



Roadway Traffic Control I

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PDH: 3

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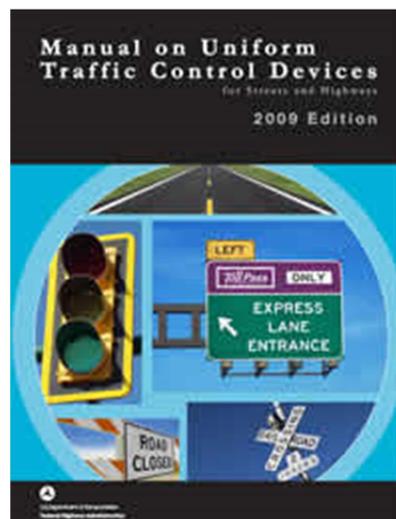


INTRODUCTION

This course is the first of two in this series that discusses how to use the *Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) Parts 1 through 3* to establish roadway traffic control. The contents of this course are intended to serve as guidance and not as an absolute standard or rule. It is intended to help you to use the MUTCD more effectively and not replace it. Should there be any conflicts between the contents of this course and the MUTCD, always follow the MUTCD.

Upon course completion, you should be familiar with the general MUTCD guidelines for traffic control devices. The overall course objective is to give engineers and designers an in-depth look at the principles to be considered when selecting and designing for traffic control.

For this course, the *Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) 2009 Edition* will serve as the text for the fundamental design principles of traffic signs and pavement markings. This document is recognized as the **national standard** for all traffic control devices installed on any street, highway, bikeway, or private road open to public travel. Any traffic control device design or application contained within the MUTCD is considered to be in the public domain and available for use.



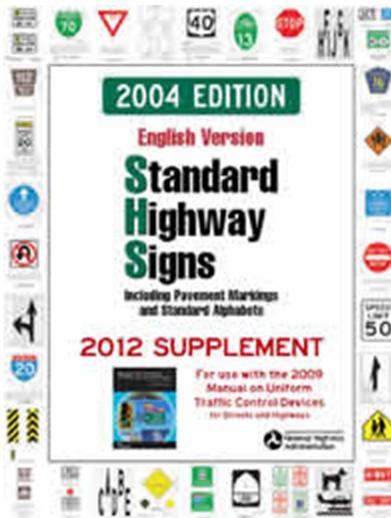
<http://mutcd.fhwa.dot.gov/pdfs/2009/mutcd2009edition.pdf>

Traffic signs and pavement markings are the primary communication devices used to convey laws and regulations, traffic and roadway conditions, and guidance and other information. These critical tools can provide important information to help users to travel safely on any U.S. roadway system.

However, traffic control devices cannot solve all traffic problems. Drivers process different types of visual and non-visual information differently: speed, roadway conditions, traffic, legal enforcement, noise levels, etc. Also, signs and markings serve as reminders of important information, so road users do not have to memorize everything.

The goal is to provide drivers with relevant information when they need it - resulting in safer, more efficient roadways with reduced liability risks. On the other hand, poor sign management and maintenance can greatly reduce safety, contribute to roadway incidents, and increase liability exposure.

The *Standard Highway Signs and Markings* book contains detailed specifications for all adopted standard signs and pavement markings. All traffic control devices shall be similar to or mirror images of those shown in this manual. Any symbols or colors cannot be modified unless otherwise stated.



http://mutcd.fhwa.dot.gov/SHSe/shs_2004_2012_sup.pdf

MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD)

By law (23 CFR 655, Subpart F), the *Manual on Uniform Traffic Control Devices* (MUTCD) is recognized as “the national standard for all traffic control devices installed on any street, highway, bikeway, or private road open to public travel”. It is the definitive authority for traffic signs and pavement markings.

The MUTCD is published by the Federal Highway Administration (FHWA) to promote safety and efficiency on our public roads by establishing uniform standards for traffic control devices. It defines the nationwide standards for the installation and maintenance of the devices on all streets and highways. The MUTCD allows us to drive anywhere in the U.S. using the same basic signs. Drivers who see a particular sign should expect it to mean the same thing and be prepared to take the same action regardless of location.

The MUTCD has nine chapters (“Parts”):

- 1 - General Information
- 2 - Signs
- 3 - Markings
- 4 - Highway Traffic Signals
- 5 - Low-Volume Roads
- 6 - Temporary Traffic Control
- 7 - School Areas
- 8 - Highway-Rail Grade Crossings
- 9 - Bicycle Facilities

For this course, we will be focusing on **Parts 1, 2 and 3**.

SHALL, SHOULD, and MAY

The terms “shall,” “should,” and “may” have specific meanings when used in the MUTCD. These words are defined as follows:

SHALL – Required, mandatory or specifically prohibitive practice. Statements with “shall” conditions are typically used as a STANDARD in the MUTCD. These items cannot be modified or compromised. There is no allowance for discretion and they must be followed.

SHOULD – Advisory or recommended practice in typical situations. Deviation is appropriate if justified by engineering judgment or study. Statements marked as “should” are used for GUIDANCE in the MUTCD.

MAY – Permissive or optional practice without requirement or recommendation.

Items marked as “may” are typically used in OPTION statements in the MUTCD and can contain allowable modifications.

SUPPORT statements do not contain the verbs “shall”, “should”, or “may”. These statements are for informational purposes only (without any mandate, recommendation, or enforcement).

BASIC REQUIREMENTS OF TRAFFIC CONTROL DEVICES

In order to be effective, any traffic control device has to be used correctly. The MUTCD lists the following principles to be used when selecting and applying each device:

❖ Fulfill a need

A sign should only be installed if there is a *need* for warning, regulation or guidance information. If a need exists and the sign in question does not meet that need, use something else. Overusing signs can lead to disrespect and loss of emphasis value while underuse can result in persistent but correctable safety problems.

❖ Command attention

Standard signs are designed to be noticed and attract attention. The high-contrast color combinations were chosen due to their ability to stand out and be easily read. Oversized signs, doubled signs, or flashing beacons may also emphasize the sign’s message.

❖ Command respect

Warning and regulatory signs that seem unneeded or unreasonable are regularly disobeyed. Good sign management and maintenance is crucial to commanding respect for traffic control devices. Nonstandard or damaged signs are more likely to be disregarded.

❖ Have one simple message

A sign’s message needs to be clear and readable. By using standard signs in the MUTCD that have been researched and evaluated by the FHWA, most drivers should understand their meanings.

❖ Provide adequate time for proper response

Traffic control devices should meet or exceed MUTCD standards so drivers have adequate time (Perception-Response Time – PRT) and distance to take appropriate actions before reaching a situation. Otherwise, insufficient response time may result in roadway crashes.

Traffic speed is crucial for determining driver response time. High speeds require longer response time and more reaction distance. This increased distance can be obtained by using larger signs, or by placing signs in advance of the location where the information is needed.

Using the five basic requirements will help make traffic control devices more effective. Design, placement, operation, maintenance, and uniformity should be considered to maximize the ability of a device to meet these principles. However, by disregarding the five requirements, road users may tend to disregard your traffic control devices.

The MUTCD defines a road user as “a vehicle operator, bicyclist, or pedestrian, including persons with disabilities, within the highway or on a private road open to public travel”. This group includes drivers of different skill levels and ages, pedestrians, wheelchairs, runners, rollerbladers, bicyclists, truck drivers, and motorcyclists. The ability to empathize with the road user is important skill for engineers in order to meet the needs of everyone using the road. By meeting their needs, you can minimize any problems that the average road user may encounter.

The Americans With Disabilities Act (ADA) of 1990

The regulations of the Americans with Disabilities Act are designed to prevent any discrimination against disabled individuals, including road users. This act requires access needs of the disabled be accommodated through the use of specialized signs, pavement markings, sign placements, etc.

SIGNS

READIBILITY and RETROREFLECTIVITY

Drivers must be able to read a sign from a reasonable distance and have adequate response time to safely travel the roadway. Improving nighttime visibility of signs and pavement markings becomes more important as we get older. As we age, our eyes gradually become less sensitive to light. As the national population gets older, the average driver gets older, and people continue driving at older ages.

Retroreflectivity is the ability of a traffic control device to reflect light from its surface to its original source. Retroflective traffic signs are used to increase nighttime visibility. Maintaining retroreflectivity is crucial to traffic safety since fatal night crashes occur approximately three (3) times as often as daytime traffic fatalities.

To work properly, retroreflectivity needs the following elements: **Light source** (vehicle headlights); **Target** (traffic control device); and **Receptor** (driver's eyes). Technologies involving glass beads or prismatic reflectors are more visible and bright because they reflect more light directly back at the original source.

All signs (regulatory, warning, and guide) and object markers need to be retroreflective or illuminated to display the same shape and color regardless of time and day. New materials or methods can be used as long as the traffic control devices meet the standard color requirements. Sign design should be uniform without any increase in: **visibility, legibility, or driver comprehension during day or night conditions.**

Sign Type and Designation

Over the years, traffic signs have been responsible for providing messages of increasing complexity. To accomplish this goal, the MUTCD specifies standard design features to encourage adequate perception-reaction time for the road user. These features (size, shape, and color) are specific to the functional category of each traffic sign.

SIGN CATEGORIES AND USE

CATEGORY	USE
Regulatory	Requires or prohibits actions by the road user
Warning	Warns user of conditions that may require an action to avoid a hazardous situation
Guide & Information	Helps user find their way, informs user of traveler services, etc.
Recreational & Cultural Interest	Guides user to recreation and cultural areas/facilities
Non-Traffic Control	Not meant for highway use, or contains information not related to highway use or traffic control

Sign Color and Shape

A sign's color and shape can be vital in conveying traffic control information. These specific combinations are used to inform drivers of the type of sign. The colors and shapes are meant to command attention and convey a clear simple message. Signs usually have one color for the legend (typically black or white), which includes symbols, text and border. Some signs (such as prohibition signs) have two-color legends containing a red circle and slash over a black symbol. The Federal Highway Administration (FHWA) established the following color code of appropriate colors for traffic control devices.

COLOR CODE FOR TRAFFIC CONTROL DEVICES

COLOR	MEANING
Black	Regulation
Blue	Road user services guidance, tourist information, evacuation route
Brown	Recreational and cultural interest area guidance
Coral	Unassigned
Fluorescent Pink	Incident management
Fluorescent Yellow-Green	Pedestrian warning, bicycle warning, playground warning, school bus and school warning
Green	Indicated movements permitted, direction guidance
Light Blue	Unassigned
Orange	Temporary traffic control
Purple	Lanes restricted to use only by vehicles with registered electronic toll collection (ETC) accounts
Red	Stop or prohibition
White	Regulation
Yellow	Warning

Table 2A-4. Use of Sign Shapes

Shape	Signs
Octagon	Stop*
Equilateral Triangle (1 point down)	Yield*
Circle	Grade Crossing Advance Warning*
Pennant Shape/Isosceles Triangle (longer axis horizontal)	No Passing*
Pentagon (pointed up)	School Advance Warning Sign (squared bottom corners)* County Route Sign (tapered bottom corners)*
Crossbuck (two rectangles in an "X" configuration)	Grade Crossing*
Diamond	Warning Series
Rectangle (including square)	Regulatory Series Guide Series** Warning Series
Trapezoid	Recreational and Cultural Interest Area Series National Forest Route Sign

* This sign shall be exclusively the shape shown.

** Guide series includes general service, specific service, tourist-oriented directional, general information, recreational and cultural interest area, and emergency management signs.

Sign Size

Standard sign sizes should be used unless engineering judgment indicates otherwise. Sign sizes should not be smaller than the minimum sizes contained in the MUTCD. However, larger sizes may be used where deemed appropriate.

Sign Location

Signs requiring different user decisions need to be spaced sufficiently far apart for the required decisions to be made reasonably safely. Multiple signs should be compatible and provide a logical sequence of communication. The road user needs to have adequate time to adjust speed, avoid any potential hazard, and continue on their desired route. These signs should be placed on the right side of the roadway where they can be easily recognized and understood. Signs in other locations should be considered supplementary to signs in the normal locations.

Potential sign locations should:

Be outside the clear zone unless on a breakaway or yielding support

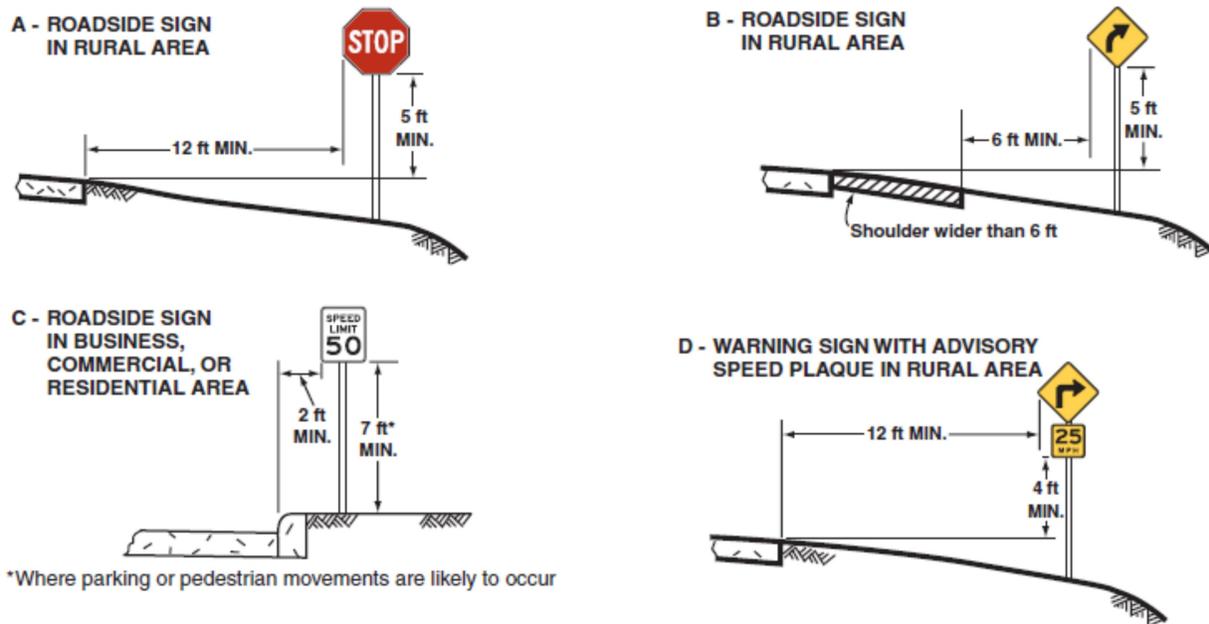
Not be hidden from view

Optimize nighttime visibility

Minimize the effects of mud splatter and debris

Not obscure each other – Avoid clutter

Figure 2A-2. Examples of Heights and Lateral Locations of Sign Installations



Lateral Distance

A sign's proximity to the road directly impacts visibility. Close placement will make it easier to read but will also make it more likely to be damaged by traffic. Signs placed further away from the roadway are less vulnerable to damage but harder to read.

Post-mounted signs should have a *minimum lateral clearance of 12 feet* from the edge of the travel way to the near edge of the sign. For shoulder widths over 6 feet, the *minimum offset should be 6 feet* from the shoulder's edge. Potential sites should be located as far as practical from the edge of shoulder with minimum traffic exposure to the traffic sign supports.

For curbed roadways with parking or pedestrians, the edge of the sign should be a *minimum offset of two feet* from the face of curb which permits an adequate clearance for opening parked vehicle doors. Increasing this lateral offset distance will minimize chances of sign damage by vehicles but caution needs to be exercised to prevent blocking the sidewalk.

Height Above the Roadway

The height of a sign can impact sign visibility, roadway safety, and pedestrian access.

The minimum height for signs installed in rural areas is *5 feet* and is measured from the edge of pavement elevation to the bottom of the sign. For urban areas with parking, pedestrian, or sight distance challenges, the *minimum height requirement is 7 feet*. At curb locations, this distance is measured from the top of curb to the bottom of sign. The minimum height for roadways without curb is measured from the edge of traveled way elevation to the bottom of the sign. For areas with sidewalks, the *minimum height is 7 feet* (measured from the top of sidewalk to the bottom of the sign).

The MUTCD specifies only *minimum heights* for sign assemblies. For hillcrests, it may be useful to place the sign higher than normal for better visibility.

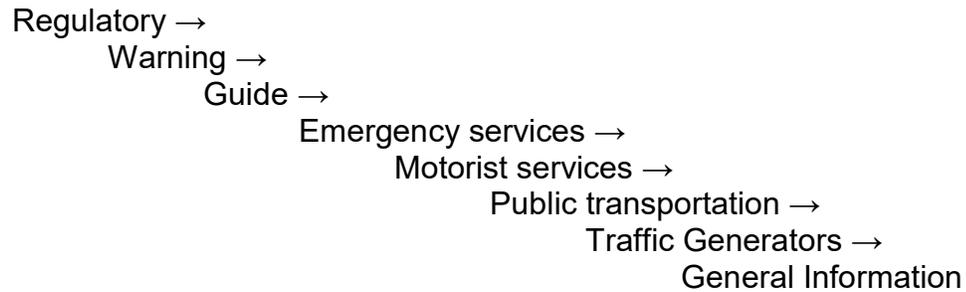
MINIMUM SIGN HEIGHT

5 ft	Rural
7 ft	Parking or pedestrian movements (non-rural)
7 ft	Directional signs on expressways and freeways
8 ft	Height of sign if secondary sign present
5 ft	Secondary sign above the level of the pavement edge
7 ft	All route signs, warning signs, and regulatory signs on expressways and freeways

Sign Priority

For locations requiring more than one sign, priority needs to be established regarding the order of placement. Regulatory signs take precedence over the other signs since they convey legal or regulatory information. Guide, informational, recreational, and cultural interest signs are less crucial due to their location flexibility.

TRAFFIC SIGN PRIORITY



REGULATORY SIGNS

Regulatory signs inform motorists of traffic regulations, laws, and applicable legal requirements. They require or prohibit the movement of vehicles, pedestrians, and other road users. Their goal is to encourage the safe and orderly flow of traffic. All signs should clearly communicate its message and provide adequate visibility (retroreflective or illumination).

Unless specifically designated otherwise, all regulatory signs shall be rectangular (exceptions include stop signs, yield signs and railroad crossing signs). The colors used for regulatory signs are white, black, and red.



R1-1



R1-3P



R1-2



R1-2aP



R1-10P

Table 2B-1. Regulatory Sign and Plaque Sizes (Sheet 1 of 4)

Sign or Plaque	Sign Designation	Section	Conventional Road		Expressway	Freeway	Minimum	Oversized
			Single Lane	Multi-Lane				
Stop	R1-1	2B.05	30 x 30*	36 x 36	36 x 36	—	30 x 30*	48 x 48
Yield	R1-2	2B.08	36x36x36*	48x48x48	48x48x48	60x60x60	30x30x30*	—
To Oncoming Traffic (plaque)	R1-2aP	2B.10	24 x 18	24 x 18	36 x 30	48 x 36	24 x 18	—
All Way (plaque)	R1-3P	2B.05	18 x 6	18 x 6	—	—	—	30 x 12
Yield Here to Peds	R1-5	2B.11	—	36 x 36	—	—	—	36 x 36
Yield Here to Pedestrians	R1-5a	2B.11	—	36 x 48	—	—	—	36 x 48
Stop Here for Peds	R1-5b	2B.11	—	36 x 36	—	—	—	36 x 36
Stop Here for Pedestrians	R1-5c	2B.11	—	36 x 48	—	—	—	36 x 48
In-Street Ped Crossing	R1-6,6a	2B.12	12 x 36	12 x 36	—	—	—	—
Overhead Ped Crossing	R1-9,9a	2B.12	90 x 24	90 x 24	—	—	—	—
Except Right Turn (plaque)	R1-10P	2B.05	24 x 18	24 x 18	—	—	—	—
Speed Limit	R2-1	2B.13	24 x 30*	30 x 36	36 x 48	48 x 60	18 x 24*	30 x 36
Truck Speed Limit (plaque)	R2-2P	2B.14	24 x 24	24 x 24	36 x 36	48 x 48	—	36 x 36
Night Speed Limit (plaque)	R2-3P	2B.15	24 x 24	24 x 24	36 x 36	48 x 48	—	36 x 36
Minimum Speed Limit (plaque)	R2-4P	2B.16	24 x 30	24 x 30	36 x 48	48 x 60	—	36 x 48
Combined Speed Limit	R2-4a	2B.16	24 x 48	24 x 48	36 x 72	48 x 96	—	36 x 72
Unless Otherwise Posted (plaque)	R2-5P	2B.13	24 x 18	24 x 18	—	—	—	—
Citywide (plaque)	R2-5aP	2B.13	24 x 6	24 x 6	—	—	—	—
Neighborhood (plaque)	R2-5bP	2B.13	24 x 6	24 x 6	—	—	—	—
Residential (plaque)	R2-5cP	2B.13	24 x 6	24 x 6	—	—	—	—
Fines Higher (plaque)	R2-6P	2B.17	24 x 18	24 x 18	36 x 24	48 x 36	—	36 x 24
Fines Double (plaque)	R2-6aP	2B.17	24 x 18	24 x 18	36 x 24	48 x 36	—	36 x 24
\$XX Fine (plaque)	R2-6bP	2B.17	24 x 18	24 x 18	36 x 24	48 x 36	—	36 x 24
Begin Higher Fines Zone	R2-10	2B.17	24 x 30	24 x 30	36 x 48	48 x 60	—	36 x 48
End Higher Fines Zone	R2-11	2B.17	24 x 30	24 x 30	36 x 48	48 x 60	—	36 x 48
Movement Prohibition	R3-1,2,3,4,18,27	2B.18	24 x 24*	36 x 36	36 x 36	—	—	48 x 48
Mandatory Movement Lane Control	R3-5,5a	2B.20	30 x 36	30 x 36	—	—	—	—
Left Lane (plaque)	R3-5bP	2B.20	30 x 12	30 x 12	—	—	—	—
HOV 2+ (plaque)	R3-5cP	2B.20	24 x 12	24 x 12	—	—	—	—
Taxi Lane (plaque)	R3-5dP	2B.20	30 x 12	30 x 12	—	—	—	—

Regulatory signs should be used to fulfill a need. Drivers tend to disregard a regulation that is perceived as unneeded. However, other road users may expect them to obey the sign, and act accordingly which may result in traffic accidents (example: Yield sign). Regulatory signs can be used to remind road users of statutory traffic laws (no parking, one way, etc.). However, some laws may not need signs to be enforceable.

WARNING SIGNS

Warning signs alert road users to unexpected/unapparent conditions on or near the roadway. These signs may require actions by the driver in order to ensure safe traffic operations.



Background colors for warning signs depend on their use. The majority of warning signs are diamond-shaped with a black legend/border and yellow background. Signs regarding pedestrians, bicyclists and playgrounds typically have a black legend/border and yellow or fluorescent yellow-green background. For buses, schools and supplemental plaques, the signs should have a black legend/border with a fluorescent yellow-green background.

School signs
 Pentagon-shaped



Railroad warning signs
 Circular



No passing signs
 Triangular



Properly located warning signs can reduce incidents by improving driver Perception-Response Times (PRT). A standard value for PRT is typically 2.5 seconds, with 2.5 to 3.0 seconds for older drivers, and longer times for unexpected events.

Although some warning signs may be more effective than others, their use should result in a significant reduction in related incidents. But like all traffic signs, improper use usually causes disrespect for all warning signs, and minimizes their effectiveness.

When considering the use of a warning sign:

Determine if the hazard can be removed.

If it will take time to remove the hazard, use a temporary sign to warn traffic.

If the hazard is impossible or too expensive to remove, install a warning sign.

Any temporary signage should be removed as soon as it is no longer needed.

Table 2C-1. Categories of Warning Signs and Plaques

Category	Group	Section	Signs or Plaques	Sign Designations
Roadway Related	Changes in Horizontal Alignment	2C.07	Turn, Curve, Reverse Turn, Reverse Curve, Winding Road, Hairpin Curve, 270-Degree Curve	W1-1,2,3,4,5,11,15
		2C.08	Advisory Speed	W13-1P
		2C.09	Chevron Alignment	W1-8
		2C.10	Combination Horizontal Alignment/Advisory Speed	W1-1a,2a
		2C.11	Combination Horizontal Alignment/Intersection	W1-10,10a,10b,10c,10d
		2C.12	Large Arrow (one direction)	W1-6
		2C.13	Truck Rollover	W1-13
		2C.14	Advisory Exit or Ramp Speed	W13-2,3
	Vertical Alignment	2C.15	Combination Horizontal Alignment/Advisory Exit or Ramp Speed	W13-6,7
		2C.16	Hill	W7-1,1a,2P,2bP,3P,3aP,3bP
		2C.17	Truck Escape Ramp	W7-4,4b,4c,4dP,4eP,4fP
	Cross Section	2C.18	Hill Blocks View	W7-6
		2C.19	Road Narrows	W5-1
		2C.20,21	Narrow Bridge, One Lane Bridge	W5-2,3
		2C.22,23,25	Divided Highway, Divided Highway Ends, Double Arrow	W6-1,2; W12-1
		2C.24	Freeway or Expressway Ends, All Traffic Must Exit	W19-1,2,3,4,5
		2C.26	Dead End, No Outlet	W14-1,1a,2,2a
		2C.27	Low Clearance	W12-2,2a
	Roadway Surface Condition	2C.28,29	Bump, Dip, Speed Hump	W8-1,2; W17-1
		2C.30	Pavement Ends	W8-3
2C.31		Shoulder, Uneven Lanes	W8-4,9,11,17,17P,23,25	
2C.32		Slippery When Wet, Loose Gravel, Rough Road, Bridge Ices Before Road, Fallen Rocks	W8-5,7,8,13,14	
2C.33		Grooved Pavement, Metal Bridge Deck	W8-15,15P,16	
Weather	2C.34	No Center Line	W8-12	
	2C.35	Road May Flood, Flood Gauge, Gusty Winds Area, Fog Area	W8-18,19,21,22	
Traffic Related	Advance Traffic Control	2C.36-39	Stop Ahead, Yield Ahead, Signal Ahead, Be Prepared To Stop, Speed Reduction, Drawbridge Ahead, Ramp Meter Ahead	W3-1,2,3,4,5,5a,6,7,8
	Traffic Flow	2C.40-45	Merge, No Merge Area, Lane Ends, Added Lane, Two-Way Traffic, Right Lane Exit Only Ahead, No Passing Zone	W4-1,2,3,5,5P6; W6-3; W9-1,2,7; W14-3
	Intersections	2C.46	Cross Road, Side Road, T, Y, Circular Intersection, Side Roads	W2-1,2,3,4,5,6,7,8; W16-12P,17P
		2C.47	Large Arrow (two directions)	W1-7
		2C.48	Oncoming Extended Green	W25-1,2
	Vehicular Traffic	2C.49	Truck Crossing, Truck (symbol), Emergency Vehicle, Tractor, Bicycle, Golf Cart, Horse-Drawn Vehicle, Trail Crossing	W8-6; W11-1,5,5a,8,10,11,12P,14,15,15P,15a; W16-13P
	Non-Vehicular	2C.50,51	Pedestrian, Deer, Cattle, Snowmobile, Equestrian, Wheelchair, Large Animals, Playground	W11-2,3,4,6,7,9,16,17,18,19,20,21,22; W15-1; W16-13P
New	2C.52	New Traffic Pattern Ahead	W23-2	
Other Supplemental Plaques	Location	2C.53	Downward Diagonal Arrow, Ahead	W16-7P,9P
	HOV	2C.53	High-Occupancy Vehicle	W16-11P
	Distance	2C.55	XX Feet, XX Miles, Next XX Feet, Next XX Miles	W7-3aP; W16-2P,2aP,3P,3aP,4P
	Arrow	2C.56	Advance Arrow, Directional Arrow	W16-5P,6P
	Street Name Plaque	2C.58	Advance Street Name	W16-8P,8aP
	Intersection	2C.59	Cross Traffic Does Not Stop	W4-4P,4aP,4bP
	Share The Road	2C.60	Share The Road	W16-1P
	Photo Enforced	2C.61	Photo Enforced	W16-10P,10aP
New	2C.62	New	W16-15P	

The minimum size for all diamond-shaped signs is 36 x 36 inches for multilane roadways with a posted speed greater than 35 mph.

GUIDE AND INFORMATION SIGNS

Guide and information signs provide information to guide users to their destination in the most simple, direct manner possible. These signs direct drivers using streets and highways by informing them of intersections, directing them to various destinations, or identifying nearby rivers, streams, parks and historical sites.



Typical guide signs on streets or highways are rectangular with white text and border on green, blue, or brown backgrounds. Work zone or detour signs are black with an orange background. All guide and information signs (message, border, legend and background) should be retroreflective or illuminated.

As a general rule, guide signs should be limited to a *maximum of 3 lines* to provide adequate time for user comprehension. Long messages (regardless of letter size) take longer for the reader to comprehend. It may be helpful to provide a distance message or action information on guide signs in addition to destinations. Providing accurate and timely navigation information is crucial to traffic safety. Guide and information signs can help prevent erratic maneuvers, and minimize potential crashes.

Freeways

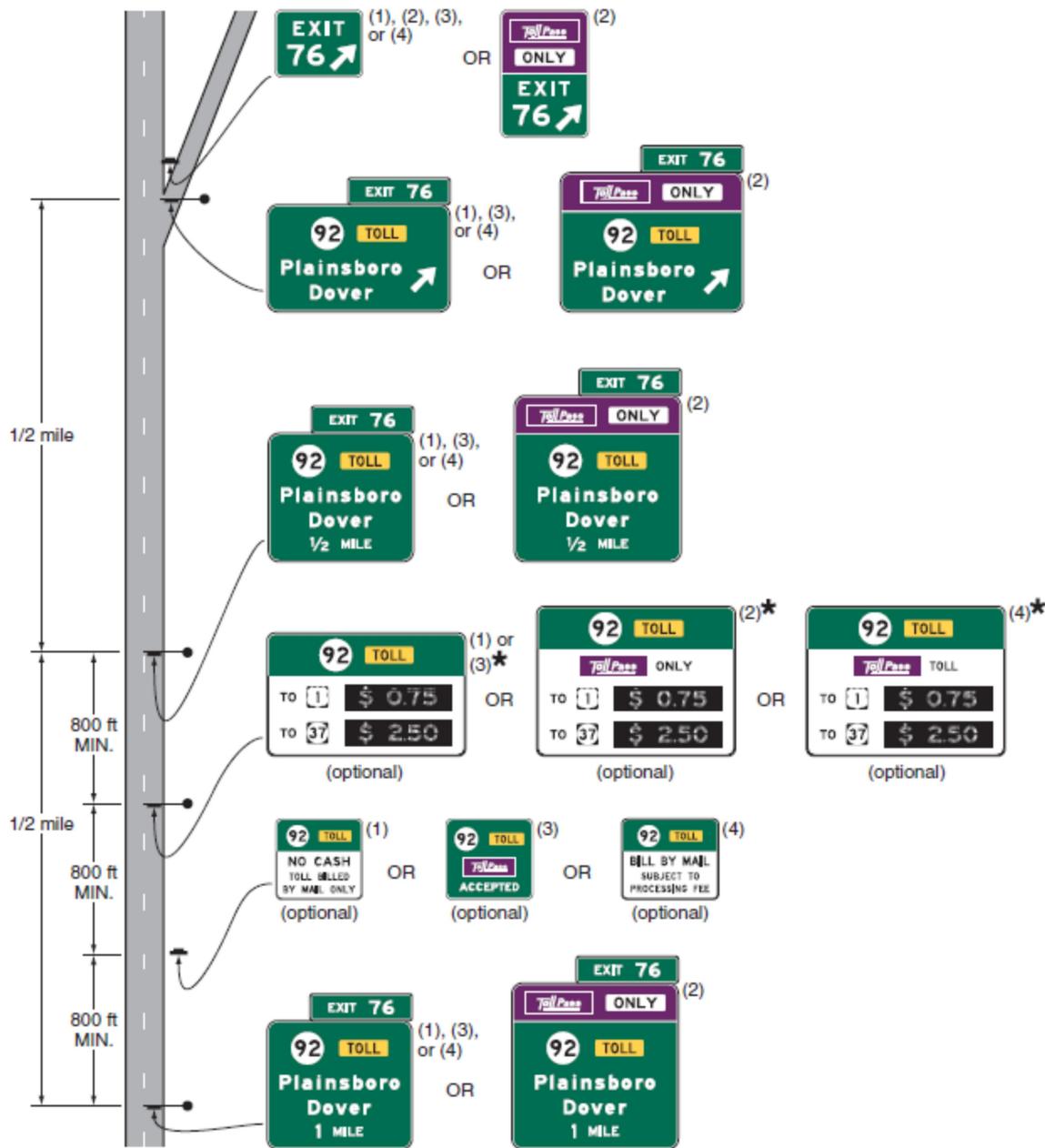
Freeway and expressway signing should be a planned system of installations. An engineering study can be useful for solving the problems of multiple locations within the context of an entire route. Consistent signing should take into account the geographical, geometric, and operating factors that create significant differences between urban and rural conditions. Functions of guide signs on freeways and expressways include:

providing directions to destinations; advance notice of the approaches; directing drivers in advance of diverging or merging movements; identifying routes and providing directions; showing distances to destinations; indicating access points to motorist services, rest, scenic, and recreational areas; and providing other informational value.

TOLL ROAD SIGNS

Toll highways are typically limited-access freeways or expressways with portions being a toll road, bridge, tunnel, or other crossing point. General signing requirements for toll roads depend on the type of facility and access (freeway, expressway, or conventional road). Toll plazas and collection points require additional modifications to the typical signing.

Figure 2F-6. Examples of Guide Signs for the Entrance to a Toll Highway on which Tolls are Collected Electronically Only



PREFERENTIAL AND MANAGED LANE SIGNS

Preferential lanes are designated for special traffic uses (high-occupancy vehicles (HOVs), light rail, buses, taxis, bicycles, etc.). Lane treatments range from restricting a turning lane to a certain class of vehicles during peak periods to providing a separate roadway system within a highway corridor for certain vehicles.

Types of Preferential Lanes

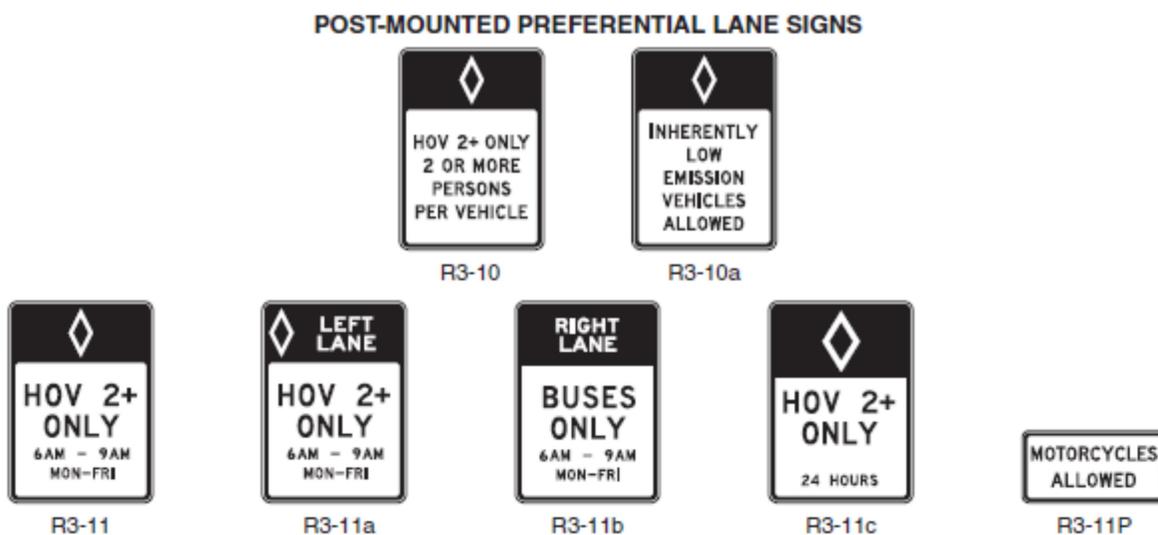
Barrier-separated: a separate alignment or physically separated from the other travel lanes by a barrier or median

Buffer-separated: separated from the adjacent traffic lanes by a narrow buffer area with longitudinal pavement markings

Contiguous: separated from the adjacent lanes by a lane line

Preferential lanes might allow access with the adjacent traffic lanes or restrict access to designated locations. They can also be operated in a constant direction or as reversible lanes. For a divided highway, reversible preferential lanes can be operated counter-flow to the direction of traffic on the adjacent general-purpose lanes.

Figure 2G-1. Preferential Lane Regulatory Signs and Plaques (Sheet 1 of 2)



GENERAL INFORMATION SIGNS

General Information signs convey various types of information that may be of interest to the traveler - landmarks, geographical interest, State lines, city limits, other political boundaries, time zones, stream names, elevations, safety and transportation-related messages. General information signs contain simple dignified designs without advertising and are commonly used in combination with recreational and cultural interest signs.

Figure 2H-1. General Information and Miscellaneous Information Signs



CHANGEABLE MESSAGE SIGNS

A changeable message sign (CMS) is capable of displaying one or more alternative messages. Some of these signs have a blank mode when no message is displayed, with others displaying multiple messages - one message displayed at a time.

Typical Changeable Message Sign Applications

- Warning situations
- Traffic regulations
- Speed control
- Destination guidance
- Incident management and route diversion
- Warning of adverse weather conditions

- Special event applications
- Crossing situations control
- Lane, ramp, and roadway control
- Lane management

Government agencies typically use changeable message signs to display information regarding safety, transportation, emergencies, homeland security, and America's Missing: Broadcast Emergency Response (AMBER) alerts.

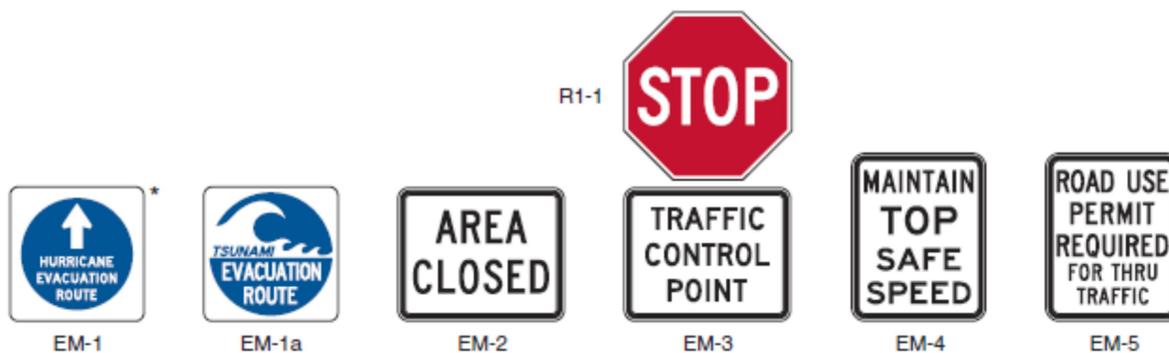
EMERGENCY MANAGEMENT SIGNING

Contingency planning for an emergency evacuation should be considered by all State and local jurisdictions for all applicable roadways. In the event of a disaster with road closures, a contingency plan should address the following elements:

- Controlled operation of certain designated highways,
- Establishment of traffic operations for expediting essential traffic,
- Provision of emergency centers for civilian aid.

Emergency Management signs should guide and control highway traffic in the event of an emergency. These signs should not permanently displace any of the standard signs that are normally applicable.

Figure 2N-1. Emergency Management Signs



State and local authorities are responsible for any advance planning addressing transportation operations' emergencies. The Federal Government provides guidance to the States due to changing circumstances.

RECREATIONAL AND CULTURAL INTEREST SIGNS

Recreational and cultural interest areas are open to the general public for the purpose of relaxation, play, or amusement. Recreational and cultural interest signs guide road users to general areas first and then to specific facilities.



Recreational areas include:

Parks Campgrounds Gaming facilities Ski areas

Cultural attractions include:

Museums Art galleries Historical buildings or sites

Recreational or cultural interest signs are rectangular with white symbols and borders on either a green, brown, or black background. The signs on highways outside of recreational interest areas will have white symbols/borders on brown backgrounds.

Exceptions include:

- Ferry, Post Office, Airport, Bus Stop, and Helicopter signs - white symbols with green backgrounds.

- Camping Tent and Trailer, Gas, Handicapped, Lodging, Picnic area, Rest Area, Telephone, Rest Room, Trailer Sanitary Station, Group Camping, Group Picnicking, Parking - white symbols with blue backgrounds.

MARKINGS

PAVEMENT MARKINGS

Pavement marking is more than just roadway striping. It relays regulatory and vehicle-path information to the user without requiring them to divert their attention from the road. Their purpose is to encourage safe, orderly traffic flow while optimizing roadway capacity. Pavement markings need to be easily recognized and understood in order to be effective. A standardized system of marking color, shape, and application has been developed to convey the same message each time they are encountered.

All pavement markings should be maintained to ensure adequate daytime and nighttime visibility. Upon installation, it is the municipality's responsibility to maintain the marking. If the municipality decides that the marking is no longer needed, their decision process should be documented. Any markings deemed non-applicable or confusing should be removed as soon as possible.

COLORS

WHITE PAVEMENT MARKING

Separates traffic flows in the same direction

Delineates the right edge of the roadway.

YELLOW PAVEMENT MARKING

Separates traffic traveling in the opposite directions

Delineates the left edge of the roadways of divided and one-way highways & ramps

Separates two-way left turn lanes and reversible lanes from other lanes.

BLUE PAVEMENT MARKING

Supplements white markings for handicap parking

PURPLE PAVEMENT MARKING

Supplements toll plaza approach lane lines or edgelines that are restricted for registered electronic toll collection vehicles.

BLACK PAVEMENT MARKING

Used in combination with other pavement markings (yellow, white, red, blue, or purple) where a light-colored pavement does not provide sufficient contrast.

MATERIALS

Pavement markings typically include paints and thermoplastics but they may also use other marking materials (colored paving, raised pavement markers, etc.). Highly visible delineators and channelizing devices can also be placed vertically above the roadway.

Paint is the easiest, cheapest, and most commonly used pavement marking material. However, it is also the least durable. To combat poor nighttime visibility, retroreflectivity is improved by adding glass beads into the wet paint.

Thermoplastic pavement markings use a heated temperature-setting plastic material for use on asphalt pavements. Based on temperature-related expansion and contraction differentials between plastic and concrete (which may result in thermoplastic separation) thermoplastic is prohibited from use on concrete.

Marking color, pattern, and orientation provide crucial information to roadway users. Complying with these standards is critical to provide positive guidance and should be maintained throughout the product's life. Materials for minimizing tripping or loss of traction for users (pedestrians, bicyclists, motorcycles, etc.) should also be considered when choosing pavement markings.

LONGITUDINAL MARKINGS

White and yellow longitudinal markings (long lines) guide traffic along the roadway by providing visual clues to the travel path. Dashed lines (broken lines) allow vehicles to pass or change lanes. These white or yellow markers are *four to six inches wide* and applied with ten foot painted dashes and thirty foot spacing. The distance from the beginning of one dash to the beginning of the next is 40 feet. These lines provide an excellent way to estimate roadway distances (example: three dashes between two side roads; the estimated distance is $3 \times 40 = \mathbf{120 \text{ feet}}$ separating the roadways).

WIDTHS & PATTERNS OF LONGITUDINAL PAVEMENT MARKINGS

Normal Line - 4 to 6 inches wide.

Wide Line - at least twice the width of a normal line. The width of the line indicates the degree of emphasis.

Double Line - two parallel lines separated by a discernible space.

Broken Line - normal line segments (10 feet) separated by (30 feet) gaps.

Dotted Line for Extensions - noticeably shorter line segments (typically 2 feet) separated by shorter gaps (typically 2 to 6 feet). The width of a dotted line shall be at least the same as the width of the line it extends.

Dotted Line for Lane Lines - 3 feet line segments with 9 feet gaps.

YELLOW CENTER LINE PAVEMENT MARKINGS AND WARRANTS

Yellow center line pavement markings are used to separate traffic lanes with opposite directions of travel. These can be installed at locations that are not the geometric center of the roadway. Center line pavement markings may be used on short roadway sections to control traffic at specific locations (curves, over hills, grade crossings, bridges, etc.) for roadways without continuous center line pavement markings,

CENTER LINE MARKINGS - TWO-LANE, TWO-WAY ROADWAY OPTIONS

Two-direction passing zone markings - a normal broken yellow line

- passing with care is permitted for traffic traveling in either direction;

One-direction no-passing zone markings - a double yellow line, one of which is a normal broken yellow line and the other is a normal solid yellow line

- passing with care is permitted for traffic traveling adjacent to the broken line, but is prohibited for traffic traveling adjacent to the solid line

Two-direction no-passing zone markings - two normal solid yellow lines

- passing is prohibited for traffic traveling in either direction.

Please note that a single solid yellow line shall never be used for center line marking on two-way roadways.

For undivided two-way roadways with four or more lanes for moving motor vehicle traffic, the centerline markings shall be the two-direction no-passing zone markings (solid double yellow line).

Center line markings may be placed on paved two-way roads with a minimum width of 16 feet.

Center line pavement markings are required on:

Paved urban arterials & collectors	Traveled way 20 feet or wider ADT = 6000 vehicles/day or more**
Paved two-way streets or highways	Three or more lanes
Rural arterials & collectors	Traveled way 18 feet or wider ADT = 3000 vehicles/day or more

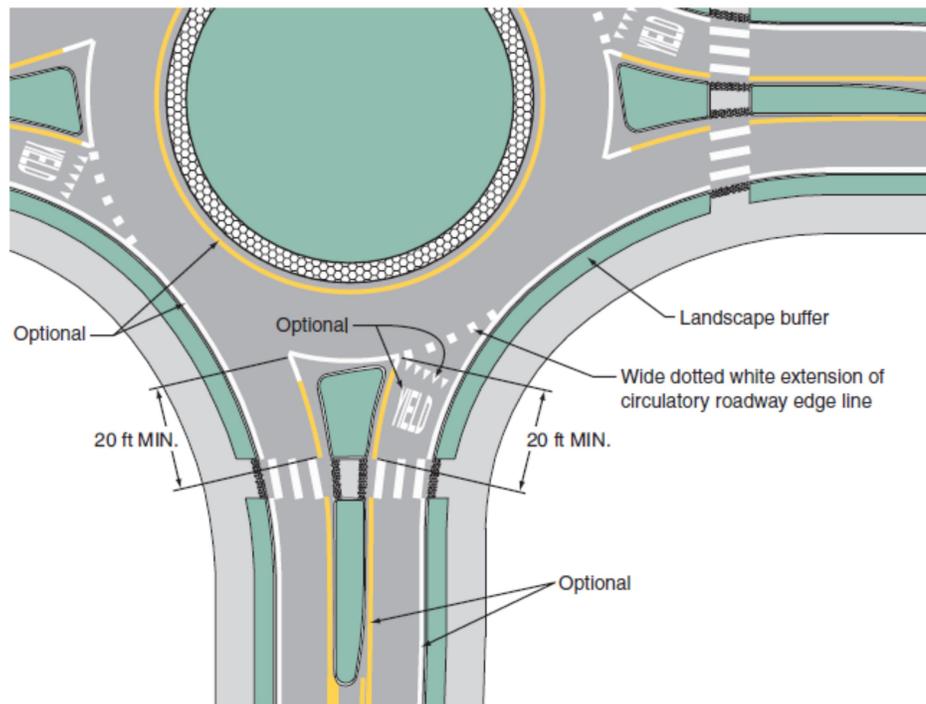
Where engineering judgment indicates a need

**May be used for a minimum ADT of 4000 vehicles/day

ROUNDABOUT MARKINGS

A roundabout is a circular intersection designed for safety and speed control with specific traffic control features. Any pavement marking design for a roundabout should be integrated to its location and intended purpose. Any markings on the roundabout's approaches or circular roadway should provide a consistent message to road users. These should promote movement through the facility with minimal lane changes within the circulatory roadway in order to exit the roundabout.

Figure 3C-1. Example of Markings for Approach and Circulatory Roadways at a Roundabout



White Lane Line Pavement Markings

Multi-lane roundabouts need to have lane line markings on the approaches as well as within the circulatory roadway to guide traffic to the appropriate exit. No continuous concentric lane lines should be installed within the roundabout's circulatory roadway.

Edge lines should be located on the outer (right) side of the circulatory roadway with a solid line adjacent to the splitter island with a wide dotted line across the entrance approaches.

For pedestrian facilities, marked crosswalks (placed a minimum of 20 feet from the edge of the circulatory roadway) should indicate where pedestrians should cross roundabout entrances and exits. See Chapter 3C of the MUTCD for further guidance, details, and examples for proper roundabout pavement markings.

TOLL PLAZAS

plaza pavement markings identify the proper lane for the type of toll payment, channelize movements, and delineate roadway obstructions.

When one or more Open Road Tolling (ORT) lanes is restricted to registered Electronic Toll Collection (ETC) vehicles that bypass a mainline toll plaza on a separate alignment, these word markings and longitudinal markings shall be used where the ORT lanes diverge from the lanes designated for the mainline toll plaza.

For ORT lanes that are immediately adjacent to a mainline toll plaza but not separated from adjacent cash payment toll lanes by a curb or barrier, channelizing devices, and/or pavement markings should be used to prevent lane changing. This separation should begin on the approach to the mainline toll plaza where vehicle speeds in the adjacent cash lanes drop below 30 mph during off-peak periods, and should extend downstream to where the departing vehicles in the adjacent cash lanes have accelerated to 30 mph.

For toll approach lanes restricted to registered ETC vehicles, the ETC Account-Only lane word markings and preferential lane longitudinal markings should be used. The solid white lane line or edge line on the right-hand side of the ETC Account-Only lane and the solid white lane line or solid yellow edge line on the left-hand side of the ETC Account-Only lane may be supplemented with purple solid contiguous longitudinal markings installed to the inside edges of the lane lines.

The **purple markings** should be a minimum of *3 inches* wide and a maximum width equal to the width of the line it supplements.

Toll booths and their islands are considered obstructions and should be marked to comply with these conditions. Any longitudinal pavement markings may be omitted alongside toll booth islands between the approach and departure markings.

DELINEATORS

Delineators are useful for roadway locations with long continuous sections or short stretches where the alignment might be confusing or unexpected (lane-reduction transitions, horizontal curves, etc.). These are effective *guidance* devices (rather than warning devices) at night and during adverse weather due to their visibility when the roadway may be wet or snow covered.

Delineator Design

Delineators consist of retroreflective devices (3-inch minimum) that normally retroreflect light from a distance of 1,000 feet when illuminated by standard automobile high beam headlights.

Single delineators: One retroreflective element for a given direction of travel at a specific location. May be installed on the left-hand side where needed

Double delineator: Two identical retroreflective elements mounted together for a direction. An appropriately sized vertically elongated delineator may be substituted for a double delineator.

Delineator Application

A series of single delineators should be located on the right side of freeways and expressways and on one side of interchange ramps, except when either of the following conditions is met:

1) On tangent sections of freeways and expressways when both of the following conditions are met:

a. Continuous raised pavement markers are used to supplement pavement markings on lane lines throughout all curves and on all tangents,

b. Roadside delineators are used to direct traffic into all curves.

2) On sections of roadways with continuous lighting between interchanges.

Delineators may also be used on other classes of roadways and their colors should comply with the edge line color.

Delineator Colors

White Left-hand side of a two-way roadway

Red Wrong direction of ramp or roadway

Truck escape ramp

Appropriate colors can indicate where either an outside or inside traffic lane merges into an adjacent lane. Delineators should be installed adjacent to the lane reduced for the full transition length and show the reduction.

Red delineators may be used on the reverse side of any delineator where it would warn a road user traveling in the wrong direction on that particular ramp or roadway. These delineators should also be used on both sides of truck escape ramps (spaced at 50-foot intervals) to identify the ramp entrance. Spacing beyond the entrance should be adequate for the escape ramp's length and design.

Delineator Placement and Spacing

The mounting height of delineators should be approximately *4 feet* (measured vertically from the bottom of the device to the elevation of the edge of the pavement). They may be mounted at a lower elevation on the face or top of guardrails or other barriers.

Delineators should be installed at a constant distance from the edge of roadway *2 to 8 feet* outside the outer edge of the shoulder; or in line with roadside barriers (maximum distance of 8 feet outside the outer edge of the shoulder). For locations with obstructions between the pavement edge and the line of the delineators, the delineators should be transitioned to the innermost edge of the obstruction. For guardrail or other longitudinal barriers, the delineators should be transitioned just behind, directly above, or on the barrier's innermost edge.

Delineators should be spaced **200 to 530 feet apart** on *mainline tangent sections* and **100 feet apart** on *ramp tangent sections*.

CHANNELIZING DEVICES

Channelization devices (cones, tubular markers, vertical panels, drums, lane separators, raised islands, etc.) are used to emphasize traffic control sites (islands, reversible lane delineation, and channelizing lines).

Colors for channelizing devices are typically orange or the same color as the pavement marking that they supplement/substitute. Channelizing devices should be retroreflective or internally illuminated for nighttime use. *White* retroreflective material should be used for devices that separate traffic in the same direction. If the channelization separates flows in the opposite direction or are located on the left side edge line of a one-way roadway, the sheeting or bands should be *yellow*. These devices should be kept clean and bright to maximize target value.

ISLANDS

Design guidelines for islands are specified in AASHTO's "*A Policy on Geometric Design of Highways and Streets*" ("*Green Book*"). Traffic islands can be designated by curbs, pavement edges, pavement markings, channelizing devices, or other devices. Typical island markings consist of pavement/curb markings, channelizing devices, and delineators. Pavement markings for approaches to an obstruction may be omitted where determined necessary by engineering judgment.

Islands outlined by curbs or pavement markings should be marked with retroreflective white or yellow material to denote the general alignment of the island's edge along which vehicles travel. The approach ends of islands should be preceded by divergent longitudinal pavement markings on the pavement surface, to guide vehicles along the island edge.

The neutral area between approach-end markings sometimes contains sections of coarse aggregate or other suitable materials (usually less than 1 inch high). Although this area can be traversed at great speeds, these materials create rumble sections that provide higher visibility and warn road users. Bars or buttons (projecting 1 to 3 inches above the pavement surface) can also be used in the neutral area to warn the operator. These raised bars or buttons should be marked with white or yellow retroreflective materials, which are determined by the direction or directions of travel.

However, these channelizing devices, when used in advance of islands having raised curbs, shall not be installed in such a way as to create an unexpected obstacle.

Island delineation should be the same colors as the related edge lines (exception: red wrong-way traffic delineation). Retro reflective or internally illuminated markers of appropriate color may be placed in front of the curb and/or on the top of curbed approaches of raised medians and curbs of islands, to supplement or substitute for retro reflective curb markings. For long islands, curb retro reflection may be discontinued along the entire length of the curb, especially if the island is illuminated, delineated or marked with edge lines.

Pedestrian Islands and Medians

Raised islands or medians in the center area of a roadway can serve as pedestrian refuge island at a midblock or intersection location. These areas allow pedestrians to find an adequate gap in one direction of traffic at a time and wait for an adequate gap in the other direction of traffic before crossing the second half of the road. The *Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)* provides the minimum widths for accessible refuge islands and for design and placement of detectable warning surfaces.

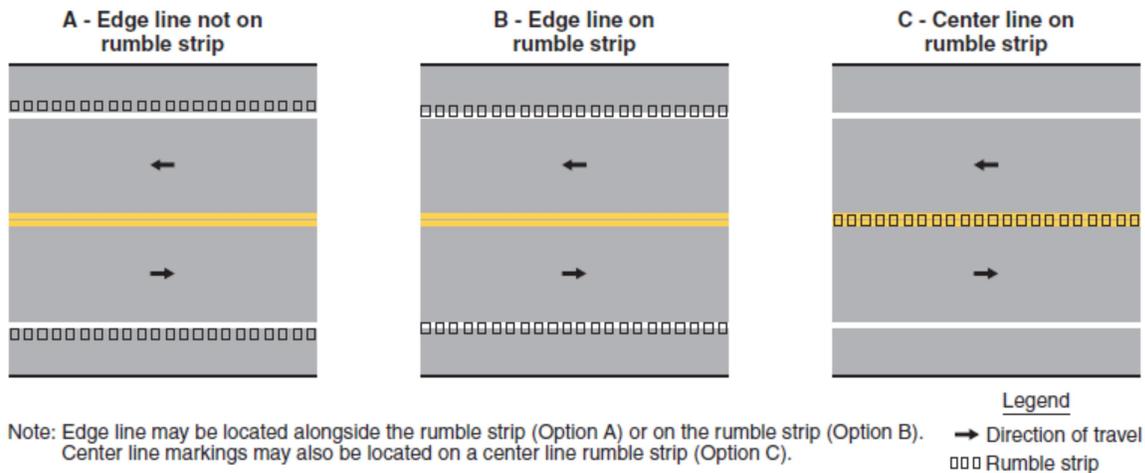
RUMBLE STRIP MARKINGS

Longitudinal rumble strips are either a series of rough-textured, slightly raised, or depressed road surfaces that warn drivers through vibration and sound of the edges of the travel lane.

Possible Longitudinal Rumble Strip Locations

Shoulder	Roadway shoulder near travel lane
Divided Highway	Median side (left) and/or outside shoulder (right)
Two-way Roadways	Along center line

Figure 3J-1. Examples of Longitudinal Rumble Strip Markings



An edge line or center line may be installed over a longitudinal rumble strip to create a *rumble stripe*. However, edge lines should not be placed in addition to a shoulder rumble stripe.

Transverse rumble strips consist of intermittent narrow, transverse areas of roughly textured, slightly raised, or depressed road surface that extend across the travel lanes. Through noise and vibration, they alert drivers to unusual vehicular traffic conditions, such as unexpected changes in road alignment or conditions that require a stop or speed reduction.

At locations where the color of a transverse rumble strip within a travel lane does not match the color of the pavement, the color of the strip should be either *black or white*. White transverse rumble strips should not be installed where they may be confused with other transverse markings (stop lines, crosswalks, etc.).

SUMMARY

The overall objective of this course was to give engineers and designers an in-depth look at traffic control selection and design principles. The *Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) 2009 Edition Parts 1 through 3* were used to explain the fundamental design principles of traffic signs and pavement markings. This text is the recognized **national standard** for all traffic control devices installed on any road or bikeway.

Traffic signs and pavement markings are critical tools that convey regulations, traffic, roadway conditions, and other important information. These devices allow users to travel safely on any U.S. roadway. The goal of traffic control is to provide drivers with relevant information when they need it.

The contents of this course were intended to serve as guidance and not as an absolute rule. It was written to help you learn to use the MUTCD more effectively for establishing roadway traffic control.

REFERENCES

A Policy on Geometric Design of Highways and Streets, 2004 Edition, American Association of State Highway and Transportation Officials (AASHTO)

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United States Road Symbol Signs, USDOT, Federal Highway Administration, Washington, DC, 2002, FHWA-OP-02-084

(Note: All figures, tables, exhibits, etc. contained in this course are from the MUTCD, except where noted otherwise.)