

## Curves and Hills

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

### Signs and Devices

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

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



**W1-1R**



**W1-1L**

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

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



**W1-2R**



**W1-2L**

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



**W1-3R**



**W1-3L**

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



**W1-4R**



**W1-4L**

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



**W1-5R**



**W1-5L**

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



**W7-3a**

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



**W13-1**

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



**W1-9**

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



**W13-5**

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



**W1-6**

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

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



**W1-8**

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

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

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

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

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

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

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

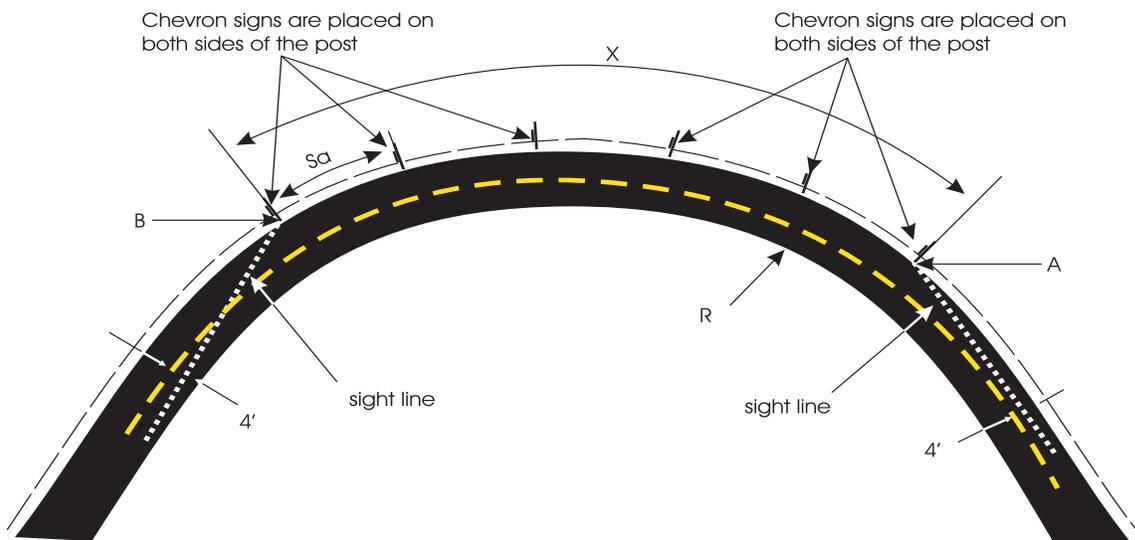
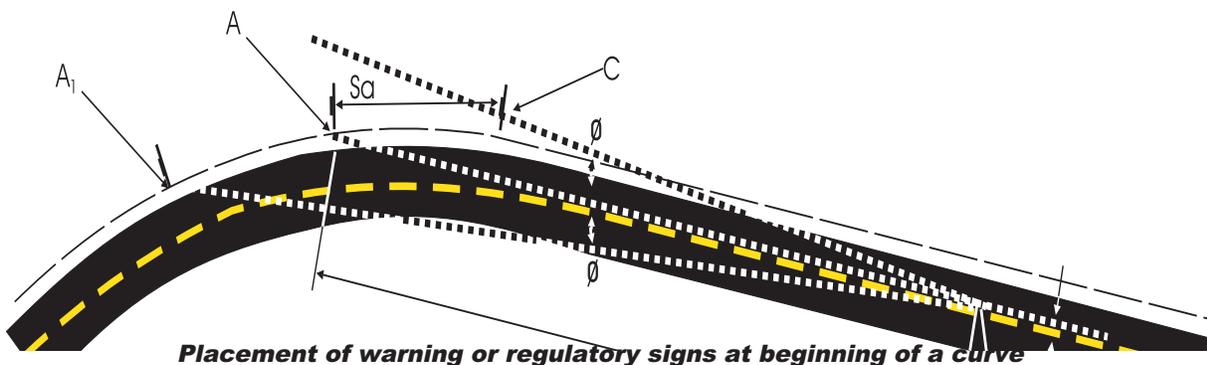


Figure XX Diagram to Illustrate Placing of Chevron Signs on Curves.

### Placement of chevron signs on curves



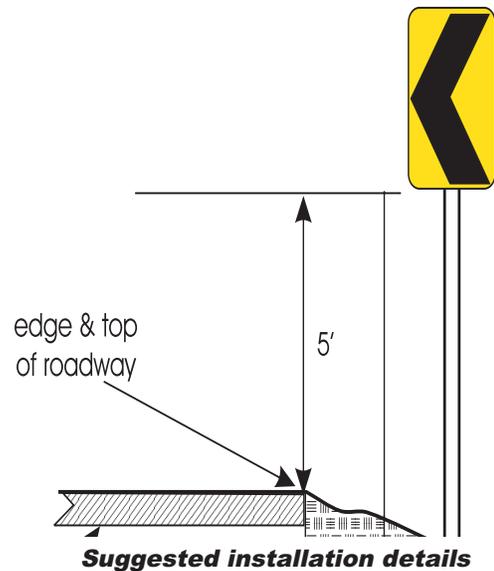
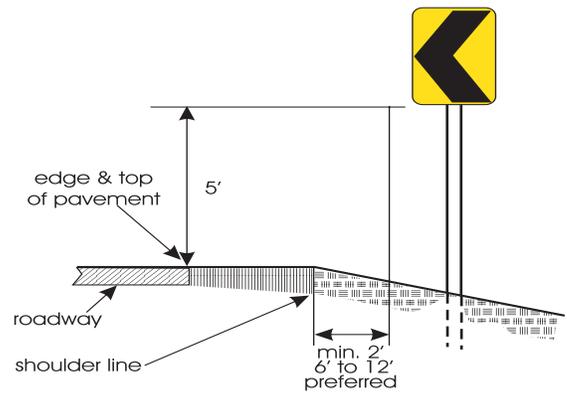
### Placement of warning or regulatory signs at beginning of a curve

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

**Suggested spacing for Chevron signs**

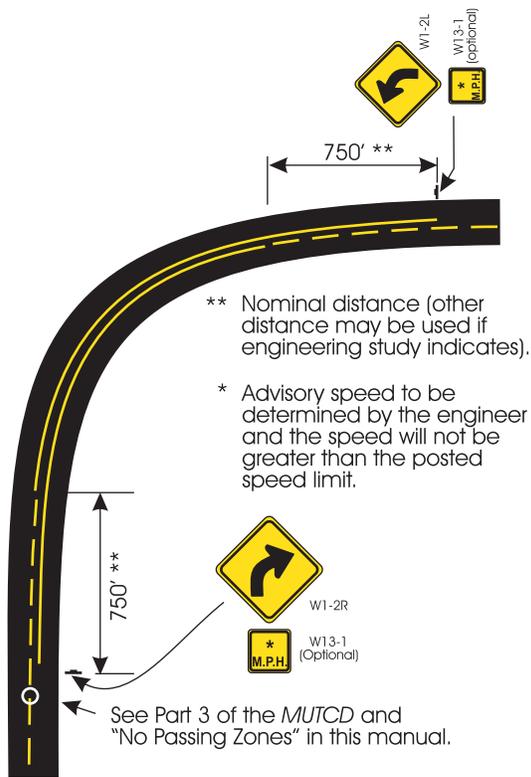
Design Speed (0.08)	Degree (D)	Radius (R)	Spacing Distance (Sc)
<b>Max Super)</b>			
60 mph	1°00'	5730'	200'
60 mph	2°00'	2865'	200'
60 mph	3°00'	1910'	200'
60 mph	4°00'	1432'	150'
50 mph	5°00'	1146'	150'
50 mph	6°00'	955'	125'
50 mph	7°00'	819'	125'
40 mph	8°00'	716'	125'
40 mph	9°00'	637'	100'
40 mph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

Suggested Installation Details

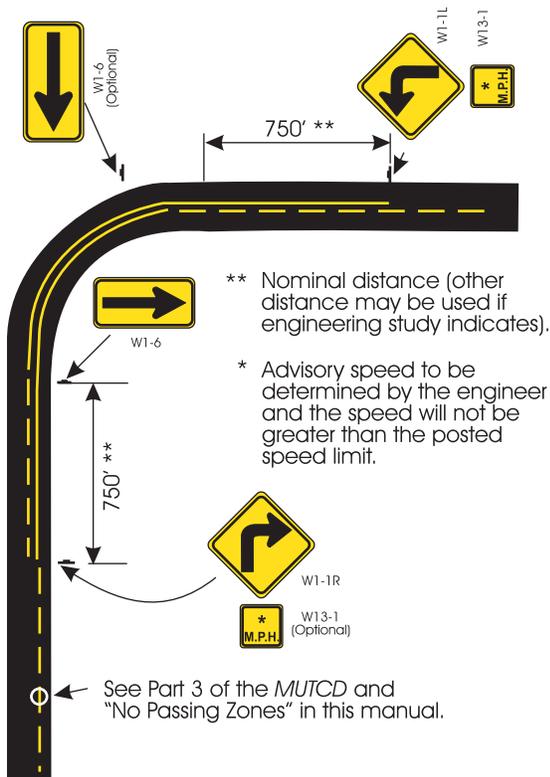


Maximum lateral installation up to 12 feet from traveled way.

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



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



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

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

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

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



**W7-1**



**W7-1a**



**W7-3**



**W7-5**