2.2.5 Curbs and Sidewalks

The face of the curb is defined as the vertical or sloping surface on the roadway side of the curb. Horizontal measurements of roadway curbs are from the bottom of the face, or, in the case of stepped back curbs, from the bottom of the lower face. Maximum width of brush curbs, if used, shall be 9 inches.

Where curb and gutter sections are used on the roadway approach, at either or both ends of the bridge, the curb height on the bridge may equal or exceed the curb height on the roadway approach. Where no curbs are used on the roadway approaches, the height of the bridge curb above the roadway shall be not less than 8 inches, and preferably not more than 10 inches.

Where sidewalks are used for pedestrian traffic on urban expressways, they shall be separated from the bridge roadway by the use of a combination railing as shown in Figure 2.7.4B.

In those cases where a New Jersey type parapet or a curb is constructed on a bridge, particularly in urban areas that have curbs and gutters leading to a bridge, the same widths between curbs on the approach roadways will be maintained across the bridge structure. A parapet or other railing installed at or near the curb line shall have its ends properly flared, sloped, or shielded.

2.3 HIGHWAY CLEARANCES FOR BRIDGES

2.3.1 Width

The horizontal clearance shall be the clear width and the vertical clearance the clear height for the passage of vehicular traffic as shown in Figure 2.3.1.

The roadway width shall generally equal the width of the approach roadway section including shoulders. Where curbed roadway sections approach a structure, the same section shall be carried across the structure.

For Roadway Width requirements, see *Caltrans Highway Design Manual*, Index 208.1, 309.1, and Chapter 300.

2.3.2 Vertical Clearance

The provisions of Article 2.2.3 shall be used.

2.4 HIGHWAY CLEARANCES FOR UNDERPASSES

2.4.1 Width

The provisions of Article 2.3.1 shall be used.

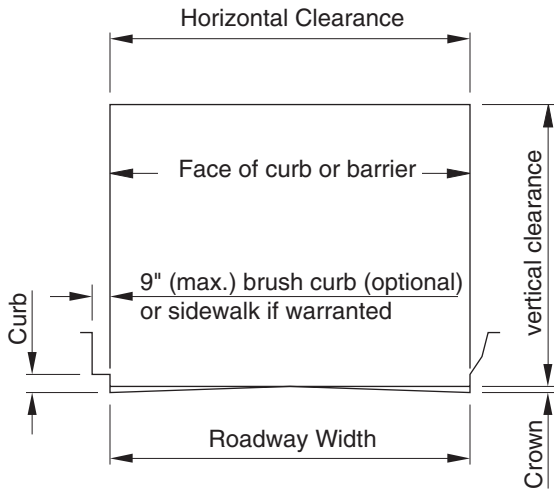


Figure 2.3.1 Clearance diagram for bridges.

2.4.2 Vertical Clearance

The provisions of Article 2.2.3 shall be used.

2.4.3 Curbs

Curbs, if used, shall match those of the approach roadway section.

2.5 HIGHWAY CLEARANCES FOR TUNNELS

2.5.1 Roadway Width

The provisions of Article 2.3.1 shall be used.

2.7 RAILINGS

Railings shall be provided along the edges of structures for protection of traffic and pedestrians. Other suitable applications may be warranted on bridge-length culverts as addressed in the 1989 AASHTO *Roadside Design Guide.*

Except on urban expressways, a pedestrian walkway may be separated from an adjacent roadway by a traffic railing or barrier with a pedestrian railing along the edge of the structure. On urban expressways, the separation shall be made by the use of a combination railing.

2.7.1 Vehicular Railing

2.7.1.1 General

2.7.1.1.1 Although the primary purpose of traffic railing is to contain the average vehicle using the structure, consideration should also be given to (a) protection of the occupants of a vehicle in collision with the railing, (b) protection of other vehicles near the collision, (c) protection of vehicles or pedestrians on roadways underneath the structure, and (d) appearance and freedom of view from passing vehicles.

2.7.1.1.2 Materials for traffic railings shall be concrete, metal, timber, or a combination thereof. Metal materials with less than 10 percent tested elongation shall not be used.

2.7.1.1.3 Traffic railings should provide a smooth continuous face of rail on the traffic side with the posts set back from the face of rail. Structural continuity in the rail members, including anchorage of ends, is essential. The railing system shall be able to resist the applied loads at all locations.

2.7.1.1.4 Protrusions or depressions at rail joints shall be acceptable provided their thickness or depth is no greater than the wall thickness of the rail member or 3/8 inch, whichever is less.

2.7.1.1.5 Careful attention shall be given to the treatment of railings at the bridge ends. Exposed rail ends, posts, and sharp changes in the geometry of the railing shall be avoided. A smooth transition by means of a continuation of the bridge barrier, guardrail anchored to the bridge end, or other effective means shall be provided to protect the traffic from direct collision with the bridge rail ends.

2.7.1.2 Geometry

2.7.1.2.1 The heights of rails shall be measured relative to the reference surface which shall be the top of the roadway, the top of the future overlay if resurfacing is anticipated, or the top of curb when the curb projection is greater than 9 inches from the traffic face of the railing.

2.7.1.2.2 Traffic railings and traffic portions of combination railings shall not be less than 2 feet 3 inches from the top of the reference surface. Parapets designed with sloping traffic faces intended to allow vehicles to ride up them under low angle contacts shall be at least 2 feet 8 inches in height.

2.7.1.2.3 The lower element of a traffic or combination railing should consist of either a parapet projecting at least 18 inches above the reference surface or a rail centered between 15 and 20 inches above the reference surface.

2.7.1.2.4 For traffic railings, the maximum clear opening below the bottom rail shall not exceed 17 inches and the maximum opening between succeeding rails shall not exceed 15 inches. For combination railings, accommodating pedestrian or bicycle traffic, the maximum opening between railing members shall be governed by Articles 2.7.2.2.2 and 2.7.3.2.1 respectively.

2.7.1.2.5 The traffic faces of all traffic rails must be within 1 inch of a vertical plane through the traffic face of the rail closest to traffic.

2.7.1.3 Loads

2.7.1.3.1 When the height of the top of the top traffic rail exceeds 2 feet 9 inches, the total transverse load distributed to the traffic rails and posts shall be increased by the factor C. However, the maximum load applied to any one element need not exceed P, the transverse design load.

2.7.1.3.2 Rails whose traffic face is more than 1 inch behind a vertical plane through the face of the traffic rail closest to traffic or centered less than 15 inches above the reference surface shall not be considered to be traffic rails for the purpose of distributing P or CP, but may be considered in determining the maximum clear vertical opening, provided they are designed for a transverse loading equal to that applied to an adjacent traffic rail or P/2, whichever is less.

2.7.1.3.3 Transverse loads on posts, equal to P, or CP, shall be distributed as shown in Figure 2.7.4B. A load equal to one-half the transverse load on a post shall simultaneously be applied longitudinally, divided among

not more than four posts in a continuous rail length. Each traffic post shall also be designed to resist an independently applied inward load equal to one-fourth the outward transverse load.

2.7.1.3.4 The attachment of each rail required in a traffic or combination railing shall be designed to resist a vertical load equal to one-fourth of the transverse design load of the rail. The vertical load shall be applied alternately upward or downward. The attachment shall also be designed to resist an inward transverse load equal to one-fourth the transverse rail design load.

2.7.1.3.5 Rail members shall be designed for a moment, due to concentrated loads, at the center of the panel and at the posts of P′L/6 where L is the post spacing and P′ is equal to P, P/2, or P/3, as modified by the factor C where required. The handrail members of combination railings shall be designed for a moment at the center of the panel and at the posts of $0.1wL^2$.

2.7.1.3.6 The transverse force on concrete parapet and barrier walls shall be spread over a longitudinal length of 10 feet.

2.7.1.3.7 Railings other than those shown in Figure 2.7.4B are permissible provided they meet the requirements of this Article. Railing configurations that have been successfully tested by full scale impact tests are exempt from the provisions of the Article.

2.7.2 Bicycle Railing

2.7.2.1 General

2.7.2.1.1 Bicycle railing shall be used on bridges specifically designed to carry bicycle traffic, and on bridges where specific protection of bicyclists is deemed necessary.

2.7.2.1.2 Railing components shall be designed with consideration to safety, appearance, and when the bridge carries mixed traffic freedom of view from passing vehicles.

2.7.2.2 Geometry and Loads

2.7.2.2.1 The minimum height of a railing used to protect a bicyclist shall be 1.37 m (54 inches), measured from the top of the surface on which the bicycle rides to the top of the upper rail member.

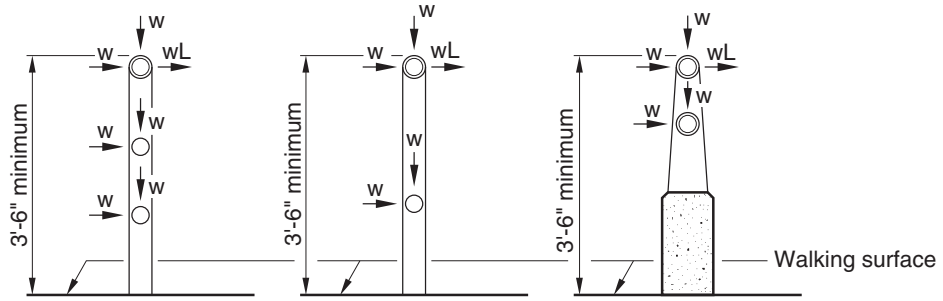
2.7.2.2.2 Within a band bordered by the bikeway surface and a line 27 inches above it, all elements of the railing assembly shall be spaced such that a 6-inch sphere will not pass through any opening. Within a band bordered by lines 27 and 54 inches, elements shall be spaced such that an 8-inch sphere will not pass through any opening. Chain link fence is exempt from the rail spacing requirements listed above. Rails should be flush or project beyond the face of posts and/or pickets. If not, post or picket protrusion will be accepted with a rubrail placed at 42 inches (1060 mm) measured from the top of the riding surface.

2.7.2.2.3 The minimum design loadings for bicycle railing shall be w = 50 pounds per linear foot transversely and vertically, acting simultaneously on each rail.

2.7.2.2.4 Design loads for rails located more than 54 inches above the riding surface shall be determined by the designer.

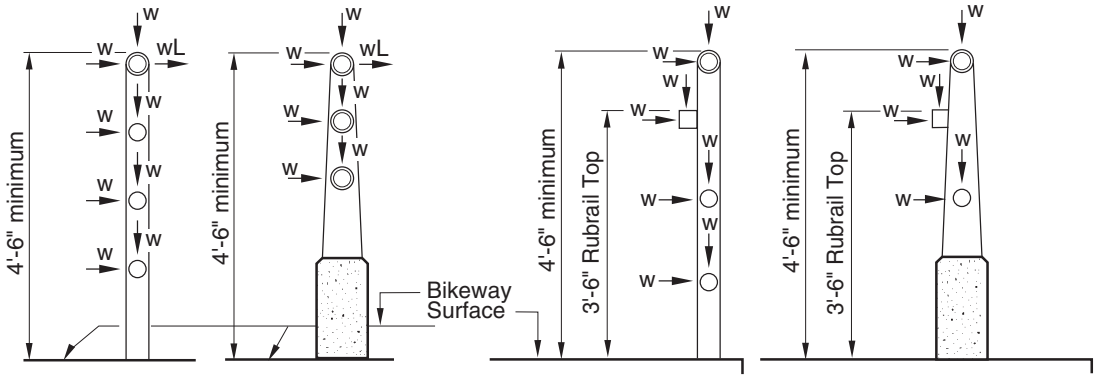
2.7.2.2.5 Posts shall be designed for a transverse load of wL (where L is the post spacing) acting at the center of gravity of the upper rail, but at a height not greater than 54 inches.

2.7.2.2.6 Refer to Figures 2.7.4A and 2.7.4B for more information concerning the application of loads.



(To be used adjacent to a sidewalk when highway traffic is seperate from pedestrian traffic by a traffic railing.)

PEDESTRIAN RAILING



BICYCLE RAILING

Note:
If screening or solid face is presented, number of rails may be reduced; wind loads must be added if solid face is utilized.

Notes:
1. Loadings on left are applied to rails.
2. Loads on right are applied to posts.
3. The shapes of rail members are illustrative only. Any material or combination of materials listed in Article 2.7 may be used in any configuration.
4. The spacings illustrated are maximum values. Rail elements spacings shall conform to Articles 2.7.2.2.2 and 2.7.3.2.1

Nomenclature:
w = Pedestrian or bicycle loading per unit length of rail
L = Post spacing

Figure 2.7.4A Pedestrian Railing, Bicycle Railing

2.7.3 Pedestrian Railing

2.7.3.1 General

2.7.3.1.1 Railing components shall be proportioned commensurate with the type and volume of anticipated pedestrian traffic. Consideration should be given to appearance, safety and freedom of view from passing vehicles.

2.7.3.1.2 Materials for pedestrian railing may be concrete, metal, timber, or a combination thereof.

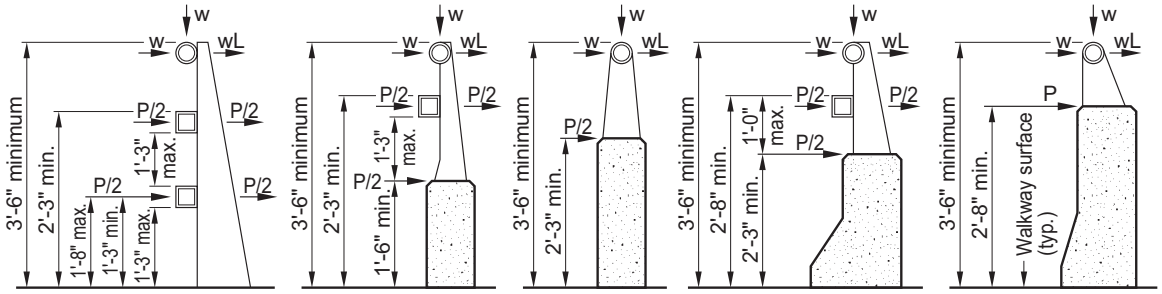
2.7.3.2 Geometry and Loads

2.7.3.2.1 The minimum height of a pedestrian railing shall be 42 inches measured from the top of the walkway to the top of the upper rail member. Within a band bordered by the walkway surface and a line 27 inches above it, all elements of the railing assembly shall be spaced such that a 6-inch sphere will not pass through any opening. For elements between 27 and 42 inches above the walking surface, elements shall be spaced such that an 8-inch sphere will not pass through any opening.

2.7.3.2.2 The minimum design loading for pedestrian railing shall be w = 50 pounds per linear foot, transversely and vertically, acting simultaneously on each longitudinal member. Rail members located more than 5 feet 0 inches above the walkway are excluded from these requirements.

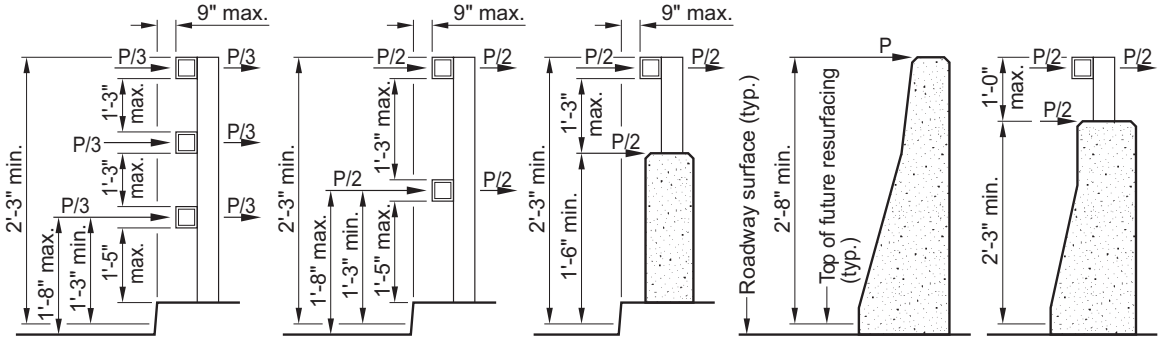
2.7.3.2.3 Posts shall be designed for a transverse load of wL (where L is the post spacing) acting at the center of gravity of the upper rail or, for high rails, at 5 feet 0 inches maximum above the walkway.

2.7.3.2.4 Refer to Figures 2.7.4A and 2.7.4B for more information concerning the application of loads.



(To be used when curb projects more than 9" from the traffic face of railing.)

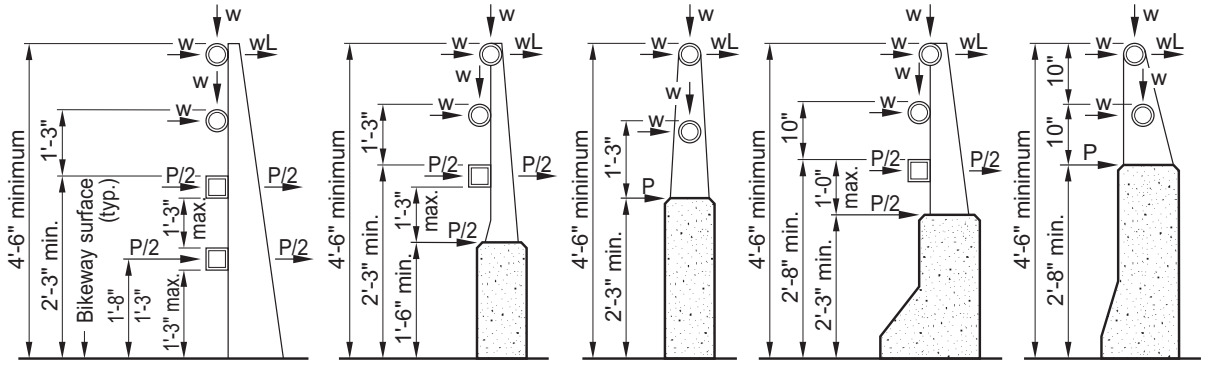
COMBINATION TRAFFIC AND PEDESTRIAN RAILING



(To be used where there is no curb or curb project 9" or less from traffic face of railing.)

TRAFFIC RAILING

Figure 2.7.4B Traffic Railing



COMBINATION TRAFFIC AND PEDESTRIAN RAILING

Notes:
1. Loadings on left are applied to rails.
2. Loads on right are applied to posts.
3. The shapes of rail members are illustrative only. Any material or combination of materials listed in Article 2.7 may be used in any configuration.
4. The spacings illustrated are maximum values. Rail elements spacings shall conform to Article 2.7.1.2.4.

Nomenclature:
P = Highway design loading = 54 kips
h = Height of top of top rail above reference surface (in.)
L = Post spacing (ft.)
w = Pedestrian or bicycle loading per unit length of rail

$$C = 1 + \frac{h - 33}{18} \geq 1$$

Figure 2.7.4B (continued)

2.7.4 Structural Specifications and Guidelines

2.7.4.1 Railings shall be designed by the elastic method to the allowable stresses for the appropriate material.

For aluminum alloys the design stresses given in the *"Specifications for Aluminum Structures"* Fifth Edition, December 1986, for *"Bridge and Similar Type Structures"* published by the Aluminum Association, Inc. for alloys 6061-T6 (Table A.6), 6351-T5 (Table A.6) and 6063-T6 (Table A.6) shall apply, and for cast aluminum alloys the design stresses given for alloys A444.0-T4 (Table A.9), A356.0-T61 (Table A.9) and A356.0-T6 (Table A.9) shall apply.

For fabrication and welding of aluminum railing see Article 11.5.

2.7.4.2 The allowable unit stresses for steel shall be as given in Article 10.32, except as modified below.

For steels not generally covered by the "Standard Specifications," but having a guaranteed yield strength, F_y, the allowable unit stress, shall be derived by applying the general formulas as given in the "Standard Specifications" under "Unit Stresses" except as indicated below.

The allowable unit stress for shear shall be $F_v = 0.33F_y$.

Round or oval steel tubes may be proportioned using an allowable bending stress, $F_b = 0.66F_y$, provided the R/t ratio (radius/thickness) is less than or equal to 40.

Square and rectangular steel tubes and steel W and I sections in bending with tension and compression on extreme fibers of laterally supported compact sections having an axis of symmetry in the plane of loading may be designed for an allowable stress $F_b = 0.60F_y$.

2.7.4.3 The requirements for a compact section are as follows:

(a) The width to thickness ration of projecting elements of the compression flange of W and I sections shall not exceed

$$\frac{b}{t} \leq \frac{1{,}600}{\sqrt{F_y}} \qquad (2\text{-}1)$$

(b) the width to thickness ratio of the compression flange of square or rectangular tubes shall not exceed

$$\frac{b}{t} \leq \frac{6{,}000}{\sqrt{F_y}} \qquad (2\text{-}2)$$

(c) The D/t ratio of webs shall not exceed

$$\frac{D}{t} \leq \frac{13{,}000}{\sqrt{F_y}} \qquad (2\text{-}3)$$

(d) If subject to combined axial force and bending, the D/t ratio of webs shall not exceed

$$\frac{D}{t} \leq \frac{13{,}300\left[1 - 1.43\left(\frac{f_a}{F_a}\right)\right]}{\sqrt{F_y}} \qquad (2\text{-}4)$$

but need not be less than

$$\frac{D}{t} \leq \frac{7{,}000}{\sqrt{F_y}} \qquad (2\text{-}5)$$

(e) The distance between lateral supports in inches of W or I sections shall not exceed

$$\leq \frac{2{,}400b}{\sqrt{F_y}} \qquad (2\text{-}6)$$

or

$$\leq \frac{20{,}000{,}000A_f}{dF_y} \qquad (2\text{-}7)$$