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DRAFT
BICYCLE FACILITIES
PLANNING AND DESIGN GUIDELINES

Facilities Planning Committee
Arizona Bicycle Task Force

July 16, 1987

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Chapter 1
INTRODUCTION

PURPOSE

This manual provides individuals and agencies in the State of Arizona with location, selection, and design information for bicycle facilities. The information presented in this manual reflects the state-of-the-art practice and is in agreement with proposed Federal guidelines.

The manual has been prepared by the Arizona Bicycle Task Force for the use of jurisdictions throughout the State of Arizona. The use of this manual will help to establish uniform bicycle facilities in conformance with Federal Highway Administration guidelines.

It is important to note that this manual reflects suggested planning and design guidelines. These guidelines are not to be construed as adopted design criteria.

PHILOSOPHY

The underlying philosophy of this manual is summarized in the following four points:

1. Official Recognition of the Bicycle as a Vehicle

   The Uniform Vehicle Code (UVC) recognizes the bicycle as a vehicle and, therefore, the bicycle is entitled to share the roadway with other vehicles except where expressly prohibited. In addition, the Urban Transportation Division Executive Committee of the American Society of Civil Engineers adopted in the 1976 the following statement as part of its official policy:

   The bicycle is recognized as a significant mode of transportation system as indicated by the history of its development as a personal transportation mode and its potential benefits for conserving energy, reducing pollution, and enhancing physical fitness.

2. Selection of Appropriate Facilities

   Bicycle facilities (i.e., bicycle routes, bicycle lanes, wide curb-lanes, and separate paths) should not be viewed as a hierarchy of facilities, but rather as various alternatives, each of which may be most appropriate depending on the circumstances.

3. Desirability of Shared Roadway Facilities

Shared roadway facilities (bike lanes, wide curb-lanes), if properly designed and located, can afford the bicyclist with facilities equally as safe separate facilities. The most significant advantages result from increased visibility and maneuverability, greater system directness and continuity, and lower cost (as compared to a totally separate system).

4. The urban and rural bicycling population consists of people of all ages who use the bicycle for exercise, efficient transportation, recreation, and an alternative to motorized transportation. A very significant percentage of the bicycling population includes youngsters and adults who have no other means of transporting themselves. In urban areas, special attention should be given to providing safe bicycle facilities in school zones and residential areas.

ORGANIZATION OF THIS MANUAL

The remaining portion of the manual is organized into three major chapters. Chapter 2 discusses general location and selection criteria for bicycle facilities. Chapter 3 presents specific design guidelines for bicycle facility design. The Appendix includes information on bicycle storage facilities. A glossary of bicycle related terms and a selected bibliography is also included.

Chapter 2
LOCATION AND SELECTION CRITERIA

The factors to be considered in choosing the proper location for bicycle facilities vary depending on the situation. The most important variables usually include those discussed in this chapter.

LOCATION CRITERIA FOR INCREASING ACCESSIBILITY

Potential Use

The facility should be located along a route where use can be maximized. The following factors should be examined to identify origins and destinations of trips:

1. Household distribution (single-family and multifamily)
2. Location of employment centers
3. Location of major commercial areas and shopping centers
4. Enrollment and location of educational institutions
5. Location of multi-modal interface points (e.g., end points of the transit system, major transfer points)
6. Location of major parks and recreational areas
7. Fast food and convenience stores

Access

In locating a bikeway, consideration should be given to provision of adequate access points. The more frequent and convenient the access points, the more the facility will be used. This is important for bikeways serving utility trips as well as recreational trips. Adequate access for emergency and service vehicles should also be provided. [2]

Directness

The bikeway should serve activity centers along a direct course. If a bikeway is not located between the trip origin and desired destination points (desire lines), it will be inconvenient and will not be used by most bicycle riders. Along recreational routes, this factor is not as important. [2]

The bicycle is considered to be a legitimate mode of transportation; accordingly, access is required from all major origins to all destinations. Ideally, all origin and destination pairs should be made accessible.

Existing Barriers

> In some areas, there are major physical barriers to bicycle travel, caused by topographical features, freeways, railroad tracks, or other impediments. In such cases, development of a bicycle facility crossing a barrier can provide new opportunities for bicyclists. [2] This would better optimize the available land and facilities.

Delays

> Bicycle travel is inherently a slower mode of travel, particularly for longer trips. If bicyclists are required to make frequent stops, they will generally avoid the route. [2]

For this reason, when a bikeway is established on a minor street, consideration should be given to orienting stop signs to restrict cross traffic at most intersections, rather than on the bike route.

This does not apply to major crossings, such as arterials and collectors, where stopping the traffic in favor of the bike route would disrupt the hierarchy of the street systems. However, it should be pointed out that this measure might also permit motorized vehicles traveling on these minor streets to increase their speed, thus attracting more traffic to this particular roadway.

LOCATION CRITERIA FOR PROMOTING BICYCLE SAFETY

Use Conflicts

> Different types of facilities introduce different types of conflicts. Facilities on the roadway can involve conflicts between bicyclists and motor vehicles. Bike paths usually involve conflicts with other bicyclists, with pedestrians on the path, and with motor vehicles at street intersections, curb cuts, and driveways. Sidewalk facilities can increase conflicts with pedestrians, with motor vehicles at highway and driveway intersections, and with fixed objects such as utility poles and guy wires. [2]

In accordance with this criterion, the following are recommended:

1. Roadway facilities should be provided only if the design criteria--intended to reduce bicycle/motor vehicle conflicts--are met.

2. Wherever possible, bike paths and pedestrian paths should be separate from each other.

3. The location of two-way bike paths immediately adjacent to a roadway should be discouraged.

4. Sidewalk facilities should be used by youthful bicyclists and only under very special conditions should they become part of the adult bikeway system.

Accidents

Reducing the number of bicycle accidents (i.e., bicycle/motor vehicle, bicycle/bicycle, bicycle/pedestrian, and single-bicycle accidents) along routes is obviously important. The potential for alleviating accident problems through the improvement of a facility should be assessed, as should the potential for introducing new accident problems. [3]

When locating bicycle facilities, the following guidelines should be followed in order to reduce the potential for accidents:

1. In general, the location of bike facilities should be governed by the principle that the facility should not encourage or require bicyclists or motorists to operate in a manner inconsistent with the normal rules of the road.

2. Two-way bike facilities within the right-of-way of a roadway should be strongly discouraged because they encourage bicycling against the flow of traffic.

3. Except for use by youthful bicyclists, and under very special circumstances (see Design Criteria, Chapter 3), sidewalk bikeway facilities should not be considered the optimimum alternative.

Traffic Volumes and Speeds

For facilities on the roadway, traffic volumes and speeds must be considered along with the roadway width, frequency of intersections, number of driveways, and signs. Commuting bicyclists frequently use arterial streets because they minimize delay and offer continuity for trips of several miles. If adequate width for all vehicles is available on more heavily traveled streets, improving heavily traveled streets can be more desirable than improving adjacent streets. When this is not possible, a nearby parallel street may be improved for bicyclists, provided that stops are minimal and the route conditions are adequate. [3]

Truck and Bus Traffic

> Because of their aerodynamic effect and width, high-speed trucks, buses, motor homes, and trailers can cause special safety problems for bicyclists. [3]

Thus, if there is a choice between comparable routes, the route with the lower traffic volume would be preferable. As a general guide, shared bikeways should be placed on roadways that carry truck/bus volumes of less than five percent of average daily traffic (ADT), and bike lanes may be accommodated on roadways with a combined truck/bus volume greater than five percent.

Pavement Surface Quality

> Facilities located on roadways must have smooth pavement. The need for a bikeway surface as smooth if not smoother than the normal road surface is predicated on the fact that most bicycles have high-pressure tires that transmit every bump and do not have a suspension system to absorb these bumps. (However, care should be taken so that pavement surfaces used by other vehicles are not so smooth as to be slick and, thus, hazardous.) Utility covers and drainage grates should be flush with the pavement surface, and drainage grates should be designed to allow the crossing of bicycles without causing a fall. Grates should have a checkerboard pattern, or have slats oriented perpendicular to the flow of traffic. Approaches to railroad crossings should be improved as necessary to provide for safe bicycle crossings. [3]

The criteria for pavement surface quality are discussed in subsequent sections.

Maintenance

> Ease of maintenance is important when locating facilities. Inadequately maintained facilities may prove to be poor investments. [3]

Proper maintenance can correct some unsafe conditions for bicycling; however, the cost of additional maintenance should also be considered.

On-Street Parking

> The turnover and density of on-street parking can affect the safety of bicyclists (e.g., opening car doors and cars entering or leaving angle parking spaces). [3]

LOCATION CRITERIA FOR IMPROVING SECURITY

Providing bicycle parking facilities is an essential element in an overall effort to promote bicycling and improve security. People are discouraged from bicycling unless sufficient and secure parking is available. Bicycle parking devices should be provided at both the trip origin and the destination and should offer protection from theft and damage.

The wide variety of bicycle parking devices fall into two categories of user needs: commuter or long-term parking, and convenience or short-term parking. The minimum needs for each differ with respect to placement and protection.

Long-term parking is needed at locations such as employment centers, schools, transit stations, and multifamily dwellings. Facilities should be provided which support the bicycle by the frame, secure both wheels and accessories, and offer protection from the weather. Bike lockers and attendant-operated storage areas are good examples of long-term parking facilities.

Short-term parking is needed at locations such as shopping centers, convenience and fast food stores, libraries, recreation areas, and post offices. Facilities should be very convenient and should be near building entrances or other highly visible areas which are largely self-policing, and should support the bicycle by the frame. Where bicycle parking is not properly designed and located, bicyclists often use trees, railings, parking meters, and other fixed objects which can both cause damage to the object and create a hazard for pedestrians.

> Several factors should be considered when planning and providing bicycle parking facilities. The facilities should protect bicycles from damage by automobiles and should not interfere with the normal pedestrian flow. Also, facilities should be adequately spaced so that persons parking their bicycles will not disturb other parked bicycles. Facilities should be able to accommodate a wide range of bicycle shapes and sizes. Finally, facilities should be simple to operate. If possible, signs depicting how to operate the facility should be posted. [3]

A wide variety of bicycle parking facilities are on the market today, ranging from simple racks, to racks complete with cable or locking devices, to lockers. Racks that rely on either of the wheels to support the bicycle can cause problems resulting in bent wheels, toppled over bicycles, and insufficient protection against theft. The best facilities do not rely on either wheel for support, yet provide secure locking. Parts theft can best be controlled by locating parking facilities in highly visible areas, or by providing for lockers or attendant-operated storage. Good design of bicycle parking facilities can help to make them attractive as well as convenient and secure.

LOCATION CRITERIA FOR IMPROVING THE RIDING ENVIRONMENT

Air Quality

> The proximity to concentrations of air pollution should be considered for its possible effect on the health of bicyclists. [3]

Roadways with heavy, slow traffic are potential offenders, although a recent study by the U.S. DOT study has shown that bicyclists do not develop higher bloodstream levels of carbon monoxide than do motorists traveling in the same corridor. Known air quality problem areas, or "hot spots," whether related to stationary or mobile pollutant sources, should be avoided if possible.

Attractiveness

> The scenic value is particularly important along a bikeway intended to serve a recreational purpose. [3]

Grades

> Steep grades on bikeways should be avoided if possible. Most bicyclists cannot negotiate steep uphill grades greater than 10 percent; so these can be a severe deterrent to use of the facility. Also, riding downhill can be risky, particularly for unskilled bicyclists or for bicyclists with faulty equipment. [2]

INTRODUCTION TO SELECTION CRITERIA

The selection process should be governed by the principle that facilities should not encourage bicycle or motor vehicle use in a manner contrary to the normal rules of the road. Adherence to this principle enhances both user safety and convenience.

One important consideration in selecting the type of facility is continuity. Alternating segments of bike paths and bike lanes (or bike routes) along a route are generally incompatible, as street crossings by bicyclists are 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.

BICYCLE FACILITY TYPE AND ROADWAY FUNCTION

Once the bikeway options have been identified, each bicycle facility/roadway function combination must be further evaluated in terms of a number of location and design criteria such as traffic volumes and speeds, truck and bus traffic, street widths, on-street parking, etc.

Selection of the appropriate facility type to meet the bicycle need is dependent on many factors. The following paragraphs describe the most common uses for each facility type.

Bicycle Paths

> Generally, bike paths should be used to serve corridors not served by streets and highways or where wide rights-of-way exist 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 commuter routes if crossflow by motor vehicles can be minimized. The most common uses are along rivers, lake shores, canals, utility rights-of-way, abandoned railroad rights-of-way, within college 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 is to eliminate impediments to bicycle travel caused by construction of freeways, or because of the existence of natural barriers. [2]

In some cases, bike paths could also be accommodated within the interstate rights-of-way, assuming that applicable laws permit and that criteria for bicycle and motorized traffic separation and compliance with the normal rules of the road are met. Right-of-way widths would have to be such that adequate room exists for the separated facilities.

Bicycle Lanes

Bicycle lanes are a portion of the roadway which has been designated for the preferential or exclusive use of bicyclists. This designation includes striped bike lanes, paved shoulders, and lanes for joint use by bicycles and disabled motor vehicles.

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 and to better accommodate bicyclists through corridors with insufficient room for safe bicycling on existing streets. Other corridors that may warrant bike lanes include:

1. Corridors with heavy bicycle traffic, where bicyclists must frequently pass each other traveling in the same direction.

2. Insufficiently lighted corridors on which frequent nighttime usage is expected, e.g., those with a nighttime entertainment/shopping/educational/recreational center as a common destination.

3. Corridors on which lane designation is not complicated by frequent residential or commercial driveways or roadway intersections.

Additional measures that might not be possible on all streets must be implemented on bike lane streets to improve the situation for bicyclists, (e.g., pavement surface improvements, stronger sweeping programs, special signal facilities, etc.). Special efforts should be made to ensure that high levels of service are provided with these lanes (i.e., bicycle-sensitive signal actuators, pavement markings, etc.), if bicycle travel is to be regulated by delineation. Additional night lighting of extensively traveled bicycle corridors also increases safety and comfort.

Bicycle lanes can be provided by widening existing roadways, paving shoulder areas, eliminating parking, or using emergency lanes for disabled vehicles.

Wide Curb-Lanes

Like bike lanes, wide curb-lanes are placed along streets in corridors where there is significant bicycle demand. Unlike bicycle lanes, however, wide curb-lanes are for shared use by bicycle and motorized traffic. The added lane width provides greater room for maneuvering and increases the lateral distance between bicyclists and vehicles.

Wide curb-lanes are appropriate bicycle facilities where traffic speeds and volumes are tolerable for shared roadway facilities.

> Wide curb-lane facilities are selected when there is insufficient room for a separate bike lane, yet significant demand exists for providing a facility of some kind. To many experienced riders, wide curb-lanes are a preferred facility type because it integrates bicycle and vehicular traffic, and forces recognition and awareness on the part of the motorist. Some studies have indicated that on-road facilities have a higher safety index than off-road (sidewalk) facilities (Deleuw, Cather and Co.) [5]

Wide curb-lane facilities can be created by widening roadways, by narrowing traffic lanes, or a combination of all three. It should be noted that both the AASHTO (American Association of State Highway Transportation Officials) and the National Advisory Committee on Uniform Traffic Control Devices have commented in favor of reducing vehicle lanes from 12 feet to 11 feet for the purpose of widening the right-most curb-lane for bicycle use.

Bicycle Routes

> Bike routes are shared facilities which serve either to: (1) provide continuity to other bicycle facilities (usually bike lanes); or (2) 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 ensure 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. [2]

Shared Roadway (No Bikeway Designation)

Most bicycle travel now occurs on streets and highways without bikeway designations. This will probably be true in the future as well. In some instances, entire street systems may be fully adequate for safe and efficient bicycle travel, and signing and striping for bicycle use may be unnecessary. In other cases, a street may be inherently unsafe for bicycle travel and it would be inappropriate to encourage additional bicycle travel by designating the street as a bikeway.

Many rural highways are used by touring and recreational bicyclists for intercity travel. In most cases, it would be inappropriate to designate the highways as bikeways because of the limited use and the lack of continuity with other bike routes. [2]

The following additional bikeway type is intended for use primarily by inexperienced adult and youthful bicyclists.

Sidewalk With Ramps

In general, bicycling on sidewalks is unsafe and is not a recommended alternative. However, the youthful inexperienced bicyclist can be accommodated adequately through the provision of sidewalks with smooth curb ramps at intersections, primarily in those areas near elementary schools, middle schools, and public parks. The standard wheelchair ramp also works for bicycles. [4]

It should be noted that the hazards of sidewalk riding (see the section entitled "Design Criteria Related to Sidewalks with Ramps" in Chapter 3) also apply to youthful and inexperienced adult riders.

Such provisions for the youthful bicyclist should be in addition to, rather than instead of, the provisions for the adult bicyclist. In addition, bike paths on their own right-of-way can also accommodate the youthful bicyclist. [4]

Some Arizona communities have a considerable number of senior citizens who ride tricycles. For planning purposes these tricyclists have been identified as inexperienced adult riders. As such, they should ride on sidewalks where allowed by law with ramps and bike paths. In such communities, special studies on the use and accommodation of tricycles may be needed.

Chapter 3
DESIGN CRITERIA

DEFINITIONS

AASHTO

American Association of State Highway and Transportation Officials

A.R.S.

Arizona Revised Statutes

Bicycle

Every device propelled by human power upon which any person may ride, having two tandem wheels either of which is more than 16" in diameter or having three wheels in contact with the ground any of which is more than 16" in diameter. (A.R.S. 28-101)

Bicycle Facilities

A general term denoting improvements and provisions made by public agencies to accommodate or encourage bicycling, including parking facilities, maps, all bikeways, and shared roadways not specifically designated for bicycle use.

Bicycle Path (Class I Facility)

A bikeway physically separated from motorized vehicular traffic by an open space or barrier and either within the highway right-of-way or within an independent right-of-way.

Bicycle Lane (Class III Facility)

A portion of a roadway which has been designated by striping, signing and pavement markings for the preferential or exclusive use of bicyclists.

Bicycle Route (Class II Facility)

A segment of a system of bikeways designated by the jurisdiction having authority with appropriate directional and informational markers, with or without a specific bicycle route number.

Bikeway

Any road, path, or way which in some manner is specifically designated as being open to bicycle travel, regardless or whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes.

Highway

A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

MUTCD

Manual of Uniform Traffic Control Devices. State law (A.R.S. 28-641) requires the adoption of a uniform system of traffic control devices which . . . shall correlate with and so far as possible conform to the system set forth in the most recent edition of the manual a uniform traffic control device for streets and highways prepared by the National Joint Committee on Uniform Traffic Control Devices.

Right-of-Way

A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to transportation purposes, but with other associated uses such as utilities, water and sewage lines, bus benches and buffer zones.

Right of Way

The right of one vehicle or pedestrian to proceed in a lawful manner in preference to another vehicle or pedestrian.

Roadway

The portion of the highway, including shoulders, for vehicle use.

Shared Roadway

Any roadway upon which a bicycle lane is not designated and which may be legally used by bicycles regardless of whether such facility is specifically designated as a bikeway.

Sidewalk

The portion of a highway designed for preferential or exclusive use by pedestrians.

INTRODUCTION

There is a wide range of facility improvements which can enhance transportation. Improvements can be simple and involve minimal design consideration (e.g., changing drainage grate inlets) or they can involve a detailed design (e.g., providing a bicycle path). The controlling feature of the design of every bicycle facility is its location (i.e., whether it is on the roadway or on an independent alignment). Roadway improvements such as bicycle lanes depend on the roadway's design. On the other hand, bicycle paths are located on independent alignments; consequently, their design depends on many factors, including the performance capabilities of the bicyclist and the bicycle.

Improvements for motor vehicles through appropriate planning and design can enhance bicycle travel and in any event should avoid adverse impacts on bicycling. A community's overall goals for transportation improvements should, whenever possible, include the enhancement of bicycling. Public involvement in the form of public meetings or hearings or bicycle advisory groups is desirable during the planning and design process.

Guidelines are presented in this chapter to help design and construct both roadway improvements and separate paths that accommodate the operating characteristics of "bicycles" as defined in this guide. Modifications to facilities (e.g., widths, curve radii, super elevations, etc.) that are necessary to accommodate adult tricycles, bicycle trailers, and other special purpose human powered vehicles and accessories should be made in accordance with expected use, using sound engineering judgment. Minimum standards should be strictly adhered to.

ROADWAY IMPROVEMENTS

To varying extents, bicycles will be ridden on all highways where they are permitted. All new highways, except those where bicyclists will be legally prohibited, should be designed and constructed under the assumption that they will be used by bicyclists. Bicycle-safe design practices, as described in this guide, should be followed to avoid the necessity for costly subsequent improvements. Because most highways have not been designed with bicycle travel in mind, there are often many ways in which roadways should be improved to more safely accommodate bicycle traffic. Roadway conditions should be examined and, where necessary, safe drainage grates and railroad crossings, smooth pavements, and signals responsive to bicycles should be provided. In addition, the desirability of adding facilities such as bicycle lanes, bicycle routes, shoulder improvements, and wide curb lanes should be considered. Information on each of the different roadway improvements is contained in this section.

Drainage Grates

Drainage grate inlets and utility covers are potential problems to bicyclists. When a new roadway is designed, all such grates and covers should be kept out of bicyclists expected path. On new construction where bicyclists will be permitted, curb inlets should be used wherever possible to completely eliminate exposure of bicyclists to grate inlets. It is important that grates and utility covers be adjusted flush with the surface, including after a roadway is resurfaced.

Parallel bar drainage grate inlets can trap the front wheel of a bicycle causing loss of steering control and, often, the bar spacing is such that they allow narrow bicycle wheels to drop into the grates, resulting in serious damage to the bicycle wheel and frame and/or injury to the bicyclist. These grates should be replaced with bicycle-safe and hydraulically efficient ones. When this is not immediately possible, weld steel cross straps or bars perpendicular to the parallel bars to provide a maximum safe opening between straps. This should be considered a temporary correction.

While identifying a grate with a pavement markings, the treatment indicated in the MUTCD, (see Chapter 4, Appendix A) would be acceptable in most situations, parallel bar grate inlets deserve special attention. Because of the serious consequences of a bicyclist missing the pavement marking in the dark or being forced over such a grate inlet by other traffic, these grates should be physically corrected, as described above, as soon as practicable after they are identified.

Railroad Crossings

Railroad highway grade crossings should ideally be at a right angle to the rails. The greater the crossing deviates from this ideal crossing angle, the greater is the potential for a bicyclist's front wheel to be trapped in the flangeway causing loss of steering control. It is also important that the roadway approach be at the same elevation as the rails.

Consideration should be given to the materials of the crossing surface and to the flangeway depth and width. If the crossing angle is less than approximately 45 degrees, consideration should be given to widening the outside lane, shoulder, or bicycle lane to allow bicyclists adequate room to cross the tracks at a right angle (see Figure 1). Where this is not possible, commercially available compressible flangeway fillers can enhance bicyclist safety. In some cases, abandoned tracks can be removed. Warning signs and pavement markings should be installed in accordance with the MUTCD.

Pavements

Pavement surface irregularities can do more than cause an unpleasant ride. Gaps between pavement slabs or drop-offs at overlays parallel to the direction of travel can trap a bicycle wheel and cause loss of control; holes and bumps can cause bicyclists to swerve into the path of motor vehicle traffic. Thus,

to the extent practicable, pavement surfaces should be free of irregularities and the edge of the pavement should be uniform in width. On older pavements it may be necessary to fill joints, adjust utility covers or, in extreme cases, overlay the pavement to make it suitable for bicycling.

Traffic Control Devices

At intersections where bicycle facilities are in place, bicycles should be considered in the timing of the traffic signal cycle, as well as the traffic detection device. Normally, a bicyclist can cross an intersection under the same signal phasing arrangement as motor vehicles; however, on multi-lane streets special consideration should be given to ensure that short clearance intervals are not used. If necessary, an all-red clearance interval may be used.

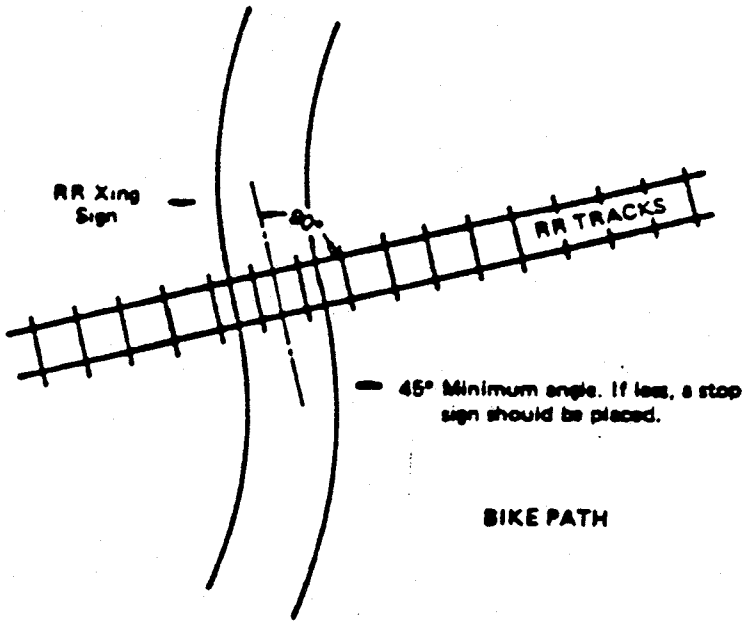
To check the clearance interval, a bicyclist's speed of 10 mph (16km/h) and a perception/reaction/braking time of 2.5 seconds should be used. Detectors for traffic-actuated signals should be sensitive to bicycles and should be located in the bicyclist's expected path, including left turn lanes. Where programmed visibility signal heads are used, they should be checked to insure that they are visible to bicyclists who are properly positioned on the road.

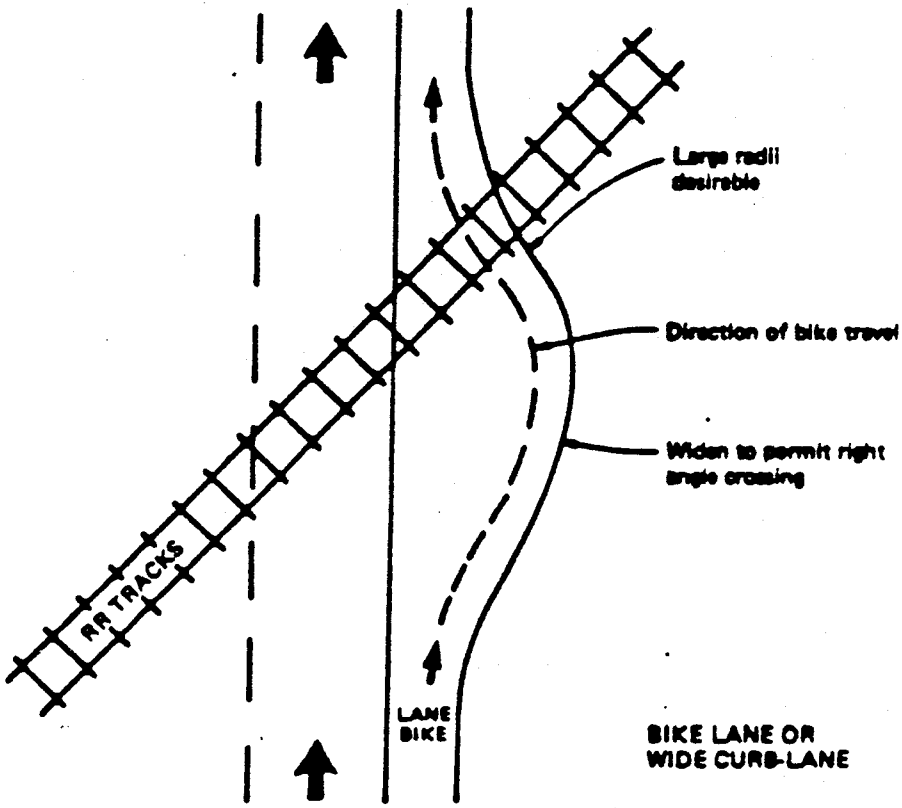
The MUTCD should be consulted for requirements on signs and pavement markings. Where bicyclists are expected to use different routings than motorists, directional signing should be used to confirm to bicyclists that the special routing leads to their destination. For additional information refer to Appendix A.

Shoulders

Wide curb lanes and bicycle lanes are usually preferred over shoulders for use by bicyclists. Shoulders are typically rough and contain much debris such as glass and obstacles. Therefore, they are usually a safety hazard. However, if it is intended that bicyclists ride on shoulders, smooth paved shoulder surfaces should be provided and maintained in a clean and safe condition. Pavement edge lines supplement surface texture in delineating the shoulder from the motor vehicle lanes. Rumble strips can be a deterrent to bicycling on shoulders and their benefits should be weighed against the probability that bicyclists will ride in the motor vehicle lanes to avoid them.

Shoulder width should be a minimum of 4 feet (1.2m) when intended to accommodate bicycle travel. Roads with shoulders less than 4 feet (1.2m) wide normally should not be signed as bikeways. If motor vehicle speeds exceed 35 mph (55km/h), if the percentage of trucks, buses, and recreational vehicles is high, or if static obstructions exist at the right side, then additional width is recommended.





Source: California State Department of Transportation, *Planning and Design Criteria for Bikeways in California*, Sacramento, CA, June 1978.

FIGURE 1 Railroad crossings.

Adding or improving shoulders can often be the best way to accommodate bicyclists in rural areas, and they are also a benefit to motor vehicle traffic. Where funding is limited, adding or improving shoulders on uphill sections first will give slow moving bicyclists needed maneuvering space and decrease conflicts with faster moving motor vehicle traffic.

Wide Curb Lanes

On highway sections without bicycle lanes, a right lane wider than 12 feet (3.7m) can better accommodate both bicycles and motor vehicles in the same lane and thus is beneficial to both bicyclists and motorists. In many cases where there is a wide curb lane, motorists will not need to change lanes to pass a bicyclist.

Also, more maneuvering room is provided when drivers are exiting from driveways or in areas with limited sight distance. In general, a lane width of 14 feet (4.3m) of usable pavement width is desired. Drainage grates, parking and longitudinal ridges between pavement and gutter sections are not considered usable pavement.

Widths greater than these can encourage the undesirable operation of two motor vehicles in one lane, especially in urban areas. When widths exceed 14 feet of usable pavement surface, a pavement edge line should be striped to discourage the undesirable operation of two motor vehicles in one lane. For example, if 15 feet of usable pavement surface exists, 11 feet could be striped for the motor vehicle lane, whereby, the minimum desirable 4 feet of remaining width adjacent to the motor vehicle lane would be provided for the cyclist. [3]

Figure 2 (a) shows a typical urban roadway with wide curb lane.

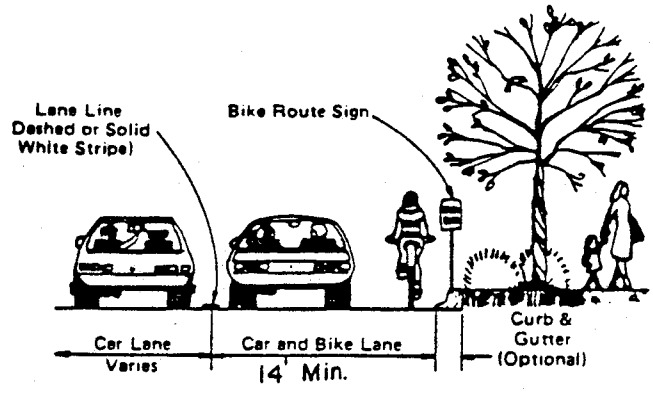
When a right-turn only lane exists at an intersection the additional width should be placed in the right-most through lane (see Figure 3).

Restriping to provide wide curb lanes can be accomplished on most existing multi-lane facilities by making the remaining travel lanes and left-turn lanes narrower. This should be performed after careful review of traffic characteristics along the corridor.

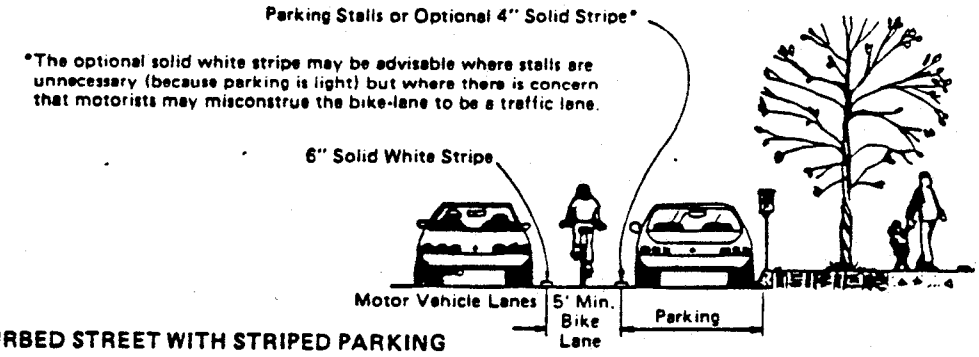
BICYCLE ROUTES

It may be advantageous to sign some urban and rural roadways as bicycle routes. When providing continuity to other bicycle facilities, such as commuting facilities, a bicycle route can be relatively short. However, a bicycle touring route can be quite long. For long bicycle routes, a standard bicycle route marker with a numerical designation can be used in place of a bicycle route sign. Refer to Appendix A, (MUTCD Page 9B-10, Figure M1-8).

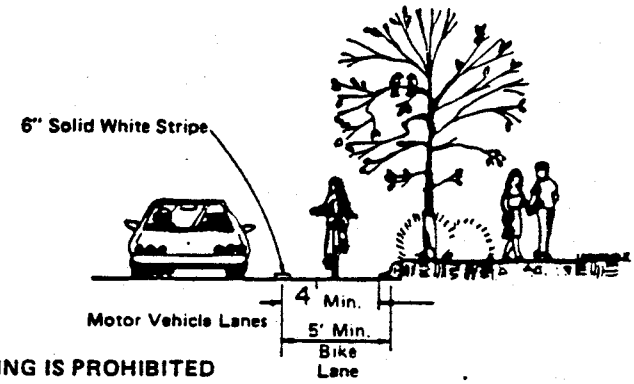
It is often desirable to use supplemental plaques with bicycle route signs or markers to furnish additional information, such as direction changes in the route, and intermediate range distance and destination information. [3]



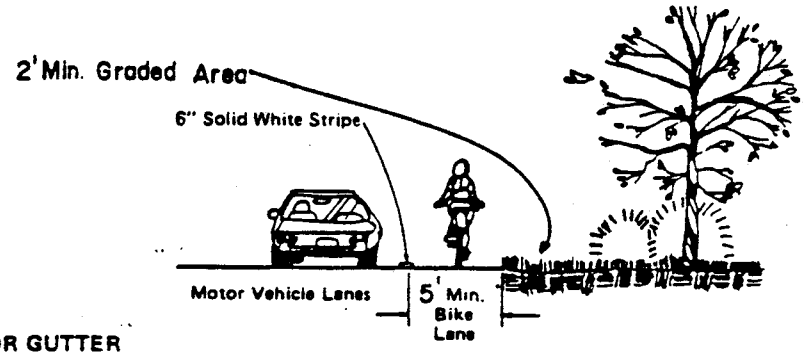
a. WIDE CURB-LANE



b. CURBED STREET WITH STRIPED PARKING



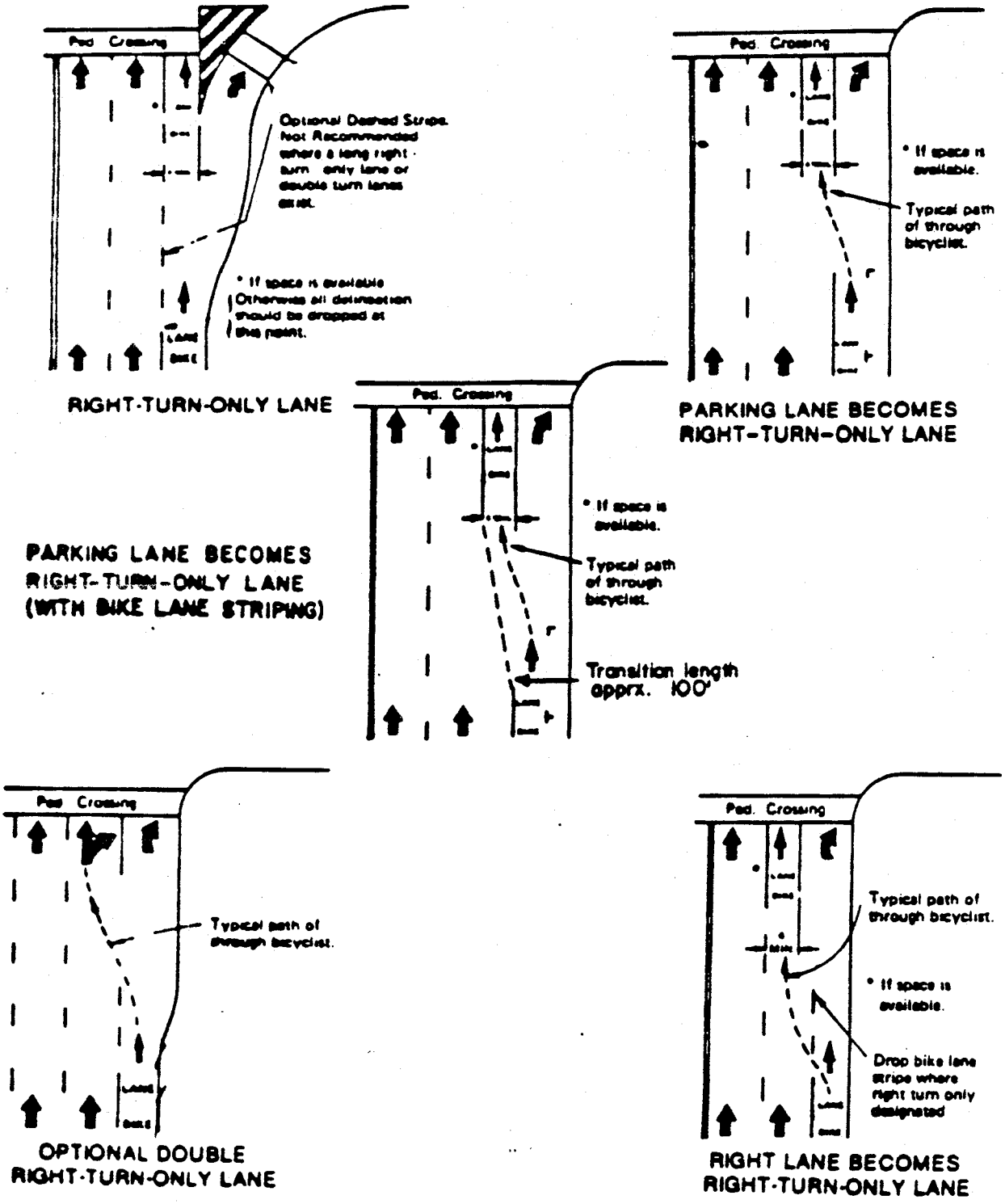
c. CURBED STREET WHERE PARKING IS PROHIBITED



d. STREET WITHOUT CURB OR GUTTER

Source: Federal Highway Administration, Department of Transportation, "Proposed Design and Construction Criteria for Bikeway Construction Projects." Federal Register, Monday, August 4, 1980.

FIGURE 2 Bicycle lane and wide curb-lane.



Source: AASHTO Guide For Development Of New Bicycle Facilities

FIGURE 3 Bike lanes approaching motorist right-turn-only lanes

Overall, the decision whether to provide a bicycle route should be based on the advisability of encouraging bicycle use on a particular road, instead of on parallel and adjacent highways. The roadway width, along with factors such as the volume, speed, and type of traffic, parking conditions, grade, and sight distance should be considered when determining the feasibility of a bicycle route. Generally, bicycle traffic cannot be diverted to a less direct alternate route unless the favorable factors outweigh the inconvenience to the bicyclist. Roadway improvements, such as safe drainage grates, railroad crossings, smooth pavements, maintenance schedules, and signals responsive to bicycles, should always be considered before a roadway is identified as a bicycle route.

Further guidance on signing bicycle routes is provided in the MUTCD.

BICYCLE LANES

Bicycle lanes can be considered when it is desirable to delineate the rights-of-way assigned to bicyclists and motorists and to provide for more predictable movements by each. Bicycle lanes may include striped lanes on the roadway, use of emergency parking lanes, or use of paved shoulders. Passing motorists are less likely to swerve into the bicycle lane, since the two have separate lanes. Bicycle lane markings can increase bicyclists' confidence in motorists not straying into their path of travel. Likewise, passing motorists are less likely to avoid bicyclists on their right. Raised pavement markings and raised barriers present a hazard to bicyclists and should not be used to delineate bicycle lanes. The use of paint or thermoplastic markings to delineate bike lanes are generally preferred. [3] Thermoplastic markings may be slick when wet.

Presently, State design directives require use of thermoplastic markings for most State contracted roadway improvements. One potential compromise may be to permit painted markings along shoulders or to delineate bicycle lanes, stop bars, or crosswalks in a bicycle lane, or other areas where encounters with bicycles are likely.

Bicycle lanes should always be one-way facilities and flow in the same direction as adjacent motor vehicle traffic. Two-way bicycle lanes on each side of the roadway are undesirable because they promote riding against the flow of traffic. Wrong way riding is a major cause of bicycle accidents and violates the Rules of the Road stated in the Arizona Statutes.

Bicycle Lane Widths

Under ideal conditions, the minimum desirable bicycle lane width is 4 feet (1.2m). However, certain edge conditions dictate additional desirable bicycle lane width. To examine the width requirements for bicycle lanes, Figure 2 shows three usual locations for such facilities in relation to the roadway. Figure 2b depicts bicycle lanes on an urban curbed street where a parking lane is provided. The recommended bicycle lane width for this location is 5 feet

(1.5m). Bicycle lanes should always be placed between the parking lane and the motor vehicle lanes. Bicycle lanes between curb and the parking lane create hazards for bicyclists from opening doors and poor visibility at intersections and driveways, and they prohibit bicyclists from making left turns; therefore, this placement shall never be considered.

Where parking is permitted but a parking lane is not provided, the combination lane, intended for both motor vehicle parking and bicycle use, should be a minimum of 12 feet (3.7m) wide. However, if it is likely the combination lane will be used as an additional motor vehicle lane, it is preferable to designate separate parking and bicycle lanes as shown in Figure 2b. In both instances, if parking volume is substantial or turnover is high, an additional 1 or 2 feet (0.3 or 0.6m) of width is desirable for safe bicycle operation.

Figure 2c depicts bicycle lanes along the outer portions of an urban curbed street where parking is prohibited. Bicyclists do not generally ride near a curb because of the possibility of debris, of hitting a pedal on the curb, of an uneven longitudinal joint, or of a steeper cross slope.

Bicycle lanes in this location should have a minimum width of 5 feet (1.5m) from the curb face. If the longitudinal joint between the gutter pan and the roadway surface is uneven and falls within 5 feet (1.5m) of the curb face, a minimum of 4 feet (1.2m) shall be provided between the joint and the motor vehicle lanes.

Figure 2d depicts bicycle lanes on a highway without curb or gutter. Bicycle lanes shall be located between the motor vehicle lanes and the roadway shoulders. Bicycle lanes may have a minimum width of 4 feet (1.2m) where the shoulder can provide additional maneuvering width if paved. A width of 5 feet (1.5m) or greater is preferable; additional widths are desirable where substantial truck traffic is present, where prevailing winds are a factor, or where motor vehicle speeds exceed 35mph (55km/h), or if the shoulder is not paved.

The typical width for a motor vehicle lane adjacent to a bike lane is 12 feet (3.6m). There are situations where it may be necessary to reduce the width of motor vehicle lanes in order to stripe bike lanes. In determining the appropriateness of narrower motor vehicle lanes, consideration should be given to factors such as motor vehicle speeds, truck volumes, alignment, and sight distance. Where favorable conditions exist, more narrow motor vehicle lanes may be feasible.

Bike Lanes on One-Way Streets

If the bike lanes are to be located on one-way streets, the following guidelines should be kept in mind:

1. It is preferable to have lanes on the right side of the one-way street.

2. Bicycle lanes on the left side may be desirable if they reduce conflicts that may occur with heavy bus traffic.

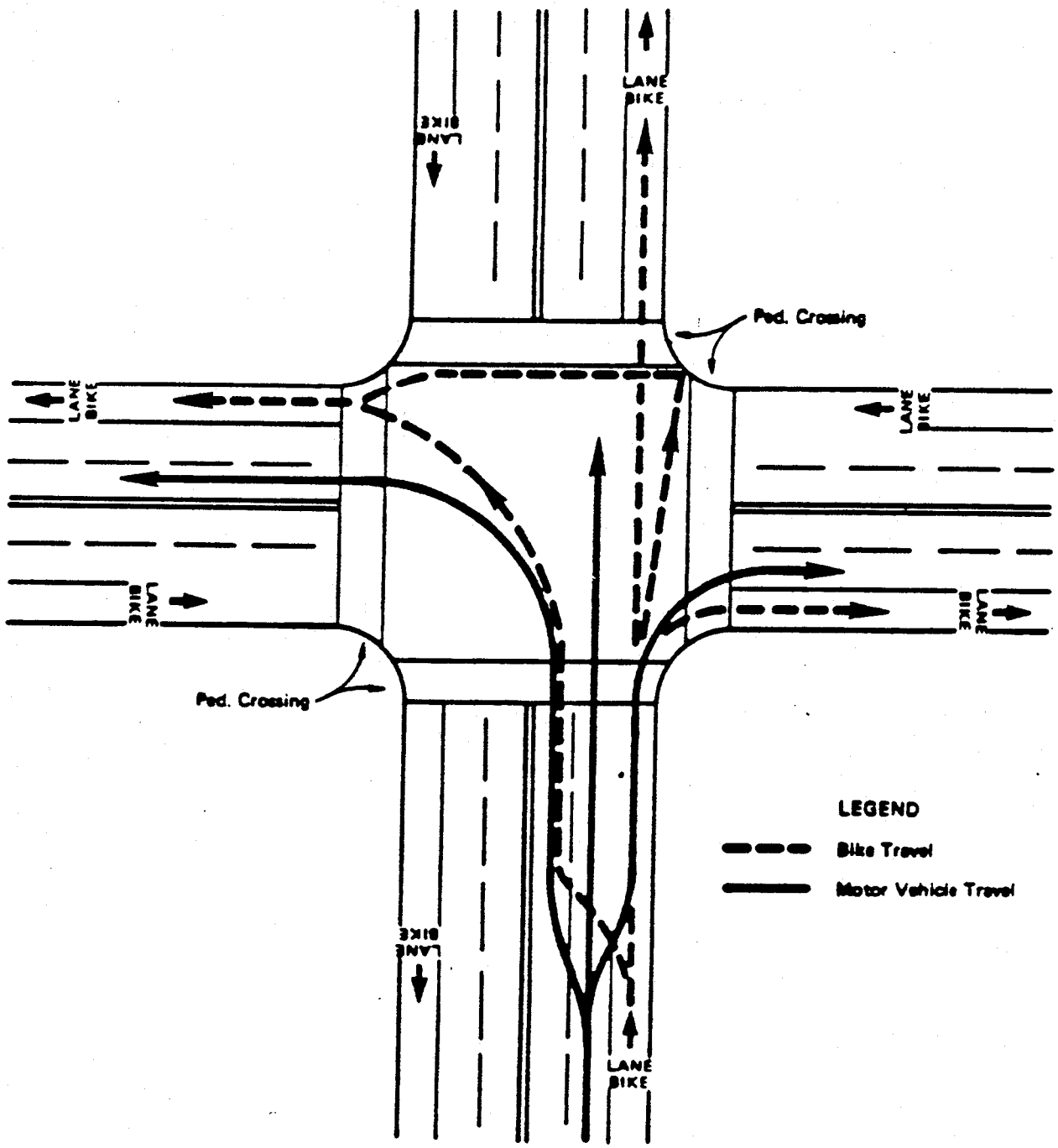
Intersections With Bike Lanes

Bicycle lanes tend to complicate both bicycle and motor vehicle turning movements at intersections. Because they encourage bicyclists to keep to the right and motorists to keep to the left, both operators are somewhat discouraged from merging in advance of turns. Thus, some bicyclists will begin left turns from the right-side bicycle lane and some motorists will begin right turns from the left of the bicycle lane. Both maneuvers are contrary to established Rules of the Road and result in conflicts. Common movements of motorists and bicyclists are shown in Figure 4.

At intersections, bicyclists proceeding through and motorists turning right must cross paths. Striping and signing configurations which encourage these crossings in advance of the intersection, in a merging fashion, are generally preferable to those that force the crossing in the immediate vicinity of the intersection. To a lesser extent, the same is true for left turning bicyclists; however, in this maneuver, vehicle codes allow the bicyclist the option of making either a "vehicle style" left turn (where the bicyclist merges leftward to the same lane used for motor vehicle left turns) or a "pedestrian style" left turn (where the bicyclist proceeds straight through the intersection, turns left at the far side, then proceeds across the intersection on the cross street).

When confronted with such intersections, bicyclists have to merge with right-turning motorists. Since bicyclists are typically traveling at lower speeds than motorists, they should signal and merge where there is a sufficient gap in right-turning traffic, rather than at any predetermined location. For this reason, it is recommended that either all delineation be dropped at the approach of the right-turn lane (or off-ramp) or that a single, dashed bike lane line be used to aid smooth transition across the right-turn lane (see Figure 3). A pair of parallel lines (delineating a bike lane crossing) to channel the bike merge is not recommended, as bicyclists will be encouraged to cross at a predetermined location, rather than when there is a safe gap in right-turning traffic. Also, some bicyclists are apt to assume they have the right-of-way, and may not check for right-turning motor vehicle traffic.

A dashed line across the right-turn-only lane (or off-ramp) is not recommended on extremely long lanes, or where there are double right-turn-only lanes. For these types of intersections, all striping should be dropped to allow the bicyclist's judgment to prevail. Bike lanes crossing on-ramps do not present the same problems, as bicyclists normally have a good view of traffic entering the roadway, and will adjust their path as necessary to cross ramp traffic. A "Bike Xing" sign may be used to warn motorists of the potential for bicyclists crossing their path. [2]



Source California State Department of Transportation, *Planning and Design Criteria for Bikeways in California*, Sacramento, CA, June 1978.

FIGURE 4 Typical bicycle/auto movements at intersection of multilane streets.

Figures 3 and 5 present examples of details on pavement markings for bicycle lanes, approaching motorists right turn only lanes and for on and off ramps. Where there are numerous left-turning bicyclists, a separate turning lane, as indicated in Part IX of the MUTCD (see Appendix A) should be considered. The design of bicycle lanes should also include appropriate signing at intersections to reduce the number of conflicts. General guidance for pavement markings for bicycle lanes is contained in the MUTCD.

Signal Design for Bicycle Lanes

At intersections where there are bike lanes and traffic signals, installation of bicycle-sensitive loop detectors within the bike lane is desirable. This is particularly important where signals are traffic-actuated, and will not change for a bicyclist unless a motor vehicle is present, or unless the bicyclist leaves the bike lane to trip the signal within the traffic lane. Generally, push button actuators are unsatisfactory at intersections; if the actuator is not properly located near the curb, bicyclists may have to dismount to reach it on the sidewalk. Often button activators are located 4 feet from the face of the curb. It is also important that loop detectors in left-turn lanes be sensitive enough to detect bicycles. Where significant bicycle use is anticipated on any street with traffic-actuated signals, it is recommended to install loop detectors that are sensitive enough to detect bicycles. [2] An example of such a loop detector is included in Appendix C.

Striping and Signing Bicycle Lanes

General requirements for striping and signing of bike lanes are contained in the MUTCD (see Appendix A and Figures 3 and 5). These guidelines are appropriate for Arizona and should always be consulted and followed.

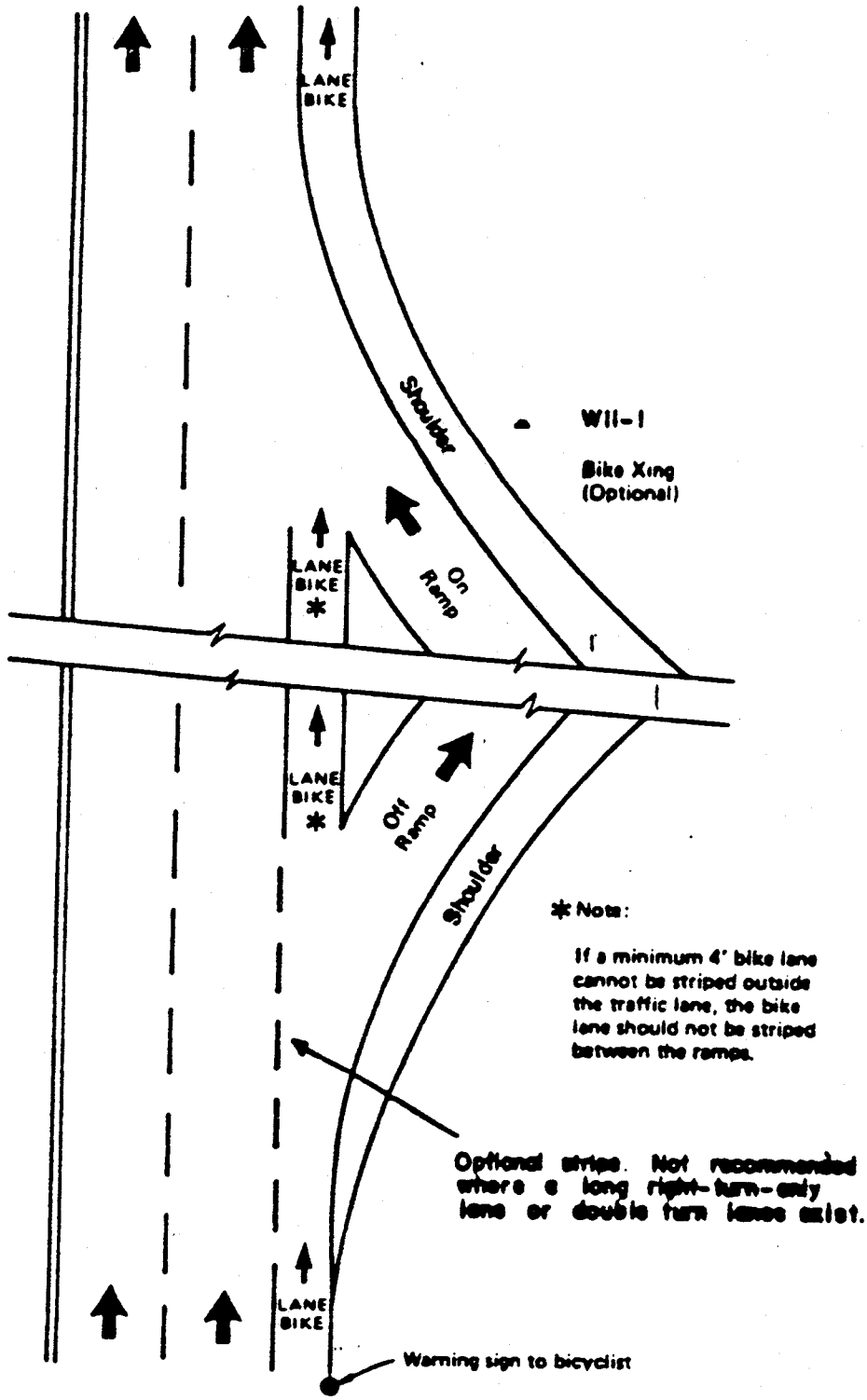
Raised barriers (e.g., raised traffic bars and asphalt concrete dikes) or raised pavement markers should not be used to delineate bike lanes. Raised barriers and pavement markers prevent motorists from merging into bike lanes before making right turns, as required by the UVC (Uniform Vehicle Code), and restrict the movement of bicyclists desiring to enter or exit bike lanes. In addition, they can impede routine maintenance activities.

Adequate pavement surface, bicycle-safe grate inlets, and safe railroad crossings should always be provided on roadways where bicycle lanes are being designated. [2]

Where funding is limited, adding or improving bike lanes on uphill sections first will give slower moving bicyclists needed maneuvering space and decrease conflicts with faster moving motor vehicle traffic.

BICYCLE PATHS

Bicycle paths are facilities on exclusive rights-of-way and with minimal cross flow by motor vehicles. Bicycle paths can serve a variety of purposes. They can provide a commuting bicyclist with a shortcut through a residential neighborhood (e.g., a connection between two cul-de-sac streets). Located in a



Source California State Department of Transportation, *Planning and Design Criteria for Bikeways in California*. Sacramento, CA, June 1978.

FIGURE 5 Bike lane ramp crossings.

park, they can provide an enjoyable recreational opportunity. Bicycle paths can be located along abandoned railroad rights-of-way, the banks of rivers and canals, and other similar areas. Bicycle paths can also provide bicycle access to areas that are otherwise served only by limited access highways closed to bicycles. Appropriate locations can be identified during the planning process.

Bicycle paths should be thought of as extensions of the highway system that are intended for the exclusive or preferential use of bicycles in much the same way as freeways are intended for the exclusive or preferential use of motor vehicles. There are many similarities between design criteria for bicycle paths and those for highways (e.g., in determining horizontal alignment, sight distance requirements, signing, and markings). On the other hand, some criteria (e.g., horizontal and vertical clearance requirements, grades, and pavement structure) are dictated by operating characteristics of bicycles that are substantially different from those of motor vehicles. The designer should always be conscious of the similarities and the differences between bicycles and motor vehicles and of how these similarities and differences influence the design of bicycle paths. The following sections provide guidance for designing a safe and functional bicycle path.

Separation Between Bike Paths and Highways

Bike paths should not be considered a substitute for the street because many bicyclists will find it less convenient to ride on these types of facilities as compared with the streets, particularly for utility trips. Some problems with bike paths located immediately adjacent to roadways are as follows:

1. Unless paired they require one direction of bicycle traffic to ride against automobile traffic, contrary to normal rules of the road.

2. When the bike path ends, bicyclists going against traffic will tend to continue to travel on the wrong side of the street. Likewise, bicyclists approaching a bike path often travel on the wrong side of the street in getting to the path. Wrong way travel by bicyclists is a major cause of bicycle/automobile accidents and should be discouraged at every opportunity.

3. At intersections, motorists entering or crossing the highway often will not notice bicyclists coming from their right, as they are not expecting contra-flow vehicles. Even bicyclists coming from the left often go unnoticed, especially when sight distances are often poor.

4. When constructed in narrow roadway right-of-way, the shoulder is often sacrificed, thereby decreasing safety for motorists and bicyclists using the roadway.

5. Many bicyclists will use the highway instead of the bike path because they have found the highway to be safer, more convenient or better maintained. Bicyclists using the highway are often subjected to harassment by motorists, who feel that in all cases bicyclists should be on the path instead.

6. Bicyclists using the bike path generally are required to stop or yield at all cross streets and driveways, while bicyclists using the highway usually have priority over cross traffic, because they have the same right-of-way as motorists.

7. Stopped cross street motor vehicle traffic or vehicles exiting side streets or driveways may block the path crossing.

8. Because of the closeness of motor vehicle traffic to opposing bicycle traffic, barriers are often necessary to keep motor vehicles out of bike paths and bicyclists out of traffic lanes. These barriers can be a hazard to bicyclists and motorists, can complicate maintenance of the facility, and can cause other problems as well.

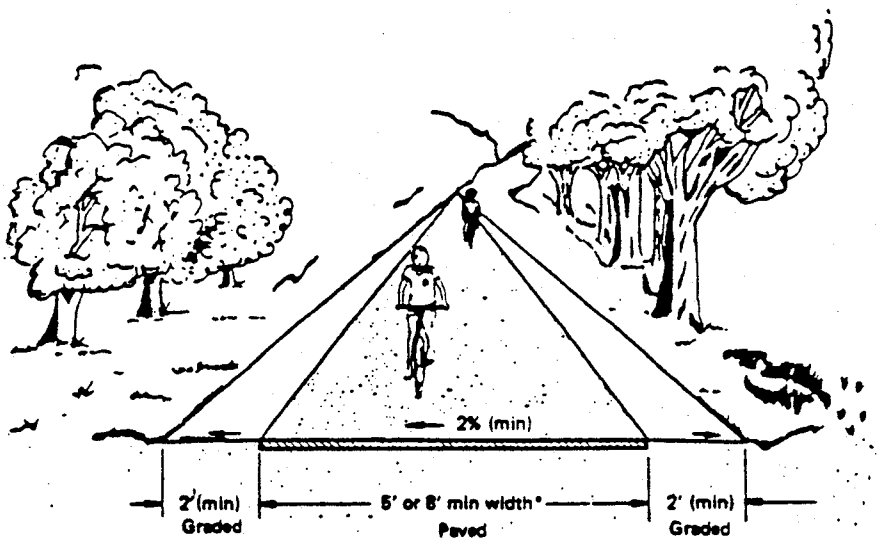
For the above reasons, bike lanes, wide curb-lanes or bike routes (shared use) may be the best way to accommodate bicycle traffic along highway corridors depending upon traffic conditions. [2]

Width and Clearance for Bicycle Paths

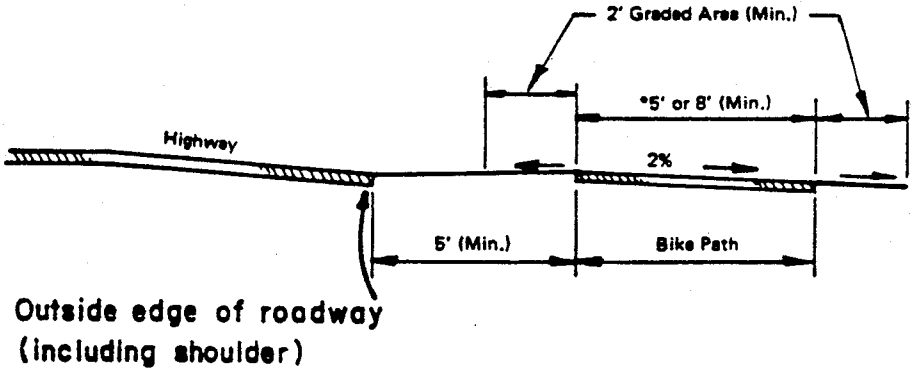
The paved width and the operating width required for a bicycle path are primary design considerations. Figure 6 depicts a bicycle path on a separated right-of-way. Under most conditions, a desirable minimum all-paved width for a two-directional bicycle path is 10 feet (3m). In some instances, however, a minimum of 8 feet (2.4m) can be adequate. This minimum should be used only where the following conditions prevail: (1) bicycle traffic is expected to be low, even on peak days or during peak hours, (2) pedestrian use of the facility is not expected to be more than occasional, (3) there will be good horizontal and vertical alignment, providing safe and frequent passing opportunities, and (4) the path will not be subjected to maintenance vehicle loading conditions that would cause pavement edge damage.

Under certain conditions, it may be necessary or desirable to increase the width of a bicycle path to 12 feet (3.7m); i.e., a substantial bicycle volume, probable shared use with joggers and other pedestrians, use by large maintenance vehicles, steep grades, and where bicyclists will likely to ride two abreast.

The minimum width of a one-directional bicycle path should be 5 feet (1.5m). It should be recognized, however, that one-way bicycle paths often will be used as two way facilities unless effective measures are taken to assure one-way operation. Without such enforcement, it should be assumed that bicycle paths will be used as two-way facilities and designed accordingly.



*One–Way: 5' Minimum Width
Two–Way: 8' Minimum Width
Metric Conversion: 1 ft. = 0.3m.
(Not to Scale)



*One-way: 5' Minimum Width
Two-Way: 8' Minimum Width

FIGURE 6 Two-way bike path on separated right-of-way.

A minimum 2-foot (0.6m) width graded area should be maintained adjacent to both sides of the pavement; however, 3 feet (0.9m) or more is desirable to provide clearance from trees, poles, walls, fences, guardrails, or their lateral obstructions. A wider graded area on either side of the bicycle path can serve as a separate jogging path.

A wide separation between a bicycle path and canals, ditches or other significant depressions is essential for safety. A minimum 5 foot separation from the edge of the bike path pavement to the top of the slope is desirable. If this is not possible, a positive barrier such as dense shrubbery or a chain link fence should be provided. (See Figure 7.)

A wide separation between a bicycle path and an adjacent highway is desirable to confirm to both the bicyclist and the motorist that the bicycle path functions as an independent highway for bicycles. When this is not possible and the distance between the edge of the roadway and the bicycle path is less than 5 feet (1.5m), a suitable physical divider, such as a fence, dense shrubs or other barrier should be included in the design. Such dividers serve both to prevent bicyclists from making unwanted movements between the path and the highway shoulder and to reinforce the concept that the bicycle path is an independent facility. Where used, the divider should be a minimum of 4.5 feet (1.4m) high, to prevent bicyclists from toppling over it, and it should be designed so that it does not become a hazard in itself.

The vertical clearance to obstructions should be a minimum of 8 feet (2.4m). However, vertical clearance may need to be greater to permit passage of maintenance vehicles and, in undercrossings and tunnels, a clearance of 10 feet (3m) is desirable for adequate vertical shy distance.

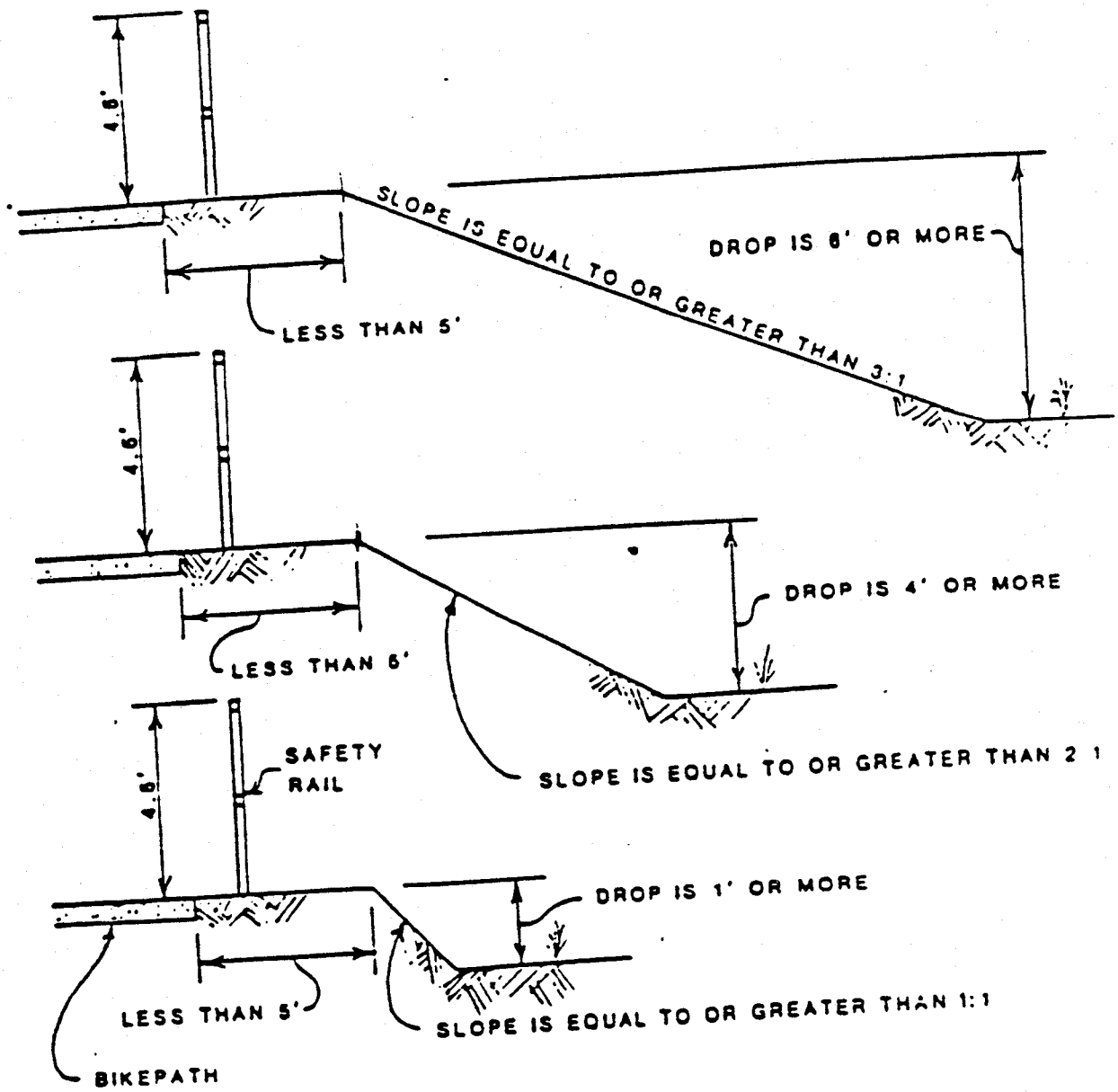
Bicycle Path Design Speed

The speed that a bicyclist travels is dependent on several factors, including the type and condition of the bicycle, the purpose of the trip, the condition and location of the bicycle path, the speed and direction of the wind, and the physical condition of the bicyclist. Bicycle paths should be designed for selected speed that is at least as high as the preferred speed of the faster bicyclists. In general, a minimum design speed of 20 mph (32km/h) should be used, however, when the grade exceeds 4 percent, or where strong prevailing tailwinds exist, a design speed of 30 mph (48km/h) is advisable.

On unpaved paths, where bicyclists tend to ride slower, a lower design speed of 15 mph (24km/h) can be used. Similarly, where the grades of the prevailing winds dictate, a higher design speed of 25 mph (40km/h) can be used. Since bicycles have higher tendency to skid on unpaved surfaces, horizontal curvature design should take into account lower coefficients of friction.

"Speed bumps" or similar surface obstructions, intended to slow down bicyclists in advance of intersections, should not be used.

BIKEPATH SAFETY RAILS ALONG SIDE SLOPES



SAFETY RAIL IS NEEDED WHERE THE CONDITIONS WILL EXCEED THE ABOVE DEPICTED LIMITS

FIGURE 7

Source: 7

Bicycle Path Horizontal Alignment and Superelevation

The minimum radius of curvature negotiable by a bicycle is a function of the super elevation rate at a bicycle path surface, the coefficient of friction between the bicycle tires and the bicycle path surface, and the speed of the bicycle. The minimum design radius of curvature can be derived from the following formula.

$$R = \frac{V2}{15\ (e + f)}$$

Where R = Minimum radius of curvature (ft.),
V = Design speed (mph),
e = Rate of super elevation,
f = coefficient of friction,

For most bicycle path applications, the super elevation rate will vary from a minimum of 2 percent (the minimum necessary to encourage adequate drainage) to a maximum of approximately 5 percent (beyond which maneuvering difficulties by slow bicyclists and adult tricyclists might be expected). The minimum super elevation rate of 2 percent will be adequate for most conditions and will simplify construction.

The coefficient of friction depends upon speed; surface type, roughness, and condition; tire type and condition; and whether the surface is wet or dry. Friction factors used for design should be selected based upon the point at which centrifugal force causes the bicyclist to recognize a feeling of discomfort and instinctively act to avoid higher speed. Extrapolating from values used in highway design, design friction factors for paved bicycle paths can be assumed to vary from 0.30 at 15 mph (24km/h), to 0.22 at 30 mph (48km/h). Although there are no data available for unpaved surfaces, it is suggested that friction factors be reduced by 50 percent to allow a sufficient margin of safety.

Based upon a superelevation rate (e) of 2 percent, minimum radii of curvature can be selected from Table 1.

TABLE 1

DESIGN RADII FOR PAVED BICYCLE PATHS

Design Speed - V (mph) (1 mph = 1/6km/hr)	(e = 2 percent) Friction Factor - f	Design Radius (Feet) (1 ft. = 0.3m)
20	0.27	95
25	0.25	155
30	0.22	250
35	0.19	390
40	0.17	565

When substandard radius curves must be used on bicycle paths because of right-of-way, topographical or other considerations, standard curve warning signs and supplemental pavement markings shall be installed in accordance with the MUTCD. The negative effects of substandard curves can also be partially offset by widening the pavement through the curves.

Grades on Bicycle Paths

Grades on bicycle paths should be kept to a minimum, especially on long inclines. Grades greater than 5 percent are undesirable because the ascents are difficult for many bicyclists to climb and the descents cause some bicyclists to exceed the speeds at which they are competent. Where terrain dictates, grades over 5 percent and less than 500 feet (150m) long are acceptable when a higher design speed is used and additional width is provided.

Bicycle Path Sight Distance

To provide bicyclists with an opportunity to see and react to the unexpected, a bicycle path should be designed with adequate stopping distances. 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. [3]

Figure 8 indicates the minimum stopping sight distance for various design speeds and grades based on a total perception and brake reaction time of 2.5 seconds and a coefficient of friction of 0.25 to account for the poor wet weather braking characteristics of many bicycles. For two-way bicycle paths, the sight distance in the descending direction, that is, where "G" is negative, will control the design.

Figure 9 is used to select the minimum length of vertical curve necessary to provide minimum stopping sight distance at various speeds on crests. The eye height of the bicyclist is assumed to be 4.5 feet (1.4m) and the object height is assumed to be zero to recognize that hazards to bicycle travel exist at pavement level.

Figure 10 indicates the minimum clearance that should be used to line-of-sight obstructions for horizontal curves. The desired lateral clearance is obtained by entering Figure 10 with the stopping sight distance from Figure 8 and the proposed horizontal radius of curvature.

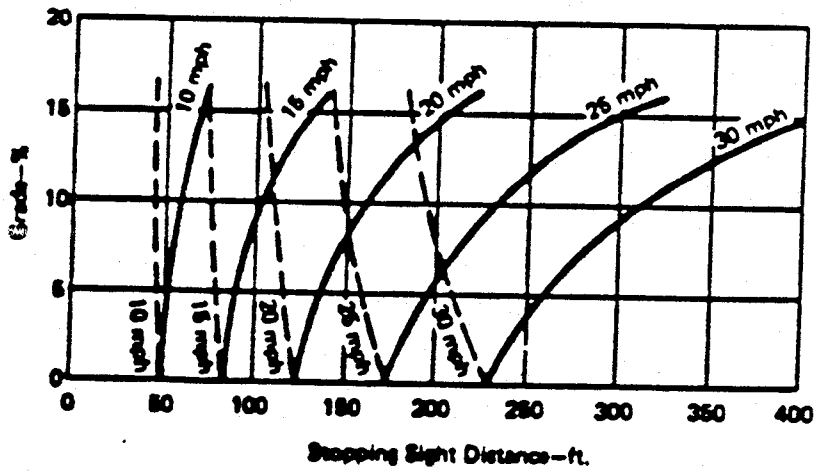
Bicyclists frequently ride abreast of each other on bicycle paths and, on narrow bicycle paths, bicyclists have a tendency to ride near the middle of the path. For these reasons, and because of the serious consequences of a head-on bicycle accident, lateral clearances on horizontal curves should be calculated 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, consideration should be given to widening the path through the curve, installing a yellow center stripe, installing a "curve ahead" warning sign, in accordance with the MUTCD, or some combination of these alternatives.

Intersections with Bicycle Paths

Intersections are an important consideration in bicycle path design. If alternate locations for a bike path are available, the one with the most favorable intersection conditions should be selected. The ideal intersection design is a grade separation, but in many cases its cost is prohibitive. Some recommended intersection treatments are shown in Figures 11 through 15.

When intersections occur at grade, a major consideration is the establishment of right-of-way. The type of traffic control to be used (signal, stop or yield sign, etc.) and location should be in accordance with the MUTCD. Care should be taken to ensure that bike path signs are located so that motorists are not confused by them, and that highway signs are placed so that cyclists are not confused by them. At crossings with infrequent automobile traffic such as residential or commercial driveways, bicycles should be given priority. In any event adequate sight distance and proper signing must be provided.

It is preferable that the crossing of a bicycle path and a highway be at a location away from the influence of intersections with other highways. Controlling vehicle movements at such intersections is more easily and safely accomplished through the application of standard traffic control devices and



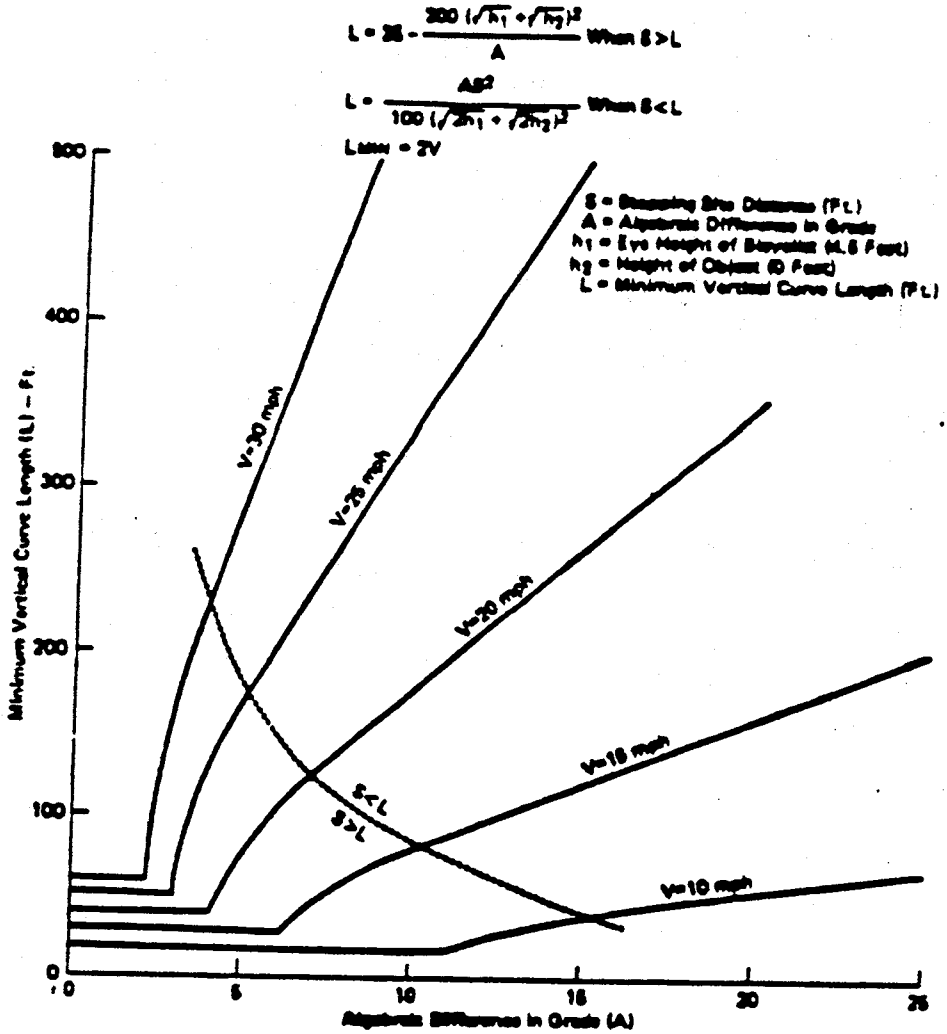
$$S = \frac{V^2}{30(f \pm G)} + 2.67V$$

where: S = stopping sight distance, ft.
V = velocity, mph
f = coefficient of friction (use 0.25)
G = grade ft./ft. (rise/run)

(-G) Descend ————
(+G) Ascend — — — —

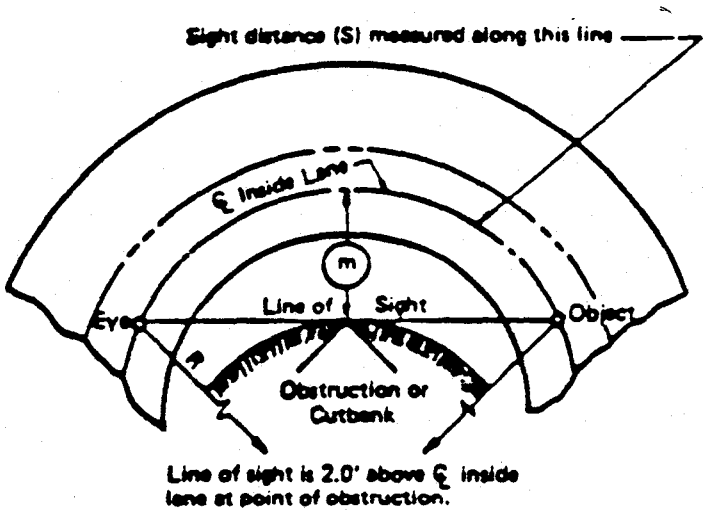
Source: AASHTO Guide For Development Of New Bicycle Facilities, October, 1981.

FIGURE 8 Stopping sight distances.



Source: AASHTO Guide For Development Of New Bicycle Facilities

FIGURE 9 Sight distances for crest vertical curves.



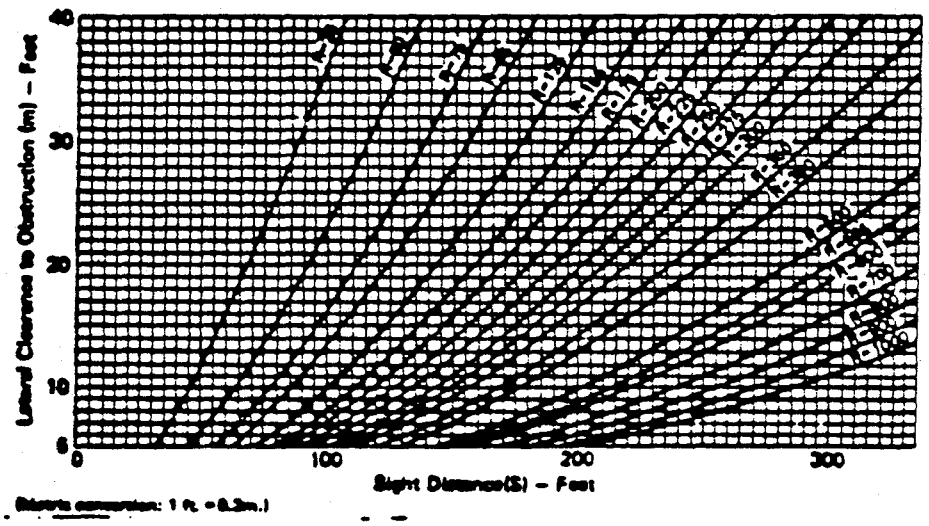
S = Sight distance in feet
R = Radium of ℄ inside lane in feet
M = Distance from ℄ inside lane in feet
V = Design speed for S in mph

Angle is expressed in degrees

$$m = R\left[\text{vers}\left(\frac{28.65S}{R}\right)\right]$$

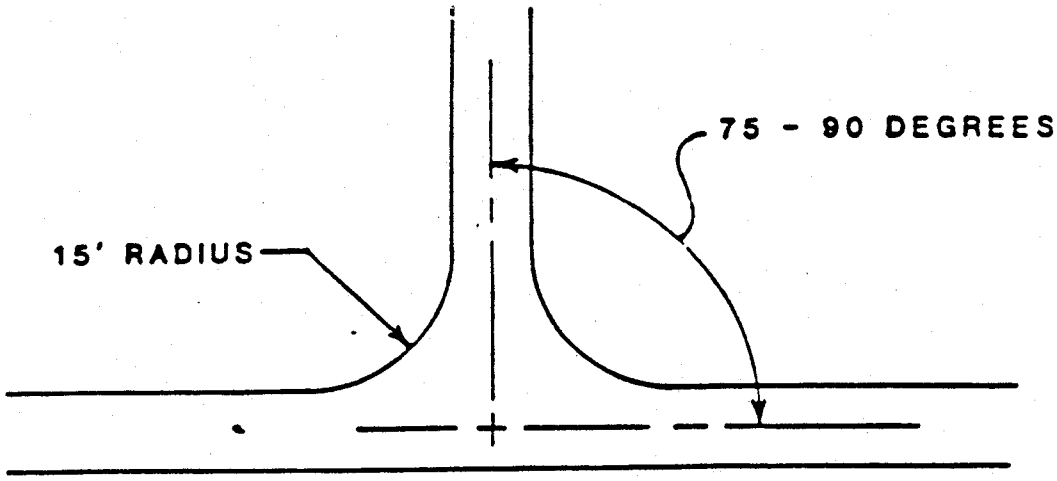
$$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R-m}{R}\right)\right]$$

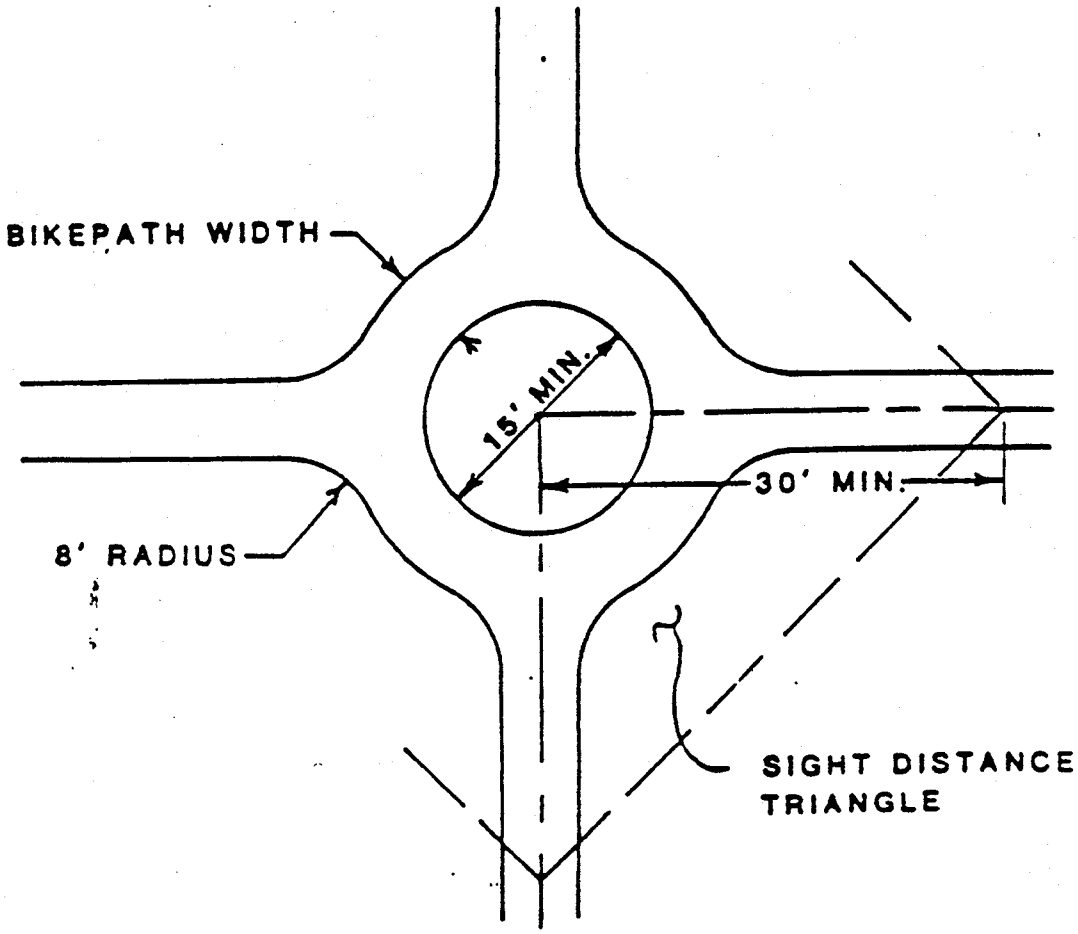
Formula applies only when S is equal to or less than length of curve.



Source: AASHTO Guide For Development Of New Bicycle Facilities

FIGURE 10 Lateral clearances on horizontal curves.





BIKEPATH INTERSECTIONS

FIGURE 11

Source 7

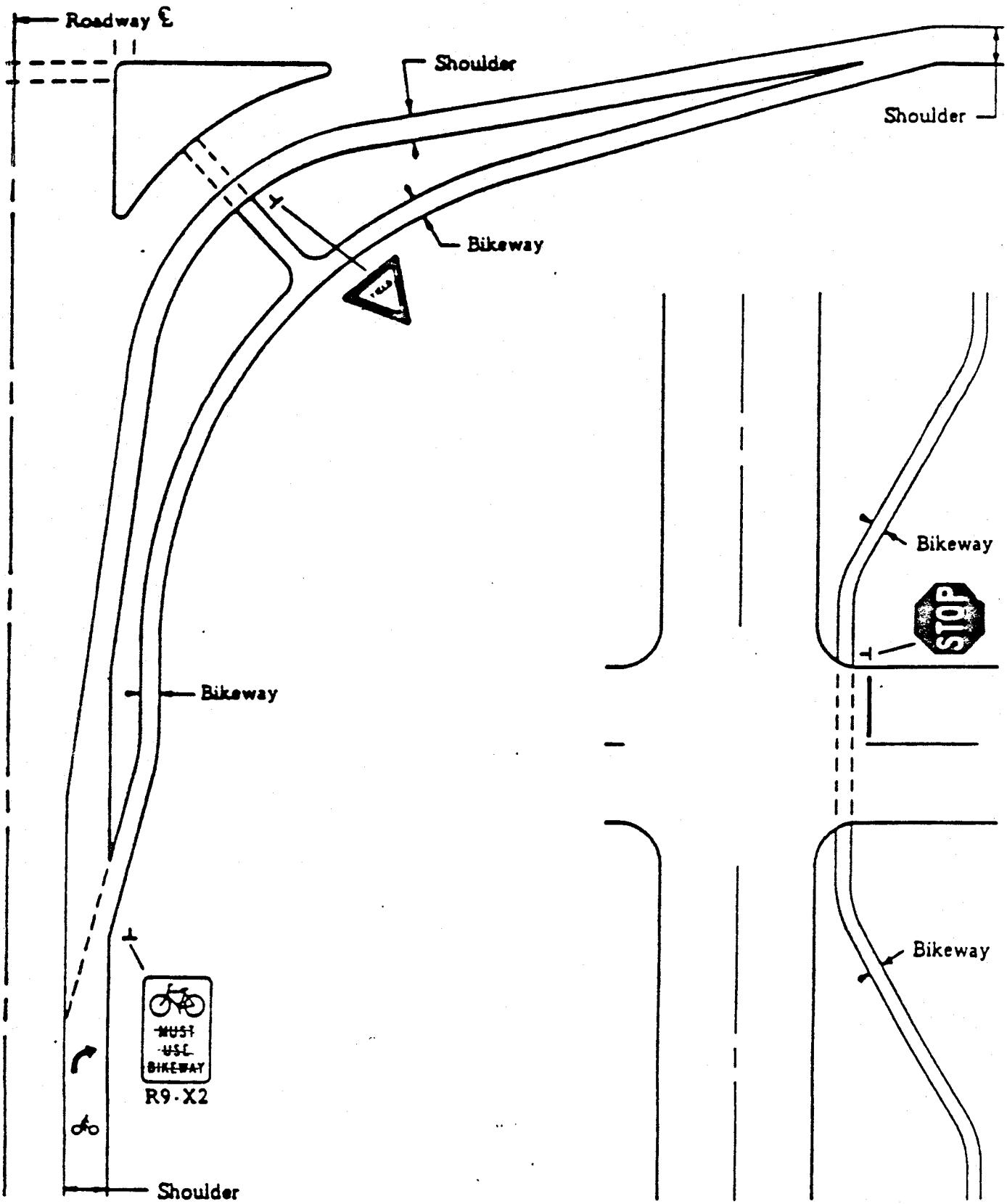


FIGURE 12
HIGH SPEED - HIGH VOLUME
ON ROAD TO OFF ROAD TREATMENT

FIGURE 13
OFFSET BIKEWAYS
INTERSECTION TREATMENT

Source: 8, p 36

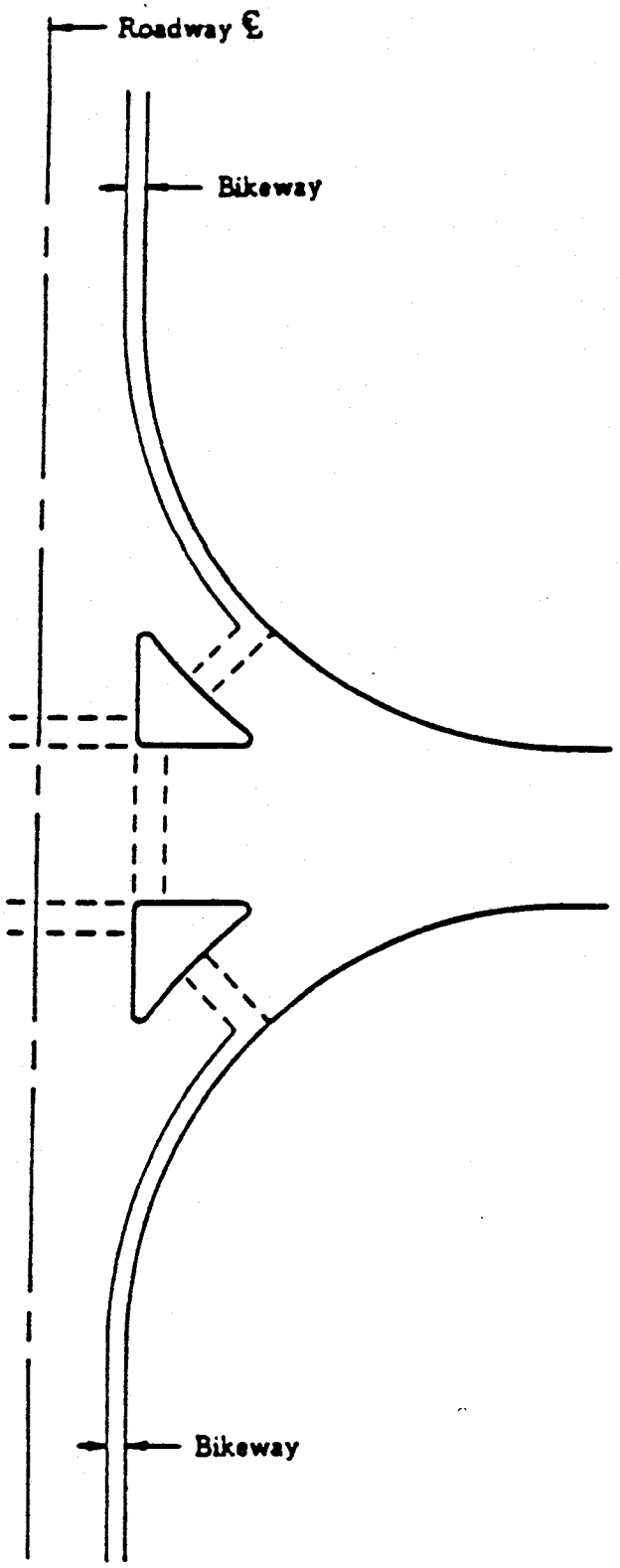


FIGURE 14
LOW SPEED - LOW VOLUME TREATMENT

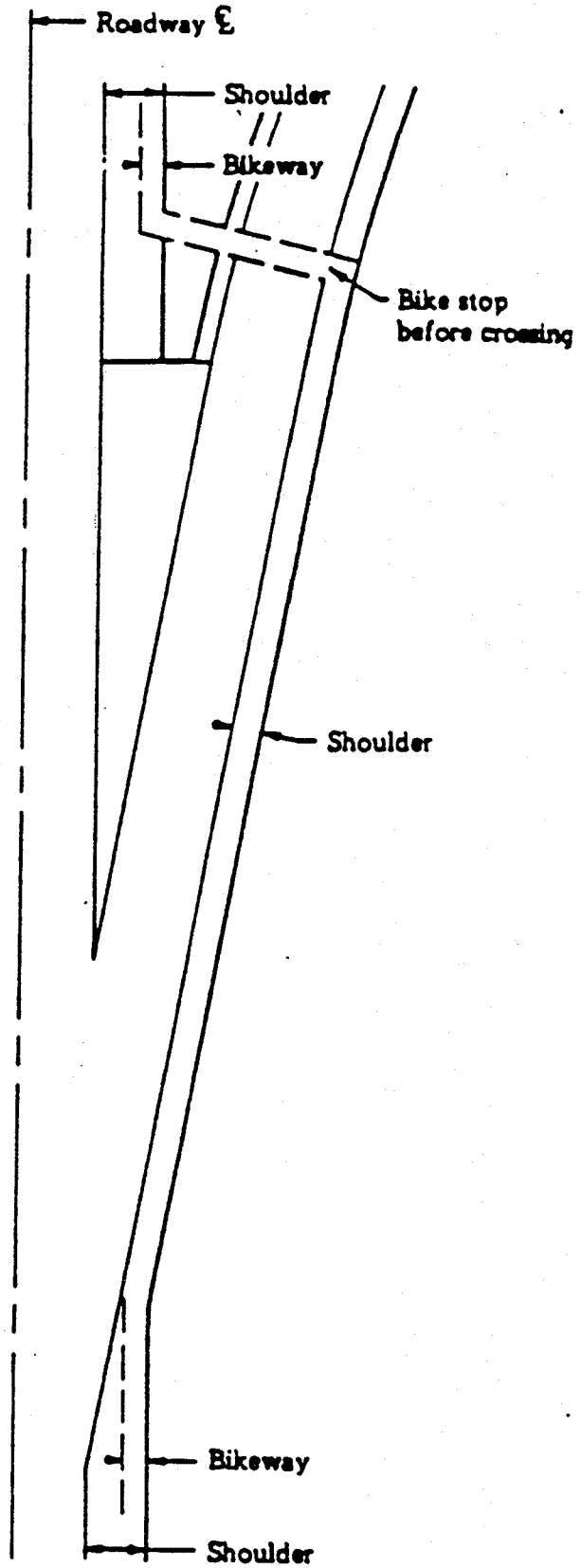


FIGURE 15
HIGH SPEED - LOW VOLUME
BIKEWAY TREATMENT

Source: 8, p. 35

normal Rules of the Road. Where physical constraints prohibit such independent intersections, the crossings may be at or adjacent to the pedestrian crossing, rights of way should be assigned and sight distance should be provided so as to minimize the potential for conflict resulting from unconventional turning movements. At crossings of high-volume multilane arterial highways where signals are not warranted, consideration should be given to providing a median refuge area for crossing bicyclists.

Bicycle path intersections and approaches should be on flat grades (to allow for starting and stopping and adequate line-of-sight requirements). Stopping sight distances at intersections must be checked and adequate warning be provided to permit bicyclists to stop before reaching the intersection, especially on downgrades.

The maximum grade of the approaches should be 5 percent. Consideration should be given to a flat approach preceded by a short, steep, vertical section, in areas where slopes are unavoidable.

Curb-cuts at intersections should be the same width as the bicycle paths. Curb-cuts and ramps should provide a smooth transition between the bicycle path along the roadway. [3]

Signing and Marking Bicycle Paths

Adequate signing and marking are essential on bicycle paths, especially to alert bicyclists to potential hazards and to convey regulatory messages to both bicyclists and motorists at highway intersections. In addition, guide signing, such as to indicate directions, destinations, distances, route numbers, and names of crossing streets, should be used in the same manner as they are used on highways. In general, uniform application of traffic control devices, as described in the MUTCD, will tend to encourage proper bicyclist behavior.

Care should be exercised in the choice of pavement marking materials. Some marking materials, for example, are slippery when wet and should be avoided in favor of more skid resistant materials. Paint is preferred.

General guidance on signing and marking is provided in the MUTCD. Part IX of the MUTCD refers specifically to traffic controls for bicycle facilities. (See Appendix A). Also see Figures 2 and 3.

Pavement Structure for Bicycle Paths

Designing and selecting pavement sections for bicycle paths is in many ways similar to designing and selecting highway pavement sections. A soils investigation should be conducted to determine the load carrying capabilities of the native soil and the need for any special provisions. The investigation need not be elaborate, but should be done by, or under the supervision of, a qualified engineer.

In addition, there are several basic principles that should be followed to recognize some basic differences between the operating characteristics of bicycles and those of motor vehicles. While loads in bicycle paths will be substantially less than highway loads, paths should be designed to sustain without damage wheel loads of occasional emergency, patrol, maintenance, and other motor vehicles that are expected to use or cross the path.

Special consideration should be given to the location of motor vehicle wheel loads on the path. When motor vehicles are driven on bicycle paths, their wheels will usually be at or very near the edges of the path. Since this can cause edge damage that, in turn, will result in the lowering of the effective operating width of the path, adequate edge support should be provided. Edge support can be either in the form of stabilized shoulders or in constructing additional pavement width. Constructing a typical pavement width of twelve feet, where right-of-way and other conditions permit, eliminates the edge raveling problem and offers two other additional advantages over shoulder construction. First, it allows additional maneuvering space for bicyclists and second, the additional construction cost can be less than for constructing shoulders because the separate construction operation is eliminated.

It is important to construct and maintain a smooth riding surface on bicycle paths. Bicycle path pavements should be machine laid; soil sterilants should be used where necessary to prevent vegetation from erupting through the pavement; and, on portland cement concrete pavements, transverse joints, necessary to control cracking, should be saw cut to provide a smooth ride. On the other hand, however, skid resistance qualities should not be sacrificed for the sake of smoothness. Broom finish or burlap drag concrete surfaces are preferred over trowel finishes, for example.

At unpaved highway or driveway crossings of bicycle paths, the highway or driveway should be paved a minimum of 10 feet on either side of the crossing to reduce the amount of gravel being scattered along the path by motor vehicles. The pavement structure at the crossing should be adequate to sustain the expected loading at that location.

Hard, all weather pavement surfaces are usually preferred over those of crushed aggregate, sand, clay, or stabilized earth since these materials provide a much lower level of service.

Good quality pavement structures can be constructed with asphaltic or portland cement concrete. Because of wide variations in soils, loads, materials and construction practices, it is not practical to present specific or recommended typical structural sections that will be applicable statewide. Attention to the local governing conditions and to the principles outlined above is needed. Experience in highway pavement, together with sound engineering judgment, can assist in the selection and design of a proper bicycle path pavement structure and may identify energy conserving practices, such as the use of sulfur-extended asphalt, asphalt emulsions, and fused waste.

There are several combinations of the above mentioned materials possible in designing the full structural section. One design that has been found satisfactory makes use of full-depth, hot mix asphalt pavement laid directly on the subgrade, (Figure 6a), with soil sterilization. The total thickness may vary from 3 to 6 inches (80 mm to 150 mm), depending on the quality of the subgrade. With this design, regular highway mixes can be used, provided they are dense graded, i.e., not more than 10 percent air voids. A fine-graded aggregate should be used in the surface course to provide a smooth texture.

Another desirable structural section consists of a 3-inch thick (80 mm) to 4-inch (100 mm) base of stabilized limerock with a 1-1/2-inch (40 mm) to 2-inch (50 mm) asphalt surface course (Figure 6b). This pavement structure is usually preferable to the full-depth, hot-mix type, because it is more economical than the full-depth course.

Portland cement concrete may also be used for bicycle paths. As mentioned previously on Portland cement concrete pavements, transverse joints necessary to control cracking must be saw cut to provide a smooth ride; however, skid resistant qualities should not be sacrificed for the sake of smoothness. A structural section of the type normally used for pedestrian walks is adequate for bicycle traffic, but a heavier section is necessary where vehicles use or cross the path. A typical Portland cement concrete structural section is shown on Figure 6(c).

Structures on Bicycle Paths

An overpass, small bridge or facility on a highway bridge may be necessary to provide continuity to a bicycle path. On new structures, the minimum clear width should be the same as the approach paved bicycle path, and the desirable clear width shall include the minimum 2-foot (0.6m) wide clear areas. Carrying the clear areas across the structures has two advantages. First, it provides a minimum horizontal shy distance from the railing or barrier, and second, it provides needed maneuvering space to avoid conflicts with pedestrians and other bicyclists who are stopped on the bridge. Access by emergency, patrol, and maintenance vehicles should be considered in establishing the design clearances of structures on bicycle paths. Similarly, vertical clearance also may be dictated by occasional motor vehicles using the path. However, where practical, a vertical clearance of 10 feet (3M) is desirable for adequate vertical shy distance.

Figure 17 shows a suggested bike overpass crossing a major street or expressway. Figure 18 shows a suggested bike bridge for crossing a canal or wash.

Railings, fences, or barriers on both sides of a bicycle path bridge should be a minimum of 4.5 feet (1.4m) high. Smooth rub rails should be attached to the barriers at a handlebar height of 3.5 feet (1.1m).

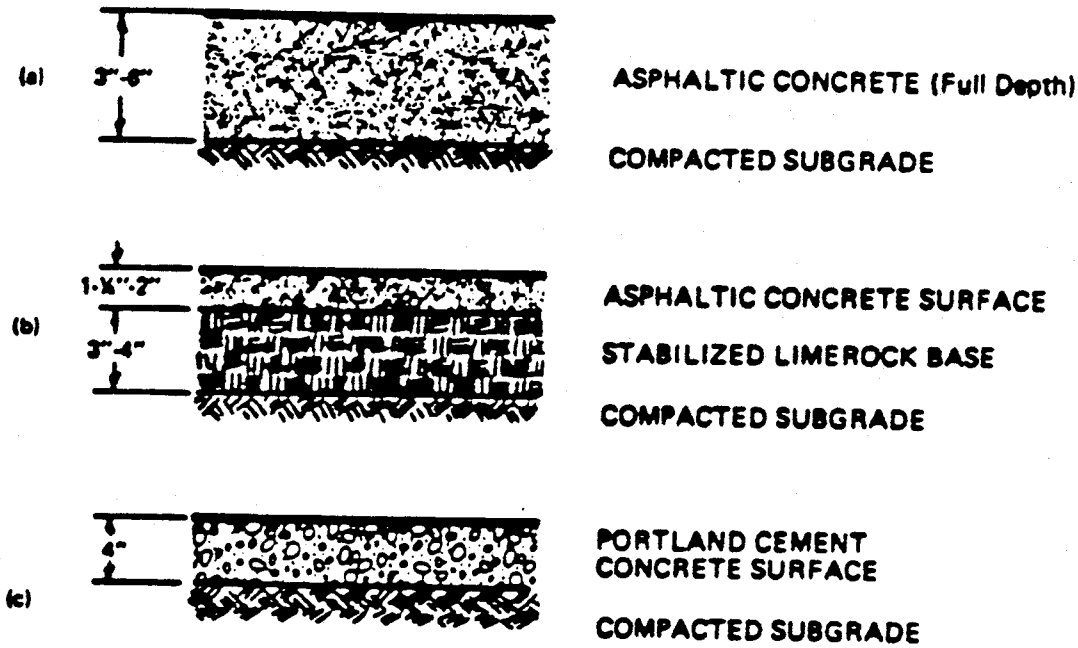


FIGURE 16 Typical pavement structural sections for bike paths.

Bridges designed exclusively for bicycle traffic may be designed for pedestrian live loadings. On all bridge decks, special care should be taken to ensure that bicycle-safe expansion joints are used.

Where it is necessary to continue a bicycle path onto a highway bridge, several alternatives should be considered in light of what the geometrics of the bridge will allow. (See Figure 19 for both new and retrofit conditions.)

One option is to carry the bicycle path across the bridge on one side. This should be done where: (1) the bridge facility will connect to a bicycle path at both ends, (2) sufficient width exists on the side of the bridge or can be obtained by widening or restriping lanes, and (3) provisions are made to physically separate bicycle traffic from motor vehicle traffic as discussed above.

A second option is to provide either wide curb lanes or bicycle lanes over the bridge. This may be advisable where (1) a one-way bicycle path becomes bicycle lanes at one end of the bridge which will allow the cyclist to cross in the same direction as motor vehicle flow, and (2) sufficient width exists or can be obtained by widening or restriping.

A third option is to use existing sidewalks as one-way or two-way facilities. This may be advisable where (1) conflicts between bicyclists and pedestrians will not exceed tolerable limits, and (2) the existing sidewalks are adequately wide.

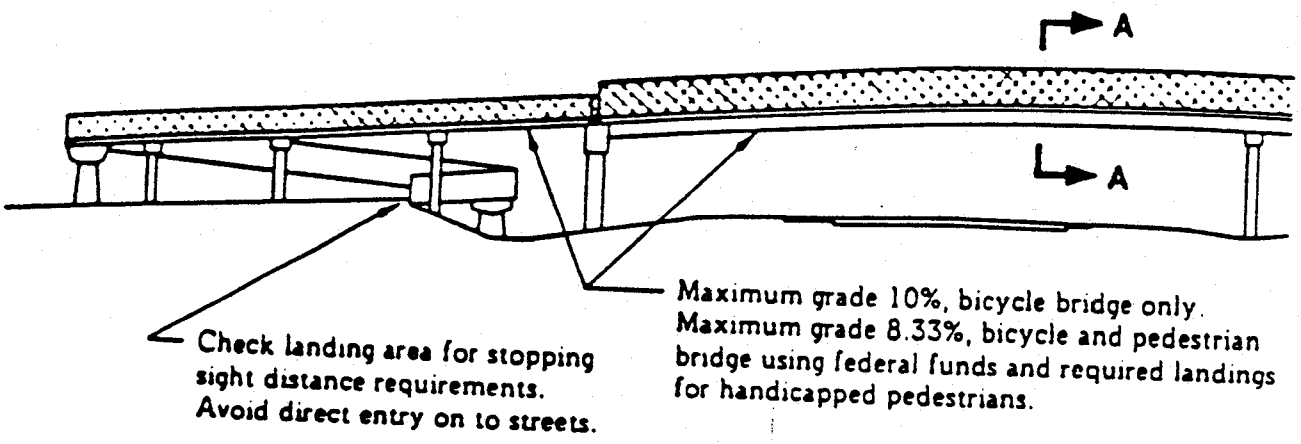
Figures 20 and 21 illustrate ways to continue a bicycle path under a new or existing bridge.

Because of the large number of parameters involved in retrofitting bicycle facilities onto existing bridges, compromises in desirable design criteria are often inevitable. Therefore, the width to be provided is best determined by the designer, on a case by case basis, after thoroughly considering all the parameters.

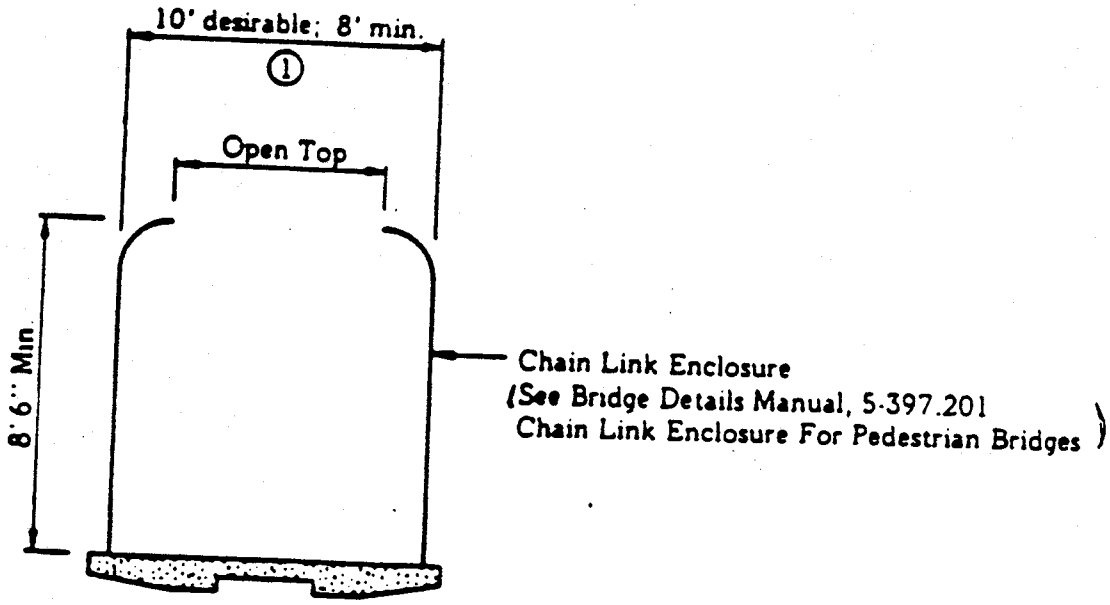
In some cases, an underpass will be the best way to carry a bicycle path under a highway. Figure 22 shows alternate underpass cross-sections for bicycle paths.

Drainage for Bicycle Paths

The recommended minimum pavement cross slope of 2 percent adequately provides for drainage. Sloping in one of the directions instead of crowning is preferred and usually simplifies the drainage and surface construction. A smooth surface is essential to prevent water ponding and potential ice formation in certain areas. Where a bicycle path is constructed on the side of the hill, a ditch of suitable dimensions should be placed on the uphill side to intercept the hillside drainage. Such ditches should not create hazards for bicyclists. Where necessary, catch basins with drains should be provided to carry the intercepted water under the path. Drainage grates and manhole covers



HALF ELEVATION



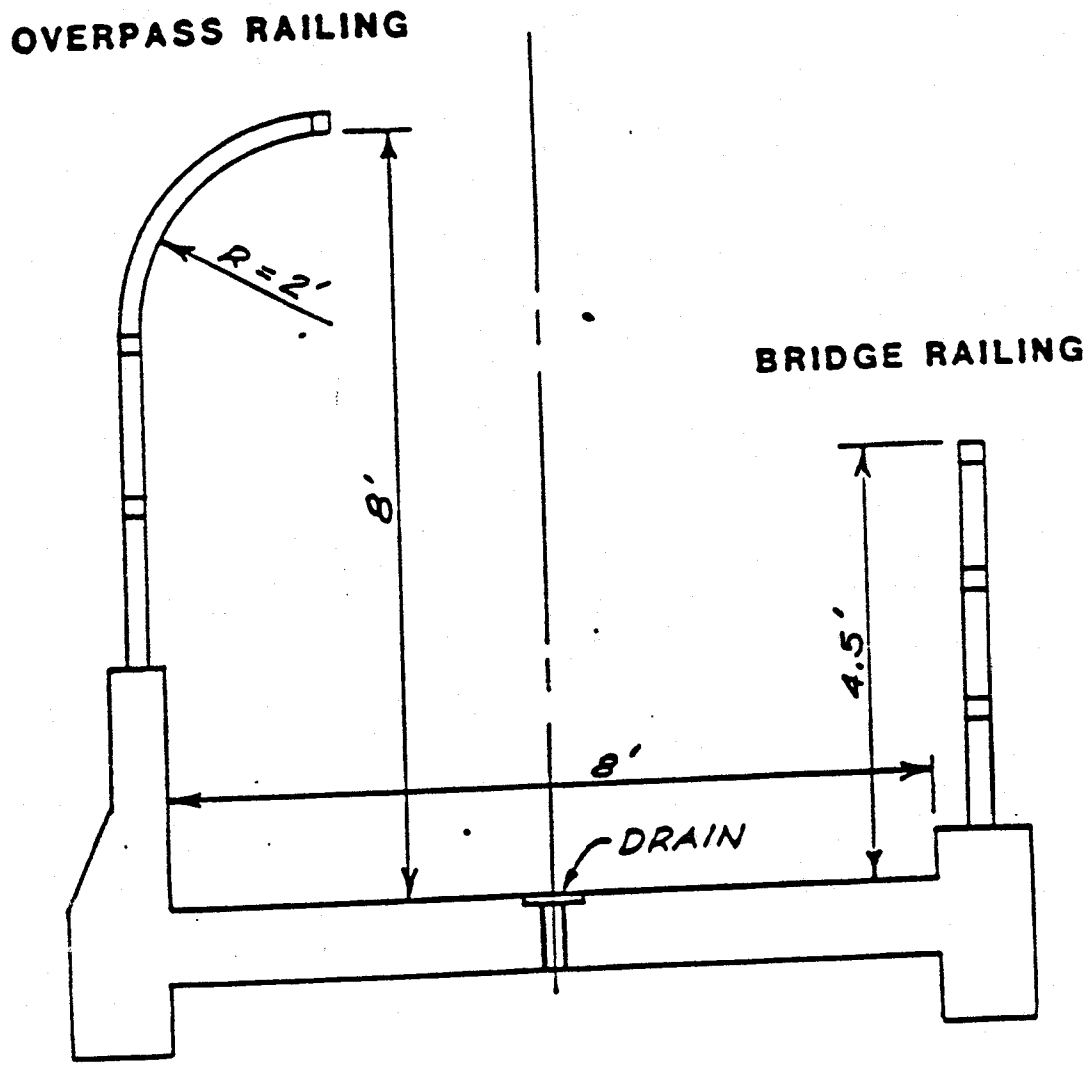
SECTION A-A

1 In areas where it is not economically feasable to separate the pedestrian and bicyclists on the bridge, it is recommended that an 8 foot minimum clear zone be utilized, for a width. In areas where more than occasional encounters between groups of pedestrians and cyclists can be anticipated, provision of facilities wider than the above minimum is desirable.

FIGURE 17

SEPARATE BIKEWAY BRIDGE

Source: 8, p 27



THE OVERPASS RAILING IS FOR BOTH SIDES OF A PATH CROSSING OVER A STREET. THE BRIDGE RAILING IS FOR BOTH SIDES OF A PATH CROSSING A CANAL OR WASH.

BIKEPATH OVERPASS OR BRIDGE

FIGURE 18

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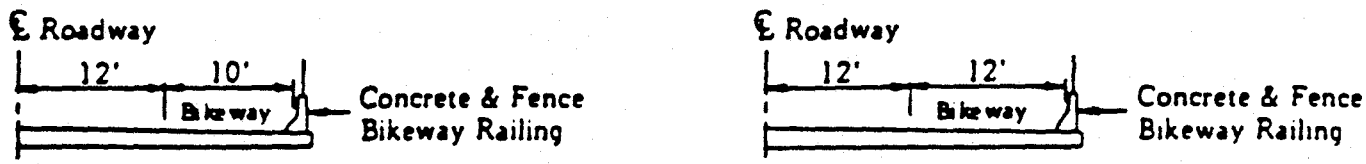
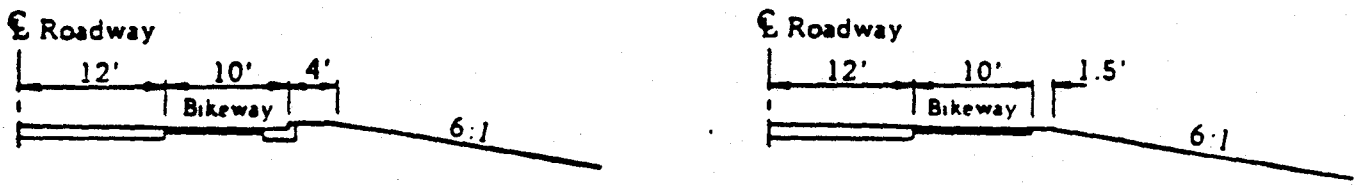
URBAN DESIGNS
See Bridge Design Manual · Fig. D 5-392.203

RURAL DESIGNS
See Bridge Design Manual · Fig. C 5-392.203

On Road Bikeways

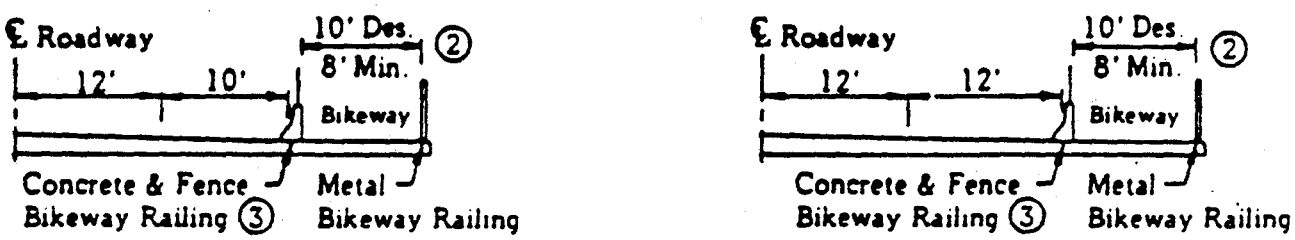


BRIDGE DECK SECTIONS

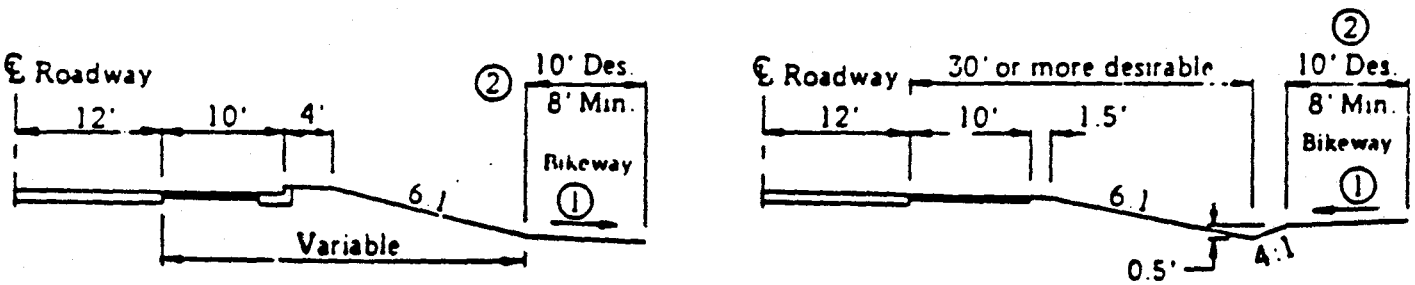


APPROACHING ROADWAY SECTIONS

Off Road Bikeways



BRIDGE DECK SECTIONS



APPROACHING ROADWAY SECTIONS

NOTES:

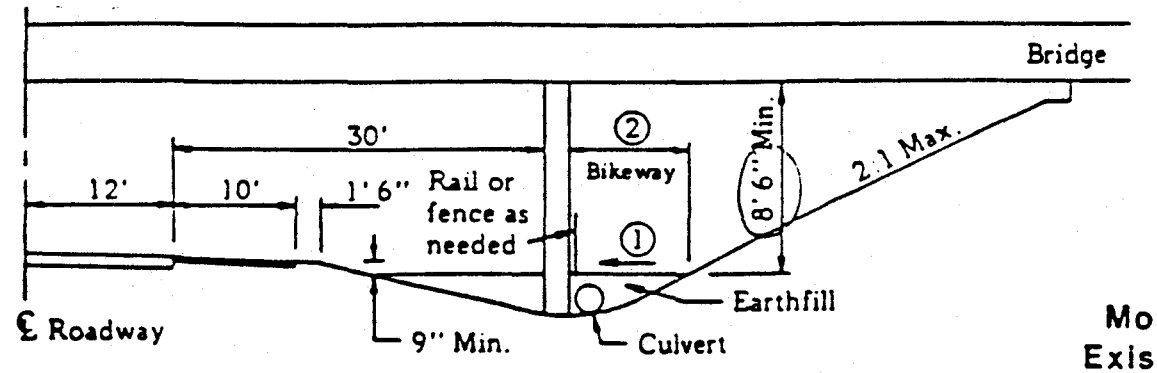
① .02 ft./ft. slope
② Minimum width. Includes provision for pedestrians
③ If shoulder width is ≤ 6' no fence is required on top of barrier.

See section F, WIDTHS AND CLEARANCES for explanation of bikeway width.

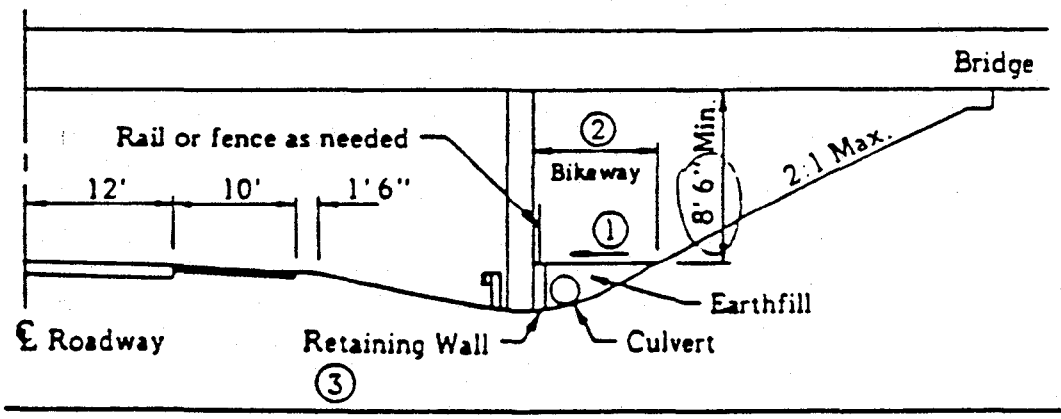
FIGURE 19

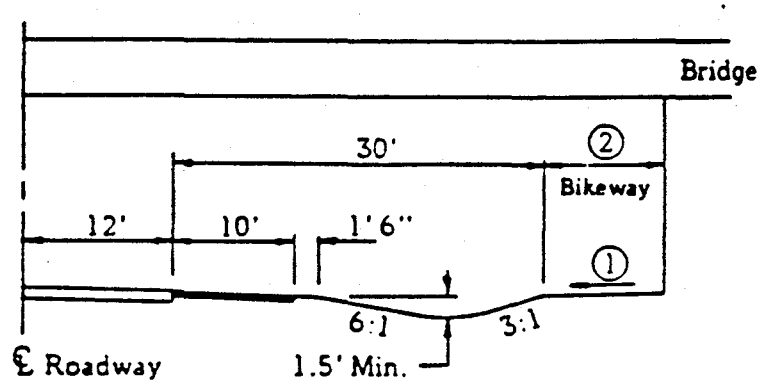
DESIGNS FOR BRIDGE DECKS WITH BIKEWAYS

Source: 8, p 25.

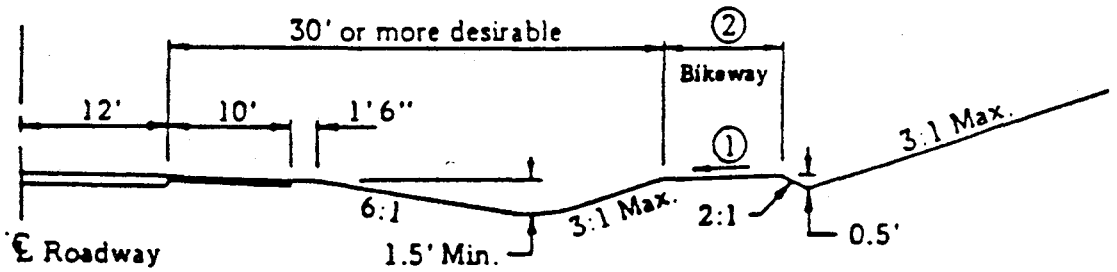


Modification Of Existing Facilities





Design For New Facilities



Approaching Roadway

① 0.2 ft./ft. slope

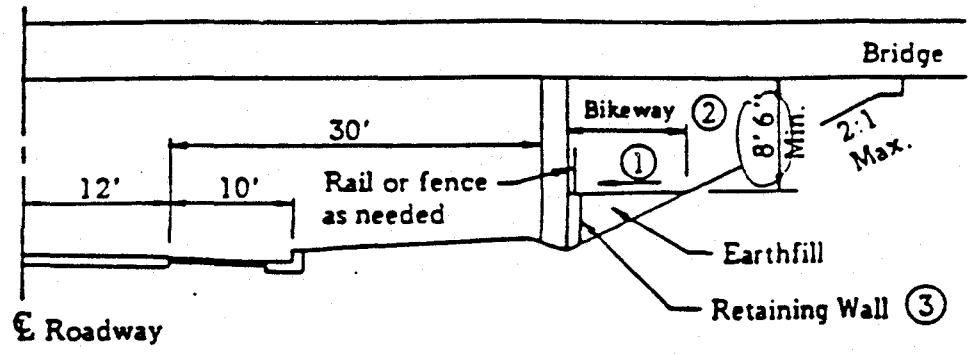
② 10' desirable: 8' minimum. See section F for explanation.

③ A barrier wall (Standard Plans 5-297.601 and .603) may be used between piers.

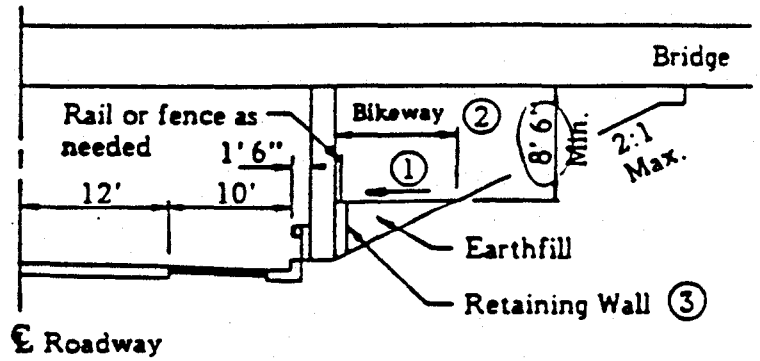
FIGURE 20

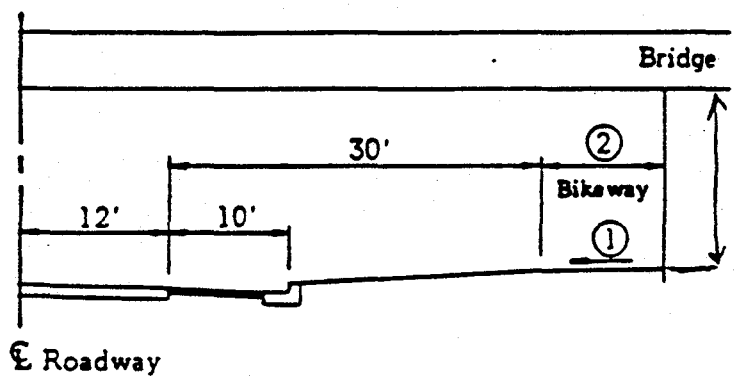
OFF ROAD BIKEWAYS UNDER BRIDGE STRUCTURES - RURAL

Source 8, p 28

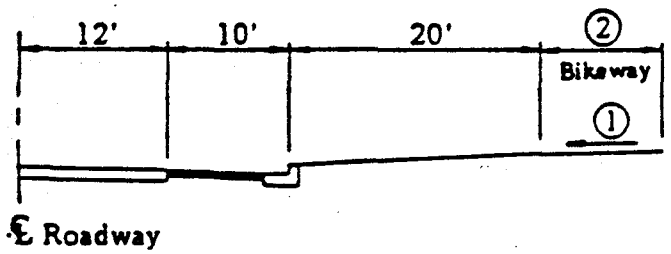


Modification Of Existing Facilities





Design For New Facilities



Approaching Roadway

① 0.2 ft./ft. slope

② 10' desirable: 8' minimum. See section F for explanation.

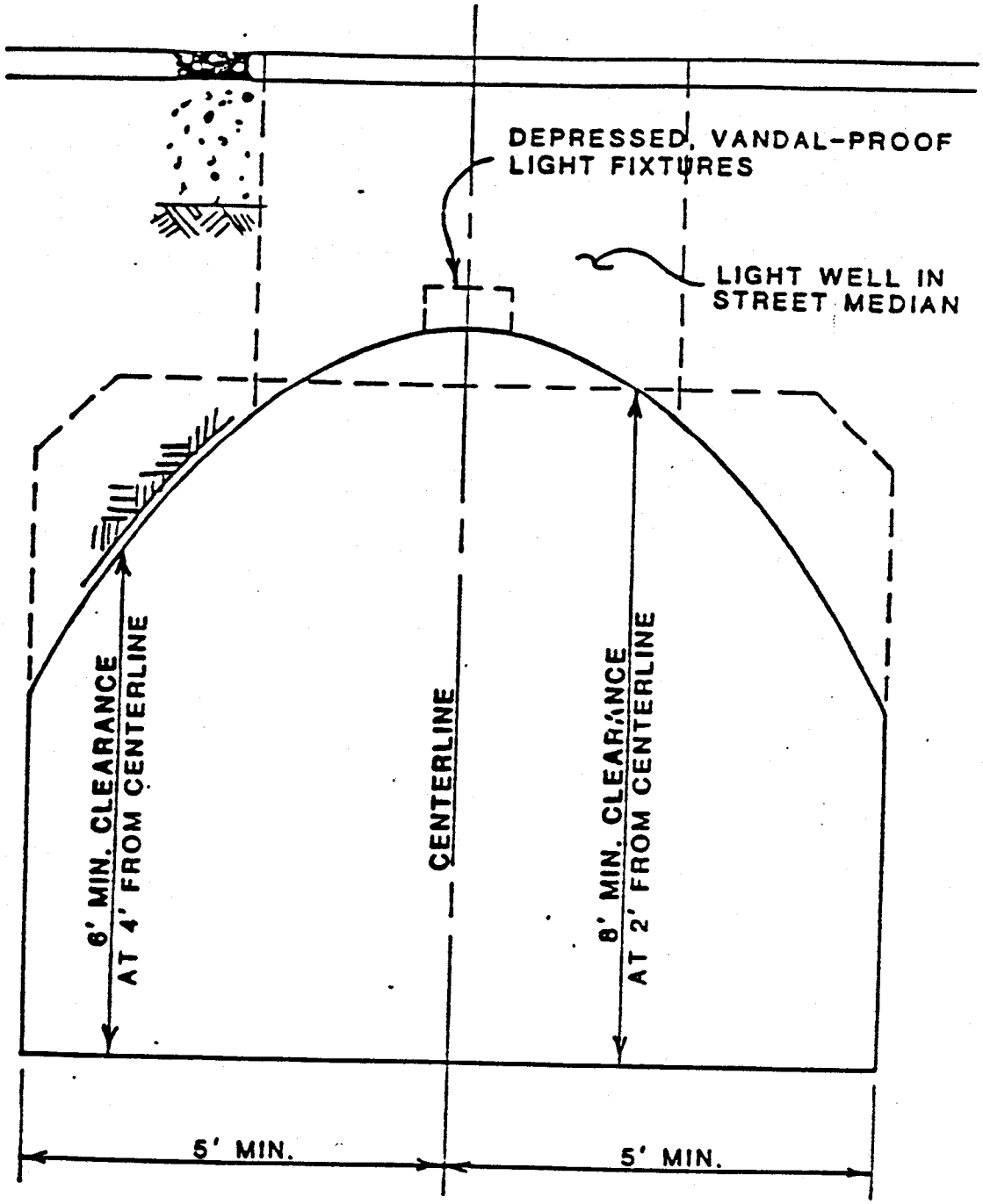
③ A barrier wall (Standard Plans 5-297.601 and .603) may be used between piers.

FIGURE 21

OFF ROAD BIKEWAYS UNDER BRIDGE STRUCTURES - URBAN

Source: 8, p 24.

should be located outside of the travel path of bicyclists. To assist in draining the area adjacent to the bicycle path, the design should include considerations for preserving the natural ground cover. Seeding, mulching, and sodding of adjacent slopes, swales, and other erodible areas shall be included in the design plans.



BIKEPATH UNDERPASS

FIGURE 22

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MULTI-USE BICYCLE PATHS

In general, multi-use paths are undesirable, bicycles and pedestrians do not mix well. Whenever possible, separate bicycle and pedestrian paths should be provided. If this is not feasible, additional width, signing and striping should be used to minimize conflicts.

Sidewalks

Providing a sidewalk bicycle path is unsatisfactory for a variety of reasons. Sidewalks are typically designed for pedestrian speeds and are not safe for higher speed use. Conflicts are common between pedestrians traveling at low speeds (or exiting stores, parked cars, etc.) and bicyclists, as are conflicts with fixed objects (e.g., parking meters, utility poles, sign posts, bus benches, trees, fire hydrants, mailboxes, etc.). Walkers, joggers, and roller skaters can, and often do change their speed and direction almost instantaneously, leaving bicyclists insufficient time to react and avoid collisions.

Lighting for Bicycle Paths

Fixed-source lighting reduces 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 cyclists riding at night are expected, such as bicycle paths serving college students or commuters, and at highway intersections. Lighting should also be considered through underpasses of tunnels, and when nighttime security could be a problem. Depending on the location, average maintained horizontal illumination levels of 0.5 foot-candle (5 lux) to 2-foot candles (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.

Restriction of Motor Vehicle Traffic on Bicycle Paths

Bicycle paths often need some form of physical barrier at highway intersections to prevent unauthorized motor vehicles from using the facilities. Provisions can be made for a lockable, removable post to permit entrance by authorized vehicles. The post should be permanently reflectorized for nighttime visibility and painted a bright color for improved daytime visibility. When more than one post is used, a 5-foot (1.5m) spacing is desirable. Wider spacing might prevent entry by adult tricycles and bicycles with trailers.

An alternative method of restricting entry of motor vehicles is to split the entry way into two 5-feet (1.5m) sections separated by low landscaping. Emergency vehicles can still enter if necessary by straddling the landscaping. The higher maintenance costs associated with landscaping should be acknowledged, however, before this alternative method is selected.

Similarly, pedestrians often have difficulty predicting the direction an oncoming bicyclist will take. At intersections, motorists are often not looking for bicyclists (who are traveling at higher speeds than pedestrians) entering the crosswalk area, particularly when motorists are making a turn. Sight distance is often impaired by buildings, walls, property fences, and shrubs along sidewalks, especially at driveways. In addition, use of sidewalks can encourage wrong way bicycling.

It is important to recognize that the development of extremely wide sidewalks does not necessarily add to the safety of sidewalk bicycle travel. Wide sidewalks encourage higher-speed bicycle use and can increase potential for conflicts with motor vehicles at intersections, as well as with pedestrians and fixed objects. (2)

Sidewalk bikeways should be considered only under the following special circumstances:

1. To accommodate the youthful bicyclist and inexperienced adult bicyclists (including tricyclists). In residential area, sidewalk riding by young children too inexperienced to ride in the street is common. With lower bicycle speeds and lower auto speeds, potential conflicts, though somewhat lessened, still exist. This type of sidewalk bicycle use is accepted, <u>but it is inappropriate to sign sidewalks as bike paths</u>. (2) Provision of sidewalk facilities for the youthful bicyclist and inexperienced adult bicyclist should always be in addition to, rather than instead of, the provision is for the adult bicyclist.

2. To provide bikeway continuity along high-speed or heavily traveled roadways which have inadequate space for bicyclists and are uninterrupted by driveways and intersections for long distances; and on long narrow bridges. In such areas, ramps should be installed at the sidewalk approaches. If approach bikeways are two-way, sidewalk facilities should be two-way. (2)

3. <u>Whenever sidewalk bikeways are established a special effort shall be made to remove obstacles that will be hazardous to bicycle travel</u>. Whenever bicyclists are not subjected to the hazards of a vertical lip crossed at a flat angle. Also, curb cuts at each intersection are necessary. Curb cuts should be wide enough to accommodate adult tricycles and two-wheel bicycle trailers. (2)

   Moreover, curb cuts should offer a smooth transition between the pavement surface and the sidewalk and the place directly in the path of the bicyclist's line of travel(see ADOT Detail "Curb Cut Ramps, Physically Handicapped").

   <u>A single ramp at the center of the curb radii directing the cyclist at a 45° angle from either sidewalk should not be considered. Such treatment directs the cyclist into traffic</u>.

While sidewalks are generally not accepted for bicycling, in a few limited situations, sidewalk improvements can be beneficial. Residential areas or areas near elementary schools where young, inexperienced children are the primary riders may particularly benefit from curb ramps, removal of obstacles, etc. Other sidewalk locations that should be evaluated for bicycle safety and comfort include long or narrow bridges and rural areas where little, if any, pedestrian traffic on the sidewalks occur.

Mopeds

It is also undesirable to mix mopeds and bicycles on the same facility. Where it is necessary to do so, the facility should be designed to account for the higher operating speeds of mopeds, the additional maneuvering requirements of mopeds, and the increased frequency of passing maneuvers. Many of the design guidelines prescribed within the "Bicycle Paths" section (e.g., widths, design speeds, horizontal alignments, grades, etc.) would be inadequate for facilities intended for moped use. Mopeds also contribute to a lessening of the quiet, relaxing experience most bicyclists desire on bicycle paths.

Bicycle/Bridle Path

Using a path for bicycles and horses creates an unsatisfactory and possibly dangerous mix. Horses startle easily and may kick out suddenly if they perceive bicyclists as danger. A bicycle path and a bridle path are also incompatible in their surface design requirements. Bicycles function best on hard surfaces, horses function best on soft surfaces. A compromise to accommodate both would result in less than adequate surface for both.

SUPPLEMENTAL BICYCLE FACILITIES

Providing bicycle parking facilities is an essential element in an overall effort to promote bicycling. People are discouraged from bicycling unless adequate parking is available. Bicycle parking facilities should be provided at both the trip origin and the trip destination and should offer protection from theft and damage. (See the Appendix for example bicycle parking facilities.)

The wide variety of bicycle parking devices fall into two categories of user needs; commuter or long-term parking, and convenience or short-term parking. The minimum needs for each differ in their placement and protection. Long-term parking is needed at locations such as employment centers, transit or subway stations, and multifamily dwellings. Facilities should be provided which secure the frame, both wheels, and accessories and which offer protection from the weather. Bicycle lockers and attended storage areas are good examples of long-term parking facilities. Short-term parking is needed at locations such as shopping centers, libraries, recreation areas, and post offices. Facilities should be very convenient and be near building entrances or other highly visible areas which are self policing. The facility should be designed so that it will not damage bicycles (bent rims are common with racks

that only support one wheel). If bicycle parking is not properly designed and located, bicyclists will use trees, railings, and other appurtenances. This practice can damage the appurtenances and create a hazard for pedestrians.

Several factors should be considered when planning and providing bicycle parking facilities. Care should be given in selecting the location to ensure that bicycles will not be damaged by motor vehicles. Parking facilities should not interfere with the normal pedestrian flow. Also, facilities should be designed so that persons parking their bicycles will not disturb other parked bicycles. The amount of security needed to prevent theft needs to be evaluated for each area.

Facilities should be able to accommodate a wide range of bicycle shapes and sizes including tricycles and trailers, if used locally. Finally, facilities should be simple to operate. If possible, signs depicting how to operate the facility should be posted.

In addition to bicycle parking facilities, there are several other improvements that complement bicycle paths and roadway improvements. Provisions should be considered for interfacing bicycle travel with public transit, such as racks on buses, buses converted to carry bicycles aboard, or allowing bicycles on rapid rail facilities. Printing and distributing bicycle route maps is a high-benefit, low-cost project that is easily accomplished. Maps can help bicyclists locate bikeways, parking facilities, and identify the relative suitability of different segments of the road system. Also, maps can help bicyclists avoid narrow, high-speed, or high-volume roads, one-way streets, barriers and other problems to bicyclists. In addition, maps can provide information on Rules of the Road, bicycle safety tips, and interfacing with mass transit.

OPERATION AND MAINTENANCE OF BICYCLE FACILITIES

The agency responsible for the control, maintenance, and policing of bicycle facilities should be established prior to construction. The costs involved with the operation and maintenance should be considered and budgeted for when planning a facility. Neglected maintenance will render bicycle facilities unrideable, and the facilities will become a liability to the State or community. Bicyclists should be encouraged to report bicycle paths and roadways needing maintenance. A central contact person with authority to authorize maintenance work should be designated to receive such reports.

Bikeways, and roadways with bicycle traffic are often susceptible to having debris, such as glass or sand, accumulate in the area where bicyclists ride, therefore, regular sweeping is necessary. A smooth surface, free of potholes and debris, should be provided. The pavement edges should be uniform. Signs and pavement markings should be inspected regularly and kept in good condition. Highways with bicycle traffic may require a more frequent and higher level of maintenance than other highways.

For bicycle paths, attention should be given to maintaining the full paved width and not allowing the edges to ravel. Trees, shrubs and other vegetation should be controlled to provide adequate clearances and sight distances. Trash receptacles should be placed and maintained at convenient locations. Seeded and sodded areas in the vicinity of bicycle paths should have regular schedule of mowing. Also enforcement is usually necessary to prevent unauthorized motor vehicles from using the bicycle path.

The routine maintenance of roadways provides an excellent opportunity to improve the bicycle travel on those roads. Several bicycle facilities described in this manual can be implemented during routine maintenance activities. When lane markings for four or six lane streets are restriped, consideration can be given to adjusting the lane widths and providing a wide curb lane for bicycles. Addition of edge lines can better delineate a shoulder, especially at night. When shoulders are resurfaced, a smooth surface suitable for bicycle riding should be considered.

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GLOSSARY

GLOSSARY OF BICYCLE AND OTHER TRANSPORTATION-RELATED TERMS

ADT

Average Daily Traffic volume.

Amenity Factor

Any design feature of a bicycle, over and above what is deemed a basically safe design, which promote bicycle usage. Examples: weather-protected parking and scenic overlooks.

Attainment

A level of service to be achieved for the purpose of evaluating the degree to which goals and objectives are met.

Bicycle Facilities

A general term denoting improvements and provisions made by public agencies to accommodate or encourage bicycling, including parking facilities, maps, all bikeways, and shared use of roadways not specifically designed for bicycle use.'

Bicycle Lane

A portion of a roadway which has been designated for a preferential or exclusive use of bicycles, with through travel by motorists and pedestrians prohibited, but with crossflows by pedestrians and motorists permitted. This designation includes striped bike lanes, paved shoulders, and lanes for joint use by disabled vehicles and bicycles. [2]

Bicycle Path

A bikeway which is physically separated from motorized vehicular traffic by an open space or barrier and which is either within the highway right-of-way or within an independent right-of-way. Crossflows with motorized traffic are minimized. [2]

Bicycle Route

A segment of a system of bikeways designated by the jurisdiction having authority with appropriate directional and informational markers, with or without a specific bicycle route number.

Bicycle Wide Curb-Lane

A portion of roadway which has been designated for shared use by bicycles and motorized traffic, characterized by a curb-lane which is of such width that bicycle and motorized traffic can be accommodated in the same lane. This lane should always be the through lane closest to the curb (when a curb is provided) or the shoulder edge of the road when a curb is not provided.

Bikeway

Any road, path, or way which in some manner is specifically designated as being open to bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes.

Capacity

Maximum number of bicycles which have a reasonable expectation of passing through a given bikeway section during a given time period under existing facility conditions.

Clearance

Lateral width required for safe passage of a bicycle as measured in a horizontal plane.

Climatological Elements

Weather as it affects bicycling in either a positive of negative manner. This includes temperature, precipitation, wind, etc.

Design Speed

A speed determined for design and correlation of the physical features of a bikeway that influence bicycle operation. It is the maximums safe speed that can be maintained over a specified section of bikeway when conditions allow the design features of the bikeway to govern usage.

Determinants

Data and facts which govern the location and design of a bikeway.

Experienced Bicyclists

All bicyclists not considered youthful (under 13) or inexperienced adult bicyclists. These riders are assumed to have the physical and judgmental skills needed to safely and comfortably maneuver their bicycles in a variety of traffic situations.

Groove

A narrow slot in the surface that could catch a bicycle wheel, such as a gap between two concrete slabs.

Highway

A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

Inexperienced Adult Bicyclists

Those bicyclists 13 years of age or older who may have the judgmental and physical maturity necessary to maneuver their bicycles in a variety of traffic situations, but typically do not feel secure or comfortable riding in all situations.

In-Street Bicycle Facility

Any bicycle facility (bicycle route, lane, or wide curb-lane) on which bicycle traffic shares the roadway with motor vehicles.

Intermodal Transfer Point

Any location at which a person or persons change from one transportation mode to another.

Legend

Words, phrases, or numbers appearing on all or part of a traffic control device.

Location Criteria

Relative predetermined standards used in selecting and weighing bikeway corridors.

Longitudinal Patterns

Stripes or markings placed parallel to the flow of traffic.

Minimum Energy Path

The route between two given points requiring the least amount of energy for a bicyclist to transverse.

MPO

Metropolitan Planning Organization.

MTPO

Metropolitan Transportation Planning Organization.

Origin--Destination Study (O & D Study)

A survey of facility users designed to determine trip frequency and termini; use in determining bikeway needs.

Parameter

A system component whose value determines the characteristics or behaviors of a system.

Pavement Marking

Painting or applied line(s) or legend placed on any bikeway surface to regulate, guide, or warn traffic.

Pedestrian

A person whose mode of transportation is on foot, including a person "walking a bicycle."

Planning Area

A geographic district or region selected for planning objectives.

Planning Sub-Area

The smallest geographic unit for which trip behavior is calculated and analyzed in transportation importance.

Representative Sampling

A planning technique designed record (to a specified level of accuracy) public opinions and attitudes regarding community issues, typically using interviews with or mailers to a segment of the population. Sampling which does not meet the specified level of accuracy is referred to as "non-representative sampling."

Right-of-Way

A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to transportation purposes.

Right-of-Way Corridor Width

The width between the furthest edges of the right-of-way property on which the roadway is located; may include the roadway, shoulder area and lawn area, and sidewalk.

Roadway

The portion of the highway, including shoulders, for vehicle use.

Secondary Bicycle Facility

Bicycle facilities designed primarily for youthful and inexperienced adult bicyclists.

Service

In bikeway operation, a qualitative measure for indicating the effect of factors such as speed, travel time, safety, travel interruptions, and maneuverability.

Shared Roadway

Any roadway upon which a bicycle lane is not designated and which may be legally used by bicycles regardless of whether such facility is specifically designated as of bikeway.

Shy Distance

The distance between the bikeway's edge and any fixed object capable of injuring a bicyclist using the facility.

Sidewalk

The portion of a highway designed for preferential or exclusive use by pedestrians.

Sidewalk with Ramps

Sidewalk designed to provide smooth transition between grades by the use of slanted ramps; such facilities are typically wider than ordinary sidewalks, so that handicapped individuals can be accommodated.

Sight Distance

A measurement of the bicyclist's visibility, unobstructed by traffic, along the normal travel path to the furthest point of the roadway surface.

Shoulder

The portion of the roadway outside the edges of the traveled way (or back of curb) and extending to the top of front slopes. The shoulders may be paved or unpaved.

Step

A ridge in the pavement, such as that which might exist between the pavement and a concrete gutter or manhole cover; or that might exist between two pavement blankets where the top level does not extend to the edge of the roadway.

Stopping Sight Distance

The total distance traveled from the instance a bicycle operator sights an object which requires him/her to stop to the point at which the vehicle stops. Perception plus reaction and braking distance equals stopping sight distance.

Superelevation

Raised outside edge of a roadway curve designed to overcome the force causing a vehicle to skid when maintaining speed; often referred to as a "banked curved."

Termini

The two ends of the travelway, i.e., the trips beginning and its end location.

Traffic Control Devices

Signs, signals or other fixtures, whether permanent or temporary, placed on or adjacent to a travelway by authority of a public body having jurisdiction to regulate, warn, or guide traffic.

Traffic Flow Patterns

Graphic presentation of vehicular or pedestrian movement at a given time on given streets.

Transportation Corridor

A strip of land between two termini within which traffic, topography, environment, and other factors are evaluated for transportation purposes.

Transverse Patterns

Pavement markings perpendicular to, or at an angle to, the flow of traffic, such as stop bars, crossover stripes, and median delineations.

Travel Generators

Particular areas or locations which represent trip destination points t the utilitarian bicyclist; for example, libraries, schools, recreation areas, and work centers.

Travelway

Any way, path, road, or other travel facility used for any and all forms of transportation.

Tributary Areas

Geographic locations which act as feeders to major transportation corridors.

Trip Attractors

Potential trip destinations, such as schools, recreation areas, shopping areas, and employment centers (essentially synonymous with "Travel Generators.")

Trip Producers

Residential areas (trip origins).

Utilitarian Bicyclist

An individual who uses a bicycle primarily to reach a particular destination.

Vehicle

Every device in, upon, or by which any person or property is or may be transported or drawn upon a travelway, excepting devices used exclusively upon stationary rails or tracks.

Volume

The number of vehicles which pass a given point for a given amount of time (e.g., hour, day, year).

Warrant

A minimum requirement for justifying the authorization of a traffic control device; for example, traffic volumes, accident statistics, and existing design.

Youthful Bicyclist

For the purpose of determining appropriate bicycle facilities, any person under 15 years of age.

APPENDIX A

MUTCD

Chapter 3 included general comments on placing traffic control devices on bicycle routes, lanes, and paths. The reader should refer to the appropriate sections for suggested applications of traffic control devices. However, specific applications of traffic control devices on bikeways must be in accordance with the MUTCD. For convenience, the section of the MUTCD "Part IX Traffic Controls For Bicycle Facilities" has been included in this Appendix.

Part IX. TRAFFIC CONTROLS FOR BICYCLE FACILITIES

A. GENERAL

9A-1 Requirements for Bicyclist Traffic Control Devices

Traffic control devices, whether they are intended for motorists or bicyclists, must adhere to five basic requirements to be able to perform their intended function. They must:

1. Fulfill a need.
2. Command attention.
3. Convey a clear, simple meaning.
4. Command respect of road users.
5. Give adequate time for proper response.

The design, placement, operation, maintenance, and uniformity of traffic control devices must be considered to meet the above requirements. Design is a critical feature to permit the device to fulfill a need and to command respect of road users. The placement—lateral, vertical, and longitudinal—plays an important part in making the device effective and in giving adequate time for proper response. The operation of traffic in response to the device is, of course, the critical test of the device's effectiveness and a check on all five of the basic requirements.

Uniformity, achieved by following the recommendations and standards of this Manual, greatly enhances the ability of a device to convey a clear, simple meaning to the user.

Whenever devices are installed, they should be warranted and based on a prior engineering study. Where the guidance provided by this part of the Manual does not fully define where particular devices should be used, qualified traffic engineers should determine the application of devices on any bicycle facility before installation is made. It is intended that this Manual define the standards for traffic control devices, but shall not be a legal requirement for their installation.

9A-2 Scope

This Part covers bicycle-use related signs, pavement markings and signals which may be used on highways or bikeways.

9A-3 Definitions Relating to Bicycles

The following terms are used throughout Part IX:

1. Bikeway—Any road, street, path, or way which in some manner is specifically designated as being open to bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes.
2. Bicycle Trail—A separate trail or path from which motor vehicles are prohibited and which is for the exclusive use of bicycles or the shared use of bicycles and pedestrians. Where such trail or path forms a part of a highway, it is separated from the roadways for motor vehicle traffic by an open space or barrier.
3. Designated Bicycle Lane—A portion of a roadway or shoulder which has been designated for use by bicyclists. It is distinguished from the portion of the roadway for motor vehicle traffic by a paint stripe, curb, or other similar device.
4. Shared Roadway—A roadway which is officially designated and marked as a bicycle route, but which is open to motor vehicle travel and upon which no bicycle lane is designated.
5. Bicycle Route—A system of bikeways designated by appropriate route markers, and by the jurisdiction having authority.

9A-4 Standardization of Devices

Standards for basic design elements and devices using these standards are given in this Manual. These standard devices generally will serve most applications. Where particular conditions require the use of a device that is not included in this Manual, the general principles in this Manual as to color, size, and shape should be followed wherever practical. Such devices should also follow the design, installation and application concepts contained in the Manual.

9A-5 Maintenance

Bicycle signs and markings should be properly maintained to command respect from both the motorist and the bicyclist. When installing signs and markings on bicycle facilities, care should be taken to have an agency designated to maintain these devices.

9A-6 Legal Authority

Traffic control devices shall be placed only by the authority of a public body or official having jurisdiction, for the purpose of regulating, warning, or guiding traffic. No traffic control device or its support shall bear any advertizing or commercial message, or any other message that is not essential to traffic control.

All regulatory devices, if they are to be enforced, need to be backed by applicable laws, ordinances, or regulations.

9A-7 Meanings of "Shall," "Should," and "May"

In this Part as in other parts of the Manual, the words "shall," "should," and "may" are used to describe specific conditions concerning traffic control devices. To clarify the meanings intended by use of these words, the following definitions are provided:

1. SHALL—A *mandatory* condition. Where certain requirements in the design or application of the device are described with the "shall" stipulation, it is mandatory that these requirements be met.
2. SHOULD—An *advisory* condition. Where the word "should" is used, it is considered to be advisable usage, recommended but not mandatory.
3. MAY—A *permissive* condition. No requirement for application is intended. If a particular device is used under a "may" condition, however, its design shall follow the prescribed format.

9A-8 Relation to Other Documents

The Uniform Vehicle Code and Model Traffic Ordinance published by the National Committee on Uniform Traffic Laws and Ordinances, have provisions for bicycles and are used as the legal basis for the control devices included herein. Under the Uniform Vehicle Code, bicycles are generally considered to be vehicles, so the bicyclists have the same privileges and obligations as other drivers.

Informational documents used during the development of the signing and markings recommendations in this part of the Manual include the following:

1. Guide for Bicycles, American Association of State Highway and Transportation Officials, 1974.
2. Bikeways, State of the Art, Federal Highway Administration, 1974.
3. Bicycle Facility Location Criteria, Federal Highway Administration, 1976.
4. Bicycle Facility Design Criteria, Federal Highway Administration, 1976
5. State and municipal design guides.

Other documents which relate to the application of traffic control devices in general, are listed in section 1A-7 of this Manual.

9A-9 Colors

The use of colors for bicycle facility traffic control devices should conform to the color code specified in section 1A-8 for signs and markings. This in part is as follows:

YELLOW—General warning
RED—Stop or prohibition
BLUE—Service guidance

GREEN—Indicated movements permitted, direction guidance
BROWN—Public recreation and scenic guidance
ORANGE—Construction and maintenance warning
BLACK—Regulation
WHITE—Regulation

B. SIGNS

9B-1 Application of Signs

Bicycle-use related signs on highways and bikeways serve three basic purposes: regulating bicycle usage, directing bicyclists along preestablished routes, and warning of unexpected conditions. Care should be taken not to install too many signs. A conservative use of regulatory and warning signs is recommended as these signs, if used to excess, tend to lose their effectiveness. The frequent display of guide signs, however, aids in keeping the bicyclist on the designated route and does not lessen their value. Some signs for the bicyclist can also serve the motorist and the pedestrian.

9B-2 Location and Position

Where signs are to serve both bicyclists and motorists, mounting heights and lateral placement shall be as specified in Part II, Signs. Figure 9-1 illustrates typical signing placement for bicycle trails. Overhead sign clearance on bicycle trails shall be a minimum of 8½ feet. The clearance provided should also be adequate for the typical maintenance vehicles used on the bikeway. Where signs are for the exclusive use of bicyclists, care should be taken that they are located so that motorists are not confused by them.

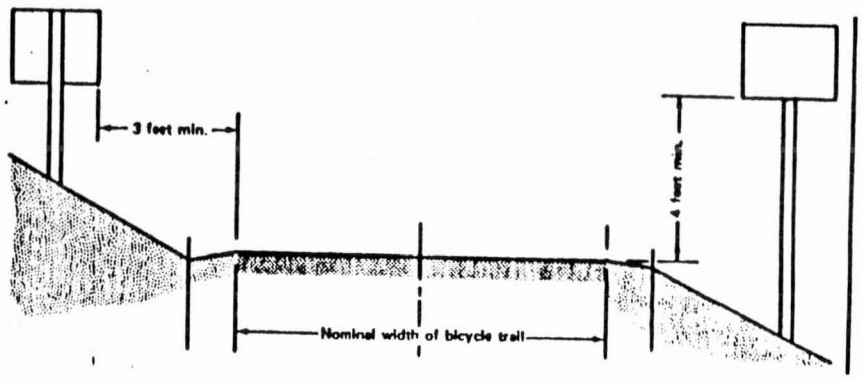


Figure 9-1. Bicycle sign placement on a trail.

9B-3 Design

The design of signs for bicycle facilities should, whenever possible, be identical to that specified in this Manual for motor vehicle travel. Uni-

formity in design includes shape, color, symbols, wording, lettering, and illumination or reflectorization. Detailed drawings of the standard signs illustrated in this Manual are available to State and local highway and traffic authorities, sign manufacturers, and similar interested agencies.* Standardization of these signs does not preclude further improvement by minor changes in the proportion of symbols, stroke width, and height of letters, or width of borders. However, all shapes and colors shall be as indicated, all symbols shall be unmistakably similar to those shown and (where a word message is applicable) the wording shall be as provided herein.

The sign dimensions shown in this part of the Manual shall be considered standard for application on all types of bicycle facilities. Where signs shown in other parts of this Manual are intended for exclusive bicycle use, smaller sign sizes from that specified may be used. Incremental increases in special bicycle facility signs are also desirable to make the sizes compatible with signs for motor vehicles, where both motorists and bicyclists benefit by a particular sign.

The sign lettering shall be in upper-case letters of the type shown in the Standard Alphabets for Highway Signs and Pavement Markings*

All signs should be reflectorized for bicycle trails as well as for shared roadway and designated bicycle lane facilities.

9B-4 Regulatory Signs

Regulatory signs are to inform bicyclists, pedestrians and motorists of traffic laws or regulations and indicate the applicability of legal requirements that would not otherwise be apparent.

Regulatory signs normally shall be erected at the point where the regulations apply. The sign message shall clearly indicate the requirements imposed by the regulations and shall be easily visible and legible to bicyclists and where appropriate, motorists and pedestrians.

9B-5 Bicycle Prohibition Sign (R5-6)

This sign is intended for use at the entrance to facilities, such as freeways, where bicycling is prohibited. Where pedestrians and motor—driven cycles are also prohibited from using these facilities, it may be more desirable to use the R5-10a word message sign (sec. 2B-28).

In reduced size (18 × 18 inches), this sign may be used on sidewalks where bicycle riding is prohibited.

9B-6 Motor Vehicle Prohibition Sign (R5-3)

This sign is intended for use at the entrance to a bicycle trail.

* Available from the Federal Highway Administration (HTO-20) Washington, D.C. 20590

R5-6
24″×24″

R5-3
24″×24″

9B-7 Bicycle Restriction Signs (R9-5 & 6)

This series of signs is intended for use where pedestrian facilities are being used for bicycle travel. They should be erected off the edge of the sidewalk, near the crossing location, where bicyclists are expected to dismount and walk with pedestrians while crossing the street.

The R9-5 sign may be used where bicycles can cross the street only on the pedestrian walk signal indication.

The R9-6 sign may be used where bicycles are required to cross or share a facility used by pedestrians and are required to yield to the pedestrians.

R9-5
12″×18″

R9-6
12″×18″

9B-8 Designated Lane Signs (R3-~~10~~ 16 & ~~11~~ 17)

The R3-~~10~~ 16 sign should be used in advance of the beginning of a marked designated bicycle lane to call attention to the lane and to the possible presence of bicyclists. The R3-~~10~~ 16 and R3-~~11~~ 17 signs should be used only in conjunction with the Preferential Lane Symbol pavement marking and erected at periodic intervals along the designated bicycle lane and in the vicinity of locations where the preferential lane symbol is used (sec. 9C-4).

Where appropriate, the message ENDS may be substituted for AHEAD on the R3-~~10~~ 16 sign and LEFT or CURB can be substituted for RIGHT on the R3-~~11~~ 17 sign.

R3-~~10~~ 16
24″×30″

R3-~~11~~ 17
24″×30″

9B-9 Travelpath Restriction Signs (R9-7)

The R9-7 sign is intended for use on facilities which are to be shared by pedestrians and bicycles and on which a designated area is provided for each (sec. 9C-3). Two of these signs may be erected back-to-back with the symbols reversed for the opposite direction.

R9-7
12″×18″

9B-10 STOP and YIELD Signs (R1-1, 2)

STOP signs are intended for use on bicycle facilities where bicyclists are required to stop. Where conditions require bicyclists and not motorists to stop, care should be taken to place the sign so it is not readily visible to the motorist.

YIELD signs are intended for use where the bicyclist can see approaching traffic and where bicyclist must yield the right of way to that traffic. The visibility of approaching traffic must be adequate to permit the bicyclist to stop or to take other measures to avoid that traffic.

For added emphasis STOP and YIELD signs in regular 30 × 30-inch and 36 × 36 × 36-inch sizes may be used.

The smaller signs shown below are intended for use on bicycle trails where bicyclists are required to stop or yield the right of way. If the sign applies to motorists and bicyclists, then the size should be as shown in Part II-B.

R1-1
18″×18″

R1-2
24″×24″×24″

9B-11 No Parking Signs (R7-9, & 9a)

Where it is necessary to restrict parking, standing, or stopping in a designated bicycle lane, appropriate signs as described in sections 2B-31 through 2B-33 may be used, or signs R7-9 or R7-9a shall be used.

R7-9
12″×18″

R7-9a
12″×18″

9B-12 Lane-Use Control Signs (R3-7, R4-4)

Where right turning motor vehicles must merge with bicycle traffic on designated bike lanes, the R3-7 and R4-4 signs may be used. The R4-4 sign is intended to inform both the motorist and the bicyclist of this merging maneuver. Where a designated bicycle lane is provided near the stop line, an R3-7 sign may be used to prevent motorists from crossing back over the bike lane.

R3-7
30" × 30"

R4-4
36" × 30"

9B-13 Warning Signs

Warning signs are used when it is deemed necessary to warn bicyclists or motorists of existing or potentially hazardous conditions on or adjacent to a highway or trail. The use of warning signs should be kept to a minimum because the unnecessary use of them to warn of conditions which are apparent tends to breed disrespect for all signs.

Warning signs specified herein cover most conditions that are likely to be met. If other warnings are needed, the signs shall be of standard shape and color for warning signs, and the legends shall be brief and easily understood.

9B-14 Bicycle Crossing Sign (W11-1)

The Bicycle Crossing sign is intended for use on highways in advance of a point where a bikeway crosses the roadway. It should be erected about 750 feet in advance of the crossing location in rural areas where speeds are high, and at a distance of about 250 feet in urban residential or business areas, where speeds are low.

If the approach to an intersection is controlled by a traffic control signal, stop sign or yield sign, the W11-1 sign may not be needed.

9B-15 Hazardous Condition Sign (W8-10)

The Hazardous Condition sign is intended for use where roadway or bicycle trail conditions are likely to cause a bicyclist to lose control of his bicycle. These conditions could include slippery pavement, slick bridge

W11-1
30" × 30"

W8-10

Roadway Signs
30" × 30"
24" × 18"

Bicycle Trail Signs
18" × 18"
12" × 9"

decking, rough or grooved pavement, or water or ice on the roadway. The W8-10 sign may be used with a supplemental plaque describing the particular roadway or bicycle trail feature which might be of danger to the bicyclist such as SLIPPERY WHEN WET, STEEL DECK, ROUGH PAVEMENT, BRIDGE JOINT, or FORD.

9B-16 Turn and Curve Signs (W1-1, 2, 4, 5, 6, 7)

On bicycle trails where it is necessary to warn bicyclists of unexpected changes in path direction, appropriate turn or curve signs should be used. They should normally be installed no less than 50 feet in advance of the beginning of the change of alignment.

W1-1
18" × 18"

W1-2
18" × 18"

W1-4
18" × 18"

W1-5
18" × 18"

W1-6
24"×12"

W1-7
24"×12"

9B-17 Intersection Signs (W2-1, 2, 3, 4, 5)

Intersection signs are intended for use as appropriate to fit the prevailing geometric pattern on bike trails where connecting routes join and where no STOP or YIELD signs are required. They should be used wherever sight distance at the intersection is severely limited, and may be used for supplemental warning at intersections where STOP and YIELD signs are erected.

W2-1
18"×18"

W2-2
18"×18"

W2-3
18"×18"

W2-4
18"×18"

W2-5
18"×18"

9B-18 Other Warning Signs

Other warning signs may be required on bicycle facilities to warn riders of unexpected conditions. The intended use of these signs generally is self-explanatory. They should normally be installed no less than 50 feet in advance of the beginning of hazards.

Where construction or maintenance activity is present on bicycle trails, appropriate signs from Part VI of the Manual should be used.

9B-19 Guide Signs

On highways where a bicyclist is sharing a lane with motor vehicles or is using an adjacent bikeway, the regular guide signing as described in Part II of this Manual will serve both modes of travel. Where a designated bikeway exists, special bicycle route signing should be

W3-1
18" x 18"

W3-3
18" x 18"

W5-4
18" x 18"

W7-5
18" x 18"

W11A-2
18" x 18"

W12-2
18" x 18"

W10-1
18" Diameter

provided at decision points along the bikeway, including signs to inform cyclists of bicycle route direction changes and confirmatory signs to ensure that route direction has been accurately comprehended.

Figure 9-2 shows an example of the signing for the junction of a bicycle trail with a highway. Figure 9-3 shows the signing and marking for the beginning and ending of designated bikeways. Guide signing should be repeated at regular intervals to ensure that bicyclists approaching from side streets know they are traveling on an officially designated bikeway. Similar guide signing should be used for shared lane bikeways with intermediate signs placed frequently enough to ensure that cyclists already on the bikeway do not stray from it and lose their way.

9B-20 Bicycle Route Sign (D11-1)

This sign is intended for use where no unique designation of routes is desired. It should be placed at intervals frequent enough to keep bicyclists informed of changes in route direction and to remind motorists of the presence of bicyclists.

D11-1
24" x 18"

M1-8
12" x 18"

M1-9
18" x 24"

9B-21 Bicycle Route Markers (M1-8, M1-9)

Where it is desired to establish a unique identification (route designation) for a State or local bicycle route, the standard Bike Route Marker (M1-8) should be used. The route marker (M1-8) shall contain a numerical designation and shall have a green background with a reflectorized white legend and border.

Where a bicycle route extends for long distances in two or more States, it is desirable to establish a unique numerical designation for that route. A coordinated submittal by the affected States for assignment of route number designations should be sent to the American Association of State Highway and Transportation Officials, 444 North Capitol Street NW., Suite 225, Washington, D.C. 20001. The route marker (M1-9) shall contain the assigned numerical designation and have a black legend and border with a reflectorized white background.

Bike Route Markers are intended for use on both shared facilities and on designated bikeways, as required, to provide guidance for bicyclists.

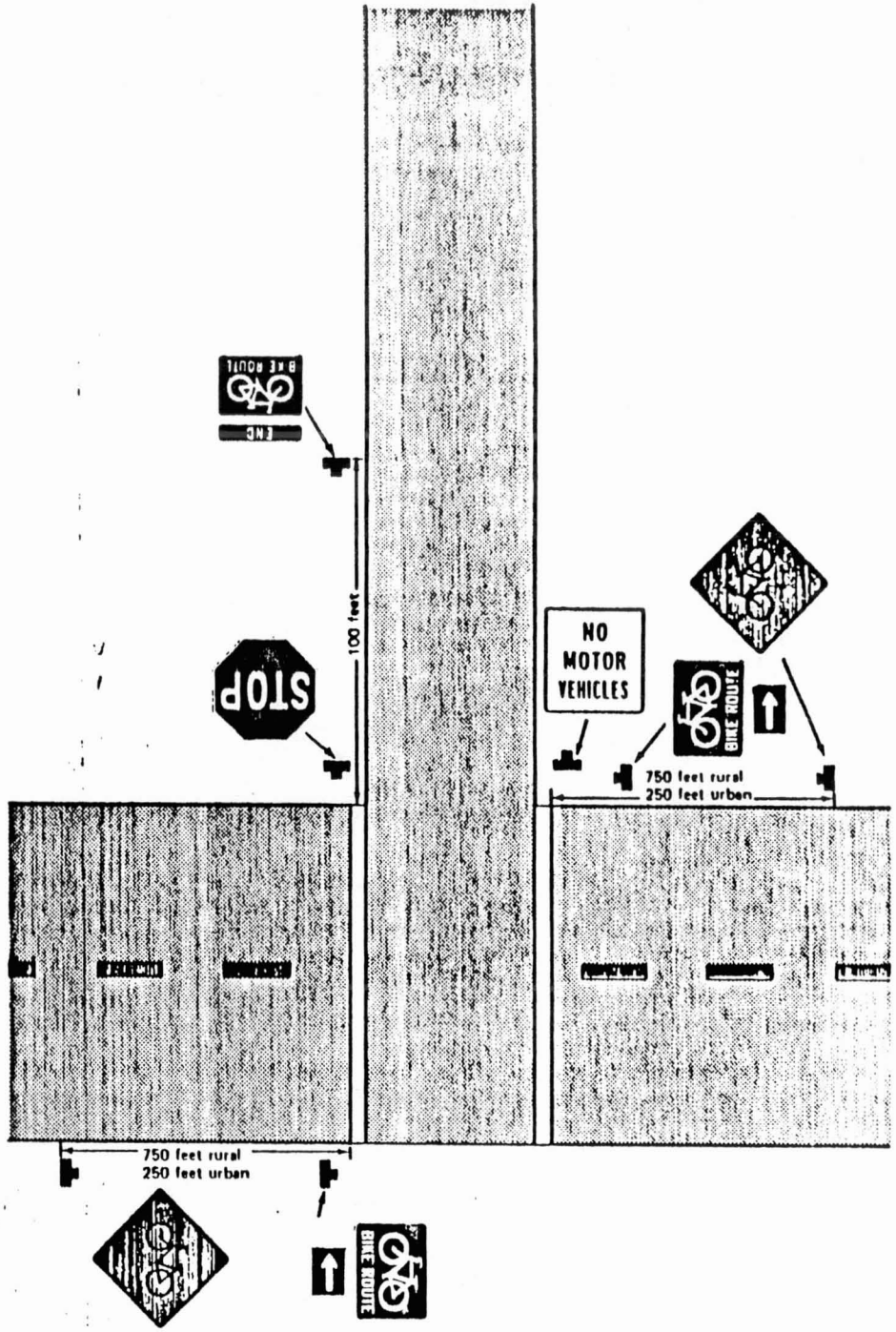


Figure 9-2. Typical signing for beginning and ending of bicycle trail.

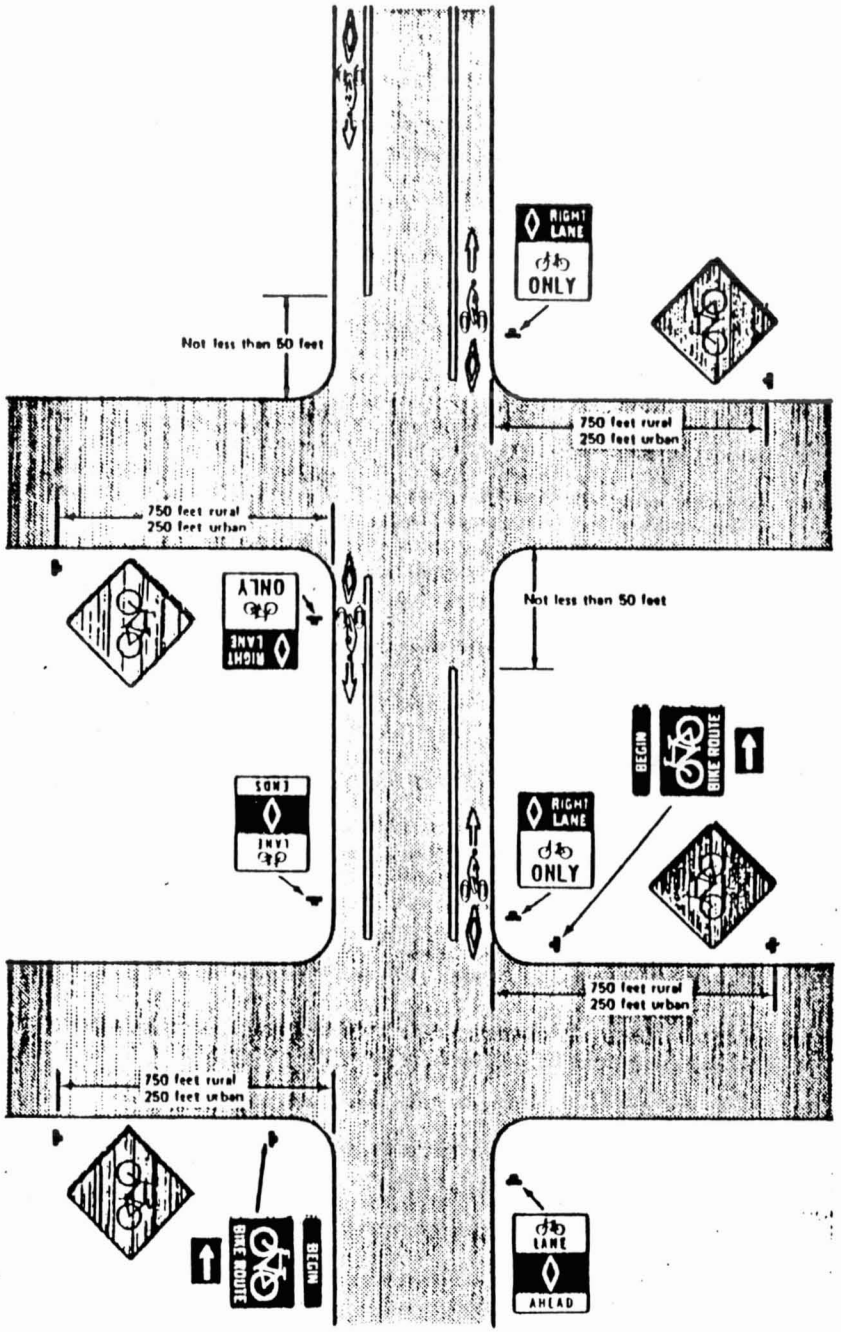


Figure 9-3. Typical signing for beginning and ending of designated bicycle lane.

9B-22 Supplemental Plaques for Route Signs and Route Markers

Where desired, supplemental plaques can be used with the D11-1 and M1-8 signs to furnish additional information, such as directional changes in the route, and intermediate range distance and destination information. The M4-11 through M4-13 signs may be mounted above the appropriate Route Signs or Route Marker. Supplemental plaques D1-1b and c are intended for use with the D11-1 Bicycle Route Sign. The appropriate arrow sign (M7-1 through M7-7), if used, should be placed below the Route Sign or Route Marker. These signs shall have a white arrow on a green background.

M4-11
24" × 6" or 12" × 4"

D1-1b(L)
24" × 6"

M4-12
24" × 6" or 12" × 4"

D1-1b(R)
24" × 6"

M4-13
24" × 6" or 12" × 4"

D1-1(c)
24" × 6"

M7-1

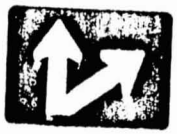
M7-2

M7-3

M7-4

M7-5

M7-6



M7-7

M7-1 through M7-7
12" × 9"

9B-23 Bicycle Parking Area Sign (D4-3)

The Bicycle Parking Area sign may be used where it is desired to show the direction to a designated bicycle parking area within a parking facility or at other locations. The sign shall be a vertical rectangle of a standard size of 12 by 18 inches. It shall carry a standard bicycle symbol, the word PARKING, and an arrow. The legend and border shall be green on a reflectorized white background.

D4-3
12" × 18"

C. MARKINGS

9C-1 Functions and Limitations of Markings

Markings are important on roadways that have a designated bicycle lane. Markings indicate the separation of the lanes for motor vehicle and bicycles, assist the bicyclist by indicating assigned travel paths, and can provide advance information for turning and crossing maneuvers.

9C-2 General Principles

Although bicycles are generally not equipped with strong lighting equipment, the added visibility of reflectorized pavement markings is desirable even where there is exclusive use by bicyclists.

Markings shall be reflectorized on bicycle trails and on facilities used by both motor vehicles and bicycles.

Recognized bikeway design guides should be used when laying out markings for a bicycle lane on a highway facility (sec. 9A-8).

The frequent use of symbols and word messages stenciled in the bike lanes, is a desirable method of supplementing sign messages. Figures 9-4 through 9-6, show acceptable examples of the application of lines, word messages and symbols on designated bikeways with and without parking for motor vehicles.

If a specific path for a bicylist crossing an intersection is to be designated, a dotted line may be used to define such a path.

9C-3 Marking Patterns and Colors

The color and type of lines used for marking bicycle facilities shall be as defined in section 3A-7. Normally, center lines would not be required on bicycle paths. Where conditions make it desirable to separate two directions of travel at particular locations, a double solid yellow line should be used to indicate no passing or no traveling to the left of the line.

Where bicycle paths are of sufficient width to designate two minimum width lanes, a broken yellow line may be used to separate the two directions of travel.

Broken lines used on bicycle paths should have the normal 1 to 3 segment-to-gap ratio. To avoid having gaps excessively long, a nominal 3-foot segment with a 9-foot gap is recommended.

Where bicycles and pedestrians use a common facility, it may be desired to separate the two traffic flows. A solid white line should be used to mark this separation of path use. The R9-7 sign may be used to supplement the pavement marking (sec. 9B-9).

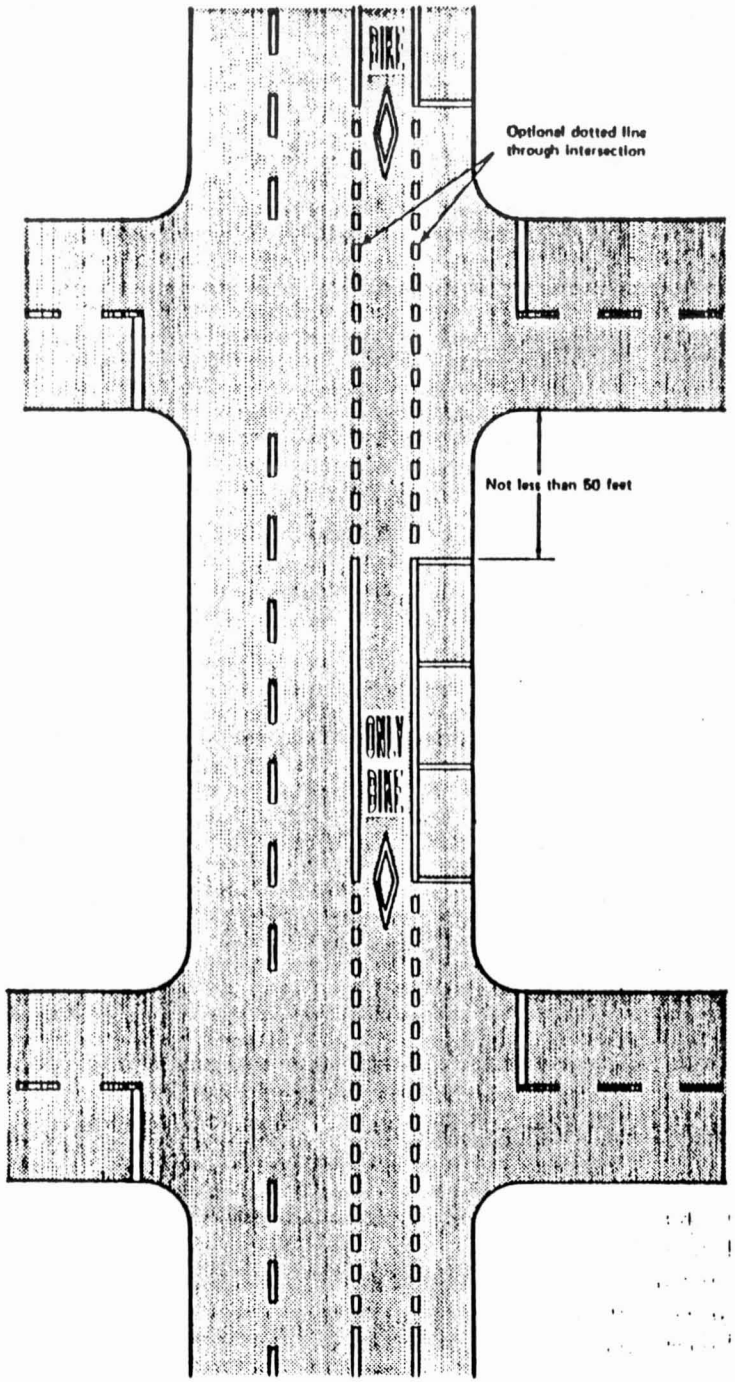


Figure 9-4. Typical pavement markings—designated bicycle lane, two-way traffic with parking and low right turn volume.

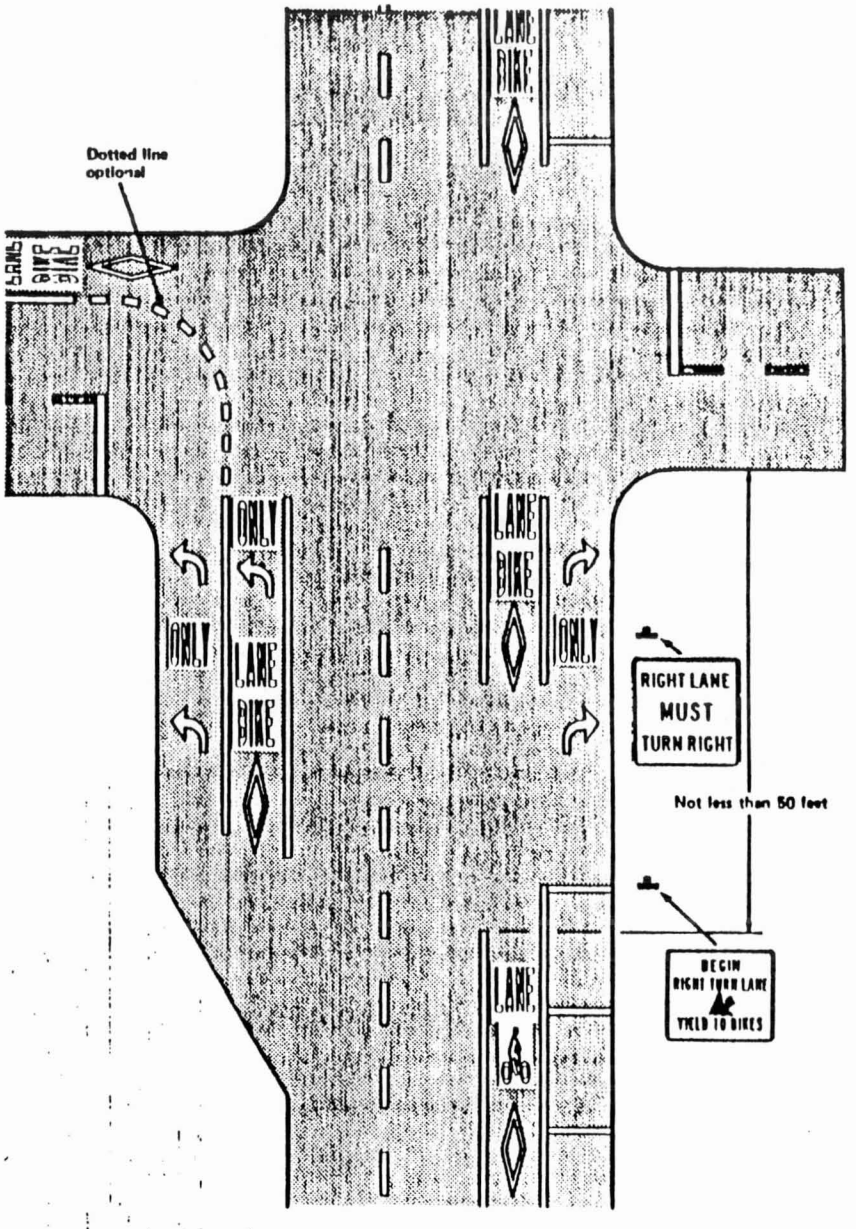


Figure 9-5. Intersection pavement markings—designated bicycle lane with left turn area, heavy turn volumes, parking, one-way traffic or divided roadway.

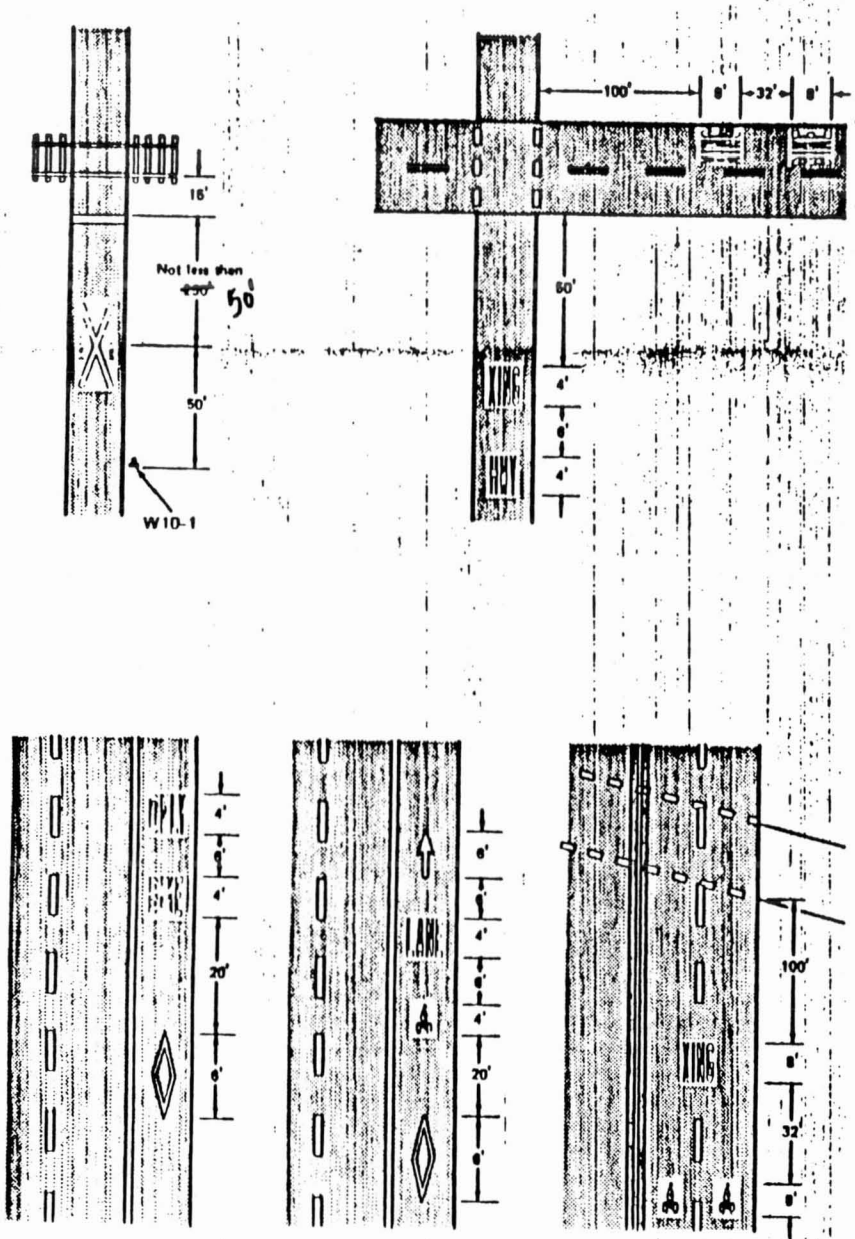


Figure 9-6. Word and symbol pavement markings for bicycle facilities.

9C-4 Marking of Designated Bikeways

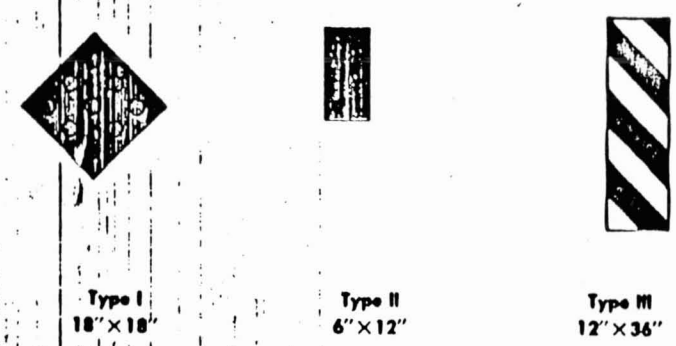
The diamond-shaped Preferential Lane Symbol is intended for use on highway facilities where lanes are reserved for exclusive use by a particular class of vehicle. Designated bikeways are considered as this type of lane and shall include use of the Preferential Lane Symbol as a pavement marking and on appropriate signing (sec. 9B-8). The symbols as a pavement marking shall be white and shall be used immediately after an intersection to inform motorists turning of the restricted nature of the lane. If the Preferential Lane Symbol is used in conjunction with other word or symbol messages, it shall precede them. A supplemental lane symbol or word may be used following as shown in figures 9-4 through 9-6.

9C-5 Word Messages and Symbols Applied to the Pavement

Where messages are to be applied on the pavement, smaller size letters can be used on exclusive bike lanes than are used on regular highways. Where arrows are needed, half-size layouts of the arrows can be used (sec. 3B-17). Optional word and symbol markings considered appropriate for use with the Preferential Lane Symbol marking are shown in figure 9-6. Standard pavement marking alphabets and symbols have been prepared.*

9C-6 Object Markings on Bicycle Trails

There may be hazardous objects located adjacent to bicycle trails which, if visible to the rider, can be avoided with little difficulty. Such objects can be marked with highly visible markings to make their identification by approaching riders more certain. Care should be taken to avoid having object markers become hazardous objects. Corners of object markers as well as signs should be rounded to prevent their becom-



* Available from the Federal Highway Administration (HTO-20) Washington, D.C. 20590

ing a hazard. All object markers should be designed using reflective materials or coatings. Where practical, markers such as those described in section 3C-1 of this Manual should be used.

Where a storm drain hazard cannot be eliminated, it may be made more visible to bicyclists by defining with a white marking applied as shown in figure 9-7.

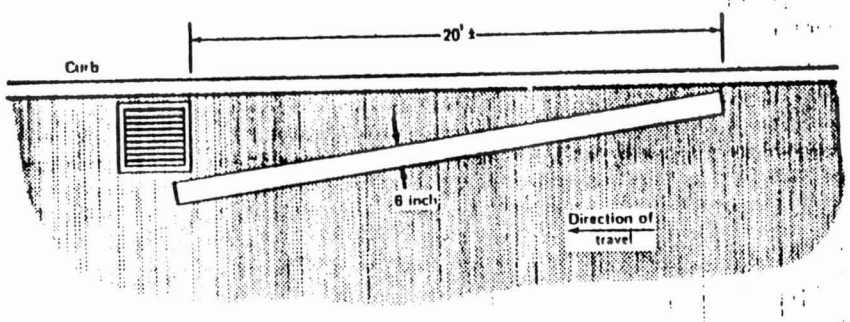


Figure 9-7. Typical marking in advance of drainage hazard.

D. SIGNALS

9D-1 Application

It is rare when a traffic signal is installed solely for bicyclists; however, at some locations there may be a need to install signal devices to facilitate bicycle travel through the intersection. For warrants and other requirements relating to signal installations, see Part IV of this Manual. Warrants used for motor vehicles are considered appropriate for use in determining the need for signals to serve bicyclists. Warrant Four for school crossings is considered to be appropriate for bicyclists also.

9D-2 Visibility Requirements

At installations where programmed signals are used, special attention should be given to adjusting the signals so bicyclists on the regular bicycle lanes or travel paths can see the signals. If programmed signals cannot be aimed to serve the bicyclist, then separate signals shall be provided.

9D-3 Signal Operation for Bicycles

Bicycles generally can cross intersections under the same signal timing arrangement as motor vehicles. Where bicycle use is expected, extremely short change intervals should not be used and an all red clearance interval may be necessary.

APPENDIX B

Bicycle Storage Facilities

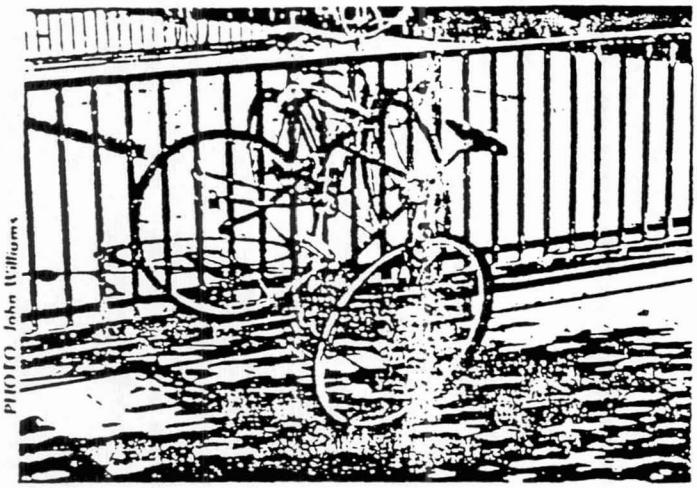


PHOTO: John Williams

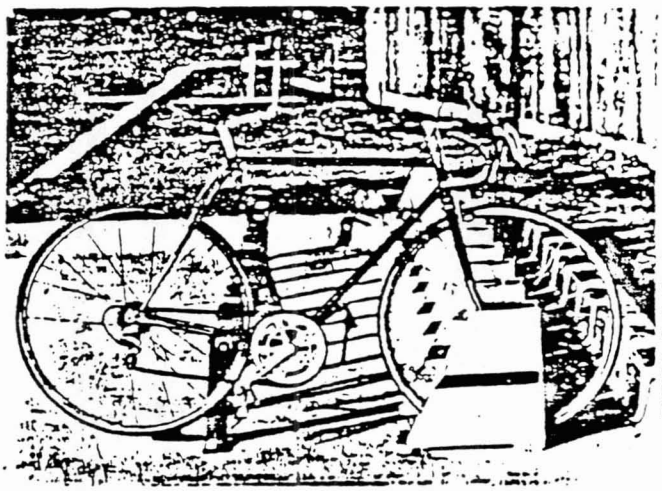


PHOTO: Rally Racks

The Bicycle Parking Link

A timely look at bicycle parking ordinances and facilities.

By John J. Protopappas and Joseph Anderson

"If bicycles could be more securely parked, their use would increase as a means of commuting, especially in connection with mass transit..."[1]

The availability of secure bicycle storage is a prerequisite to any urban bicycle trip, yet there is a definite, pervasive deficiency in the amount and/or security of bicycle parking facilities throughout urban areas. Both the social, economic and environmental desirability of bicycling and the public's interest in bicycling are apparent. It is a stated policy or goal in many communities that "bicycling should be encouraged". To this end, many improvements to benefit bicycling have been studied and some have been implemented. Many bicycle paths and lanes have been constructed, but little attention has been paid to "incidentals" such as bicycle parking. Bicycle parking is an essential link in the chain of improvements that must be made to serve existing and potential bicycle users.

Why has bicycle parking, relatively easily and inexpensively implemented, fared so poorly in the "chain" of improvements? Most official public attention has focused on bicycle *riding*. Bicyclists have been competing for road space for years, raising the ires of motorists, precipitating reported accident statistics and expressing a certain amount of dissatisfaction with the inevitable traffic mix. Pressure has been brought from motorists and bicyclists alike for bikeway, education and enforcement programs. Bicycle parking, on the other hand, is a *personal* problem, one which raises little public sensitivity.

As slight as the public pressure for bicycle parking may be, the problem of securing a bicycle from theft is real and is shared by every individual bicyclist. This need can be met by public action and has the potential of being a substantial benefit and encouragement to the bicycling community.

An example of the magnitude of the problem was cited recently in a survey in the City of Baltimore.[2] Based on survey data, 25 percent of the bicyclists had been victims of a bicycle theft and of these, 20 percent had given up bicycling. These facts are indicative of the problem which is commonly known in most American cities. The vulnerability and value of bicycles have made them attractive targets for theft. As the value and demand for bicycles have increased, the total number of bicycle thefts has also gone up.

A well thought-out and effectively executed bicycle parking program which appeals to both the implementors and the users is the answer to reducing bicycle theft and is a positive factor in encouraging bicycle use. In addition to implementing a program to provide adequate, secure bicycle parking, serious attention should be given to a bicycle registration program and user education. These are complimentary elements. Mandatory registration is a logical means for identifying and returning stolen bicycles, for limiting resale potential, for providing a record of the magnitude of bicycle ownership and for discouraging theft from the outset. Education, as an instructive tool as well as a marketing element, should provide information on the

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Joseph Anderson is a Professional Engineer, with a transportation planning degree. Currently is Principal Transit Planner and Bikeway Coordinator for Montgomery County, Maryland. Anderson developed a countywide bikeway plan for Montgomery County.

availability of parking, its proper use and practical theft preventive measures.

In designing a parking program, facilities must be selected to meet the need of bicyclists who are, in many cases, not involved in the decision-making process. Three features must be considered:

(1) incorporation of bicycle parking policy requirements into parking or zoning ordinances and local building codes, thus tying facilities into the public and private development process;

(2) developing design standards to insure proper location, weather protection, equipment integrity and degree of security; and

(3) budgeting funds for implementing public bicycle parking facilities. Each program must be tailored to local needs and resources. Where it may not be possible to successfully budget public funds to construct parking, it may be possible to require private developers to provide adequate facilities in conjunction with new development.

Bicycle Parking Ordinances and Codes

In order to insure that there is adequate space allocated for bicycle parking on an on-going basis, a bicycle parking ordinance may be formulated for incorporation into local zoning regulations. This is much like the typical regulations which require automobile parking spaces based on the square footage of building development.

A number of forward-looking communities have bicycle parking ordinances and a number of others have ordinances under consideration. One of the more notable of these is Palo Alto, California. In this city, developers are required, by Zoning Ordinance, to dedicate 5½ percent of the total required parking space to secure bicycle storage facilities. This ordinance not only details what percentage of space must be dedicated to bicycle parking, but it goes on to define what type of storage facility (Class I, II or III) must be provided.[3]

Another jurisdiction, Montgomery County, Maryland, updated off-street parking space requirements in the Zoning Ordinance to incorporate compact car, bicycle, handicap, and motorcycle spaces. The ordinance stipulates that all owners of parking facilities containing more than 40 parking spaces must provide 1 bicycle parking space or locker for each 20 automobile parking spaces. Not more than 20 bicycle parking stalls or lockers are required on any one lot. It further states.. "Bicycle parking facilities shall be so located as to be safe from motor vehicle traffic and secure from theft. Interior storage and lockers are encouraged. They shall be properly repaired and maintained. Facilities that are used for overnight parking must be protected from the weather when they are part of an enclosed parking facility." Owners of *existing* parking facilities who take advantage of the space savings of compact car layout must also abide by the requirement for bicycle parking facilities. This ordinance revision reduces the amount of land necessary for parking facilities, making more efficient use of existing space. Other jurisdictions, such as Arlington County, Virginia, have rewritten guidelines for subdivision and building permit approval to include the provision of bicycle storage facilities.

Other policy considerations may be incorporated into codes and regulations to benefit bicycle security. For example, provisions for allowing bicycles on public transit vehicles or in the public areas of buildings and private offices can improve the bicyclists' mobility and/or avoid having to leave the bicycle unattended. The AC Transit and BART systems in San Francisco, the San Diego Transit Corporation and the New Jersey-New York PATH system have all instituted forms of bicycle "carry-on" service.

Bicycle Storage Facility Types and Design

The facets of design must be considered in providing bicycle parking area:

1) Degree of security and safety from vandalism and theft;
2) Location — convenience of parking relative to destination;
3) Weather protection (sun and rain).

Each factor elicits certain criteria which must be considered in determining what type of parking facility is best for the situation at hand. Bicycle storage needs may be differentiated between long-term parking and short-term or convenience parking. The distinction is similar to that for automobiles. The most important criterion for short-term/convenience parking (shopping centers, libraries, post offices, etc.) is for the bicycle storage facility to be located *immediately contiguous* to the building entrance. For long-term/commuter parking (places of employment, apartment buildings, schools, transit stations, etc.) security from theft is the *most* critical consideration.

Location

The closer bike parking is to a bicyclist's destination, the more likely it (and the bicycle) is to be used. "Many bikers, particularly those with more expensive machines, have such a case of theft paranoia (a not unreasonable affectation) that they prefer not to be separated from their bikes at all and would blithely wheel into elevators, dentist's offices, bank lobbies and ice cream parlors if allowed to."[4] Many people make it a practice to ask for space for their bicycle when first accepting a new job so there are no misunderstandings when they arrive at a new office with a 10 speed.[5]

The point to point convenience of bicycle travel is undermined when parking is located in the far corner of a parking lot. It's best to locate a parking facility as near a building entrance as possible and (in high visibility areas) within the sight lines of passersby. The location

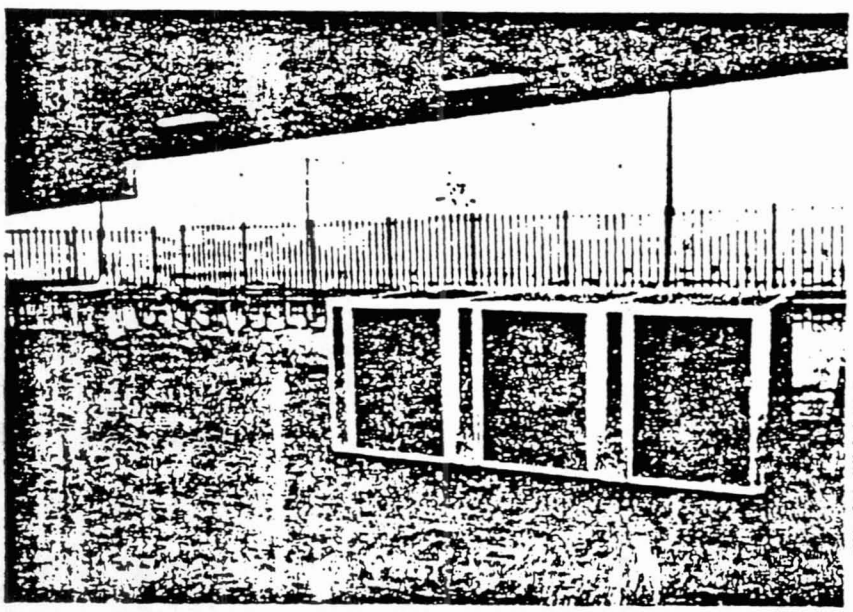


PHOTO BIKE LOKR

San Francisco Bay Area BART Station Bicycle Lockers.

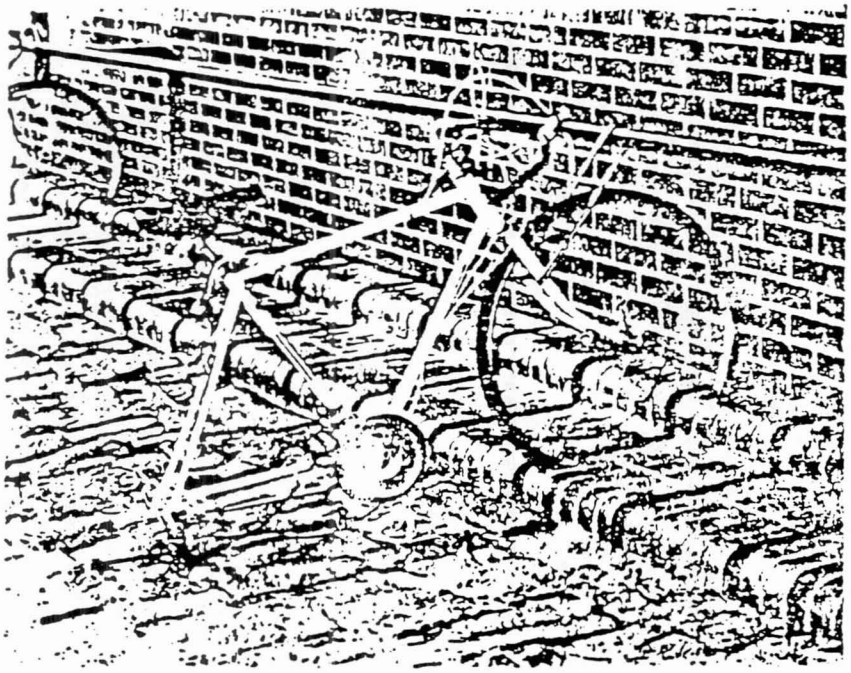


PHOTO John Williams

Protection from theft is the individual's primary concern.

should be sufficiently removed or protected from the possibility of collision with automobiles or interference with pedestrian traffic. It is most advantageous to specify location during the initial planning of buildings, associated accessways and parking facilities. Revised local ordinances are particularly helpful in succeeding with this approach.

Weather Protection

Protecting the bicycle from the elements — sun and rain — is particularly important for long term/commuter parking. For trips with a shorter parking duration, such as shopping and other personal business, open air parking may be acceptable. These trips are generally more flexible in schedule and may be delayed to a better time or day. It is best, however, under any circumstances, to utilize a location that already provides weather protection, if otherwise suitable. For long-term parking in particular, consideration must be given to protection by awnings, canopies, interior spaces or lockers (where warranted for theft protection).

Security & Safety

Protection from theft is the individual's primary concern when leaving the bicycle unattended. Procuring the ultimate security parking device has been the relentless pursuit of many manufacturers. Separate attempts by both BART in San Francisco and METRO in Washington, D.C. to specify custom-made bicycle lockers failed to produce cost effective equipment. Both agencies have since returned to stock items which yield satisfactory results. A good variety of locking and parking devices currently exists but careful selection is still necessary. Three categories of bicycle parking devices according to degree of security, have been suggested:[5]

Class I — *Lockers or controlled access areas where bicycles may be stored, protected from theft, weather, and vandalism.*

Class II — *Devices which lock the bicycle frame and wheels, secured from theft of the unit. The individual may have to provide a padlock.*

Class III — *Bicycle racks or fixed objects to which a bicycle may be secured by the individual's own locking device.*

Class III or "bicycle racks" are the traditional and currently predominant facility for bicycle parking. It is left to the bicyclists to shoulder the responsibility for protecting their investment by buying and using lock sets. Unfortunately, the value and theft experience of today's bicycle has outmoded this approach.

Independent tests conducted across the country confirm that there are no really secure bike lock hardware systems in this class. Some locks carried by cyclists are better than others, but in a high crime setting, none would last longer than 10 minutes; in fact most will give way in under two minutes, according to the *Consumer Report*.[6] Another testing report confirms that no lock will last longer than two minutes.[7] In the words of one lock manufacturer, a bicycle lock will delay a thief momentarily, but "... if somebody sees a $150 bicycle and plans to get it, it is his. Basically what you're protecting against is the chance thief or opportunist."[8] Though suitable for short term convenience parking, long-term parking requires more than a system which provides only a moral deterrent.

Class II bicycle parking devices are designed to secure the bicycle frame and wheels in an upright position, typically by a post and chain construction. Accessory parts of the bicycle, such as the seat, air pump, tool kits, are not protected. Weather protection may be provided by a special structure or by selecting a location under an existing overhang. Different locking mechanisms are available: coin operated, key-operated or the bicyclist's own padlock. The locking mechanism is an important consideration. Key- or coin-operated equipment costs twice as much initially, requires more maintenance, and necessitates a user charge.

Generally, the padlock systems are most popular. The added costs of the other systems cannot be justified unless it is imperative that revenue be collected or tourists without padlocks are the anticipated users. Transit systems which have utilized the Class II devices include: MARTA in Atlanta, Seattle's Transit System, BART in San Francisco, PATH in New York-New Jersey, PATCO in Pennsylvania-New Jersey. Many universities have also installed these parking devices, reporting mixed user acceptance and security from theft.

Table A lists the various manufacturers of secure parking devices, (Class I and II) including products and approximate prices. The prices range from $25 to $250 per parked bicycle. Class II devices have been tested by two independent investigators. The Bicycle and Pedestrian Research Center, Philadelphia and the University of Maryland, College Park, Maryland.

The University of Maryland Planning Department made an in-use study of eight of the Class I and II bicycle racks available today.[9] Table B summarizes test results. As these results indicate, no rack is perfect. Each rack has its pros and cons. The use intended, site location, and economics will define which rack will serve a particular situation better than another. The University of Maryland set up the following criteria and then made their choice after testing eight racks over a year's time.

TABLE A — AVAILABLE BICYCLE STORAGE FACILITY TYPES

Name of Device	Manufacturer — City, State	Class	Model	Price	Notes
1. Rack III	Rack III, 1714 Stocton St. San Francisco, Ca. 94133	II	Key Coin-Op Padlock	$120.00 each $120.00 each $ 41.75 each	*Used at many locations throughout U.S.* *Each rack holds one bicycle*
2. Rally Rack	Rally Enterprises, Inc. Box 299, Sonoma, Ca. 95476	II	RR-100	$ 22.00 each	*Each rack holds one bicycle* *Used by PATH system (NY-NJ) at Journal Sq. Transportation Center*
	(Minimum Order 6)	II	RR-200	$ 25.00 each	*Used by WMATA (DC) at present and future stations*
		II	RR-300	$ 55.00 each	*PATCO (PA-JN) installing 171 RR-300's*
		II	RR-400	$160.00 each	*Key-Coin operated*
3. Cycle-Sentry	Sentec Industries P.O. Box 4043 San Francisco, Ca. 94110	II	Galvanized Painted	$ 36.00 each $ 39.00 each	*Each rack holds one bicycle*
4. Bike Safe	Patterson-Williams P.O. Box 4040 Santa Clara, Ca. 95054	II	1615-2 1615-5	$100.00 each $210.00 each	*Holds two bicycles* *Holds five bicycles*
5. Bala-Byk Lok-Rak	Bala-Byk-Lok-Rak 691 Parkview Circle Pacifica, Ca. 94044	II	Padlock Coin-Op	$ 31.50 each $ 65.50 each	*Installed at U. of Maryland* *Each rack holds one bicycle.*
6. Bike Lock Up	Howard Enterprises 1250 Wilson Way Stockton, Ca. 95205	II	Standard Deluxe	$ 31.00 each $ 35.00 each	*Each rack holds one bicycle.* *Installed U. of Maryland*
7. Park-A-Bike	Park-A-Bike Systems 180 Coor St., Suite 111 Denver, Col. 80206	II	—	$ 25.00 to $ 75.00 each	*Holds one bicycle* *Installed U. of Maryland*
8. U-Lok	Sunshine Recreation Co. 22713 Ventura Blvd., Suite A Woodland, Ca. 91364	II	Security stand	$ 45.00 each	*Holds two bicycles; installed at various colleges, special lock option.*
9. Bike Root Bike Rack	The Bike Root Co. 31½ Mt. Vernon St. Charlestown, Mass. 02129	II	—	$ 28.50 each	*Holds one bicycle.*
10. Bike Lokr	Bike Lockers P.O. Box 978 North Highlands, Ca. 95660	I	Padlock Coin-Op/ Key-Op	$320.00 each $320.00 each	*2 bicycles per locker; installed by BART, EPA, Metro Md.*
11. Bike Stable	Bike Stable Co. P.O. Box 1402 South Bend, Indiana 46624	I	Key-Op	$214.00 each	*Holds one bicycle. No units have been sold up to this date.*
12. Mac Cycle Vault	BMR Fabrications P.O. Box 610 Tocca, Ga. 30577	I	Padlock Coin-Op	$194.00 each $250.00 each	*One bicycle per locker* *One bicycle per locker*

University of Maryland Planning Department Bicycle Rack Criteria

- The rack must secure both wheels and the bicycle frame.
- Securing the bicycle in the rack is to be a simple operation.
- The rack is to accommodate a wide range of bicycle types and locking mechanisms.
- Securing the bike must be possible with only a user-supplied lock.
- Although data is not available on durability, racks should be selected for their apparent quality. Members and joints should be rustproof and designed to minimize or eliminate structural and mechanical failures.
- The appearance of the rack is to be "aesthetically pleasing" within the financial and functional parameters.
- The rack design is to allow for flexibility in site development.
- While racks must be capable of being securely anchored, the ability to relocate them is an option to be considered.

The final University of Maryland report states that..."Research has determined that the Rally Rack Models RR-200 and RR-300 are superior to all other manufacturers in meeting the established criteria."

The Bicycle and Pedestrian Research Center, tested three Class II devices considering security, ease of operation, versatility (to accept locks), and aesthetics. All models were reported superior to traditional bike rack lock set security when subjected to most methods of attack. Three high security locking devices were tested for compatibility with each parking device. Results are summarized on Table C. Economics were not a consideration in the ranking, the top rated Rack III unit costs $10 to $15 more than other units, a small difference relative to the average personal investment in a bicycle.[10]

Class I, bike lockers or storage spaces, are a significant, important step forward in protecting bicycles. They afford virtually complete protection from theft, vandalism and weather. There are two approaches: a locker unit similar to baggage storage lockers and controlled storage areas which are attended or accessible only by keys held by a limited number of individuals or responsible attendants.

In urban areas with attended parking garages or lots, areas can be adapted to store bicycles with relative ease, although without mandates or enforced ordinances, garages are reluctant to do so. In Washington, D.C., where some of the private parking garages installed bike racks, the same fees as charged to automobiles were levied against the cyclists. This parking program was not well received by bicyclists. A good example of controlled storage area is found in Union Station, the Amtrack & commuter rail terminal in Washington, D.C. A caged area for bicycle storage is provided inside the station, administered and maintained by the National Park Service. For a small initiation fee, bicyclists obtain a key to the storage area. Most of the bike/rail commuters use the storage for overnight parking, using their bicycles for the work trip end of their commute.

Standard bicycle lockers are currently available from three manufacturers (Table A) ranging in price from about $160 to $250 per bicycle stored. Construction is either steel or aluminum and fiberboard and all units are wedge shaped, allowing a variety of layout patterns — circular and rectangular (back to back). Although little data is available, one source notes that no successful thefts have occurred at either BART or Southern California Rapid Transit District installations.

TABLE B — UNIVERSITY OF MARYLAND RACK COMPARISON

TRADE NAME	ADVANTAGES	DISADVANTAGES
Rally Rack RR-100	• Secures rear wheel and frame with a single lock • Rack consists of a single post and has no moving parts • Rack is very easy to use • Rack has aesthetic appeal by virtue of its good design	• Does not secure the front wheel
Rally Rack RR-200	• Rack has the advantages of the RR-100 with the addition of a cable attached to the post which secures the front wheel	• Cable is vulnerable to bolt or wire cutters
Rally Rack RR-300	• Rack has the advantages of the RR-100 with the addition of a formed steel plate which prevents removal of the front wheel	• Cost is more than twice that of the Rally Rack RR-200
Standard Rack	• Least expensive of all rack systems	• Provides the least security of all rack systems, requiring an unusually long chain or cable supplied by the user to secure both wheels and frame of a bike making it vulnerable to bolt or wire cutters • Bikes parked in these racks are easily damaged • Rack design encourages inefficient and cluttered parking arrangement
Bala Byk-Lok Rak	• Secures both wheels and frame with a single lock • All locking components are constructed of steel	• Poorly constructed — welds break with normal use • Not easy to use — requires four steps to secure bike • Does not provide arrangement flexibility • Visually clutters the environment — has no aesthetic appeal • Rusts over time
Howard Bike Lockup	• Secures both wheels and frame with a single lock	• Disadvantages are identical to those listed for the Bala Byk-Lok Rak
Park-A-Bike	• Secures both wheels and frame with a single lock • Relatively easy to use	• Visually clutters the environment — has no aesthetic appeal • Cable which secures both wheels may be vulnerable to bolt or wire cutters
Rack III	• Secures both wheels and frame with a single lock • All locking components are constructed of steel	• Secures bicycles with a pivoting three-pronged device — this moving part may prove troublesome

TABLE C — TEST RESULTS
(Bicycle and Pedestrian Transportation Research Center)

Rack	Rack III	Rally Rack 200	Bala Byk-Lok-Rak
Security	second	third	first
Ease of Operation	first	second	third
Versatility	first	third	second
Aesthetic Quality	first	second	third

Lockers can be coin operated, locked by separate padlock, or a cyclist can be issued a key on a lease basis. The latter system is used in Washington, D.C. and San Francisco where lockers have been installed at several of the new rail transit stations.

The first ten lockers installed at METRO's Silver Spring Station were offered for lease for variable period rates to $70 per year. All lockers were leased for a full year prior to the station's opening day (without the benefit of advertising). Although the $70 per year fee was regarded as high, the public's response indicates a high demand for this type of facility. Based on an installed cost of $320 per double locker unit, the METRO locker rentals will cover the capital investment in two and one-half years. Since all the lockers were leased for a full year the first day offered, almost half of the capital cost was covered immediately after installation. With demonstrated high demand, 16 more lockers have been ordered for the Silver Spring Station and the District of Columbia has 250 on order to be installed at stations throughout the city.

The BART system in San Francisco has a relatively long-standing experience with lockers. BART planners indicate that the initial installation of 60 lockers throughout the system would have been recommended for increase if based on current experiences. It is believed that the initially inadequate supply of bike racks and lockers has been a deterrent to many potential bicycle users. In response to demand, 648 additional lockers are in the process of being installed. At first BART offered lockers at 25¢ per day or on a lease basis for $5 per month. Daily coin rental has since been abandoned in favor of a wholly leased system. "Leasing is preferred among regular bike commuters because it guarantees a place in a locker, which are available in limited numbers". As stated earlier, both BART and METRO also include Class II parking devices in their parking programs which are free of charge and well utilized.

The Future

There are many signs that the future looks bright for the bicycle commuter. The Federal government allows *federal highway monies and transit capital funds* to be spent on bicycle facilities including parking.* Local governments including the traffic engineers, architects, and planners are recognizing the needs of the cyclists. With the proper amount of interest and forethought by these people we can hope to see a continuation of the trend toward installing first class bicycle parking facilities. The first step is establishing the need for parking and making a specific proposal. Bike parking is easy, simple, and inexpensive to implement relative to many other improvements being considered to enhance bicycling. With initiative, care and thought, very high quality parking can be provided to the benefit of user and community alike.

* *See Federal Funds for Bicycles, this issue*

References

1. *Traffic Engineering, Vol. 47, No. 3, March 1977.*
2. *Baltimore County Bikeways Task Force, "Bicycling Parking, a Design Manual." January 1976.*
3. *City of Palo Alto, "Zoning Regulations," adopted March 20, 1978. Sections 18.83.040 through 18.83.070.*
4. *Skrabek, Darryl, "Bike Law," Bicycling Magazine, March 1975.*
5. *Baltimore Bicycling Parking Manual.*
6. *"Bike Lock Sets", Consumer Reports, November 1975.*
7. *"Most bicycle locks yield to thieves in seconds", The Minneapolis Star, August 5, 1974.*
8. *The Minneapolis Star, August 5, 1974.*
9. *"UMCP Bicycle Parking — Stage Two", Department of Physical Plant, Office of Plans, Programs and Campus Development, University of Maryland, April 14, 1976.*
10. *"Bicycle Parking: Tests of Parking Racks", Bicycle and Pedestrian Transportation Research Center, Philadelphia, Penn. 1976.*
11. *Skrabek, Darryl, "Bike Law", Bicycling Magazine, March 1975.*

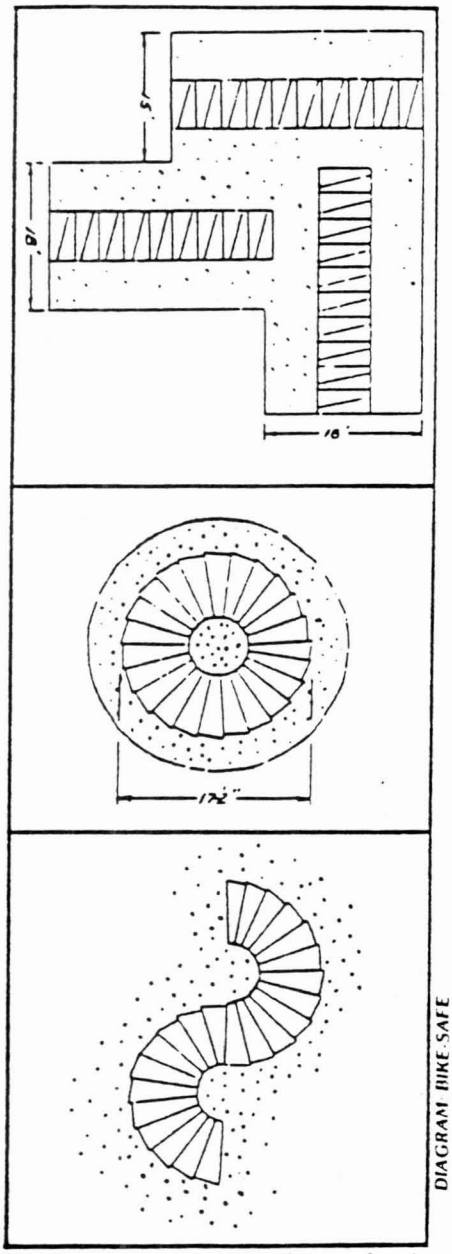


DIAGRAM BIKE-SAFE

Units are wedge-shaped allowing a variety of layouts.

For more information on Bicycle Parking Ordinances contact:

Joseph Anderson
Transportation Planner
Maryland National Capital Park and Planning Commission
8787 Georgia Avenue
Silver Spring, Md. 20907
Telephone: (301) 565-7394

Ellen Fletcher, Council Person
City of Palo Alto
3543 Greer Rd
Palo Alto, California 94303
Telephone: (415) 494-7605

APPENDIX C

Bicycle Loop Detector

DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

UNITED STATES GOVERNMENT

memorandum

Subject: Bicycle Detection

Date: JUL 25 1980

From: Director, Office of Traffic Operations
Washington, D.C. 20590

Reply to Attn. of: HTO-22

To: Regional Federal Highway Administrators
Regions 1, 3-10

We have had several inquiries regarding the ability of loop detectors to detect the presence of bicycles, particularly in the street where a bicycle lane is used. Reliable detection is possible through the use of a "quadrapole" loop with some loop detector amplifiers. A drawing of this loop as used in California is attached.

The loop detector amplifiers capable of sensitivities required to detect bicycles are manufactured by three companies:

Sarasota Engineering Company
Sarasota, Florida 33580
Model #222

Detector Systems
Los Alamedos, California 90720
Models #810, #823, #840, #222

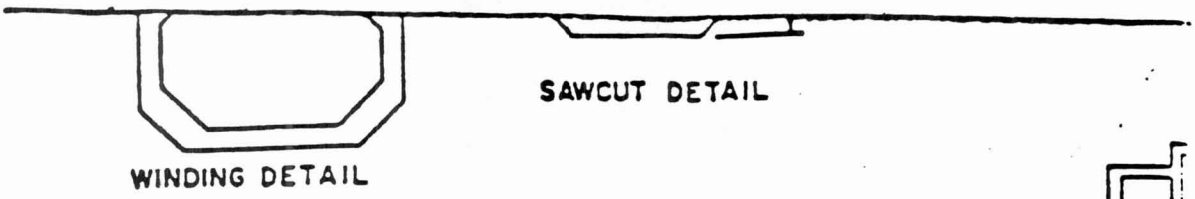
Canoga Controls Corporation
Canoga Park, California 91304
Models P4021, P404

We suggest this information be relayed to your respective divisions and through them to the States so that the bicycle detector problem may be minimized.

Marshall Jacks Jr.

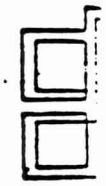
Marshall Jacks Jr.

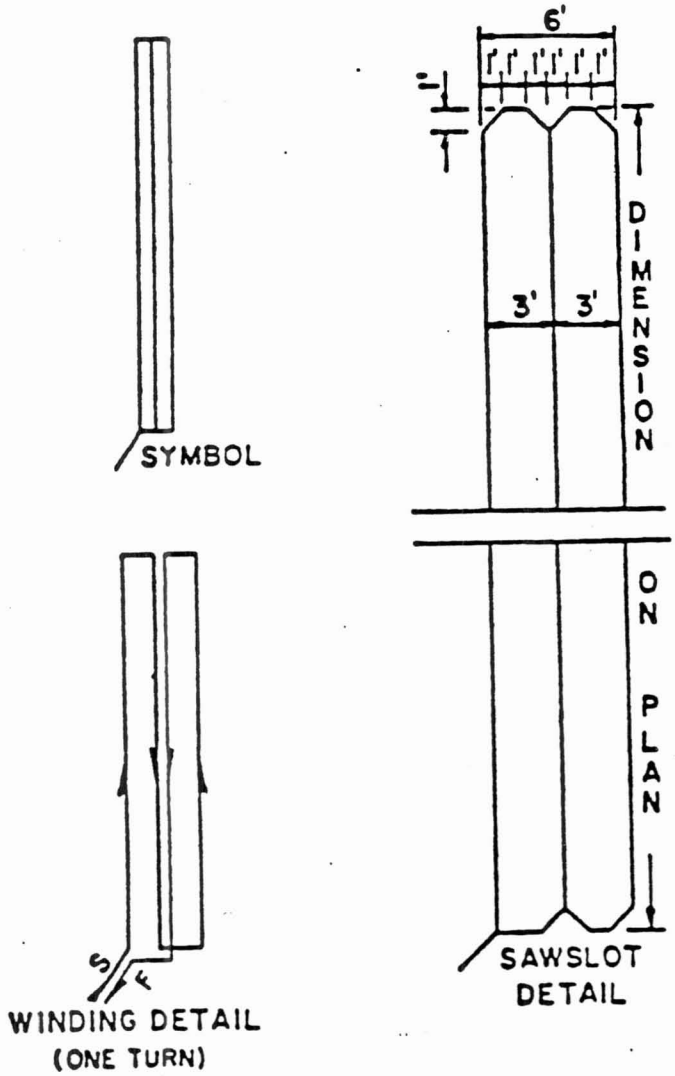
Attachment



TYPE Q LOOP DETECTOR DETAILS

(Use only when specified or shown on the plans)





TYPE C LOOP DETECTOR CONFIGURATION

(Use only when specified or shown on the plans)