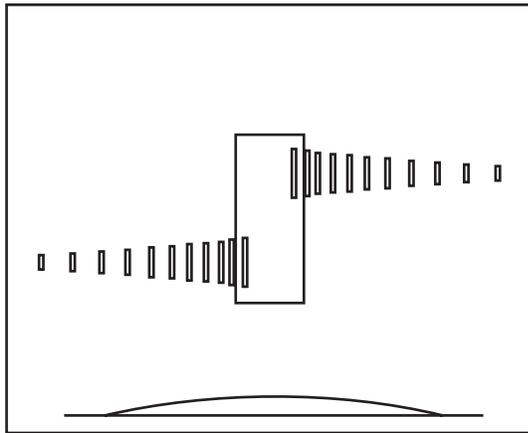
Traffic diverter

Medians and Islands

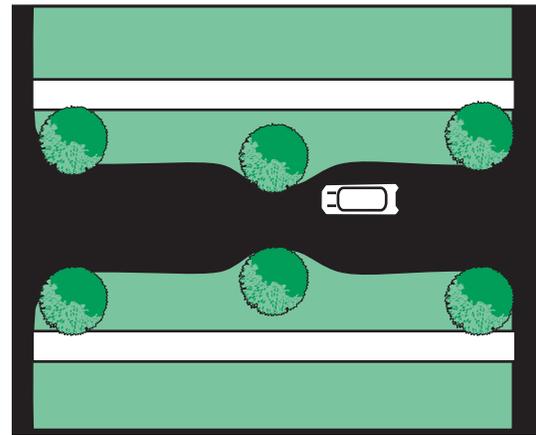
These installations can separate opposing traffic, prevent undesirable turns, and reduce road or street width.

Speed Bumps, Humps, Tables, and Rumble Strips

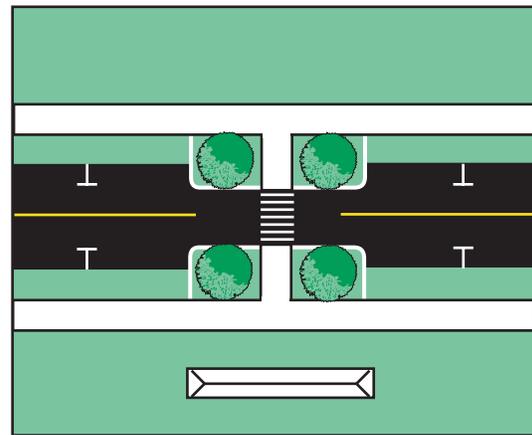
These devices usually vary from 12 to 20 feet in length and consist of a vertical displacement in pavement surface or, with rumble strips, an audible and physical sensation to gain motorist attention.



Speed humps



Choker



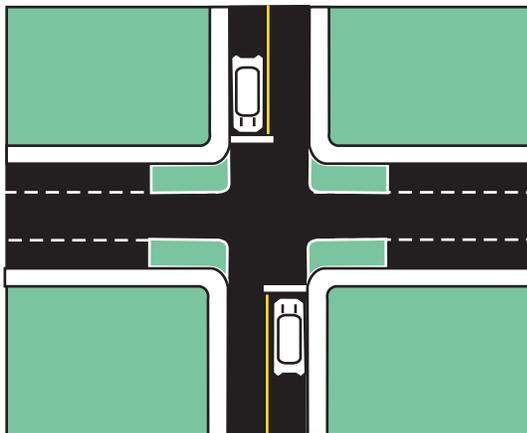
Midblock bulb-out with speed hump

Chokers and Bulb-Outs

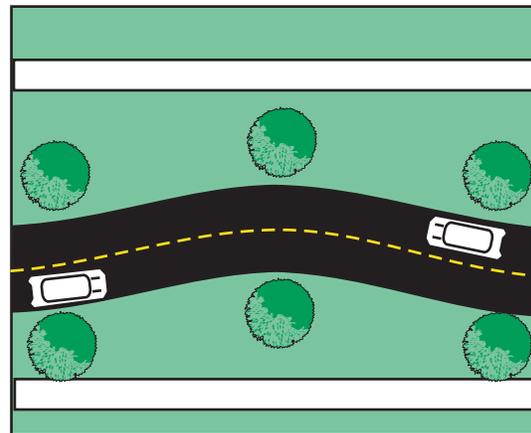
These measures involve semicircular or longer extensions of curb or roadside landscaping to invite drivers to slow down. Narrowing of the street to permit easier pedestrian usage is also a potential benefit.

Chicanes

Chicanes are short, horizontal displacements in alignment that encourage slower speeds.



Bulb-out intersection



Chicane

Roundabouts and Traffic Circles

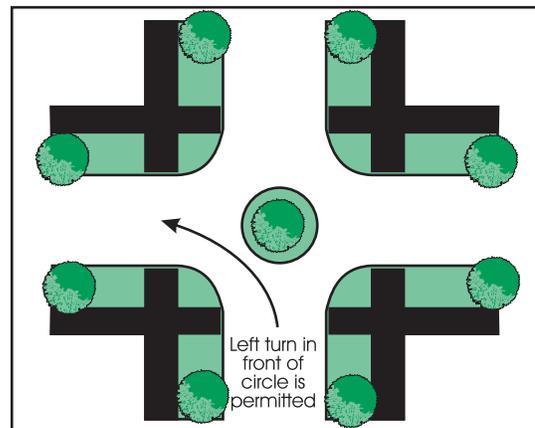
While generally not considered a traffic calming measure, roundabouts involve an intersection design that can often improve operation, reduce crashes, and eliminate signal need. Extensive design recommendations are available for roundabouts in particular. Traffic circles are small islands placed in intersections. They are meant to reduce traffic speeds by requiring through vehicles to navigate around the circle.

Still other measures such as landscaping, fencing, pedestrian crossings, and lighting can have beneficial effects in slowing traffic and providing a safer environment for all roadway users.

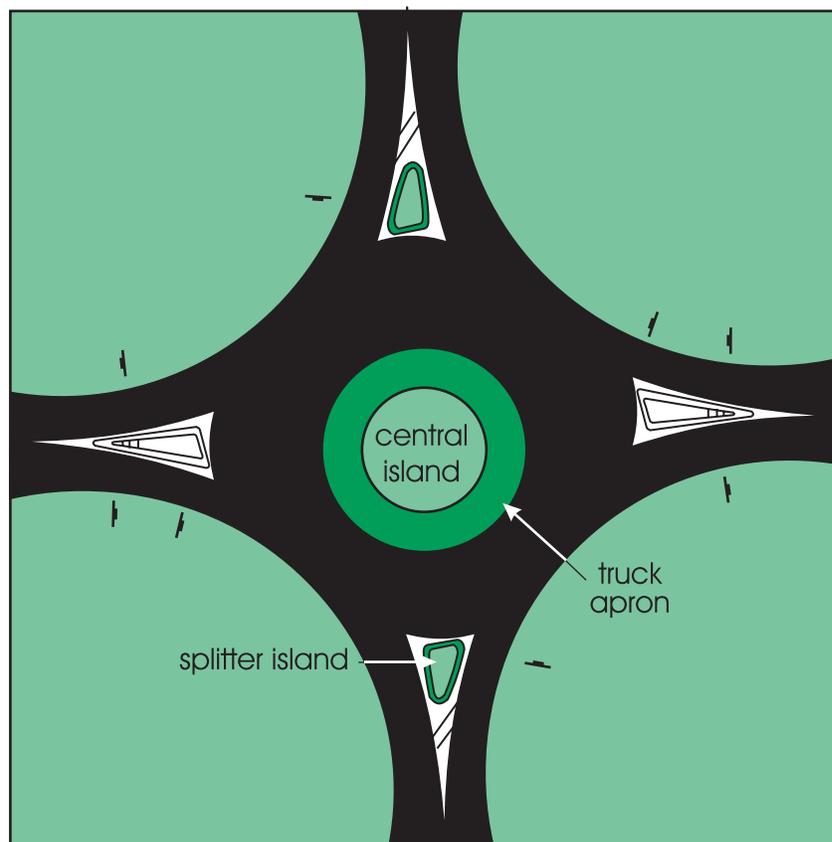
Traffic calming measures may also have negative impacts on snow removal, bus and commercial traffic, and emergency response, etc., which should be considered. Effects on surrounding routes should also be considered by viewing potential traffic calming projects as part of the

entire roadway network. Advice from the Iowa Department of Transportation, ITE publications, and other jurisdictions with traffic calming experience is also advisable.

Refer to Parts 2 and 3 of the *MUTCD* and “Pavement Markings” (D1) in this manual for advice on signing and marking for certain traffic calming measures.



Mini traffic circle



Roundabout

Weight Restrictions

Seasonal weakening of the road structure, obsolete bridges, structurally unsound pavements, and other deficiencies may dictate the need to restrict the weight of loads permitted on certain roadways.

Sections 321.471 through 321.475 of the Code of Iowa allow state and local jurisdictions to apply temporary load restrictions where needed to avoid damage or destruction of a road or structure. However, the Code may exempt implements of husbandry and certain other vehicles under specific conditions and times of year.

Weight Restriction Signs

The Weight Limit sign (R12-1) may be used to indicate restrictions pertaining to total vehicle weight including the load.



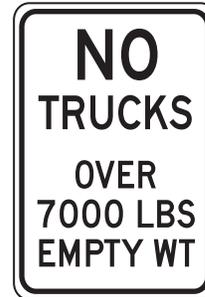
R12-1

If the restriction applies to axle weight rather than total load, the sign legend "AXLE WEIGHT LIMIT X TONS" (R12-2) can be used.



R12-2

In residential areas, where it is intended to restrict commercial vehicles of a certain size when empty, the legend may read "NO TRUCKS OVER X LBS EMPTY WT" (R12-3).



R12-3

In locations where multiple restrictions apply, a sign combining the necessary messages on a single panel may be used, such as "WEIGHT LIMIT X TONS PER AXLE X TONS GROSS" (R12-4).



R12-4

Increasing sign size may be needed when combining messages to be sure adequate lettering size is maintained.

Posting of specific load limits may be accomplished by use of the Weight Limit Symbol sign (R12-5). This sign includes the legend Weight Limit on the top two lines and shows three different truck symbols with allowable weight limits shown to the right of each symbol. A bottom line stating Gross Weight is permissible if needed for enforcement purposes. Only the truck symbols and respective weight restrictions need to be shown.



R12-5

A Weight Limit sign shall be located immediately in advance of the section of roadway or structure to which it applies. A Weight Limit sign (R12-1) with advisory message plaque (“Ahead”) as shown below may be installed at an approach road intersection or another location where vehicles can turn around.

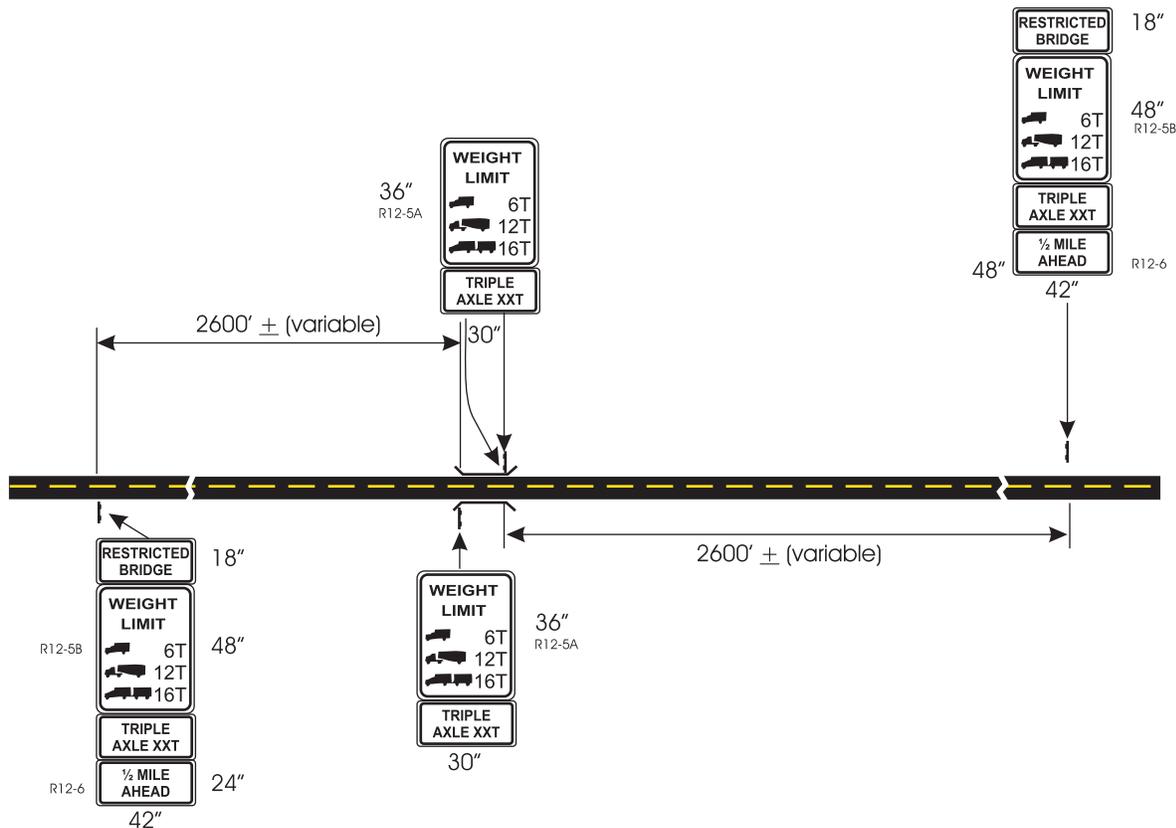
The standard and minimum regulatory sign size for most R12 series is 24 x 30 inches, but a

larger size may be advisable for major roads and streets or to maintain desirable lettering dimensions.

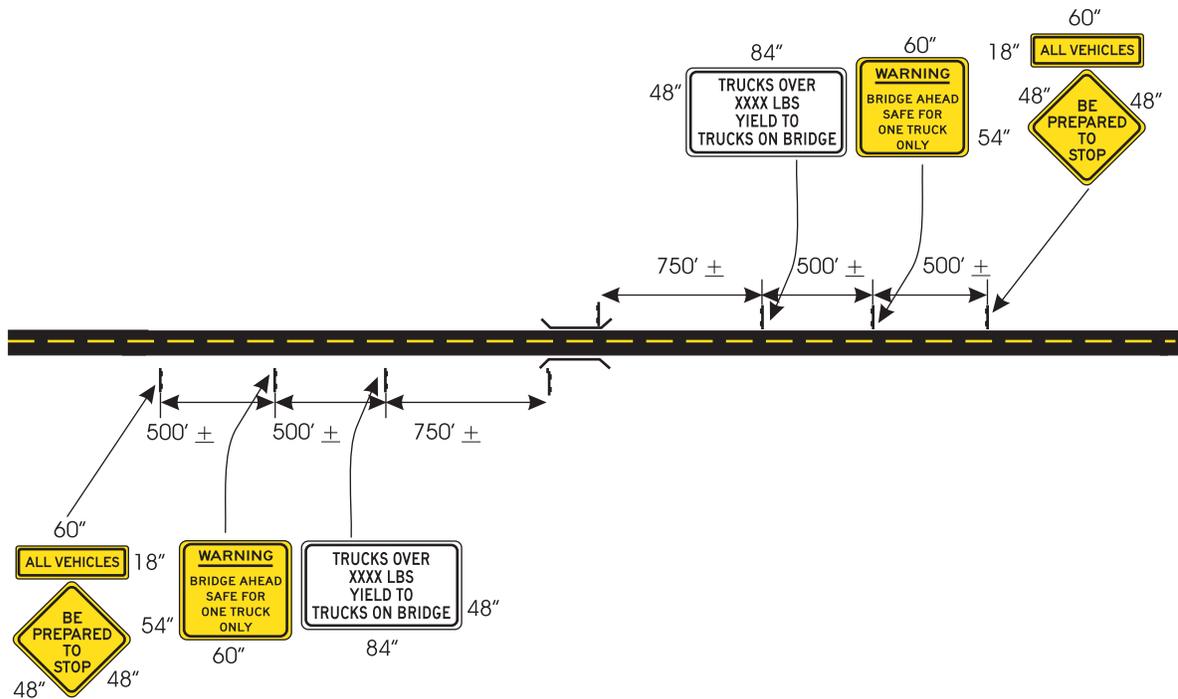
All regulatory signs described in this section (R designation) require official action, ordinance, or resolution to enforce.

When establishing any weight restriction, be sure to consider potential effects on delivery vehicles or school buses before implementation.

In some situations, use of special warning signs such as One Truck at a Time or others, as shown in the illustration “Suggested signing layout for alternating traffic control on restricted bridges” on the following page, may be appropriate. When using special warning signs, always be sure to increase sign size if needed to maintain minimum lettering size.



Suggested signing layout for weight restricted bridges



Suggested signing layout for alternating traffic control on restricted bridges

All Vehicles Plaque

The supplemental All Vehicles plaque is used for defining load restrictions for nonstandard vehicles, implements of husbandry, and other legal or permitted trucks including equipment trailers, milk trucks, and special livestock truck-trailer combinations.

In 1998, legislation allowed new triple axle trailers that can legally weigh from 93,000 to 96,000 pounds when combined with an appropriate semitrailer tractor. Implements of husbandry can legally include from 24,000 to 28,000 pound axle loads, depending on the season of the year, with no restriction on total gross load.

These newly defined legal vehicles and implements of husbandry may not utilize standard truck configurations, are subject to different axle weight restrictions, and often exceed H-15, H-20, and HS-20 loads for which many bridges in Iowa were designed. Therefore, some bridges may not safely carry these new legal configurations and/or increased axle loads. The All Vehicles plaque allows cities and counties to apply necessary restrictions for these nonstand-

ard vehicles, which do not match standard axle configurations.

The All Vehicles plaque is a black on white regulatory sign, available in three sizes with a minimum size of 12 inches by 24 inches. The All Vehicles plaque can be used in conjunction with other weight limit signs, particularly the Weight Limit Symbol sign, R12-5, common on many weight restricted bridges in Iowa. The R12-5 sign defines weight limits for standard straight truck, semitrailer and tractor, and double-bottom trailer configurations.

The All Vehicle plaque should be posted beneath the R12-5 sign and combined with an R12-1 showing the weight restriction for nonstandard vehicles below the All Vehicle plate. A common configuration, shown on the following page, can be used in place of the sign combinations in the illustration “Suggested signing layout for weight restricted bridges” on page G10.2. Note that an Ahead plaque should be used with the configuration for the advance signing. The configuration immediately preceding the restricted bridge should consist of R12-5, the All Vehicles plaque, and R12-1.



Sign configuration including All Vehicles plaque

The weight limit posted in combination with the All Vehicle plaque should be determined based on the recommendation of a licensed professional engineer who has inspected and performed structural capacity calculations for the structure.

The R12-1 sign may also be used to restrict the use of bridges by overweight and nonstandard trucks, truck-trailer combinations, and implementations of husbandry that otherwise have no restrictions for standard legal truck weights and configurations. Since this sign applies to all traffic, use of an additional All Vehicles plaque may not be necessary.

The applied weight restriction allows all legal combination vehicles prior to the 1998 legislation but restricts the newer, heavier loads.

Sample embargo resolutions and overweight permits are included in the appendix.

Section H

Traffic Studies

H: Traffic
Studies

Advisory Speed Determination

Determining a safe driving speed for curves in order to post advisory speeds can be accomplished after considering the radius/degree of curvature along with road surface cross slope or by simply driving the road segment several times at increasing speeds and making a judgement of appropriate driving speed at which an acceptable comfort level is reached.

Another method is with the use of a ball bank indicator, also known as a slope meter, shown here. This device can be mounted in the front of a test vehicle for convenient observation by either the driver or a passenger. The slope meter is calibrated to read "0" when the vehicle is level but will indicate a degree of "tilt" up to 25 degrees on each side. A scale in the device is

colored red beyond 10 degrees to indicate potential danger. By driving the subject curve at successively higher speeds and observing readings on the slope meter, it is possible to select the safe driving speed and determine if posting of an advisory speed is appropriate.

One source of ball bank indicators is the Slope-Meter Company of Minneapolis, Minnesota, although other models and vendors may also be available.



Slope meter

No Passing Zones

As Section 3B.02 of the *MUTCD* provides, where center lines are installed, no passing zones should be established at vertical and horizontal curves and other locations on two- and three-lane roads where engineering study has indicated passing must be prohibited due to inadequate sight distance or other special conditions. The *MUTCD* describes applications of markings and warrants for no passing zones. Section 321.304 of the Code of Iowa also describes conditions where passing should be prohibited on two-lane roads. The following table lists recommended minimum passing sight distances for various speeds.

<i>Minimum passing sight distances</i>	
Posted or Statutory Speed Limit (mph)	Minimum Passing Sight Distance (ft)
25	450
30	500
35	550
40	600
45	700
50	800
55	900
60	1,000
65	1,100
70	1,200

Several methods of determining no passing zones have been developed and used successfully, including

- line of sight (eyeball)
- walking
- towed target
- two vehicle
- distance measuring equipment

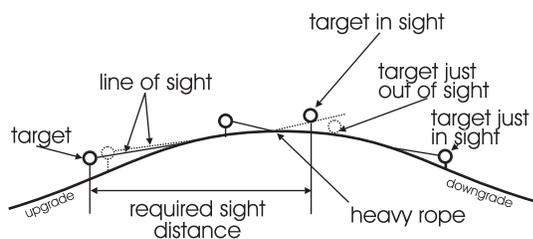
Suggested procedures for two of these methods are described here: a variation of the towed target or rope method and the distance measuring equipment method.

Towed Target or Rope Method

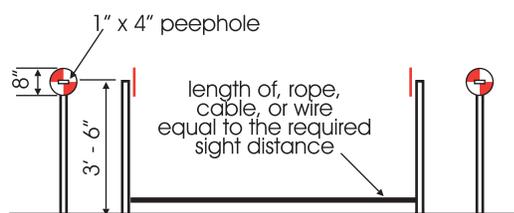
This procedure requires a two-member crew, two vehicles, targets of 3.5 feet height, and a rope, cable, or wire with a minimum length of 1,000 feet for a 55 mph road. The length of rope will vary based on the posted speed limit of the road as shown in the table at the end of this article.

1. The first crew member proceeds along the road with the rope trailing behind and the second crew member following the rope. Both vehicles should have a target 3.5 feet in height attached for observation by the other crew member. When sight of the targets is hampered by a crest or obstruction in or just outside the right of way, both crew members stop and stretch the rope between them.
2. With one member sighting the other's target, a location that provides adequate sight distance for approaching traffic can be determined. From that point, the advance member will walk toward the trailing member until a clear view over the crest or around the obstruction from a height of 3.5 feet is found. This is the end of the no passing zone for traffic approaching from the opposite direction. Simultaneously, the trailing crew member walks a recommended 100 feet away and marks the beginning of the no passing zone for traffic traveling in the same direction as the crew.
3. Again the crew proceeds along the road to determine the location where line of sight is no longer broken by the crest or obstruction. At this point the rope is extended to locate the point where traffic from the opposing direction will encounter restricted sight distance. The advance crew member then paces a recommended 100 feet away to mark the beginning of the no passing zone for traffic coming from the opposite direction. The trailing crew member walks forward until

clear sight is available from an eye height of 3.5 feet. This point is marked as the end of no passing for the same traffic direction as the crew.



profile - vertical curve



targets

Method of establishing no passing zones on vertical curves using sight targets

Note that the leading crew member always marks no passing zones for opposing traffic while the trailing member marks for traffic in the same direction as survey travel.

When using this procedure on horizontal curves, the crew should work from the inside wheel path for improved simulation of the anticipated location of a driver's eye. Also it is recommended to extend the beginning point of no passing zones 100 feet as with vertical crests, but it may not be necessary to extend the ending point.

Distance Measuring Equipment Method

This method requires a two-member crew with vehicles equipped with distance measuring instruments, range finder, two-way radios, and targets 3.5 feet high. The crew will proceed along a road separated by a distance based on posted speed (shown in the table at the end of this article). The separation distance of the two

observers is established by matching readings on the distance measuring instruments in each vehicle and is continuously maintained with radio communications.

1. The procedure begins with the crew proceeding along the road with each member observing the 3.5-foot target on the other vehicle. When line of sight is interrupted by a hill crest or obstruction in or near the right of way, both should stop.
2. With one observer sighting through the range finder, the other holding a 3.5-foot height target, and both using radio communications, the crew can determine the location with adequate sight distance for approaching traffic. From that point, the lead observer should walk toward the trailing crew member until a clear view over the crest or around the obstruction from an eye height of 3.5 feet is obtained. This point is marked as the end of the no passing zone for traffic approaching from the opposite direction. The trailing member then walks a recommended 100 feet back and marks the beginning of a no passing zone for traffic traveling in the same direction as the crew.
3. The crew then proceeds along the road until line of sight between them is no longer broken by the crest or obstruction. Separation distance is verified with the distance measuring equipment and communicated by radio. At this location, again one observer uses the range finder to sight a 3.5 foot target held by the other and, with radio communication, determines where necessary sight distance is not available for oncoming traffic. The lead observer then paces a recommended 100 feet away and marks the beginning of the no passing zone for opposing traffic. The trailing member walks forward until clear sight from a 3.5-foot height is available. This point is marked as the end of the no passing zone for traffic traveling in the same direction as the crew.

Note that the leading crew member always marks no passing zones for opposing traffic and the trailing observer marks for traffic traveling in the same direction as the crew.

When marking no passing zones for horizontal curves, it is recommended that crew members work from the inside wheel track to better simulate the location of a driver’s eye. Also it is suggested to extend the beginning point of the zone 100 feet from observed sight restriction, but it is probably not necessary to also extend the ending location.

It is suggested that no passing zones on 55 mph roads be a minimum of 500 feet in length with any necessary extensions added at the beginning. No passing zones of 50 feet or less probably need not be marked.

Crew safety when making observations and establishing no passing zones should be addressed with appropriate warning signs and signals. Refer to Part 6 of the *MUTCD* and “Temporary Traffic Control During Operations” (K1) in this manual for suggested traffic control.

No passing zones may be adjusted under these situations for 55 mph posted speed:

- a. When adjacent no passing zones are located within 400 feet or less, connection of the two zones is recommended.
- b. When a no passing zone ends within 300 feet of an at-grade intersection, consider extending the zone to the intersection.
- c. When a no passing zone ends 300 feet or less from a narrow structure, consider extending the zone through the structure.
- d. When a no passing zone begins 1,000 feet or less from a stop sign, the zone can be extended back to the intersection and the No Passing pennant possibly eliminated.
- e. For traffic approaching a stop intersection, a no passing zone line should begin 600 feet in advance of the Stop sign.

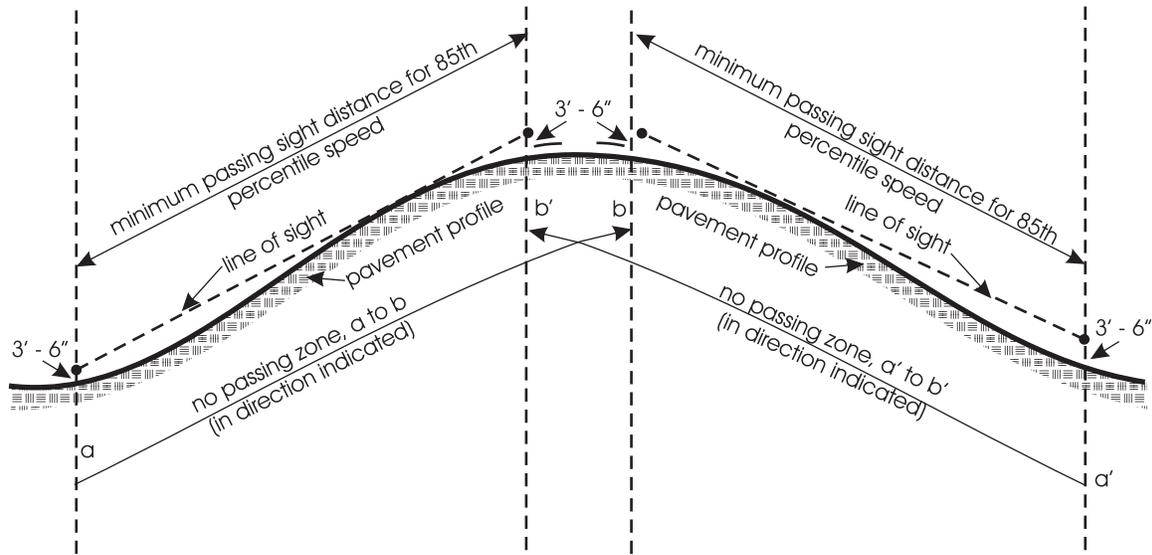
For additional information on this subject, please refer to Section 3B.02 of the *MUTCD* and to the Iowa Department of Transportation *Manual On Pavement Marking Program*. The following table and figures are included for reference.

No passing zone adjustments for slower speeds

Minimum Passing Sight Distance		Adjusting Length of Special Zones and Extensions for Various Speeds				
Posted or 85th Percentile Speed	Survey (Rope) Length	Minimum Length	(a)	(b, c)	(d)	(e)
55	1,000	500	400	300	1,000	600
50	1,000	500	400	300	1,000	600
45	800	400	320	240	800	480
40	800	400	320	240	800	480
35	600	300	240	180	600	360
30	600	300	240	180	600	360
25	500	250	200	150	500	300
20	500	250	200	150	500	300

For a, b, c, d, and e, note explanations above.

Vertical Curve



a, a' begin no passing zone

b, b' end no passing zone

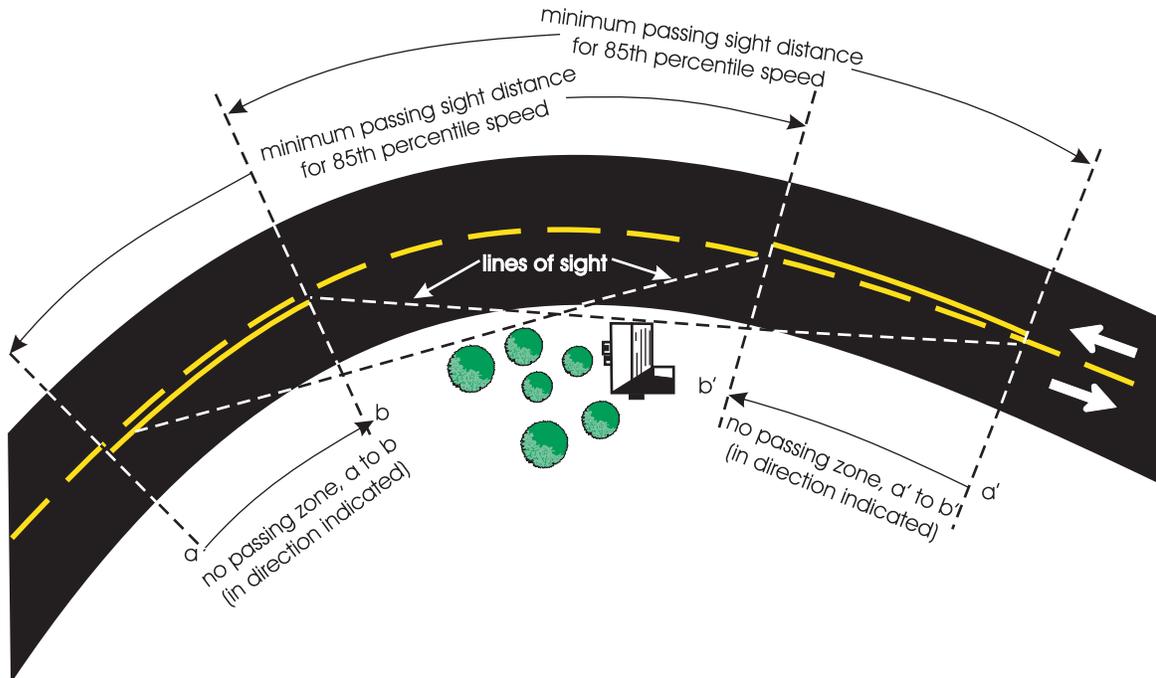
Sight distance becomes less than minimum measured between points 3' - 6" above pavement.

Sight distance again exceeds minimum.

Note: No passing zones in opposite directions may or may not overlap, depending on alignment.

Method of locating and determining the limits of no passing zones at vertical curves

Horizontal Curve



a, a' begin no passing zone

b, b' end no passing zone

Sight distance, measured along center line (or right-hand lane line on three lane road) becomes less than minimum.

Sight distance again exceeds minimum.

Note: No passing zones in opposite directions may or may not overlap, depending on alignment.

Method of locating and determining the limits of no passing zones at horizontal curves

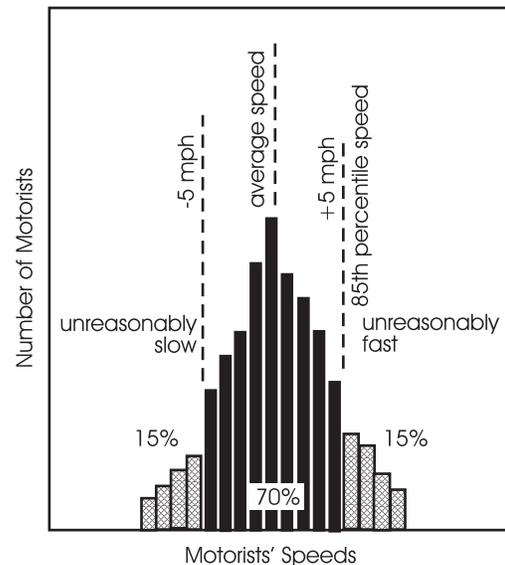
Speed Limits

Establishing safe and reasonable speed limits is an important and sometimes challenging responsibility of a transportation agency. Speed restrictions should advise drivers of limits within which a vehicle can be operated safely under normal conditions and allow sufficient time to react to unexpected conditions. Properly selected speed limits should facilitate efficient traffic flow, reduce violations, and promote safe driving conditions.

Several types of speed control are used on streets and highways. These include statutory limits established by state code, such as in school zones or business districts, other regulatory limits, which are established by the authorities responsible for the road, and advisory speed limits, which are unenforceable recommendations often used in situations such as curves and work zones.

The Code of Iowa, primarily in Chapter 321, describes several statutory speed limits and procedures for altering and establishing more appropriate control when warranted by proper study. To accomplish such a study, it should be assumed that most drivers will operate their vehicles in a reasonable manner, considering such things as road and weather conditions, traffic volumes, adjacent obstructions and distractions. This assumption leads to the theory of “85th percentile speed,” defined as the speed 85% of drivers are moving at or below.

Many studies have shown that despite the posted speed limit on a given section of road, most drivers tend to travel at a speed that is comfortable relative to roadway conditions and, at that speed, the least amount of congestion and crashes will occur. The following graph illustrates a typical distribution of driver speed on a given section of road.



Typical distribution of driver speed

The 70% of drivers who maintain a speed within 5 mph of the average speed, plus the 15% slow drivers, equal the 85th percentile speed. The remaining 15% are exceeding reasonable limits and thus are subjects for enforcement.

85th Percentile Speed

Determining the 85th percentile speed is the first step in establishing a reasonable speed limit for a section of road or street. The 85th percentile speed is usually determined with a radar check for that area, although electronic counters are available and can be downloaded into a computer for analysis. This process is referred to as a “spot speed study,” defined as measuring a sample of vehicle speeds passing a given location over a period of time. This information is then used to estimate the speed distribution of the entire traffic stream. Here are some suggestions for collecting this data:

- Select a location away from the influence of signals, intersections, etc.
- Ensure that the visibility of the observer and

or equipment does not influence driving habits.

- Minimize variables that may affect results, such as curves, rough roads, work zones, adverse weather, or excess traffic flows.
- Conduct the study during off-peak hours.
- Select study vehicles at random, not always the first vehicle in a platoon.
- Collect speeds of commercial vehicles in relation to their approximate percent of total volume.

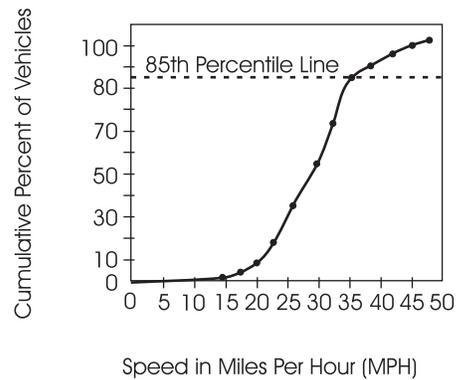
It is usually recommended to collect the speeds of at least 50 and preferably 100 vehicles, half from each direction of travel (on lower volume roads, a lesser number may be used). After data are obtained, analysis can be conducted, starting with creation of a frequency distribution table, as shown in the following figure.

Frequency distribution table

mph (1)	Mid-Point (2)	Frequency (3)	Cum. (4)	% (5)
13–15	14	1	1	1
16–18	17	2	3	3
19–21	20	5	8	8
22–24	23	11	19	19
25–27	26	15	34	34
28–30	29	21	55	55
31–33	32	17	72	72
34–36	35	13	85	85
37–39	38	7	92	92
40–42	41	6	98	98
43–45	44	1	99	99
46–48	47	1	100	100

Column 1 lists the observed speeds in 3 mph increments and column 2 records the midpoint of those speeds, which will be used later in constructing a graph. Column 3 lists the number of vehicles observed at each speed. Columns 4 and 5 indicate the cumulative frequency of these observed speeds in number and percent, respectively.

After the data are displayed in the frequency distribution table, a cumulative speed distribution curve (shown in the following figure) is constructed, using the midpoint speeds from column 2 on the horizontal axis and the cumulative percent from column 5 on the vertical axis. The 85th percentile speed is shown where the plotted curve intersects the 85% line, in this example, 35 mph. The speed limit selected for posting should be rounded to the nearest 5 mph increment.



Cumulative speed distribution curve

Other Factors

In addition to 85th percentile speed, other factors may be considered in selecting the most appropriate posted limit.

Crash History. If a section of street or road has experienced a high frequency of crashes, this data should be analyzed for contributing effects of speed. Lowering or raising the posted limit may be warranted, depending on predominant crash causes.

Traffic Volume. As volumes increase, it becomes more important that most vehicles maintain a similar speed. Adjusting the posted limit may be of assistance.

Roadway Environment and Features. Physical features (undesirable geometrics, poor sight distance, or surface conditions) and environmental factors (schools, residential areas, and large

numbers of pedestrians and/or bicyclists) may influence posted speed limits.

Engineering Judgement. Occasionally, establishment of appropriate speed limits in a given location must be based on judgement and experience. For instance, in very low volume areas where gathering a statistical speed sample is difficult, it may be necessary to base speed limit decisions on impressions from simply driving that section of road.

Selection of the most appropriate speed limit to post can be a challenging responsibility, but proper speed limitations will result in safer and more efficient traffic flow. Setting realistic speed limits is important in inviting driver compliance, allowing effective enforcement, minimizing public antagonism, and reducing crash incidence. In contrast, unrealistic limits fail to reflect behavior habits of the majority of drivers, tend to breed disrespect for all traffic control devices, result in antagonism toward enforcement efforts, create a poor community image for visitors, and increase the potential for crashes and the need for focused enforcement.

Section 2B.15 of the *MUTCD* requires that Speed Limit signs (R2-1) be erected at the point where a change occurs in established speed limitations. Although no specific spacing or interval for Speed Limit signing is included, the *MUTCD* further states that signs be posted beyond major intersections and at other locations where it may be necessary to remind motorists of the established limits. These signs should not be erected until speed limits are officially approved and authorized by the controlling jurisdiction.

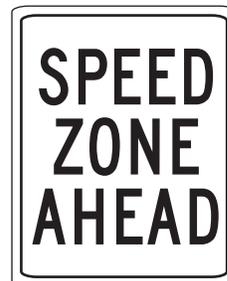
The *MUTCD*, Sections 2B.11 through 2B.16, also describes the proper application of associated speed limitation signing, such as Minimum Speed (R2-4), Speed Zone Ahead (R2-5c), and other specialized signs.



R2-1



R2-4



R2-5c

Warning Signs for Special Conditions

If engineering studies, past experience, or judgment indicate a need to advise motorists of existing roadway conditions, the *MUTCD* includes description of several warning signs. Sections 2C.20 through 2C.25 discuss several specific use signs, including Bump and Dip signs (W8-1 and W8-2), Pavement Ends (W8-3), various shoulder condition signs (W8-4, W8-9, and W8-9a), and Slippery When Wet (W8-5).



W8-1



W8-2



W8-3



W8-4



W8-5

These warning signs should be installed in advance of the affected area in accordance with Section 2C.05 of the *MUTCD* and repeated as needed where conditions exist.

Section I

Operations

Inspection Procedures

Timely and periodic inspections, both day and night, are an important element of a sign and marking management program. Section 668.10 of the Iowa Code states in part, “In any action brought pursuant to this chapter, the state or a municipality shall not be assigned a percentage of fault for any of the following: 668.10(1). The failure to place, erect, or install a Stop sign, traffic control device, or other regulatory sign as defined in the *MUTCD* adopted pursuant to Section 321.252. However, once a regulatory device has been placed, created or installed, the state or municipality may be assigned a percentage of fault for its failure to maintain the device.”

In addition to the requirements of the code, motorists depend on traffic control devices and markings that are uniform, legible, understandable, and easy to see both day and night. Highway agencies should take appropriate steps to ensure that signs are maintained in good condition. Timely inspections are a major element in this responsibility.

Features to be noted during inspections might include legibility, obstructions, mounting height, offset, reflectivity, and overall conditions. Besides noting physical deficiencies, quality inspections also can identify signs no longer needed, unnecessary redundancies, missing devices, vandalism, condition of supports, and need for additional control. In addition to signs and markings, other devices used for traffic control in the agency should be included in an inspection program including delineators, object markers, and barricades.

While the use of trained, experienced observers, especially for night reviews, is recommended, input from others is also valuable and worthwhile to solicit. Other agency employees who travel jurisdiction roads and streets frequently, law enforcement, and even the general public can be an important adjunct to the inspection effort.

Night reviews are particularly important to assess visibility performance of signs and markings. It is essential that night inspections be carried out in conditions that duplicate those experienced most commonly by drivers. Use of a retroreflectometer or similar device can document quantitative measures of reflectivity, but visual observations by a trained inspector, using clean headlights on low beam, will provide good evidence of nighttime visibility for motorists.

Recording the inspection effort is important. Use a standard inspection form, and note the date and conditions observed, along with any corrective action taken, in the agency’s inventory system.

Write your agency’s established inspection schedule in the following blanks:

Daytime inspections: _____

Night reviews: _____

A sample inspection form is shown on the following page.

Please refer to Sections 1A.05 and 2A.23 of the *MUTCD* for additional comments on inspection and maintenance of signs.

Maintenance of Traffic Control Devices and Pavement Markings

While the Code of Iowa allows considerable latitude in establishing traffic control, once signs and markings are installed, jurisdictions accept a duty to maintain those traffic control devices and markings. This duty is further discussed in the article “Inspection Procedures” (I1) in this manual. Maintenance of signs and markings can be divided into three major areas: preventative, routine, and emergency response.

Preventative maintenance is a useful concept involving replacement of aging devices, supports, and markings on a regularly scheduled basis. This practice can be very cost-effective and, because of the predictability of needs, quite simple to budget.

Routine maintenance involves minor repairs, straightening of devices, cleaning, and removing vegetation and debris, as well as many other necessary daily requirements. These activities are more difficult to estimate for budgeting, but past experience can be helpful.

Emergency maintenance is important for providing a safe environment for motorists. Damaged, missing, or vandalized signs and markings can be a potential hazard, which supports a need for established guidelines to properly address this situation. Budgeting for this activity can be based on past requirements.

Preventative Maintenance

Exposure to environmental conditions and traffic as well as normal aging will cause all signs and markings to deteriorate and fade. Programmed replacement of large groups of signs and markings can be adopted using data from an inventory system. (See “Inventory Systems for Traffic Control Devices” (J1) in this manual.) Whether automated or manual, an established inventory database can be searched to identify age, location, and quantity of traffic control devices, supports, and pavement markings that should be considered for replacement. This information then can be used for budget estimation.

Routine Maintenance

Field observations will determine the type and schedule for much of the daily routine maintenance necessary to keep signs and markings in acceptable condition. These activities are important, although they are not always viewed in this manner. Visibility of devices is mandatory for proper performance. Routine maintenance can involve the following activities.

Repairs. Signs and devices should be repaired in a timely manner primarily to provide safe driving conditions for the public. Poorly maintained signs and markings may result in lessened respect for these devices and their messages. These routine repairs might also include sign supports.

Vegetation. Signs and other devices are visible when installed, but often trees, shrubs, and even ground vegetation can obstruct visibility during certain times of the year. Need for vegetation control can be identified by regular inspections, work crew reports, and even input from the public.

Cleaning. This activity might be based on localized need and budget considerations. Dusting conditions in certain areas, mud splashing in construction areas, and snow and ice buildup in the winter can adversely affect sign and marking visibility. Rain can act to naturally clean traffic control devices, but certain signs and markings, particularly regulatory, may merit extra attention. Many times need for special cleaning is confined to specific locations and conditions.

Replacements. Replacement of signs and markings can be accomplished on a routine basis as needed. After identification, aging and deteriorated devices can be scheduled and replaced in an efficient manner. Supports can also be replaced, considering such conditions as rusting or oxidation of metal or rotting and deterioration of wood supports.

Whenever replacing Stop or Yield signs, it is good practice to use temporary signs or flaggers to control traffic during the operation. Adequate supports for these temporary signs will be needed and many agencies have developed their own designs. Refer to “Temporary Traffic Control During Operations” (K1) in this manual for more in-depth discussion of this topic.

Emergency Maintenance

This activity can be a challenging aspect of a management program. Emergency response can include replacing a missing sign or other device due to vandalism, storm, or accident. Installation of necessary traffic control in response to a major catastrophe also can be included in this category.

Development of a priority system for response in emergencies is important, particularly for certain regulatory signs, such as Stop, Yield, and Do Not Enter. In addition, the need for emergency maintenance can occur at any hour, so an established program for response is highly suggested. This system might include carrying an inventory of possibly needed devices, adoption of a response priority, and designation of an individual to receive notice from law enforcement and the public during nonworking hours. See “Responding to a Deficiency Notice” (K1) in this manual.

Recycling signs can be a cost-efficient practice for road agencies. Bent signs can be straightened and sheeting replaced, usually at a cost much less than a new purchase. When replacing devices from vandalism or even normal aging, this service should be considered as part of a good management program. Refer to “Signs” (C1) in this manual for more information.

Pavement Marking Maintenance

Appropriate maintenance, including monitoring, cleaning, and periodic replacement, should be a major factor in the pavement marking management program. The following are suggested replacement guidelines to assure reasonable visibility and retroreflectivity levels for pave-

ment markings. (Note: These guides apply only to water-based paint markings. Durable markings and tape should be replaced when necessary or as recommended by the manufacturer.)

Center Lines. Center-line markings should be considered for repainting once in each 12-month period or as needed.

Edge Lines. Edge-line markings should be considered for repainting once in each 12-month period or as needed.

Transverse Lines. These markings should be considered for repainting once in each 12-month period or as needed.

Symbols and Miscellaneous Markings.

Symbols and all other pavement markings should be considered for repainting once in each 12-month period or as needed.

Individual agencies should use replacement schedules most appropriate for local needs.

Public Response and Documentation

To provide expected service to the public, agencies may want to adopt a procedure to handle public contacts, including recording of names, phone numbers, dates, and the information presented. A follow-up with the public on any actions taken is also important for good relations.

With all types of maintenance, complete documentation is recommended. Whether routine or emergency in nature, recording maintenance activities can be extremely valuable. Documentation can be included in an established inventory system for major work or placed in a diary with minor routine activities. See “Inventory Systems for Traffic Control Devices” (J1) in this manual.

With any maintenance activity, be sure to check for utilities by using One Call (1-800-299-8989) whenever digging is anticipated.

Responding to a Deficiency Notice

Observations of defects and deficiencies in traffic control devices and pavement markings come from many sources, including law enforcement, other agencies, the public, and office staff. Receipt of such a report constitutes legal notice for an agency. Reasonable response and appropriate action is necessary.

The following response times for suitable action are suggested guides for crew activities:

Signs and Devices

Regulatory: Stop, Yield, etc. Appropriate action upon notice, down and/or missing signs replaced within 24 hours of notice.

Warning: Speed Limits, Curve, Narrow Bridge, etc. Appropriate action within 3 working days.

Guide: Route Markers, Service, Tourist, etc. Appropriate action within 5 working days.

Chevrons, Delineators, Arrows, etc. Appropriate action within 3 working days.

Barricades and Miscellaneous Devices.

Appropriate action within 3 working days.

Common sense and good judgement must always be used when responding to all deficiency notices or other requested actions. The predetermined guidelines listed here may not be appropriate for all situations.

Pavement Markings

Notices and complaints about deficient pavement markings should be investigated within 3 working days. If reasonable action is possible within crew capabilities, such as cleaning mud from road, this activity should be scheduled as soon as reasonably possible, preferably within 5 working days. If addressing a deficiency requires outside services, the observation should be noted and appropriate action taken within the next regularly scheduled contract period.

Individual agencies should establish response times most appropriate for local needs.

Sign Shop and Stock Management

Sign shop and stock management are very important aspects to assure proper signing, reflectivity levels, sign life, and availability in emergency situations. The sign shop must maintain an adequate supply of signs, determine sizes and material types, provide proper storage areas, fabricate signs in emergency situations, and work within budget constraints. Sign shops vary from agency to agency based on population, number of road miles, types of roadways, political structures, and numerous other factors.

The following is a discussion of some basic methods of sign fabrication, storage, and sign inventory management. As mentioned, a sign shop can vary greatly. However, the same goals are true for all: to provide signs that meet today's *MUTCD* standards, are cost-effective for the agency, achieve long life on the roadway, and most important, provide a safe driving environment for the motorist.

The following list contains basic items to consider in the operation of a sign shop:

- Is the method of sign fabrication and storage cost-effective?
- Are personnel available for the planned method of sign fabrication?
- Can the agency support the level of sign fabrication?
- How much storage and space will be required with the process?
- What peripheral materials and supplies are required?
- Are there any environmental concerns with the process?
- Are there any safety concerns involved?
- What will the final product accomplish?

Sign Materials

To understand the basics of sign shop and stock management, we must consider the different materials used in sign fabrication. Signs are available in a variety of materials for their

various parts. These include the retroreflective sheeting (background), the legend (foreground), and the substrate on which the sign is placed. Further discussion of sign materials can be found in the article "Signs" (C1) in this manual.

Substrate. The substrate gives a sign rigidity and can be made from various materials including steel, aluminum, wood, and several types of plastics. Each material has advantages and disadvantages.

Sheeting Material. The sheeting material covers the substrate and is typically the background color of the sign. Some signs are designed with reverse colors so that the actual sheeting material becomes the letter material when an extra film or silk screen ink covers the remainder of the sign. These are known as "reversed" signs.



**Standard foreground and background
(not a standard sign)**



**Reversed background using white sheeting and
green film**

Sheeting material is available in different levels of retroreflectivity and quality. Retroreflectivity is what makes light return from the sign to the driver and is especially important for night driving. See “Signs” (C1) in this manual for different levels of retroreflectivity and possible uses.

Legend. The legend of the sign transfers the information from the sign to the motorist. Legends can be words or symbols. Established standards for symbols and word messages should be followed when fabricating or purchasing signs. Do not use nonstandard signs or symbols. Chapter 1A of the *MUTCD* contains lists of acceptable and unacceptable abbreviations for use on signs.

A publication of the Federal Highway Administration, *Standard Highway Signs*, shows the proper design details of roadway signs. The manual also provides information on the proper dimensions for lettering and sign sizes for



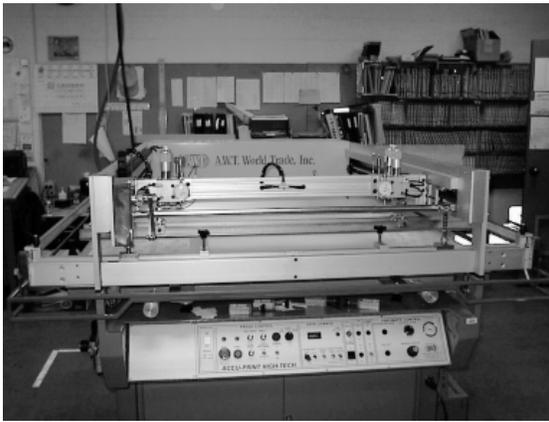
Automated sheeting installation unit

different types of roadway environments. See “Signs” (C1) for more information.

The legend on a sign can be produced by several methods. The method used is dependent on the equipment the agency owns, the quantity of signs needed, the size of the sign, and the urgency with which the sign is needed. The table below lists several methods for producing sign legends.

Sign legend production methods

Method	Typical Use	Equipment Required	Advantages/Disadvantages
Hand Layout	Emergency signs, street name signs	Precut letters	Minimal investment, stocked letters deteriorate, slow process, small quantities only
Die Cutting	Emergency signs, street name signs	Dies, press	Considerable investment, limited by different die sets, considerable storage for die sets, little material waste
Computer Cutter/Plotter	Emergency signs, everyday use signs, street name signs	Computer and software, cutter/plotter, “clean room”	Highly flexible, make almost any type of sign, considerable material waste, high cost for warning/regulatory
Silk Screening	Bulk sign production	Silk screen area, cleaning facility, UV screen burner, drying racks	Lowest cost per sign, considerable initial investment, equipment and clean up areas, fumes and flammable materials



Automated silk screen machine



Assortment of cutting dies



Computerized cutter/plotter unit

Shop and Stock Management

The larger the agency, the more complex shop and stock management becomes as many more types of materials and signs are needed. Smaller jurisdictions typically require fewer signs and consequently can utilize simpler stocking methods and storage areas.

Generally, smaller agencies may not produce any signs, buying them from an outside source instead. Therefore, the only portion of the product that requires inventory or management is that of signs and supports. However, a large facility must manage inventories of blank substrates, sheeting materials, cutting films, silk screen inks and cleaners, highly complex equipment, and computer systems, in addition to the finished signs.

A very small agency could conceivably stock all signs in a sign truck. However, small agencies may not have a truck dedicated to traffic control, so storage in racks may be necessary.

Storage racks can be designed in many shapes and sizes. Some racks use dividers for groups of signs; others use individual supports for each sign. Individual supports for each sign work well for small signs but are not always practical for larger signs. Whatever type of storage system is used, be sure the rack is strong enough to support the total weight of the signs. Even if an individual sign is not heavy, several hundred signs can weigh several thousand pounds. In addition, be sure the surface of the signs will be protected in the storage system. Signs stored together should be protected with slip sheets or other protective coverings.



Typical sign storage unit

Stocking and Fabrication Practices

Small Agencies. A small agency, such as a small town, has no more than a few hundred

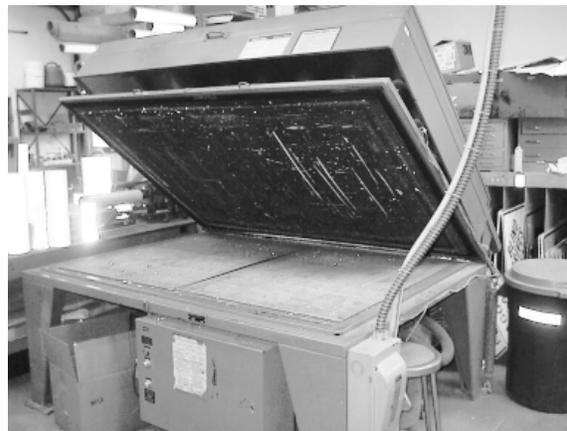
signs. In this situation, all signs will be purchased, because fabrication is not practical. However, it would be good practice to keep enough signs in storage to replace signs that have been knocked down, vandalized, or removed. Critical signs to have in storage are Stop, Yield, and any warning signs that may be critical. Another way of maintaining signs in a very small community is to contract with either a vendor or larger political subdivision, such as the county. This practice eliminates the need for stocking materials.

If an agency chooses to maintain and install its own signs, the agency should remember the following guidelines:

- Install signs that meet *MUTCD* standards.
- Use retroreflective sheeting where required.
- Avoid specialty signs, such as Children at Play.
- Keep only enough signs in the inventory to address emergencies.
- Store signs in an area where they will be protected from abrasion, dust, excessive heat, and sunlight.

Medium Agencies. This category includes cities with population up to 5,000 and counties of average size. An agency in this category may have a thousand or more signs under its jurisdiction and staff in charge of signs and other local functions. These agencies would stock enough signs to replace those that are fading or have been knocked down, vandalized, or removed.

Again, as with the small jurisdictions, an agency of medium size may find that fabrication is not practical. However, if the agency wishes to fabricate a few specialty signs each year such as No Parking signs, a small assortment of precut letters applied with either a vacuum-heat activation machine or a small roller press may be practical. (Note: The vacuum-heat activation machines are becoming obsolete as most signs are now made with pressure sensitive legends and lettering.)



Typical vacuum/heat sheeting applicator

If precut lettering is used, small cabinets or boxes should be used to store the letters. The stock of letters must be rotated as the letters have a limited shelf life. Use “first in, first out” inventory practices to keep stock fresh. The local agency can order completed signs with borders, but no legend, which results in greater efficiency if only a few signs are needed.

Medium-Large Agencies. This category includes 5,000 to 50,000 populations. Agencies of this size usually have at least one person assigned to sign maintenance full-time. On the higher end of the scale, an agency may have several full-time sign personnel, including one in charge of fabricating and/or maintaining the sign inventory stock.

Agencies of this size may maintain from 1,000 to 20,000 signs. Assuming that the average sign lasts for ten years, an agency with 20,000 signs will replace approximately 2,000 signs per year for maintenance purposes alone. With additional sign revisions, work zones, new streets, knockdowns, vandalism, and stolen signs, replacements could increase to about 3,000 signs per year. This number is significant and a reasonable stock of signs must be maintained to have signs available when needed. At 3,000 signs per year, an average of 60 new signs could be required every week.

A major concern for an agency of this size is maintaining adequate sign stocks and the flexibility to make specialty signs as needed. All signs can be purchased from an outside source. However, a larger agency will continuously require specialty signs. With enough planning, an agency could order even the specialty signs from a vendor that can guarantee delivery of the signs within a day or two. However, for most cities and counties, this method is not practical.

Many agencies are now using a combination of stocking standard signs made by an outside vendor and having a system such as a computerized cutter/plotter to make specialty signs and/or street name signs. Some agencies in this population group may elect to make all signs. However, total sign fabrication requires extensive materials and equipment. Three levels at which a sign shop can be stocked are listed in the following table.

Sign shop options

Equipment	Completed Signs/ Sign Types	Substrates/Sheeting	Legend Material
Level 1			
-	All warning and regulatory	Aluminum with high-intensity sheeting	-
Small squeeze roller system	Specialty parking, information, etc.	Completed aluminum sign blank with engineer grade sheeting	Precut letters
Level 2			
-	Common warning and regulatory signs	Aluminum with high-intensity sheeting	-
Squeeze roller system	Specialty parking, information, etc.	Completed aluminum sign blank with engineer grade sheeting; small amount of high intensity for specialty signs	Die-cut letters
Level 3			
-	Stop and Yield signs	Aluminum with high-intensity or diamond-grade sheeting	-
Pressure roller unit with air cylinders	Completed aluminum blanks with sheeting	Aluminum blanks in standard sizes; engineer grade, high-intensity and diamond-grade in all standard colors	-
Computerized cutter/plotter	Street names, specialty, regulatory, and warning signs	-	Electro-cutting film

Large Metropolitan Agencies. The practices of large metropolitan facilities can also vary greatly. However, as the total number of signs and particularly specialty signs increase, flexibility and productivity become key factors. Standard signs can be computer-generated but are typically produced by silk-screening. Silk-screening provides very high production rates and quality. However, silk-screening requires a considerable investment in equipment and involves many environmental concerns. The process should be undertaken only after considering these factors. Please refer to comments on “nesting” in the article “Signs” (C1) in this manual.

Storage of Materials and Completed Signs

As noted previously, the size of the agency influences the level of sign production. With each added method of sign fabrication, additional storage is needed for sign materials and equipment. A large facility will require storage for sign blanks, sheeting, silk screen inks, electro-cutting films, transfer tapes, and many different types of application equipment. Storage space must be a factor whenever a process for sign production is considered. See the illustrations on the next page for examples of storage systems.

Sign fabrication considerations

Equipment	Completed Signs/Sign Types	Substrates/Sheeting	Legend Material
-	Stop and Yield	Aluminum with high intensity or diamond grade sheeting	-
Pressure roller with air cylinders	Completed aluminum blanks with sheeting	Aluminum blanks in standard sizes; engineer grade, high-intensity and diamond-grade in all standard colors	-
Computerized cutter/plotter system	Street names, specialty, regulatory, warning	Aluminum or plastic for special signs	Electro-cutting film, rubyolith film
Silk screens, UV developer, dark room, production unit, drying racks	Warning, regulatory, and street name	Aluminum with engineer-grade, high-intensity, or diamond-grade sheeting	Screen inks
Automated sheeting applicator	-	Aluminum with any of the different sheeting types	-



Storage for rolls of sheeting material



Sign separators in storage truck

**Note: When storage requires supports on top and bottom similar to this vehicle rack, use plastic rather than wood for dividers. Plastic does not swell like wood and tends to have fewer problems with breakage and splintering.



Storage for sign blanks



Small sign truck

Note sign storage cabinet in front of box



Truck storage compartment for completed signs



Sign storage cabinets on medium-sized truck

Theft and Vandalism

Theft and vandalism of traffic control devices is a common occurrence in most areas and can become a serious problem for local transportation agencies.

Vandalism and theft of signs or other devices result in increased maintenance costs and can even expose local agencies to liability if an appropriate response is not made.

Regulatory signs, such as Stop, Yield, and Do Not Enter, seem to be the most popular for theft. Specific street name signs and certain route markers are also frequently removed.

Many approaches have been developed to reduce theft and vandalism. Higher mounting and increased lateral displacement are often successful. Various sign substrates (plywood, steel, or aluminum) have particular attributes to consider. Several types of vandal-proof fasteners that resist removal are available. Special anchors, anti-twist, and pull-out devices make supports more resistant to push over.

Sign face treatments, coatings, and transparent sheeting all make removal of graffiti less difficult. Identification stickers can be beneficial in identifying stolen signs and devices when they are found.

Not all damage to traffic control devices is intentional, and the use of flexible supports can

reduce maintenance on narrow roadways frequently used by wide agricultural equipment.

A proactive approach to address theft and vandalism of traffic control devices is often warranted in local road agencies. Frequent inspections together with good record keeping of losses and increased maintenance costs can be very beneficial, as are educational initiatives and public service announcements. Raising public awareness of these costs and potential safety exposure using displays of damaged signs and devices can be effective. Cooperation and communication with law and justice officials is important in achieving a more successful rate of enforcement and conviction for violations.

Response time for replacement of vandalized signs should be part of a jurisdiction's sign policy. Regulatory signs, such as Stop and Yield signs, should be given highest priority for reinstallation and should be replaced as soon as possible. Some jurisdictions replace Stop and Yield signs on a 24-hours-a-day, 7-days-a-week basis. Most other sign replacements may be carried out during normal working hours. Each jurisdiction should develop and follow a policy for repair and replacement of road signs.

For more information, refer to the 1986 U.S. Department of Transportation Federal Highway Administration's *Manual on Countermeasures for Sign Vandalism*.

Section J

Inventory Systems

Inventory Systems for Traffic Control Devices

An inventory of signs and markings is a critical element for effective governmental transportation management practices. The investment in signs and markings is significant when considering all the assets of a government agency. The ideal inventory system would track signs and markings from initial installation, through inspections and maintenance, and until removal from the system.



Rural highway with signs and pavement markings

A traffic control device inventory can be a valuable asset in tort liability cases. This inventory can provide documentation of the condition of specific signs and markings in place for any given period. In addition, pertinent inspection and maintenance activities would be noted in the inventory and available for use by the agency.

An inventory system can be used for many activities. It can identify signs for replacement based on criteria such as age or condition. Recording and evaluating maintenance and replacement history can help an agency to identify high-vandalism areas or sign locations with visibility or operational deficiencies. In addition, planning and budgeting for sign replacement or expansion of new development areas is much easier to accomplish with inventory records identifying existing signs and required maintenance activities. A sign inventory can be used to manage personnel and maximize production by combining work orders and scheduling routine maintenance activities. The system can track responses to requests and complaints, resulting in an improved level of service to the public.



Urban street with signs and pavement markings



Stop sign in poor condition
Note: Street sign is improperly placed.



Vandalized Speed Limit sign



Vandalized sign

A critical element of a successfully operating inventory is the involvement of all staff whose job requires an interest in traffic control devices. This staff may include engineers, transportation planners, accountants, office managers, enforcement officers, administrators, and most important, installation and maintenance staff. This involvement is particularly important for the staff responsible for collecting the original data, maintaining traffic control devices, and keeping the inventory system current. An efficient inventory system results from involvement of all interested parties.

Choosing a System

Inventory systems range from very basic to quite sophisticated depending on the resources available to and the needs of an agency. A very basic inventory system might consist of manual records, such as paper files of activities or a card system, to maintain the system and keep it current.

Many transportation agencies use an automated or computerized system. Each agency should consider several factors before making a selection between one of the many computer programs available:

- agency requirements
- computer capabilities
- availability of trained staff to support the system and keep it current
- improved accuracy and production with use of laptop computers for field operations

When selecting an inventory system, the following issues should be addressed:

- Does the system match the selected data elements? Are all data elements recorded?
- Is there an understanding of the basic features of a software program as compared to data elements?
- Do the hardware and software requirements of computer programs match the existing computer system?
- Have user support and references been reviewed?
- What does the initial cost include?
- Are there maintenance costs with the program?

Software that provides basic inventory features has been developed and is available at minimal cost to local agencies. These programs can be effectively used as a low-cost supplement to a sign management system.

Developing the System

Development of the system should involve key personnel, including management representatives, office staff, work crew supervisors, sign

workers, and other affected offices within the agency. The development of an inventory system should also include all critical tasks: selecting and purchasing software, collecting initial data, daily operations, and reporting procedures, along with ancillary tasks such as enforcement and risk management.

Choosing a Reference System

Several reference systems can be considered to locate traffic control devices for the inventory. The chosen reference system should be compatible with other systems within the agency and use the same reference points. The most common references used are shown in the following list:

- route/milepost/distance
- route/mile point/distance
- link/node/distance
- route/intersection/direction/distance
- global positioning systems, which may offer additional location options for the future
- linear referencing systems

Each of these reference methods has particular advantages to consider, but the most important factors are compatibility with other agency systems, staff buy-in, and ease of use.

Determining Elements of the Inventory

Inventory data elements are selected to provide most appropriate information to meet agency needs. These elements can be divided into three categories: core, critical, and desirable.

Core Elements. Core data elements reveal location, description, condition, and inspection and maintenance history. Core elements are essential to an inventory. These elements identify replacements, provide documentation in tort liability, and furnish benefits in management and budgeting.

Core elements typically include the following:

- location
- position
- sign code (*MUTCD* designation)

- sign condition
- maintenance activities
- installation, inspection, and maintenance dates

Critical Elements. Critical data elements provide more information about devices. These elements are valuable in keeping proper inventories in stock and can provide additional information that supports the agency in tort liability issues. With data from the following critical element list, an agency can document that traffic control devices comply with established standards and guidelines.

Critical elements normally include the following:

- dimensions
- sheeting type
- sign blank type
- post/support type and condition
- sign orientation
- posted speed limit at the time activities were conducted

Desirable Elements. Desirable data elements can provide additional information about sign installation that can help with maintenance and replacement activities. Desirable elements include the following:

- offset
- height
- retroreflectivity (documentation will be more important when minimum standards are adopted nationally)
- inspector name
- sign identification number, if different from *MUTCD*
- images of the sign
- comments
- other reference numbers

Collecting the Data

The most formidable task after selecting an inventory management system, whether manual or computerized, is the collection of initial data. In addition to a significant investment in staff time, collection costs can range from \$2 to \$5 per sign. To reduce initial cost and staff time, phased data collection can be considered. A

systematic approach should be developed that completes the task within a reasonable time, i.e., four years or less. Data may be collected by area or sign type. Regular agency staff, temporary employees, or consultants can be used to collect this data, but all should be properly trained. It is very important that initial information be accurate.

When the initial data collection effort is organized, the following recommendations should be considered and/or followed:

- Select a standard approach that matches other data bases within the agency, if possible.
- Decide whether to use route names or route numbers for location.
- What signs should be included? All or one specific type, such as regulatory signs?
- How do we determine whose sign is it?
- Train personnel to collect and enter data.
- Determine the area to be inventoried (do only a section each year until the initial data collection is completed.)
- Decide whether to use manual data collection, laptop computers, or photo/video logging to gather initial data.

Maintaining the Inventory

After an inventory system has been adopted and initial data collection activities are completed, the next critical task is keeping the system current. If the inventory is not up to date, much of the value and the investment in resources will be lost in a relatively short time.

A work order process is a common method of keeping inventories current. With this procedure, work orders are completed at the time any activity is finished. Usually, the field crews that perform the work are best qualified to record the data. Pen-based computers have been used successfully for this purpose in some agencies. It is important to enter this information into the database on a regular schedule, daily if possible. Documentation of important daily activities should be a key factor in software selection.

Inventories of traffic control devices can be a very valuable asset for any transportation agency. However, development and establishment can involve a significant investment in staff time and funding. Continued maintenance of the system is mandatory for efficient and effective operation.

Please refer to the following sources for more in-depth information:

Institute of Transportation Engineers, *Traffic Signing Handbook*.

Institute of Transportation Engineers, *The Traffic Safety Toolbox: A Primer on Traffic Safety*.

The Center for Transportation Research and Education, a center of Iowa State University.

Section K

Temporary **Traffic Control**

K: Temporary
Traffic Control

Temporary Traffic Control During Operations

Any work performed in or near streets and roadways can expose the public and workers to hazardous safety conditions. Proper temporary traffic control should be a high priority in any agency. Good quality devices, apparel, training and supervisory support for all staff who work in streets and roadways are necessary. Development and use of a traffic control plan for many routine maintenance operations can be beneficial.

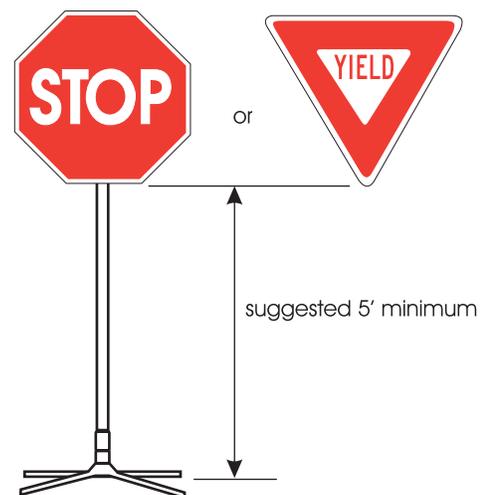
It is mandatory that temporary traffic control complies with the requirements of the *MUTCD* Part 6. Close referral to Part 6 is recommended prior to making any decisions for proper work zone traffic control. No one standard sequence of signs and devices can be applied in all situations due to wide variation in conditions and factors; judgement and common sense must be applied in selecting the most appropriate temporary traffic control for individual applications. However, some frequently used situations are included here.

In selecting the desired level of control, consider traffic volume and prevailing speed, time of exposure, degree of lane restriction, sight distance, time of day, and other elements.

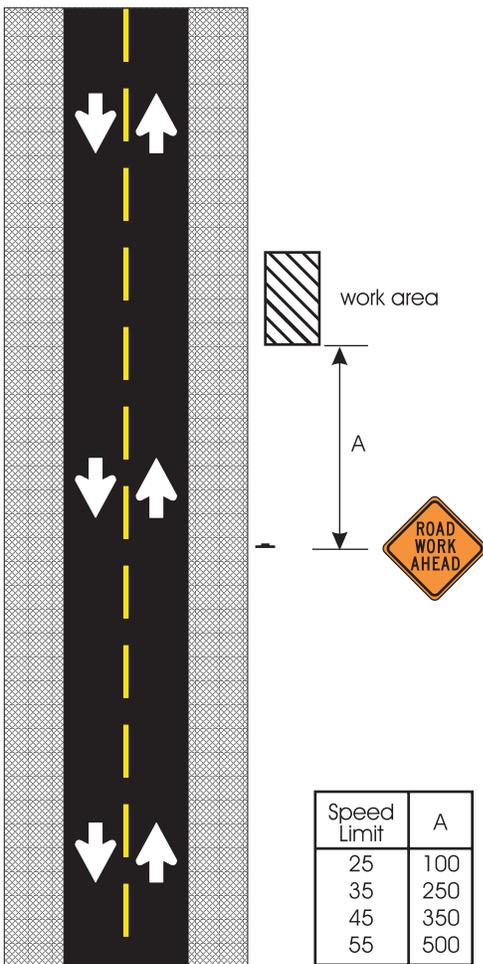
For short-term (less than an hour) exposure with relatively low traffic volumes and adequate sight distance, traffic control may only consist of an amber revolving light on the work vehicles. Longer duration work, more lane encroachment, inadequate sight distance, or higher speeds may all require additional temporary controls including signs, channelizing devices, and possibly one or more flaggers. The *MUTCD* and other resources should be carefully consulted for assistance in selecting any necessary traffic control.

Maintenance of signs and other devices presents unique considerations for temporary traffic control. An individual technician working independently often performs much of this work. This worker must exercise a good deal of judgement to maintain safe working conditions. Necessary signs, cones, and other devices as well as safety vests, hardhats, and other personal protective equipment should be carried in the truck at all times.

When repairing or replacing Stop or Yield signs, it is recommended that temporary stop or yield control be utilized. Many agencies have designed portable signs specifically for this purpose. If temporary Stop or Yield signs are not available, use of a flagger during this operation is suggested.



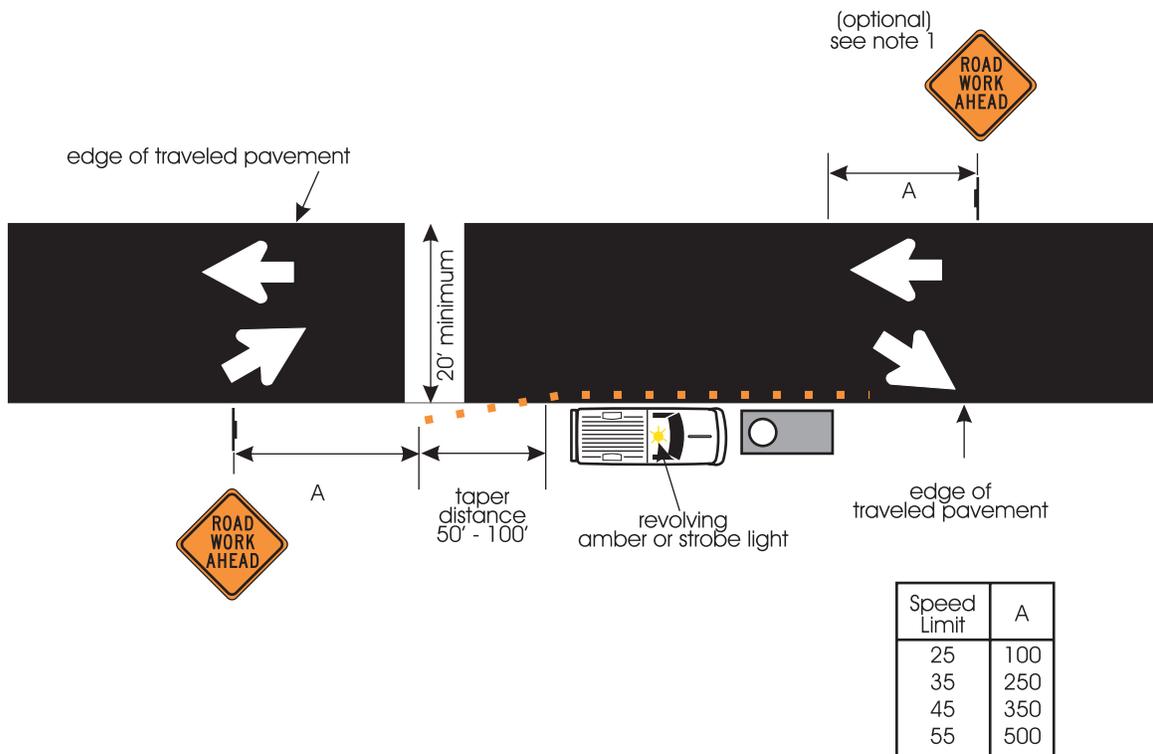
Temporary Stop or Yield sign



Notes:

1. The sign illustrated in this figure is not required if the work space is behind a barrier, more than 2 feet behind the curb, or 15 feet or more from the edge of the roadway.
2. The Road Work Ahead sign may be replaced with other appropriate signs, such as the Workers sign.
3. For short-term, short-duration, or mobile operation, all signs and channelizing devices may be eliminated if a vehicle with an activated flashing or revolving amber or strobe light is used.

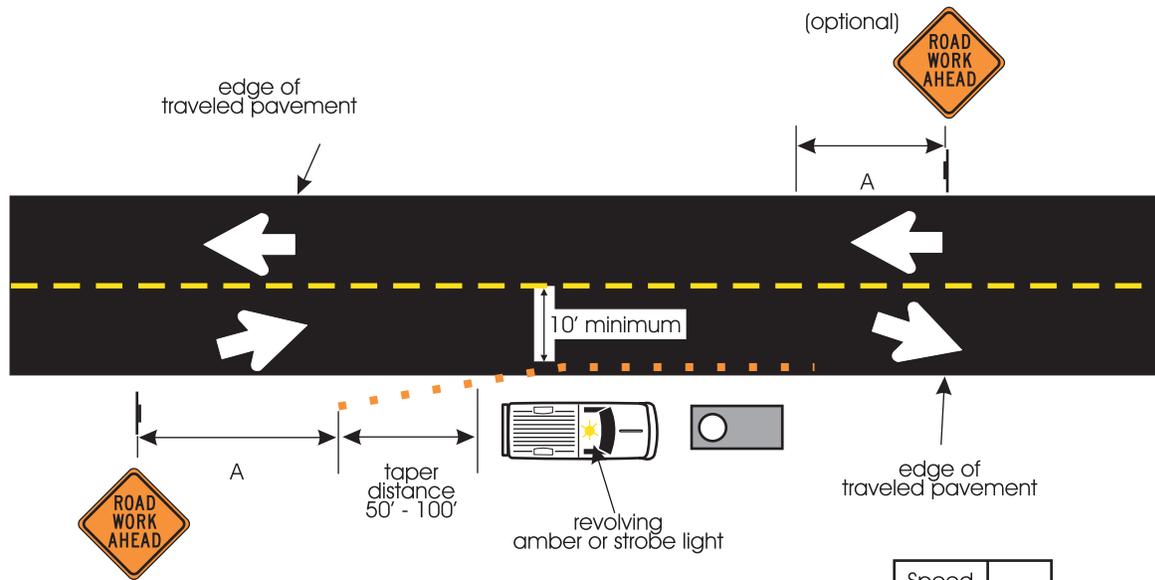
Work beyond the roadway



Notes:

1. Sign required only when sight distance is restricted (typically a no passing zone in the workspace).
2. Flagger protection not required, provided bidirectional traffic can move freely at reduced speed through the workspace.
3. The number of channelizing devices is variable.
4. For short duration work of one hour or less, all signs and channelizing devices may be eliminated if work vehicle has a revolving yellow or amber light.

Minor encroachment on two-lane road without center line

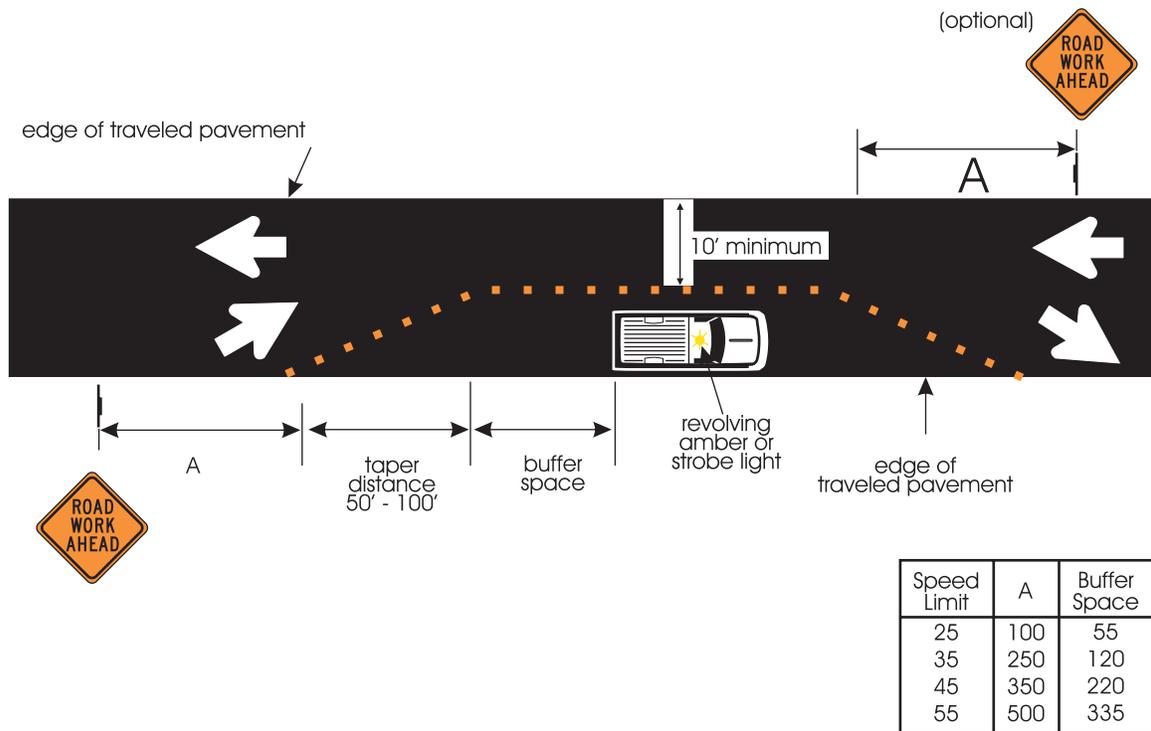


Speed Limit	A
25	100
35	250
45	350
55	500

Notes:

1. The lane encroachment should permit a remaining lane width of 10 feet or the lane should be closed. However, 9 feet is acceptable for short-term use on a low-volume, low-speed roadway for traffic that does not include commercial vehicles.
2. The number of channelizing devices is variable.

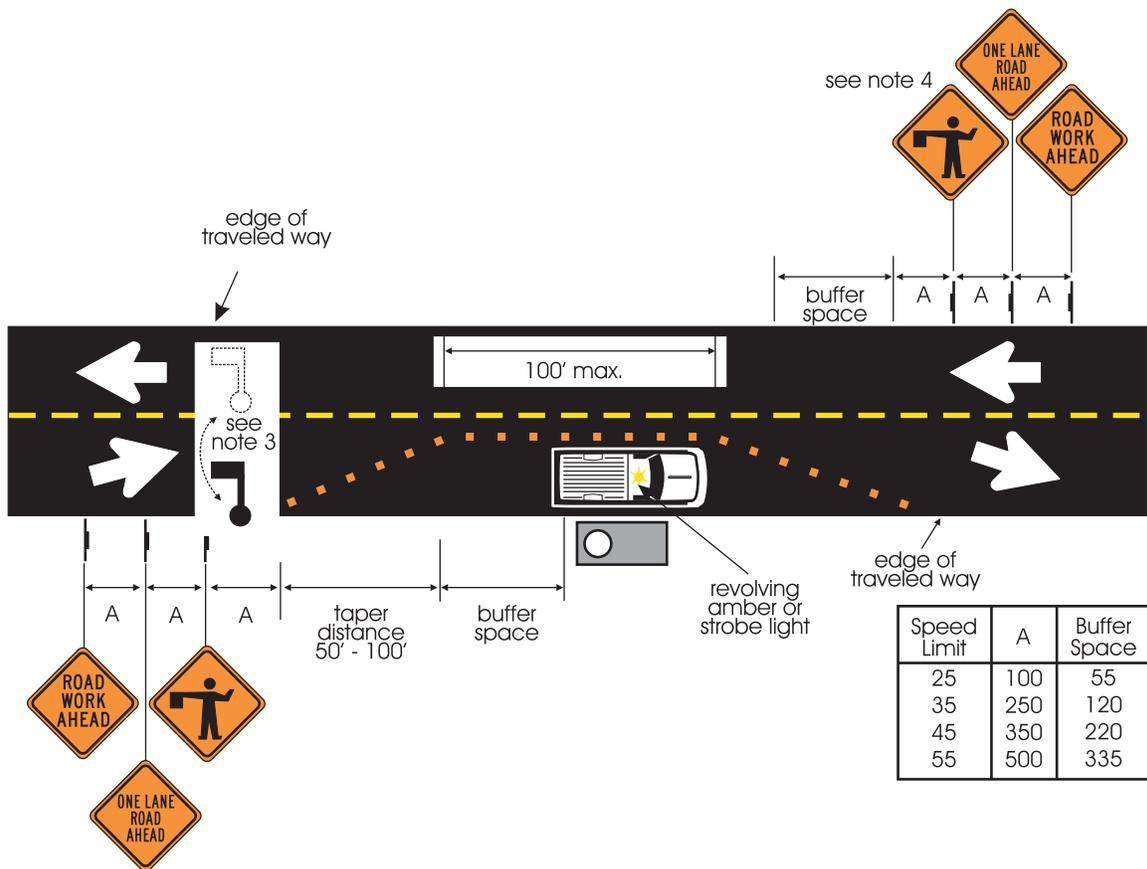
Minor encroachment on two-lane road with a marked center line



Notes:

1. Conditions represented are for work that requires closing a lane of traffic during daylight hours only.
2. No parking for work vehicles on opposite shoulder within 500 feet of work area.
3. A flagger may be required if visibility is restricted or potential traffic conflict exists.
4. A 2-foot safety zone is suggested between the cones and the truck when access to the truck is necessary on the side exposed to traffic.
5. The number of channelizing devices is variable.

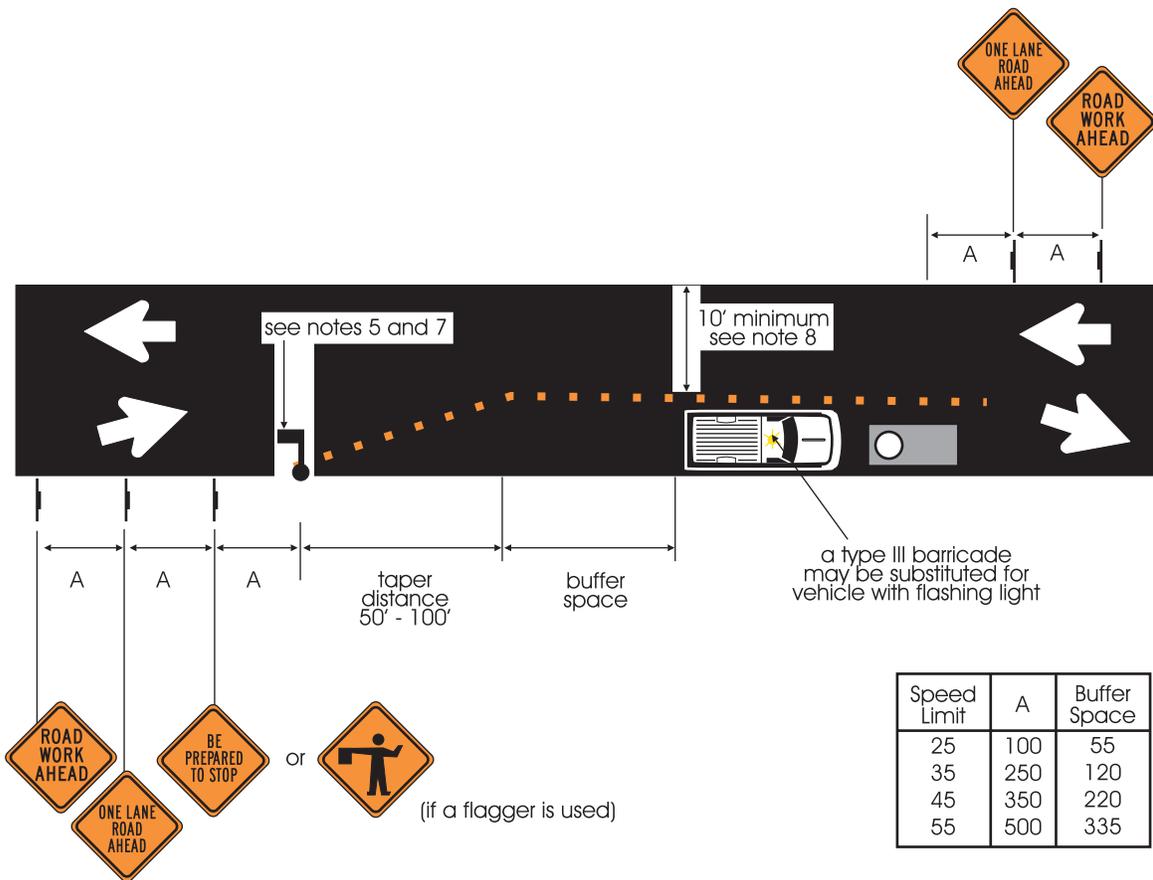
Major encroachment on low-volume residential street or rural gravel roadway



Notes:

1. This layout is intended for traffic volumes less than 2,000 vehicles per day.
2. No parking on opposite shoulder within 500 feet of work area.
3. Traffic in the open lane shall be allowed to flow freely. The flagger shall stop the first vehicle in the closed lane from the position shown, then cross the traffic lane to stop other vehicles.
4. A second flagger and sign may be required:
 - a. if the flagger's view of approaching traffic in the open lane is less than 1/4 mile or the work site is in an area of restricted sight distance (such as a no passing zone); or
 - b. if excessive traffic delays are encountered.
5. The number of channelizing devices is variable. Some devices may be eliminated if they interfere with the work.

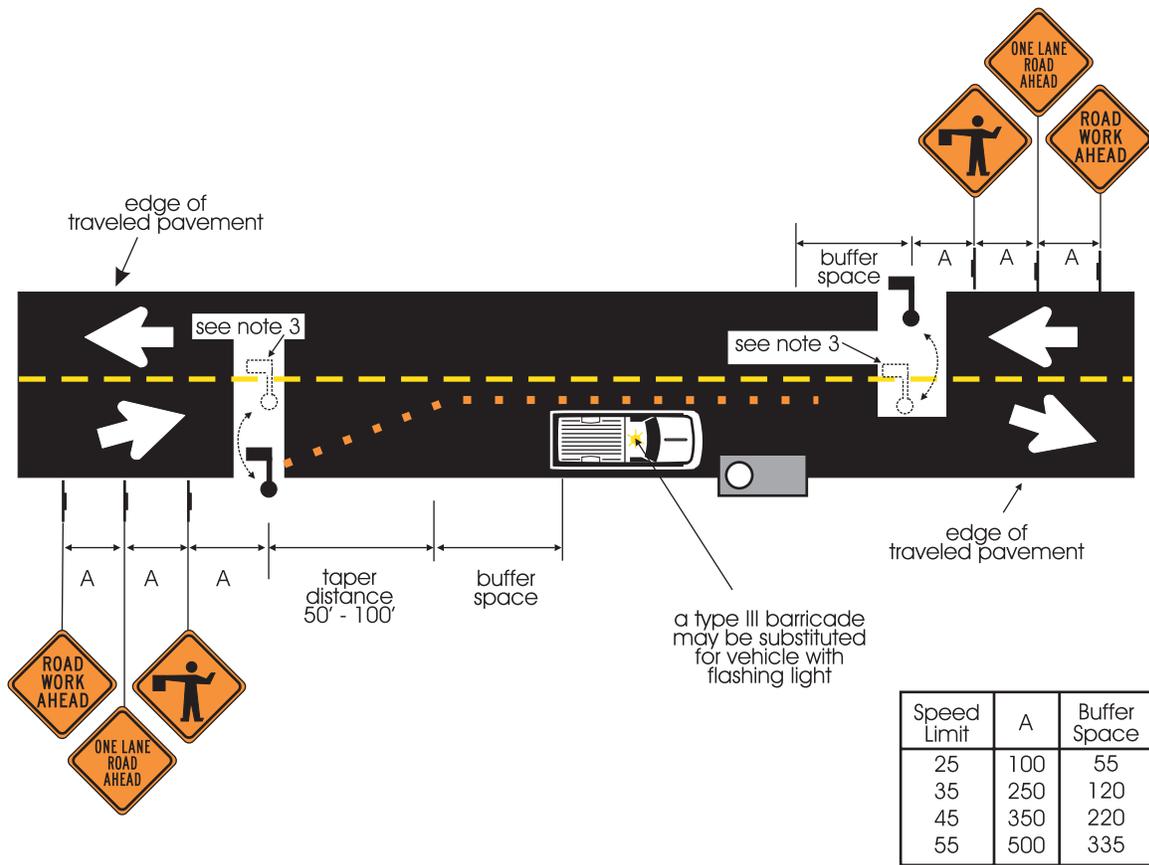
Major encroachment on higher volume urban street with marked center line



Notes:

1. Conditions represented are for work that requires closing the traffic lane during daylight hours only.
2. This layout is intended for traffic volumes of less than 2,000 vehicles per day.
3. No parking on opposite shoulder with 500 feet of workspace.
4. Traffic in the open lane shall be allowed to flow freely.
5. A flagger shall be required if visibility is less than 1/4 mile or the work space is in an area of restricted sight distance.
6. The number of channelizing devices is variable.
7. If traffic volume is more than 15 vehicles in any given 15 minutes, a flagger may be required.
8. The lane encroachment should permit a remaining lane width of 10 feet. However, 9 feet is acceptable for short-term use on low-volume, low-speed roadway for traffic that does not include longer and heavier commercial vehicles.

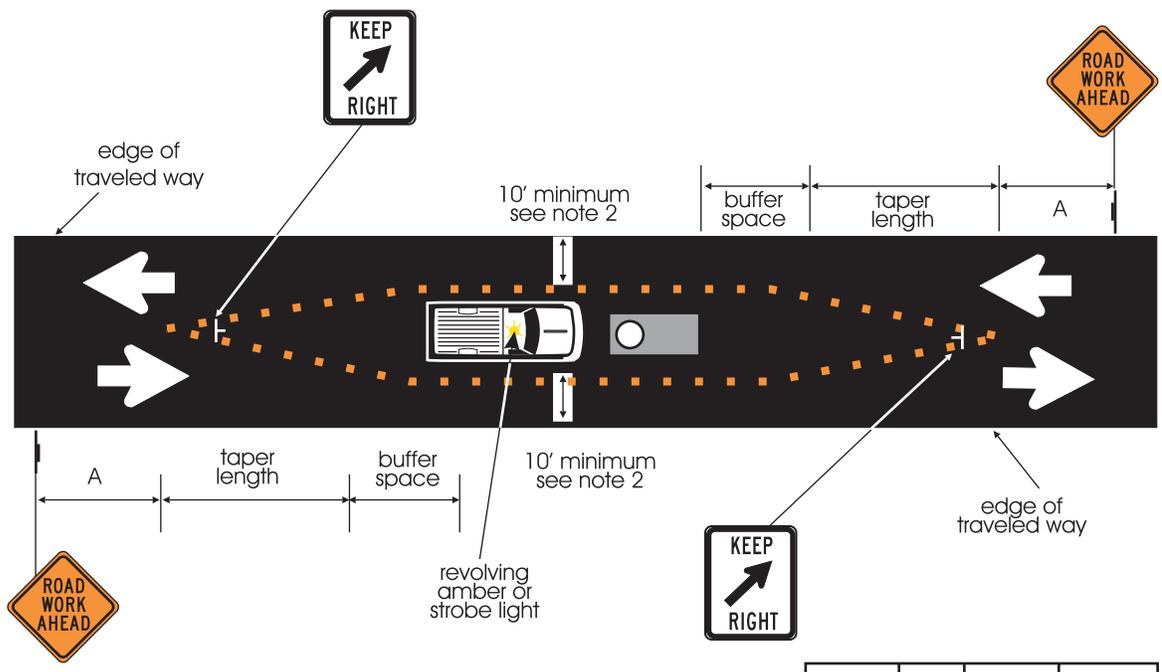
One-lane closure of a higher volume two-lane gravel roadway



Notes:

1. Conditions represented are for daylight hours only.
2. No parking on opposite shoulder within 500 feet of work area.
3. The flagger shall stop the first vehicle from the position shown, then cross traffic lane to stop other vehicles.
4. Channelizing devices in taper are required at all times. The number of channelizing devices is variable.
5. A Be Prepared to Stop sign (W20-7b) may be added to the advance warning series.

Major encroachment on higher volume road or street

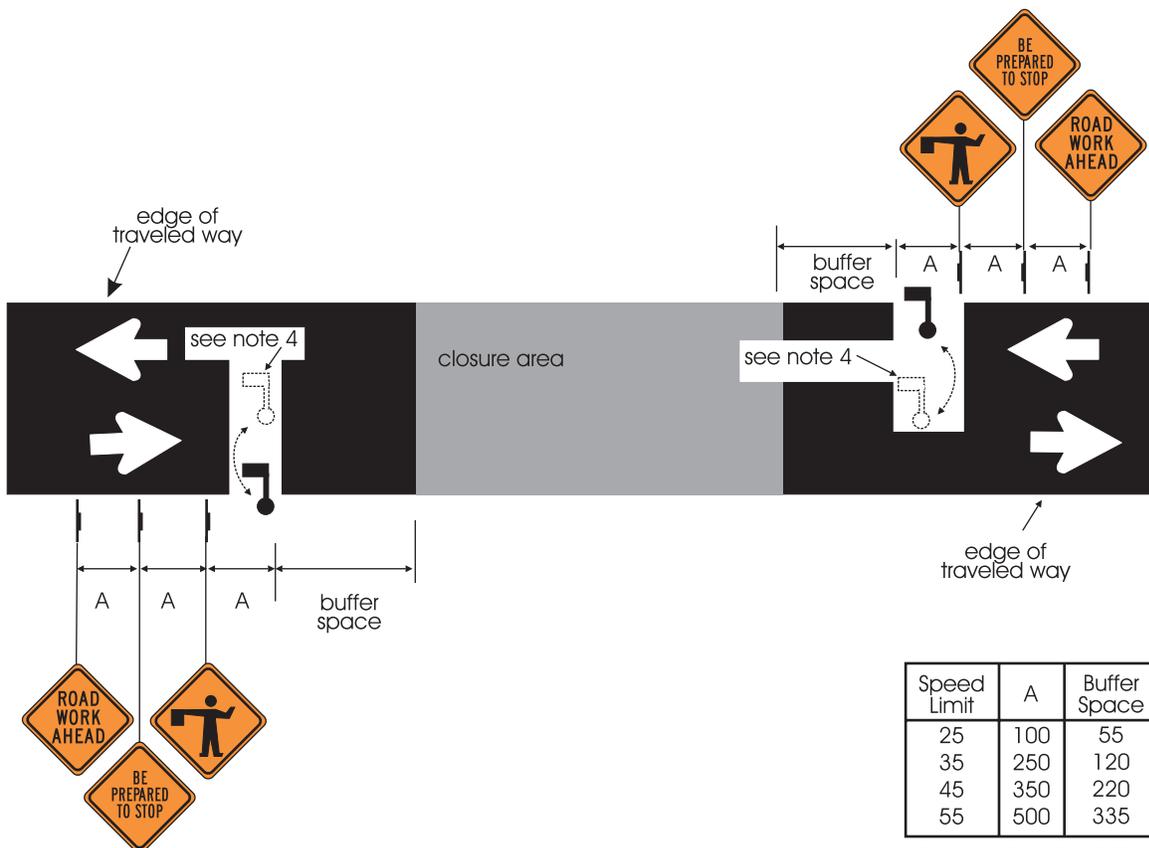


Speed Limit	A	Taper Length	Buffer Space
25	100	25	55
35	500	45	120
45	700	90	220
55	1000	110	335

Notes:

1. Street parking should be removed within limits of work area.
2. The lane encroachment should permit a remaining width of 10 feet or the lane should be closed. However, 9 feet is acceptable for short-term use on low-volume, low-speed roadways for traffic that does not include heavy commercial vehicles.
3. The number of channelizing devices is variable.
4. On low-volume roads, tapers may be eliminated if work vehicle has a revolving yellow or amber light.

Work zone in center of two-lane urban street

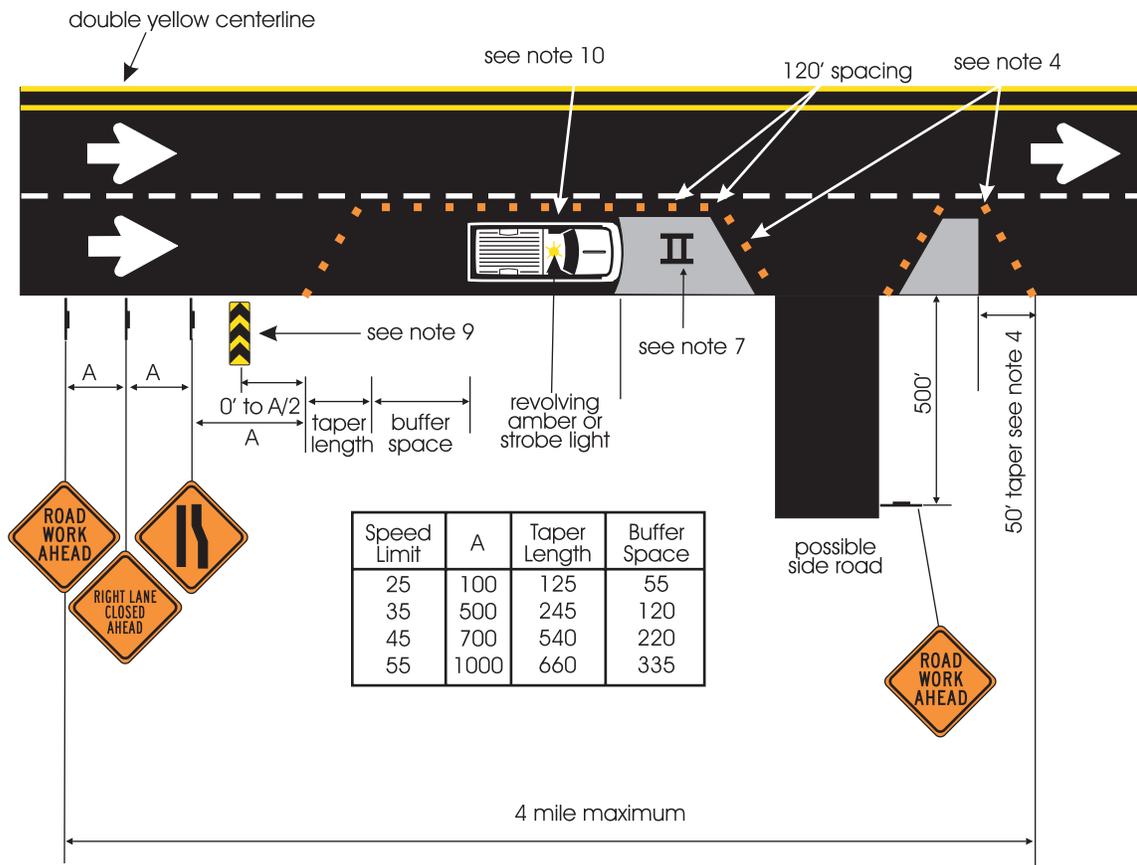


sign spacing should be increased on higher volume roadways

Notes:

1. Use of this layout may require contact with schools, law enforcement, and emergency services.
2. Conditions represented are for work that requires closings during daylight hours only.
3. This application is intended for a planned temporary closing not to exceed 15-20 minutes.
4. The flaggers shall stop the first vehicle from the position shown, then move to the center line to stop approaching traffic.
5. Distance from flaggers to flagger signs may be increased to provide space for anticipated number of vehicles to be stopped.

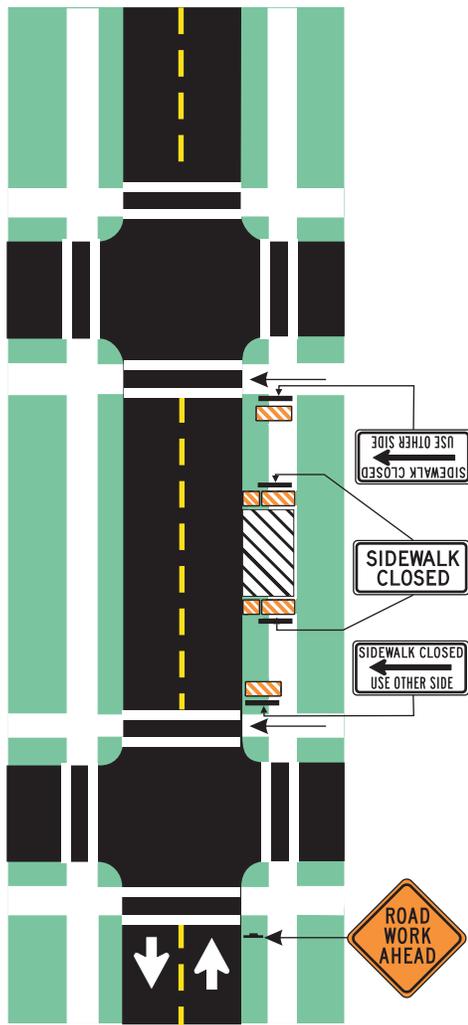
Temporary road closure



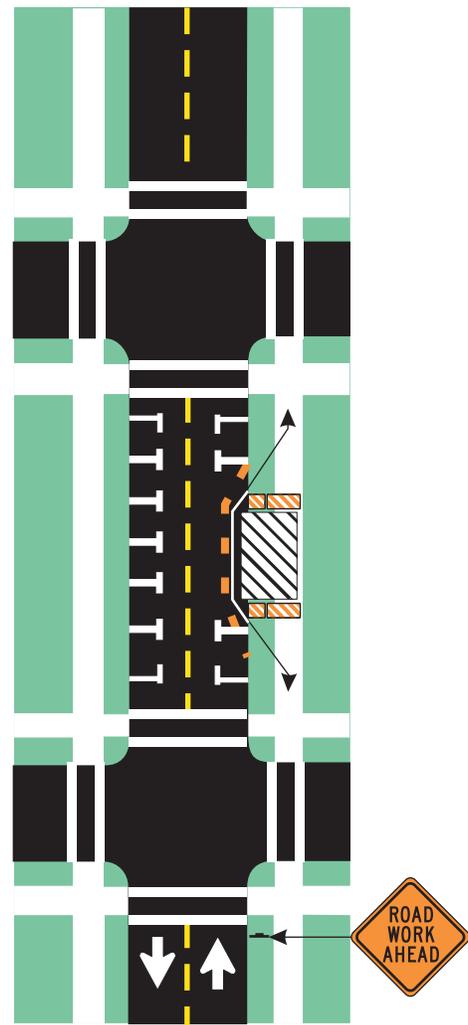
Notes:

1. This layout is intended for short-term use.
2. Cones may be used as channelizing devices in the tapers and along the lane line during daylight hours only.
3. The maximum spacing between channelizing devices in a merging taper shall be equal in feet to the speed limit.
4. Downstream tapers shall contain a minimum of five channelizing devices.
5. "Speed Limit" refers to the legally established speed limit.
6. Channelizing device types shall not be intermixed on the lane line through the work area.
7. Type II barricades may be placed in the closed lane at a 1,000-foot interval.
8. A flagger may be used to alert motorists when equipment or workers encroach within 2 feet of an open lane. The flagger shall be posted adjacent to the open traffic lane and immediately upstream of each operation. Encroachment shall be held to a minimum.
9. The use of an arrow panel is optional. When there is no shoulder area, the arrow panel shall be placed within the closed lane behind the channelizing devices and as close to the beginning of the taper as practical.
10. A Type III barricade may be substituted for the vehicle with an amber rotating or strobe light.
11. Channelizing devices may be placed up to two feet beyond the lane line only at specific locations where actual work activity is taking place. The devices shall be returned to the lane line when the work activity has passed.

Right-lane closure on a four-lane roadway



Pedestrian detour



Walkway provided

Notes:

1. Additional advance warning may be necessary.
2. Only the traffic control devices controlling pedestrian flows are shown. Other devices may be needed to control traffic on the streets. Use lane closure signing or Road Narrows signs, as needed.
3. Street lighting should be considered.
4. For nighttime closures, Type A flashing warning lights may be used on barricades supporting signs and closing walkways. Type C steady-burn lights may be used on
5. Where high speeds may be anticipated, use a barrier to separate the temporary walkway from vehicular traffic.
6. Signs may be placed along a temporary walkway to guide or direct pedestrians. Examples include Keep Right and Keep Left signs.
7. Provisions shall be made for disabled pedestrians.

Sidewalk closures and bypass walkway

Section L

Appendix

L: Appendix

Conversions and Formulas

Length

Inches	x 0.0833	= Feet
Inches	x 0.028	= Yards
Feet	x 12	= Inches
Feet	x 0.33	= Yards
Feet	x 0.06	= Rods
Feet	x 1.5	= Links
Yards	x 36	= Inches
Yards	x 3	= Feet
Yards	x 0.18	= Rods
Links	x .22	= Yards
Links	x .66	= Feet
Rods	x 198	= Inches
Rods	x 16.5	= Feet
Rods	x 5.5	= Yards
Miles	x 5,280	= Feet
Miles	x 1,760	= Yards
Miles	x 320	= Rods

Area

Square Inches	x 0.007	= Square Feet
Square Feet	x 144	= Square Inches
Square Feet	x 0.11	= Square Yards
Square Yards	x 1,296	= Square Inches
Square Yards	x 9	= Square Feet
Square Yards	x 0.03	= Square Rods
Square Rods	x 272.25	= Square Feet
Square Rods	x 30.25	= Square Yards
Square Miles	x 640	= Acres
Acres	x 43,560	= Square Feet
Acres	x 4,840	= Square Yards
Acres	x 160	= Square Rods

Volume

Cubic Feet	x 1,728	= Cubic Inches
Cubic Feet	x 0.04	= Cubic Yards
Cubic Feet	x 7.48	= Gallons
Cubic Yards	x 27	= Cubic Feet
Cubic Yards	x 202	= Gallons
Quarts	x 2	= Pints
Quarts	x 0.25	= Gallons
Gallons	x 8	= Pints
Gallons	x 4	= Quarts
Gallons	x 0.13	= Cubic Feet

Force

Ounces	x 0.06	= Pounds
Pounds	x 16	= Ounces
Tons (short)	x 2,000	= Pounds
Tons (metric)	x 2,204	= Pounds

Velocity

Miles/Hour	x 88	= Feet/Minute
Miles/Hour	x 1.47	= Feet/Second

Surveyor's Measure

7.92 Inches = 1 Link
25 Links = 1 Rod
4 Rods = 1 Chain = 66 Feet
10 Square Chains = 1 Acre
160 Square Rods = 1 Acre
640 Acres = 1 Square Mile
36 Square Miles (6 miles sq.) = 1 Township

Metric Conversion Factors

Length

Inches	x 25.40	= Millimeters (mm)
Inches	x 2.540	= Centimeters (cm)
Inches	x 0.0254	= Meters (m)
Feet	x 0.305	= Meters (m)
Yards	x 0.91	= Meters (m)
Rods	x 0.199	= Meters (m)
Miles	x 1.61	= Kilometers (km)

Area

Square Inches	x 6.45	= Square Centimeters
Square Feet	x 0.093	= Square Meters
Square Yards	x 0.836	= Square Meters
Acres	x 4,047	= Square Meters
Square Miles	x 2.59	= Square Kilometers

Volume

Cubic Inches	x 16.4	= Cubic Centimeters
Cubic Feet	x 0.028	= Cubic Meters
Cubic Yards	x 0.765	= Cubic Meters
Gallons (U.S.)	x 3.8	= Liters
Gallons (U.S.)	x 0.0038	= Cubic Meters
Acre-feet	x 1,233	= Cubic Meters

Mass

Ounces (avdp)	x 28.35	= Grams
Pounds (avdp)	x 0.4536	= Kilograms
Tons (short)	x 907.2	= Kilograms
Tons (metric)	x 1,000	= Kilograms

Force

Pounds (force)	x 4.45	= Newtons
Kilograms	x 9.81	= Newtons

Density

Pounds/ Cubic Foot	x 16.20	= Kilograms/ Cubic Meter
Pounds/ Cubic Yard	x 0.5933	= Kilograms/ Cubic Meter

Stress

Pounds/ Square Foot	x 47.9	= Newtons/ Square Meter
Pounds/ Square Inch	x 6.9	= Kilonewtons/ Square Meter

Pressure

Pounds/ Square Inch	x 6,895	= Pascals (Pa)
Pounds/ Square Foot	x 47.88	= Pascals (Pa)
Newtons/ Square Meter	x 1.00	= Pascals (Pa)

Flow

Gallons (U.S.)/ Minute	x 0.0038	= Cubic Meters/ Minute
Gallons (U.S.)/ Minute	x 0.06309	= Liters/ Second (L/s)
Cubic Feet/ Second	x 28.317	= Liters/ Second (L/s)

Velocity

Miles/Hour	x 1.609	= Kilometers/ Hour (km/hr)
Miles/Hour	x 0.4470	= Meters/ Second (m/s)
Feet/Second	x 0.3048	= Meters/Second (m/s)

Temperature

Fahrenheit	x 5/9(°F-32)	= Celsius
Celsius	x 9/5(°C+32)	= Fahrenheit

Converting Common Fractions to Decimals

Fraction	Decimal Equivalent	Fraction	Decimal Equivalent
1/2	0.50	1/10	0.10
		2/10	0.20
1/3	0.33	3/10	0.30
2/3	0.67	4/10	0.40
		5/10	0.50
1/4	0.25	6/10	0.60
2/4	0.50	7/10	0.70
3/4	0.75	8/10	0.80
		9/10	0.90
1/5	0.20		
2/5	0.40	1/12	0.08
3/5	0.60	2/12	0.17
4/5	0.80	3/12	0.25
		4/12	0.33
1/6	0.17	5/12	0.42
2/6	0.33	6/12	0.50
3/6	0.50	7/12	0.58
4/6	0.67	8/12	0.67
5/6	0.83	9/12	0.75
		10/12	0.83
1/7	0.14	11/12	0.92
2/7	0.29		
3/7	0.43	1/16	0.06
4/7	0.57	2/16	0.13
5/7	0.71	3/16	0.19
6/7	0.86	4/16	0.25
		5/16	0.31
1/8	0.13	6/16	0.38
2/8	0.25	7/16	0.44
3/8	0.38	8/16	0.50
4/8	0.50	9/16	0.56
5/8	0.63	10/16	0.63
6/8	0.75	11/16	0.69
7/8	0.88	12/16	0.75
		13/16	0.81
		14/16	0.88
		15/16	0.94

Perimeter, Area, and Volume Formulas

Perimeter

Scalene Triangle	$P = a + b + c$
Isosceles Triangle	$P = 2a + b$
Equilateral Triangle	$P = 3s$
Quadrilateral	$P = a + b + c + d$
Rectangle	$P = 2l + 2w$
Square	$P = 4s$
Circle	$C = \pi d$ or $C = 2\pi r$

Area

Rectangle	$A = lw$
Square	$A = lw$ or $A = s^2$
Parallelogram	$A = bh$
Triangle	$A = 1/2bh$
Trapezoid	$A = 1/2h (b_1 + b_2)$
Circle	$A = \pi r^2$
Cube	$A = 6e^2$

Volume

Cylinder	$V = bh$
Rectangular Solid	$V = lwh$
Cube	$V = e^3$
Circular Cylinder	$V = \pi r^2 h$
Pyramid	$V = 1/3bh$
Cone	$V = 1/3bh$ or $1/3\pi r^2 h$
Sphere	$V = 4/3\pi r^3$ or $V = (4\pi r^3)/3$

Safety

Review all operating procedures to assure that activities are performed in the safest manner. Safety is everyone's responsibility. When performing duties in the presence of traffic, review necessary traffic control requirements.

Signs and Markers Uniform Color Code

Utility Location and Coordination Council

Red:	Electric power lines, cables, or conduits Lighting cables
Yellow:	Gas or gaseous materials Oil or petroleum materials Steam
Orange:	Alarm lines, cables, or conduits Communication lines, cables, or conduits Signal lines, cables, or conduits
Blue:	Irrigation lines Slurry lines Water lines
Green:	Drain lines Sewers

References

- A Guide for Erecting Mailboxes on Highways.* American Association of State Highway and Transportation Officials, 1994.
- Handbook of Traffic Control Practices for Low Volume Rural Roads, 2nd Edition.* Kansas County Engineers Association and Kansas Department of Transportation, 1991.
- Manual on Pavement Marking Program.* Office of Traffic Engineering, Iowa Department of Transportation, Ames, Iowa, June 1996.
- Manual on Uniform Traffic Control Devices for Iowa Streets and Highways.* Iowa State Highway Commission, Ames, Iowa, 1963.
- Manual on Uniform Traffic Control Devices for Streets and Highways.* Federal Highway Administration, U.S. Department of Transportation, Washington D.C., 1988.
- Manual on Uniform Traffic Control Devices.* Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., December 2000.
- Roadside Design Guide.* American Association of State Highway and Transportation Officials, Washington D.C., 1996.
- Sign Crew Field Book: A Guide to Proper Location and Installation of Signs and Other Devices, 2nd Edition.* Traffic Operations Division, Texas Department of Transportation, Austin, Texas, April 1998.
- Sign Installation and Maintenance Guidelines.* Office of Traffic Engineering, Iowa Department of Transportation, Ames, Iowa, October 1999.
- Standard Alphabet for Highway Signs and Pavement Markings.* HHS-10. Federal Highway Administration, U.S. Department of Transportation, Washington D.C.
- Standard Highway Signs, Revision 2.* Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 1979.
- Traffic Control Devices Handbook.* Federal Highway Administration, 1983.
- Traffic Control Practices for Low Volume Roads.* South Dakota Local Transportation Assistance Program (SD LTAP), Brookings, South Dakota, and Division of Planning, Traffic, and Safety Engineer's Office, South Dakota Department of Transportation, 1993.
- The Traffic Safety Toolbox: A Primer on Traffic Safety.* Institute of Transportation Engineers, Washington, D.C., 1999.
- Traffic Signing Handbook.* Institute of Transportation Engineers, Washington, D.C., 1997.
- Various manuals and instruction memoranda from the Iowa Department of Transportation, 2000.

90-Day Embargo on Specific Roads Resolution (Sample)

WHEREAS: The _____ County Board of Supervisors recognizes the severity of the past winter and its effect on certain paved roads during the period of thawing this spring, and

WHEREAS: Sections 321.236(8), 321.255, 321.471, and 321.473 of the Code of Iowa provide the authority for local authorities to impose restrictions as to the weight of vehicles to be operated on any highway under their jurisdiction, and Section 321.463 establishes the penalty for violating said restrictions.

NOW, THEREFORE, BE IT RESOLVED by the Board of Supervisors of _____ County, Iowa that the following weight restrictions are in effect for a period of 90 days from _____, 20__, or until rescinded by the removal of signs by the proper authority, if conditions warrant an earlier date:

5 Ton Axle Limit (Gross Load = Number of Axles x 5 Tons)

Complete Listing of Roads to be Embargoed

#	Road Name/Number	From	To
1			
2			
3			
4			
5			

The county engineer is hereby directed to have erected such signs as are necessary to advise the traveling public of these limits, in accordance with Section 321.472.

Passed and approved this ___ day of _____ 20__.

_____ County, Iowa

Board of Supervisors

Chairman: _____ Member: _____

Member: _____ Member: _____

Member: _____

I, Auditor in and for _____ County, Iowa, do certify the above to be a true and exact copy of a resolution passed and approved by the board of supervisors of _____ County, Iowa at its meeting on the _____ day of _____, 20__.

ATTEST: _____, County Auditor

Application for Permit for Overweight Vehicle (Sample)

_____ County Application for Permit for Overweight Vehicle	Permit No.	Date
--	------------	------

I hereby request that the county engineer issue a "Permit for Overweight Vehicle" allowing the operation of the permitted vehicle, designated below, with weight in excess of current restrictions as follows:

Requested Permit Dates (not to exceed eight weeks): _____

Bridge(s) or Culvert(s) Covered by Permit (structure # or location): _____

Maximum Dimensions (including vehicle) Weight: _____ Length: _____

Description of Vehicle: _____

Agricultural Hardship Claimed: _____

This permit is being issued as required by Iowa Code section 321.471(2)(b)(1999) to allow permitted vehicles with excessive loads to traverse specified bridges and/or culverts on this route on a temporary basis. ****LOADS IN EXCESS OF POSTED WEIGHT LIMITS MAY CAUSE SERIOUS DAMAGE OR FAILURE OF THE ENTIRE STRUCTURE. BY ISSUING THIS PERMIT, NEITHER THE COUNTY NOR ANY OF ITS EMPLOYEES MAKE ANY REPRESENTATION THAT THE SPECIFIED BRIDGES AND/OR CULVERTS ARE SAFE FOR OVERWEIGHT VEHICLES.****

I agree that in consideration of the issuance of the Permit for Overweight Vehicles, I am responsible for any damage caused to county bridges or culverts due to the excess weight of permitted vehicle.

Applicant Signature: _____

Name (print): _____

Address: _____

Date: _____

For Official Use Only:

Date: _____

_____ Permit Approved: By _____

_____ Permit Denied: Insufficient Showing of Agricultural Hardship

_____ Permit Denied: Other Reason _____

The operator of the vehicle covered by this permit is required by Iowa Code section 321.471(2)(b) to carry this permit while operating the vehicle and shall show this permit to any peace officer upon request.

Blanket 90-Day Embargo Resolution (Sample)

WHEREAS: The board of supervisors is empowered, under the authority of Section 321.236(8), 321.255, and 321.471 to 321.473 of the Code of Iowa, to prohibit the operation of vehicles upon secondary roads or to impose restrictions as to weight of vehicles to be operated upon said secondary roads, except farm tractors as defined in Section 321.1(7), for a total period not to exceed ninety days in any one calendar year, whenever any said highway by reason of deterioration, rain, snow, or other climatic conditions will be seriously damaged or destroyed unless the use of vehicles thereon is prohibited or the permissible weights thereof reduced, and

WHEREAS: Severe spring weather conditions have caused certain secondary roads to be incapable of bearing the customary traffic thereon without undue damages,

NOW, THEREFORE, BE IT RESOLVED by the _____ County Board of Supervisors that the county engineer be authorized to order any of the secondary roads closed to vehicles in excess of _____ tons gross weight, wherever the county engineer deems it necessary and for the period of time deemed expedient (not to exceed ninety days), by erecting signs in accordance with Section 321.472.

BE IT FURTHER RESOLVED that the county engineer may grant permits of exemption upon a showing that there is a need to move farm produce of a type subject to rapid spoilage or loss of value to market or to move any farm feeds or fuel for home heating purposes.

Passed and approved this _____ day of _____ 20____.

Chairman Board of Supervisors

ATTEST: _____
County Auditor

Bridge Embargo Resolution (*Sample*)

WHEREAS: The board of supervisors is empowered under the authority of Sections 321.236(8), 321.255, and 321.471 to 321.473 to prohibit the operation of vehicles or impose limitations as to the weight thereof on designated highways or highway structures under their jurisdiction, and

WHEREAS: The county engineer has completed (or has caused to be completed) the structure inventory and appraisal of certain county bridges, in accordance with the National Bridge Inspection Standards, and has determined (or it has been determined) that these bridges are inadequate for two-lane legal loads at allowable operating stress.

NOW, THEREFORE, BE IT RESOLVED by the _____ County Board of Supervisors that vehicle and load limits be established and that signs be erected advising of the permissible maximum weights thereof on the bridges listed, as follows:

Structure Number	Feature Crossed	Location	Load Limit

Passed and approved this ____ day of _____ 20__

Chairman Board of Supervisors

ATTEST: _____
County Auditor

Letter to Schools (Sample)

To: Superintendent of Schools

From: County Engineer

Subject: School Bus Routes and Signs

Date:

This memo is intended to update and inform you and your personnel about county snow removal policies, county operating procedures, and School Bus Stop Ahead signs and to request routing and bus stop information from each school district serving county residents. I hope you will share this information with your school bus drivers and bus superintendents.

I also recommend at this time that you develop emergency routes for impassable conditions due to snow or spring thaw. While the roads are in good shape in the fall, spring may bring about very different conditions and may lead to temporary embargoes on the gravel road system. These spring embargoes include school buses. Please try to be prepared and work out a notification procedure through radio or television stations to allow overnight alteration of your routes.

Snow Removal Procedures

County snow removal procedures are based on County Ordinance Number _____. This ordinance establishes county policy for level of snow and ice removal and maintenance under these conditions. A copy of this policy is enclosed.

As stated in the policy, paved roads will be opened first. If conditions require road graders to assist in snow removal on paved roads, the opening of unpaved roads will be delayed. When work begins on unpaved roads, we will initially open one lane on all unpaved roads that are above level B service, improving them as time and weather allow. Level B roads may not be plowed at all during the winter. If you are using any level B roads as school bus routes, I recommend you have alternate routes prepared since these are last priority roads for snow removal.

Please remember that county staff does not open private roads. These roads are maintained by individual homeowner associations, and the condition of these roads may vary greatly from county roads.

If weather conditions create hazardous working conditions, as may be the case during heavy falling or blowing snow, county snow removal units may be pulled off the roads. If this occurs while school is in session, our department or the sheriff's office will notify you as early as circumstances allow. You may also call our office (555-555-5555) or shop (555-555-1234) with questions on our daily operations.

Operating Procedures

Our winter operating procedure calls for our maintenance foremen to check road conditions early in the morning to determine the severity of the storm and the level of snow removal response necessary. Secondary road forces will generally not operate before sunrise or after sunset on paved or gravel roads, except in emergencies. We do not have adequate staff to operate more than one snow removal shift, and we do not operate 24-hours-a-day. We will respond as quickly as possible to any and all genuine emergencies 24-hours-a-day, but we ask you and your personnel to use good judgment to prevent putting lives and property at risk.

I suggest purchasing and using tire chains on your school buses when operating in slippery and snowy conditions. The traction gained by using chains may help to prevent buses from getting stuck.

School Bus Stop Ahead Signs

The county will place School Bus Stop Ahead signs in concurrence with standards in the *Manual on Uniform Traffic Control Devices (MUTCD)*. School Bus Stop Ahead signs are placed at locations where hills or curves may obscure a stopped school bus from approaching traffic and where sight distance is less than 500 feet in advance of the stop. It is not possible or necessary to sign every school bus stop location. Our reviews will be prompt and consistent, as we study your requests for new school related signs on county roads.

When we receive future requests for these signs, we will request that residents route these requests first through your district. Your drivers, who likely have the best knowledge of whether a traffic hazard genuinely exists at any bus stop location, should concur with a request to review a new location for a sign. This procedure assures that my staff time will be used efficiently by eliminating reviews of locations where adequate sight distance exists. However, driver concurrence will not replace the county's review of sign requests and final determination of the need for a sign.

If you have any School Bus Stop Ahead signs at locations that no longer have students, please notify us so the signs can be removed for later use or moved to a location where they are needed. We will remove or relocate any unneeded signs, as their continued presence tends to promote general disrespect for school bus stop signs.

Request for Bus Route Maps

I would like to compile an updated map of all roads that are school bus routes in this county. These maps will be used for aiding us in the snow removal effort this winter. Enclosed are two county maps. Please mark all roads that your school buses will be utilizing in red. Please return one completed map to this office at your earliest convenience. Your cooperation in this matter will be most appreciated.

If you have any questions or concerns, please feel free to call me at (555-555-5555). We will do everything within our power to ensure good roads and prompt snow and ice removal, and we ask your cooperation in providing safe travel for our school children.

Thank you for your cooperation.

Sincerely,

John Doe, _____ County Engineer

Policy on Erection of Supplemental Signs and Traffic Control Devices on County Roads (Sample)

This policy serves as a supplement to the *Manual on Uniform Traffic Control Devices (MUTCD)*, which as stated in Section 321.252 of the Code of Iowa, is the official sign manual of the state for placement of signs either not contained in the manual or not required by the manual. Examples of signs in the category are: Children at Play, Farm Machinery, Trucks Entering Highway, and historic and park signs as requested by other departments, public agencies, and members of the public. Speed limit signs, STOP and YIELD signs, and other warning signs on county roads are not covered under this policy but are covered by the warrants in the *MUTCD*. This document outlines county policy for placement of supplemental signs and defines who will pay for the signs, posts, and installation of each sign.

School Bus Signs

School signs are divided into two categories: signs related to school buses and school warning signs. The installation of both types of signs is not required by the *MUTCD*, and it is not the policy of the secondary road department to place these signs at department expense. Signs of these types are placed at the request of the schools under the terms of this policy.

Two types of signs fall into the category of school bus signs: the School Bus Stop Ahead sign and the school bus turnaround sign. Both signs are designed as warning signs by the *MUTCD*, although they warn of conditions that are not always present throughout the day or year. These signs may be placed at the request of the school district. Any requests for the placement of these signs must come through the school bus superintendent or the superintendent of the school district. Requests from residents of the county or school district will be directed to the school.

Upon receipt of a request from the school bus superintendent or the superintendent of schools, the engineer or maintenance staff will review the location for the adequacy of available sight distance according to the *MUTCD*. The determination of adequate sight distance will be based on whether or not sight distance in advance of the location in question exceeds the values shown in the High Judgement Conditions column of Table 2C-4, "Advance Warning Sign Placement Distances," of the *MUTCD*. The speed selected for the determination of adequate sight distance will be based upon the legal speed limit of the road, unless there are circumstances present that lead the engineer or maintenance staff to believe that the speed is significantly higher or lower than posted. If the location has less than optimum sight distance, the county will install a sign at the appropriate distance ahead of the school bus stop or turnaround. The school district will pay for the sign if the school district does not already have one in stock with the county, and the county will provide the post, labor, and equipment to erect the sign at no cost to the school.

If the location has adequate sight distance for the speed limit of the road, the engineer will recommend that the sign not be placed. If the school insists that a sign be placed at the location against the recommendation of the engineer, the school will be responsible for all cost associated with the installation including sign, post, labor, and equipment costs.

Signs no longer needed will be removed upon request of the school district and stored in the sign shed for future use of the district. The school district will be reminded annually to review the need for these signs.

Children at Play and Related Signs

Children at Play, Horses on the Highway, and other similar warning signs requested by county residents will be installed by the county sign crew after review of need. Signs will be placed at the appropriate advance distance for the posted speed limit according to *MUTCD* Table II-1, “Advance Warning Sign Placement Distances.”

The cost of the sign and post shall be paid by the resident or other party making the request for the sign. The county will provide the equipment and labor to install the sign at no cost to the party making the request. The county will install the sign at its earliest convenience and periodically review the continued need.

All sign installations will be done by a county crew. Signs installed by others will be removed. Private property owners may not install signs on county right of ways. Replacement of faded or vandalized signs is the responsibility of the party originally requesting the sign. The county will place a replacement sign on the existing post or replace a failed or damaged post but will not replace the sign. If the party requesting the sign is not willing to pay for a new sign, the sign will be removed. Signs that are no longer needed and are removed become the property of the county.

Farm Machinery and Trucks Entering Highway

Farm Machinery, Trucks Entering Highway, and other similar warning signs requested by county residents will be installed by the county sign crew after review of need. Signs will be placed at the appropriate advance distance for the posted speed limit according to *MUTCD* Table 2C-4, “Advance Warning Sign Placement Distances.”

The cost of the sign and post shall be paid by the resident or other party making the request for the sign. The county will provide the equipment and labor to install the sign at no cost to the party making the request. The county will install the sign at its earliest convenience and periodically review the continued need. If the resident so requests, an advisory speed plate may also be installed with the warning sign. The appropriate advisory speed will be established based on a survey of the location by engineering staff and a determination of stopping sight distance by the county engineer.

All sign installations will be done by a county crew. Signs installed by others will be removed. Private property owners may not install signs on county right of ways. Replacement of faded or vandalized sign faces is the responsibility of the party originally requesting the sign. The county will place a replacement sign on the existing post or replace a failed or damaged post but will not replace the sign. If the party requesting the sign is not willing to pay for a new sign, the sign will be removed. Signs that are no longer needed and are removed become the property of the county.

Historical Markers

Upon request, the secondary road department will erect signs guiding traffic to historical markers and sites. This will be done at the request of the county or state Historical Society, a community, or a public service organization. Signs requested by one of these parties must meet the guidelines of the *MUTCD*. The requesting party will be liable for the cost of the post and the sign. The county will install the sign appropriate for the site at no cost, after consultation with the party requesting the sign.

Replacement of faded or vandalized sign faces is the responsibility of the party originally requesting the sign. The county will place a new sign on the existing post or replace a failed or damaged post but will not replace the sign. If the party requesting the sign is not willing to pay for a new sign, the sign will be removed. The sign will remain the property of the party requesting the sign and will be returned to the organization.

Park Signs

Park signs guiding traffic to city, county, and state parks and recreation areas may be placed within county right of ways. These signs will be placed at the request of the county conservation commission, the Iowa Department of Natural Resources, or an incorporated city within the county. Signs requested by one of these parties must meet the guidelines of the *MUTCD*.

The party making the request will be liable for the cost of the post and the sign. The county will install the sign appropriate for the site at no cost, after consultation with the party requesting the sign.

Replacement of faded or vandalized sign faces is the responsibility of the party originally requesting the sign. The county will place a replacement sign on the existing post or replace a failed or damaged post but will not replace the sign. If the party requesting the sign is not willing to pay for a new sign, the sign will be removed. The sign will remain the property of the party requesting the sign and will be returned to the organization.

Commercial Enterprise Signs

New commercial enterprise signs, that is, signs that guide highway traffic to privately owned restaurants, small businesses, campgrounds, activities, services, shops, or stores, will not be placed within county right of ways, effective January 1, 2000. Signs placed before that date will be allowed to remain as long as the sign faces are legible. The signs may be replaced when they reach the end of their service life at the option of the party originally placing the request for the sign.

This supplemental signing policy has been reviewed and approved by the board of supervisors this _____ day of _____, 20__.

Approved:

Chair, Board of Supervisors

Recommended:

County Engineer

Attest:

County Auditor

Political Sign Policy (*Sample*)

This policy will serve as a guide to political candidates, party chairs, campaign workers, and county employees concerning the placement of political signs adjacent to public right of ways on the county secondary road system. This policy is a local regulation, established by resolution, and is designed to acquaint candidates with how the county enforces state law concerning the placement of political signs adjacent to county secondary roads. This is a supplement to the state policy on political signing titled, "Guide to Iowa Outdoor Advertising Sign Regulations," used to guide candidates on county highway signing policy.

General Prohibitions:

1. No sign may encroach on or hang over the county right of way.
2. No sign may be lighted so it impairs the vision of a motor vehicle driver.
3. No sign may obstruct the view of any highway or railroad or any intersection such that the sign makes it dangerous to use the highway or creates a sight distance obstruction.
4. No sign may imitate or resemble an official traffic control sign, signal, or device.
5. No sign may obscure or physically interfere with an official traffic control sign, signal, or device.

Political Sign Definition:

Chapter 306C of the Iowa Code defines a political sign as "an outdoor sign of a temporary nature, not larger than 32 square feet in surface area, erected for the purpose of soliciting votes or support for or in opposition to any candidate or any political party under whose designation any candidate is seeking nomination or election or any public question on the ballot in an election held under the laws of the state." Political sign may be erected upon private property adjacent to county secondary roads as allowed by state code on primary highways.

Signs adjacent to county roads must be removed within seven days following the election.

Signs improperly placed within the county road right of way must be removed within 24 hours of notification. Secondary road employees will first try to notify the candidate to remove the sign from the right of way. If the secondary road employee is unable to contact the candidate, the county party chair will be notified of the improper placement of the sign. Contact with and messages left on an answering machine will constitute sufficient notice for removal of a political sign.

If the sign is not removed within the 24-hour period following notification, the sign will be removed by secondary road employees and taken to the maintenance garage where it can be collected by the candidate. The candidate will be billed the cost of sign removal for any signs removed by county employees.

Snowmobile Permit and Agreement (*Sample*)

_____ County, State of Iowa, and _____ (hereinafter referred to as sponsor) do hereby enter into the following permit and agreement:

1. _____ County hereby consents to and grants permission to the undersigned sponsor and their snowmobile club to utilize county road right of ways for the purpose of snowmobile club activities to the county roads shown on the attached map.
2. All of the sponsors activities will be in compliance with the Code of Iowa, sections 321 and 321G and the _____ County Snowmobile Policy. This permit does not give any rights to the sponsor or snowmobile club members beyond those expressly stated in the Code of Iowa and the _____ County Snowmobile Policy.
3. In consideration of _____ County granting said permission and consent, the sponsor hereby promises and agrees to the following:
 - A. The sponsor, at his/her own expense, shall provide all safety measures and warning devices necessary to protect their members such as, but not limited to, signs and directional markers. Any snowmobile trail signing placed in the right of way will be removed within 30 days of the end of the period covered by this permit.
 - B. If the organization places any temporary structures, including bridges and culverts for the purpose of crossing streams and waterways, these will be removed in their entirety within 30 days of the end of the period covered by this permit. Plans for the structures will be submitted to the county engineer for review prior to installation. The sponsor will also obtain a permit to do construction within county right of way from the county engineer's office prior to undertaking any work.
 - C. Right of ways utilized for the sponsor's activities shall be left in a satisfactory condition subject to the approval of the county engineer.
 - D. The traveled portion of the roadway surface shall not be used for travel by snowmobiles except as provided in Section 321G, Code of Iowa.
 - E. The sponsor shall notify Iowa One Call, and any utilities not registered with One Call, in advance of any excavation or construction of trail structures and follow all appropriate instructions from the utilities to protect those aboveground and underground utilities.
 - F. The sponsor agrees to provide all necessary snowmobile warning signs such as snowmobile legend signs, crossing signs, etc. The sponsor will pay for, or apply for available state grants to provide funding for the purchase of these signs. Signs will become the property of _____ County and will be installed and placed by the county. _____ County will pay the cost of installation of the signs (i.e. posts, labor).
 - G. The sponsor assumes all liability for and agrees to reimburse _____ County for any damage to the roadway or ditch caused by the activities of the snowmobile club.

H. Sponsor will reseed disturbed areas created by the club's activities. _____ County will furnish necessary seed to do so.

I. SPONSOR HEREBY AGREES TO SAVE HARMLESS AND INDEMNIFY _____ COUNTY AGAINST ANY AND ALL CLAIMS FOR DAMAGES FOR PERSONAL INJURY OR PROPERTY DAMAGE ARISING OUT OF ACTIVITIES OF THE SPONSOR OR ORGANIZATION MEMBERS PURSUANT TO THIS PERMIT AGREEMENT. SPONSOR WILL PRESENT A CERTIFICATE OF INSURANCE TO THE COUNTY UPON APPLICATION FOR THIS PERMIT IDENTIFYING THE COUNTY AS AN ADDITIONAL NAMED INSURED FOR A MINIMUM OF ONE MILLION DOLLARS IN LIABILITY COVERAGE.

J. NOT CONFORMING OR ACQUIRING A PERMIT IS A VIOLATION OF SECTIONS 319.14 AND 321G.9 (1995) CODE OF IOWA.

4. The period for which this permit is approved shall be from the _____ day of _____, 20__ through the _____ day of _____, 20__.

Entered into this _____ day of _____, 20__.

Recommended, _____ County Engineer

Chair, _____ County Board of Supervisors

Sponsor

Address _____

Phone _____

Snowmobile Policy (Sample)

I. Purpose

To provide a policy for authorizing and monitoring the usage of secondary highway right of ways for snowmobiling.

II. Definitions

- A. Sponsor: Shall mean an incorporated private organization who have proof of incorporation and liability insurance in an amount of no less than one million dollars.
- B. Established trails: Shall refer to those trails located within highway right of ways as authorized by Section 321G of the Iowa Code and as approved by the _____ County Board of Supervisors and the county engineer.

III. References

- A. Current *Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)*
- B. FHWA's *Standard Highway Signs*
- C. Code of Iowa, Sections 319.4 and 321G

IV. General Guidelines

- A. Snowmobile operation within highway right of way is governed by the regulations and requirements of the Iowa Code, Chapter 321G.
- B. Snowmobile trails are not permitted on freeway right of way as per Iowa Department of Transportation rules, but trails established on the nonfreeway right of way are permissible through a freeway interchange area as long as the trail is continuous through the interchange area and adjacent to the nonfreeway public highway.
- C. Establishing trails, building bridges or placing signs within the highway right of way shall be reviewed and shall have been received at the county engineer's office for review prior to approval by the engineer and board of supervisors.

V. Procedures

- A. Transverse crossing of the secondary road system and an established snowmobile trail shall be by mutual agreement between the sponsor and the county engineer.
 - 1. To avoid a proliferation of crossings and signs, crossings should be kept at a minimum and at locations where consideration has been given to the overall safety of the highway user and the snowmobile operator.
 - 2. When crossing locations have mutually been agreed upon, the department will place W11-6B signs and W11-6C advance warning signs to identify the crossing location. Signs will be placed by the county with the cost of the signs to be paid, or signs supplied, by the petitioning snowmobile club. _____ County will provide posts and labor for the installation.
- B. Signing of established longitudinal trails shall be the responsibility of the sponsor.
 - 1. Uniform trail signs are available to the sponsor from the Department of Natural Resources and should be the only signs allowed within the secondary highway right of way.
 - 2. Signs may be placed to mark trails, identify hazards, and establish operating controls. No signs are to be placed or attached to any official highway sign, delineator, or object marker post. Signs and markers are to be placed independently on their own standard and

should be placed near the right of way line except for the “Danger” sign, which may be used to identify or mark an obstacle or hazard closely adjacent to the trail at the point of hazard. Signs should not be permitted within the established clear zone or within the roadway slope limits, whichever is greater; right of way width permitting.

- C. Requests received to place temporary bridge structures on established trails within secondary highway right of way shall be handled as follows:
 - 1. The sponsor shall be responsible for submitting to the county engineer an appropriate design and supporting information for review.
 - a. Supporting information shall include location of stream, location of structure as to right of way line and etc., type of material used in constructing structure and a statement to the effect that the sponsor shall assume liability and maintenance responsibility for the structure.
 - b. If a structure is requested to be placed on the right of way to be located on the upstream side of the highway, the structure shall be tied with cables and anchored in such a manner as to not allow the structure to be carried onto the roadway or into the roadway drainage structure during periods of flooding.
 - c. The structure shall be placed as to not interfere with or cause a restriction to the natural drainage.

- D. Requests received to operate a “Trail Groomer” on an established trail within secondary highway right of way shall be handled as follows:
 - 1. The Trail Groomer shall be operated under the jurisdiction of the sponsor and shall meet the requirements of the Department of Natural Resources.

- E. Authorization granted by the department for requests received as outlined in Section V-B, C & D shall be on _____ County form for “Permit and Agreement to Perform Work Within _____ County Right of Way”.
 - 1. The application shall be submitted by an authorized sponsor as defined below:
 - a. Application shall be signed by the chairperson or chief executive officer of the applying sponsor.
 - b. If the alignment of the trail includes secondary highways located within the corporate limits of a city, an authorized city official shall be required to sign the application as concurring in approval.
 - 2. A statement shall be added to the application as to a specific time period the application shall be in force.
 - a. The intent is to have all temporary signs and temporary bridges removed from the right of way prior to the normal spring maintenance program. An example would be from November 1 to April 15.
 - b. The permit will be an annual process.
 - c. In no instance will bridges be allowed to remain within the right of way.
 - 3. All applications submitted shall include the following hold harmless clause:
 - a. The sponsor agrees to hold harmless _____ County and the _____ County Secondary Road Department and to indemnify them from any claim, demand, or action by or on behalf of any person or entity arising out of or in connection to anything having to do with the snowmobile route, including but not limited to, its establishment, construction, use, maintenance, signing, configuration, or existence.

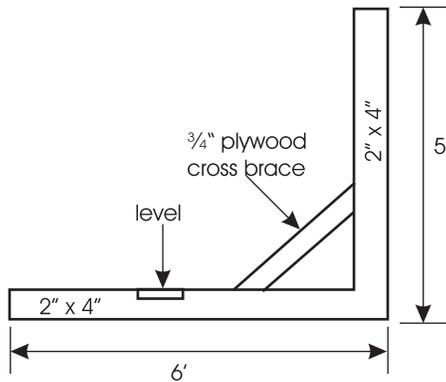
Tools for Signing and Marking

Sign Height Check Tool

This tool can quickly check the proper height of roadway signs.

Materials

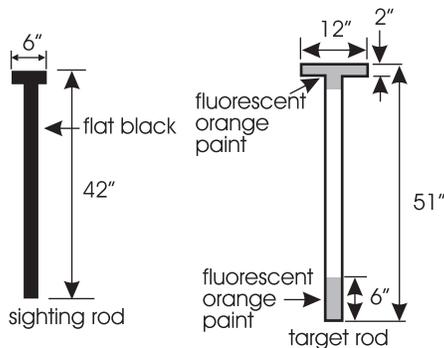
1. 2" x 4" (6 feet)
2. 2" x 4" (5 feet)
3. Level
4. 3/4" plywood cross brace



Sign height check tool

Sight Distance Target Rods

Target rods are used to determine clear sight distance triangles and stopping sight distances. A distance wheel should also be used with the rods.



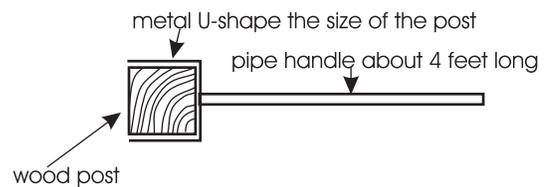
Sight distance target rods

Sign Turner

This tool is used to align the sign and post before final tamping. One person checks the sign to make certain it is facing the roadway at the proper angle to be seen at night, while the other person rotates the post with the tool. Small signs should be mounted at 90 degrees to the road.

Materials

1. Pipe handle about 4 feet long
2. Metal U-shape the size of the post



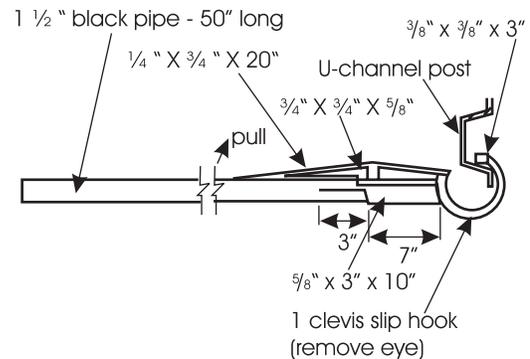
Sign turner

Metal Post Straightener

This tool is used to straighten bent metal posts.

Materials

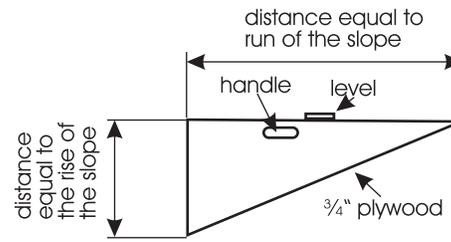
1. one piece, 1 1/2" black pipe, 50" long
2. one piece, 5/8" x 3" x 10" long
3. one piece, 3/4" x 3/4" x 5/8" long
4. one piece, 1/4" x 3/4" x 20" long
5. one piece, 3/8" x 3/8" x 3" long
6. one Clevis slip hook (remove eye)



Metal post straightener

Embankment Slope Meter

The embankment slope meter is used as a template to measure the slopes of embankments along the roadway. For slopes of 1:6 to 1:10, reduce the size by half to make the tool easier to handle. For example, to measure a 1:8 slope, cut the plywood to 4 feet long and 1/2 feet deep.



Embankment slope meter



MUTCD (Optional)

MUTCD
(Optional)