

CHAPTER 1000 – BICYCLE TRANSPORTATION DESIGN

Topic 1001 – Introduction

Index 1001.1 – Bicycle Transportation

The needs of nonmotorized transportation are an essential part of all highway projects. Mobility for all travel modes is recognized as an integral element of the transportation system. Therefore, the guidance provided in this manual complies with Director’s Policy 37 “Complete Streets” (DP-37). See AASHTO, “Guide for the Development of Bicycle Facilities” for supplemental guidance.

Design guidance for Class I bikeways (bike paths), Class III bikeways (bike routes), and Trails are provided in this chapter. Design guidance that addresses the mobility needs of bicyclists on all roads as well as on Class II bikeways (bike lanes) is distributed throughout this manual where appropriate. Design guidance for Class IV bikeways (separated bikeways) is provided in DIB 89. The AASHTO Guide for the Development of Bicycle Facilities also provides additional bikeway guidance not included in this chapter. In addition, bikeway publications and manuals developed by organizations other than FHWA and AASHTO also provide guidance not covered in this manual.

See Topic 116 for guidance regarding bikes on freeways.

1001.2 Streets and Highways Code References

The Streets and Highways Code Section 890.4 defines a “bikeway” as a facility that is provided primarily for bicycle travel. Following are other related definitions, found in Chapter 8 Nonmotorized Transportation, from the Streets and Highway Code:

- (a) Section 887 – Definition of nonmotorized facility.
- (b) Section 887.6 – Agreements with local agencies to construct and maintain nonmotorized facilities.
- (c) Section 887.8 – Payment for construction and maintenance of nonmotorized facilities approximately paralleling State highways.
- (d) Section 888 – Severance of existing major non- motorized route by freeway construction.
- (e) Section 888.2 – Incorporation of nonmotorized facilities in the design of freeways.
- (f) Section 888.4 – Requires Caltrans to budget not less than \$360,000 annually for nonmotorized facilities used in conjunction with the State highway system.
- (g) Section 890.4 – Class I, II, III, and cycle tracks or separated bikeway definitions.

- (h) Section 890.6 - 890.8 – Caltrans and local agencies to develop design criteria and symbols for signs, markers, and traffic control devices for bikeways and roadways where bicycle travel is permitted.
- (i) Section 891 – Local agencies must comply with design criteria and uniform symbols.
- (j) Section 891.9 – Prohibits the installation of a new Shared Lane Marking for the development or operation of bikeways or highways with a posted speed limit greater than 30 mph, except at or near an intersection for the purpose of connecting a Class I, Class II, or Class IV bikeway through the intersection.
- (k) Section 892 – Use of abandoned right-of-way as a nonmotorized facility.

1001.3 Vehicle Code References

- (a) Section 21200 – Bicyclist's rights and responsibilities for traveling on highways.
- (b) Section 21202 – Bicyclist's position on roadways when traveling slower than the normal traffic speed.
- (c) Section 21206 – Allows local agencies to regulate operation of bicycles on pedestrian or bicycle facilities.
- (d) Section 21207 – Allows local agencies to establish bike lanes on non-State highways.
- (e) Section 21207.5 – Prohibits motorized bicycles on bike paths or bike lanes.
- (f) Section 21208 – Specifies permitted movements by bicyclists from bike lanes.
- (g) Section 21209 – Specifies permitted movements by vehicles in bike lanes.
- (h) Section 21210 – Prohibits bicycle parking on sidewalks unless pedestrians have an adequate path.
- (i) Section 21211 – Prohibits impeding or obstruction of bicyclists on bike paths.
- (j) Section 21400 – Adopt rules and regulations for signs, markings, and traffic control devices for roadways user.
- (k) Section 21401 – Only those official traffic control devices that conform to the uniform standards and specifications promulgated by the Department of Transportation shall be placed upon a street or highway.
- (l) Section 21717 – Requires a motorist to drive in a bike lane prior to making a turn.
- (m) Section 21960 – Use of freeways by bicyclists.
- (n) Section 21966 – No pedestrian shall proceed along a bicycle path or lane where there is an adjacent adequate pedestrian facility.

1001.4 Bikeways

- (1) *Role of Bikeways.* Bikeways are one element of an effort to improve bicycling safety and convenience - either to help accommodate motor vehicle and bicycle traffic on the roadway system, or as a complement to the road system to meet the needs of the bicyclist.

Off-street bikeways in exclusive corridors can be effective in providing new recreational opportunities, and desirable transportation/commuter routes. Off-street bikeways can also provide access with bridges and tunnels which cross barriers to bicycle travel (e.g., freeway or river crossing). Likewise, on-street bikeways can serve to enhance safety and convenience, especially if other commitments are made in conjunction with establishment of bikeways, such as: elimination of parking or increased roadway width, elimination of surface irregularities and roadway obstacles, frequent street sweeping, established intersection priority on the bike route street as compared with the majority of cross streets, and installation of bicycle-sensitive loop detectors at signalized intersections.

- (2) *Decision to Develop Bikeways.* Providing an interconnected network of bikeways will improve safety for all users and access for bicycles. The development of well conceived bikeways can have a positive effect on bicyclist and motorist behavior. In addition, providing an interconnected network of bikeways along with education and enforcement can improve safety and access for bicyclists. The decision to develop bikeways should be made in coordination with the local agencies.

Topic 1002 – Bikeway Facilities

1002.1 Selection of the Type of Facility

The type of facility to select in meeting the bicyclist's need is dependent on many factors, but the following applications are the most common for each type.

- (1) *Shared Roadway (No Bikeway Designation).* Most bicycle travel in the State now occurs on streets and highways without bikeway designations and this may continue to be true in the future as well. In some instances, entire street systems may be fully adequate for safe and efficient bicycle travel, where signing and pavement marking for bicycle use may be unnecessary. In other cases, prior to designation as a bikeway, routes may need improvements for bicycle travel.

Many rural highways are used by touring bicyclists for intercity and recreational travel. It might be inappropriate to designate the highways as bikeways because of the limited use and the lack of continuity with other bike routes. However, the development and maintenance of 4-foot paved roadway shoulders with a standard 4 inch edge line can significantly improve the safety and convenience for bicyclists and motorists along such routes.

- (2) *Class I Bikeway (Bike Path).* Generally, bike paths should be used to serve corridors not served by streets and highways or where wide right of way exists, permitting such facilities to be constructed away from the influence of parallel streets. Bike paths should offer opportunities not provided by the road system. They can either provide a recreational opportunity, or in some instances, can serve as direct high-speed commute routes if cross flow by motor vehicles and pedestrian conflicts can be minimized. The most common applications are along rivers, ocean fronts, canals, utility right of way, abandoned railroad right of way, within school campuses, or within and between parks. There may also be situations where such facilities can be provided as part of planned developments. Another common application of Class I facilities is to close gaps to bicycle travel caused

by construction of freeways or because of the existence of natural barriers (rivers, mountains, etc.).

(3) *Class II Bikeway (Bike Lane)*. Bike lanes are established along streets in corridors where there is significant bicycle demand, and where there are distinct needs that can be served by them. The purpose should be to improve conditions for bicyclists in the corridors. Bike lanes are intended to delineate the right of way assigned to bicyclists and motorists and to provide for more predictable movements by each. But a more important reason for constructing bike lanes is to better accommodate bicyclists through corridors where insufficient room exists for side-by-side sharing of existing streets by motorists and bicyclists. This can be accomplished by reducing the number of lanes, reducing lane width, or prohibiting or reconfiguring parking on given streets in order to delineate bike lanes. In addition, other things can be done on bike lane streets to improve the situation for bicyclists that might not be possible on all streets (e.g., improvements to the surface, augmented sweeping programs, special signal facilities, etc.). Generally, pavement markings alone will not measurably enhance bicycling.

If bicycle travel is to be provided by delineation, attention should be made to assure that high levels of service are provided with these lanes. It is important to meet bicyclist expectations and increase bicyclist perception of service quality, where capacity analysis demonstrates service quality measures are improved from the bicyclist's point of view.

Design guidance that addresses the mobility needs of bicyclists on Class II bikeways (bike lanes) is also distributed throughout this manual where appropriate.

(4) *Class III Bikeway (Bike Route)*. Bike routes are shared facilities which serve either to:

- (a) Provide continuity to other bicycle facilities (usually Class II bikeways); or
- (b) Designate preferred routes through high demand corridors.

As with bike lanes, designation of bike routes should indicate to bicyclists that there are particular advantages to using these routes as compared with alternative routes. This means that responsible agencies have taken actions to assure that these routes are suitable as shared routes and will be maintained in a manner consistent with the needs of bicyclists. Normally, bike routes are shared with motor vehicles. The use of sidewalks as Class III bikeways is strongly discouraged. For Class III guidance, see Index 1003.3.

(5) *Class IV Bikeway (Separated Bikeway)*. See DIB 89 for guidance.

A Class IV bikeway (separated bikeway) is a bikeway for the exclusive use of bicycles and includes a separation required between the separated bikeway and the through vehicular traffic. The separation may include, but is not limited to, grade separation, flexible posts, inflexible posts, inflexible barriers, or on-street parking. See DIB 89 for further Class IV guidance.

It is emphasized that the designation of bikeways as Class I, II, III, and IV should not be construed as a hierarchy of bikeways; that one is better than the other. Each class of bikeway has its appropriate application.

In selecting the proper facility, an overriding concern is to assure that the proposed facility will not encourage or require bicyclists or motorists to operate in a manner that is inconsistent with the rules of the road.

An important consideration in selecting the type of facility is continuity. Alternating segments of Class I to Class II (or Class III) bikeways along a route are generally incompatible, as street crossings by bicyclists is required when the route changes character. Also, wrong-way bicycle travel will occur on the street beyond the ends of bike paths because of the inconvenience of having to cross the street. However, alternating from Class IV to Class II may be appropriate due to the presence of many driveways or turning movements. The highway context or community setting may also influence the need to alternate bikeway classifications.

Topic 1003 – Bikeway Design Criteria

1003.1 Class I Bikeways (Bike Paths)

Class I bikeways (bike paths) are facilities with exclusive right of way, with cross flows by vehicles minimized. Motor vehicles are prohibited from bike paths per the CVC, which can be reinforced by signing. Class I bikeways, unless adjacent to an adequate pedestrian facility, (see Index 1001.3(n)) are for the exclusive use of bicycles and pedestrians, therefore any facility serving pedestrians must meet accessibility requirements, see DIB 82. However, experience has shown that if regular pedestrian use is anticipated, separate facilities for pedestrians maybe beneficial to minimize conflicts. Please note, sidewalks are not Class I bikeways because they are primarily intended to serve pedestrians, generally cannot meet the design standards for Class I bikeways, and do not minimize vehicle cross flows. See Index 1003.3 for discussion of the issues associated with sidewalk bikeways.

(1) *Widths and Cross Slopes.* See Figure 1003.1A for two-way Class I bikeway (bike path) width, cross slope, and side slope details. The term “shoulder” as used in the context of a bike path is an unobstructed all weather surface on each side of a bike path with similar functionality as shoulders on roadways with the exception that motor vehicle parking and use is not allowed. The shoulder area is not considered part of the bike path traveled way.

Experience has shown that paved paths less than 12 feet wide can break up along the edge as a result of loads from maintenance vehicles.

(a) **Traveled Way.** **The minimum paved width of travel way for a two-way bike path shall be 8 feet**, 10-foot preferred. **The minimum paved width for a one-way bike path shall be 5 feet.** It should be assumed that bike paths will be used for two-way travel. Development of a one-way bike path should be undertaken only in rare situations where there is a need for only one-direction of travel. Two-way use of bike paths designed for one-way travel increases the risk of head-on collisions, as it is difficult to enforce one-way operation. This is not meant to apply to two one-way bike paths that are parallel and adjacent to each other within a wide right of way.

Where heavy bicycle volumes are anticipated and/or significant pedestrian traffic is expected, the paved width of a two-way bike path should be greater than 10 feet, preferably 12 feet or more. Another important factor to consider in determining the appropriate width is that bicyclists will tend to ride side by side on bike paths, and bicyclists may need adequate passing clearance next to pedestrians and slower moving bicyclists.

See Index 1003.1(16) Drainage, for cross slope information.

- (b) Shoulder. **A minimum 2-foot wide shoulder, composed of the same pavement material as the bike path or all weather surface material that is free of vegetation, shall be provided adjacent to the traveled way of the bike path when not on a structure;** see Figure 1003.1A. A shoulder width of 3 feet should be provided where feasible. A wider shoulder can reduce bicycle conflicts with pedestrians. Where the paved bike path width is wider than the minimum required, the unpaved shoulder area may be reduced proportionately. If all or part of the shoulder is paved with the same material as the bike path, it is to be delineated from the traveled way of the bike path with an edgeline.

See Index 1003.1(16), Drainage, for cross slope information.

- (2) *Bike Path Separation from a Pedestrian Walkway.* The CVC requires a pedestrian to use a pedestrian facility when adjacent to a bike path. Thus, the bike path would be only for bicycles if there is an adjacent pedestrian facility. This may be either immediately adjacent or with a separation between the pedestrian facility and the bike path. The separation may be—but not limited to—fences, railings, solid walls, or landscaping. If a separation is used, it should not obstruct stopping sight distance along curves or corner sight distance at intersections with roadways or other paths.

- (3) *Clearance to Obstructions.* **A minimum 2-foot horizontal clearance from the paved edge of a bike path to obstructions shall be provided.** See Figure 1003.1A. 3 feet should be provided. Adequate clearance from fixed objects is needed regardless of the paved width. If a path is paved contiguous with a continuous fixed object (e.g., fence, wall, and building), a 4-inch white edge line, 2 feet from the fixed object, is recommended to minimize the likelihood of a bicyclist hitting it. **The clear width of a bicycle path on structures between railings shall be not less than 10 feet.** It is desirable that the clear width of structures be equal to the minimum clear width of the path plus shoulders (i.e., 14 feet).

The vertical clearance to obstructions across the width of a bike path shall be a minimum of 8 feet and 7 feet over shoulder. Where practical, a vertical clearance of 10 feet is desirable.

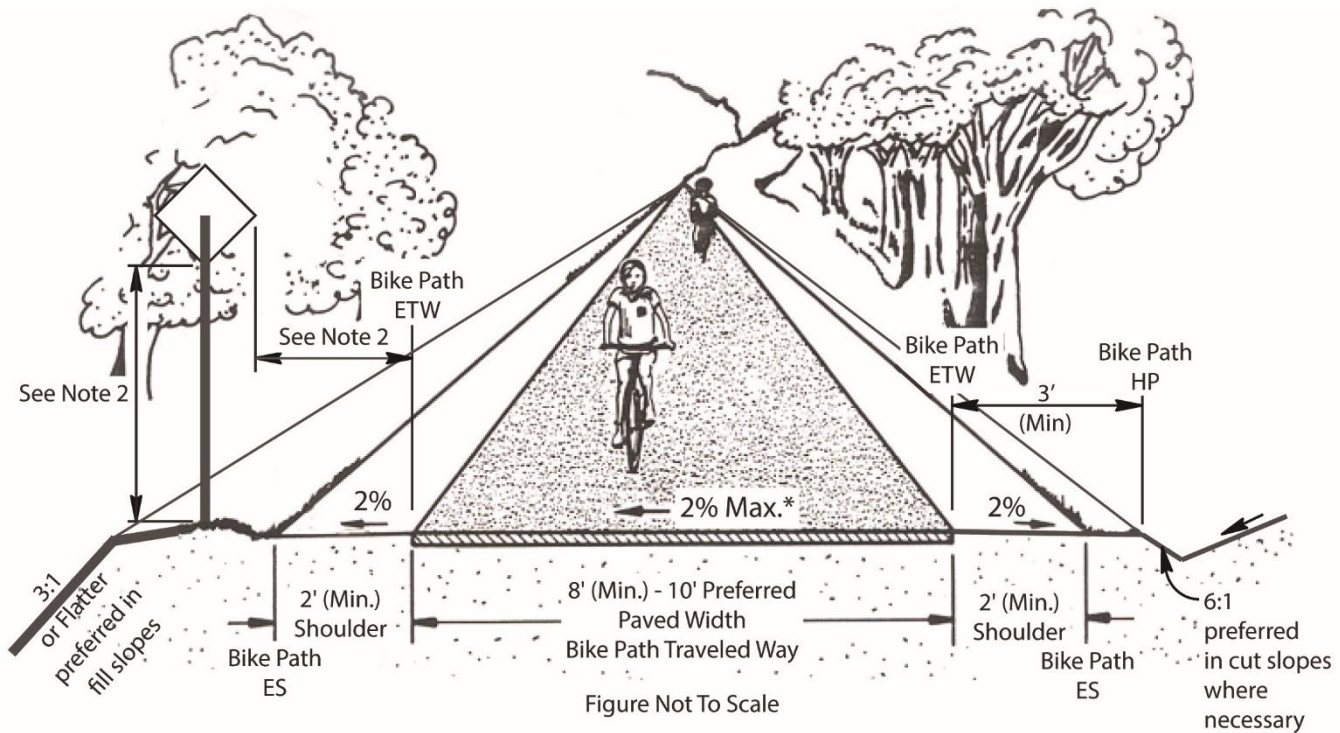
- (4) *Signing and Delineation.* For application and placement of signs, see the California MUTCD, Section 9B. For pavement marking guidance, see the California MUTCD, Section 9C.

- (5) *Intersections with Highways.* Intersections are an important consideration in bike path design. Bicycle path intersection design should address both cross-traffic and turning movements. If alternate locations for a bike path are available, the one with the most beneficial intersection characteristics should be selected.

Where motor vehicle cross traffic and bicycle traffic is heavy, grade separations are desirable to eliminate intersection conflicts. Where grade separations are not feasible, assignment of right of way by traffic signals should be considered. Where traffic is not

Figure 1003.1A

Two-Way Class I Bikeway (Bike Path)



NOTES:

- (1) See Index 1003.1(15) for pavement structure guidance of bike path.
- (2) For sign clearances, see California MUTCD, Figure 9B-1. Also, for clearance over the shoulder see Index 1003.1(3).
- (3) The AASHTO Guide for the Development of Bicycle Facilities provides detailed guidance for creating a forgiving Class I bikeway environment.

*1% cross-slope minimum.

heavy, "STOP" or "YIELD" signs for either the path or the cross street (depending on volumes) may suffice.

Bicycle path intersections and their approaches should be on relatively flat grades. Stopping sight distances at intersections should be checked and adequate warning should be given to permit bicyclists to stop before reaching the intersection, especially on downgrades. When contemplating the placement of signs the designer is to discuss the proposed sign details with their District Traffic Safety Engineer or designee so that conflicts may be minimized. Bicycle versus motor vehicle collisions may occur more often at intersections, where bicyclists misuse pedestrian crosswalks; thus, this should be avoided.

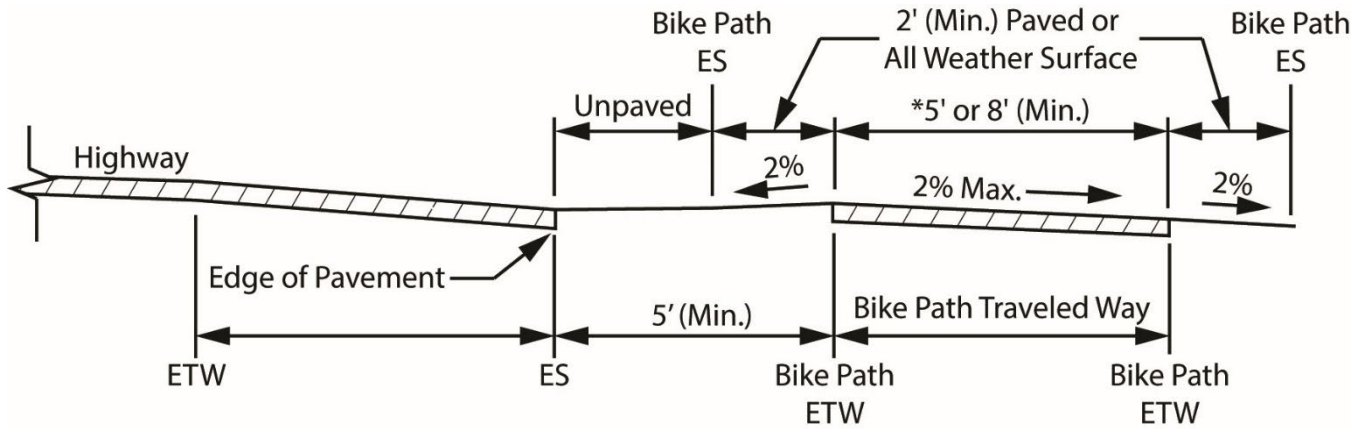
When crossing an arterial street, the crossing should either occur at the pedestrian crossing, where vehicles can be expected to stop, or at a location completely out of the influence of any intersection to permit adequate opportunity for bicyclists to see turning vehicles. When crossing at midblock locations, right of way should be assigned by devices such as "YIELD" signs, "STOP" signs, or traffic signals which can be activated by bicyclists. Even when crossing within or adjacent to the pedestrian crossing, "STOP" or "YIELD" signs for bicyclists should be placed to minimize potential for conflict resulting from turning autos. Where bike path "STOP" or "YIELD" signs are visible to approaching motor vehicle traffic, they should be shielded to avoid confusion. In some cases, Bike Xing signs may be placed in advance of the crossing to alert motorists. Ramps should be installed in the curbs, to preserve the utility of the bike path. Ramps should be the same width as the bicycle paths. Curb cuts and ramps should provide a smooth transition between the bicycle paths and the roadway.

Assignment of rights of way is necessary where bicycle paths intersect roadways or other bicycle paths. See the California MUTCD, Section 9B.03 and Figure 9B-7 for guidance on signals and signs for rights of way assignment at bicycle path intersections.

- (6) *Paving at Crossings.* At unpaved roadway or driveway crossings, including bike paths or pedestrian walkways, the crossing roadway or driveway shall be paved a minimum of 15 feet to minimize or eliminate gravel intrusion on the path. The pavement structure at the crossing should be adequate to sustain the expected loading at that location
- (7) *Bike Paths Parallel and Adjacent to Streets and Highways.* A wide separation is recommended between bike paths and adjacent highways (see Figure 1003.1B). **The minimum separation between the edge of traveled way of a one-way or a two-way bicycle path and the edge of traveled way of a parallel road or street shall be 5 feet plus the standard shoulder width. Bike paths within the clear recovery zone of freeways shall include a physical barrier separation.** The separation is unpaved and does not include curbs or sidewalks. Separations less than 10 feet from the edge of the shoulder are to include landscaping or other features that provide a continuous barrier to prevent bicyclists from encroaching onto the highway. Suitable barriers may include fences or dense shrubs if design speeds are less than or equal to 45 miles per hour. Obstacles low to the ground or intermittent obstacles (e.g., curbs, dikes, raised traffic bars, posts connected by cable or wire, flexible channelizers, etc.) are not to be used because bicyclists could fall over these obstacles and into the roadway.

Figure 1003.1B

Typical Cross Section of Class I Bikeway (Bike Path) Parallel to Highway



NOTE:

(1) See Index 1003.1(6) for guidance on separation between bike paths and highways.

*One-Way: 5' Minimum Width

Two-Way: 8' Minimum Width

Bike paths immediately adjacent to streets and highways are not recommended. While they can provide separation between vehicles and nonmotorized traffic, they typically introduce significant conflicts at intersections. In addition, they can create conflicts with passengers at public transit facilities, and with vehicle occupants crossing the path. They are not a substitute for designing the road to meet bicyclist's mobility needs. Use of bicycle paths adjacent to roads is not mandatory in California, and many bicyclists will perceive these paths as offering a lower level of mobility compared with traveling on the road, particularly for utility trips. Careful consideration regarding how to address the above points needs to be weighed against the perceived benefits of providing a bike path adjacent to a street or highway. Factors such as urban density, the number of conflict points, the presence or absence of a sidewalk, speed and volume should be considered.

(8) *Bike Paths in the Median of Highway or Roadway.* Bike paths should not be placed in the median of a State highway or local road, and shall not be in the median of a freeway or expressway. Bike paths in the median are generally not recommended because they may require movements contrary to normal rules of the road. Specific problems with such facilities may include:

- (a) Right-turns by bicyclists from the median of roadways are unexpected by motorists.
- (b) Devoting separate phases to bicyclist movements to and from a median path at signalized intersections increases intersection delay.
- (c) Left-turning motorists must cross one direction of motor vehicle traffic and two directions of bicycle traffic, which may increase conflicts.
- (d) Where intersections are infrequent, bicyclists may choose to enter or exit bike paths at midblock.
- (e) Where medians are landscaped, visibility between bicyclists on the path and motorists at intersections may be diminished. See Chapter 900 for planting guidance.

(9) *Bicycle Path Design Speed.* The design speed of bicycle paths is established using the same principles as those applied to highway design speeds. **The design speed given in Table 1003.1 shall be the minimum.**

Installation of "speed bumps", gates, obstacles, posts, fences or other similar features intended to cause bicyclists to slow down are not to be used.

(10) *Horizontal Alignment and Superelevation.* The minimum radius of curvature negotiable by a bicycle is a function of the superelevation of the bicycle path surface, the coefficient of friction between the bicycle tires and the bicycle path surface, and the speed of the bicycle.

For all bicycle path applications the maximum superelevation rate is 2 percent.

The minimum radius of curvature should be 90 feet for 20 miles per hour, 160 feet for 25 mile per hour and 260 feet for 30 miles per hour. No superelevation is needed for radius of curvature meeting or exceeding 100 feet for 20 miles per hour, 180 feet for 25 miles per hour, and 320 feet for 30 miles per hour. When curve radii smaller than those given because of right of way, topographical or other considerations, standard curve warning signs and supplemental pavement markings should be installed. The negative

Table 1003.1

Bike Path Design Speeds

Type of Facility	Design Speed (mph) ⁽¹⁾
Bike Paths with Mopeds Prohibited	20
Bike Paths with Mopeds Permitted	30
Bike Paths on Long Downgrades (steeper than 4%, and longer than 500')	30

NOTE:

⁽¹⁾On bike paths with mopeds prohibited, a lower design speed can be used for the crest vertical curve, equivalent to 1 mile per hour per percent grade for grades exceeding a vertical rise of 10 feet, when at a crest in path.

effects of nonstandard curves can also be partially offset by widening the pavement through the curves.

(11)*Stopping Sight Distance.* To provide bicyclists with an opportunity to see and react to the unexpected, a bicycle path should be designed with adequate stopping sight distances. **The minimum stopping sight distance based on design speed shall be 125 feet for 20 miles per hour, 175 feet for 25 miles per hour and 230 feet for 30 miles per hour.** The distance required to bring a bicycle to a full controlled stop is a function of the bicyclist's perception and brake reaction time, the initial speed of the bicycle, the coefficient of friction between the tires and the pavement, and the braking ability of the bicycle.

Stopping sight distance is measured from a bicyclist's eyes, which are assumed to be 4 ½ feet above the pavement surface to an object ½-foot high on the pavement surface.

(12)*Length of Crest Vertical Curves.* Figure 1003.1C indicates the minimum lengths of crest vertical curves for varying design speeds.

(13)*Lateral Clearance on Horizontal Curves.* Figure 1003.1D indicates the minimum clearances to line of sight obstructions, *m*, for horizontal curves. It is assumed that the bicyclist's eyes are 4 ½ feet above the pavement surface to an object ½-foot high on the pavement surface.

Bicyclists frequently ride abreast of each other on bicycle paths, and on narrow bicycle paths, bicyclists have a tendency to ride near the middle of the path. For these reasons, lateral clearances on horizontal curves should be calculated based on the sum of the stopping sight distances for bicyclists traveling in opposite directions around the curve. Where this is not possible or feasible, the following or combination thereof should be

Figure 1003.1C

Minimum Length of Bicycle Path Crest Vertical Curve (L) Based on Stopping Sight Distance (S)

$$L = 2S - \frac{1600}{A} \quad \text{when } S > L$$

$$L = \frac{AS^2}{1600} \quad \text{when } S < L$$

Double line represents S = L

L = Minimum length of vertical curve – feet

A = Algebraic grade difference – %

S = Stopping sight distance – feet

Refer to Index 1003.1(11) to determine “S”, for a given design speed “V”

Height of cyclist eye = 4½ feet

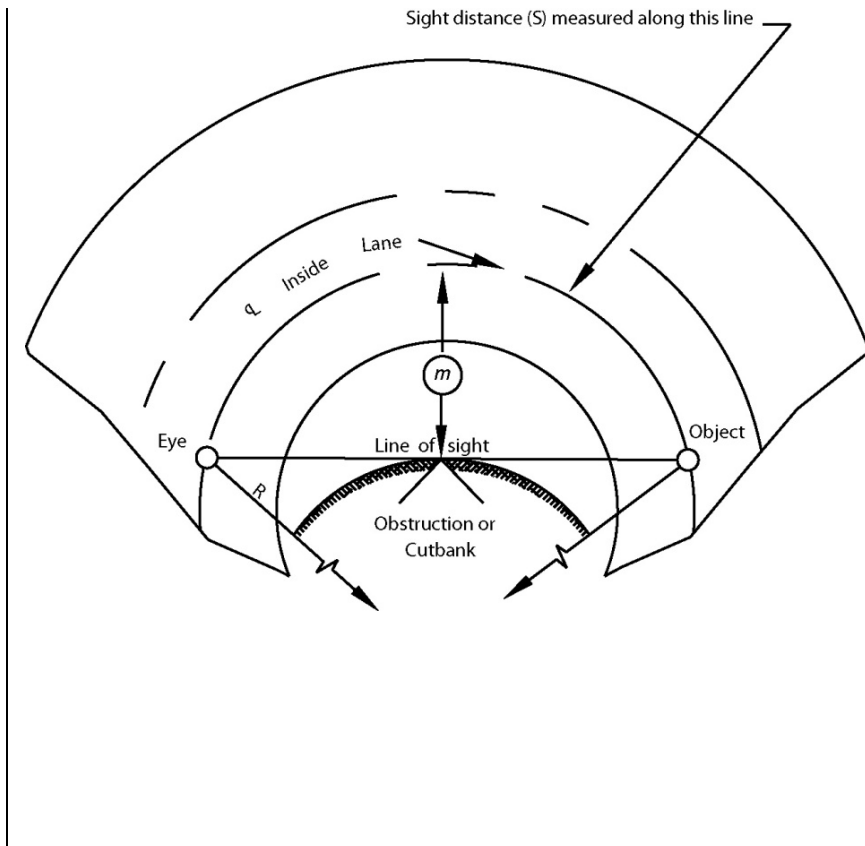
Height of object = ½ foot

A (%)	S = Stopping Sight Distance (ft)													
	70	90	110	125	130	150	170	175	190	210	230	250	270	
3													7	
4										20	60	100	140	
5							20	30	60	100	140	180	220	
6		S > L				33	73	83	113	153	193	233	270	
7				21	31	71	111	121	151	191	231	273	319	
8			20	50	60	100	140	150	180	221	265	313	365	
9		2	42	72	82	122	162	172	203	248	298	352	410	
10		20	60	90	100	140	181	191	226	276	331	391	456	
11		35	75	105	115	155	199	211	248	303	364	430	501	
12	7	47	87	117	127	169	217	230	271	331	397	469	547	
13	17	57	97	127	137	183	235	249	293	358	430	508	592	S < L
14	26	66	106	137	148	197	253	268	316	386	463	547	638	
15	33	73	113	146	158	211	271	287	338	413	496	586	683	
16	40	80	121	156	169	225	289	306	361	441	529	625	729	
17	46	86	129	166	180	239	307	325	384	469	562	664	775	

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Figure 1003.1D

Minimum Lateral Clearance (m) on Bicycle Path Horizontal Curves



S = Sight distance in ft.

R = Radius of Φ of lane in ft.

m = Distance from Φ of lane in ft.

Refer to Index 1003.1(11) to determine "S" for a given design speed "V".

Angle is expressed in degrees

$$m = R \left[1 - \cos \left(\frac{28.65S}{R} \right) \right]$$

$$S = \frac{R}{28.655} \left[\cos^{-1} \left(\frac{R-m}{R} \right) \right]$$

Formula applies only when S is equal to or less than length of curve.

Line of sight is 28" above Φ inside lane at point of obstruction.

Height of bicyclist's eye is 4 1/2 ft.

R (ft)	S = Stopping Sight Distance (ft)											
	60	80	100	120	140	160	180	200	220	240	260	
25	15.9											
50	8.7	15.2	23.0	31.9	41.5							
75	5.9	10.4	16.1	22.8	30.4	38.8	47.8	57.4	67.2			
95	4.7	8.3	12.9	18.3	24.7	31.8	39.5	48.0	56.9	66.3	75.9	
125		6.3	9.9	14.1	19.1	24.7	31.0	37.9	45.4	53.3	1.76	
155		5.1	8.0	11.5	15.5	20.2	25.4	31.2	37.4	44.2	51.4	
175		4.6	7.1	10.2	13.8	18.0	22.6	27.8	33.5	39.6	46.1	
200		4.0	6.2	8.9	12.1	15.8	19.9	24.5	29.5	34.9	40.8	
225			5.5	8.0	10.8	14.1	17.8	21.9	26.4	31.3	36.5	
250			5.0	7.2	9.7	12.7	16.0	19.7	23.8	28.3	33.1	
275			4.5	6.5	8.9	11.6	14.6	18.0	21.7	25.8	30.2	
300			4.2	6.0	8.1	10.6	13.4	16.5	19.9	23.7	27.7	
350				5.1	7.0	9.1	11.5	14.2	17.1	20.4	23.9	
390				4.6	6.3	8.2	10.3	12.8	15.4	18.3	21.5	
500					4.9	6.4	8.1	10.0	12.1	14.3	16.8	
565					4.3	5.7	7.2	8.8	10.7	12.7	14.9	
600					4.1	5.3	6.7	8.3	10.1	12.0	14.0	
700						4.6	5.8	7.1	8.6	10.3	12.0	
800						4.0	5.1	6.2	7.6	9.0	10.5	
900							4.5	5.6	6.7	8.0	9.4	
1000							4.0	5.0	6.0	7.2	8.4	

provided: (a) the path through the curve should be widened to a minimum paved width of 14 feet; and (b) a yellow center line curve warning sign and advisory speed limit signs should be installed.

(14) *Grades*. Bike path grades must meet DIB 82. The maximum grade rate recommended for bike paths should be 5 percent. Sustained grades should be limited to 2 percent.

(15) *Pavement Structure*. The pavement material and structure of a bike path should be designed in the same manner as a highway, with a recommendation from the District Materials Branch. It is important to construct and maintain a smooth, well drained, all-weather riding surface with skid resistant qualities, free of vegetation growth. Principal loads will normally be from maintenance and emergency vehicles.

(16) *Drainage*. For proper drainage, the surface of a bike path should have a minimum cross slope of 1 percent to reduce ponding and a maximum of 2 percent per DIB 82. Sloping of the traveled way in one direction usually simplifies longitudinal drainage design and surface construction, and accordingly is the preferred practice. **The bike path shoulder shall slope away from the traveled way at 2 percent to 5 percent to reduce ponding and minimize debris from flowing onto the bike path.** Ordinarily, surface drainage from the path will be adequately dissipated as it flows down the gently sloping shoulder. However, when a bike path is constructed on the side of a hill, a drainage ditch of suitable dimensions may be necessary on the uphill side to intercept the hillside drainage. Where necessary, catch basins with drains should be provided to carry intercepted water under the path. Such ditches should be designed in such a way that no undue obstacle is presented to bicyclists.

Culverts or bridges are necessary where a bike path crosses a drainage channel.

(17) *Entry Control for Bicycle Paths*. Obstacle posts and gates are fixed objects and placement within the bicycle path traveled way can cause them to be an obstruction to bicyclists. Obstacles such as posts or gates may be considered only when other measures have failed to stop unauthorized motor vehicle entry. Also, these obstacles may be considered only where safety and other issues posed by actual unauthorized vehicle entry are more serious than the safety and access issues posed to bicyclists, pedestrians and other authorized path users by the obstacles.

The 3-step approach to prevent unauthorized vehicle entry is:

- (a) Post signs identifying the entry as a bicycle path with regulatory signs prohibiting motor vehicle entry where roads and bicycle paths cross and at other path entry points.
- (b) Design the path entry so it does not look like a vehicle access and makes intentional access by unauthorized users more difficult. Dividing a path into two one-way paths prior to the intersection, separated by low plantings or other features not conducive to motor vehicle use, can discourage motorists from entering and reduce driver error.
- (c) Assess whether signing and path entry design prevents or minimizes unauthorized entry to tolerable levels. If there are documented issues caused by unauthorized motor vehicle entry, and other methods have proven ineffective, assess whether the issues posed by unauthorized vehicle entry exceed the crash risks and access issues posed by obstacles.

If the decision is made to add bollards, plantings or similar obstacles, they should be:

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- Yielding to minimize injury to bicyclists and pedestrians who may strike them.
- Removable or moveable (such as posts, bollards or gates) for emergency and maintenance access must leave a flush surface when removed.
- Reflectorized for nighttime visibility and painted, coated, or manufactured of material in a bright color to enhanced daytime visibility.
- Illuminated when necessary.
- Spaced to leave a minimum of 5 feet of clearance of paved area between obstacles (measured from face of obstacle to face of adjacent obstacle). Symmetrically about the center line of the path.
- Positioned so an even number of bicycle travel lanes are created, with a minimum of two paths of travel. An odd number of openings increase the risk of head-on collisions if traffic in both directions tries to use the same opening.
- Placed so additional, non-centerline/lane line posts are located a minimum of 2 feet from the edge of pavement
- Delineated as shown in California MUTCD Figure 9C-2.
- Provide special advance warning signs or painted pavement markings if sight distance is limited.
- Placed 10 to 30 feet back from an intersection, and 5 to 10 feet from a bridge, so bicyclists approach the obstacle straight-on and maintenance vehicles can pull off the road.
- Placed beyond the clear zone on the crossing highway, otherwise breakaway.

When physical obstacles are needed to control unauthorized vehicle access, a single non-removable, flexible, post on the path centerline with a separate gate for emergency/maintenance vehicle access next to the path, is preferred. The gate should swing away from the path.

Fold-down obstacle posts or fold-down bollards shall not be used within the paved area of bicycle paths. They are often left in the folded down position, which presents a crash hazard to bicyclists and pedestrians. When vehicles drive across fold-down obstacles, they can be broken from their hinges, leaving twisted and jagged obstructions that project a few inches from the path surface.

Obstacle posts or gates must not be used to force bicyclists to slow down, stop or dismount. Treatments used to reduce vehicle speeds may be used where it is desirable to reduce bicycle speeds.

For obstacle post visibility marking, and pavement markings, see the California MUTCD, Section 9C.101(CA).

(18)Lighting. Fixed-source lighting raises awareness of conflicts along paths and at intersections. In addition, lighting allows the bicyclist to see the bicycle path direction, surface conditions, and obstacles. Lighting for bicycle paths is important and should be considered where nighttime use is not prohibited, in sag curves (see Index 201.5), at

intersections, at locations where nighttime security could be a problem, and where obstacles deter unauthorized vehicle entry to bicycle paths. See Index 1003.1(17). Daytime lighting should also be considered through underpasses or tunnels.

Depending on the location, average maintained horizontal illumination levels of 5 lux to 22 lux should be considered. Where special security problems exist, higher illumination levels may be considered. Light standards (poles) should meet the recommended horizontal and vertical clearances. Luminaires and standards should be at a scale appropriate for a pedestrian or bicycle path. For additional guidance on lighting, consult with the District Traffic Electrical Unit.

1003.2 Class II Bikeways (Bike Lanes)

Design guidance that addresses the safety and mobility needs of bicyclists on Class II bikeways (bike lanes) is distributed throughout this manual where appropriate.

For Class II bikeway signing and lane markings, see the California MUTCD, Part 9.

1003.3 Class III Bikeways (Bike Routes)

Class III bikeways (bike routes) are intended to provide continuity to the bikeway system. Bike routes are established along through routes not served by Class I, II, or IV bikeways, or to connect discontinuous segments of bikeways (normally bike lanes). Class III facilities are facilities shared with motor vehicles or pedestrians, which are designated by signs or permanent markings. Section 891.9 of the Streets and Highways Code prohibits the installation of a new Shared Lane Marking on a highway with a posted speed limit greater than 30 mph, except for the purpose of connecting a Class I, Class II, or Class IV bikeways through an intersection. For application and placement of signs and pavement markings, see the California MUTCD Part 9.

Minimum widths for Class III bikeways are represented in the minimum standards for highway lanes and shoulder.

Since bicyclists are permitted on all highways (except prohibited freeways), the decision to designate the route as a bikeway should be based on the advisability of encouraging bicycle travel on the route and other factors listed below.

- (1) *On-street Bike Route Criteria.* To be of benefit to bicyclists, bike routes should offer a higher degree of service than alternative streets. Routes should be signed only if some of the following apply:
 - (a) They provide for through and direct travel in bicycle-demand corridors.
 - (b) Connect discontinuous segments of bike lanes.
 - (c) They provide traffic actuated signals for bicycles and appropriate assignment of right of way at intersections to give greater priority to bicyclists, as compared with alternative streets.
 - (d) Street parking has been removed or restricted in areas of critical width to provide improved safety.
 - (e) Surface imperfections or irregularities have been corrected (e.g., utility covers adjusted to grade, potholes filled, etc.).

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(f) Maintenance of the route will be at a higher standard than that of other comparable streets (e.g., more frequent street sweeping).

(2) *Sidewalk as Bikeway*. Sidewalks are not to be designated for bicycle travel. Wide sidewalks that do not meet design standards for bicycle paths or bicycle routes also may not meet the safety and mobility needs of bicyclists. Wide sidewalks can encourage higher speed bicycle use and can increase the potential for conflicts with turning traffic at intersections as well as with pedestrians and fixed objects.

In residential areas, sidewalk riding by young children too inexperienced to ride in the street is common. It is inappropriate to sign these facilities as bikeways because it may lead bicyclists to think it is designed to meet their safety and mobility needs. Bicyclists should not be encouraged (through signing) to ride their bicycles on facilities that are not designed to accommodate bicycle travel.

(3) *Shared Transit and Bikeways*. Transit lanes and bicycles are generally not compatible, and present risks to bicyclists. Therefore sharing exclusive use transit lanes for buses with bicycles is discouraged.

Bus and bicycle lane sharing should be considered only under special circumstances to provide bikeway continuity, such as:

(a) If bus operating speed is 25 miles per hour or below.

(b) If the grade of the facility is 5 percent or less.

1003.4 Trails

Trails are generally, unpaved multipurpose facilities suitable for recreational use by hikers, pedestrians, equestrians, and off-road bicyclists. While many Class I facilities are named as trails (e.g. Iron Horse Regional Trail, San Gabriel River Trail), trails as defined here do not meet Class I bikeways standards and should not be signed as bicycle paths. Where equestrians are expected, a separate equestrian trail should be provided. See DIB 82 for trail requirements for ADA. See Index 208.7 for equestrian undercrossing guidance.

- Pavement requirements for bicycle travel are not suitable for horses. Horses require softer surfaces to avoid leg injuries.
- Bicyclists may not be aware of the need to go slow or of the separation need when approaching or passing a horse. Horses reacting to perceived danger from predators may behave unpredictably; thus, if a bicyclist appears suddenly within their visual field, especially from behind they may bolt. To help horses not be surprised by a bicyclist, good visibility should be provided at all points on equestrian paths.
- When a corridor includes equestrian paths and Class I bikeways, the widest possible lateral separation should be provided between the two. A physical obstacle, such as an open rail fence, adjacent to the equestrian trail may be beneficial to induce horses to shy away from the bikeway, as long as the obstacle does not block visibility between the equestrian trail and bicycle path.

See FHWA-EP-01-027, *Designing Sidewalks and Trails for Access* and DIB 82 for additional design guidance.

1003.5 Miscellaneous Criteria

The following are miscellaneous bicycle treatment criteria. Specific application to Class I, and III bikeways are noted. Criteria that are not noted as applying only to bikeways apply to any highway, roadways and shoulders, except freeways where bicycles are prohibited), without regard to whether or not bikeways are established.

Bicycle Paths on Bridges – See Topic 208.

- (1) *Pavement Surface Quality.* The surface to be used by bicyclists should be smooth, free of potholes, and with uniform pavement edges.
- (2) *Drainage Grates, Manhole Covers, and Driveways.* Drainage inlet grates, manhole covers, etc., should be located out of the travel path of bicyclists whenever possible. When such items are in an area that may be used for bicycle travel, they shall be designed and installed in a manner that meets bicycle surface requirements. See Standard Plans. They shall be maintained flush with the surface when resurfacing.

If grate inlets are to be located in roadway or shoulder areas (except freeways where bicycles are prohibited) the inlet design guidance of Index 837.2(2) applies.

Future driveway construction should avoid construction of a vertical lip from the driveway to the gutter, as the lip may create a problem for bicyclists when entering from the edge of the roadway at a flat angle. If a lip is deemed necessary, the height should be limited to ½ inch.

- (3) *At-grade Railroad Crossings and Cattle Guards.* Whenever it is necessary for a Class I bikeway, highway or roadway to cross railroad tracks, special care must be taken to ensure that the safety of users is protected. The crossing must be at least as wide as the traveled way of the facility. Wherever possible, the crossing should be straight and at right angles to the rails. For bikeways or highways that cross tracks and where a skew is unavoidable, the shoulder or bikeway should be widened, to permit bicyclists to cross at right angles (see Figure 1003.5). If this is not possible, special construction and materials should be considered to keep the flangeway depth and width to a minimum.

Pavement should be maintained so ridge buildup does not occur next to the rails. In some cases, timber plank crossings can be justified and can provide for a smoother crossing.

All railroad crossings are regulated by the California Public Utilities Commission (CPUC). All new bicycle path railroad crossings must be approved by the CPUC. Necessary railroad protection will be determined based on a joint field review involving the applicant, the railroad company, and the CPUC.

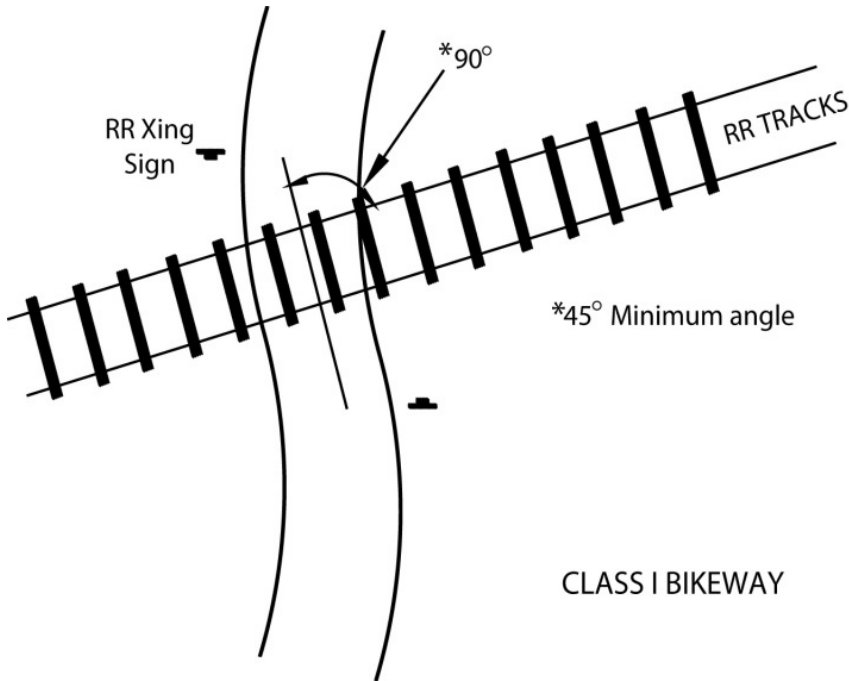
Cattle guards across any roadway are to be clearly marked with adequate advance warning. Cattle guards are only to be used where there is no other alternative to manage livestock.

The California MUTCD has specific guidance on Rail and Light Rail crossings. See Part 8 of the California MUTCD.

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Figure 1003.5

Railroad Crossing Class I Bikeway



NOTE:

See Index 403.3 Angle of Intersection for Class II and Class III facilities.