
321 HORIZONTAL ALIGNMENT WARNING SIGNS

Horizontal alignment warning signs are intended to be placed only when an engineering evaluation of roadway, geometric, and operating conditions shows that a reduction of speed by the vehicle operator may be required to comfortably maneuver through the change in the horizontal alignment of the roadway.

Trial speed runs are made using a passenger car equipped with a ball bank indicator to show the combined effect of the vehicle body roll, the centrifugal force, and the superelevation.

The first trial run should be made at the posted speed limit or at a lower speed somewhat below the anticipated maximum comfortable speed. Subsequent trial runs, if needed, should be conducted at increasing five mile per hour speed increments until the ball bank indicator exceeds the maximum ball bank reading (as listed in the Ball Bank Table) or the posted speed limit is reached.

The need for horizontal alignment warning signs is based on ball bank indicator readings. The correlation between comfortable curve and turn speeds and ball bank readings is as follows:

BALL BANK TABLE
(Ball Bank Indicator Criteria for Comfortable Speeds for Curve Signs)

Trial Run Speed (mph)	Maximum Ball Bank Reading
20 or less	16 degrees
25 - 30	14 degrees
35 or greater	12 degrees

Existing horizontal alignment warning signs may remain in place until maintenance is required.

321.1 SIGNING APPLICATIONS

Horizontal alignment warning signs should be installed where the comfortable speed of a curve, turn, or combination thereof is less than the speed limit. For multilane divided highways, horizontal alignment warning signs should be installed on both sides of the roadway.

Horizontal alignment warning signs may be installed where it is determined by a traffic engineering evaluation that the 85th percentile speed approaching the curve or turn is greater than the speed limit, and the comfortable speed of the curve or turn is less than the 85th percentile speed. Accident data, maintenance records, and traffic conflicts observed in the field may be included in the engineering evaluation.

A. Curve and Turn Signs

i. Turn Sign (W1-1)

The Turn sign (W1-1R or W1-1L) should be installed where the maximum comfortable speed on a turn is 30 miles per hour or less.

ii. Curve Sign (W1-2)

The Curve sign (W1-2R or W1-2L) should be installed where the maximum comfortable speed on a curve is greater than 30 miles per hour with ball bank readings as indicated by the Ball Bank Table.

B. Combination Curve Signs

A combination curve consists of two or more successive curves or turns in any combination in the same or opposite directions, either contiguous or connected by tangent sections less than 600 feet long. The recommended comfortable speed for a combination curve should be the lowest recommended speed on any of the curves making up the combination curve and, if that curve justifies a sign, the entire combination curve should be signed.

If the first curve or turn is to the left, a 'left' sign shall be used. If the first curve or turn is to the right, a 'right' sign shall be used.

i. Reverse Turn Sign (W1-3)

The Reverse Turn sign (W1-3R or W1-3L) should be installed where the combination curve consists of two turns or a curve and a turn in opposite directions.

ii. Reverse Curve Sign (W1-4)

The Reverse Curve sign (W1-4R or W1-4L) should be installed where the combination curve consists of two curves in opposite directions.

iii. Winding Road Sign (W1-5)

The Winding Road sign (W1-5R or W1-5L) should be installed where the combination curve consists of a series of three or more curves or turns.

iv. Horseshoe Curve Turn Sign

The Horseshoe Curve turn sign may be installed where a turn or a combination curve consisting of two turns or a curve and a turn in the same direction results in a change in the horizontal alignment greater than 90 degrees. Engineering judgment should be used to ensure that a roadway tangent segment connecting two turns or a curve and a turn is insufficient in length to allow independent signing.

The Horseshoe Curve turn sign is not intended for use where the comfortable speed on the curve or combination curve is greater than 30 miles per hour; instead, appropriate curve signing should be used.

C. Supplemental Horizontal Alignment Warning Signs

Supplemental horizontal alignment warning signs may be used to give notice of a sharp change in horizontal alignment. When used, they should be erected on the outside of the turn or on the far side of an intersection, in line with and at right angles to, approaching traffic.

i. Large Arrow Sign (W1-6)

The Large Arrow sign (W1-6R or W1-6L) may be used where a Turn sign is justified.

ii. Chevron Alignment Sign (W1-8)

Chevron Alignment signs should be installed as discussed in Section 2C.09 of the MUTCD.

iii. Curves/Mountain/Grades Sign

Roadway conditions in mountainous areas containing frequent curves and/or turns and gradients may require a signing supplement to describe approaching roadway conditions for a general section of roadway rather than a specific location. The Curves/Mountain/Grades sign may be used as a supplement to standard horizontal alignment warning signs under the following conditions:

- a. The Winding Road sign is being used to warn of a series of turns and/or curves, or

- a. The Winding Road sign is being used to warn of a series of turns and/or curves, or
- b. The Use Lower Gears sign is being used to warn of steep grades, or
- c. The roadway section containing frequent curves and/or turns and gradients has a minimum length of 5 miles.

Where the Curves/Mountain/Grades sign is used, it shall be supplemented with the Next ___ Miles plate. The and signing combination shall be installed for both directions in advance of the roadway section and may be repeated as deemed necessary within each section.

The Curve sign, Turn sign, or Large Arrow sign may be used to provide supplemental warning of a change in horizontal alignment when the alignment is not visible to the driver, such as a horizontal curve at or just beyond a vertical curve.

D. Advisory Speed Signs

Advisory speed values shall be in increments of five miles per hour. The minimum Advisory Speed sign shall be ten miles per hour. The Advisory Speed sign shall not exceed the speed limit.

i. Advisory Speed Plates (W13-1)

Advisory Speed plates (W13-1) should supplement Turn signs (W1-1R or W1-1L) and Curve signs (W1-2R or W1-2L). The advisory speed shall be determined by trial speed runs using a passenger car equipped with a ball bank indicator.

ii. Advisory Exit Speed Signs (W13-2)

The Advisory Exit Speed sign (W13-2) may be used on expressway and freeway off-ramps leading to a lower-type facility. The sign shall indicate the comfortable speed for that portion of the ramp from the painted gore to a point 1000 feet beyond the painted gore. Horizontal alignment warning signs for the first 1000 feet may be omitted. For curves and turns beyond the first 1000 feet of the ramp, horizontal alignment warning signs should be installed where justified.

iii. Advisory Ramp Speed Signs (W13-3)

The Advisory Ramp Speed sign (W13-3) should be used on direct ramp connections at the junction of two expressways or freeways where a normal exit ramp is not involved or at an entrance to an expressway or freeway from another high-type facility where an advisory speed sign is justified. The sign shall indicate the comfortable speed for that portion of the ramp from the painted gore to a point 1000 feet beyond the painted gore. Horizontal alignment warning signs for the first 1000 feet may be omitted. For curves and turns beyond the first 1000 feet of the ramp, horizontal alignment warning signs should be installed where justified.

321.2 UNPAVED ROADWAYS

Unpaved roads normally should not be speed zoned, due to the high potential for varying roadway conditions, nor should Advisory Speed plates (W13-1) be installed with Curve or Turn signs. However, a field investigation shall be conducted to determine an approximate "reasonable and prudent" speed for a section of highway. Using this as a guideline, sections of roadway shall be run at that particular speed. Using a combination of engineering judgment and present curve sign criteria, Curve (W1-2), Reverse Curve (W1-4), or Winding Road (W1-5) signs should be installed at those locations requiring a speed reduction of at least 5 mph below the estimated "speed limit". The Turn (W1-1) or Reverse Turn (W1-3) sign should be installed at locations where the safe speed is 30 mph or less. The Large Arrow (W1-6) or Chevron Alignment (W1-8) signs may be installed in conjunction with turn signs, if deemed necessary during the field review.