
321 HORIZONTAL ALIGNMENT WARNING SIGNS

Horizontal alignment warning signs should 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.

The use of horizontal alignment warning signs is based on ball bank indicator readings. Trial speed runs to determine comfortable speed are made using a passenger car equipped with a ball bank indicator to show the combined effect of vehicle body roll, centrifugal force, and 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 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, or until replaced with newer signing conforming to the above criteria.

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 the left and right-hand side of the roadway.

Horizontal alignment warning signs may also 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. Crash 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): This sign should be installed where the maximum comfortable speed on a turn is 30 miles per hour or less.
- ii. Curve Sign (W1-2): This sign 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): This sign 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): This sign should be installed where the combination curve consists of two curves in opposite directions.
- iii. Winding Road Sign (W1-5): This sign should be installed where the combination curve consists of a series of three or more curves or turns.
- iv. Hairpin Curve (W1-11) or 270 Degree Loop (W1-15) Sign: These signs may be installed where a turn or a combination curve consisting of two turns or a curve and/or 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.

C. Supplemental Horizontal Alignment Warning Signs

Supplemental horizontal alignment warning signs such as the Large Arrow Sign (W1-6) or Chevron Alignment Sign (W1-8) may be used to give added notice of a sharp change in horizontal alignment. Where 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. If a single Large Arrow sign is used, it may be placed centered on the line of sight of traffic approaching the turn or curve to maximize its conspicuity and visibility.

The Warning Signs chapter of the MUTCD contains criteria for the optional, recommended, or mandatory use of these signs based on the difference between posted or 85th percentile speed and curve or turn advisory speeds.

Curves Mountain Grades Sign (W7-103)

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
- b. Hill signing 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 a W16-104P or W16-104aP Next ___ Miles plaque. Sign assemblies should be installed for both directions in advance of the roadway section and may be repeated as deemed necessary within each section.

A Curve, Turn, or Large Arrow sign may also 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 and Plaques

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.**

Advisory Speed Plaques (W13-1P): These may be used to supplement Turn or Curve signs, or other warning signs based on engineering judgment. **For turn and curve signs, the advisory speed shall be determined by trial speed runs using a passenger car equipped with a ball bank indicator.**

Advisory Exit and Ramp Speed Signs (W13-2, W13-3, W13-6, W13-7):
See TGP 327 for determination of advisory speeds for these ramps.

321.2 UNPAVED ROADWAYS

Unpaved roads having a gravel or dirt surface normally should not use Advisory Speed plaques with Curve or Turn signs. However, a field investigation may be conducted to determine an approximate “reasonable and prudent” speed for a section of highway. Using this as a guideline, sections of roadway may be run at that particular speed. Using a combination of engineering judgment and 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 “reasonable and prudent” speed. The Turn (W1-1) or Reverse Turn (W1-3) sign should be installed at locations where the estimated “reasonable and prudent” speed is 30 mph or less. Large Arrow (W1-6) or Chevron Alignment (W1-8) signs may be installed in conjunction with turn or curve signs based on the criteria in the Warning Signs chapter of the MUTCD.