

## 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**

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

<sup>1</sup> Service life can vary with traffic and weather conditions

<sup>2</sup> Cost based on averages, will vary based on quantities, locations, placement factors, etc.

<sup>3</sup> 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

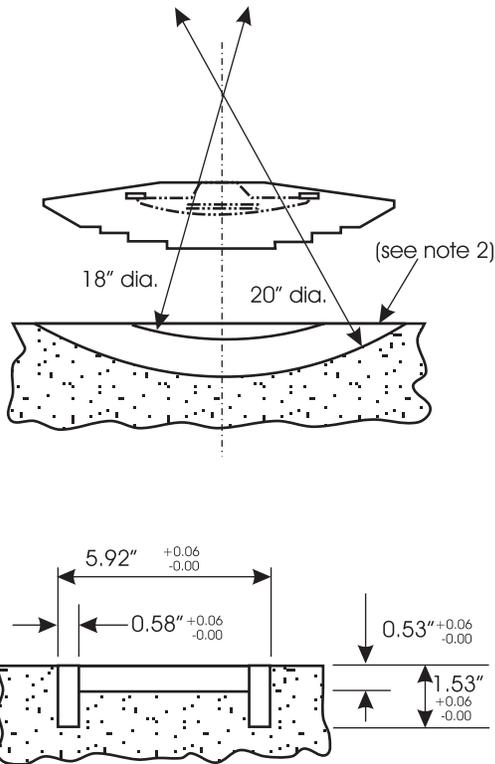
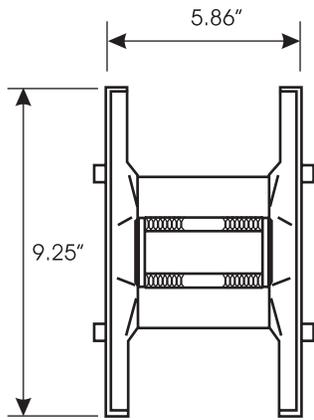
visibility in needed locations. RPMs have not been accepted for general use in many northern states due to high initial cost and susceptibility to damage from snowplow activity. However with care in design and installation, RPMs can be an effective means of guidance for vehicles at night. The following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

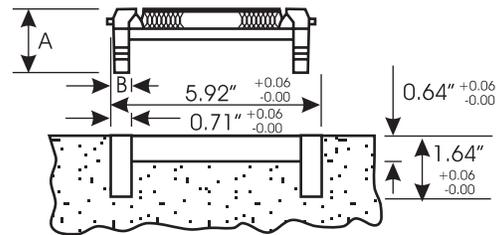
The illustrations on the following pages depict typical raised pavement marker applications.



optional for conventional type

Notes:

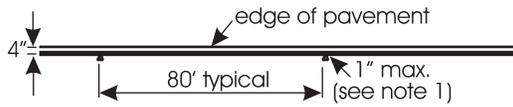
1. Center-line raised pavement markers shall be placed between the two painted lines. Markers installed along an edge line or channelizing line shall be placed so that the casting is not more than 1 inch from the near edge of the line. Markers installed along a lane line or dashed yellow center line 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.



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

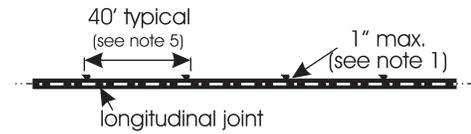
**Casting and saw cut details for raised pavement markers**

Source: Ohio Department of Transportation.



**Edge Line**

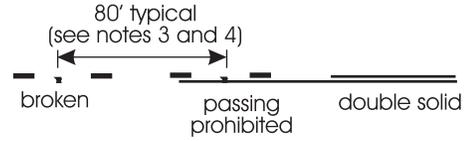
one way (white) with right edge line and  
one way (yellow) with left edge line or  
two way (yellow both sides)



**Channelizing Line**  
two way (white)

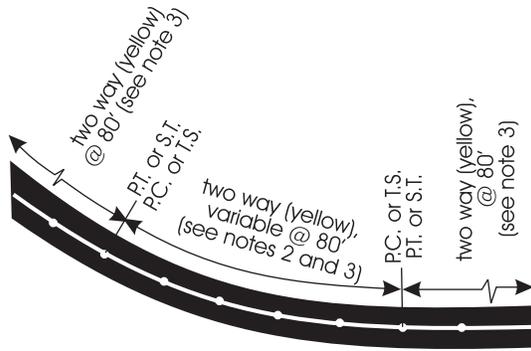


**Lane Line**  
one way (white)



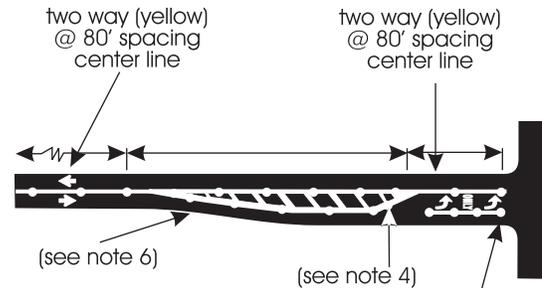
**Center Line**  
two way (yellow)

**Typical raised pavement marker placement with longitudinal pavement markings**



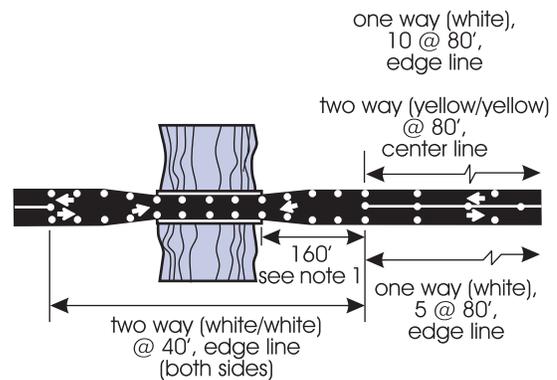
Legend  
■ reflectors

**RPM details for horizontal curve**



Legend  
■ reflectors

**RPM details for approach with left turn lane**



**RPM details for one-lane bridge**

placed at each end of the line and one shall be placed in the center of the line.  
6. Raised pavement markers shall not be placed on edge lines on a through approach.

**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

Source: Ohio Department of Transportation.

**Specifications and application rates for placing pavement marking lines**

	<b>Broken Center Line</b>	<b>Broken Lane Line</b>	<b>Double Center Line</b>	<b>No Passing Zone Line</b>	<b>Right Edge Line</b>	<b>Left Edge Line</b>
<b>Color</b>	Yellow	White	Yellow	Yellow	White	Yellow
<b>Width</b>	4"	4"	two at 4"	4"	4"	4"
<b>Pounds of Beads per Gallon of Paint<sup>1</sup></b>	8	6	8	8	6	8
<b>Wet Film Thickness (mils)</b>	11	11	11	11	11	11
<b>Gallons of Paint per Mile<sup>1</sup></b>	3.02	3.02	24.14	12.07	12.07	12.07
<b>Feet per Gallon of Paint</b>	1748	1748	219	437	437	437
<b>Gallons of Paint per Minute<sup>2</sup></b>	0.60 <sup>3</sup>	0.60 <sup>3</sup>	4.40 <sup>4</sup>	2.42	2.42	2.42

- <sup>1</sup> 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.
- <sup>2</sup> Based on a uniform travel rate of 12 mph, or 1,056 feet per minute.
- <sup>3</sup> Rate of application when 10-foot segments of broken line are being placed.
- <sup>4</sup> 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.

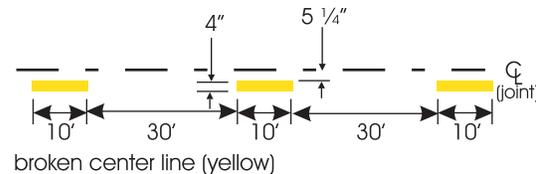
Section 3B.01 of the *MUTCD* recommends use of center lines on paved rural arterials and collectors with a width of 18 feet or greater and traffic volumes exceeding 3000 ADT. Rural roads not meeting these minimum characteristics can also be considered for center-line application when warranted by an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

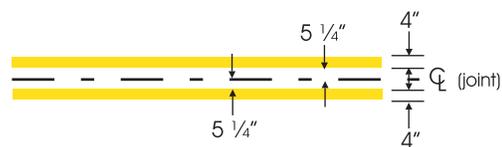
For urban arterials and collectors, the *MUTCD* recommends center lines be placed where roadways are 20 feet or greater in width and traffic volumes meet or exceed 4,000 ADT.

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

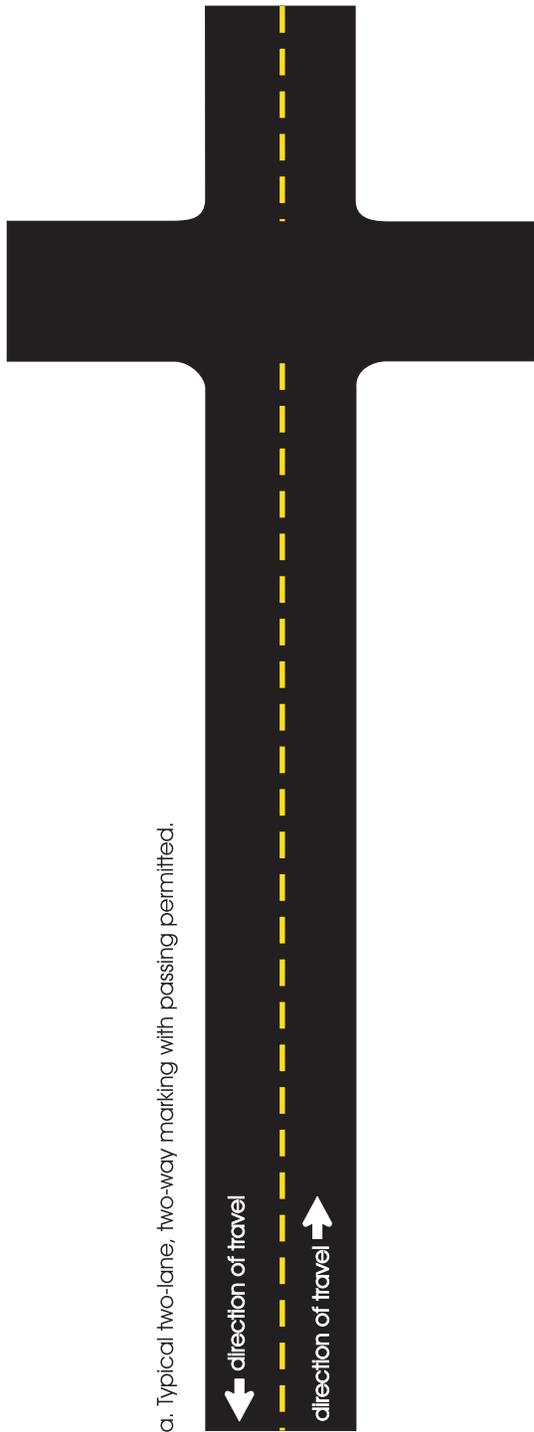
Typical two-lane, two-way road applications are shown in the following illustrations and those on the following page:



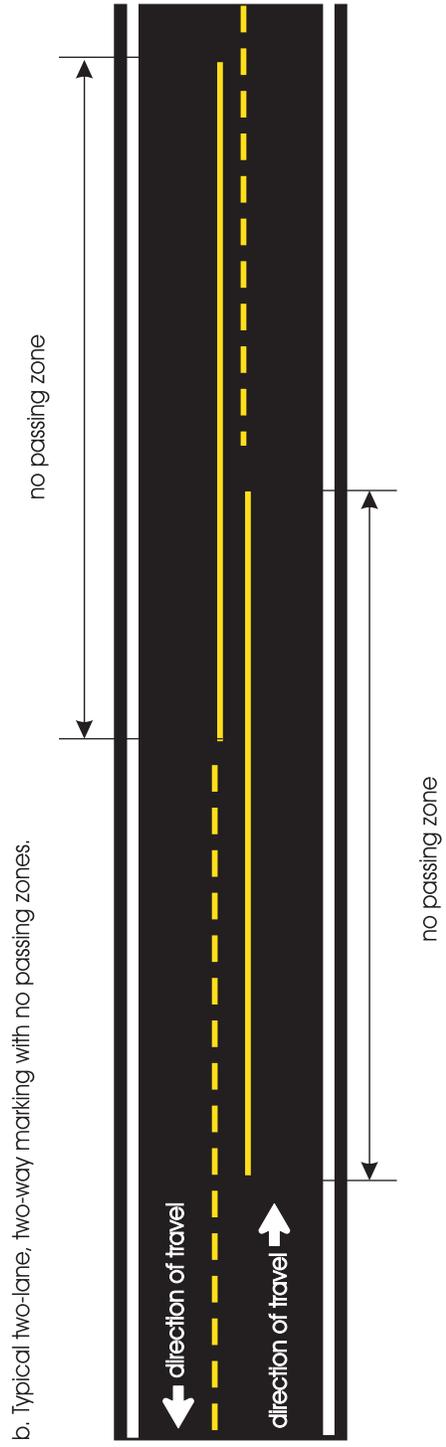
### Broken center line (yellow)



### Double center line (yellow)



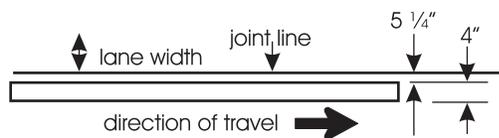
a. Typical two-lane, two-way marking with passing permitted.



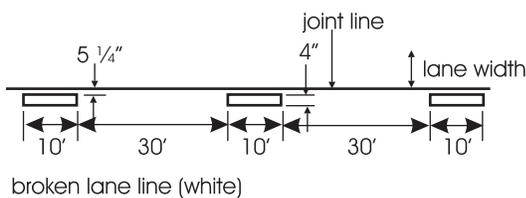
b. Typical two-lane, two-way marking with no passing zones.

**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*.

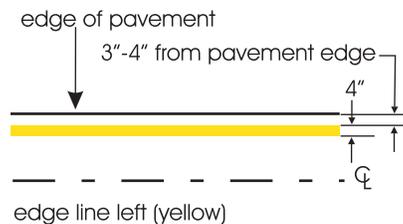
**Edge Lines.** Edge lines are used to delineate the edges of the traveled way on paved roadways. These markings have unique value as visual reference guides for drivers at night and under adverse weather conditions. When these lines are used, they should not be continued through intersections but should 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

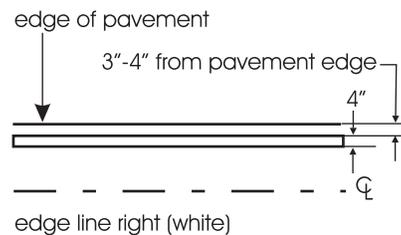
greater, where the edge is not delineated with curbs or other markings.

- 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.



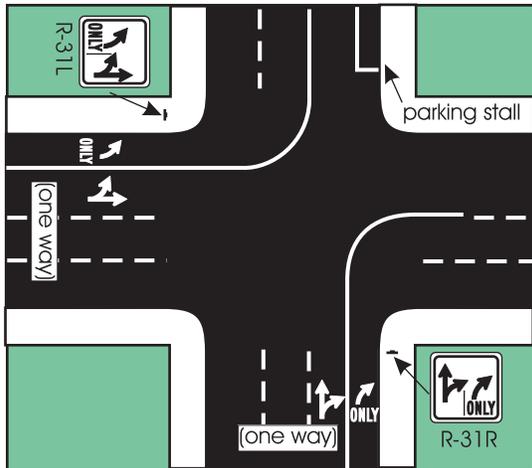
**Left edge line, one way (yellow)**



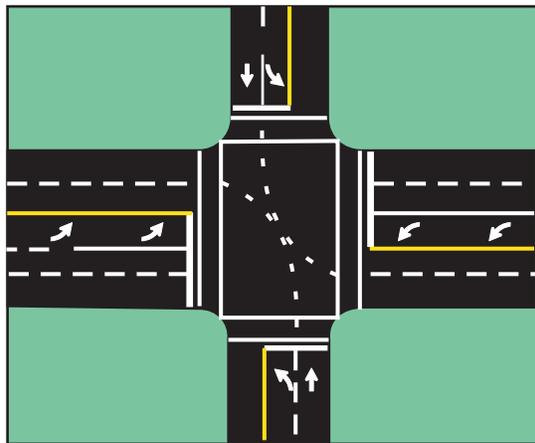
**Right edge line (white)**

**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

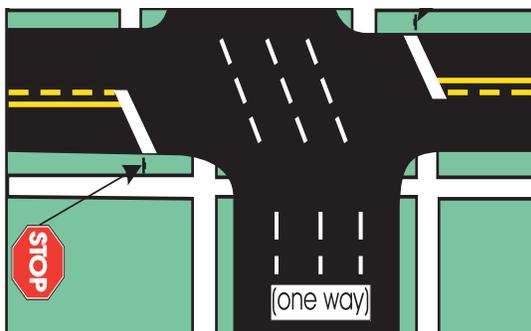
with greater width or raised pavement markers utilized for additional emphasis. The following diagrams illustrate several options for pavement marking extensions through intersections.



**Solid double turn lane lines**



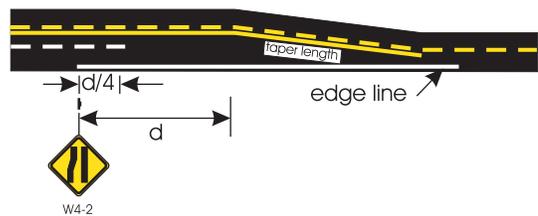
**Dotted line markings to extend longitudinal lane line markings**



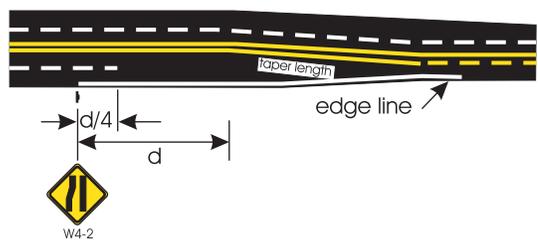
**Offset lines continued through the intersection**

**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.

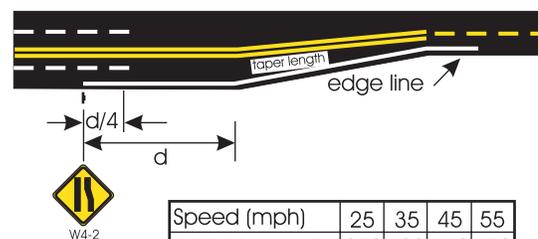
a. from 3 lanes to 2 lanes



b. from 4 lanes to 3 lanes



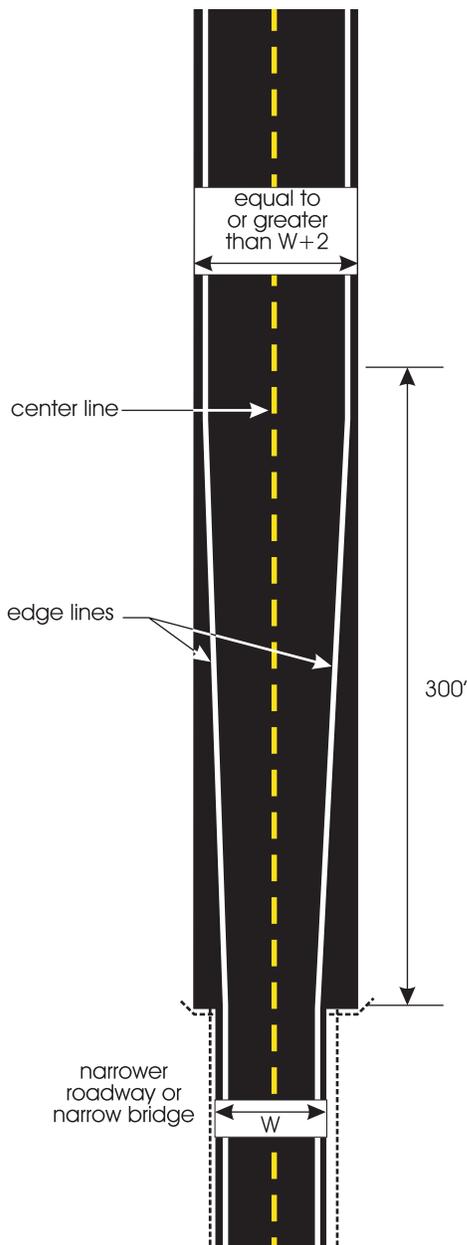
c. from 4 lanes to 2 lanes



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.



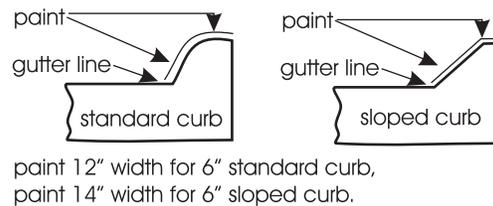
**Edge-line transition at abrupt changes in pavement width or approaches to narrow bridges**

**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.

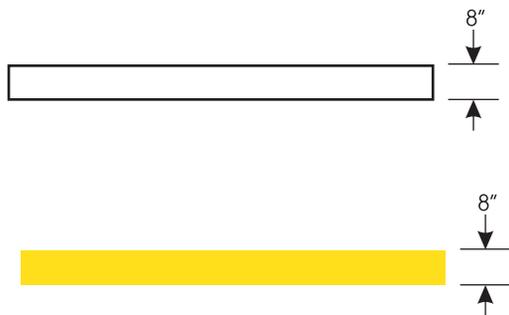
All curb markings can be costly and labor intensive to apply and maintain; therefore, placement should be carefully studied prior to initial installation.



**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.

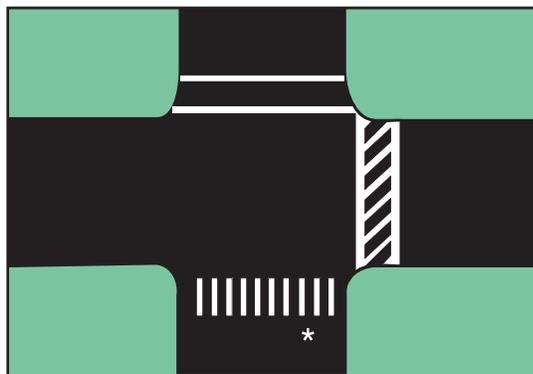
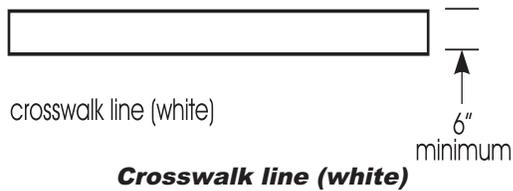
For additional visibility, the area of the crosswalk may be marked with white diagonal lines. Increased durability can be gained by using white longitudinal lines placed perpendicular to the crosswalk. These lines may be 6 feet long, approximately 12 to 24 inches in width and spaced 12 to 60 inches apart.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

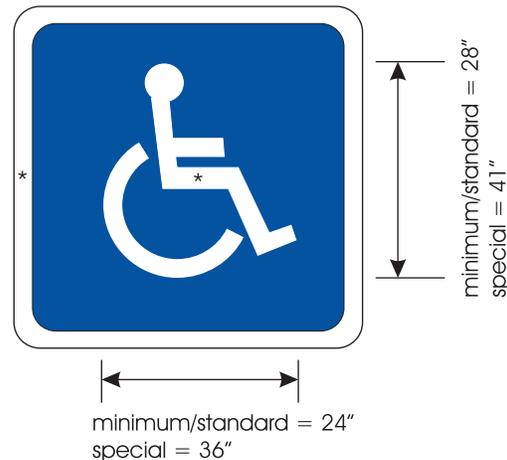


\*Spacing of lines selected to avoid wheel path.  
**Typical crosswalks**

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

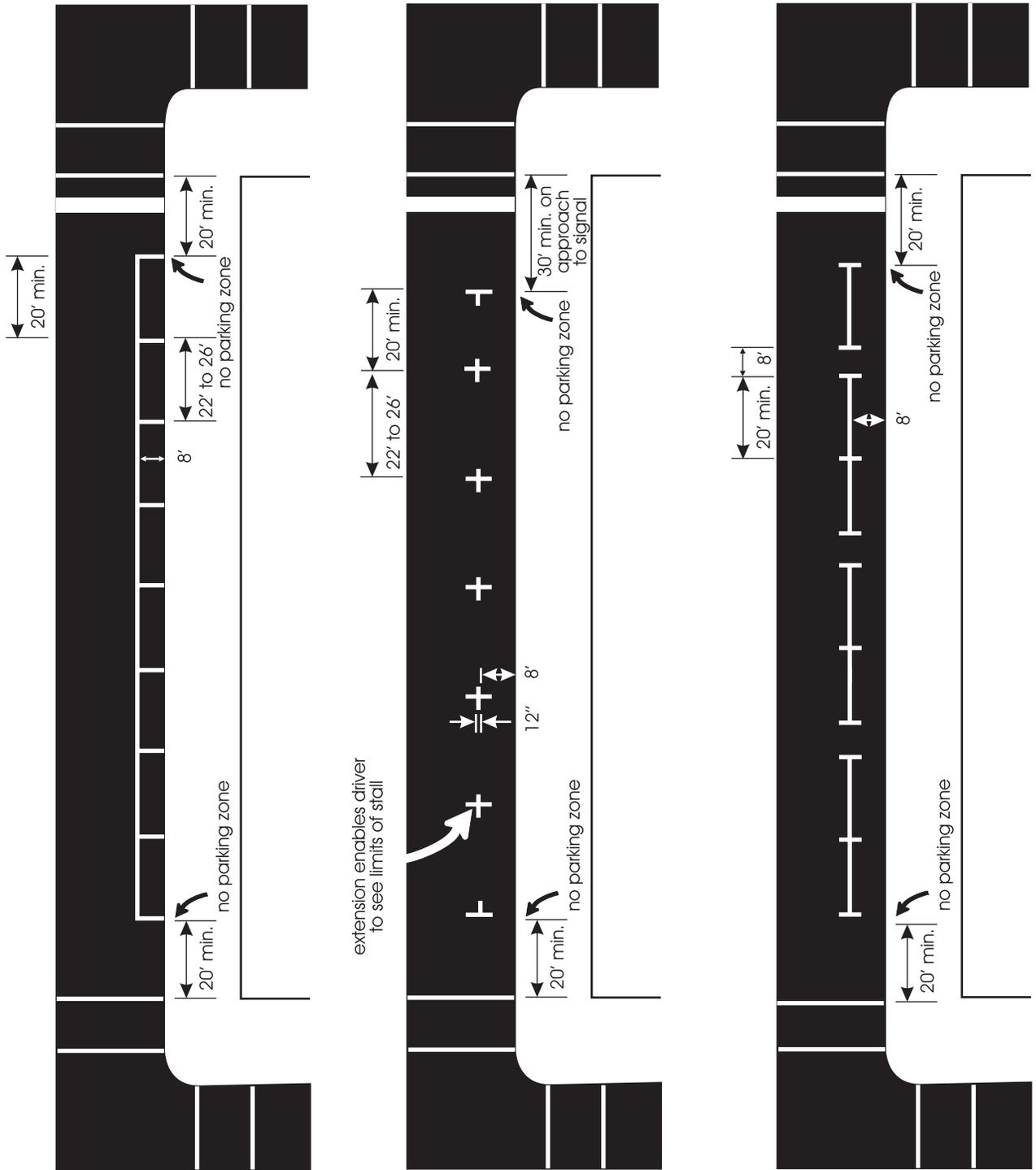
**Parking Spaces.** The marking of parking spaces will encourage more efficient use of available parking along public streets. Markings can also be used to prevent encroachment at fire hydrants, bus stops, loading zones, intersection approaches, and other locations where parking restrictions are established. 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**

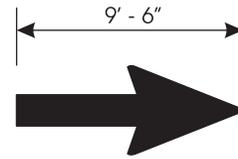
**Words and Symbols.** Words and symbols can be placed on the pavement surface to provide guidance, warning, or regulation for traffic. Symbols are preferred over word messages. Section 3B.19 of the *MUTCD* requires these markings to be white in color. The design should comply with the FHWA's *Standard 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

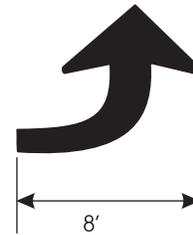
For maximum effectiveness, the following recommendations are listed for word and symbol markings:

- 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.

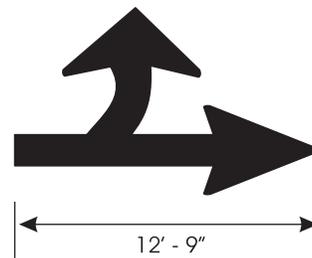
The following figures illustrate several typical word and symbol markings.



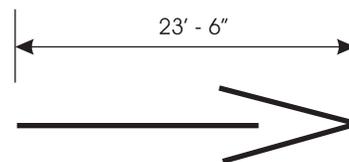
**Through lane-use arrow**



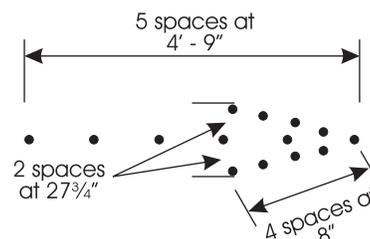
**Turn lane-use arrow**



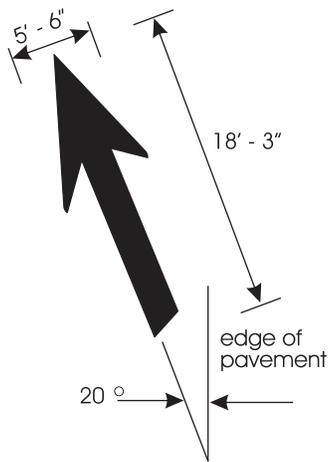
**Turn and through lane-use arrow**



**Wrong way arrow**

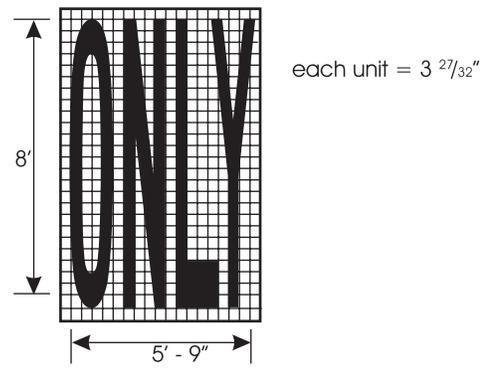


**Wrong way arrow**

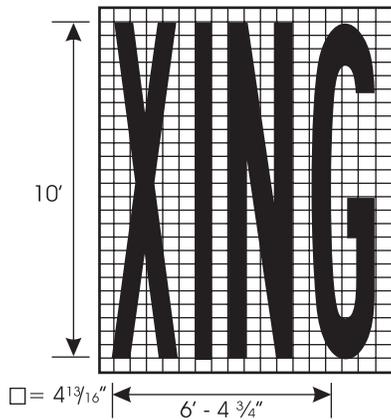


**Lane-reduction arrow**

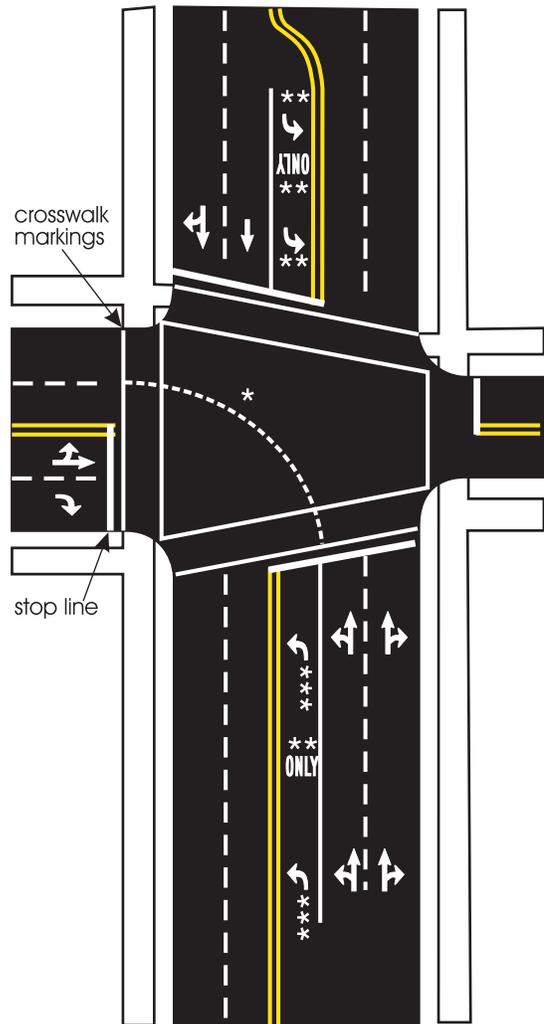
The markings shown here are standard sizes for normal installation. Sizes may be reduced approximately one-third for low-speed urban condition. Larger sizes may be needed for freeways, above average speeds, and other critical locations. A narrow elongated arrow design is optional. For proper proportion,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



**"Only" marking**

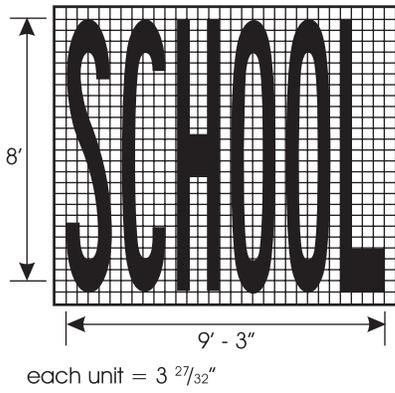


**"XING" marking**

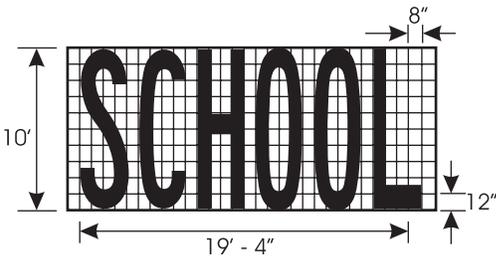


- \* Line extension may be solid or dotted line.
- \*\* Optional.
- \*\*\* Required where through lane becomes mandatory turn lane.

**Typical lane-use control word and symbol markings**



**"School" marking, one-lane approach**



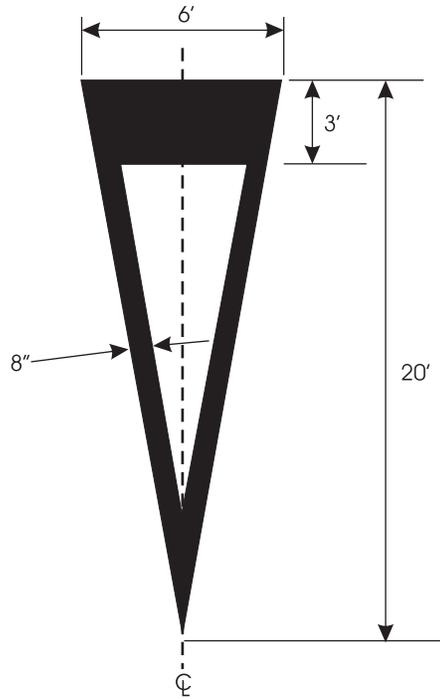
**"School" marking, two-lane approach**

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

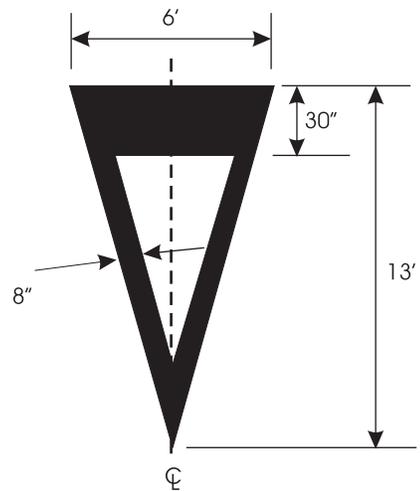
- Yield Ahead symbols
- markings for roundabouts and other circular intersections
- advance warning markings for speed humps and tables

Examples of these markings are shown in the following figures.

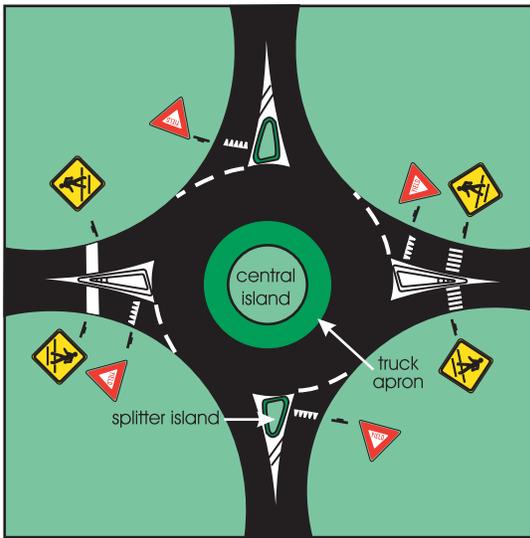
posted or statutory speed limit  $\geq$  45 mph



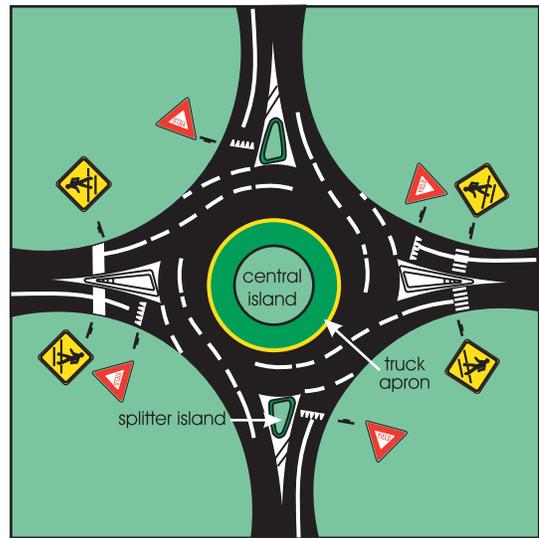
posted or statutory speed limit < 45 mph



**Typical yield ahead triangle symbols**



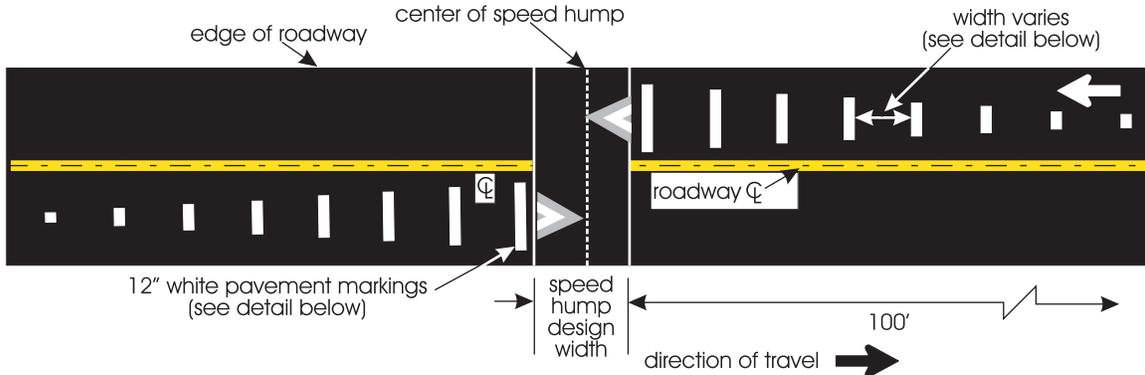
**Typical markings for roundabouts,  
one lane**



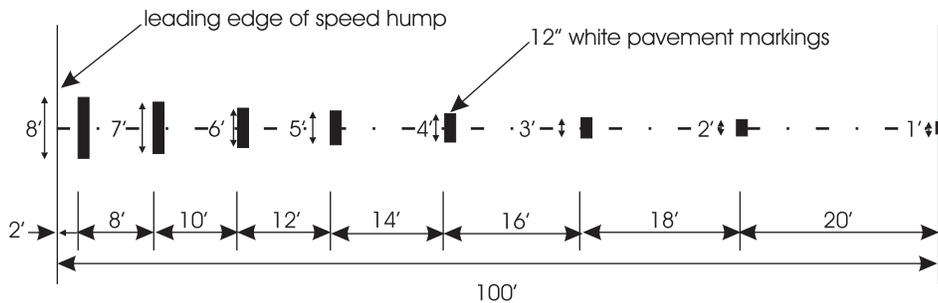
**Typical markings for roundabouts,  
two lanes**

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**