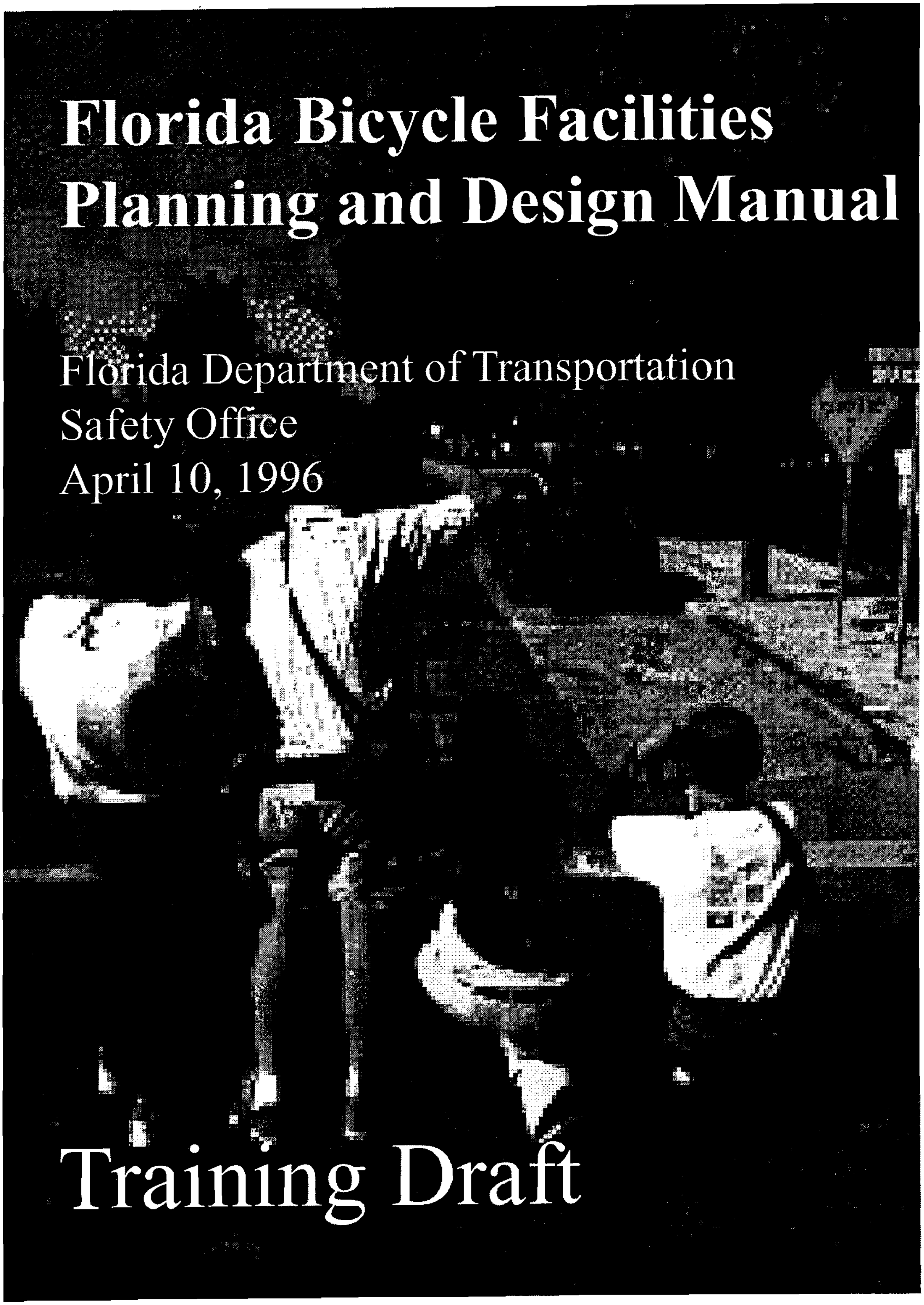
Florida Bicycle Facilities Planning and Design Manual

Florida Department of Transportation
Safety Office
April 10, 1996



Training Draft

Contents

Section 1

100 - Introduction

The purpose of this manual is to provide guidelines and criteria for planning, design, construction, operation and maintenance of on-road bicycle facilities and multiuse trails.

101 - Pupose Of This Manual

This manual is intended to serve as an aid to engineers, designers, planners, architects, landscape architects, citizens and others interested in improving Florida's bicycling environment. Information found in this document can be useful for private, local, state or federal projects.

101.1 Principles, Policies, Guidance

The manual offers general principles and policies followed by The Florida Department of Transportation (FDOT, also referred to as the Department). It also offers guidance to cities, counties, citizens and private groups for the development of local plans and projects.

101.2 Use of This Manual

- Training
- Reference
- Local roadway improvements
- State projects
- Local/state trails development

101.3 Roadways that Promote Predictable Behavior

This manual provides information to help accommodate bicycle traffic in all riding environments and encourage predictable bicyclist behavior. Bicyclists can be expected to ride on all roadways except limited access highways. A lack of safe, convenient and appropriate facilities often leads to bicyclists riding in unsafe locations, such as on commercial district sidewalks. Sometimes they ride against traffic.

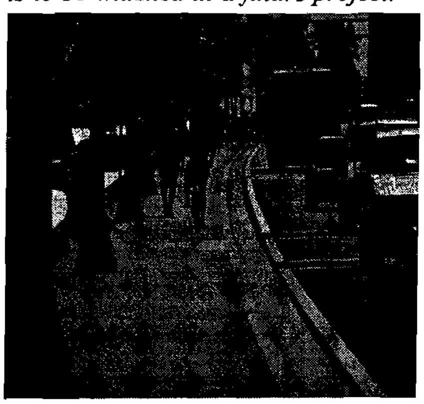
Department Goal

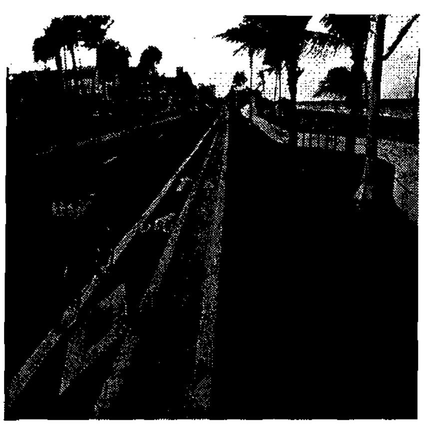
The Department supports the *National Walking and Bicycling Study's* goal to double walking and bicycling activity by the year 2000, while reducing crashes by 10%. This manual provides tools to achieve these goals.

Above: A Place for Cars, Not for People. *Older roadways, built solely for auto transport, created discomfort and unsafe conditions for motorists, bicyclists and pedestrians.*

Left: A Place for Everyone. *In contrast, modern highways are being designed as shared use facilities. Such designs are increasing the comfort and safety of all roadway users.*

(1) ***U.S. A-1-A in Ft Lauderdale*** *was modernized to encourage walking, following older FDOT policy to build wide curb lanes, (2) novice bicyclists chose to use the sidewalks instead. (3) With the installation of bike lanes (below) most bicycling now occurs in the roadway. This discovery that novice bicyclists need bike lanes has speeded up State policies toward widespread use of bike lanes. Pedestrians and motorists benefit when bicyclists are included in the conceptual and final highway design. This 3.5 (1 m) foot bike lane is to be widened in a future project.*





This manual is not intended to set forth strict standards. Instead it presents sound guidelines that will be valuable in attaining good design, sensitive to the needs of both bicyclists and other highway users. However, in some sections of this manual, criteria include minimums. These are established only where further deviation from desirable values would result in unacceptable safety compromises.

The information in this manual flows progressively from general concepts through the planning process to actual design. Samples of design details, specifications and photographs are included whenever possible.

Key information on crash types, categories of bicyclists, the design bicyclist, and the design bicycle is presented in Section 3 on safety. Please take time to become familiar with these concepts, since such information is rarely offered in planning, engineering or design schools. This information is key to understanding the design portion of this text.

The manual provides essential background on planning procedures and design.

This manual is not meant to act as a stand-alone document. Designers should use this document for background.

This manual also serves as a supplement to Chapter IX of The *Florida Manual of Uniform Minimum Standards for Design, Construction and Maintenance For Streets and Highways* (Green Book).

When designing projects for the Florida State Highway System, designers must comply with the *Plans Preparation Manual* (PPM). Should a discrepancy occur between this manual and the *Plans Preparation Manual,* the PPM applies.

110 - Criteria Definitions

To further clarify the use of this manual for state roadway projects, definitions of roadway design criteria and project standards are offered here:

110.1 Roadway Design Criteria:

The criteria for design of new roads or major reconstruction projects on the Florida State Highway System are found in Chapter 2 of the *Roadway Plans Preparation Manual.* Design criteria for resurfacing, restoration, and rehabilitation (RRR) are presented in Chapter 25 of the *Plans Preparation Manual.*

110.2 Design Standards:

The specific values selected from the roadway design criteria become the design standards for a design project. These standards will be identified and documented by the designer.

The following tips will make this document easier to use:

GUIDELINES: For engineering criteria, consult the main text of each section. Minimum criteria are single underlined.

REFERENCES: For additional technical detail and support, consult the appendix and check the references.

The provisions for bicycle travel are consistent with and similar to standard highway engineering practices. Signs, signals, and markings for bicycle facilities which are presented in the *Manual on Uniform Traffic Control Devices* (MUTCD) should be used in conjunction with this guide.

Key to Success. *Bicycling activity results from a concerted effort by a community to provide transportation choices. In this Davis, California scene two autos moving 3 people are dwarfed by more than 20 people being moved by an equivalent number of bicycles.*

120 - Background

There is a growing need for designers, citizens and others to have a common vocabulary, common concepts and common knowledge of successful bicycling systems and facilities in different places. This manual serves as a "convenience store" of the most commonly referenced concepts, practices, policies, issues and laws.

This document also provides information missing in other publications, such as an explanation of behavior of bicyclists, common crash types, bicycling laws, and working definitions.

Bicycling facilities planning and design is still not offered in most college and university curricula. This omission results in a wide variance in planning and design concepts, facilities placement and final designs by individual designers.

Finally, we have become such a nation of specialists that many designers lack the opportunity to see a project from concept to concrete. This lack of continuity is complicated by the tendancy of designers to be assigned vast territory, which means they rarely live in the neighborhood, sector of town, or even in the town that they are helping to design. A consultant in Atlanta, Georgia, may be completing a plan for a project in Ft. Meyers, Florida. This manual attempts to bridge the gap by urging every citizen, planner and designer to become familiar with each phase of a project.

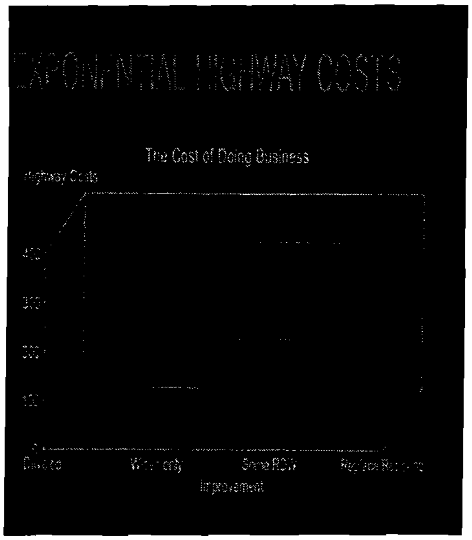
In our national move to become specialists, much is lost. The ultimate goal of this manual is to allow all of us to have a common general knowledge of how bicycling facilities work. In this way specific projects are more likely to do what they are intended to do - serve the public with well conceived, well located, affordable, safe, secure, and friendly enviroments.

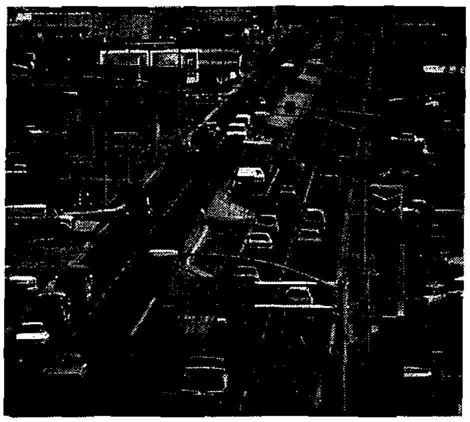
120.1 Why Bicycling?

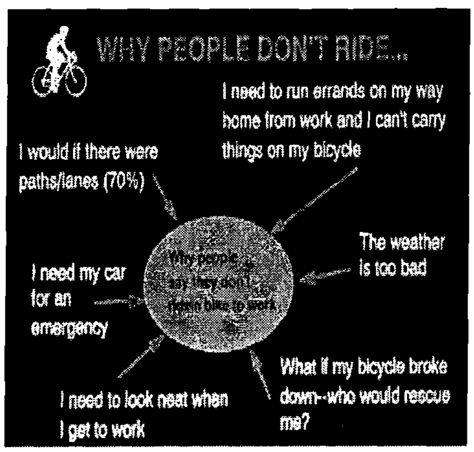
Increasingly, transportation officials throughout the United States are recognizing that bicycles provide a viable mode of transportation. Since the early 1970's, bicycling for commuting, for recreation, and for other travel purposes has increased in popularity. Nationwide, people are increasingly recognizing the energy efficiency, economy, health benefits, pollution-free aspects, and the many other advantages of bicycling.

Recent legislation such as the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the Clean Air Act Amendments and other

Gainesville's vision saves lives. *Gainesville's bicycle friendly spaces started later than Davis. But the results are equally convincing. Near campus over 40% of all travel is non-auto. Meanwhile, the construction of 100 miles of bicycle lanes and paved shoulders has resulted in an 80% drop in bicyclist fatalities.*







initiatives now require governments to give full consideration to all modes of transportation. Special emphasis is put on clean, energy-efficient, socially responsible modes, such as bicycling.

120.2 Bicycling Can Help . . .

- Form a seamless transportation system.
- Achieve intermodal links with transit.
- Create safe and effective links between neighborhoods, i.e. link neighborhoods to destinations where people go for their daily needs.
- Reduce complex and costly parking problems.
- Allow employers to offer choices in mode of transportation for their employees.
- Incorporate greenways development, urban redevelopment and resource preservation.
- Rail bank with rails-to-trails conversions.
- Achieve other timely, sensible and sensitive urban and rural land use practices.

Bicycling is for all people of ages. Along with walking, bicycling is more affordable than auto transport, and most people are physically capable of bicycling. Bicycling is more efficient than walking. It is the most efficient means of assuring independent travel for children, elder adults, many people with disabilities and those with reduced incomes. Bicycling gives all people mobility at an affordable cost. Bicycling helps keep them fit and improves health. However, bicycling does not replace the car or transit options for longer trips.

Local, state and federal agencies are responding to the increased use of bicycles by implementing a wide variety of bicycle-related projects and programs. The emphasis now being placed on bicycle transportation requires an understanding of bicycles, bicyclists, and bicycle facilities. With adequate planning and facilities development, the bicycle can play an important role in the overall transportation system. Bicycling promotes important land use and conservation policies, which call for compact and integrated land use patterns. These patterns provide reduced parking needs, urban infill, proximity, mixed use development and more balanced and efficient land use for transport systems.

***Communities are running out of right-of-way** for affordable highways. As trip times increase there is more and more demand for alternative transportation. Yet, until planners and designers build safe, convenient, efficient, comfortable and welcoming places to bicycle, the public is not likely to switch to other modes. People need places to ride their bikes in the same way they need places to drive their cars.*

130 - Research

Research is currently underway in Florida and elsewhere to develop additional criteria for the design of bicycle facilities. Specifically, additional information is under development regarding the selection of appropriate types of bicycle facilities. Such selections may depend on vehicular and bicycle traffic characteristics, adjacent land use and expected growth patterns, as well as other factors.

Should future research provide improved selection criteria, that information will be included in subsequent editions of this guide.

140 - Training Courses

The Department recognizes that much of this information is new to many readers. Since roadway designers are now required to understand and apply these principles on all future transportation, maintenance and operations projects, the Department is making available, at no charge, one-day training courses throughout the state. Consult your local Pedestrian/Bicycle Coordinator for details on when the next course is scheduled in your area, or call the Florida Pedestrian and Bicycle program staff at (904) 487-1200, SUNCOM 277-1200 or FAX (904) 922-2935.

150 - What's In Each Section?

Section 2 - Planning

provides an overview of planning considerations for bicycles, a discussion of the types of facility improvements, performance measures to the year 2005, and a description of factors to consider when locating a facility.

Section 3 - Safety

describes the customer's needs, behavior and problems. It provides background on crash causation, human performance, the design bicyclist and the design bicycle.

Section 4 - On-Road Design

provides guidelines to follow when constructing or improving highways and streets.

Section 5 - Multi-Use Trails

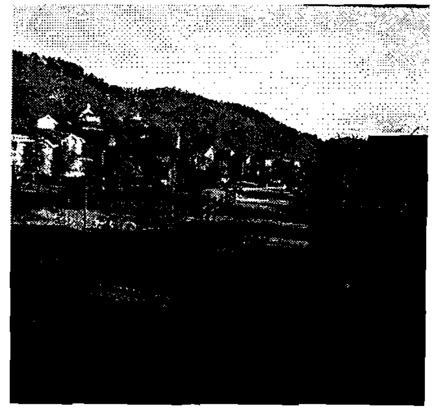
provides guidance to follow when constructing trails, greenways, intersections, bridges, overpasses and tunnels.

Section 6 - Supplemental Topics

provides information on parking, transit links, maintenance, traffic operations and law.

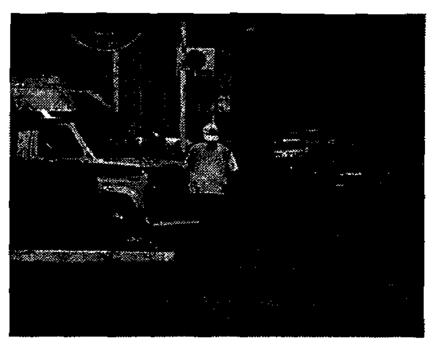
Section 7 - Appendix

provides a review of the legal status of bicycles, and provides helpful technical information from other frequently referenced manuals.



***Planning goals** in Boulder, Colorado lead to objectives and strategies that increase bicycling. A simple strategy to connect cul-de-sac streets increased local bicycling two-fold.*

***Sidewalks Risky.** Early attempts in Gainesville to place bicyclists on sidewalks led to high numbers of crashes. Improved planning and design to provide on-street bicycling dropped crash rates dramatically in less than a decade. Below: The discouragement and danger of mixing bicycling and sidewalks is made evident in this existing Key West scene. Only a raised median to help bicyclists cross to the correct side will alleviate their tendancy to take these conflict packed rides.*



160 - Authority

F.S. 335.065 SPECIFIES:

"Bicycle and pedestrian ways along state roads and transportation facilities. --

(a) Bicycle and pedestrian ways shall be given full consideration in the planning and development of transportation facilities, including the incorporation of such ways into state, regional and local transportation plans and programs. Bicycle and pedestrian ways shall be established in conjunction with the construction, reconstruction, or other change of any state transportation facility, and special emphasis shall be given to projects in or within 1 mile of an urban area.

(b) Notwithstanding the provisions of paragraph (a), bicycle and pedestrian ways are not required to be established:
(1) Where their establishment would be contrary to public safety;
(2) When the cost would be excessively disproportionate to the need or probable use;
(3) Where other available means or factors indicate an absence of need."

160.1 Department Policy

The Department incorporates the needs of bicyclists into all appropriate urban and rural construction and RRR projects. In some instances, right-of-way constraints and safety considerations may limit the extent that facilities and treatments can be applied in a given section. Considering these limitations, projects are to incorporate the needs of bicyclists to the maximum extent practicable.

170 - COMPREHENSIVE PROGRAM

Facilities are only one of the several elements essential to a community's overall bicycle program. A comprehensive community approach to bicycle use also includes bicycle safety education and training, bicycle use encouragement, and the application and enforcement of the Rules of the Road as they pertain to interactions between bicyclists, motorists and pedestrians. This manual provides information on facilities. Information on other elements of an overall bicycle program can be found in other publications (see Reference section).

Which Side Is Safe? *(1) The shops and lodgings are on one side, the bike path on the other. Key West's North Roosevelt Boulevard scramble lane offers too little safety for crossings. (2) Meanwhile, bicyclists stay on the service side, darting in and out, or use the sidewalks when available. This behavior creates high potential for crashes. A true boulevard style raised median will simplify roadway crossings and increase safety.*

Policies are backed by research. *(3) New research by FDOT in seven cities reveals that presence of bike lanes creates more predictable movement and less displacement of motorists and bicyclists while passing.*

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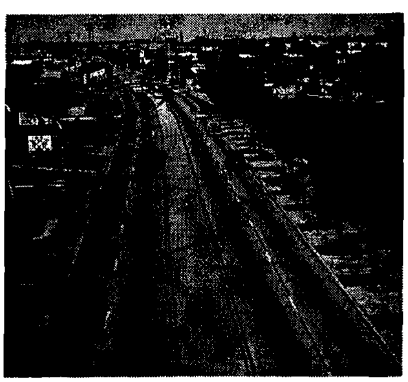

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180 - Supporting Florida References

The following Florida documents also urge improvements to bicycling to achieve agency goals:

- *Florida Transportation Plan*
- *Long Range Transportation Systems Plan*
- *Safety Management Systems Plan*
- *Congestion Management Systems Plan*
- *Intermodal Systems Plan*
- *Transit Systems Plan*
- *Florida Bicycle 2000*
- *Plans Preparation Manual*
- *Roadway Standard Index*

The Florida Bicycle Council has general and specific recommendations for bicycling. In general this group and many local bicycle advisory committees each urge bicycle friendly designs on all new roadway construction, reconstruction and resurfacing opportunities, or along with any other change in the roadway system.

Federal mandates under the Intermodal Surface Transportation Efficiency Act (ISTEA) require each state to adopt a statewide bicycle and pedestrian plan.

190 - DEFINITIONS

AASHTO - American Association of State Highway and Transportation Officials.

ACCESS MANAGEMENT - The principles, laws and techniques used to control access to highways.

ADA - The *Americans with Disabilities Act;* civil rights legislation passed in 1990, effective July 1992.

ADT - Average Daily Traffic. The measurement of the average number of vehicles passing a certain point each day on a highway, road, street or path.

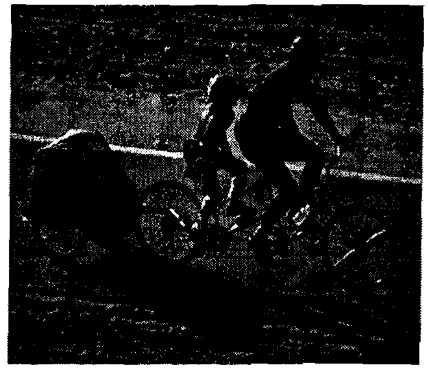
ARTERIAL (ROAD) - A road designated to carry traffic, mostly uninterrupted, through an urban area, or to different neighborhoods within an urban area.

BACKCOUNTRY TRAILS - Any multi-use trails that are non hard surfaced, commonly used for mountain bike or "off-road" riding and joint hiking uses.

BICYCLE - A vehicle having two tandem wheels, either of which is more than 16 inch (.4m) in diameter, or having three wheels in contact with the ground, any of which is more than 16 inch (.4m) in diameter, propelled solely by human power, upon which any person or persons may ride.

BICYCLE ADVISORY COMMITTEE - Most Metropolitan Planning Organizations (MPO's) and some counties have a politically appointed group of citizens and technicians who oversee bicycle planning and provide technical review of local bicycling facilities. These groups are known as Bicycle Advisory Committees (BAC's).

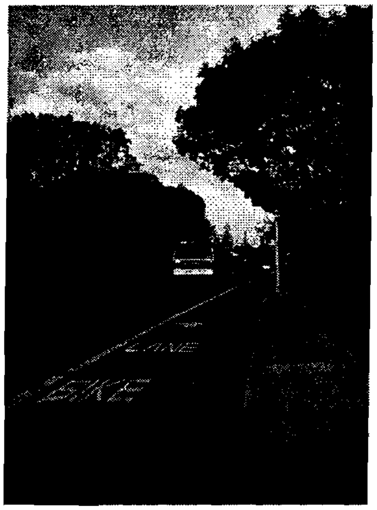
BICYCLE FACILITIES - A general term denoting improvements and provisions made by public agencies to accommodate or encourage bicycling, including bicycle paths, bike lanes, parking facilities, maps of bikeways, marked routes and shared roadways not specifically designated for bicycle use.



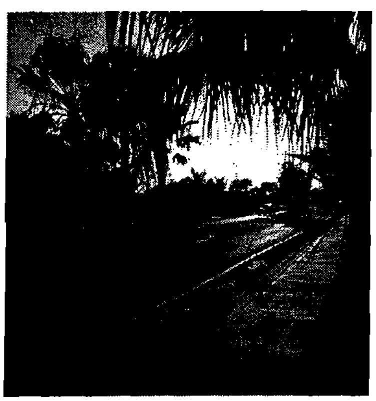
What is a bicycle? *A tandem bicycle pulling a trailer is legally defined as a bicycle. Wheel diameter, tandem wheels, and self-propulsion are criteria for defining a bicycle. This vehicle can move three or even four people.*

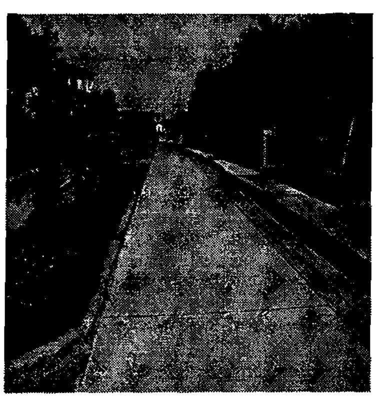
An adult trike is still a bike according to law. Handling characteristics are different. Which of these bikes has the greatest problem as the designer increases cross slope?

Fog and early morning light *lead to high crash rates. Bike lanes work best when conditions are worst. It is the presence of these facilities that has led to Gainesville's remarkable decline in serious car/bike conflicts.*



***Bicycle facilities and roadways** vary in dimensions according to traffic and safety needs. (1) The bike lane above is large enough to permit bus movements.*
(2) This roadway purposefully slows motorist speeds with use of a median. (3) In this private development a nine foot travel lane with median slows cars to 12-18 mph (bicycling speed).





BICYCLE BOULEVARD -
A system of roadways and connections between neighborhoods or areas in a community that forms a bicycling throughway, but discourages through and higher speed motor vehicle movement.

BICYCLE LANE (BIKE LANE)-
A portion of a roadway (typically 1.2 - 2.0 m, 4-5 feet wide) which has been designated by striping, signing and pavement markings for the preferential or exclusive use by bicyclists (Also see "Undesignated Bicycle Lane").

BIKE ROUTE - A system of roads and ways that are linked by signs to aid bicyclists. Bike Routes are ineffectual unless signs are highly specific, giving a clear indication of destination.

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

CLEARANCE, LATERAL - The width required for safe passage of a bicyclist as measured in a horizontal plane.

CLEARANCE, VERTICAL - The height necessary for the safe passage of a bicyclist as measured in a vertical plane.

CLEARANCE INTERVAL-
The amount of time a traffic signal provides to allow a type of traffic to clear the intersection before releasing conflicting traffic.

COLLECTOR (ROAD)-

A road designated to carry traffic between local streets and arterials, or from local street to local street.

CROSS SECTION, "TYPICAL CROSS SECTION" or "TYPICAL" - Diagrammatic presentation of a highway or path profile which is at right angles to the centerline at a given location.

DESIGN STANDARDS
The specific values selected from the roadway design criteria become the design standards for a design project. These standards will be identified and documented by the designer.

EDGE LINE - A painted or applied line to designate the edge of the road (150-200 mm, 6-8 inches)

ENHANCEMENT FUNDS - under ISTEA, set aside funds for eleven categories of spending including bicycling and pedestrian facilities and trails.

FRONTAGE ROAD - A road designed and designated to serve local traffic parallel and adjacent to a highway or arterial street.

GRADE - A measure of the steepness of a roadway, bikeway or walkway, expressed as a ratio of vertical rise per horizontal distance, usually in percent. For example, a 5% grade equals 5 meters of rise over a 100 meter horizontal distance.

GRADE SEPARATION - The vertical separation of conflicting travelways with a structure. An overpass or tunnel are examples of common grade separations used to avoid conflicts.

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

ISTEA - The Intermodal Surface Transportation Efficiency Act enacted in 1991. Federal legislation guiding the expenditure of federal highway funds.

MULTI-USE PATH/TRAIL (BIKE PATH, BIKE TRAIL) - Any hard surfaced bikeway that is physically separated from motorized vehicular traffic by an open space or barrier. It is either within the highway right-of-way or within an independent right of way. Due to a lack of pedestrian facilities, most bike paths/trails are commonly designed and referenced as multi-use paths or trails. For common convention, the term Multi-Use Trail will be used throughout this document.

MUTCD - The *"Manual on Uniform Traffic Control Devices,"* approved by the Federal Highway Administration as a national standard for placement and selection of all traffic control devices on or adjacent to all highways open to public travel.

PAVEMENT MARKINGS - Painted or applied lines or legends placed on a roadway surface for regulating, guiding or warning traffic.

RAISED PAVEMENT MARKING (RPM)-- A special raised marking device that is applied to a roadway to help designate lanes. Such markings are used judiciously or not at all in the presence of bike lanes.

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

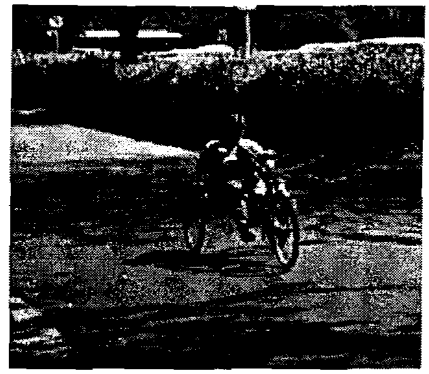
RIGHT OF WAY - The right of one vehicle or pedestrian to proceed in a lawful manner in preference to another vehicle or pedestrian.

ROADWAY - That portion of the highway, including shoulders, for vehicle usage.

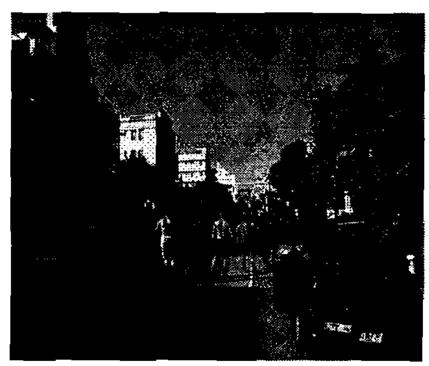
SHARED ROADWAY - Any roadway upon which a bicycle lane is not designated and which may be legally used by bicycles regardless of whether such facility is specifically designated as a bikeway.

ROADWAY DESIGN CRITERIA Criteria for the design of new or major reconstruction projects on the Florida State Highway System. These criteria are found in Chapter 2 of the *Roadway Plans Preparation Manual (RPPM)*. Design criteria for resurfacing, restoration, and reconstruction (RRR) are presented in Chapter 25 of the manual.

RRR PROJECTS - Specific roadway improvement projects that include resurfacing, restoration and rehabilitation of roadways. These projects use a different pot of funds than new construction.



Specialized customers. *The two mobility impaired travelers above use bicycle facilities in Davis, California (multi-use trail) and in a Manhatten bike lane. Below: When forced by law onto sidewalks, in-line skaters bring danger to pedestrians. Bike lanes and quiet streets may be safer places.*



Shoulder width provides separation, allows free movement of motorized vehicles and promotes tourism. Top: No shoulders on U.S. Alt 19 holds back motorists. U.S. 41 has 4 foot (1.2 m) paved shoulders and allows low speed passing. Many northern roads (Banff National Park) have ample 10 foot (3.0 m) wide shoulders.

RULES OF THE ROAD - That portion of a motor vehicle law that contains regulations governing the operations of vehicular and pedestrian traffic.

SHOULDER (PAVED) - That portion of a highway which is contiguous to the traffic lanes, allowing use for emergencies of motor vehicles, for specialized use of pedestrians and bicyclists, and for lateral support of base and surface courses.

SHY DISTANCE - The distance between the edge of a travelway and a fixed object. Also, the separation distance a roadway user needs to feel safe operating near a fixed object.

SIDEWALK - That portion of a highway designed for preferential or exclusive use by pedestrians.

SIGHT DISTANCE - The distance a person can see along an unobstructed line of sight.

SKEW ANGLE - The angle formed between a roadway, bikeway or walkway and an intersecting roadway, bikeway, walkway or railroad line, measured away from the perpendicular.

STRUCTURE - A bridge, overpass, retaining wall or tunnel.

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 VOLUME - The given number of vehicles that pass a given point for a given amount of time (hour, day, year). See ADT.

UNDESIGNATED BIKE LANE - That portion of a highway to the right of the edge line that is of sufficient width for a bicyclist to navigate and which has not been marked for bicycling (typically 1.2 - 2.0 m, 4-5 feet wide). Most rural paved shoulders, and a few urban roads are left undesignated as an engineering judgment.

VEHICLE - Any device in, upon or by which any person or property is or may be transported or drawn upon a highway and includes vehicles that are self-propelled or powered by any means. Includes legally defined bicycles (See Florida Statutes). Does not include in-line skates, roller skates or sidewalk bikes ("hot bikes").

VEHICLE (MOTOR) - To help differentiate those laws that apply to all vehicles (includes bicycles) from those for motor vehicles, the term *motor vehicles* is applied. To properly search for laws that apply to bicycles, look in the Florida Statutes (Section 316) for the word *vehicles*, and ignore all references to *motor vehicles*.

WIDE CURB LANE OR WIDE OUTSIDE LANE - A minimum roadway improvement where the curbside lane is typically widened to 4.2 m (14 ft). This treatment is generally being replaced in Florida with a designated or undesignated bike lane.

***Avoid these four conditions** All of these conditions exist in many communities. Whether designing a multi-use trail crossing, lane, or simply improving the roadway, it is essential to treat all highway users with equal respect. Our changing world calls for new ways of thinking and designing. This manual provides many tips for understanding and addressing the needs of this new, ever changing public demand for multi-modal highways.*

191 - Other References

Other documents that we recommend include:

AASHTO *Policy on Geometric Design of Highways and Streets,* and the *Guide for the Development of Bicycle Facilities.* These can be obtained from:

AASHTO
444 N. Capitol Street, NW,
Suite 225
Washington, DC 20001

Information on signing and pavement markings is contained in the *Manual on Uniform Traffic Control Devices* (MUTCD). It is available from:

Federal Highway Administration
400 Seventh Street, SW
Washington, DC 20590

Information on trail roadway crossings will be published by the Florida Department of Transportation after January, 1996. Reference: *Multi-Use Trails Intersection Design Manual.* (After July 1, 1996) Write to:

Florida Department of Transportation,
Maps & Publications Office
605 Suwannee Street
Tallahassee, Florida, 32399-0450

Section 2

200 - PLANNING

200.1 Organization

This Section has four parts. Part 1 introduces bicycle planning, Part 2 describes the elements and issues associated sith bicycle planning. Part 3 describes the bicycle planning process, and offers a model. Part 4 describes community planning and shows how to build bicycling into the greater vision of the community.

210 - What is bicycle planning? Part 1

211 - Bicycle Systems

Bicycle transportation planning is commonly construed as the effort undertaken to develop complete/comprehensive bicycle transportation and recreation activities. The resulting system is composed of multi-use trails, improved roadways, bicycle lanes, bicycle parking, bicycle mapping and transit links. All facilities are interconnected and spaced closely enough to satisfy the travel needs of bicyclists.

212 - Bicycling Uses the Existing Systems

Existing highways and streets, often with relatively inexpensive improvements, must serve as the base system to provide for the travel needs of bicyclists. Multi-use trails and trail connectors can augment this existing system in scenic corridors, greenways or places where access is limited. Water and land transit are important future linkages and partners to a comprehensive bikeway system.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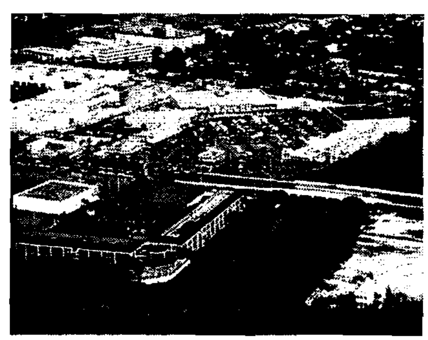
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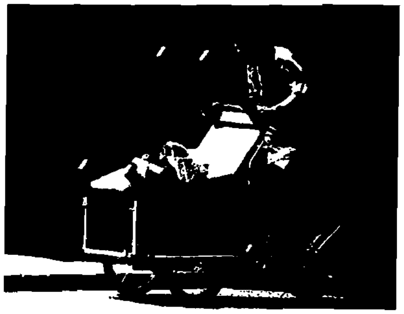
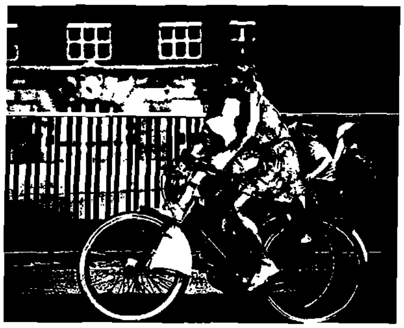
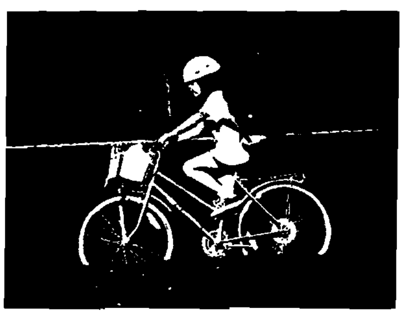
Bike planning should be pro-active and comprehensive. *Reactive, stand alone-planning does not work. Top: (1) U.S. A-1-A was not initially planned for bicycling. (2) Riders took over the new wide sidewalks. (3) Retrofit bike lanes were squeezed into the space at added cost, and results were limited. (4) More striking, the example land use in the New Town portion of Key West excluded bicycle access. Today a retrofit bridge is being considered to link neighborhoods with shopping and work.*







Bicycling is often a pleasurable activity. Thus, with the exception of the top photo, it is hard to separate utility from recreational riding. Both utility and recreational riding encourage fitness, community awareness and relaxation. Bicycle facilities that offer some transportation use now qualify for funding.

Thus, bicycle transportation planning is more than planning for bikeways. It is an effort that should consider many alternatives to provide for safe and efficient bicycle travel.

213 - Bike Planning Does Not Stand Alone

Planning for bicycle facilities must be concurrent with planning for other transportation modes, other public works projects and other land use planning. Often an improvement which enhances bicycle travel also benefits other modes of travel and helps a community achieve better land use and conservation objectives. Highway improvements, through appropriate planning and design, can enhance bicycle travel as well. Plans for implementing bicycle projects must be in harmony with a community's overall goal for transportation improvements. Transportation plans, in turn, should be consistent with overall community vision and goals.

220 - Basic Bicycle Planning Needs, Principles & Issues Part 2

221 - Utilitarian and Recreational Bicycling

The wide range of bicyclists' abilities and multitude of purposes for riding must be understood before planning for bicycle transportation improvements. In general, bicycle trip purposes can be divided into two broad types, utilitarian and recreational. For a bicyclist on a utility trip, the primary objective is reaching a specific destination quickly, with few interruptions. The bicycle happens to be the chosen mode of transportation or, in some cases, the only mode available.

On the other hand, a bicyclist on a recreational trip is riding for pleasure. The timing to a destination is often of less importance. Of course, for many trips and bicyclists these purposes are not absolute or mutually exclusive. New bicycle facilities, therefore, should be designed to accommodate different types of bicycle trips.

Bicyclists differ widely in their abilities and in their preferences for riding environments. Some bicyclists place high importance on directness and have the ability to ride safely and confidently in heavy traffic. They will often choose to travel on arterial roads in lieu of quieter, more aesthetically pleasing alternate routes, because arterial roads are more direct and result in perceived or actual time savings. Arterial and major collector roads also offer bicyclists increased signal and operations support, better lighting and other benefits over local and minor collector routes.

If an arterial road is not improved for bicycling, then many novice bicyclists are likely to make use of sidewalks. By doing so, especially in commercial districts, they endanger pedestrians and subject themselves and motorists to numerous conflicts that neither is prepared to handle. Thus, the Department now strongly urges the full consideration of on-road bicycling facilities on all principal roadways.

Since major attractors are often located on these roadways and rear access to properties is often limited or denied, a significant amount of bicycling should be anticipated by most age groups on all principal roadways.

In some cases additional design support can be given on parallel roads to attract bicyclists. This shift from the arterial road will only occur, however, when bicyclists find the alternate route provides direct access and personal security, as well as traffic safety. Cooperation is sought from each community to incorporate attractive bicycle boulevards, lanes or routes on available roads that parallel principal roadways. Decisions not to fund off-system roads ultimately dictate that the best riding conditions are on the most heavily traveled principal roadways. Every effort should be made to offer financial assistance for the development, operations and maintenance of bicycle facilities on both principal roadways and quiet collectors.

Some bicyclists place more importance on the quality of the trip and are willing to go out of their way to ride on residential streets or paths. While it is important to understand that a range of bicyclists' abilities and preferences exists, it will usually be a mistake to plan or design bicycle facilities primarily or exclusively around the needs of bicyclists at either end of this spectrum. Rather, bicycle facilities should be planned and designed to accommodate a broad range of bicyclists.

222 - Basic Principles

It is recommended that the following basic principles be considered when beginning any transportation project:

♦ Just as with motor vehicle support, assume that every street is a bicycling street and that all locations accessible to a motor vehicle should be accessible by bike.

♦ Involve all appropriate agencies and public participation in planning corridors and communities.

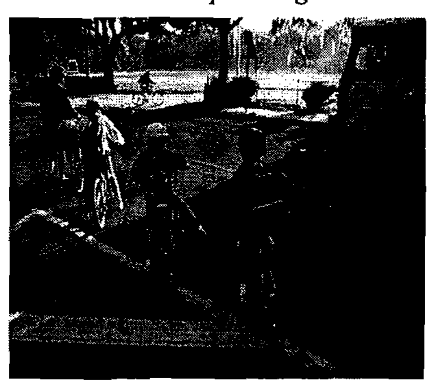
♦ Use public funds only for transportation projects that fully consider the needs of all modes of transportation including bicycling and walking.

♦ Use public funds for land use development that fully considers bicycling or mitigates the harmful effects caused by that development to bicycling.

Through the use of a comprehensive planning approach, Davis, California's schools are well located and laced with greenways. Nearly 100% of school-aged children walk or bicycle to school.

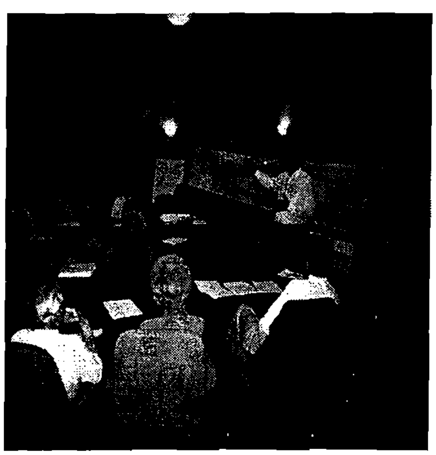
In contrast, the Florida school below has no connections to neighborhoods. Set amidst sprawl, only about 10% of area children walk or ride their bikes to school. Resulting auto trips add to peak hour traffic and create unsafe conditions for those who do walk or ride.

In Florida an average of 1 child in 8 gets to school on his own. Such a dismal record is the result of poor coordination and planning.



Can't Get There From Here. *Bicyclists face many barriers to destinations. Some impediments are simply unsafe conditions. Others force them to ride miles out of their way. Federal and state legislation, and new Department policy prohibit discrimination as pictured above on non-limited access roads.*

Public Involvement. *Under new ISTEA guidelines, the public has become an integral part of the transportation planning process. On a given project the public can and should be involved in all planning steps. Below: This Gainesville 26 and 26A road project involved the public in 48 hours of meetings, over a period of one year. Bicycle facilities were built into the corridor design.*



- ♦ Transportation planning should give priority to bicycling for all trips under seven kilometers (4.2 miles).
- ♦ Plans should overcome existing barriers to bicycle travel and create no new barriers.
- ♦ Roadway improvements should provide access to all destinations through the most direct or feasible route.
- ♦ The planning and design phases should have options, and afterwards, when monitoring the success of the project these options should be re-evaluated.
- ♦ Involve the public in the conceptual stage, data gathering, goals development, and all other reviews and phases of work.
- ♦ Planning should be flexible throughout the development process. Accept new design concepts and anticipate future changes to the system.

> The best planning efforts use an integrated approach to bicycle and pedestrian facilities based on the existing roadway system and other urban visions, goals and infrastructure.

230 - Bicycle Planning Process. Interactive and public driven. Part 3

203.1 Model Planning Process

The best planning efforts use an integrated approach to bicycle and pedestrian facilities based on the existing roadway system and other urban visions, goals and infrastructure. The separate bicycle and pedestrian plan approach is not recommended. These stand alone plans often fail to integrate the various components needed to develop sustainable communities and facilities. Such documents are only seen by a few. They are rarely referenced, thus the lack of consideration of them often results in many lost opportunities. Planners and practitioners are strongly urged to build the needs of bicycling and walking into all transportation, land use, school development, utility, conservation, public access and recreation documents.

Ensure that planning for bicyclists and pedestrians is incorporated into any document or policy statement guiding local and regional Metropolitan Planning Organizations (MPO's), Regional Planning Councils (RPC's) or other municipal or county officials, boards, councils or commissions. Bicycle facility plans should be included in standard municipal design specifications. By following these steps, financing bicycle facility and construction and maintenance will become a regular part of the budget process. These functions will no longer be considered separate embellishments that can be ignored.

230.2 Bicycle Advisory Committees

Throughout the planning process, every effort should be made to involve the public and bicycle user groups. This is most efficiently done by forming and making use of local Bicycle Advisory Committees (BAC's). These committees can simultaneously review pedestrian plans as well. If they serve both functions, they are called Bicycle/Pedestrian Advisory Committees (BPAC's). The public should be involved at the beginning of and throughout all public works, land use and transportation projects. Too often errors are made by well-intentioned public officials who have not heard from the public until it is "too late". This public involvement process can save costly mistakes. Public involvement must go well beyond traditional bicycle groups. Public participation should include social services, schools, neighborhood groups, employers, retailers, and others.

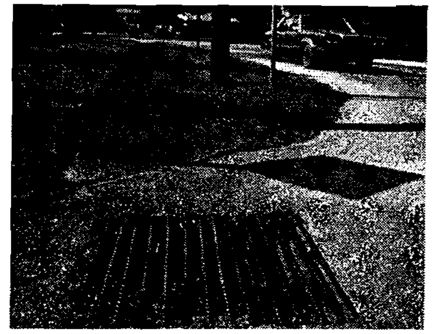
230.3 Planning Checklist

There are fourteen steps to be considered as an action checklist. Note the ongoing public involvement throughout the process.

1. Staff Conceptual stage
2. *Public involvement - concept*
3. Budget and schedule for planning process
4. Bicycling background and research analysis
5. *Public involvement*
6. Examination of opportuni ties and constraints
7. *Public involvement*
8. Development of goals and objectives
9. *Public involvement*
10. Development of options and criteria
11. *Public involvement*
12. Selection of preferred options
13. Development of implementation strategy
14. Development of monitoring mechanism

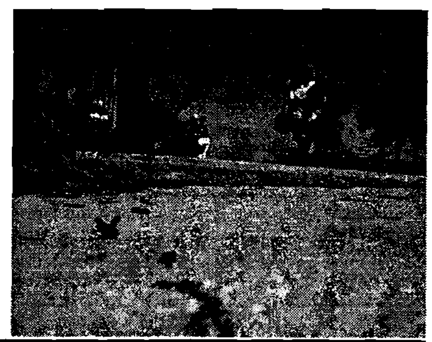
231 - Inventory of Existing Conditions

Planning for bicycle facilities begins with observing and gathering data on the existing conditions affecting bicycle travel. Problems, deficiencies, safety concerns, and bicyclists' needs must be identified. The existing bicycling environment should be observed.



Wheel's eye view. *This "home-made" drainage grate existed for more than a decade on the principal route to an elementary school. Adults often overlook such obvious hazards to their children.*

Public risks *remain undocumented for years since many adult transportation or safety specialists make virtually all of their trips in cars. This disparity can only be overcome by new and better processes.*



Place Public Involvement Chart

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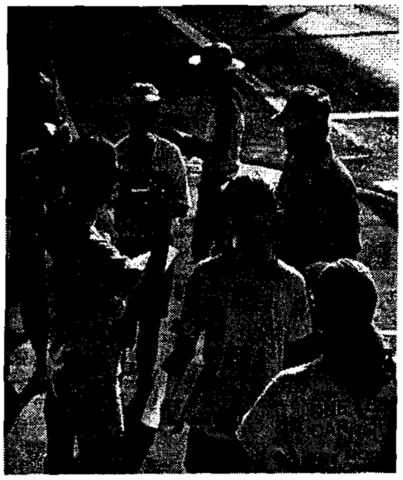


Florida bike planners and others from around the nation joined with Key West citizens to devote 3000 person hours to analyze bicycling and pedestrian conditions. The 10-day effort has resulted in a detailed listing of problems and opportunities facing Key West as it makes its decisions for transportation for the next decade.

Bikeways, roadways where bicyclists ride and roadways where bicyclists do not ride should be examined for their suitability for bicycling.

Obstructions and impediments on existing highways, such as unsafe grates, debris, shoulder rumble strips, narrow lanes, driveways, rough pavement, high-speed or high-volume traffic, high truck volume, curbside auto parking, lighting, railroad crossing flanges, bridge expansion joints, metal grate bridge decks, and traffic signals that are not responsive to bicycles should be considered for their effect on bicycling. The existing bicycle parking situation should be examined for its adequacy.

Areas near probable bicycle traffic generators, such as major employment centers, schools, parks and shopping centers, should be reviewed to identify existing or potential bicycle travel. Convenient access to mass transit stations and other intermodal transfer points for bicyclists should be checked. Barriers such as rivers and freeways should be identified and examined for their effects on bicycling. The existence of bicycle parking, lockers, showers and other services should be noted.

Bicycle crash locations should be investigated to identify any physical obstructions which may contribute to crashes. Data should be collected on the amount of recreational versus utilitarian riding and on the ages and experience of bicyclists.

231.1 Background Report

At a minimum, the following points should be considered when preparing a background report:

1. Existing conditions
2. Demographics
3. Crash statistics (location, type, causal factors)
4. User surveys, questionnaires
5. Existing standards (design, engineering)
6. Existing safety programs
7. Existing enforcement programs
8. Known or proposed projects affecting bicyclists (i.e. new subdivisions, new or redevelvelopment projects such as commercial, indus trial, residential, new or reconstructed roads, bridges, sewers, greenways, utility corridors, etc.)
9. Current planning policy documents
10. Forthcoming revisions to existing planning, policy documents
11. Jurisdictions
12. Resource groups or individuals
13. Funding Sources

231.2 Public Participation

Public participation is essential during the conceptual stage and inventory of existing conditions or physical factors affecting bicycle transportation. Observations and surveys of active and potential bicyclists will be useful, as will the views of the non-bicycling public. The attitudes and needs of destination-oriented, traffic-tolerant bicyclists greatly differ from those of casual, trafficintolerant bicyclists. Citizen Bicycle Advisory Committees and groups and individuals responsible for recreation planning can also be good sources of information. Thus, a wide variety of views should be sought. The views of all of these various groups should be weighed against each other and tempered with sound professional judgment.

Other important existing conditions to inventory include the effectiveness of existing laws affecting bicycling, and education and enforcement programs.

232 - Analysis of Improvements

Bicycle-use goals and objectives should be in harmony with the overall transportation, land use, urban design and environmental policies of the community or state. The inventory of existing conditions provides an opportunity to modify and/or refine bicycle-use goals and objectives. With established goals and objectives in hand, the existing conditions are analyzed and a plan is developed. Programs and projects for bicycle user encouragement, enforcement, education, and improvements complement each other and are all options that should be considered. The end result is a plan of proposed improvements for bicycle travel. Tye following types of improvements should be considered:

A. A wide range of improvements should be considered in the facility improvement portion of a plan. These include roadway improvements, maintenance and operations, bikeways, and bicycle parking facilities, transit links and other elements.

B. Reduce conflicts between pedestrians, bicyclists and motorists through separate facilty types, and correct conditions unsafe for bicycle riding. Improvements to drainage grates, speed bumps, rumble strips, utility caps, railroad grade crossings, pavement surfaces, traffic signals, signing and markings will be beneficial.

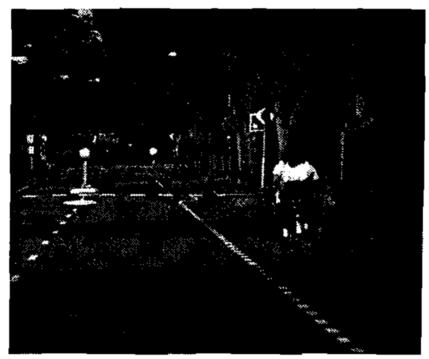
C. Bicycle Routes can provide continuity to other bicycle facilities or designate preferred routes.

D. Bicycle Boulevards can provide continuity and direct links to key destinations within a community along preferred routes.

E. Bicycle Lanes, together with signs and pavement markings, can improve conditions in corridors where there is significant or potential bicycle demand. They delineate the intended or preferred path of travel and encourage the separation of bicycles and motor vehicles. Bicycle lanes also help increase total capacities of highways carrying mixed bicycle and motor vehicle traffic.

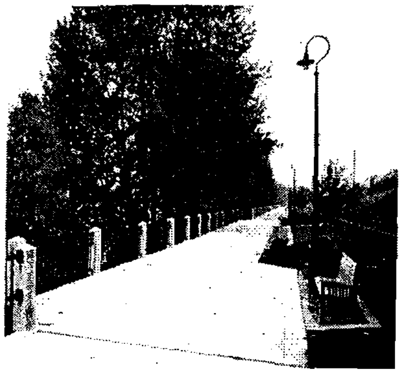
F. Multi-use Trails can provide enjoyable recreational opportunities as well as desirable commuter routes. Trails can create opportunities not provided by the road system. Many bicycle paths can be used to help form and preserve a network of greenways through a community.

This popular, shaded bike route in Palo Alto, California connects numerous quiet neighborhood streets with the downtown. Bike Routes and Bike Boulevards provide links to Bike Lanes and Multi-Use Trails.

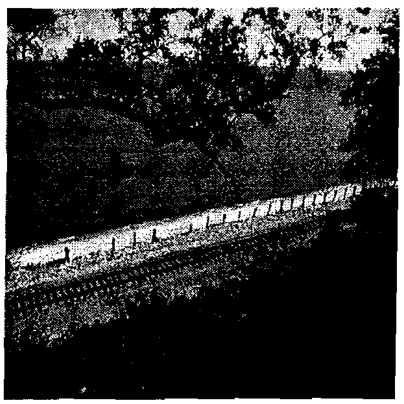


This Dutch red ochre pigmented bike lane creates a narrow tunneling effect, holding down motorist speeds. The treatment has received popular support in a number of Florida towns and new developments.

This Davis, California trail helps connect over 3000 bicyclists with their daily school and park destinations.



River fronts offer one of the few occasions where sidewalks can transport bicyclists with minimal conflict with motorized traffic. Sufficient width must be provided to reduce conflict with pedestrians.



Whether planning for the future when this rail line will be abandoned, or providing a bicycle rental and storage facility along a new rail line, bicyclists and transit users benefit from planning.

G. Multi-Use Trails can sometimes provide shortcuts to roadway routes, thus providing incentives to bicycle use instead of auto use.

H. Sidewalks are generally not acceptable for bicycling. However, in a few limited situations, they may complete the bicycle system, such as on long and narrow bridges or where sidewalks are uninterrupted and have the same characteristics as one-way bicycle paths. In such situations bicyclists must be incidental or infrequent users. Recognition that the sidewalk will be used for bicycling can be beneficial.

I. Bicycle Parking facilities are essential to encourage all types of bicycling: cycling to the park, library, ball diamond, dance class or commuting. In particular, the provision of parking facilities promotes utilitarian bicycling by giving bicyclists the same priority as cars with respect to end of trip facilities. To be effective, bicycle parking must offer protection from theft and vandalism. Bicycle parking should be clearly labeled and located as close to a building entrance as possible. It should be convenient with no stairs to negotiate. It should be covered or sheltered from the elements. Parking is most effective located where there are people or security personnel present and not interfere with pedestrian traffic. Good lighting is essential. Bicycle parking should be separated from automobile parking by a barrier or sufficient distance to prevent possibility of damage to parked bicycles by automobiles. In general, bicycle parking should be provided at all major traffic generators, especially where motor vehicle parking is provided at mass transit stations. Bicycle parking encourages intermodal travel.

Bicycle racks on buses and water taxis and bicycle parking at transit stops can increase transit use. It can also increase intermodal trips to schools and key employment and commercial districts.

233 - Goals and Objectives

It is important to measure the success of planning and developing bicycling facilities and programs. The state bicycle program and each community should have clear goals and objectives. A project should then be evaluated to determine if it adds to or fails to satisfy these measurable objectives. Local and regional goals and objectives must be set to help achieve state continuity. As a minimum the following statewide goals and objectives are suggested:

♦ Level and rate of growth in bicycling as a transportation mode should increase. By the Year 2005, bicycling should comprise 4% of commute trips and 30% of city-wide, school-related travel. (Current rates are <2% for commuting and <10% for school trips).

♦ Bicycling should increase as a transportation mode to key employment centers (level and rate of growth). Each metropolitan area should select two key employment centers (100+ employees) and increase bicycling to a 15%+ share of the total commute trips.

♦ Bicycling should increase as a transportation mode for errands and non-work trips (level and rate of growth). By 2005, bicycling should comprise 15% of short errand trips (currently less than 5%).

♦ Bicycling should have increased access to public transit. By the Year 2005 bicycling/bus trips should comprise 10% of urban area bus/transit trips. (Current rates are <1%). By the Year 2005, all buses should have bike racks and all transit hubs/ centers and all express bus stops should have secure and convenient bicycle parking.

♦ Bicycling access should be improved to all public rail, air and sea ports. By the Year 2005, 90% of Florida's ports and rail stations should have direct access by bicycle, and provide secure and convenient parking.

♦ Bicycle crashes should decrease by 10%.

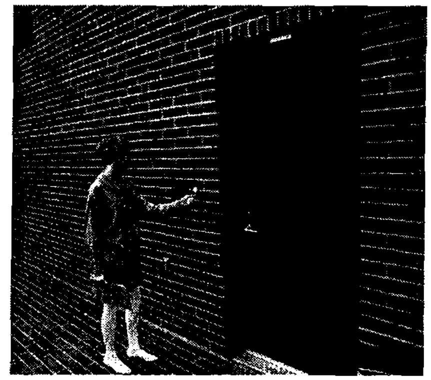
♦ Bicycle proportions of total traffic should increase within certain corridors. An increase from current levels of 2-3% at key intersections to over 15% at the same sites is desired. Each district is expected to identify 10 locations for an annual count of bicycling/ traffic percentages. Measurements will be for daylight hours. Bicycle-friendly designs should be incorporated on roadway projects in urban/ rural areas, comprising at least 90% of all local and state roads (limited access roads excepted).

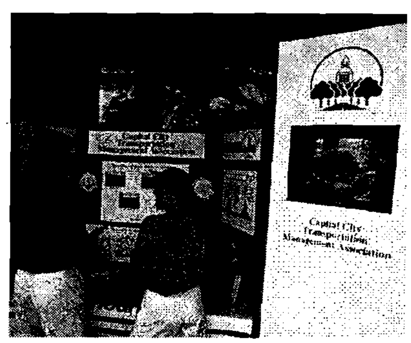
♦ By 1996 at least 50% of all staff, state, district, regional and local transportation planning and engineering design, construction, PD&E, right-of-way, permits, safety, operations, and maintenance staff, and representatives from all FDOT transportation project consulting firms, will be trained in bicycle facilities design.

♦ By 1997 at least 25% of all safety funds in the five-year work program will be dedicated to eliminating hazardous conditions to bicyclists and pedestrians. These two groups currently comprise 25% of Florida's transportation fatality rate.

Other measures that should be considered as goals to be achieved by locals by the year 2000:

- 10% of all parking within a city should be for bicycles
- 100% of all non-limited access bridges should be accessible by bicycle
- 100% of all non-limited access urban roadways should be rated as bicycle friendly.





(1) Some Florida high schools have more auto than classroom space. If other modes are to compete, incentives for bicycling must be equally strong. (2) Some employers now offer high security parking and shower/locker rooms. (3) This Dutch office handles bicycle touring requests throughout Europe in much the same way as AAA handles auto trips in the USA. (4) With the development of Transportation Management Organizations, alternative transportation trips are given additional promotion.

Safety must come first. This Gainesville bicyclist has no other transportation. Providing choices in safe, convenient and accessible transportation is an essential goal of all communities.

234 - Selection of Facilities

This section alerts planners to be aware of certain factors in deciding which facilities are needed in which locations. It also provides general solutions to identified problems.

When a facility improvement is desired, its primary purpose (e.g., utilitarian or recreational) and the following factors should be considered to determine its type, location and priority:

234.1 Barriers

In some areas, there are physical barriers to bicycle travel, caused by lack of accessible bridges, topographical features, freeways, high speed roadway sections, intersections or other impediments. In such cases, providing a facility or bike on transit service to overcome a barrier can create new opportunities for bicycling.

234.2 Crashes

The reduction or prevention of bicycle crashes (i.e., bicycle/motor vehicle, bicycle/bicycle, bicycle/pedestrian and single bicycle crashes) along routes is important. The potential for alleviating crash problems through the improvement of a facility should be assessed. During the 1980's and early 1990's, Florida had the highest rate of bicycle crashes per capita in the nation. The conditions leading to these crashes (i.e. high urban motorist speeds, narrow roads, poor lighting, few alternative bicycle routes, etc.) continue to dominate. Plans should be reviewed on all proposed roadway and transportation improvements including resurfacing projects to avoid introducing new bike crash problems, and to reduce/eliminate existing problems.

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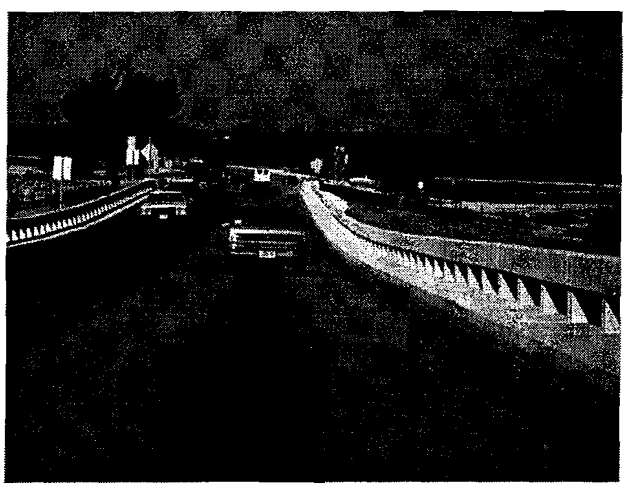

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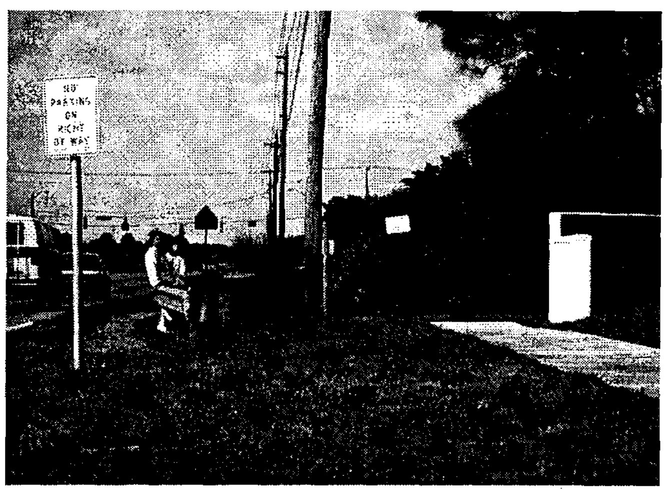

Barriers. *(1) For years bicyclists were denied access to this southern Florida bridge. Today the prohibition is removed. All future non-limited access bridges are to have paved shoulders accessible to bicyclists (ISTEA).* (2) Students are often denied *safe access to their schools. (3) Developers often provide sidewalks only to the end of their projects. It is then the responsibility of area government to make the connections. Public officials must assure that funds are programmed or developers complete the connections.*

234.3 Directness

For utilitarian bicycle trips, facilities should connect traffic generators and should be located along a direct line, convenient for users. To encourage bicycling, bicyclists should have equal access to all corridors and attractions, especially for short trips within a neighborhood or between neighborhoods. Within a neighborhood, links should be considered through cul-de-sacs, making use of greenways and other open ways.

234.4 Access

In locating a bicycle path, consideration should be given to the provision for frequent and convenient bicycle access, especially in residential areas. There should be many links to the places people live, shop, attend school and work, and connect to transit. Adequate access for emergency, maintenance and service vehicles should also be considered. Too often bicyclists are denied convenient access to major destinations, including airports, rail stations and seaports. Planners and policy makers must ensure that bicycling access is provided to every public facility and across all waterways where other transportation is being provided. When a corridor formerly accessible to bicyclists becomes a freeway, planners must assure that some alternative access along the route is provided to non motorized users.

234.5 Attractiveness

Scenic value is particularly important along facilities intended to serve primarily recreational purposes. Facilities should add to rather than reduce the character of the surroundings. When a facility is attractive, longer bicycling distances and greater use will be achieved.

234.6 Security

The potential for criminal acts against bicyclists, especially along remote bicycle paths, and the possibility of theft or vandalism at parking locations should be considered. High levels of use, lighting, and environmental design are key factors in assuring a high level of security. During low light hours, lone bicyclists may prefer to travel on roadways which have more pedestrian and vehicular traffic than an adjacent trail or path.

234.7 Delays

Bicyclists have a strong inherent desire to maintain momentum. If bicyclists are required to make frequent stops, they may tend to avoid the route or disregard the traffic controls. Total trip time is important to utilitarian bicyclists. If system delays are substantial, the potential bicyclist is likely to seek some other form of movement. Thus, both point source delays and corridor-long delays should be weighed and measured. Bike lanes often reduce delays to motorists and bicyclists. This is especially true on crowded arterial and major collector roads, since

Directness and Access. *This special traffic diverter prohibits cars but remains a connection for pedestrians and bicyclists into and out of this neighborhood. Convenience wins as bicycles are chosen instead of motor vehicle trips. A 10-minute advantage on a 30 minute trip increases those willing to bicycle by as much as 50%.*

Attractiveness and Security. *Espanola Way in South Beach recently underwent an $80,000 face lift. This street now serves as an attractive connector from the beach to the far west side of the island. By designating every 5th or 6th street as a "Green Street" it is possible to add both attractiveness and security to travel. Increased pedestrian and bicycling traffic leads to higher levels of security for everyone.*

1

2

Sight Distances & Conflicts. *(1) This sight restricted sidewalk style bike path creates high risk and discomfort for bicyclists.*
(2) A 13 year old child lost his life at this intersection when he could not see the car about to hit him.

Maintenance and Design. *(3) A simple overlayment of 10 yards of an asphalt apron would eliminate this ongoing maintenance and safety problem. (4)The shoulderless roadway edge dropoff below resulted in a fatal crash to another 13 year old in Tallahassee.*

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bicyclists have the opportunity legally and conveniently to move to the head of the queue at each intersection, while motorists can legally and safely pass bicyclists mid-block.

235 - Other Factors

235.1 Facility Conflicts

Different types of facilities introduce different types of conflicts. Facilities on the roadway can result in conflicts between bicyclists and motorists. Multi-use trails can involve conflicts between bicyclists, moped operators, roller skaters and pedestrians on the facility. Conflicts arise between bicyclists and motorists at highway and driveway intersections as well.

235.1.1 Other Conflicts

Facilities should be designed and located to minimize conflicts with cross traffic, especially through access management, use of raised medians, regulatory control of turning movements in commercial districts, and other measures.

235.2 Sight Distances

Adequate sight distances must be maintained, especially to aid bicyclists and motorists in detecting each other at key conflict locations.

235.3 Maintenance

Maintenance-sensitive design and constant attention to maintenance are important. An improperly maintained bikeway will often be shunned by bicyclists in favor of a parallel roadway. Regularly scheduled sweeping of roadways and bike lanes is essential, especially on popular routes and bridges.

235.3.1 Surface Quality

Bicycles are disproportionally affected by roadway maintenance. Bikeways must be free of bumps, holes and other surface irregularities if they are to attract and satisfy the needs of bicyclists. Utility covers and drainage grates should be at grade and, if possible, outside the expected area of travel.

Approaches to railroad crossings should be improved as necessary to provide for safe perpendicular bicycle crossings. Bridge decks should be designed to minimize the effect of expansion joints and deck surfaces on bicyclist stability.

235.4 Traffic and Parking Factors

235.4.1 Truck and Bus Traffic

High-speed trucks, buses, motor homes, and trailers, because of their aerodynamic effect and width, can cause special problems for bicyclists. Where bus stops are located along a route, conflicts with bus loading and discharging may pose problems. Pavement deterioration by large vehicles may also cause problems for bicycle use.

235.4.2 On-street Motor Vehicle Parking

The turnover and density of on-street parking can affect bicyclist safety (e.g., opening car doors and cars leaving angle parking spaces).

235.4.3 Traffic Volumes and Speeds

For facilities on roadways, traffic volumes and speeds must be considered along with the roadway width. Commuting bicyclists frequently use arterial streets because they minimize delay and offer continuity for trips of several miles. It can be more desirable to improve heavily traveled high-speed streets than adjacent streets, if adequate width for all vehicles is available on the more heavily traveled street.

When this improvement is not possible, a nearby parallel street may be improved for bicycling. Stops must be minimal and other route conditions adequate. When such a parallel facility is improved, care must be taken that motor vehicle traffic is not diverted to the improved facility.

This discouragement can often be accomplished with traffic calming techniques, such as an occasional diagonal diverter which still permits bicycle and pedestrian flow. In general, inexperienced bicyclists will not ride on heavily traveled, high-speed arterials but will prefer quieter streets. Thus, cyclists' preferred routes may change over time as their skills change, or as traffic volume continues to increase.

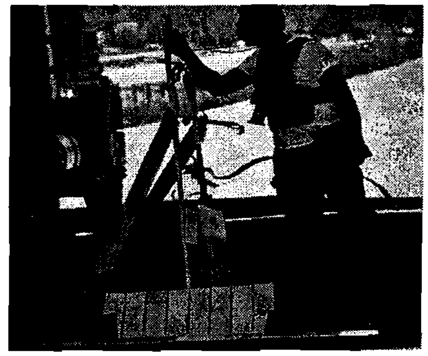
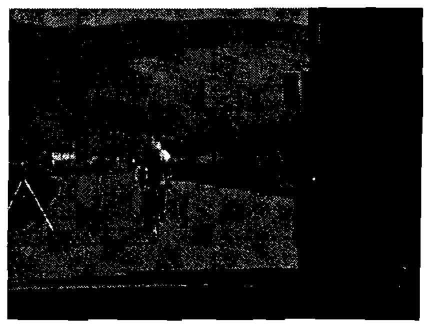
235.5 Cost/Funding

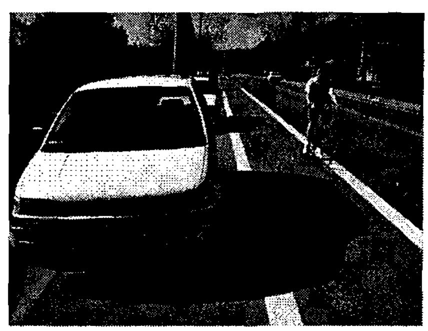
Selection of location will normally involve a cost analysis of alternatives. Funding availability can limit the alternatives. However, it is important that a lack of funds not result in a poorly designed or constructed facility. It is usually more desirable not to construct a bicycle facility than to construct a poorly planned or designed facility. The decision to implement a bikeway plan should be made with a conscious, long-term commitment to a proper level of maintenance. If only a small amount of funding is available, emphasis should usually be given to low-cost improvements (i.e., bicycle parking, removal of barriers and obstructions to bicycle travel, roadway improvements and non-construction projects such as mapping).

235.6 Local Ordinances

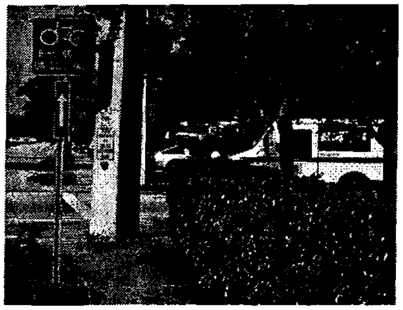
Bicycle programs must reflect local laws and ordinances. Bicycle facilities must not encourage or require bicyclists to operate in a manner inconsistent with the adopted Rules of the Road. Lack of adequate facilities may encourage unlawful behavior such as:

- Wrong way riding
- Running stop signs and signals
- Commercial district sidewalk riding
- Erratic riding when lanes are too narrow or road surface bumpy



Two meters of buffer *(1-3) Author Dan Burden tests walls of wind blasted from large vehicles traveling at 90 kph. Blasts drop appreciably at 2 meters of lateral clearance.* ***Bike Parking Lanes*** *(4) This Auzzie parking lane is too narrow. (5) A bike lane in Boulder, Colorado helps separate bicyclists from conflicts with car doors and pullouts.*



Design Affects Law Obedience. *Poor design converts bicyclists to scofflaws. Sidewalk bikepaths are universally ignored, while rough shoulder pavement forces bicyclists to adjacent lanes. Attention to basic needs must be foremost.*

Bridge surface conditions *impact bicyclists. Below: FDOT tests confirmed the advantage of a newly designed decking surface for bascule bridges.*

235.7 Bridges

Bridges can serve an important function by providing bicycle access across barriers. However, some features found in bridges can be unsuitable where bicyclists are to be accommodated. The most common of these are curb-to-curb widths that are narrower than the approach roadways (especially where combined with relatively steep grades). Open grated metal decks found on many movable spans, low railings or parapets, and certain types of expansion joints can cause bicyclists steering difficulties or swallow a narrow wheel.

235.8 Conditions at Intersections

A high proportion of bicycle accidents occur at intersections. Facilities should be selected so as to minimize the number of crossings, reduce turning speeds of motorists, provide responsive side street signal detection for bicyclist entry, provide adequate night lighting, and make certain that the clearance interval accommodates bicycle crossing speeds.

236 - Continuity

Discontinuous bicycle facilities can be dangerous and should be avoided. It is possible to provide width for bike lanes in the highway, and hold off on marking them as designated lanes until there is sufficient length.

237 - The Selection and Development of Options

Criteria should measure the suitability of options. There are four basic sets of criteria to consider:

- Community vision, transportation goals
- Design criteria
- Bicyclists' criteria
- Other users' criteria

If there is effective interaction and process, the bicyclist criteria should closely match the criteria of the motorist and the community/transportation vision and goals. Likewise, design criteria may be modified to permit flexibility for a community to achieve its goals and objectives. It is important to recognize that this is a dynamic process that can be achieved only with full involvement of the community in each phase of planning. If this process has not been effective, major planning revisions are usually necessary at every stage of the project.

237.1 Selection of Preferred Options

Selection is based on the evaluation of the options developed in the previous step. Each option is evaluated further with respect to goals, objectives and benefit/cost analysis.

237.2 Development of Implementation Strategy

There are three steps in developing a strategy for implementation:

237.2.1. Identification. Identify required actions and the departments or agencies to carry them out;

237.2.2. Budget development. This may flow from the benefit/cost analysis done for each option in the previous step; and

237.2.3. Work program. Development of a work program schedule.

The success of any program or planning exercise can only be determined by assessment at regular intervals. Feedback can be obtained from surveys, usage rates, comments and complaints and from comparison of observed behavior and crash statistics before and after implementation. This monitoring can lead to reassessment of the goals and objectives and/or the selected option.

238 - Ongoing Public Involvement

Ongoing public involvement is crucial to the success of any planning work. Any changes occurring during the planning phases must be communicated to those who have expressed interest in the project. Reasons for the changes should also be clearly explained so that the cooperation between the different groups is not lost.

The following techniques and processes are recommended to involve the public, interest groups and staff in a productive team effort:

238.1 Preliminary meetings . . . with the Bicycle Advisory Committee. On large projects, meet with key groups and individuals so that opportunities for advisory assistance, issues and constraints and perceived needs of the various users can be identified.

238.2 Open houses . . . to involve the general public, to publicize the process and allow staff and elected officials a chance to appreciate the concerns which the community has regarding the provision of bicycle facilities in their area;

238.3 Surveys and Questionaires . . . properly administered to solicit reactions to and suggestions for a proposed project. They are also effective follow-up after a facility has been built;

238.4 Advisory committee . . . for a specific project can help communicate the process to the public. The committee can present issues for consideration. Such committees can consist of staff and elected officials or, in larger municipalities or regional projects, it can include staff, elected officials and members of the public. For instance, for a trail development, representatives of area schools, safety organizations, garden clubs, neighborhood associations, merchants, conservation groups, and outdoors clubs or organizations should all be involved.


1

Balloons capture polarization. *(1) Captivia Island residents were evenly split on a bike path issue in this (2) tight corridor. State Coordinator, Dan Burden, served the community as an outside facilitator.* ***The Process:*** *(1) Engage and involve all sides, (2) Give citizens the tools to collect data and insights on options. (4) Use public process for a community solution. The result: A full 95% of residents became involved, and they approved an engineering study with a 98% approval rate.*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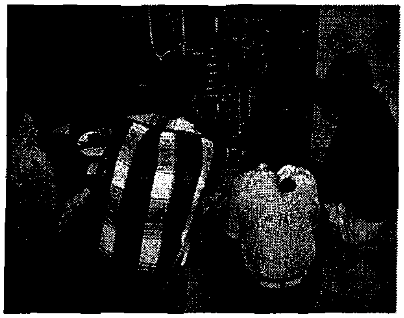

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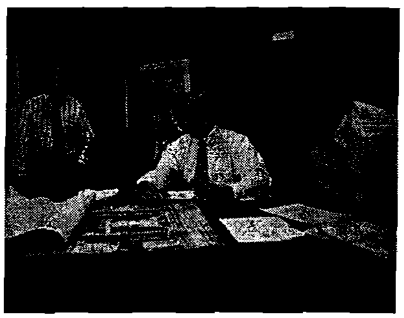

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238.5 Ongoing liaison . . .
with interested groups or individuals is essential. This continuing communication effort can be a key source of information regarding the project's success. In some communities bicycle program newsletters are published and circulated widely to keep all interested members of the public and press involved and sensitized to key issues. The Friends of the Pinellas Trail, for example, publish a quarterly newsletter that has been an effective communication tool for nearly five years.

239 - Planning Effectiveness

The effectiveness of the planning process will ultimately depend upon the following:

A. Ensuring the integration of the final product into local policy documents by following a clearly defined process involving local elected officials, planners, engineers and the public.

B. Identifying the size and nature of the area (urban center or rural locale) being considered for the provision of bicycle and trail facilities or programs and tailoring the process to meet the area's needs.

C. Identifying the available human, money and time resources.

D. In Florida, as elsewhere, this process often involves taking a project or element through the local Bicycle Advisory Council (BAC), and then having the project reviewed through the Technical Advisory Committee (TAC), the Citizen's Advisory Committee (CAC), and then forwarded for final approval by the Metropolitan Planning Organization (MPO).

E. Once a project has been approved by the MPO, it is accepted in the community Transportation Improvement Plan (TIP), and prioritized along with other roadway improvement projects.

F. In areas not large enough to have an MPO (under 50,000 population), a similar process should be followed. For instance, it is always essential to have a formal BAC or other citizen's group, a technical review committee, and then a political hearing of commissioners or others that can give final sanction and budget authority to the project.

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Engage the public early and often. *Engaging the public early and often in each step of the plan will reap huge benefits. (1) Using a highly compressed charrette style plan, Elizabeth Plater-Zyberk leads a discussion of West Palm Beach neighborhood leaders on their community vision. (2) Technicians check out routing possibilities into downtown West Palm Beach. (3) District Four Transportation Secretary Rick Chesser confers with staff on placement of bicycles in the new Lake Worth downtown plan (4) Ken Sides, a Key West traffic engineer and project consultant Anita Chapman, talk openly with citizens on a popular Key West radio call-in talk show. (5) Greg Wilson assesses roadway conditions to present to the public as part of a detailed bicycle and pedestrian plan for Key West.*

G. Non-transportation projects such as Traffic-Ed Training or a Velodrome can follow a similar route of approval using other political groups such as recreation boards, school boards, or other appropriate councils or government bodies.

239.1 - Official Plans

As mentioned earlier, separate (stand alone) bicycle plans have minimal effect. But an independent planning effort is helpful as one step in the overall planning process It will help focus efforts and prioritize projects. Many opportunities will be missed if the needs of bicyclists are not fully built into area land use plans, short and long range transportation plans, recreation and conservation plans, greenways plans, neighborhood plans, transit plans and other planning documents.

Obtain the schedule of updates for each of these plans and assure that a representative of bicycling interests, either staff member or chair of the BAC, is on the review team for updating these plans.

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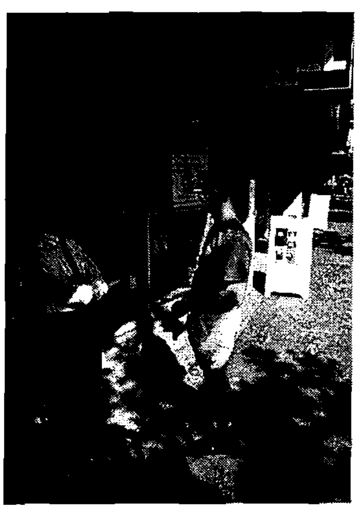


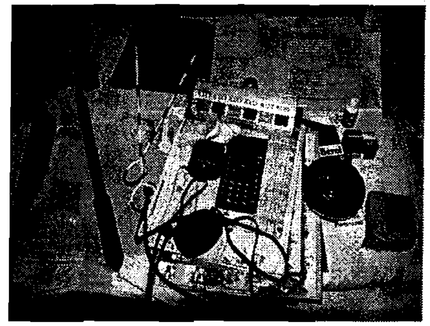
240 - Comprehensive Community Planning Part 4

241 - Zoning Ordinances, Development Codes

Many bicycling opportunities are missed due to ineffective and uncoordinated land use practices that create sprawl, isolated services and a fragmented community. Although there is much discussion of improved zoning and development leading to more compact and mixed land use, implementation requires commitment and major public involvement. Bicycle planners and project proponents need to remain central to these changes.

Special planning districts which promote alternative transportation, transportation commercial management areas, and transportation exception areas each offer opportunities to promote bicycle transportation.

Using Davis, California as an example, development codes serve as the genetic code for all areas of town. Davis is well-known for its preference for bicycles, energy conservation and slow and carefully managed growth. Its



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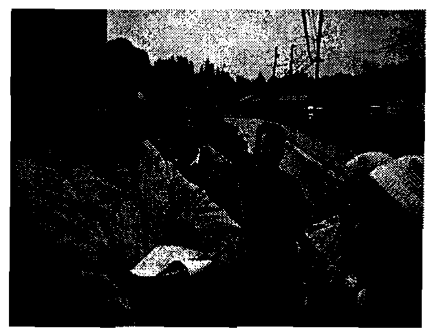

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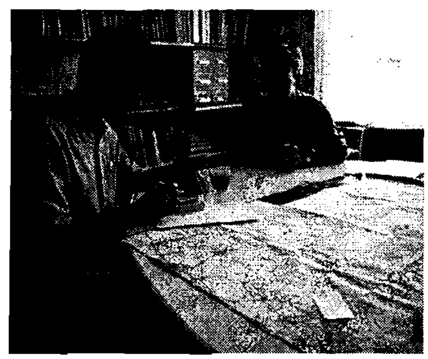

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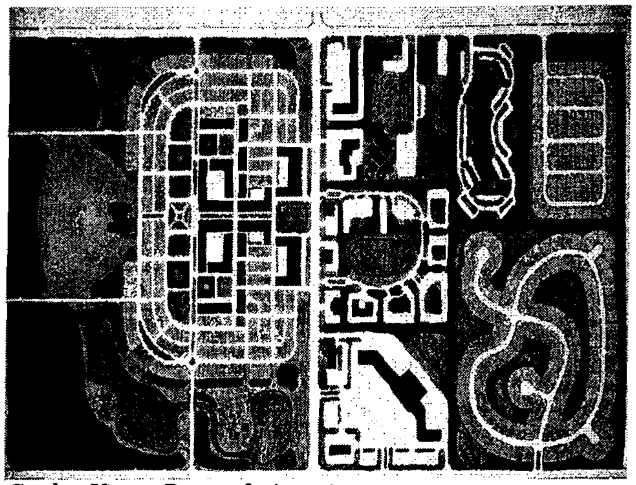
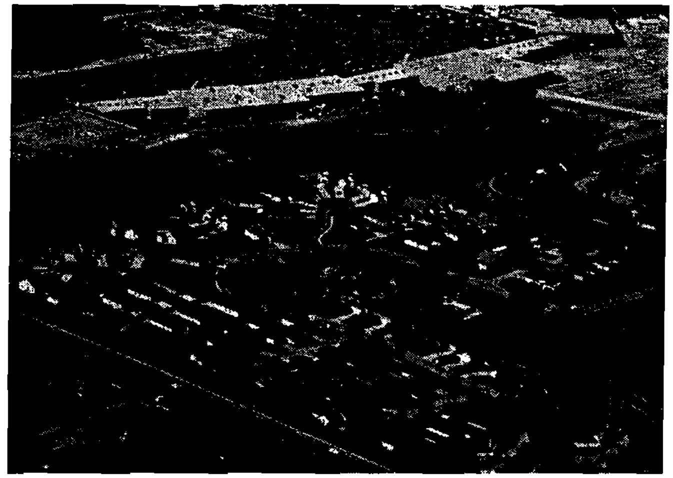
Meet the People. *Planning is not something done in an office. Planning is interactive. Use the 80/20 measure. If your plan writer has not spent at least 80% of the invested time surveying, meeting with people and engaging in meetings, then it is likely to lack community vision and desire. Bicycle planning gains concensus as it develops. (1) Common planning tools; (2) Key West planners involved an area commissioner in their data collection; (3) Portland, Oregon's famous citizen-driven planning brings out citizens on the coldest of days; (4) Dutch bicycle planner Geisbert Valstar confers with the Dutch Bicycling Federation on a bicycle facility tour for Dan Burden.*
(5) William Roll interviews a Vancouver, B.C. street retailer on his vision.





Credit: Victor Dover & Associates

Photo Above: New urbanism in a nutshell. *Current zoning and development codes, banking and other regulations dictate that most development must take the pattern right side of the above drawing. In reality policies translate to the scene at the far right. People living in these common suburban developments generate nine auto trips per family each day. These practices fill our highways and consume nine parking places for each car. This style of development makes walking or bicycling to a destination lengthy, challenging or impossible.*

In contrast, New Urbanism, depicted in the upper left pattern places shops, stores, schools, recreation and most other needs within easy walking and bicycling distances of residential communities. Note the lot sizes are the same. Parking spaces are greatly reduced since fewer people choose to drive such short distances. Bicyclists fare better in either New Urbanism development, or in older (pre-1950's) developments that typically followed a grid or highly interlaced pattern.

Develoment codes serve as the genetic code for towns. Want a livable city? Change the code.

notable physical characteristics are its innovative neighborhood design, traditional downtown, absence of large scale shopping centers, rear access to all shopping centers and high density living with convenient walking or bicycling to most destinations.

While zoning ordinances and development codes can be tools to inhibit sprawl, decrease auto trips and recreate the character of urban form, they are also tools to implement site specific practices. Key decisions are needed on such practices as:

1. Minimum safe and convenient bicycle access to all commerce. Access management policies, especially with commercial establishments, should be regulated to minimize the number and location of entry points. The existence of too many or poorly placed driveways, is closely linked with bicycling crashes, especially those associated with bicyclists riding commercial district sidewalks.

2. Minimum and desired levels of secure and convenient bicycle parking for commercial and public buildings. There is ample opportunity to initiate positive language in support of public bicycle parking facilities. Many times such facilities can be installed as a trade with the merchant or land owner through a variance or change in parking requirements.

3. Minimum thresholds for shower/locker provisions at all large employment centers with at least 50-100 employees.

4. Required connections between cul-de-sacs with trails, schools and public transit in new and retrofitted neighborhoods. Often the public supports non-motorized connections while disapproving motorized connections.

5. Greenways development. A major opportunity for future bicycling is to support the preservation of open space and greenways on

undeveloped land. For new developments, (especially in low lands) drainage areas, wetland habitats, and other natural areas should be preserved. These areas can be sensitively designed for trails that serve as the backbone for a bicycle recreation and transportation network. Davis, California now has over 50 miles of greenways. It is difficult to find a neighborhood in Davis that lacks the green canopy that connects all cul-de-sacs to minor and major trails.

241.1 Local/County Codes/ Ordinances

Additional support can be given to bicycling by regulating changes that can improve bicycle safety. For instance, bicycling on commercial district sidewalks, a high risk activity, can be restricted. However, such restrictions may prove unpopular and unenforceable if alternate facilities in the roadway section or on parallel streets are not provided. Locking bicycles to light poles, parking meters and other locations, where they become a tripping hazard and clutter the sidewalk, can and should also be regulated. Close cooperation with merchants, and a plan to provide public racks in appropriate locations must be established through public policy.

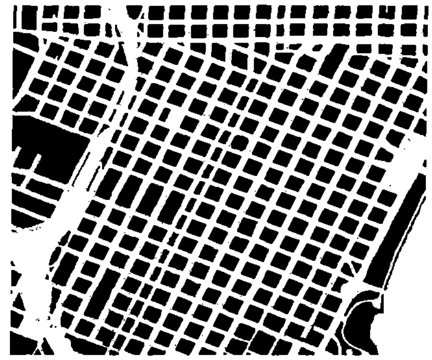
242 - Other Strategies

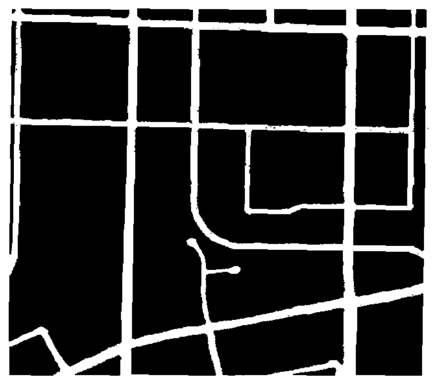
242.1 Site Plan Agreements

Proposals for development or redevelopment of residential, commercial and industrial projects often involve site plan agreements. The agreements provide the ideal opportunity to negotiate the inclusion of bicycling facilities into the overall design. The agreements can address access, parking, internal roadways (bicycle boulevards or lanes) and the location of structures on the land that will be developed or redeveloped.

242.2 New Subdivision Amendments

Many of the items mentioned in the planning concepts section should also be considered here. Law enforcement should be consulted on proposed circulation patterns. Public notification can assist in developing a mutually acceptable final design. The planning process should examine road patterns and connections with existing transportation routes so that residents of the subdivision will be able to use their bicycles for commuting or other purposes. Main bicycle routes to work places, shopping areas, connecting transit station stops and terminals





Same Scale, different cities. *(1) The City of Portland, top grid, has the markings of a successful city. Bicycling works best when there are many choices for routing. With many links, traffic is less likely on any one road, and speeds remain sensible. New Urbanism and pre-1950's development have fine grained roadway patterns.*

(2) Less is not better. *As society moved toward auto trips, fewer intersections allowed for higher speeds. Bicyclists have a tough way to go in Irvine, California, and most suburban sectors of any town. There are few choices. Any road that goes any place seems to be a main road.*

(3) Contours of Farming become Contours of Development. *Under current development practices, the land on the left will soon be converted to the development on the right, furthering sprawl, auto trips and reducing this community's chance to be sustainable.*

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or other destinations should also be considered. For example, the internal road network should ensure that short trips to schools, recreation centers or parks and local shops are easily reached through low volume streets or trails. A return to traditional neighborhood design concepts, where there are many links into and out of neighborhoods, to nearby stores, and schools, are all key to a successful neighborhood.

242.3 Dedication of Land

Many municipal governments require dedication of land for parks, schools and other public needs. The location of these lands in a central part of the development, or with a perimeter that permits greenways, is key to the success of associated bicycle facilities. Such planning keeps trip distances within range of a bicycle ride.

242.4 Redevelopment

As environmental issues force reconsideration of formerly underdeveloped lands, opportunities abound for urban infill. Greatly improved bicycling can result from sensitive design, proper increases in density, addition of new links between formerly closed roadways, and the location of schools, parks and other infrastructure.

242.5 Road Reconstruction

New highways are rarely built. The majority of opportunities to improve conditions for bicyclists are found on roadways bursting at the seams. Often these roadways can and should be improved to provide safer travel for everyone, including bicyclists. These improvements can and should be included on every project, regardless of scale, so that eventually a corridor can provide a continuous facility for bicycling. It is estimated that during the 1980's, project-by-project bicycle sensitive designs increased the total supportive lane mileage from 5% to 40-60% of the urban state system in some districts.

242.6 Major Urban Infrastructure

Planning and design for bicycles must be incorporated into the fabric of any development project. The bicycle facility is not to be viewed as a separate entity any more than a new arterial road or the redevelopment of an older industrial area is viewed in isolation from the area surrounding it. The integration of bicycles into the overall transportation network must be dealt with at the base level within the context of the larger

Where do people want to live? *(1) Contrary to popular myth a great majority of Americans vote to live in places depicted in these scenes. Nearly 80% of Americans want to live in cities or towns which have sidewalks and porches which encourage neighbors to interact (Crystal Beach, Florida) (2) or on narrow, quiet streets like Espanola Way's one-way one lane road (South Beach Fl.). (3) or Key West's neighborhoods which have alleys and garages in the back, (4) or Vancouver, B.C.'s Broadway Street with mixed uses. Here residences are above stores and everything needed is within an easy bike ride. (5) Fifth Avenue in Naples, Florida has a small scale and pleasant deli, outdoor cafe and grocery. The popular trend and desire of most American's is to have interactive neighborhoods, communities and cities as depicted here.*

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urban area, if it is to be cost-effective, efficient and ultimately successful. The overall concept of an urban design is often lost in the details of many individual projects, but planning for changes to the urban infrastructure is both feasible and practical.

The aspect of budget considerations is of equal importance in the pre-planning stage. The cost of bicycle facilities when they are incorporated into the base budget of the project is minor compared to the cost of undertaking such a project separately.

242.7 Land Exchange

Often developers or land owners are willing to trade part or all of their land for a more favorable site. In this way, municipalities and departments can acquire lands that can be used for the development of bicycle facilities. Such parcel trades can simplify the design and eliminate conflicts by developing a trail where conflicts are low and service is high.

242.8 Easements

An effective tool for improved bicycling and walking is the acquisition of easements. Easements:

- ♦ are low cost compared to market value purchase
- ♦ usually have no management responsibility
- ♦ have the ability to use land and preserve scenic views
- ♦ provide an option to purchase in the future

243 - Other Opportunities

Florida land use policies and practices are being constantly upgraded at both state and local levels. It is essential that all bicycling proponents look to the future by staying involved and alert to community developments. Many practices in the past, such as building major arterial traffic corridors through residential areas near downtown in order to get traffic out to the suburbs as fast and as efficiently as possible, are no longer deemed socially responsible.

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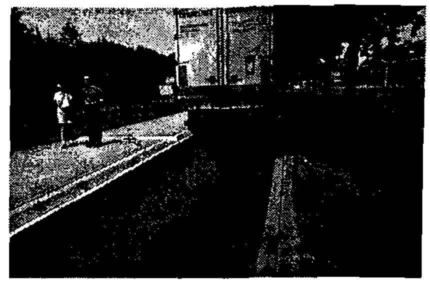

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Skinny Houses and Skinny Streets. *(1 & 2) These Dutch skinny streets slow autos in neighborhoods at special choke points. New urbanism works best when density is moderate (5-7 units per acre). Such densities are considered minimum to allow walking, transit and bicycling to succeed. This contrasts with 1-3 units per acre for suburban style development. Seattle developers are encouraged to build more houses to the block by using 25 foot wide lots. An older ranch style house lot can often provide space for 2 or 3 homes.*

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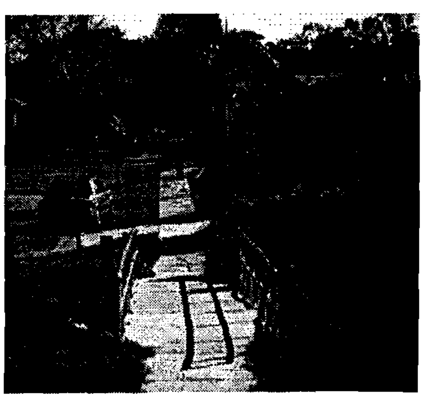

(3) A neighborhood connection is made to an elementary school by this bridge . Right. (4) Bulbouts help bicyclists and pedestrians by reducing turning speeds and narrowing crossings, but may be disliked by some bicyclists in some locations since it forces them to merge. (5) Edmonds, Washington has developed "half-bulbs" for site specific solutions to this complaint.

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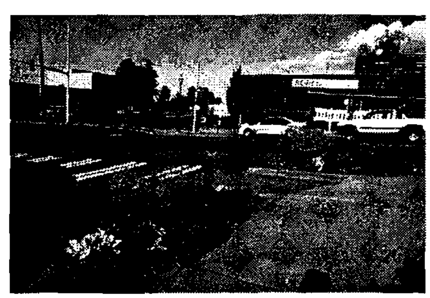

__Rolling through public space.__ Our roadways, walkways and bikeways constitute much of what is left of urban public space. Neighborhood leaders, affectionados for beautiful cities and roadways, pedestrians, bicyclists and others are taking a stand. Single use roadways, vacuous open space, sprawl and noxious fumes are stressful and debilatating. Citizens and planners can take new inspiration from dozens of cities that have gotten their feet back on the ground.

There are many inner areas of cities that should be redesigned or refocused for livable, secure and convenient movement of people. Town and city planners should step back and take a broader view of conditions that affect their citizens. Cities designed for people work far better than cities designed for cars. With such a view town planners will be able to make transportation decisions that make sense to everyone. This concept will result in more interactive, efficient and sustainable cities. It will also enrich the lifestyles of its people.

Town and city planners should step back and take a broader view of conditions that affect their citizens. Cities designed for people work far better than cities designed for cars.

Section 3
300 - Safety

> **The safety of the public is the highest law.**
>
> \- Roman Law

300.1 Introduction

Who are we designing for? Basic human performance is detailed in this section. Reading this section before the design sections to follow allows better understanding of the needs of bicyclists and the motoring public they mix with. Many designers do not ride bicycles in public streets. As a result they may lack basic knowledge which is abundantly clear to other designers. Some designers who do ride also often lack fundamental knowledge. **Part 1** includes crash causation, bicycle crash classes and identifies root causes of crashes. In **Part 2** human performance is detailed. This includes abilities and limits of bicyclists according to age. **Part 3** includes the bicyclist as a design customer. Also addressed are the unique properties of a bicycle. The unique problems of vision and visual detection of bicyclists are explained. Bicycle physical/spatial needs and bicycle physics are also explored in this section. Other principles of physics are detailed.

Bicyclists are involved in highly characteristic crashes, often associated with age, experience and ability. While only 15% of bicycle crashes involve a motor vehicle, these crashes tend to be the most serious, and hence have been studied more. The two types of crashes (motor vehicle related and non-motor vehicle related) are detailed below.

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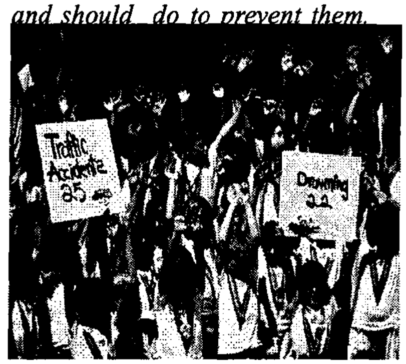
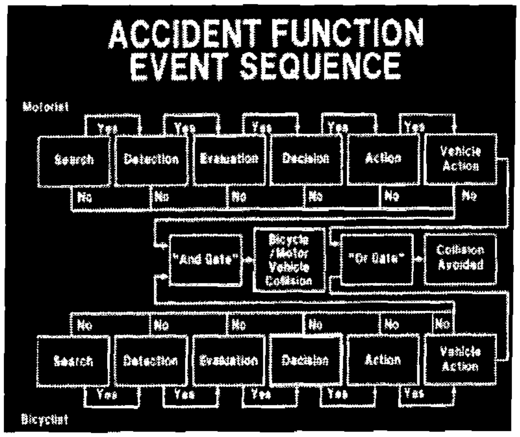
310 - Bicycle Crash Causation, Crash Types, Non-motor Vehicle and Motor Vehicle Crashes
Part 1

311 - Bicycle Falls and Crashes

By studying the morphology, mechanism and forensics of injuries and bicycle or trail related crashes, it is possible to see how a particular design influences or fails to change essential human performance.

Children are highly over-represented in bicycle injuries. *Walking and bicycling related crashes are childrens' single greatest risk of injury and death. These injuries are not accidents, and they are not random events. Bicyclist injuries are highly predictable, preventable events that result from known circumstances. There is much we can and should do to prevent them.*





Non Motor Vehicle Crashes are quite common. Only one in ten bike crashes are reported to police. Yet bike crashes make up as much as 15% of emergency room care. We lack a complete understanding of their nature. We do know that bicycle helmets can greatly reduce the likelihood and severity of a head injury. It is important to understand that a simple fall can produce "g " forces to the brain three times that required to produce death. Bike helmets save lives.

312 - Non-Motor Vehicles Crashes

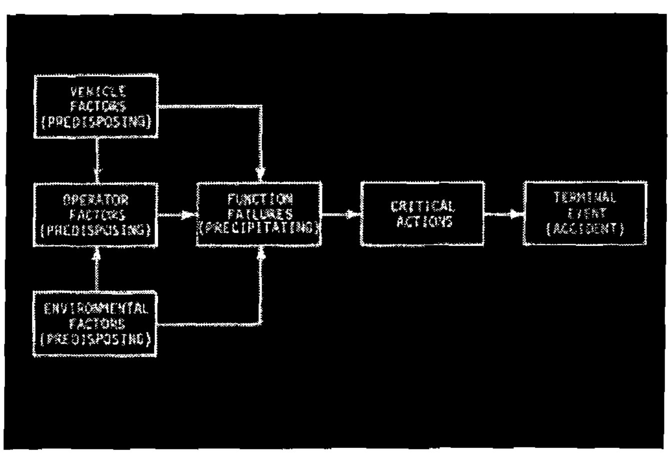
In this crash event the bicyclist loses control of the bicycle, going off the road or path. Causes include hitting an obstruction, skidding on sand, ice, water, wet leaves; or hitting a seam, flange, pothole or other surface irregularity that affects the wheels and hence the stability of the bicycle.

Another common form of non-motor vehicle crash is a bicyclist colliding with another bicyclist, a pedestrian, in-line skater, dog, or other moving object. Such crashes can be serious. Thus, attention to proper maneuvering widths and sight distances to help bicyclists maintain control are essential on pathways and other locations where mixed use can be anticipated.

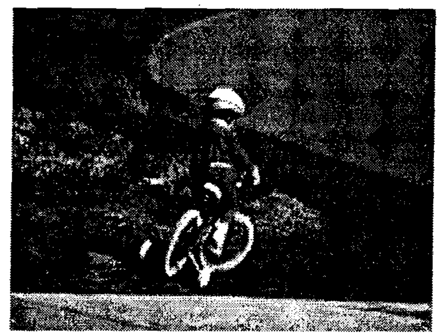
Non-motor vehicle crashes comprise over 85% of all crashes. Yet they are studied less, since only 10-15% of fatal or severe trauma crashes occur in this way. We need more knowledge about their causes.

Top Left: Bicycle/car crashes can often be prevented by either party. If a bicyclist makes a mistake, the motorist can and often does correct for that mistake, and visa versa. For childhood injuries, usually the child makes the primary error and the driver can correct. With adult bicycle crashes, the motorist most often makes the error, and the bicyclist has a chance to correct for the driver's error.

Precipitating Events. *See chart below, left Below. In the photo to the bottom left the truck driver pulled too far forward. The front end of his cab will hide the children. A poorly marked stop bar is considered a contributing environmental cause to this crash. Other pre-disposing operator attributes include the inexperience of the children who don't predict that they will be un-detected.*



313 - TransAmerica Bicycle Trail Crashes



***Loss of control**: Typical in-line skater and bicyclist crashes taking place as a concerned and unpracticed mom tries to rescue her daughter.*

One problem we have determining causes and frequency of crashes is the lack of reporting. The most comprehensive and best documented cause of crashes to a large number of bicyclists, riding a well defined number of miles, using rural type roadways, was documented in 1976. During that summer, researchers Dan Burden and Bruce Burgess analyzed the results of 10.4 million miles of exposure to 4,065 novice and skilled bicyclists using the 3,600 mile long *TransAmerica Bicycle Trail.* Most of these bicyclists rode in small groups or alone. The *TransAmerica Trail* uses low-volume-traffic, paved roadways, 20-24 feet (6.1 - 7.3 m) wide.

Even with light to moderate traffic, and thousands of junctions with motor vehicles, most crashes occurred between bicyclists. Two fatalities occurred. Both involved motor vehicles. In both cases the motorist was found to be at fault. From this exposure analysis, it was determined that a mix of beginning to experienced riders on a rural road trail have an injury-producing crash every 12,500 miles, a crash resulting in permanent injury every 250,000 miles, and risk a fatality every 5.2 million miles. Skilled bicyclists had a much better rate. Fatigue and higher traffic volumes play a big factor, with 75% of crashes occurring late in the day, usually after riding 70 miles (107 km).

Principal non-fatal causes are listed as follows:

Bicyclist hit bicyclist	**20.1%**
Pothole or broken pavement	**10.7%**
Car hit bike	**7.8%**
Loss of control	**6.5%**
Bike crashed trying to avoid car	**5.8%**
Loose gravel on roadway	**5.2%**
Rider fell off bike	**4.9%**
Slipped on gravel road	**2.6%**

It should be noted that surface conditions and other maintenance issues are significant factors in bicyclists stability and safety.

314 - Potholes and longitudinal seams.

Bicyclists are most likely to hit potholes when traveling at higher speeds, such as on a downhill descent, or when light conditions are poor. Another significant maintenance problem for all bicyclists are longitudinal seams, such as those created by a dropoff from the road or trail edge, bridge expansion joint or skewed railroad crossings and drainage inlets.

313.1 Intersection and Trail Junction Crashes

In a recent nationwide sample (by Wachtel and Lewiston) it was found that 57 percent of pedestrian and 73 percent of bicyclist crashes occurred at junctions. Another study examining police-reported bicycle motor vehicle collisions covering a four-year period in Palo Alto, California found that 74% occurred at a junction.

Sensitive design of trail and roadway junctions is vital to safe trail development.

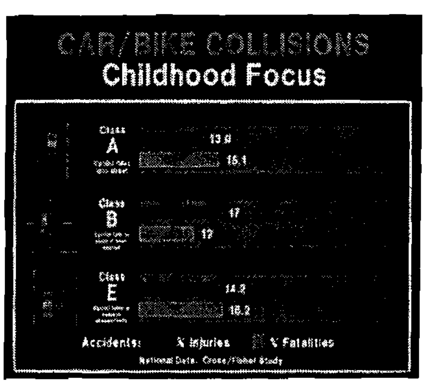
Source: Wayne Pein, University of North Carolina Highway Safety Research Center (HSRC)

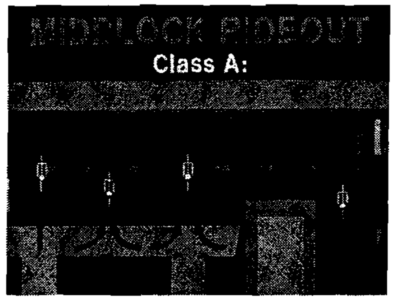
315 - COMMON MOTOR VEHICLE CRASHES

Research (Cross & Fisher) has identified 36 mutually exclusive types of motor-vehicle/bicycle related crashes. Most of these can be generalized into 7 classes (A-G). These classes are explained below. As a general rule, children are involved heavily in classes A, B and E, where they most often make the primary errors. In contrast, adults are more typi cally involved in classes C, D, F and G, where the motorist most often makes the primary errors. Numerous local and Florida state studies reveal striking similarity between this data base and current crash statistics.

315.1 Wrong Way Riding

Wrong-way riding, although a major factor in many of the crash classes, was not isolated as a separate class during the original research. It is known that wrong way riding contributes heavily to many crashes, and especially class B, C and F categories.

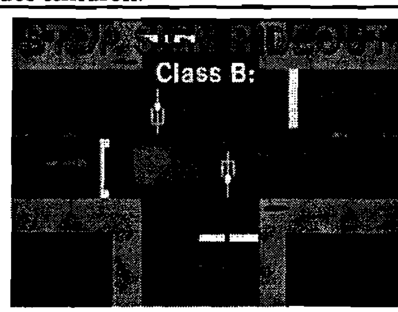




315.2 Bicyclist Rideout: Driveway/Alley And Other Mid-block
Class A: 15.1% of fatalities, 13.9% of Nonfatalities

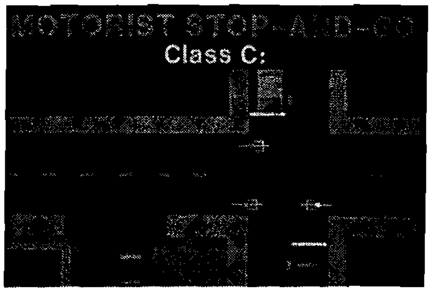
This crash type involves bicyclists who enter roadways without adequate searches. Skilled bicyclists had a much lower rate. In nearly 70% of the occurrances it is near-side motorists that are involved in crashes. The majority of these crashes are restricted to children under 12 years of age. Complicating factors include restricted sight distances, blocked sidewalks, forcing the bike rider into the street and lack of parental guidance.

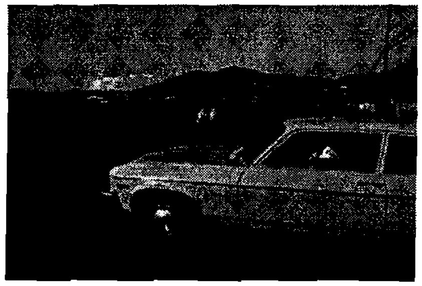
These crashes occur (79% of the time) on two-lane urban roadways with light traffic and a posted speed of 25 mph or less. Only 2% occur on multi-lane highways, while the other 19% occur on 2-lane rural roadways. One of the subtypes, where the bicyclist is riding along a sidewalk then goes out a driveway, occurs on multi-lane highways 16% of the time. Class A crashes comprise over half of fatalities to young children, and up to 1/3 of fatalities to older children.



315.3 Bicyclist Intersection Rideout
Class B: 12% of fatalities, 17% of nonfatalities

This class is very similar to the driveway rideout. Bicyclists fail to yield the right of way, usually at non-signalized intersections. The majority of these crashes involve children, who may have competing interests/needs (e.g., riding with friends, being chased by dogs, or hurrying to school). Most often the intersections involved are familiar to the bicyclists. These bicyclists rarely encounter any traffic and thus fail to make adequate searches. One sub-class of this crash involves bicyclists who enter intersections with latent green phase signals. Due to inadequate clearance intervals, they become trapped in the intersections. Children under age 15 are highly over represented in this crash class (up to one-third of the fatalities).

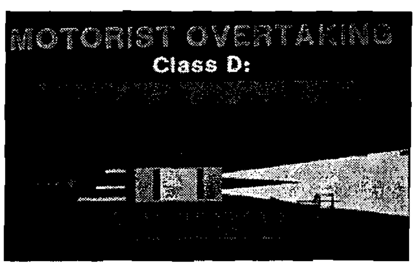




315.4 Motorist Turn-Merge/Drive Through/Driveout
Class C: 2.4% of fatalities, 18.7% of nonfatalities

Typically in this crash type motorists fail to yield the right of way to bicyclists at a controlled intersection, a driveway or other road entry. Although motorists stop or slow significantly, they fail to detect or respond to the presence of bicyclists. Low speed conditions often result in minor injuries, although both bicyclists and motorists often feel victimized by the conditions that created the crash scenario. In many cases bicyclists complicate the situations by coming from unanticipated directions, such as from the motorists' right side on a sidewalk or wrong way street approach (62.5%). In some cases motorists are making right on red turns and fail to detect or respond to bicyclists. Recent Florida data reveals that these crashes often occur on multi-lane highways, comprising 14-16% of all bicycle crashes. In 75% of these cases bicyclists are on sidewalks coming from unanticipated directions. Increased bicycle friendly roadway operating conditions on multi-lane highways can substantially reduce these surprised-condition crashes.

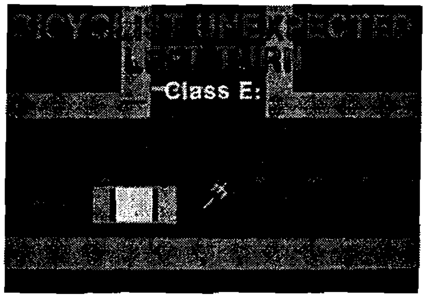
Class C is one of the most common crashes in Florida. The lack of other routes through neighborhoods which forces bicyclists to principle roadways which lack bike lanes in these roadways, place many bicyclists in this common crash pattern. These Class "C" Crashes rarely result in fatal injuries. The crash is so common, however, that it is the subject of many motorist law suits. Both parties feel victimized by these conditions.



315.5 Motorist Overtaking/Overtaking Threat
Class D: 37.8% of fatalities, 10.5% of nonfatalities

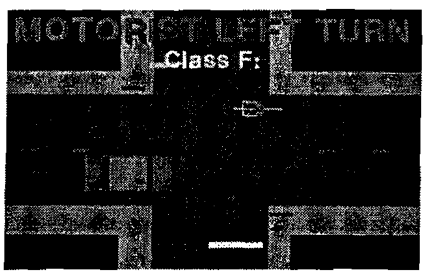
Typically in this crash group motorists drive right into cyclists from the rear. This is the most serious crash class, comprising nearly 60% of fatal bicycle crashes in Florida (37.8% nationwide). These crashes often occur on suburban or rural 2-lane or multi-lane highways with design speeds above 40 mph, under low light conditions (71% of the time). They occur where provisions (shoulders/bike lanes) are lacking to separate bicyclists from motorists. In over one third of these cases, an intoxicated driver is involved. In another third the bicyclist is impaired. In many cases the bicycle and rider are poorly lit, and roadway lighting may be inadequate. This class of crash largely involves adults or older teens. Complicating factors of night riding include alcohol and higher speed.

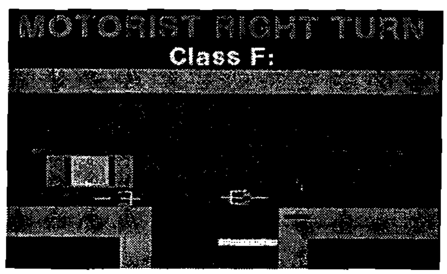
Class D crashes are Florida's most frequent and deadly, accounting for nearly 60% of Florida's fatal bicycle crashes. Gainesville, Florida's system of on-road bicycle facilities, which eliminates much of this conflict pattern, is now being copied statewide in hopes that enough such facilities will be built to eliminate many of these typically low light, overtaking crashes.



315.6 Bicyclist Unexpected Turn/Swerve
Class E: 16.2% of fatalities, 14.2% of nonfatalities

In this crash group bicyclists suddenly turn left without warning. About half of the bicyclists initiated unexpected turns at intersections or driveways. The other half made turns mid-block toward unidentified points. Nearly 50% of the crashes occur on 2-lane, urban roads, while 30% occur on rural 2-lane roads. The other 20% occur on multi-lane roadways in both urban and rural settings. In 94% of the cases bicyclists failed to search or conduct an adequate search. Researchers suspect that bicyclists in such cases are relying on auditory cues to detect the presence of overtaking cars. Too often, however, the sounds of cars may be masked by other traffic, wind, or other noise. It is also suspected that many, especially younger bicyclists, feel uncomfortable scanning to the rear. This task often causes them to steer toward the traffic lane. Children 14 years and under make up 75% of this crash class.

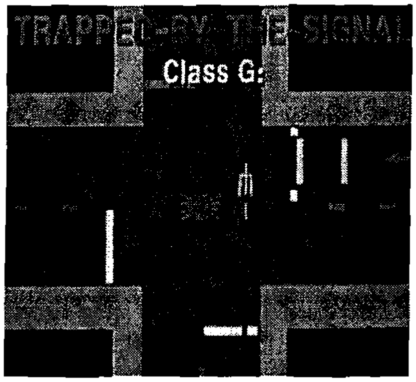


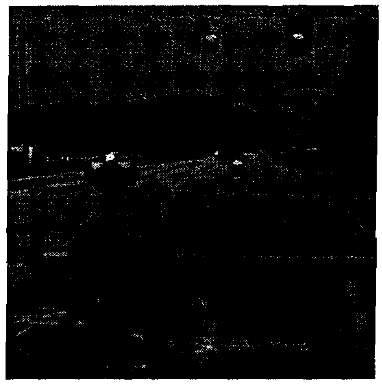


315.7 Motorist Unexpected Turn.
Class F: 2.4% of fatalities, and 14.5% of nonfatalities

In nearly all cases motorists turn directly into paths of bicyclists (left and right turns). Usually bicyclists are coming from unexpected directions (on sidewalks or wrongway lane positions). The most serious of these crashes occur when motorists turn left into the path of bicyclists (either on roadways or sidewalks). These crashes tend to be higher speed, resulting in more severe injuries. These unexpected left turns are the most serious bicycle crashes in many college communities. Glare, inattentiveness and information overload to motorists are suspected to be major contributing factors to this crash class. Driveway access management (right in, right out) should be considered as an engineering countermeasure in some locations. Motorists' right turn crashes are often caused by serious misjudgments of the speed of bicyclists just passed by these motorists. Most (64%) are at roadway junctions, while 29% are at driveways. Bicyclists travelling undetected on sidewalks contribute significantly to this crash class.

The above classes of crashes are common among adults and highly preventable. Bike lanes place bicyclists in the motorist's visual field. It is anticipated that these lanes can be effective in reducing the frequency of these crashes.





Children and socio-economically disadvantaged citizens are highly over-represented in bicycle crashes. Their involvement rate can be 3 to 8 times the general population.

315.8 Other

Class G: 13.8% of fatalities, and 11.2% of nonfatalities

This category involves numerous other crash conditions, such as uncontrolled intersections, parking lots, other crossing conflict situations, head-on collisions with wrong way bicyclists or motorists, and objects falling from vehicles.

316 - Transportation Disadvantaged and Children

A high percentage of Florida's citizen's neither own nor operate automobiles. These people make at least 37% of our state population. Unfortunatly, harsh roadway conditions where they live and must travel make their movement challenging. Many of these people must use bicycles during all times of day, and many times in low light (on the way to school), exposing them to higher risk. Their crash involvement can be 3-8 times that of the general population. Extra efforts must be made to provide safe roadway environments in low socio-economic environments. Affordable housing and quality, low-speed roadways need to be synonymous.

320 - Types of Bicyclists, Part 2

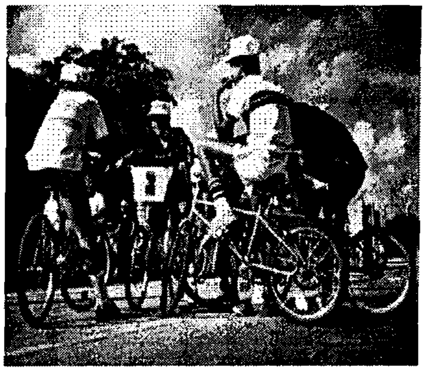
From a planning and design perspective, bicyclists can be divided into six overlapping categories that cover a range of physical, psychological, physiological and emotional abilities, experience and skill. In general, these abilities are broken down by age and experience. The ages and abilities of bicyclists are far more varied than those of motorists. Indeed, before, during and after motorists gain or lose their abiltiy to drive they bicycle for mobility.

Bicyclists can be any age. *There are no restrictions to bicycling ability, just as there are no restrictions to walking. However, parents should be cautioned that most children are not ready to bicycle out of sight until ages 9-11. Once children are 12-13, they often explore many places on their own. The developmental abilities of children are well explained in the "Children in Traffic" video available at most AAA Clubs.*

320.1 YOUNG CHILDREN

Ages 5-11:

At a young age children lack traffic experience. They are often impulsive. They have limited peripheral vision and cannot easily detect the source of sounds. They feel compelled to complete an action they have started and they think grownups will look out for them. Young children have not fully developed depth perception, gap assessment, peripheral vision and sound directionality. Since children do not drive cars, they have difficulty understanding why adults cannot see and respond to them. They are primarily involved in class A, B and E crashes, and numerous non-motorized crashes.



320.2 YOUTH

Ages 12-15:

Children at this age take increased risks, travel farther from home, ride at night, and use main roads to access shopping malls, schools, parks and other places they wish to go. Children of this age often over-estimate their abilities. They are primarily involved in class A, B, C and E crashes.

320.3 YOUNG ADULT

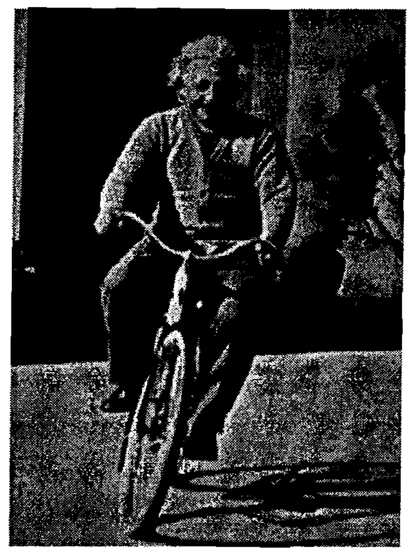
Ages 16-22:

People of these ages now travel at higher bicycling speeds. Many have developed a keen sense of invincibility and have increased experimentation with drugs and alcohol. For some, bicycles may be their only means of transportation to school or work. Many of this age work night jobs and rely on bicycles for transportation. They know the basic rules of the road. They are primarily involved in class C, D and F crashes.

320.4 NOVICE ADULT

Ages 23-64:

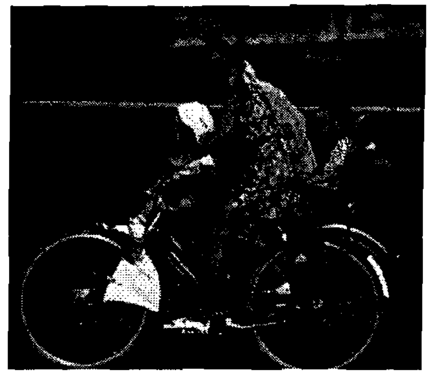
The majority of adults (95%) are novice bicyclists. This category of bicycle riders uses bicycles too infrequently to develop many cycling skills. Some ride at night, greatly increasing their risk. They are primarily involved in class C, D, and F crashes.



320.5 SENIOR ADULT

Ages 65+:

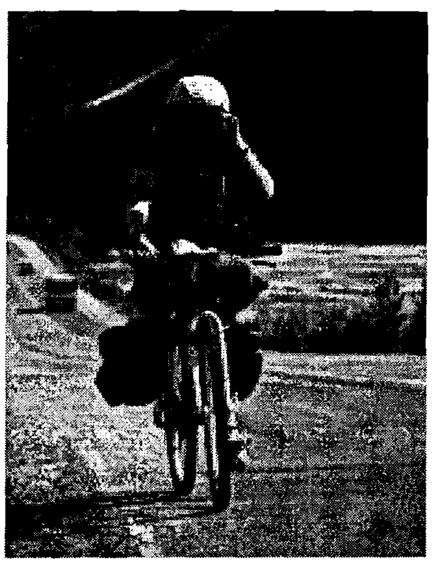
Senior adults increasingly experience some physiological decline, especially in vision. There are pronounced loss of physical abilities starting around age 75 which can include: loss of balance, vision, hearing, and strength. Reduced bicycling speed is common to this age group. Their needs to be independent, to get exercise and to move about the community do not diminish. They are primarily involved in class A, B, C and F crashes.



320.6 PROFICIENT ADULT

All Ages:

These cyclists comprise only 1-4% of the bicycling population. But their frequency of bicycling on major roadways is high. These cyclists tend to ride in all seasons and weather. Some ride mostly for recreation, others mostly for primary transportation. They most often have highly predictable road behavior. Most are excellent role models. A few are scofflaws. Speeds of 18-24 mph (28-38 km/h) are common for this category of cyclist. They are primarily involved in class D and F crashes.



Above Center: Effective Cycling affectionado, John Forester, leads a group of potential bicycling skills instructors through the streets of Gainesville. Other proficient cyclists include cops on bikes, serious bicycle tourists, mothers with children, bicycle commuters, and highly skilled children.

330 - THE DESIGN BICYCLE, Part 3

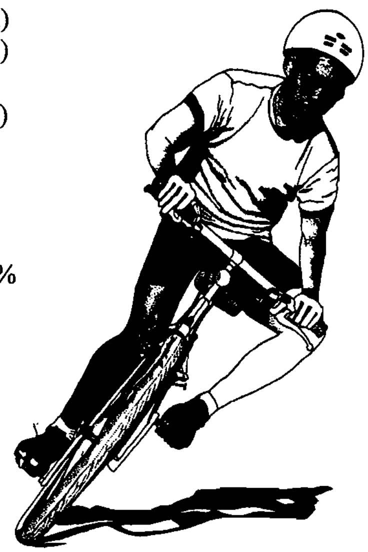
The bicycle is a single track human propelled vehicle having highly similar properties to other single track vehicles (i.e. motorcycle). Bicycles have been tinkered with for more than a century. There are many variations, but all operate according to basic principles outlined in the following pages. Keep these variations in mind when you design.

What Do Bicycles Look Like?

330.1 Dimensions, Speed, Psychological Needs

THE DESIGN BICYCLIST

In order to design effectively for bicycle riders, physical details of typical riders must be understood. Although riders vary in their dimensions and needs, virtually all riders are covered by considering these dimensions:



What is the Norm? *Bicyclists and bicycles vary in their speed, width, height, center of gravity and viewing height. For the most part, the dimensions to the left will accommodate normal and even many extraordinary features of riders and bikes.*

Question: *Where is the center of gravity of these bicyclists?*

Answer: *On a bicycle the center of gravity often is at belly button height.*

330.2 The Design Bicyclist Minimum Needs:

Design Viewing Ht	54" (1.37m)
Rail Height	42" (1.1m)
Center of Gravity (adult, child varies)	33+" (.84-1.02m)
Speed for Crossing Intersections	10 mph (15 km/h)
Speed, (level terrain)	20 mph (30 km/h)
Downhill Speed (roads and bridges)	30 mph (50 km/h)
Uphill Speed (roads and bridges)	5-12 mph (8-19 km/h)

Note: Try not to exceed 5-6% grade, 3% preferred for long sections

330.3 Width and Distances, Minimum Needs:

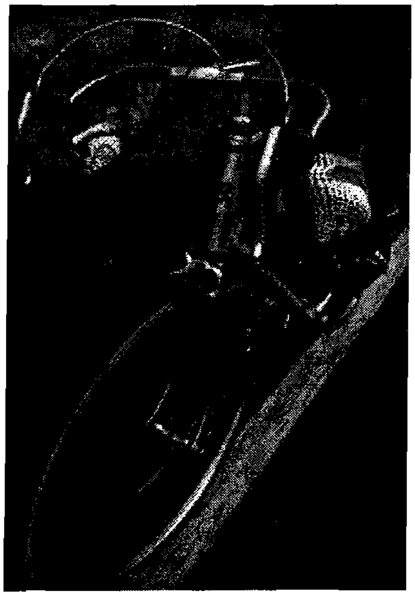
Riding width, including trailers (per direction/rider)	4.0 ft (1.2 m)
Shy distance to seams, smooth walls, curbs	2.0 ft (0.6 m)
Lateral clearance to trees, posts, other	4.0 ft(1.2 m)
Lateral clearance to steep grade	6.0 ft (1.8 m)
Vertical clearance	8.0 ft (2.4 m)
Psychological clearance (tunnels)	10.0 ft(3.0 m)

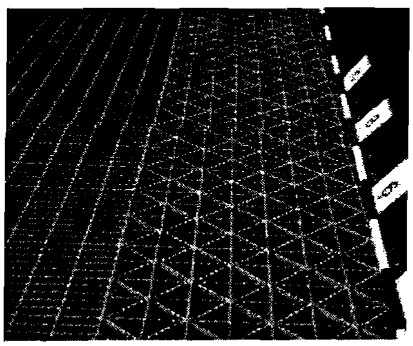
Note: These figures are minimum widths. To design facilities, widths such as riding width and shy distance to a wall are added [i.e. 4feet + 2feet= 6feet, (1.2m +.6 m =1.8m)]

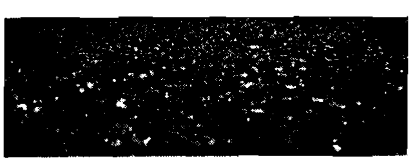
330.4 Likely Speeds by Age:

Child:	6-9 mph (10-14 km/h)
Youth:	7-11 mph (11-17 km/h)
Yng Adult:	8-15 mph (13-24 km/h)
Adult:	8-15 mph (13-24 km/h)
Pro. Adult:	12-24 mph (19-38 km/h)
Senior Adult:	8-15 mph (13-21 km/h)

331 - Wheels andTires



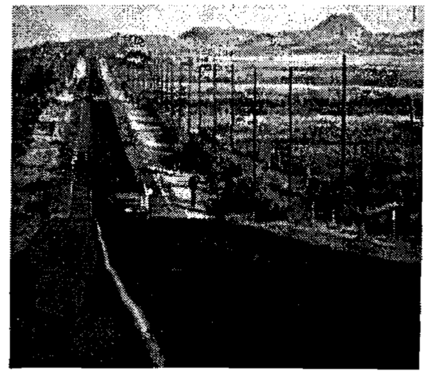


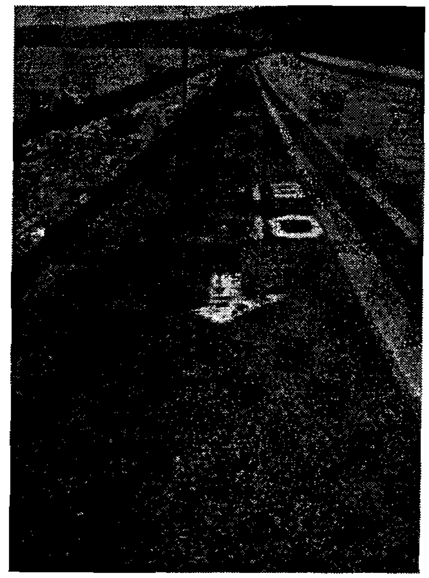


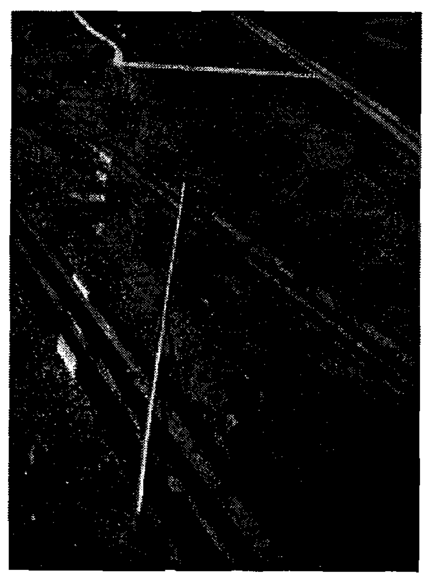
Wheels and tires on bicycles are much narrower than other roadway vehicles. Like motorcycles, bicycles are a single track vehicle, and are far more sensitive to surfaces. Unlike motorists, bicyclists must maneuver to avoid even tiny obstacles or defects. In contrast, autos have complex suspension systems to overcome surface defects. Pedestrians travel slowly enough to step around most defects. Bicyclists, when surprised by potholes, seams or fissures, may suddenly swerve in order to avoid the irregularity. Thus surface irregularities are a serious problem for all bicyclists. Roadside maintenance should be accomplished with this in mind. Considerations when designing for bicyclists are:

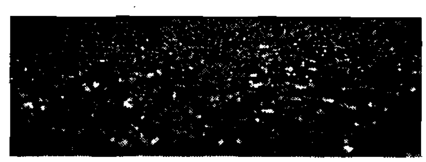
- ♦ Bicycle tires contact the earth with the equivalent of 2 dimes of surface area
- ♦ Bicycles rarely have shock absorbers or suspensions
- ♦ Sand, mud, leaves, oil and skewed railroad tracks and moisture cause slippage
- ♦ Longitudinal seams greater than1/4 inch wide impact control (gobble ability of tire)
- ♦ Steel (rails, bridge decks) and rubber tires do not mix well

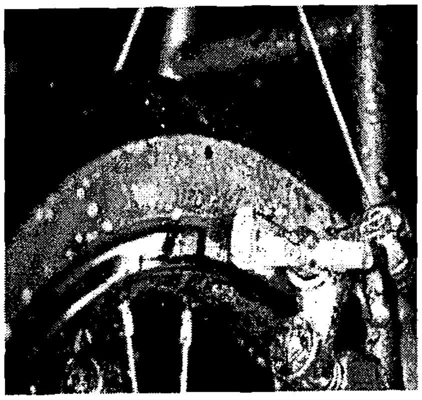
- ♦ Bicyclist stability calls for a narly zero vertical object design height for roadway objects.

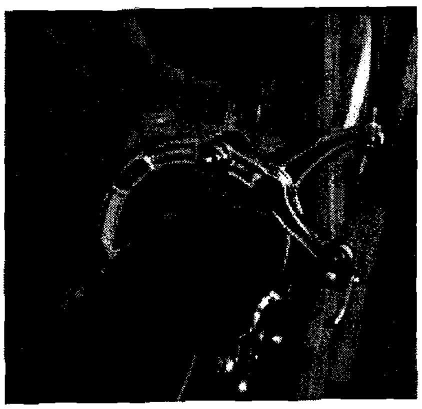








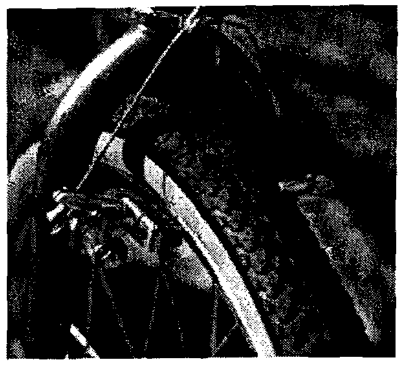


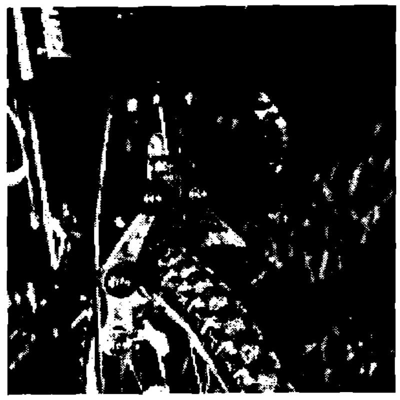


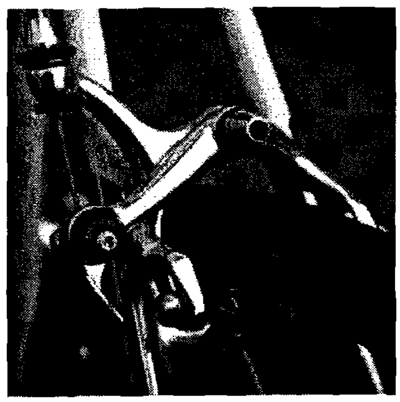
332 - BRAKES and BRAKING

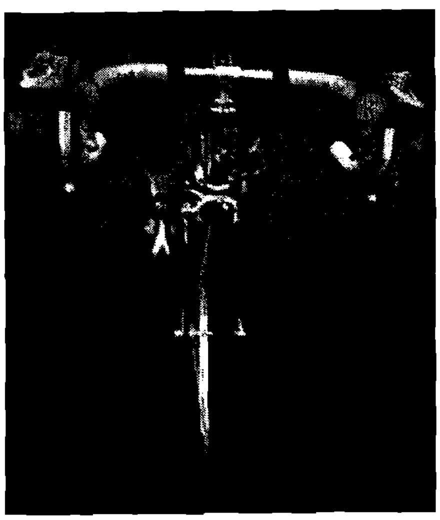
Bicycles vary in their ability to stop quickly. Some brake designs (cantilever) approach the efficiency of autos, and others (cheap side pull) require much longer stopping distances at high speed. Coaster brakes are the least efficient design. Due to overheating they can lose further effectiveness on long downhills. Caliper (hand) brakes are inefficient when the rims are moist. Since many people bicycle infrequently, their reaction and braking response times may increase. Surfaces affect braking. Loose materials such as sand, ice and moisture can increase braking distance by a factor of 1.5-10.0.

- Allow 2.5 seconds reaction time
- Allow an added 3.0 seconds for surprised condition reaction time
- It takes about 1.5 seconds to fully set up braking (reach, mechanical delay)
- Maximum deceleration for a bicycle is 11 mph (17 km) per second
- When rims are wet or coaster brakes are used, braking performance is 50-80% less efficient.







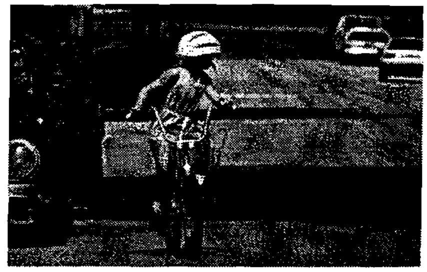


Above: Author, Dan Burden, re-enacts a loss-of-steering control crash on a bicycle path with a turning radius that was too tight. Complicating this design is the misplacement of shrubs hiding the curve until well into the turn.

333 - STEERING

Emergency maneuvers on bicycles cannot be accomplished quickly, because it takes time to set up for a quick turn. Most people do not understand how bicycles steer. Mechanically emergency turns take much longer on bicycles than in autos.

- ♦ To turn right bicyclists must first steer left a bit to set up a counter lean.
- ♦ It takes about 1.5 seconds to set up for a turn.
- ♦ Bicycles steer more slowly when fully loaded.
- ♦ In order to stay upright riders must constantly steer bicycles to keep them in balance and under the body's center of gravity (wobble).



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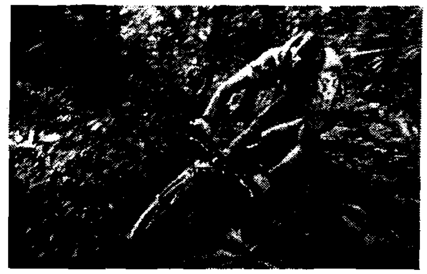

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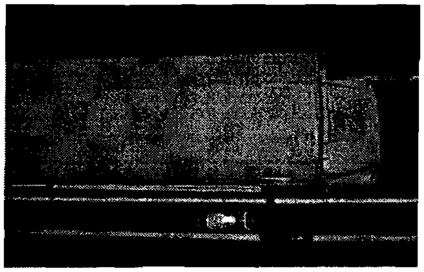
Below, left: Shifting weight suspended from handlebars while climbing a hill is a risky combination to safe steering. Upper right: (1) Many bicyclists have learned the tendency to turn in the search direction. By knowing this tendency, skilled bicyclists learn to counter the steering. (2) Mountain bicyclists learn quick turning judgement, reading their downstream conditions seconds before they arrive. (3) A quick thinking urban cyclist, faced with a left turning motorist, has learned to do an emergency turn by first steering towards the auto to go into a counter-lean. (4) A lean rail supports this bicyclist in Australia. When his gap comes he will use his arms for a more balanced start.

4

334 · PROFILE and VISIBILITY

1 

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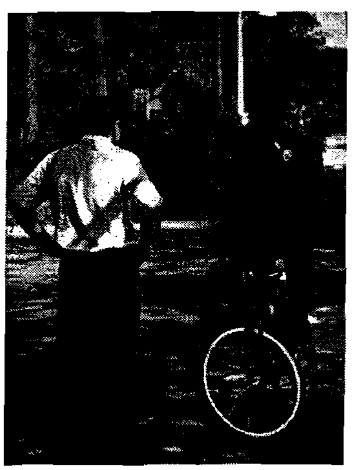
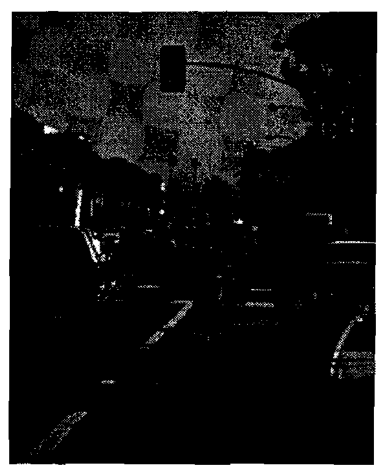
Top panels: (1) Bicycles have a pencil thin profile compared with motorized vehicles. Parents should insist that their children wear bright, conspicuous clothing. (2) Most bicyclists forget the challenge of detecting small objects in traffic. (3) Children, who do not drive, have less understanding of why motorists have difficulty seeing them. (4) Which individual is most likely to be detected in traffic?

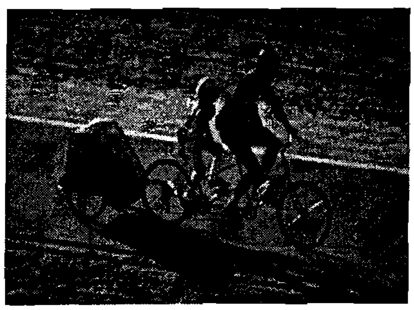
As many as 80% of motorists involved in car/bicycle or pedestrian/car crashes report that they did not see the individuals. While this lack of cognition may be true in many cases, the motoring public must learn to regularly search for non-motorized traffic. Ultimately increased bicycle use will increase motorist awareness. In Holland and in U.S. cities where bicycles are common, car/bicycle crashes are decreasing as use increases. The design community can help by recognizing the following:

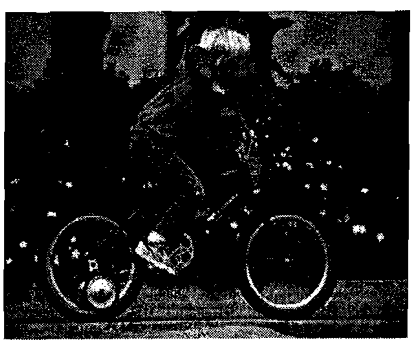
♦ Bicyclists are pencil thin in the complex visual traffic soup
♦ Their curbside location often hides them from other traffic
♦ Motorists tend to see what they expect to see (Many are not looking for bicycles or pedestrians.)
♦ Motorists tend to overlook objects they see infrequently.
♦ More bicycles and pedestrians are needed to increase detection.
♦ Bicyclists are especially hard to detect under low light and night-time conditions.

Top Middle: The majority of Florida's roadways are straight, horizontal and non-challenging. Normally seen as a safety benefit, this lack of challenge can lull drivers into semi-hypnotic states. Below: Bike lanes can be effective in defining the space where bicyclists normally appear. The presence of bike lanes and markings can be a visual message to motorists to remain alert.

4 







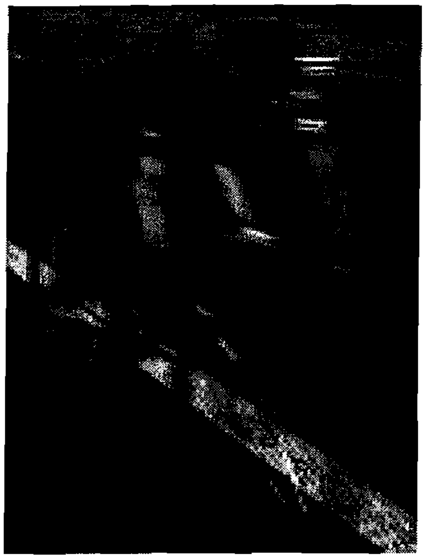
335 - VEHICLE DIMENSIONS

Although many existing bicycles are 10 to18 speed touring/racing "road" bikes, most bicycles sold today are "mountain" bicycle designs. Mountain bicycles tend to have greater handlebar widths and be wider and lower than other bikes. Dimensions for the design bicycle include the full range of existing common commercial bicycles. Use these dimensions to determine median storage and other facilities design details.

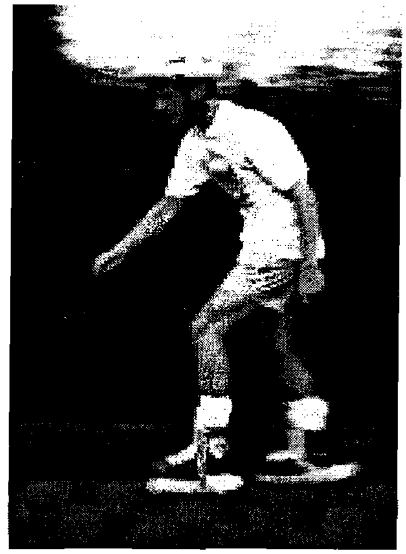
BICYCLE DIMENSIONS

Bicycle Width at Handlebars	28"	(0.71 m)
Width of Bicycle with Trailer	34"-36"	(0.864-0.914 m)
Width of Adult Tricycle	34"-36"	(0.864-914 m)
Length of Average Bicycle for an Adult	68"	(1.7 m)
Length of Kid's Bike	36-46"	(0.91 - 1.16 m)
Length of Tandem Bicycle	95"	(2.4 m)
Length of Tandem towing Trailer	140"	(3.6 m)
Height of Average Bicycle	44"	(1.1 m)
Weight of Average Bicycle	20-30 lbs	(10-20 kg)
Weight of Tandem Bicycle	35-50 lb	(15-25kg)

Due to steering wobble, bicyclists typically track over a 4.0 foot (1.2 m) width. This width should be increased to 6-10 feet (2.3 m) for steep hill climbs and descents. With variable gearing, bicyclists can comfortably climb up to a 10% grade for short stretches. Grade of 6% are the more common limit. Increases in grade generate more wheel wobble by bicyclists and thus require a wider design width.



340 - HELMETS



340.1 Bicycle Helmets Work !

A full 75% of bicycle fatalities and permanent injuries are head injuries. At least 60% of all fatalities include only a brain injury. Thus, bicycle helmets can eliminate up to 60% of all fatalities.

340.2 Gravity's "g" Force

A bicycle helmet works by reducing the "g" forces to the brain. A fall while a person is sitting stationary on a bike onto a concrete surface can produce forces of nearly 2000 g's. It only takes 150 g's to produce minor injury, 300 g's to produce permanent injury. At 600 g's, no one survives. A bicycle helmet reduces the nearly 2,000 g's from a hard fall or crash to often below 150 g's.

Section 4

400 - DESIGN, On-Road

> *Special Note: Prior to reading this section, designers are asked to read the contents of Section 3 (Crash Causation, Human Factors, Physical space requirements, The Design Bicycle, and the Design Bicyclist.*

400.1 DESIGN CRITERIA for Accommodating Bicycles in Combined (Roadway) Facilities.

The ultimate test of any design is the response to this question: ***"Does this design impove the safety and performance of the motoring, walking and bicycling public?"*** It is important to observe how the design provides desirable operations and controls or improves those conditions or eliminates conflicts between users. Generally, bicycling improvements improve conditions for motorists, both when bicyclists are present and when they are not present.

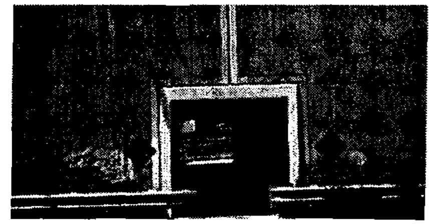
The criteria printed in standard type are recommended general design recommendations, provided as guidance; those underlined are minimum safety design criteria (standards).

We recognize that in certain isolated instances, it may not be possible or feasible to meet the mandatory minimum safety design criteria, but projects can be developed in a way that they do not jeopardize the safety of bicyclists, pedestrians and motorists using the corridor. Deviations from standards can be tolerated only where one of the following applies:

1. When a deviation is judged by the project proponent and the funding authority to be a safety equivalent (i.e., as good as or better than the criteria).

2. When a lesser facility is judged by the project proponent and the funding authority not to jeopardize the safety of the public. (The intent is to permit deviations for isolated sections where criteria cannot be met, but where mitigating action or other conditions are such that the lesser facility will not result in unsafe conditions).

3. Deviations from criteria shall be considered on a case-by-case basis, and the rationale clearly documented by the implementing agency. For FDOT projects a variance must be requested. It is not the intent that deviations be used for the purpose of permitting wholesale exemptions from width or alignment criteria which would result in undesirable width, alignment, or wrong-way travel.



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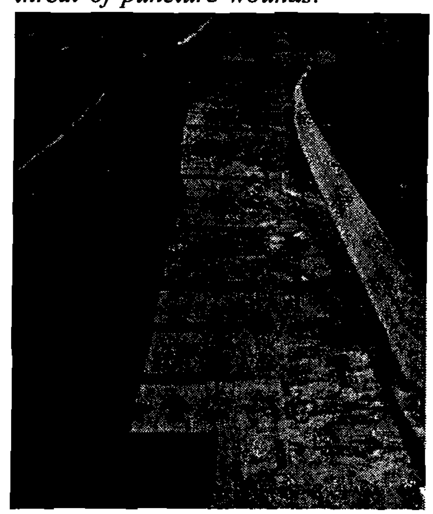
*Principle: **– Improve the safety of everyone.** Protector of errant autos, guard rails also impact bicyclists. The designer must be alert so guardrails and all design treatments benefit all users. (1) Sections of guardrail are a hazard to those they were placed to protect (2) A falling bicyclist can be seriously hurt. (these do not meet standards). (3) Solution: FDOT standards now require guardrails to have protective pipes to minimize the threat of puncture wounds.*



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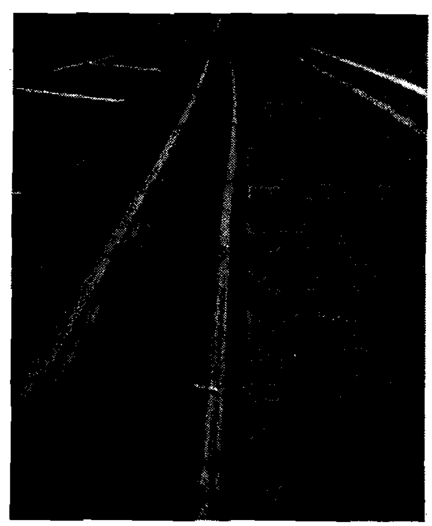

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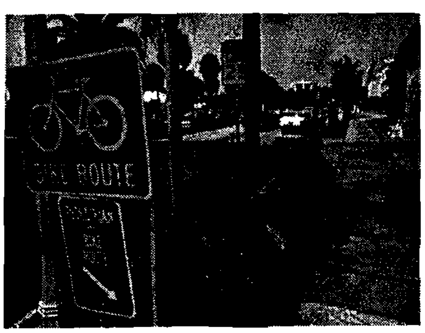
Early roadway designers asked "Where do we put the bicyclist?" The answer often came up wrong, largely because the wrong question was being asked. Instead, as we now know, the question is "How do we help the bicyclist?"
....Michael Ronkin
Oregon DOT

Asking the wrong question led to early Florida bike facilities failing to meet the public need. Pedestrians, bicyclists and motorists were affected. These signs were removed.



We recognize that the recommendations and criteria do not cover all types of design details encountered in development of bicycle facilities. Where details are not covered, appropriate engineering principles and judgement must be applied in providing for the safety and convenience of bicyclists, pedestrians and motorists.

400.2 History of Design

Most urban roadways were designed and built during a period of little bicycle use. Hence, early design decisions to provide for bicyclists were often based on the assumption that to separate bicycling from roadways was best. This concept quickly proved unpopular with bicyclists. It led to a proliferation of conflicts due to lack of facilities, bicyclists being on sidewalks and thereby hidden from motorists, poorly built bike paths, and bicyclists and motorists attempting to mix on roadways with inadequate mixed use design.

400.3 Current Practice

The current approach to bicycle-facility design, now required under F.S. 335.065, the Florida Department of Transportation *Plans Preparation Manual,* the *Roadway and Traffic Design Standards* and the intent of national legislation, is that every road is a potential bicycle way and bicycling should be accessible, friendly and promoted to all destinations.

Key attractions are found along main thoroughfares; and they attract bicyclists, just as they attract motorized traffic. This concept requires full consideration of bicycling for new transportation projects.

400.4 Full Consideration

New construction, as well as RRR projects, must give full consideration to the needs of bicyclists. Measures should also be taken to retrofit the backlog of roadways not currently scheduled for improvement. This can and should include attention to safety needs identified through the statewide Safety Management System, and Community/Corridor Traffic Safety Programs.

There is a wide range of facility improvements which can enhance bicycle 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, traffic counts, conflicts, traffic mix, vehicle speed and many other factors. On the other hand, bicycle paths or mixed use trails are located on independent alignments; consequently, their design depends on many factors, including the performance capabilities of bicyclists and bicycles.

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 design process.

400.5 Guidelines, Criteria and Standards

Guidelines, criteria and standards 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 manual. Modifications to facilities (e.g., widths, curve radii, superelevations, etc.) that are necessary to accommodate adult tricycles, bicycle trailers, and other special purpose human-powered vehicles and accessories should be made using sound engineering judgment and be based on anticipated use of the facility. (Project standards are established from criteria and controls).

It is best to estimate high levels of use. Presently there are so many disincentives for bicycling that to judge the need for a bicycle facility based on existing bicycle counts or projections can be highly deceiving. A design that ultimately benefits a bicyclist, such as paved shoulders, can usually be justified for reasons other than bicycling. Many facility designs provide great benefits to motorists, maintenance, general safety, and other joint uses. As a result, a given facility can often be warranted with little or no projection of increased short term bicycling activity.

410 - Roadway Improvements

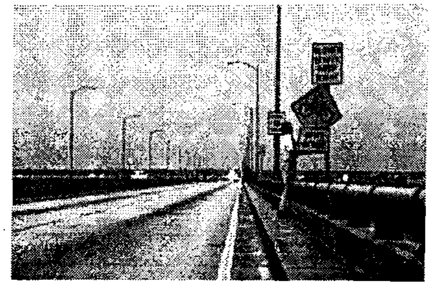
To varying extents, bicycles will be ridden on all highways other than limited access highways, where they are not normally permitted. Thus, all urban non-limited access roadways should be designed and constructed under the assumption that they will be used by bicyclists.

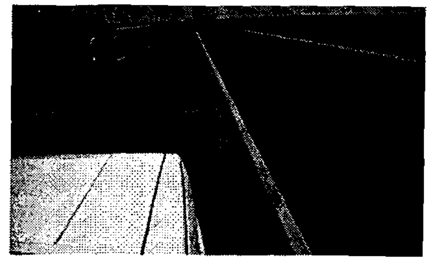
Bicycle-safe design practices, as described in this manual, should be followed to avoid the necessity for costly subsequent improvements. Because most highways have not been designed with bicycle travel in mind, there are often many ways in which roadways should be improved to more safely accommodate bicycle traffic.

Roadway conditions should be examined, and safe drainage grates and railroad crossings, smooth pavements, and signals responsive to bicycles should be provided where necessary. In addition, the desirability of adding facilities such as bicycle lanes, shoulder improvements, and wide curb lanes should be considered (wide curb lanes are the least preferred option). Information on each of the different roadway improvements is contained in this section.

410.1 Drainage Grates

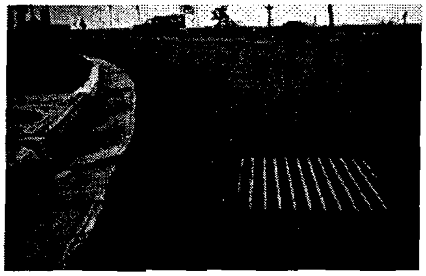
Drainage grate inlets and utility covers are potential problems to bicyclists because they can be:



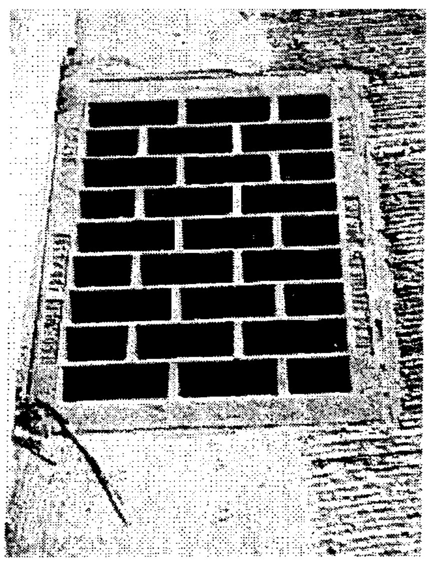


Good Design Helps Everyone. *A very costly cantilevered retrofit of Pensacola's "Three Mile Bridge" benefited motorists by creating a much needed vehicle emergency lane. A side benefit was the creation of narrow but essential shoulders for bicycling. Fatal bicycle crashes dropped from an average of one a year in the early 80's to zero since the treatment in 1986.*

Bike Lanes Help Motorists and Pedestrians. *Even if this Siesta Key bike lane were never used by bicyclists, its value to the roadway is significant. Pedestrians now have a buffer from moving traffic. Traffic may move slower due to the reduced lane width.*



"Open Slot Grates". Keep these out of the roadway. Use inlet grates (pictured on the left in the photo above, following FDOT Standard Index 229. If roadside placement is necessary, replace with the below pictured "bicycle safe" grate. Note that any grate tends to be slick, traps sediment, and creates a nuisance for bicyclists.



Standard Index 229 identifies which FDOT Standard Inlets are considered Bicycle Safe.. Roadway and Traffic Standards

- slippery
- often not flush with the road surface
- a prime location for debris and water, and
- capable of trapping bicycle wheels.

When a new roadway is designed, all such grates and covers should be kept out of bicyclists' expected path, or they should be designed to accommodate bicycle traffic, as described on the next page.

On construction where bicyclists will be permitted, curb inlets should be used, wherever possible, to 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, resulting in loss of steering control and often serious damage to the bicycle wheel, frame and/or injury to the bicyclist. These grates should be replaced with bicycle-safe and hydraulically efficient ones. When this installation is not immediately possible, consider welding 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 only.

As a last and temporary resort, identifying a grate with a pavement marking would be acceptable in some situations. As indicated in the MUTCD, 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.

Grates with parallel slat designs that trap bicycle wheels are still used frequently in some roadway and many non-roadway environments, such as in parking lots, across driveways, and other hazardous locations. Designers must be vigilant always to specify bicycle safe inlet grate designs.

410.2 Railroad Crossings

At highway grade crossings of railroads the rails should ideally be at a right angle to the road. The greater the crossing deviates from this ideal 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.

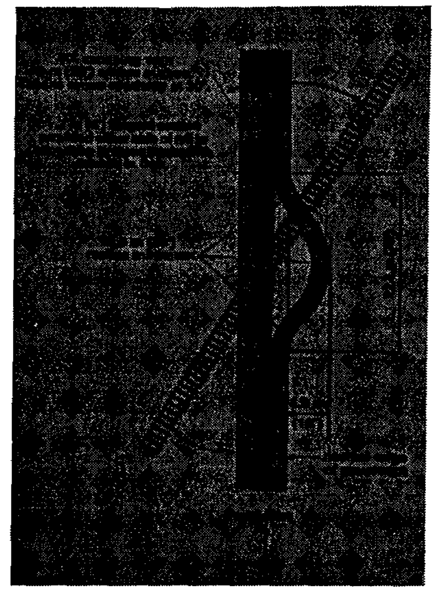
Consideration should be given to the materials of the crossing surface and to the flangeway depth and width. If the crossing angle is less than approximately 45 degrees (crossing angles of 30 degrees or less are considered exceptionally hazardous), consideration should be given to widening the outside lane, paving the shoulder or providing a bulbed out bicycle lane to allow bicyclists adequate room to cross the tracks at a closer to a right angle. The approach and departure shoulder should be paved, and should provide sufficient length to allow the bicyclist to merge into a gap in traffic. 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. Additional pavement markings directing the bicyclisttoward the best crossing angle should be considered.

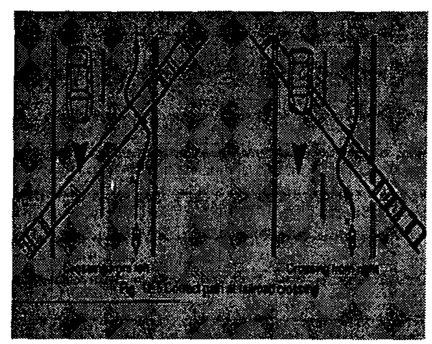
410.3 Pavements

Often it is the right-most porion of a travel lane that deteriorates first in a highway cross section. Since this is the area of a roadway where the bicyclist generally rides to stay out of traffic, it is imperative that pavements be designed and constructed to provide long life. Pavements' 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.

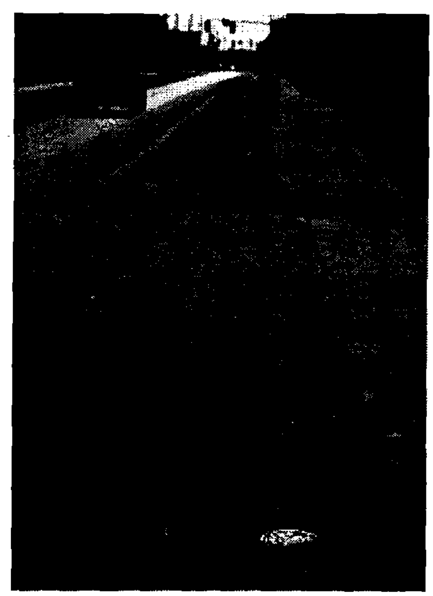
410.4 Traffic Control Devices

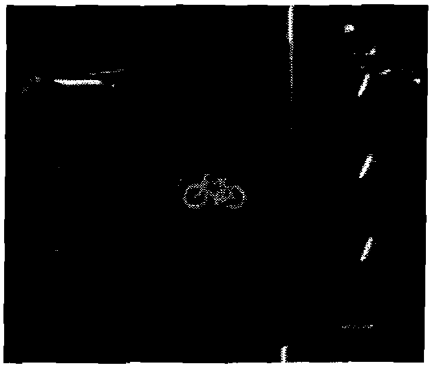
At intersections where bicycle traffic exists or is anticipated, bicycles should be considered in the timing of traffic signal cycles, as well as the traffic detection devices. Normally, a bicyclist can cross an intersection under the same signal phasing arrangement as motor vehicles. On multi-lane street crossings, special consideration should be given to ensure that short clearance intervals are not used. An all-red clearance interval is often used in intersections today, and benefits bicyclists who need the extra time. With wider and wider intersection designs, the traffic engineer must pay close attention to crossing times. The desire to keep lanes full width and to add more turn lanes must be balanced by alternatives that provide protective channeling, reduced crossing width or other designs. For the above reasons, geometric designers and operations staff must work closely to create supportive bicycle crossings.

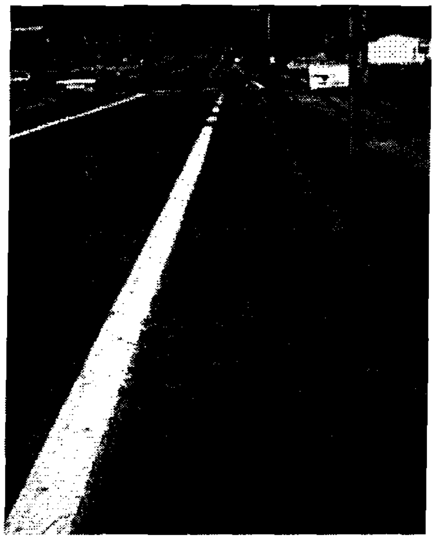




Right edge portion lane stability and maintenance are essential to a safe roadway. Pay special attention to utility caps, gutter seams, pavement quality and pavement life.







Bicycle Signals should be engineered to gain the highest practicable level of compliance among bicyclists. Top: Davis, California uses a bike symbol signal for special bike crossings. Center: Corvallis, Oregon uses an advance detector. Bottom: Boulder, Colorado detector instructs bicyclists on best location for maximum detection (see diagonal lines).

To check the clearance interval, a bicyclist's speed of 10 mph (16 km/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. In some situations, the use of pedestrian actuated buttons may be a preferred alternative to the use of detectors, provided they they are placed so that they do not require bicyclists to dismount or make unsafe leaning movements. Where programmed visibility signal heads are used, they should be checked to ensure that they are visible to bicyclists who are properly positioned on the road. Mast arm and box span signal systems should be used to permit the bicyclist to detect any change in traffic signals. Diagonal spans signal systems are hard to detect from curbside locations, and should be a last resort.

410.5 Bicycle Actuated Signals

Many traffic signals in urban areas are activated by detector loops embedded in the roadway. These traffic detector loops respond to the magnetic field induced by the metal in a vehicle in the detector loop.

The sensitivity of these loops should be adjusted to detect a bicycle without sensing passing vehicles in adjacent lanes. This can be facilitated by using a short length (under 50' or 15 m) quadrapole loop. This minimizes sensitivity outside the loop while increasing it within.

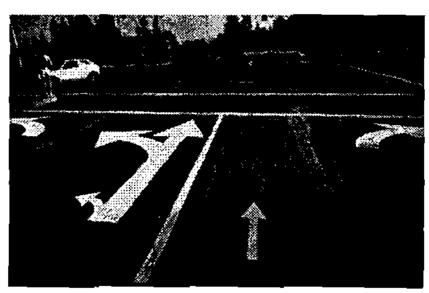
Detector loops are not usually installed across the entire lane and it is quite possible that a bicycle on the far right side of the road will not be detected. Pavement markings, either stencils or indicator dots, should be used on the right edge of the loop. This will allow cyclists to line up on the loop and activate the signal. Some children's bicycles have plastic rims, and thus greatly reduce the chance for these bicycles to be detected.

The MUTCD should be consulted for guidance on signs and pavement markings. Part Nine (IX) is specifically devoted to bicycles (See Appendix).

410.6 Paved Shoulders and Bike Lanes

Bicycle lanes are preferred in restrictive urban conditions, and the widened shoulder will generally be more accommodating in rural circumstances. Current

Below: Glenn Grigg, traffic engineer for Cupertino, California created the special detector for bicycles (center) and then used the baby arrow system to communicate with bicyclists on which lane to use to queue and turn left.



FDOT criteria call for a 5 foot (1.5m) wide paved shoulder on both sides of all rural roadway sections. Additional width can be considered when heavy truck volumes or other conditions warrant (*Plans Preparation Manual,* Vol 1. Ch 2. for details). Since bicyclists often ride on shoulders, smooth paved shoulder surfaces should be provided and maintained as shown (right). Pavement edge lines (6 inch or 0.15m minimum) supplement surface texture in delineating the shoulder from the motor vehicle lanes.

410.6.1 Rural Area Shoulders

Adding or improving shoulders often can be the best way to accommodate bicyclists in rural areas. Paved shoulders are also a significant safety 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.

410.6.2 Shoulder Width

The minimum Paved Shoulder width is 5 feet (1.5 m) when intended to accommodate bicycle travel. When designated as a bike lane, it must be 5 feet (1.5 m).

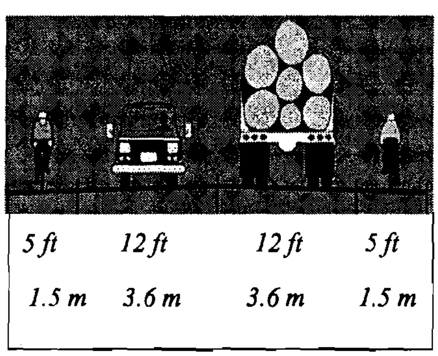
The safe passage of bicyclists by motorists is a function of the combined width of the paved shoulder or bike lane and the width of the adjacent travel lane.

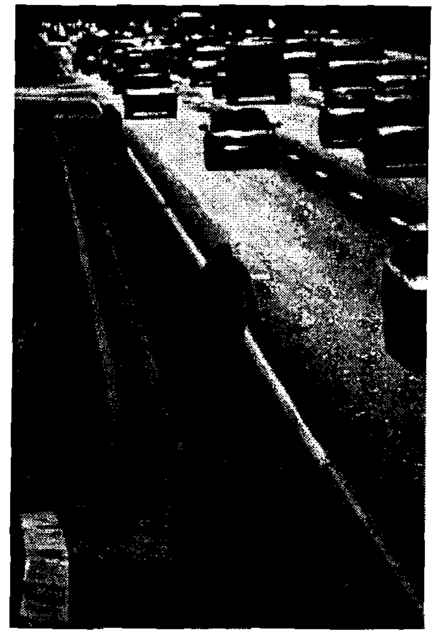
Acknowledging this need, the 1995 standard for paved shoulder width for state system roads is 5 feet (1.5 m). If motor vehicle speeds exceed 35 mph (60 km/h), if the percentage of trucks, buses, and recreational vehicles is high, or if static obstructions exist at the right side, then a full 12 foot (3.6m) lane creates proper passing width. At speeds above 45 mph, bicyclists need a 6 foot (1.8m) minimum lateral separation from trucks. Again, full 12 foot (3.6 m) width travel lanes in combination with 5 foot (1.5m) paved shoulders accommodates this lateral separation need.

410.7 Rumble Strips

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. As a general rule, rumble strips should only be used on curves, approaches to bridges and other locations where there is high motorist benefit. *The FDOT Roadway and Traffic Design Standards (Standard Index)* gives locations for rumble strips.

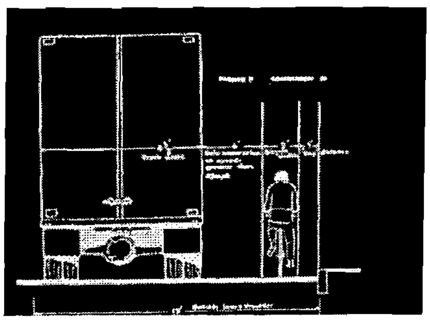
In other width restricted conditions, the shoulder should provide at least a 4 foot (1.2 m) riding surface. Rumble strips and speed bumps, tables and humps should be of a design that does not create instabil-



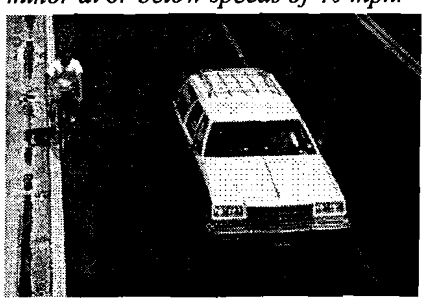


Traffic moves freely. *Motorists benefit from Fruitville Road's friendly features. Sarasota motorists are able to move more freely with bicyclists separated from the travel lane. The 5.0 ft (1.5 m) paved area is attractive to many adult bicyclists.*

Since bicyclists often ride on shoulders, smooth paved shoulder surfaces should be provided and maintained. Current FDOT criteria call for a 5 foot (1.5m) wide paved shoulder on all rural roadway sections and a bicycle lane on all urban roadway sections.



***High Speed Truck Wind Blast** effect extends 2 meters. The combination of travel lane and paved shoulder should allow a 6 ft (2 m) physical separation between truck and rider. Truck wind blasts are considered minor at or below speeds of 40 mph.*



***Wide Outer or Outside Curb Lanes.** Although wide curb lanes benefit motorists and bicyclists, only a small percentage of bicyclists feel comfortable using these facilities.*

ity to the bicyclist who inadvertently drifts onto one, especially under low light conditions.

410.8 Bridge Shoulders

Due to the buildup of debris, and the trapped condition that a bicyclist faces, shoulders on bridges should have a minimum width of 6 feet (1.8 m). Bridge shoulder width, as a minimum, should match the approach roadway shoulder width.

Bridges exceeding a 3% grade benefit from wider shoulder widths (10 feet [3 m]) preferred. This added width compensates for climbing wobble conditions and higher descent speeds.

410.9 Wide Curb Lanes

Wide curb lanes are a "least preferred" option in Florida. Although it is current practice within the Department to convert wide curb lanes to undesignated or designated bike lanes, in some conditions a wide curb lane is still desirable. The following principles and details are provided.

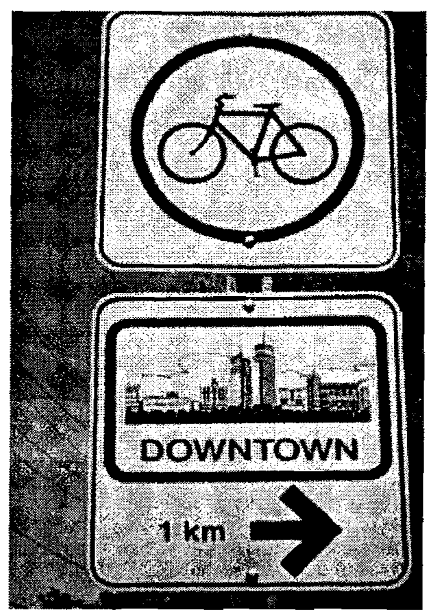
On highway sections without bicycle lanes, a right lane wider than 12 feet (3.6 m) can better accommodate both bicycles and motor vehicles in the same lane and thus is beneficial to both bicyclists and motorists. In many cases where there is a wide curb lane, motorists will not need to change lanes to 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 (4.2 m) of usable width is desired. Usable width would normally be from edge of pavement (gutterpan seam), but adjustments need to be made for drainage grates, parking and longitudinal ridges between pavement and gutter sections.

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

410.10 Bicycle Routes

Following the cautions about Bike Routes in Section 3 on Planning, it may be advantageous to sign some urban and rural roadways as bicycle routes. When providing continuity to other bicycle facili-



***Above:** This Canadian bike route sign serves as an important navigational aid.*

ties, a bicycle route can be relatively short. However, a bicycle route can be quite long. For longer bicycle routes, a standard bicycle route marker with a numerical designation in accordance with the MUTCD can be used in place of a bicycle route sign. The number may correspond to a parallel highway, indicating the route is a preferred alternate route for bicyclists.

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. Bicycle route signing should not end at a barrier. Information directing the bicyclist around the barrier should be provided.

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 types 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 adequate pavement width, drainage grates, railroad crossings, pavement smoothness, 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.

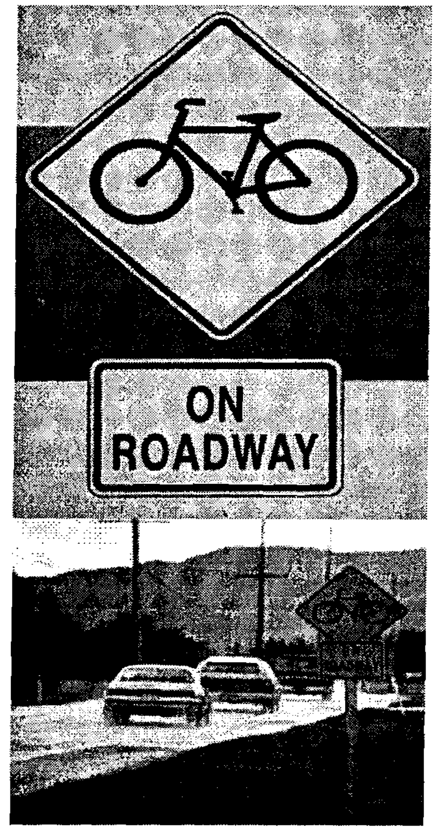
410.11 Bicycles Sharing Roadway Signing

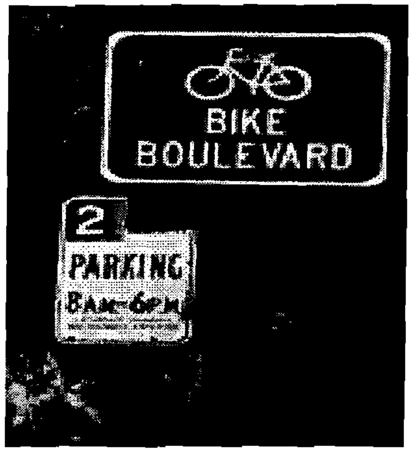
Special guidelines have been issued (see page II-29 in the FDOT Traffic Engineering Manual) to warn motorists that bicyclists and motor vehicles are legally required to use/share travel lanes. These signs are generally used where safety problems or inappropriate motorist behavior indicate a need to remind users that they are sharing the roadway with others. These signs are also appropriate for long narrow bridges in both urban and rural locations. The signs have been proven effective in increasing courtesy between users. Before issuing the signs, the district or community bicycle coordinator is asked to review the signing request. As with any sign, overuse tends to breed disrespect for those cases where they are needed most.

410.12 Bicycle Boulevards

In contrast to bicycle routes, bicycle boulevards offer more support to bicyclists by enhanced signing, traffic controls and connections. Bicycle boulevards serve as a primary route for bicyclists through a collection of lower speed side roads where traffic controls favor the through movement of the bicycle rider. The motorist attempting to use the same route for distance travel is thwarted through an occasional

Sample of Bicycles Sharing Roadway Signing used in more than a dozen states.





Bike Boulevards. Palo Alto (left photo) offers a traffic calming canopy and a quality surface as a Boulevard connecting bicyclists from neighborhoods to downtown.

These treatments call for special side entry signing to alert motorists of the bi-directional bike travel. The local bicycle streets should only be considered through full involvement of neighborhoods, where at least 60% of the adjacent residents approve of the design. Other criteria include the number of conflict points and the volumes of motorized traffic and potential bicycle traffic.

traffic diverter, a series of roundabouts, and other devices used to slow or rechannel the motor vehicle. Boulevards may also have special trails, bridges or connections, offering the rider the most direct and quiet routing to primary destinations such as a downtown.

410.13 Special Neighborhood Bike Lanes

Special bike lanes can be created on highly select local streets by restricting auto movement to one way, placing a low median divider of at least 70 inch width (1.7 m), and with a 6 inche (150 mm) curb face on the traffic side. The bicycle side can have a zero curb height to allow additional maneuvering width. The created space can thus be dedicated for bi-directional bicycle travel.

420 - Bicycle Lanes

Bicycle lanes are to be used on future urban roadway sections, whenever right of way and existing curb/drainage sections permit. Often it is possible to convert wide curb lanes on multi-lane highways to bike lanes by reducing the travel lane widths to 11feet (3.3 m), and turn lanes to 10 feet (3.0m).

420.1 Primary Benefits of Bike Lanes

Bike Lanes have proven their value to all highway users. Among their benefits in creating a smooth, efficient and safe sharing of the highway are the following:

- Establish the correct riding position for bicyclists
- Establish the correct riding direction for bicyclists
- Send a message to motorists that bicyclists have a right to the roadway.
- Reduce motorist and bicyclist sudden swerves (lane changing)
- Reduce serious bicycle crashes by up to 80% within some corridors (Gainesville, Florida)
- Guide bicyclists through intersections in the safest, most predict able course.
- Permit bicyclists to pass motorists stopped at a signal.
- Permit motorists to pass bicyclists on 2-lane roadways.

420.2 Secondary Benefits of Bike Lanes

There are many secondary benefits of bike lanes as well:

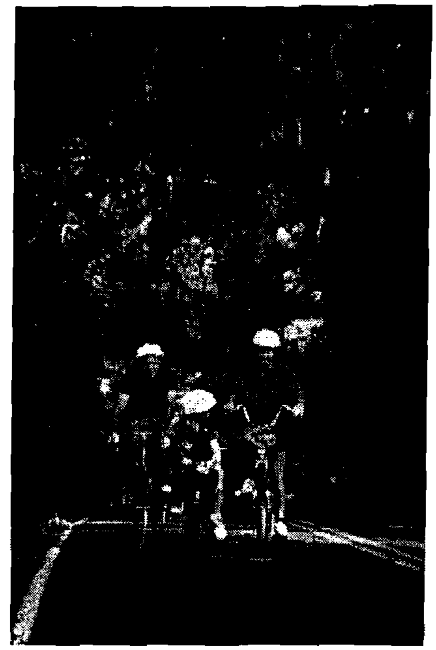
- Provide added border width
- Enhance highway drainage and reduce vehicle hydroplaning
- Create an essential buffer between the pedestrian and motorist
- Improve opportunity for landscaping (border width)
- Reduce pedestrian/bicyclist conflicts (no longer on sidewalks)
- Add turn radii at driveways and intersections (see page 4-20)
- Improve sight distances

421- Bicycle Lane Widths

The minimum bicycle lane widths are:

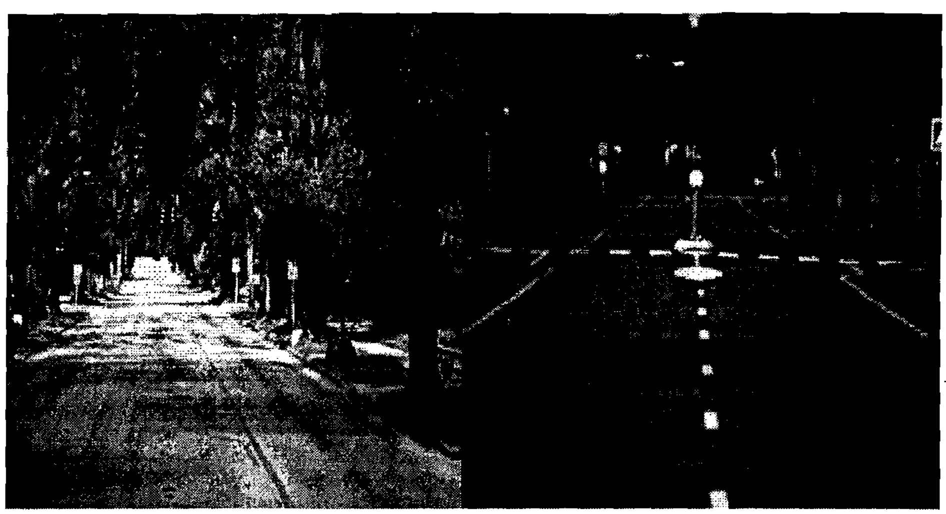
Urban	4 feet (1.2 m)
Rural	5 feet (1.5 m)
Parking	5 feet (1.5 m)

However, certain edge conditions dictate additional desirable bicycle lane width. To examine the width requirements for bicycle lanes, Figure 3 (page 4-15) shows three usual locations for such facilities in relation to the roadway. These include, (a) curbed street with parking (b) curbed street without parking, and (c) street or highway without curb or gutter.



422 - Signing, Marking Bike Lanes

In Florida bike lanes are to be marked with signs, pavement markings, and especially a 6-8 inch (0.15-.20 m) wide stripe to emphasize the edge of the travel



From This to This

By dropping the center scramble lane, neighbors enjoy slower, quieter traffic, reduced chance for a serious crash and a place to bicycle. The effect includes deep red (ocher) pigmented top coat for the bike lanes, and small refuge islands to force slower traffic movements at each intersection.

lane. A complete marking includes signing (See MUTCD), a directional arrow, and a bike symbol. The diamond marking shown to the right is being discontinued in Florida applications. The added marking is considered non-essential. For preferred marking and placement, see page 4-22.

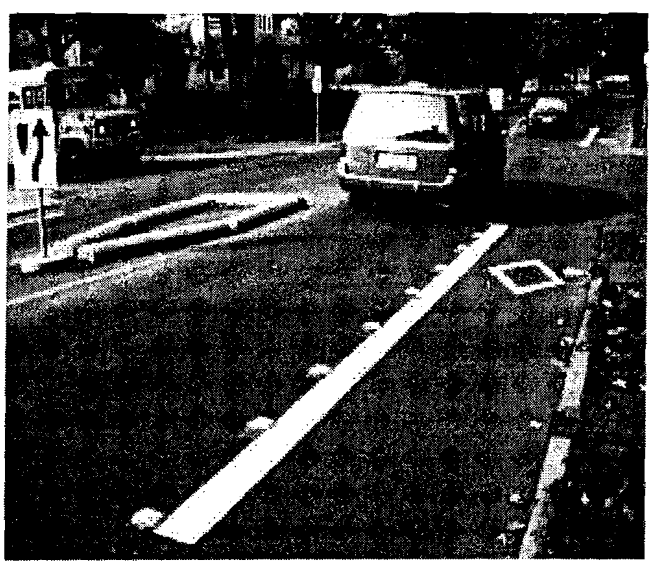
422.1 Additional Emphasis Markings

In especially hazardous rural and higher speed suburban locations, such as bridges, curves and areas where motorists frequently run off the roadway, added emphasis may be given to the markings. In these locations, additional glass beads, special bicycle-safe markers, and other treatments may be considered.

Standard size Raised Pavement Markings (RPM's) and raised barriers present a hazard to bicyclists and shall not be used to delineate bicycle lanes. Experimental low level RPMs, inset into the pavement, are being tried in test sections with effective results. RPM's may be considered for special areas where additional guidance and control are war-

Bike Lanes. *Top photo: Florida's first bike lane, 13th Street, in Gainesville, Florida, is well accepted and understood by motorists and bicyclists. The lane has operated effectively for 14 years.*

Bottom left, Portland is experimenting with traffic calming enhanced with bike lanes. Speeds in this neighborhood have been reduced from 47 mph to 37 mph. Bottom right: San Francisco's Bus/ Bike lane serves both modes well.



ranted. Also, thermoplastic pavement markings pose a hazard to bicyclists because they are slick, especially when wet. The Florida Department of Transportation has developed a special thermoplastic mix using additional grit to combat this problem. For an illustration of a product now being tested for special emphasis markings see page 4-16.

422.2 Directionality

Bicycle lanes should always be one-way facilities, be marked as such, and carry traffic in the same direction as adjacent motor vehicle traffic. Two-way bicycle lanes on one side of the roadway are unacceptable because they promote riding against the flow of motor vehicle traffic. Wrong-way riding is a major cause of bicycle accidents and violates the Rules of the Road stated in the Uniform Vehicle Code.

422.3 Wrong Way Signs

The Department has approved a special sign that can be placed on the back side of the bike lane sign (R3-17) that notifies bicyclists when they are riding the wrong direction in a bike lane (See Sign Below). This sign, in addition to the lane directional arrow, reduces wrong way riding. This sign also makes it easier for police to cite bicyclists and defend a violation before a judge.

423 - One Way Streets

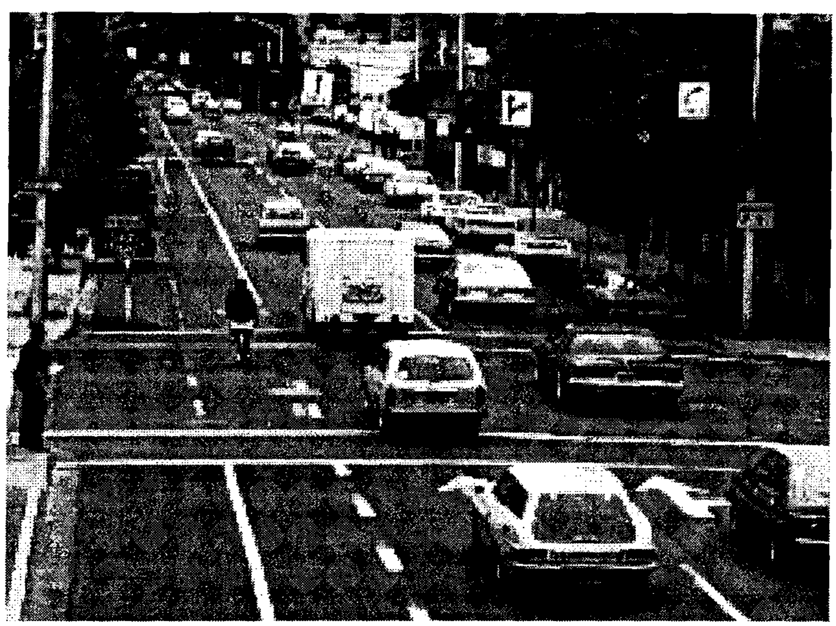
Bicycle lanes on one-way streets should be on the right side of the street, except in areas where bicycle lane on the left will decrease the number of conflicts (e.g., those caused by heavy bus traffic).

424 - Bicycle/Parking Lanes

Figure 3(a) (page 4-15) 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 (1.5 m).

Bicycle lanes should always be placed between the parking lane and the motor vehicle traffic lane. Bicycle lanes between the curb and the parking lane can create obstacles for bicyclists from opening car doors and poor visibility at intersections and driveways. They also prohibit bicyclists from making left turns; therefore, this placement should not 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 is a minimum of 12 feet (3.6 m) wide.
The Department recommends 13 feet (3.9 m) from the lip of the curb as the desired width. Since 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 3(a). In both instances, if parking volume is substantial or turnover is high, an additional 1 or 2 feet (0.3 or 0.6 m) of width is desirable for safe bicycle operation. This gives a total of 13 (3. 9m) or 14 feet (4.2m).

425 - Urban Section Curbing

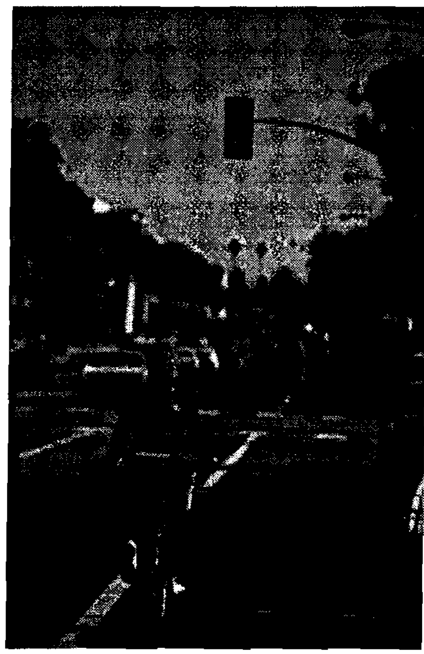
Figure 3(b) depicts bicycle lanes along the outer portions of an urban curbed street where parking is prohibited.

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. However, many novice bike riders will ride in a curb if the roadway is too narrow, and thus bike lanes help reduce this problem. Bicycle lanes in this location should have a minimum width of 4 feet (1.2 m) from the lip of asphalt, to the motor vehicle lane.

Since Florida measures all dimensions from the lip of asphalt, it can be assumed that at least an additional 12 inches (typically 16-18 inches) of lateral separation exists from the curb face.

426 - Rural Section (No Curbing)

Figure (c) depicts bicycle lanes on a highway without curb or gutter. Bicycle lanes should be located between the motor vehicle lanes and the roadway shoulders. When the shoulders are paved, the bike lanes are normally placed there. Bicycle lanes may have a minimum width of 4 feet (1.2 m) where the shoulder can provide additional maneuvering width. A paved shoulder width of 5 feet (1.5 m) is required on all resurfacing projects built by the Department.

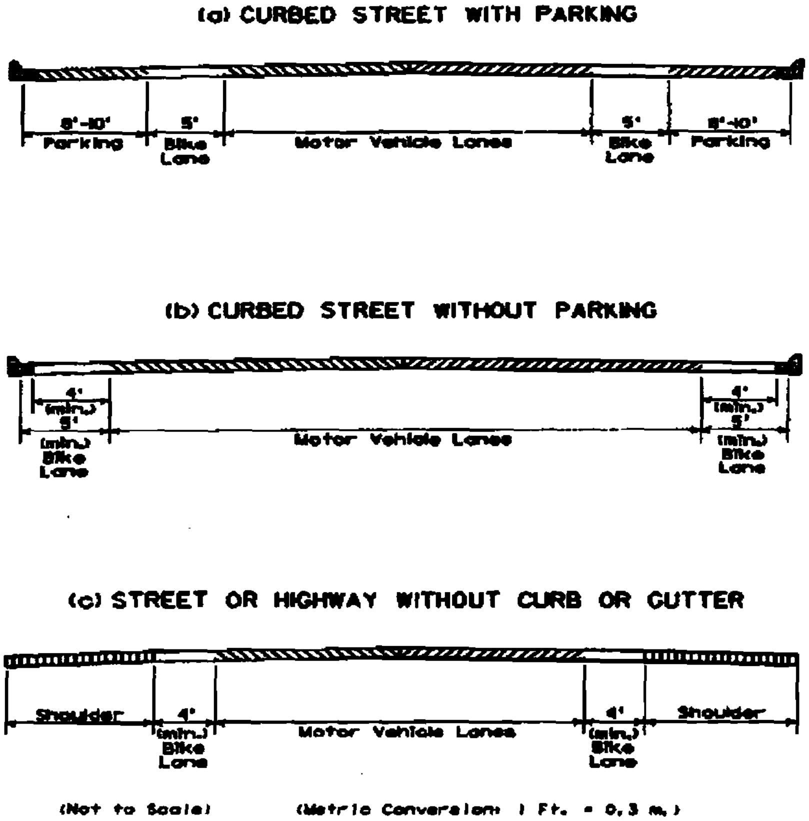


4

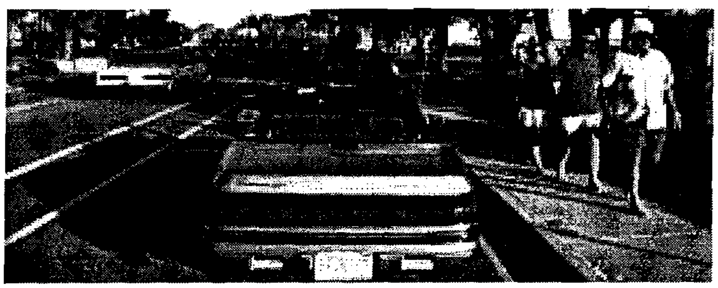
Upper left, clockwise: (1) When bicycle lanes are not provided, some motorists and bicyclists make erratic moves. (2) Dutch multi-modal street has near perfect form. Sidewalks, are buffered by orderly parking. Space is delineated for bicycling, tram lines, and bi-directional motorized traffic. (3) Sarasota preserves pleasant bicycling space in new downtown section, (4) Eugene's one-way street has marked bike lane fully separated from parking. Left: Santa Monica's principal roadway provides on-street parking and a full width bike lane.

1 2 3

Left to Right: (1) When bicycle lanes are not provided, some motorists and bicyclists make erratic moves. (2) Dutch multi-modal street has near perfect form. Sidewalks, are buffered by orderly parking. Space is delineated for bicycling, tram lines, and bi-directional motorized traffic. (3) Sarasota preserves pleasant bicycling space in new downtown section, (4) Eugene's one-way street has marked bike lane fully separated from parking. Left: Santa Monica's principal roadway provides on-street parking and a full width bike lane.



Source: AASHTO, Guide for the Development of Bicycle Facilities, 1991



430 - 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 lane to the left of the bicycle lane. Both maneuvers are contrary to established *Rules of the Road* and result in conflicts.

The best practice is to merge motorists and bicyclists in advance of the intersection. In this way most bicyclists behave as follows:

430.1 Right Turning Bicyclists

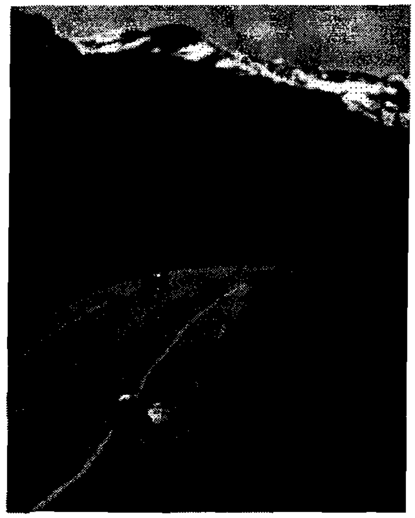
Right turning bicyclists simply turn right by staying to the right. It is best if they center themselves in the turn lane. Staying too far to the right encourages motorists to pass them.

***Figure (a)** and the top photo depict on-street parking in combination with a bike lane. This bike lane is located in Sarasota, Florida, and provides a separate space for motorists, bicyclists and pedestrians.*

***Figure (b)** and the center photo depict a standard width bike lane*

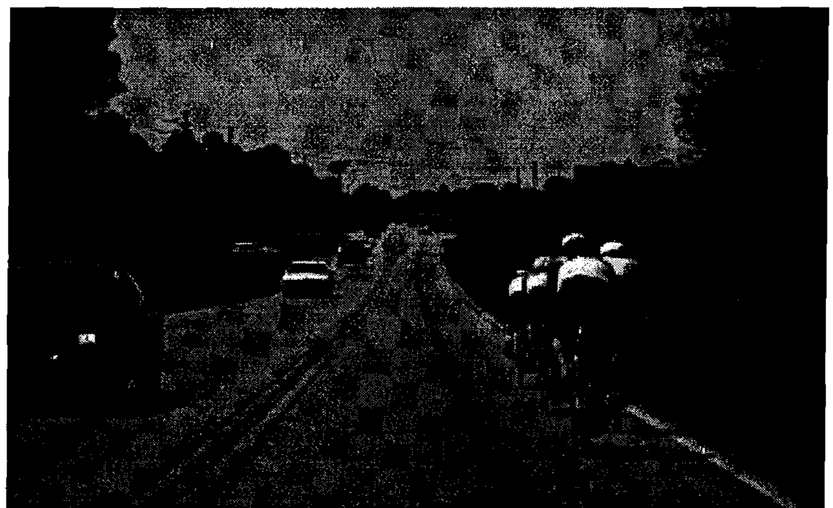
***Figure (c)** and the bottom photo depict a standard paved shoulder. This shoulder is 4 feet wide (1.2 m), and is located in Gainesville, Florida. These facilities have helped reduce serious bicycle crashes by up to 80%.*

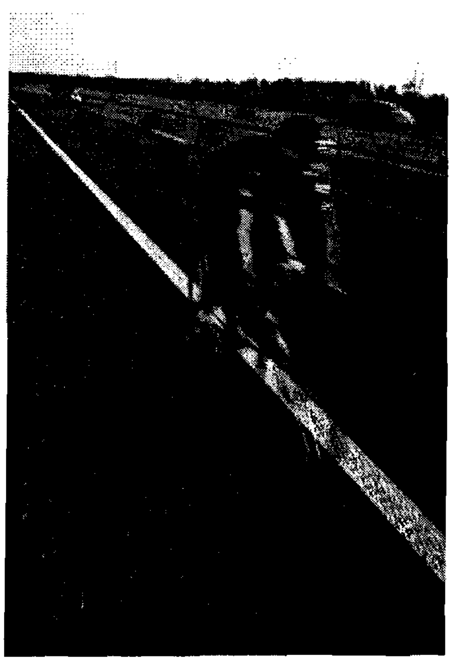
Examples of rural paved shoulders, and the lack of shoulders. *Recent research (1996) from the University of North Carolina, Highway Safety Research Center reveals that motorists and bicyclists both feel greater comfort when the edge line and paved shoulder are provided. This improves the perception of safety by both user groups. Bike lanes and paved shoulder reduce motorist lane encroachment from 27% (without special lanes) to 3% (with marked bike lanes or paved shoulders).*



Rural section facilties. *One of the best bicycling trails in North America takes bicyclists through Canada's Banff National Park. The ample 10' wide paved shoulders are not marked as bike lanes. Yet they perform equally well, doing double service to motorists and bicyclists, and help one another pass. Below: In constrast, U.S. Alternate 19, in Pinellas County Florida awaits a 3R improvment that will allow the addition of a 5.0 foot (1.5 m) shoulders. Once the shoulders are in place bicyclists and motorists will be able to share the space and move in greater safety.*

Below: *On U.S. 441 near Gainesville, Florida, FDOT is testing a special shoulder edge line marking. This lightly dimpled marking creates a sound and vibration that reminds motorists to stay in their own lane. This bicycle-friendly rumble strip also alerts bicyclists to a motorist who might be drifting out of the normal lane position. The application does not work if both the motorist and bicyclist are listening to radios and wearing headsets.*





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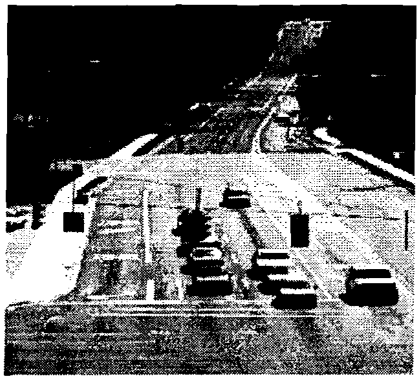
430.2 Left Turning Bicyclists

Left Turning bicyclists search, signal and move left if traffic gaps occur. Others may choose to go straight through the intersection to the far side, pivot their bikes, and when the light changes, complete their movement. Both procedures are permitted under Florida traffic law. The second method is referred to as a "box left hand turn". Note that the bicyclist in the photo to the left (100 yards back) is in a position to search, find a gap and move to his left. This is a simple procedure when traffic is slowing.

2



430.3 Straight Through Bicyclists

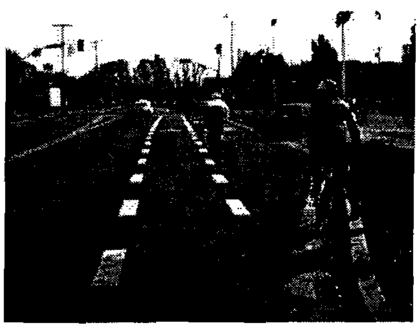
Left Turning bicyclists merge to the left, staying alert to right turning motorists. Competent bicyclists often do this early in the taper (100 or so feet back from the intersection). Novice bicyclists more typically complete the maneuver closer to the intersection, where speeds are lower. Either technique works well in practice.

430.4 Storage Lane Optional Markings

3

The standard solution when dedicated right turn lanes are used is to end the bike lane where the right turn lane taper begins. Either an open space, a single dashed line or a double dashed line is used. As a general practice, the no dashed line is used when speeds and right turning volumes are low. A double dashed line is used when speeds are low and more motorists' attentiveness is desired. The single dashed line is used for higher speed merges (above 35 mph).

4



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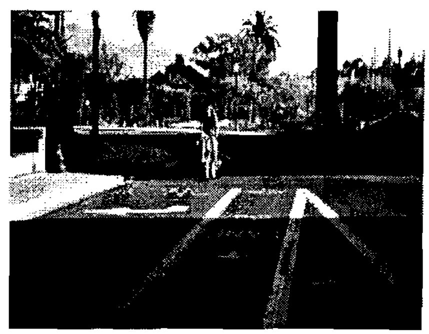

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8

***Turns:** (1) Right turns are simple, (2) left turns require a merge or (3) bicyclist can use a straight move to far side, then turn. (4) alternative striping for low speed, (5) Ocala's special T- intersection jughandle left hand turn for bike left turns, (6) begin bike storage box at intersection storage queue, (7-8) Tempe, AZ and Boulder, CO.*

430.5 Reference

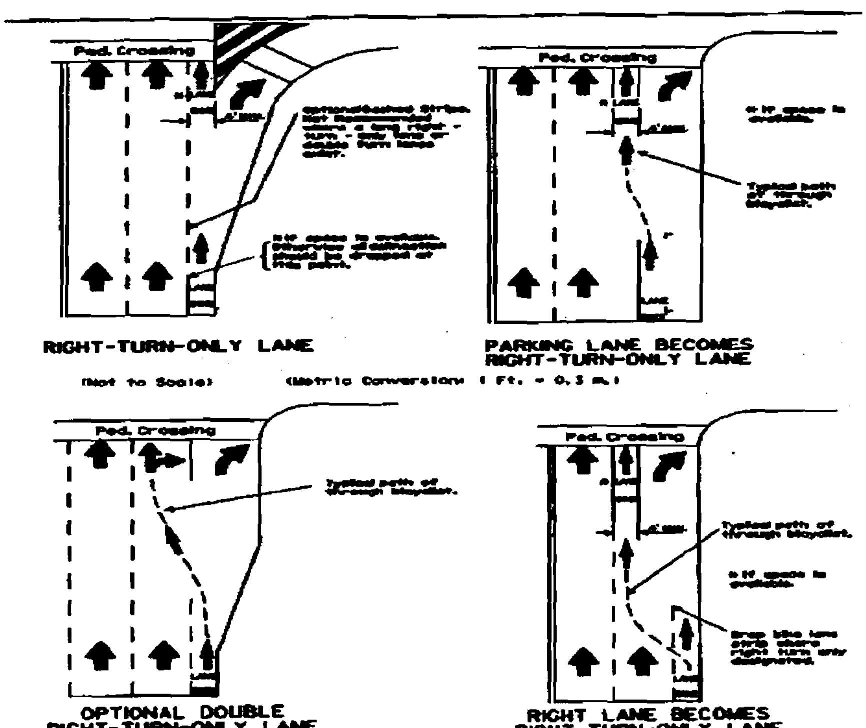
Two excellent references are provided for striping details. The MUTCD, Part 9 has standard markings. (See below) The Appendix to this document provides more elaborate and sophisticated markings for highly complex multi-lane highways. These more detailed marking were developed by FDOT District 4 and Central Office design staff.

430.6 Alternative Marking

Cupertino and Davis, California are two towns using a different approach. Where speeds and right turning volumes are moderate they have found it desirable to widen out the bike lane to 10 feet (3.0 m) on final approach to an intersection, rather than to create a dedicated right turn lane. This has the effect of inviting the motorist into the bicyclist's space, as opposed to forcing the bicyclist out of the right portion of the roadway. This can be a safe practice due to the lower speed of turning traffic. The treatment should be 75-100 feet (24-30 m), in order to control the entering speed. In such a case bicyclists intending to go straight may end up centered in the lane and thus will tend to momentarily block a right turning vehicle, although in actual practice this has minimal negative effect.

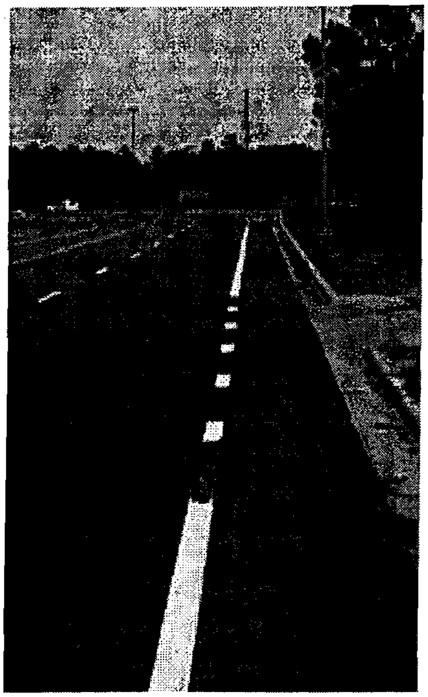
Above: Experimental treatments in California. Instead of creating a dedicated right turn lane, motorists are invited into a widened bike lane for low speed cautious entry.

Below: Gainesville's 13th Street & Archer Road high speed turn lane was seen as too complex to cross by novice riders. Many bicyclists rode against traffic on the far side, creating serious conflicts at this blind intersection. Special bike lanes were added (bottom photo) to assist the merge.



Source: MUTCD, Part 9

1



431 - Intersections, tapers and markings

Pavement markings are used to communicate best actions for a location. In each of these settings the motorist and bicyclist are in conflict. The science of marking bike lanes at conflict points is under development. Here are some treatments in place. In general, markings are varied to give a stronger or weaker invitation for bicyclists and motorists to cross.

A skip dash used in (1) should communicate to the bicyclist a stronger alert signal for entering/exiting traffic than the solid line in (2).

2

A variety of markings are used to indicate a cross-over into a bike lane, through an intersection, a driveway, or other area. The decision to use a (1) skip dash line across one driveway, and (2) a solid line across another rests heavily on the volume of motorist movement. The same principle applies to transitions at intersections. (3) double solids are used here to communicate that motorists should stay in their own lane. As seen in (4) a single skip dash is used here to communicate a higher conflict potential. The bicyclist is meant to feel less secure. (5-6) In this setting there is less traffic, and speeds are reduced. A double skip dash pattern is used in these low speed turning environments to stress to motorists that they are encroaching.

3

6

5

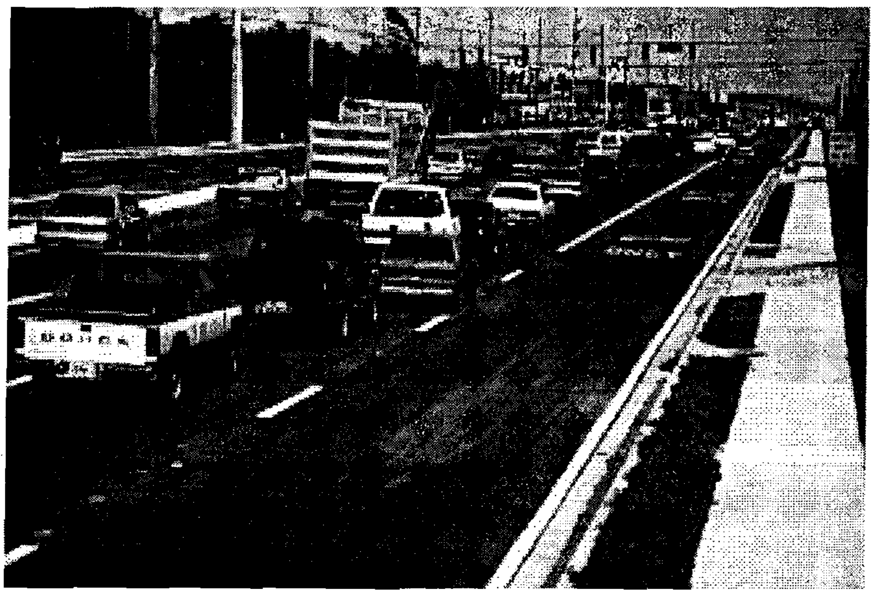
4

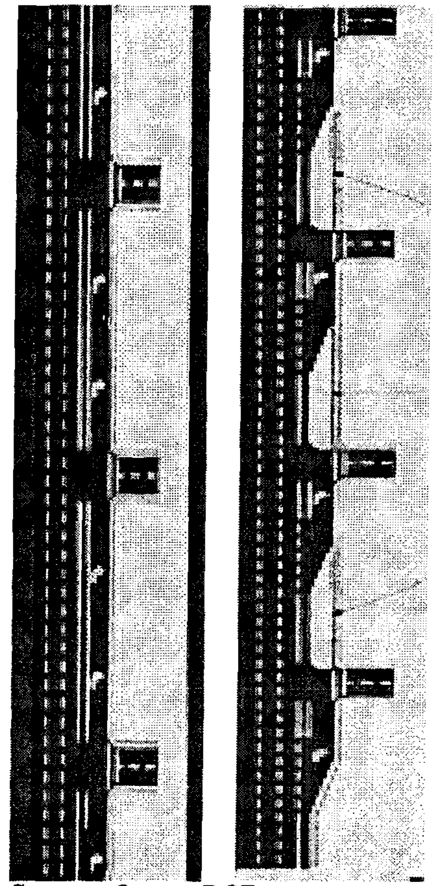
440 - Existing Conditions and Designating Bike Lanes

441 - Existing Hazardous Conditions

441.1 Continuous Right Turns

In some cases, designers have permitted right turn only lanes for extended distances. This creates a continuous high conflict zone for the bicyclist, who must now negotiate high speed traffic passing on the right and left. Continuous turn lanes are also hazardous to pedestrians and



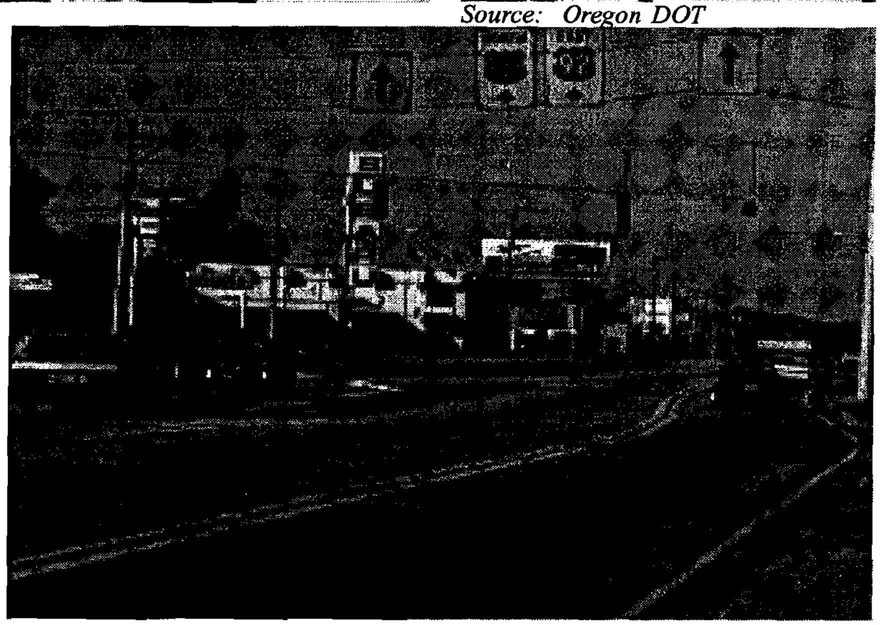


Source: Oregon DOT

motorists. These right turn lanes can be discontinued with a raised (not 441.2 Continuous Through Lanes

In a few isolated cases, at Tee intersections, designers have permitted a continuous green through lane on the long leg, allowing motorists to continue higher speed through movement, while traffic is entering from their left. This creates an impossible merge condition for bicyclists and pedestrians. Both bicyclists and pedestrians become trapped in an interior lane. For this reason such operations are discouraged in most urban applications.

At intersections, bicyclists



Continuous Green Through Lane. *An example of an exotic engineering treatment not suported by AASHTO. Such practices create high levels of discomfort to pedestrians and bicyclists. Forced to cross by their own wits, many bicyclists and pedestrians make highly bizarre movements. Such practices must be omitted from future design and corrected where they exist.*

4

proceeding straight 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 preferable to those that force the crossing in the immediate vicinity of the intersection. The Appendix, Item 5, provides 10 sample illustrations for lane markings for a variety of multi-lane highways.

To a lesser extent, the same set of crossing conflicts is true for left-turning bicyclists; however, in this maneuver, Florida 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 "box style" left turn where the bicyclist proceeds straight through the intersection, turns left at the far side, then proceeds across the intersection again on the cross street.

The MUTCD Figure on page 4-15 presents examples of details of pavement markings for bicycle lanes approaching motorist right-turn-only lanes. Where there are numerous left turning bicyclists, a separate turn lane, as indicated in the MUTCD, 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 marking of bicycle lanes is contained in the MUTCD, and in the appendix to this document.

442 - Intersection Improvements

Since bicycle facilities are commonly installed on a project-by-project basis, bicycle lanes should be provided even for such short sections as an intersection improvement. If desired, the lane markings and signing can be left out until a longer facility can be connected. Designers should extend the bike lane portion of such intersection improvements into a logical merge location, allowing the bicyclist to accept a comfortable gap. This lane extension may require extending the normal length of the project several hundred additional feet.

Above: *Bike lanes were added to this intersection improvement, beginning and ending several hundred feet from the intersection.* ***Below:*** *This special bicycle signal in Copenhagen, Denmark gives motorists a signal to cross right while bicyclists wait, then bicyclists get a through movement while right turning motorists wait.*

443 - Special Signs and Signals

Where bicycle lane volumes are heavy, and on a case-by-case basis, the designer may consider a special phase signal for bicycle use only. This allows cyclists to cross the street and make turns without having to contend with motor-vehicle traffic. This approach solves the problem of intersection conflicts inherent in the use of bike lanes.

This specially marked lane in Copenhagen, Denmark illustrates a method used when bicycle and motorists volumes are high. The bicyclists and motorists each have their own signal for right turns and through movements.

444 - When to Designate, Special Signs

A number of exceptional conditions exist in any developing area. The following guidance is provided to aid the designer in when to designate bike lanes, and when to leave some areas unmarked, and other marked with special widths.

445 - Climbs, Descents

Bicyclists require extra room to climb and descend. Six to eight feet is recommended for the ascent side, and ten to twelve feet is recommended for the descent. Typically the descent requires bicyclists to take the full lane. Speeds of 30 mph or greater are common. Special markings to create the best actions of motorists and bicyclists have been developed. These markings and signs are applied in Boulder, Colorado. See Photos (left).

446 - Designated versus Undesignated Bike Lanes

Preliminary research and observations reveal a wider separation of motorists and bicyclists when Wide Curb Lanes are converted to a travel lane and a bicycle lane of even as little as 3-3.5 feet (0.9-1.1 m). The Department prefers, in many instances, to leave this substandard width undesignated. There are some cases where even a full width 4 feet (1.2 m) space may be left undesignated. Decisions on when to designate and leave undesignated should be made by a joint partnership of the Department and the local Bicycle Advisory Committee (BAC).

446.1 When to Leave Undesignated

Generally a space is left undesignated when a section is:

- Short, discontinuous
- Rural, low probability of use
- First segment, to be joined later by other pieces

446.2 Advantages of Marking

The advantages of designating a bike lane are as follows:

- Reminds motorists to stay alert for bicyclists
- Creates a true system of support
- Provides system continuity
- Further reduces likelihood of wrong way sidewalk riding
- Allows signing warning against wrong way riding

When older drainage facilities extend into the paved area, mark the hazard to steer bicyclists around them. New construction on state roadways uses inlet style drainage, which keeps lanes free of these hazards.

Hills require special treatments when bike lanes are used. Typically roadways with more than a 5% grade should be specially marked, or wide shoulder allowances should be made (such as on high span bridges).

450 - Bike Lane Conditions and Maintenance

Adequate pavement surface, bicycle-safe grate inlets, safe railroad crossings and traffic signals responsive to bicycles should also be provided on all urban roadways. These treatments should be provided especially where bicycle lanes are being designated. Raised pavement markings and raised barriers can cause steering difficulties for bicyclists and should not be used to delineate bicycle lanes.

470 - Travel Lane Reductions

There are a few places where roadway sections were either overbuilt (beyond capacity demands) or where a new emphasis is being given to balanced transportation. Communities can shift lanes to other roadways. To assist the designer with lane reductions this section illustrates some of these conversions.

470.1 Four Lane Reductions

Where traffic speed and volumes and other conditions warrant, 4-lane highways can be reduced to two lane designs (with turn medians). The left over space can be used for bike lanes. Since many major collectors were widened to four lanes largely for capacity, much higher levels of safety and capacity can be achieved through the median turn lane.

Undesignated Bike Lane. The lane to the right is left undesignated. The rural character of this roadway, with minimal intersections and infrequent bicycling does not warrant marked bike lanes.

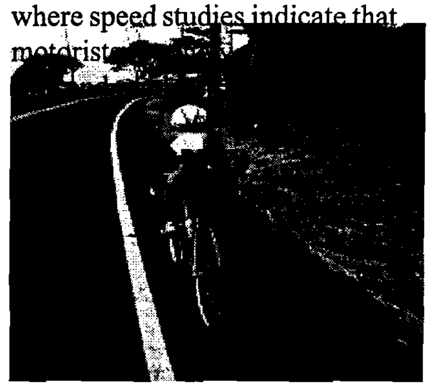
An engineering study and citizen support are required before a lane reduction is permitted.

470.2 Three Lane Reductions

Some local and minor collector roadways were constructed with three lanes and yet carry very light traffic. Where traffic volumes and speeds are sufficiently low and other conditions warrant, bike lanes can be placed in the curb- to-curb width. In this treatment the center scramble lane is converted to a raised median with turn lanes. Such treatments may require speed controls every or every other intersection. An engineering study and citizen support are required before a lane reduction is permitted.

470.2.1 Pigmented Bike Lanes

On some minor and major collector roadways there is a need to keep the visual width of the roadway narrow. Under such conditions, bike lanes can be pigmented a deep ocher, giving the effect that the overall roadway width has been decreased. Such treatments are often desirable where speed studies indicate that motorist



460 - Parking Lane Transition Markings and Placement

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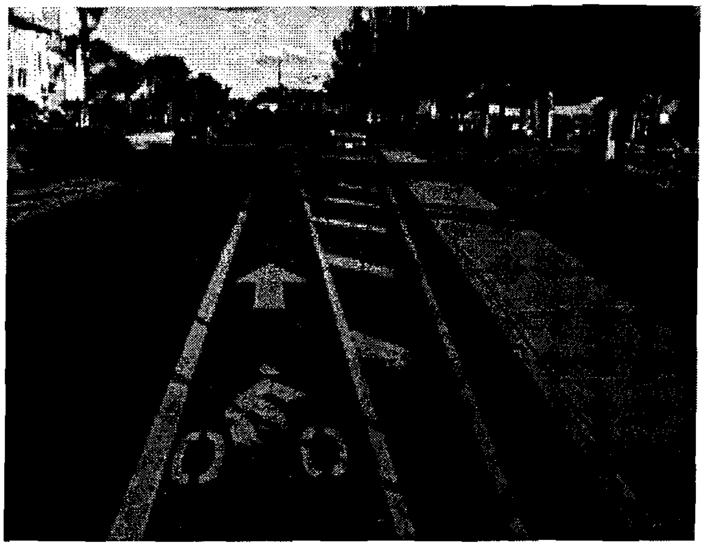

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Transition taper lengths around parking lanes are based on speed, sight distances, type of vehicles, and related factors. Make sure that both the bicyclist and motorist are given adequate information and decision making time. Some treatments, like (2) (left) need to be observed to see what level of compliance can be handled with paint, or if added channelization is needed.

When parking and bike lanes are used in a pattern as shown here, the motorist ends up with added turning radii; sometimes a needed bonus for trucks and buses. To reduce your maintenance, and improve the life of your markings, make sure you keep the bike lane markings out of the turning radius, as shown in (4) below. To reduce wrong way bike riding use directional arrows in bike lanes.

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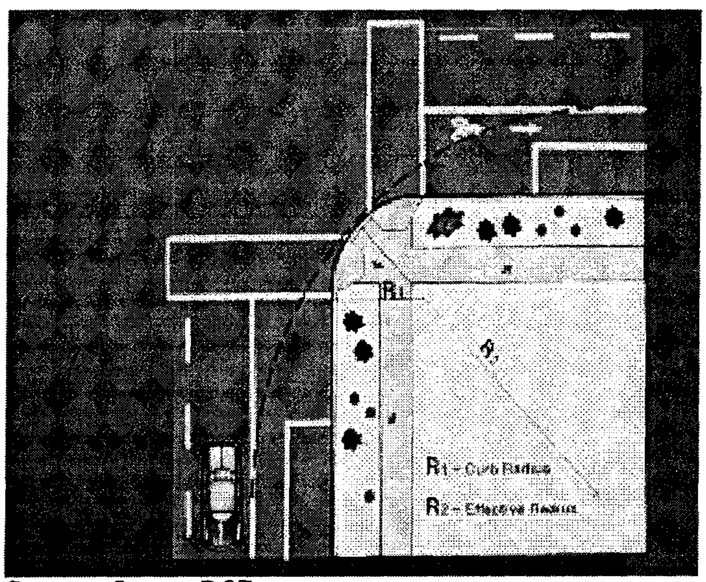

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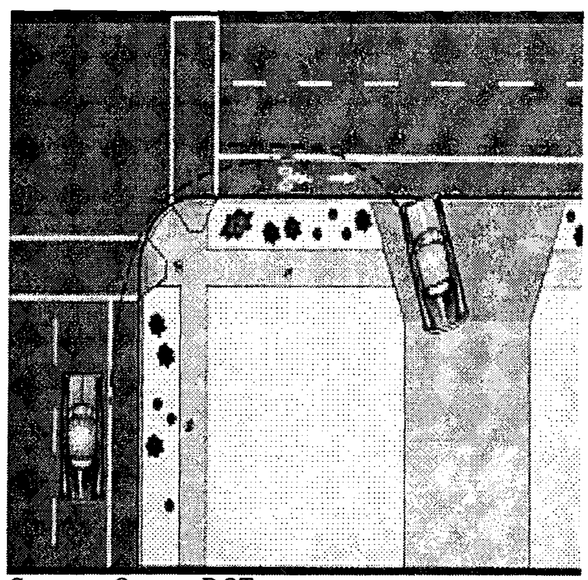

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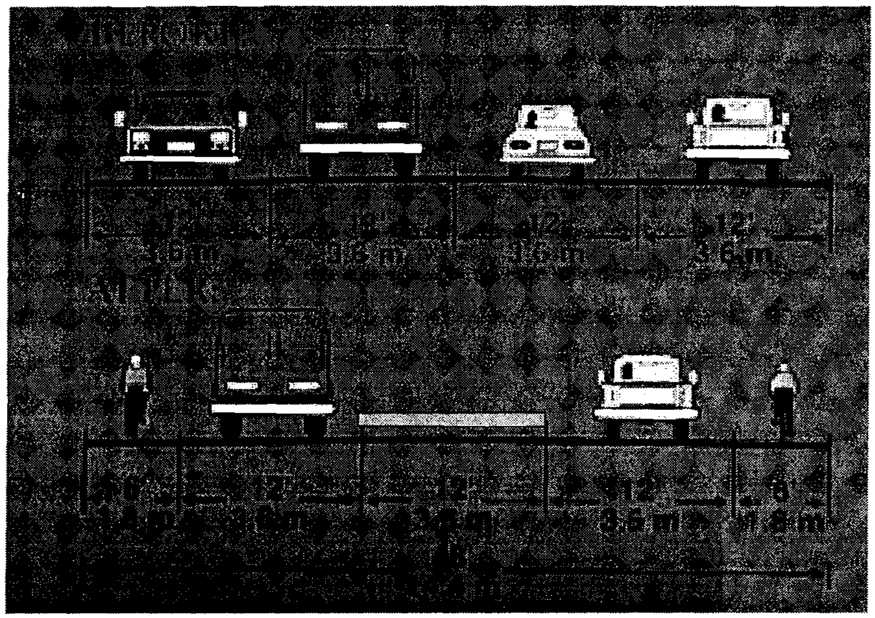

12'
3.6 m

470.3 Four Lane to Three Lane
Case Study - NW 8th Avenue, Gainesville, Florida

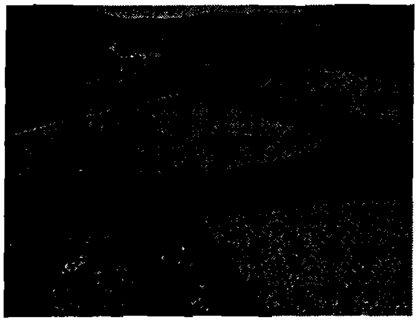
Gainesvile designers have been asked to consider reducing this 4-lane roadway to the diagramed cross section (below). The new section could be reduced to two through lanes, a full median with left turning lanes, and bike lanes. An engineering analysis reveals that the proposed 2-lane section can handle all of the needed peak traffic. Upstream is a 2-lane section. Just below this section is an intersection. By narrowing and simplifying the crossing bicyclists, pedestrians and motorists can share the road with greater courtesy. By removing the merge 4 lanes to 2 lanes from this area motorists can better concentrate on the crossing. An analysis concludes that by reducing the merge condition the capacity of the roadway will increase.

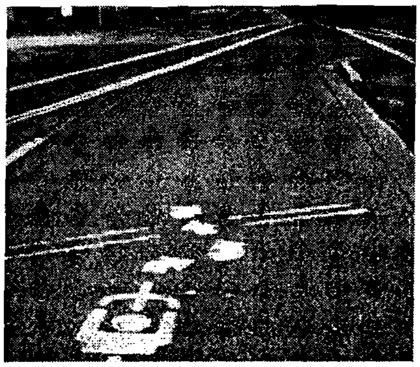
Arnall's drawing here

Vertical Profile Here

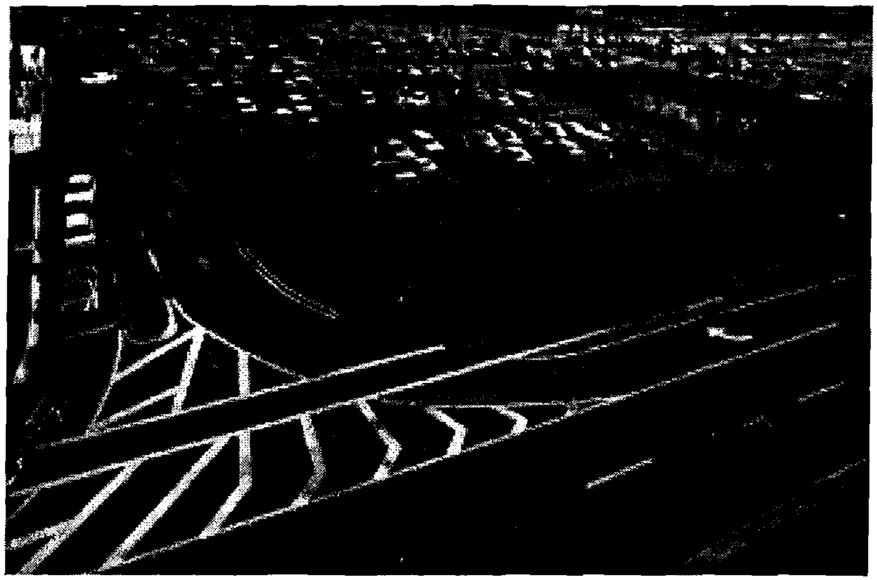
Courtesy: Arnall Downs, Larking M Sullivan

480 - TRANSITIONS, MERGES AND OTHER CROSSINGS

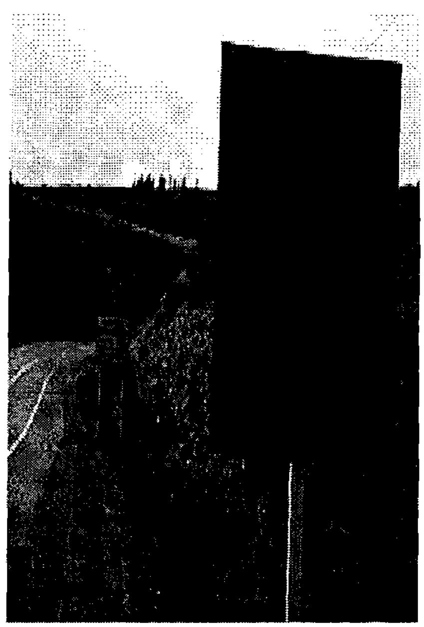


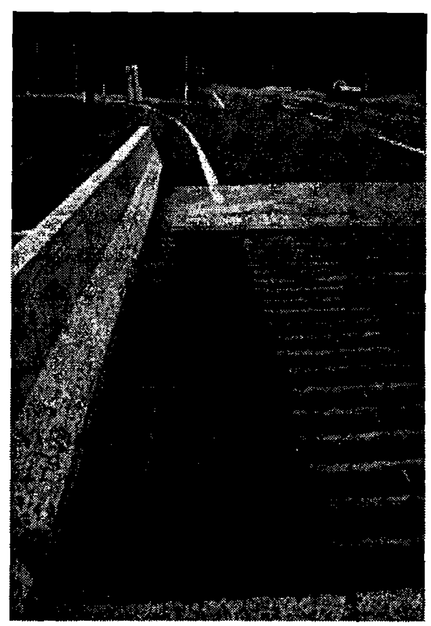


Steel and Rubber Don't Mix Well. *Railroad tracks are serious conflict points for bicyclists. Designers should not only treat the geometrics of skewed railroad crossings (See page 4-5), but in the interim, provide guidance and warning of any special risk. (2-3) Some areas do not lend themselves to a bulbout, and so, as a minimum, special warning signs and pavement markings should be provided.*



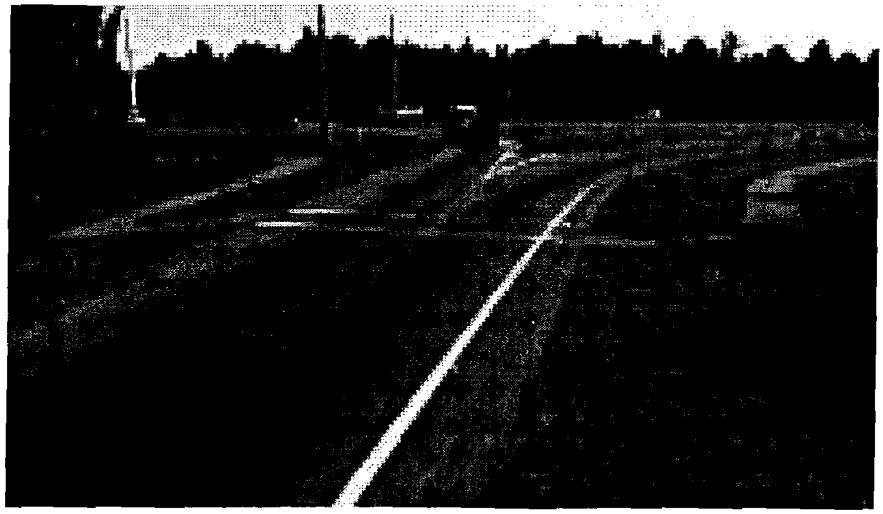
Big Box Retailers. *The bicyclist along this roadway has little choice. Mix with high speed traffic, or stay on the parallel facility and risk higher speed and right exiting turns. A full median, highly channelized islands with low turning speeds will help. However, the lack of paved shoulders will lead to constant narrow misses from the right turning motorists.*





Cattle Guard Treatment. *The warning comes first. Located at the bottom of a steep hill, this cattle crossing leaves little warning. Note that the deck treatment and sign have been used in combination.*

Limited access and other on-off ramp crossings pose special problems for bicyclists and designers. The principles include: (1) convert from lanes to paths on wide roadways and cross where motorist is steering, not searching. Bicyclists should yield. (2) Avoid acceleration lanes like these in urban areas. They are rarely needed. (3) For low volume (bicyclist and motorist) merge such as here in rural British Columbia, no special treatment is needed. (4) use this design on high volume crossings, (5) Never cross the pedestrian and bicyclist here where the motorist is searching over his shoulder for autos. The crossing should be upstream where the motorist is steering.



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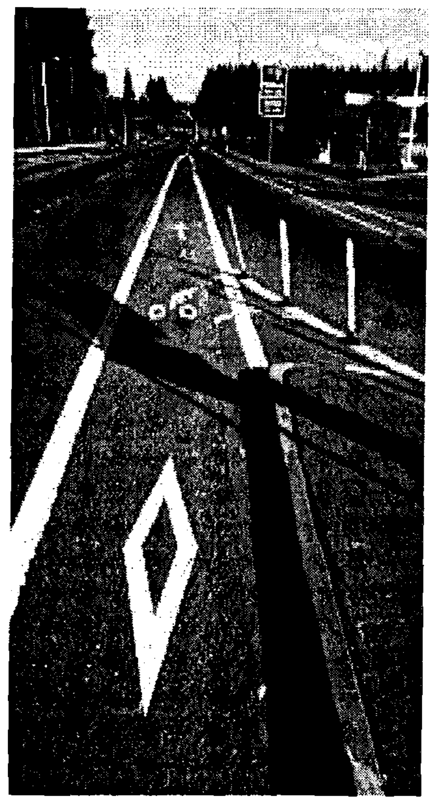
481 - CROSSINGS
Limited Access, etc.



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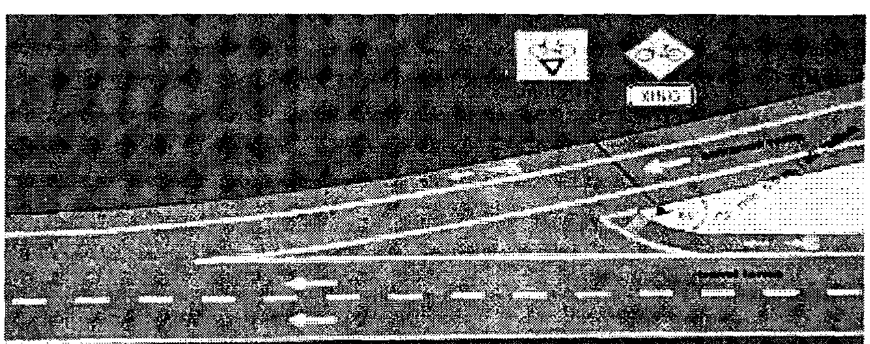

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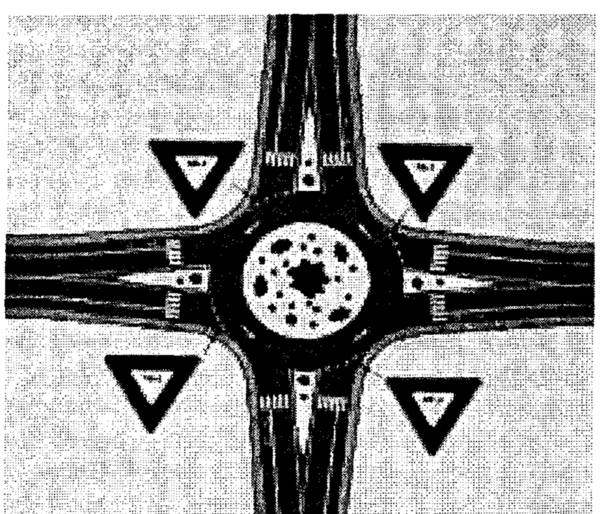
490 - Traffic Calming, Roundabouts and Bicyclists

Bicyclists should merge with low speed traffic and command space through the intersection. At most intersections this entry occurs when there are no other cars present. Bicyclists benefit from lower speeds. When arriving at a slow speed, motorists have more time to slow down and yield for bicyclists.

491 - Bicyclists At Roundabouts

Bicyclists can manage better at roundabouts than at a traditional signalized intersection or stop controlled intersection. Seattle, Washington now has 400 neighborhood roundabouts in place. Records show an 80% reduction in all types of crashes. This includes a reduction in bicycle crashes as well. Typically bicyclists need not stop, since they can see the vehicle in their conflict path, and simply increase or lower their entry speed.

Bicyclists fare well at roundabouts for two reasons: First, there is no possibility of a left hand crossing movement. Second, the right turning conflict can be fully controlled by the bicyclist by not being alongside a motorist, or permitting a motorist to be alongside the rider. The only remaining threat is for the bicyclist to watch for the entering motorist or exiting motorist. As long as bicyclists follow the rule to not be alongside a motorist while in an intersection there is a very low chance of conflict. When bike lanes are used, it is a general rule to drop the bike lane about 75-100 feet before the intersection, and allow a low speed merge. Separate paths are recommended for high volume roundabouts (3000 VPH or higher)

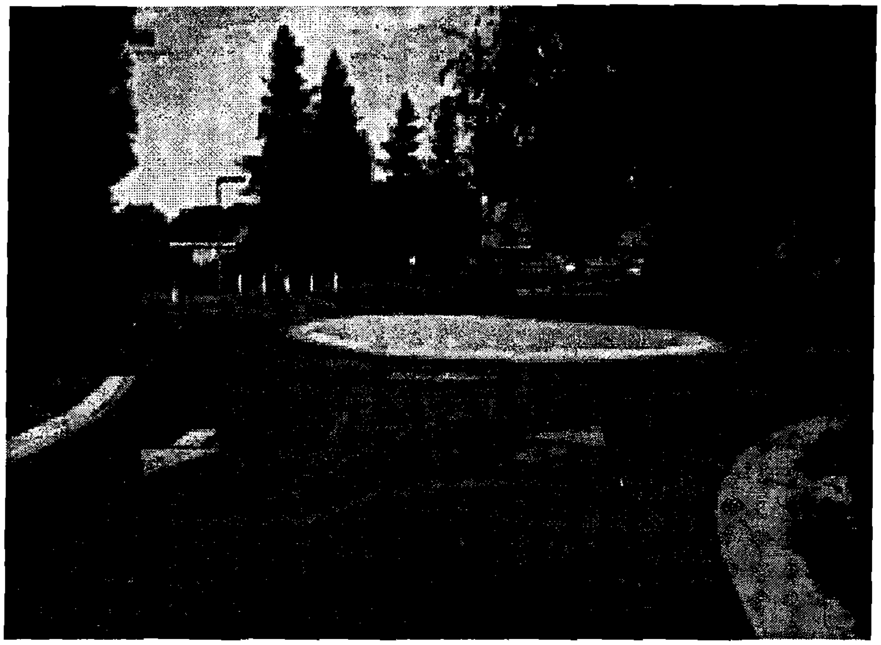


491.1 Roundabout Merge Treatment for Bicycles

For one lane roundabouts, bicycle lanes shall end and permit a merge during the last 75 feet (22.5 m) of approach. No special markings are needed in the roundabout. Urban roundabout speeds shall be controlled through design at no more than 22 mph (40 km/h).

For high capacity roundabouts of 2 lanes or more, special crossing areas set back 20 feet (6.0 m) from the intersection can be considered.

For rural roundabout locations where higher entry and exit speeds are permitted, multi-use trails and crossings set back 20 feet (6.0 m) from the intersection should be considered.



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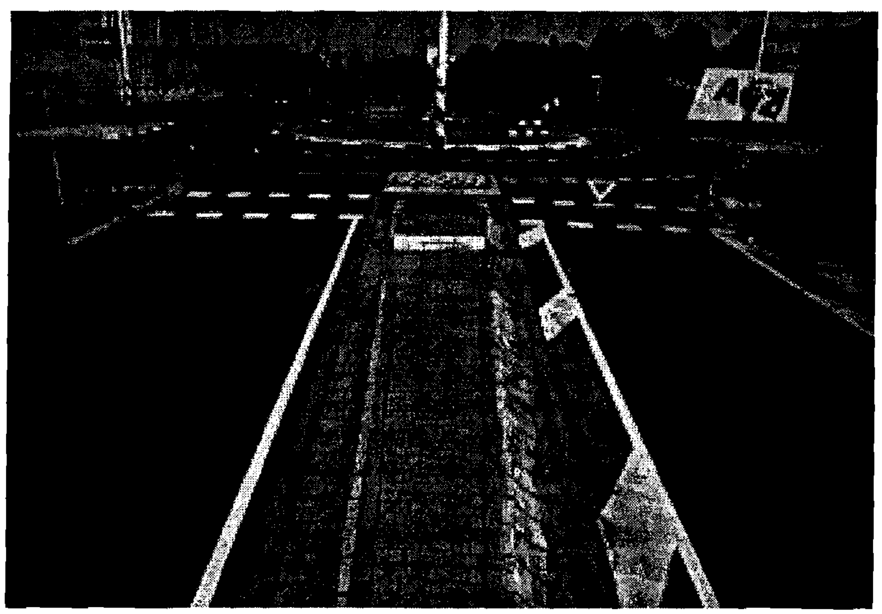

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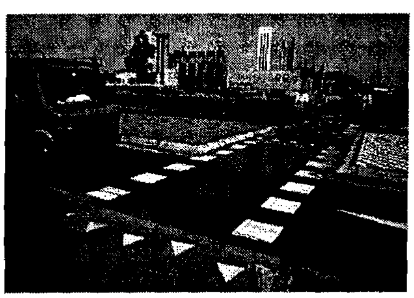

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(1,3) Bicycle Roundabouts at the Davis, University of California, Davis campus have proven highly effective in safe movement of bicycles. (3) This roundabout is capable of moving 9,000 bicycles each hour. It also handles buses, emergency vehicles, and other motor vehicles.

(2,4) The Dutch roundabout (above) has a heavy volume of motorized vehicles, including trucks. The Dutch roundabouts are designed well, and report a 50% reduction in bicycle crashes compared with signalized intersections.

492 - Traffic Calming

Florida is one of the lead states in traffic calming and new urbanism (see Planning section). The designer must pay close attention to the elements of designing collector and local roads, making sure speeds are kept low.

As a general rule, well designed neighborhoods need little traffic calming. Many of these principles apply to developments already in place where motorists exceed prudent neighborhood speeds (20 mph). New developments, such as Truman Annex in Key West, and Seaside; as well as older developments such as Coral Gables and Winter Park, need only limited refining.

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(1) A traffic calmed neighborhood, either through initial design such as Truman Annex and (2) A Florida panhandle development (above); or through any of a number of speed reduction measures shown in the right column. There are at least 36 traffic calming features that can be added either at the intersection, or mid-block. For a full listing and treatment of these features, consult the FDOT Walkable Communities course handbooks.

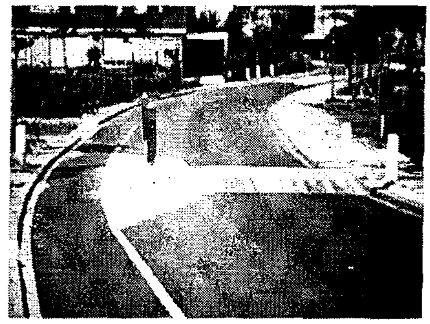
492.1 Bicyclists Needs

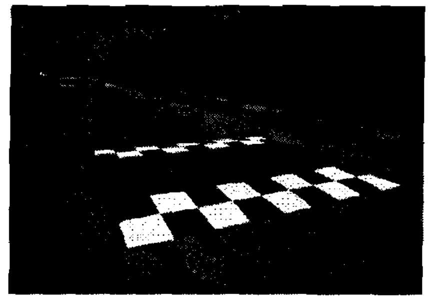
Bicyclists are concerned with things they don't see (speed bumps), but they don't mind speed humps or tables that are properly marked and constructed (3-6).

Use tapers and full openings for bicycle movement. The approach to a speed table (4), a raised intersection, or other raised object should have a taper of 1:6. A more sudden rise creates problems, and a shallower rise has reduced effect. Always mark changes in elevations with roadway markings and signs. This increases the effect. Use lighting (bikes lack adequate lighting).

492.2 Key principles

- Keep blocks short
- Provide tight turning radii
- Provide tree canopies
- Permit narrow lanes, or medians
- Slow speeds at intersections
- Create constant movement to maintain flow (avoid stop signs in favor of roundabouts)





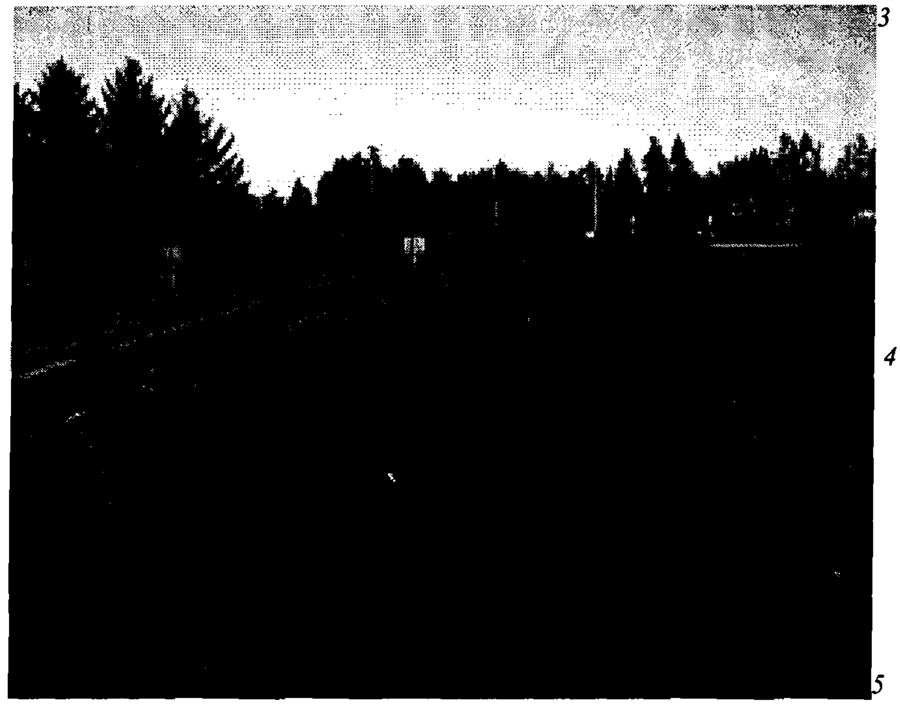
493 - Limited Access Intersections

Crossing the intersection terminal on freeway ramps pose special hazards to bicyclists due to speed of entry and exit, long tapers, and expansive roadway crossing widths. Bicyclists can be aided through several principles of design:

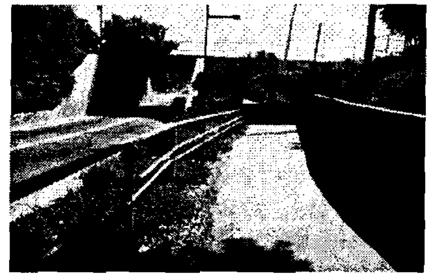
- Slow the speed of the bicyclist on final approach, and create a yield for the bicyclist
- Create a right angle crossing and a reasonable viewing distance by separating the bicyclist with a jughandle pathway, and crossing the bicyclist at a point in the ramp where the motorist is attending to steering control as opposed to an over-the-shoulder gap assessment.

494 - Limited Access Corridors

Although a new concept for Florida, most western states have been providing for bicycles within many freeway rights of way. Here are two scenes of treatments used in Olympia (I-5) (land) and Seattle (water) (I-90). Florida is considering bicycle use in some future freeway and tollway corridors. Attention to design detail, especially at bridges and on-off ramps will be important.



Top: Olympia, Washington. Bicyclists are provided an independent right of way in the I-5 corridor, and are exited to the right of each off ramp. A crossing is provided at grade, and bicycists continue on the other side. Bottom: Mercer Island's floating bridge accommodates bi-directional bicycle traffic across the bridge. Unique bridge features include see-through railing, permitting motorists to view water activities, and low angle lighting imbedded in the barrier wall to light the trail without creating glare for motorists.



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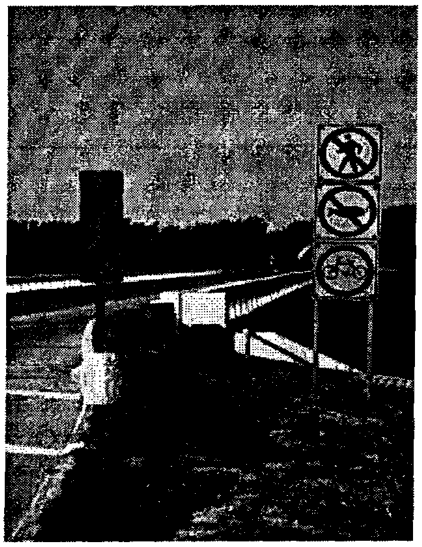

495 - Overcoming Barriers with Bridges, Overpasses, Tunnels

495.1 Bridges Are Essential

Bridges are an essential issue in bicycle transportation. "Unless the bridge issue is addressed, there are no other issues" *(Peter Lagerwey, Seattle Pedestrian/Bicycle Coordinator).*

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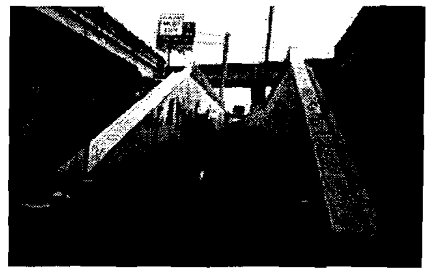
Without linkages there can be no system. Every manner of barrier, whether man made or natural, must be bridged. Common barriers include water, canyon or gully, rails, freeway or major arterial. Each barrier must be bridged one way or another. No new barriers should be created.



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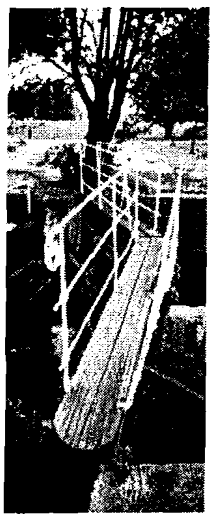

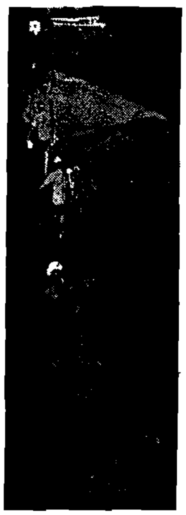

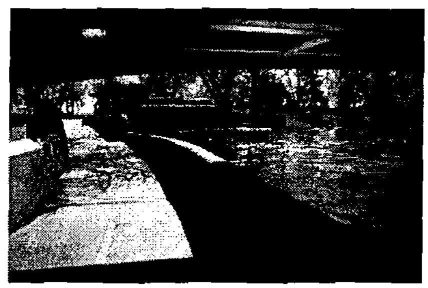

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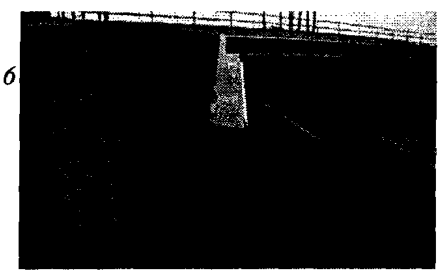

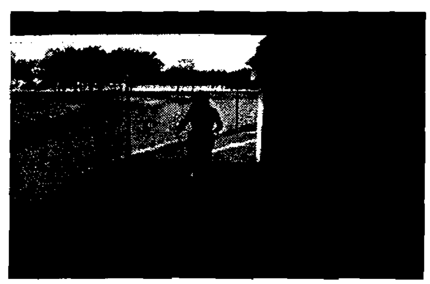

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Top (8) For fifty years bicyclists were denied access to Captiva Island, a popular bicycling destination. Finally, in 1991 the commission listened to Alex Sorton, a top bicycle engineering consultant who advised that this bridge was safer than most in the area. The barrier finally came down, and with it died many myths of children being attracted to the bridge, or the island being over-run with transients. (7) Even a simple (Dutch) one person crossing is better than balancing on the levee wall. Although not supported by anyone's design standards, there is a need to come up with realistic solutions to people's problems. This little bridge is better than a do it yourself "walking the plank" approach.

Manmade barriers. *(1) Whether rail, (2-3) Freeway, or bridge, bicyclists seek understanding and support for crossings that work.(4) Boulder's well designed below water bridge under a bridge. (5-6) A homeowners association was sued, and lost, when two bicyclists collided coming out of this under-the-bridge tunnel. Sight distance is poor. The insulting sign was brought up in court. "Motorists crossing on the bridge deck had full design support, and were not being asked to get out of their vehicles to push their cars across, and so it was argued "Why must bicyclists have a lesser standard?"*

496 - Structures That Work For Everyone

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Top: (1) Washington and (2) Oregon spared no expense to provide access for bicyclists across their major water barriers. Added to the initial design of these structures the costs were affordable, and the only way to provide continuity to their systems. (3-4) Below, Vancouver, Washington address the barrier wall with style, while (5-6) (center photos) (Seattle connected two neighborhoods using a canyon bridge no longer safe for motorized loads.

Top right: (7) Construction from overhead requires safety for pedestrians and bicyclists. Rather than cross bicyclists to the far side of the street this structure was provided. (8) Above: Topple-free (4.5 feet (1.4 m) high rails help novice roller bladers control their descent speed. Bottom right (9-10) Davis, California and Boulder, Colorado each tunneled major roadways to provide bright, attractive tunnels. The Boulder tunnel has fossil embedded walls with glazing, to prevent vandalism. The center shaft of light is essential on wide and long tunnels. Another secret to tunneling is to raise the roadway half-way, so that people entering the tunnel can see the land on the far side of the tunnel.

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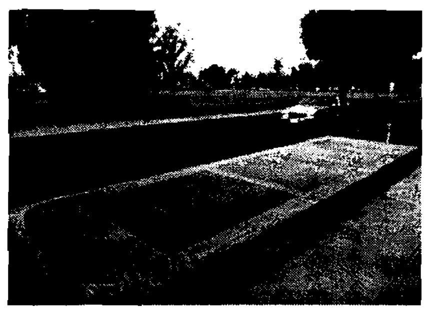

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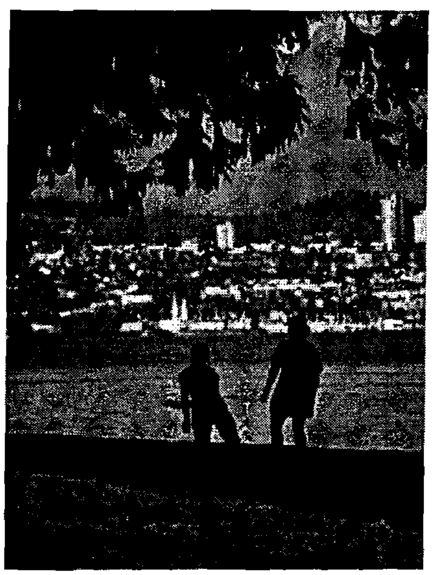
Section 5
500 - MULTI-USE TRAILS DESIGN

501 - Introductory Essay

You may well ask, "What's an essay doing here in the middle of this book?" Good question. In response, there is a vast difference in what we, as designers, seek to achieve with a trail, as compared to a roadway. It is necessary to look at trails as features of the land, adding value to the experience of place.

Trails require far greater sensitivity than has been given them in the past. We fail in our mission, when we look at the design of a trail in a purely physical sense. Our AASHTO design criteria, wonderful for highways, limit our understanding of how to work with trails. Trails must fit into nature, not the other way around.

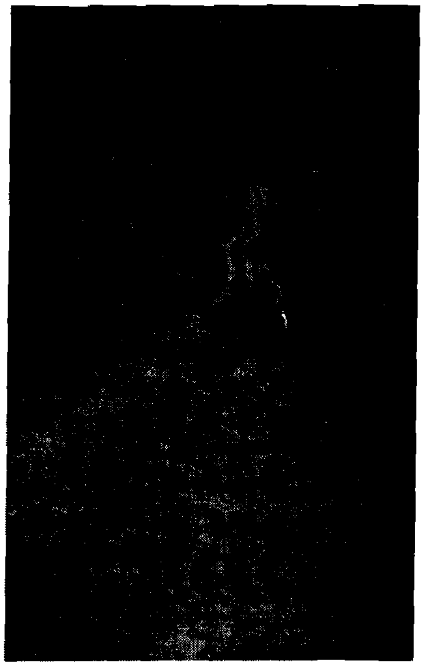
Penciled in the margins of a book I recently read, *The Experience of Place,* by Tony Hiss, I jotted this note: "Too many cities in America have become places to survive. We need more places to thrive." What was I thinking? I had just re-read Jane Jacobs' book, *The Death and Life of Great American Cities.* Both her book and Tony's emphasized

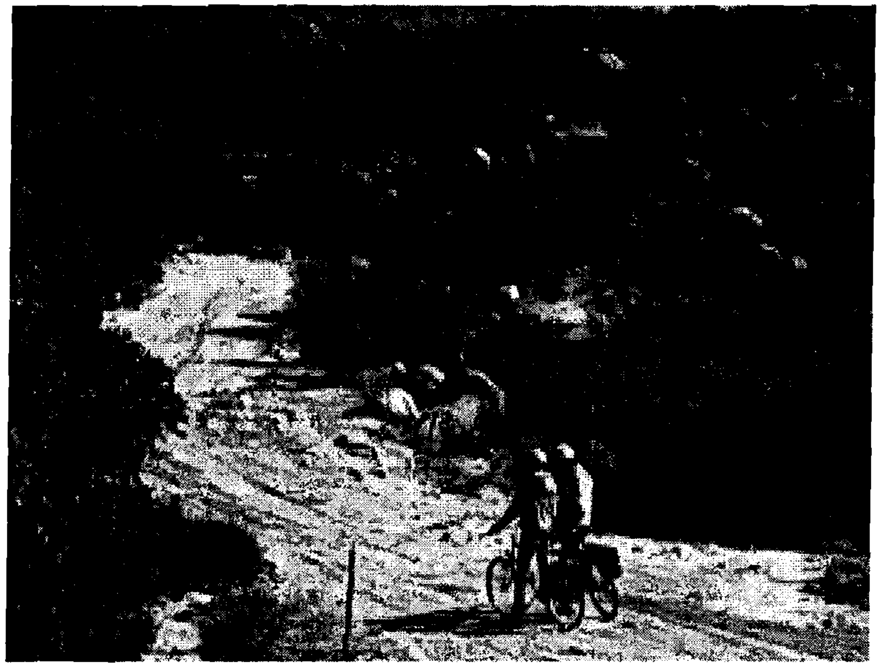


People need immediate places to refresh, reinvent themselves. Our surroundings, built and natural alike, have an immediate and a continuing effect on the way we feel and act, and on our health and intelligence. These places have an impact on our sense of self, our sense of safety, the kind of work we get done, the ways we interact with other people, even our ability to function as citizens in a democracy. In short, the places where we spend our time affect the people we are and can become. .....Tony Hiss, The Experience of Place

"Too many cities in America have become places to survive. We need more places to thrive".

.....Dan Burden





how we have become lost in our need to create real places where individuals can enrich their lives.

Urban settings can and should be designed as places to live. Trails, greenways and other open spaces are just as vital an ingredient of succesful towns or cities as efficient highways. If trails and highways are going to be designed or at least funded by the same professionals, then we need to make sure that these designers understand the distinction between highways and trails. To detail these differences, I take you back a step to a very different place. The time is 1972.

When I took the above photo, I was absorbed in nature. My wife, companions and myself were into our seventh month of a one and a half years bicycling journey from Alaska to Argentina for *National Geographic*. We were following the mountainous backbone of the Western Hemisphere. We spent our time equally on roads and on trails. We preferred the trails for more reasons than those that are obvious.

The Sonora Desert in Baja, Mexico is a natural space. The road here, sinewy and rugged, was built from a former animal trail. The designers were people attempting to move themselves and goods by foot, burro, or wagon. They had no spare labor, so they carved this road by pick, shovel and wheel barrow. But mostly they just let the wagon wheels etch the land. The builders never attempted to undo a kink, change a grade or tunnel into a hillside. The land kept its natural form. Indeed, the road is a trail. This trail has endured largely because it focuses movement in a natural way. It is far less efficient in moving goods than a road. If people want to go thirty, forty or fifty miles an hour, it won't work.

Today, when I go back to nature to re-invigorate myself, I may find an adventuring friend or two and head for California's Anza Borrego Trail. Like the Baja, it is another place in the Sonora, forgotten by time. Although Jeeps and Bronchos share the space, the jeep road will never be widened. Nothing will ever go fast here. The Anza Borrego is an historic trail. By law it's features are preserved for all of time. And that is why the Anza Borrego Trail is worth returning to, again and again.

Why the Anza Borrego and other Trails Work

A trail offers its users awareness of surroundings. Trails preserve vistas. Trails preserve ecosystems which allow natural sounds to drown out urban sounds. Trails invite touch and discovery. Trails protect and preserve fragrance. The trail experiences offer users feelings of bigness and connection with the earth. Trails unfold mystery, offer surprise, preserves the detail. In fact, well designed trails offer the hikers, bicyclists, skaters or other adventurers new sensations each time they are used.

I have walked trails in Northern European towns where I lost all sense of self, where the only sounds were comforting ones, where each turn brought a new reward. And as I encountered others on these trails it became obvious that they too were off in private worlds of thought and contemplation. "These trails are working", I said to myself, as I attempted to capture first in my own mind, and later with camera, this special link from urban surroundings to natural world.

Of course, roadways cannot do this. They are not supposed to, and they don't. The mission of a roadway is to preserve free movement, to offer choice in transportation and to move people and goods safely and efficiently.

The mission of trails is vastly different. Trails allow visits with the natural world; they do not disturb it. At the same time trails share places that people find cheering, attractive, sparkling, comfortable, reassuring, and welcoming.

We all have our favorite walking and riding places. As designers it is our task to learn why these places are so special. Once we understand these principles, then we can begin to apply them to our own trail designs.

For me a ride along Boulder Creek in Boulder, Colorado is a yearly must; as is a stroll through Stanley Park in British Columbia. The vista's there are like none other. Where I enjoy "people watching" as I ride or stroll the trails of Santa Barbara, South Beach or Venice, these places fail to give me trail "experiences" like the former ones.

Finally, where I caution the reader to pay close attention to the standards and guidance found in this section, I urge that equal attention be devoted to how and why a trail must first serve the land through which it passes. Take down no unnecessary trees, work within the natural terrain, narrow when you must for short distances. Never speed up bicyclists or skaters when your quest is to preserve the land.

We have overbuilt many roadways in America. We can afford to do that. We cannot afford to

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overbuild our trails. For in making them "better," we make the experience worse.

510 - Definition

Multi-use trails (paths) are facilities on exclusive rights-of-way and with minimal cross flow by motor vehicles. Since bicycle paths are almost always used by pedestrians, joggers in-line skaters, equestrians and bicyclists, they will subsequently be referred to as multi-use trails.

Multi-use trails can serve a variety of purposes. They can provide a school age child or a commuting bicyclist with a shortcut through a residential neighborhood (e.g., a connection between two cul-de-sac streets). Located in a park, they can provide an enjoyable recreational opportunity. Multi-use trails can be located along abandoned railroad rights-of -way, the banks of rivers and other similar areas. Multi-use trails can provide bicycle access to areas that are otherwise served only by limited access highways and closed to bicycles. Appropriate locations can be identified during the planning process.

Multi-use trails should be thought of as extensions of the highway system that are intended for the exclusive or

Trails offer a variety of purpose. (1) Some trails offer children a link between cul-de-sac streets so they can go places, (2) Others offer college students a way to study nature without getting into cars, (3) Others offer children a safe place to move, (4) Others create a cathedral for awe inspired movement. (5) Experts in visual preference surveys have learned to leave out scenes of water, everyone responds so favorably it skews all other measures, (6) A European red textured pathway moves this shopper gracefully through an urban space.

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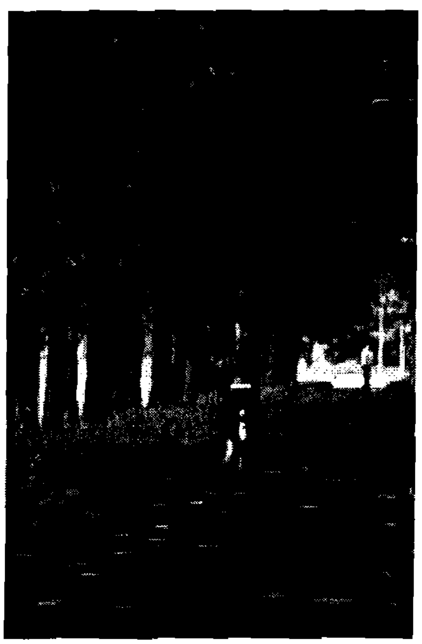

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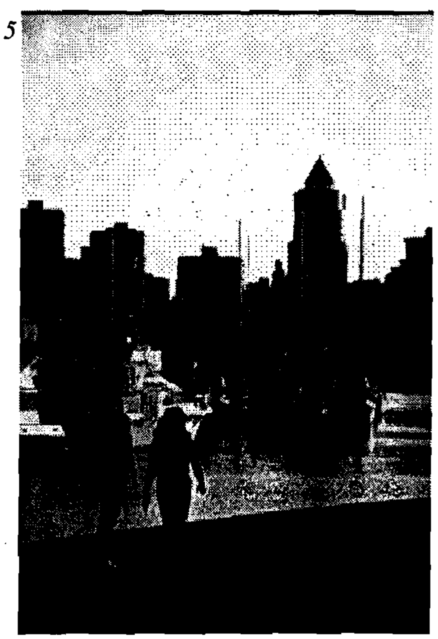

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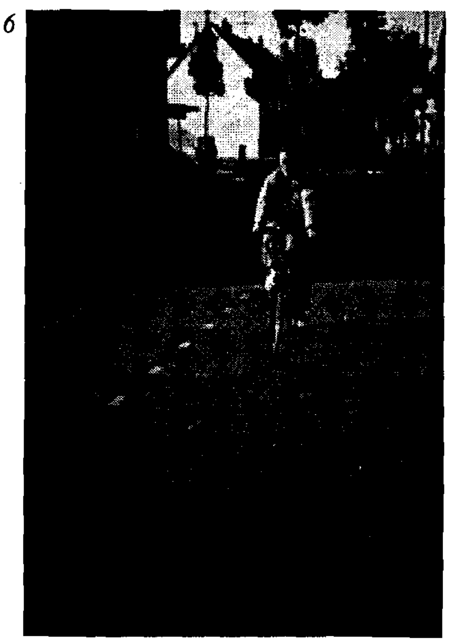


preferential use of bicycles and pedestrians in much the same way as freeways are intended for the exclusive or preferential use of motor vehicles.

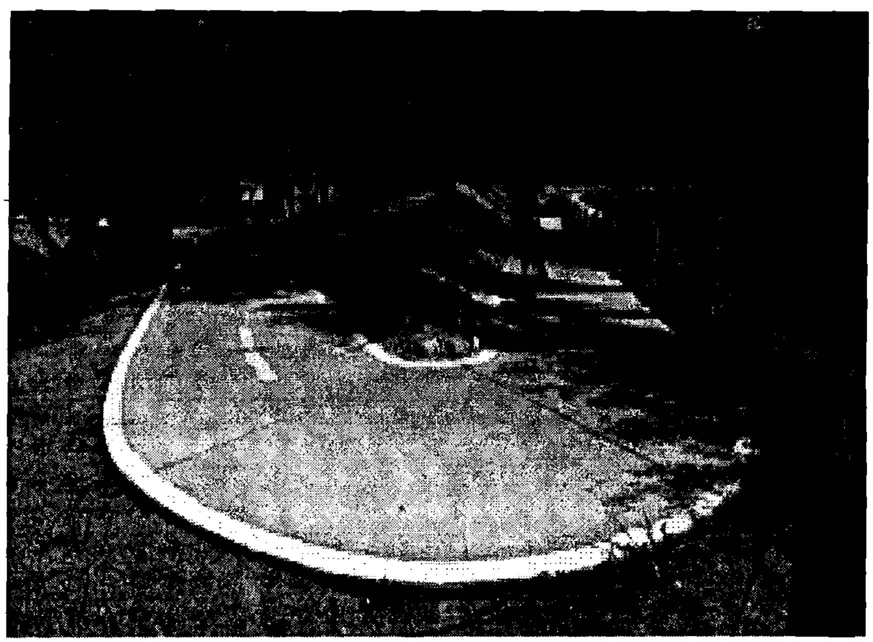
There are many similarities between the design criteria for multi-use trails and those for highways (e.g., in determining horizontal alignment, sight distance requirements, signing and markings). On the other hand, some criteria (e.g., horizontal and vertical clearance requirements, grades and pavement structure) are dictated by operating characteristics of bicycles that are substantially different from those of motor vehicles. The designer should always be conscious of similarities and differences between bicycles and motor vehicles and how these similarities and differences influence the design of multi-use trails. The following section provides guidance for designing a safe and functional multi-use trail.

510.1 Separation Between Multi-Use Trails and Roadways

When two-way, multi-use trails are located immediately adjacent to roadways, some operational problems may occur:

- Unless trails are paired, they require one direction of bicycle traffic to ride against motor vehicle traffic, contrary to normal rules of the road.

Fails to Meet AASHTO, But is it Safe? *A multi-use trail, to meet AASHTO, and therefore current FHWA funding guidelines, must handle 20 mph turns. This 20 mph speed calls for a 95 foot turning radius, which would consume far more land than available to this Scottsdale, Arizona trail. The designer must answer the question whether a particular design is safe. Balancing natural aspects and function of a trail and existing standards requires more knowledge.*



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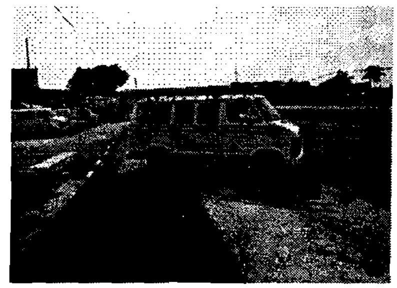

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Sidewalk Bike Paths Often Fail. *(1) Each driveway can be a conflict to bicyclists. Half of all riders come against traffic. (2) Where does the designer place the facility laterally? Too close to the road and there are serious operational problems. The motorist blocks the path, and some bicyclists are inclined to go to the front. Too far back the turning motorist picks up speed and fails to notice the crossing. This motorist lost in court when the bicyclist was injured while going in front.*

Sometimes safety needs can be met by careful placement of users. (3) Stanley Park recommends all wheeled users stay to the left, away from the water. If adhered to, this low wall, important for vistas, is safe for pedestrians.

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This movement greatly increases Class C and F bicycle crashes (See Section 3). The designer is often left with complex placement issues. Should the facility be placed close to the highway creating turning/merge conflicts at the intersection? Should it be placed at the back of the right-of-way, increasing detection problems at each driveway and intersection? Shrubs, other vegetation and fencing can hide the bicyclist from the motorist.

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

♦ At intersections, motorists entering or crossing the roadway often will not notice bicyclists coming from the right, as they are not expecting or looking for contra-flow vehicles. Even bicyclists coming from the left (the expected direction) often go unnoticed, especially when sight distances are poor.

♦ Bicyclists using the roadway are often subjected to harassment by motorists who feel that, in all cases, bicyclists

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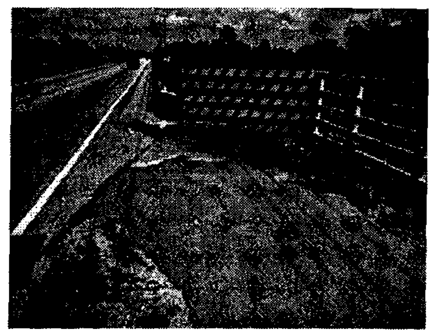
Every driveway is a conflict. *(1) An adult bicyclist, moving at 15 mph here, crashed into the side of a car exiting the drive. A settlement of over $500,000 was assessed against the motorist. (2) Parallel paths often face barriers and challenges.*



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Left: Captiva Island Residents were divided nearly 50/50 on installing a bi-directional bike path behind these trees. Although the facility has not been built, islanders are united now on building a facility that includes mostly paved shoulders, with some traffic calming elements where narrow lanes must be shared. Right: Sanibel Island residents duck under a tree nearly a foot below standards. Off-road bicycle facilities have numerous problems and issues not easily resolved. When these trails are provided, safety must be the primary issue

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should be on the trail instead. Many bicyclists will use the roadway instead of the multi-use trail because they have found the roadway to be safer, less congested, more convenient, or better maintained.

♦ Bicyclists using multi-use trails generally are required to stop or yield at all cross streets and driveways. Whereas, bicyclists using the roadway usually have priority over cross traffic, because they have the same right of way as motorists.

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

♦ Because of the proximity of motor vehicle traffic to opposing bicycle traffic, barriers are often necessary. They keep motor vehicles separated from multi-use trails and bicyclists from traffic lanes. These barriers can represent obstructions to bicyclists and motorists. They can complicate maintenance of facilities and cause other problems as well. (3) There will be good horizontal and vertical alignment providing safe and frequent passing opportunities.

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Sidewalk Bike Paths. *(1-2) This community has chosen to place a bi-directional bike path parallel to this roadway. Exotic signing and measures do not eliminate motorist/bike crashes. The frequency of driveways and intersections alone is ample reason to not build parallel bike paths in most locations. Bike lanes work better for everyone. (3) Another problem is the bike/ped conflict -- who belongs where? (4) Santa Barbara has had its bi-directional bike path parallel to this major road for many years. The risk still persists. Note, the motorists entering or exiting this roadway are surprised by bicyclists, especially from their right (entering motorist) or coming up behind (left turning motorist).*

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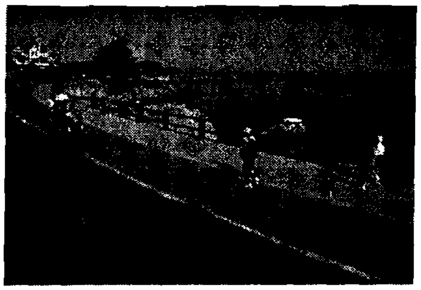
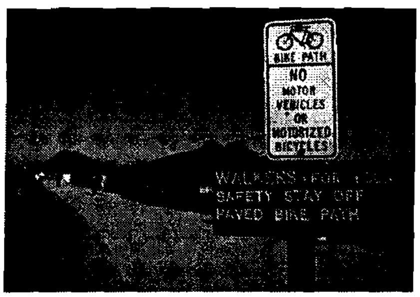
510.2 Wheels n' Heels

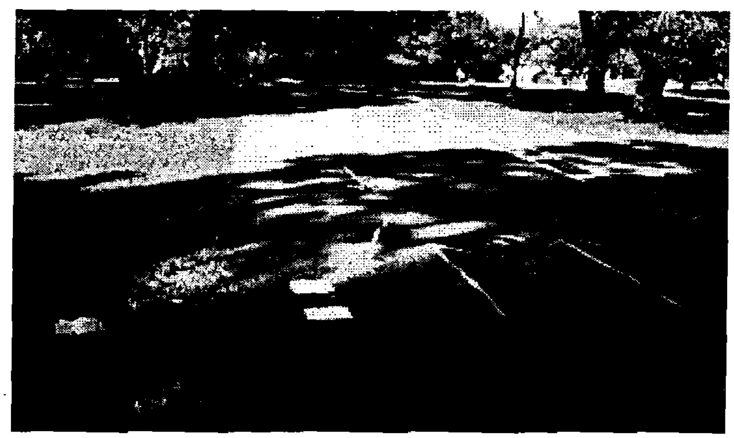
Is it best to mix bicyclists, pedestrians, equestrians or to keep them separate? The question is best answered in terms of volume and exotic type. Horses do not mix well. Horses prefer a softer surface and a space away from wheeled things. At low volumes of each group a fully mixed trail is observed to work. Once volumes increase there is a need to provide separate spaces. Increased volume also requires lower operating speeds. The most universal answer is to provide a simple "Wheels n' heels" design shown in these photos. Circular pathways normally restrict wheeled vehicles to one direction.

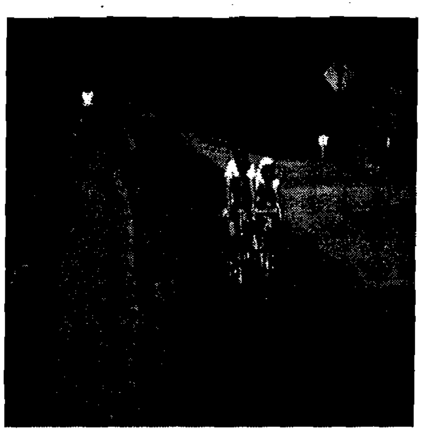


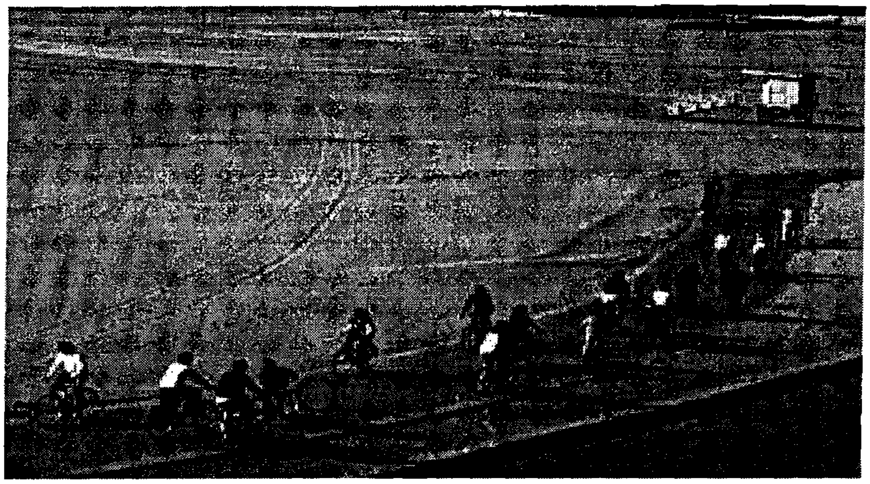


Post Rules of Etiquette. *London, Ontario provides these rules for trail etiquette; including "go slow when there are crowds, keep to the right except when passing, warn others when passing".*

Right: A roller skater (single arrow) approaching two bicyclists swerved to pass between the bicyclists and four pedestrians (white papers), clipped the left bicyclist and fell at the heels of the pedestrian, shattering her ankle. The skater skated, and so the pedestrian sued the park. The park won the case on having provided adequate width and design for mixed trail use.







Left: The Venice Beach Bike Path, well used and most photographed in the nation. The pathway is a 15.0 foot (4.5 m) wide facility in most locations. Right: The newer Long Beach Bike Path boasts a 17 foot(5.2 m) width.

520 - Width and Clearance

The paved width and the operating width required for multi-use trails are primary design considerations. The photo above depicts a multi-use trail on a separated right-of-way. <u>Under most conditions, a recommended paved width for a two-directional multi-use trail is 10-12 feet (3.0-3.6 m).</u> In some instances, where a trail is a link or connection, a minimum of 8 feet (2.4 m) 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.

(4) The path will not be subjected to maintenance vehicle loading conditions that would cause pavement edge damage.

520.1. Increasing Width

Under certain conditions it may be necessary or desirable to increase the width of a multi-use trail to 12-22 feet (3.6 - 6.6 m). Examples include:

- substantial bicycle volume
- probable shared use with joggers, in-line skaters and other pedestrians
- use by large maintenance vehicles
- steep grades
- places where bicyclists will be likely to ride two abreast.

Wide paths may benefit by designating separate sections for use by "wheels and heels."

520.2 Trails Are Two-Way Facilities

The minimum width of a one-directional, multi-use trail is 5 feet (1.5 m). It should be recognized, however, that one-way, multi-use trails almost certainly will be used as two-way facilities unless effective measures are taken to assure one-way operation. Without such design and enforcement, it should be assumed that multi-use trails will be used as

Pinellas Trail *-- 12 feet + 6 foot pedestrian trail. Pedestrians use separate trail when wheeled use is heavy. Other times they mix by choice.*

two-way facilities and they should be designed accordingly.

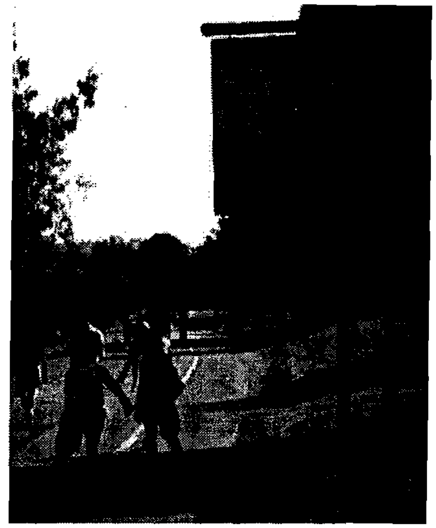
521- Horizontal Clearances

A minimum 2-foot (0.6 m) width graded area should be maintained adjacent to both sides of the pavement; however, 4 feet (1.2 m) of clearance or more is desirable to provide distance from trees, poles, walls, fences, guardrails, or other lateral obstructions.

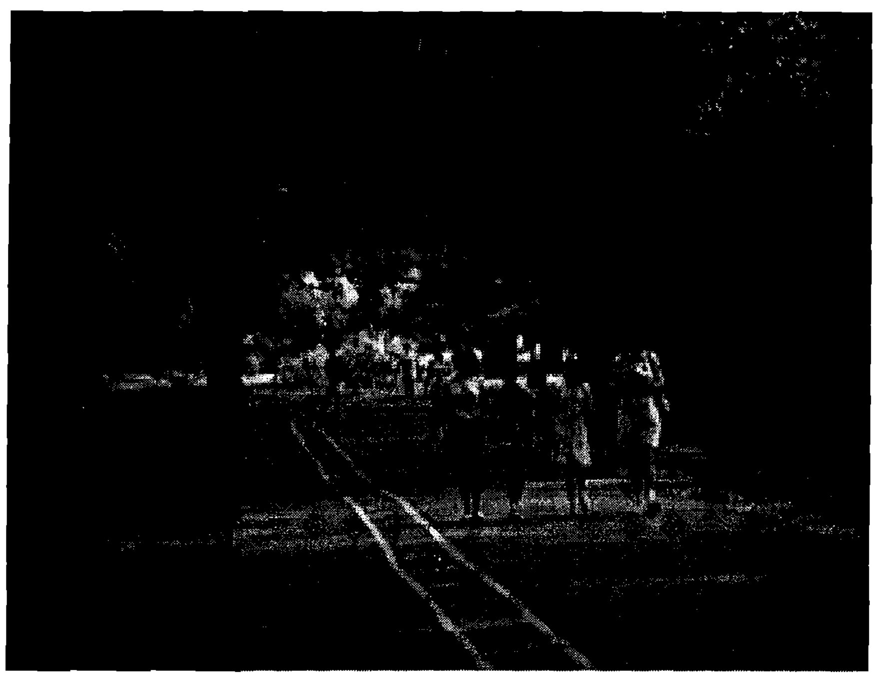
A 6-foot (1.8 m) lateral separation is desirable from any embankment that would create difficulties for bicyclists. If this is not possible, a positive barrier such as dense shrubbery or chain link fence shall be provided. Culverts and other drainage and piping should be extended laterally at least 10 feet (3.0 m) from a pathway. A wider graded area on either side of the multi-use trail can serve as a separate jogging path. Any edge dropoff should be eliminated.

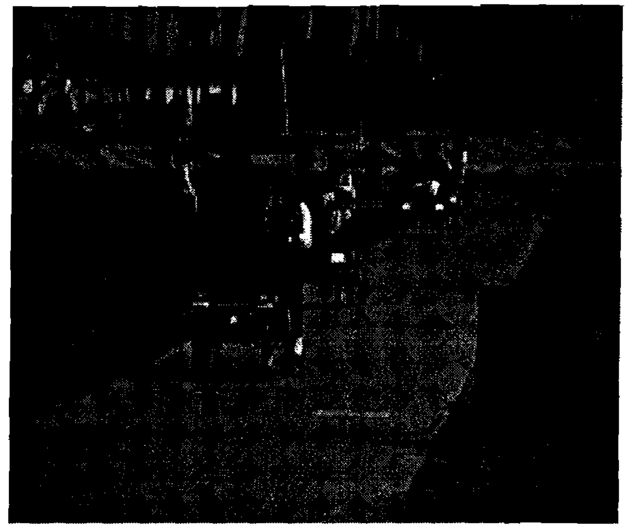
Scottsdale, Arizona, *voted the Most Beautiful City in America, has one of the most ample trails systems. This section follows the natural curves of the land, focused in one of many floodways. It's width, just 8.0 feet wide, fails to meet AASHTO standards. A wider trail here, however may not fit into the natural features of the land. It's usage is light, sight distances are ample, and there is excellent horizontal clearance.*

Audubon Park, New Orleans, *carriageway turned into a multi-use trail, first for walking in the sixties, then for bicycling in the seventies, and now for all non-motorized uses. It's 20-22 foot width permits bicyclists and other wheeled devices to flow one way only. The interior pathway is exclusively for walking and beginning skaters.*



Green Lake Trail, Seattle, Washington. *Centered in a prestiegious neighborhood, the Green Lake Trail may be America's most loved trail. Built more than a decade ago this trail has always operated beyond capacity. At first conflicts were managed by having all wheeled movement in one direction and on one side only. Environmental issues kept the trail from being widened. However, the trail is to be widened to meet its ever increasing popularity.*





***Horizontal clearance** to surface objects is 2.0 feet (0.6 m), with 4.0 feet (1.2 m) for standing objects such as trees, poles, guardrail or trashcans. Above, Amsterdam to Harlem pathway maintains an excellent canopy, with a well spaced planting of trees.*

On the right, Santa Barbara's coastal bike path, like many others, has trash cans within the recovery area. Why? "The maintenance crews prefer it this way" a park manager related. Both trail users and the trash collection staff can walk the extra distance. Safety comes first.

Below: If the side slope is more than 6% within 6 feet (1.8 m) it is vital to place a positive barrier to eliminate loss of control. The barrier wall or top rail should be at least 4.5 feet (1.4 m) high to prevent toppling, and can be designed to allow viewing.

A wide separation between a multi-use trail and adjacent highway is desirable to confirm to both bicyclists and motorists that the multi-use trail functions as an independent way for bicycles. When this is not possible and the distance between the edge of the roadway and the multi-use trail is less than 5 feet (1.5 m), a suitable physical divider may be considered. Such dividers serve both to prevent bicyclists from making unwanted movements between path and highway shoulder and to reinforce the concept that the multi-use trail is an independent facility.

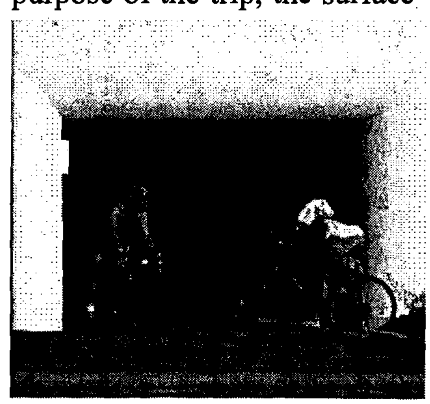
<u>Where used, dividers should be a minimum of 4.5 feet (1.4 m) high, to prevent bicyclists from toppling over it. It should be designed so that it does not become an obstruction in itself.</u>

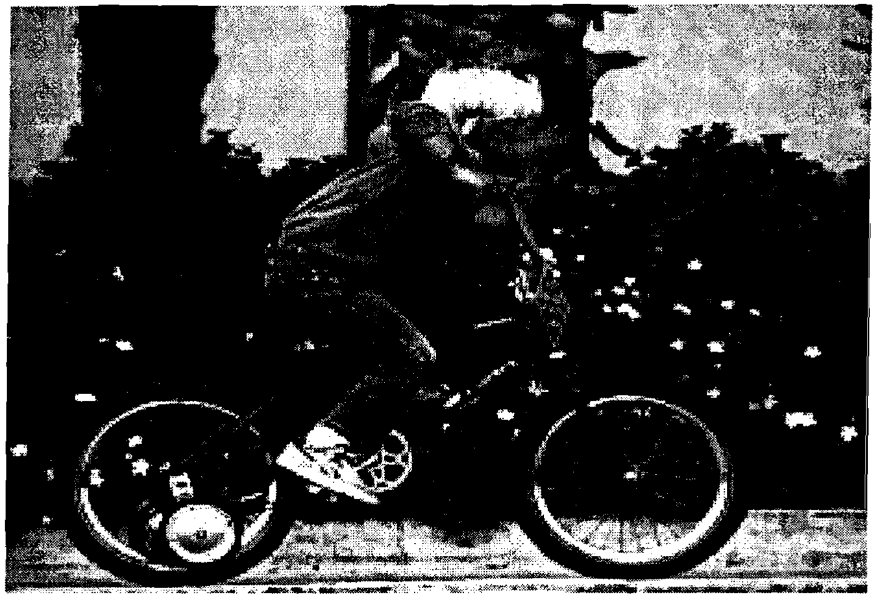
522 - Verticle Clearances

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

530 - 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 surface





condition and location of the multi-use trail, the speed and direction of the wind, and the physical condition of the bicyclist. Multi-use trails should be designed for speeds that are at least as high as the preferred speed of the fastest bicyclists. *However, trails should not be designed to encourage speed.*

530.1 AASHTO Design Speed

In general, a minimum design speed of 20 mph (30 km/h) should be used; however, when the downgrade exceeds 4 percent, or where strong prevailing tailwinds exist, a design speed of 30 mph (50 km/h) is advisable.

530.2 Lower/Higher Design Speeds

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

530.3 Controlling Speed

There is growing concern that the 20 mph (AASHTO) design speed may create too great of a differential between families riding and those using a trail for conditioning (8-20 mph span). Designers are encouraged to use reduced speeds, especially on approaches to intersections, where the conditions may call for reducing the approach speed. Unless the speed reduction is obvious, posting of the recommended speed and changed condition is essential (See MUTCD).

530.4 Horizontal Alignment and Super Elevation

The minimum radius of curvature negotiable by a bicycle is a function of the super-elevation rate of the multi-use trail surface, the coefficient of friction between the bicycle tires and the multi-use trail surface, and the speed of the bicycle.

The minimum design radius of curvature can be derived from the following formula:

$$R = V^2/15\,(e+f)$$

Where:

R = Minimum radius of curvature (ft)
V = Design Speed (mph)
e = Rate of super-elevation
f = Coefficient of friction

For most multi-use trail applications the super-elevation rate should not exceed 2% (the minimum necessary to encourage adequate drainage). A higher cross slope cannot be handled by

wheelchairs or 3-wheelers. The minimum super-elevation rate of 2% 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 multi-use trails can be assumed to vary from 0.30 at 15 mph (25 km/h) to 0.22 at 30 mph (50 km/h). Although there are no data available for unpaved surfaces, it is suggested that friction factors be reduced by 50% to allow a sufficient margin of safety. Based upon a super-elevation rate (e) of 2%, minimum radii of curvature can be selected from Table 1.

TABLE I Minimum Radii for Paved Multi-use trails (e = 2 %)

Design Speed-V (mph) 1 mph = 1.6km/h	Friction Factor - f (e = 2 %)	Minimum Radius - R (Feet) 1 ft = 0.3m)
15 mph (20 km/h)	0.30 friction	47 ft radius
20 mph (30 km/h)	0.27 friction	95 ft radius
25 mph (40 km/h)	0.25 friction	155 ft radius
30 mph (50 km/h)	0.22 friction	250 ft radius

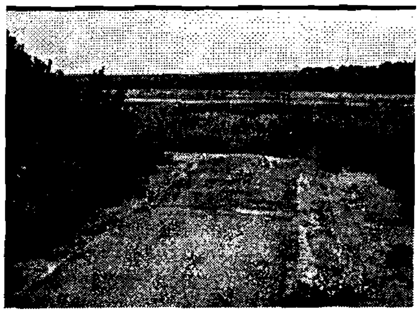
When substandard radius curves must be used on multi-use trails because of right-of-way, topographical or other considerations, standard curve warning signs and supplemental pavement markings should be installed in accordance with the MUTCD. The negative effects of substandard curves can also be partially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

531 - Grade

Grades on multi-use trails should be kept to a minimum, especially on long inclines. Grades greater than 5% are undesirable, because ascents are difficult for many bicyclists to climb and descents cause some bicyclists to exceed the speeds at which they are competent. Where terrain dictates, grades over 5% and less than 500 feet (150 m) long are acceptable, when a higher design speed is used and additional width is provided. Grades steeper than 3% may not be practical for multi-use trails with crushed stone surfaces.

531.1 Steep Grades

Grades can be increased to 6% for bridges where wide paved shoulders [10 feet (3.0 m)] or paths are provided and a leveling off at the base permits adequate recovery before an intersection or other conflict



Descending this grade (11%) for 900 feet, calculate the speed of a freewheeling bicyclist. Working with the reaction times and maximum deceleration rate, will an average bicyclist discover this turn in time to slow to a safe cornering speed?

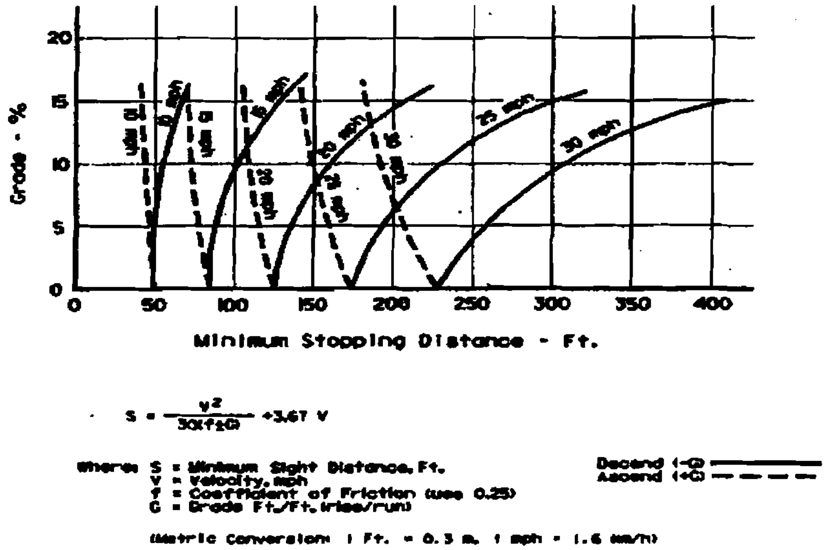


Figure 1 (Above)

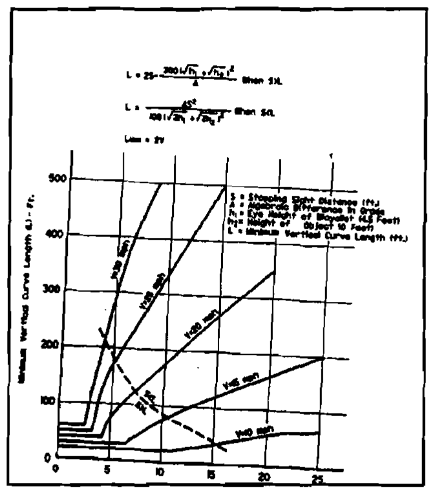


Figure 2 (Above)

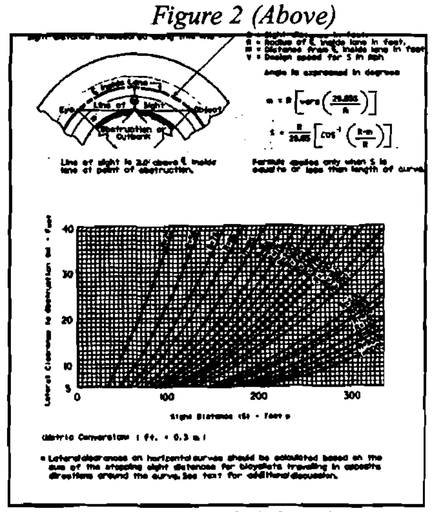


Figure 3 (Above)

point. ADA/ADAAG rules apply (level are is needed for 10 feet each 30 feet).

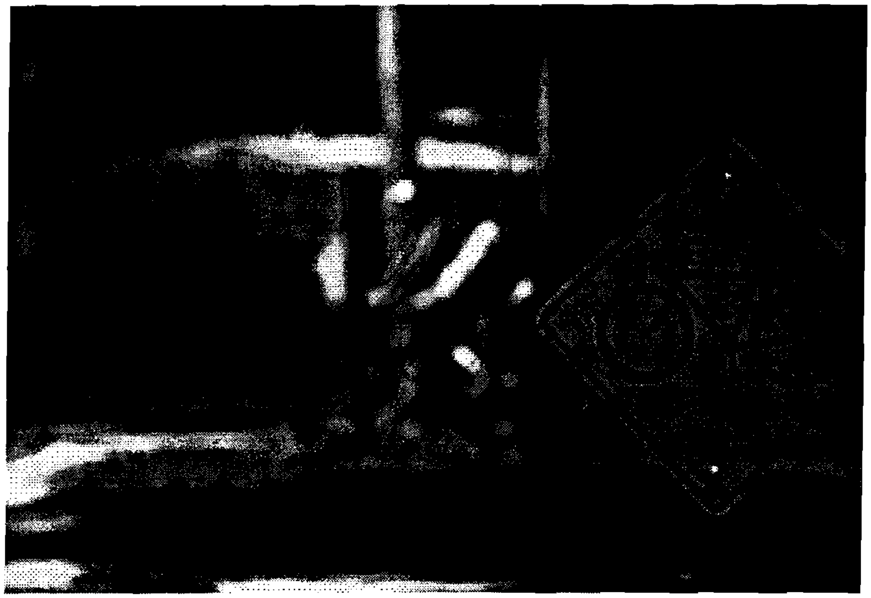
532 - Sight Distance

To provide bicyclists with an opportunity to see and react to the unexpected, a multi-use trail should be designed with adequate stopping sight 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 bicyclist.

Full size copies of Figures 1-3 are found in the appendix. Figure 1 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 multi-use trails, the sight distance in descending direction, that is, where "G" is negative, will control the design.

Figure 2 is used to select the minimum length of vertical curve necessary to provide minimum stopping sight distance at various speeds on crest vertical curves. The eye height of the bicyclist is assumed to be 4.5 feet (1.4 m) and the object height is assumed to be zero to recognize that impediments to bicycle travel exist at pavement level.

Figure 3 indicates the minimum clearance that should be used to line-of-sight obstructions for horizontal curves. The lateral clearance is ob-



tained by entering Figure 11 with the stopping sight distance from Figure 9 and the proposed horizontal radius of curvature.

Bicyclists frequently ride two abreast on multi-use trails; and, on narrow multi-use trails, bicyclists have a tendency to ride near the middle of the trail. For these reasons, and because of the serious consequences of a head-on bicycle crash, 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 trail through the curve, installing a yellow center stripe, installing a curve ahead warning sign in accordance with the MUTCD, or proper combination of these alternatives.

540 - Intersections

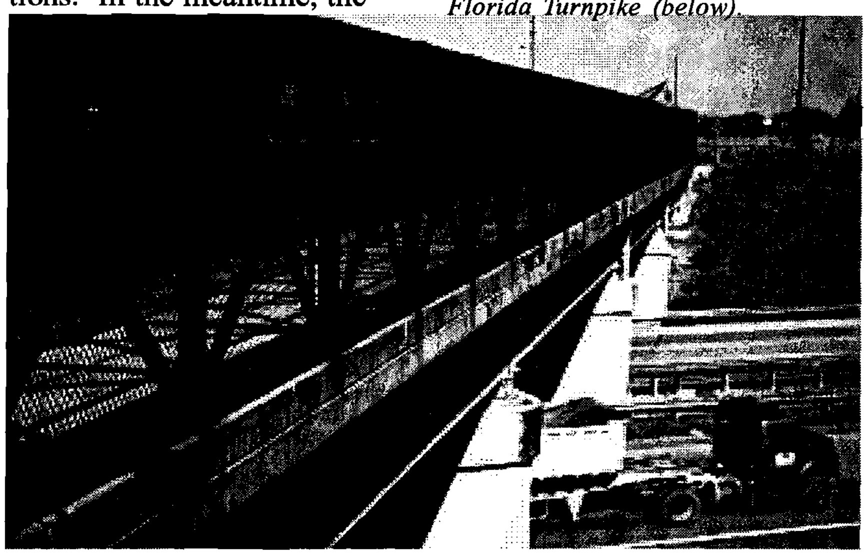
The Department is preparing a separate publication dealing with trail-roadway intersections. In the meantime, the following principles apply. Trail intersections with roadways are important considerations in multi-use trail design. If alternate locations for a multi-use trail are available, the one with the most favorable intersection conditions should be selected.

541 - Limited Access Crossings

For crossing freeways and other high-speed, high-volume arterials, a grade separation structure may be the only possible or practical treatment. Unless bicycles are prohibited from the crossing highway, providing for turning movements must be considered. In many cases, however, the cost of a grade separation will be prohibitive.

542 - Trail/Roadway

Limited Access Crossing. *The Orlando, Florida area Orange Blossom Trail takes advantage of an existing railroad crossing, adding the cage and other refinements. It provides a critical separated grade crossing of the Florida Turnpike (below).*



Intersections

542.1 Assigning Right-of-Way

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 sign, yield sign, etc.), and location, should be provided in accordance with the MUTCD.

542.2 Signing

Sign type, size and location should also be in accordance with the MUTCD. Care should be taken to ensure that multi-use trail signs are located so that motorists are not confused by them and that roadway signs are placed so that bicyclists are not confused by them.

542.3 Where to Locate Crossing

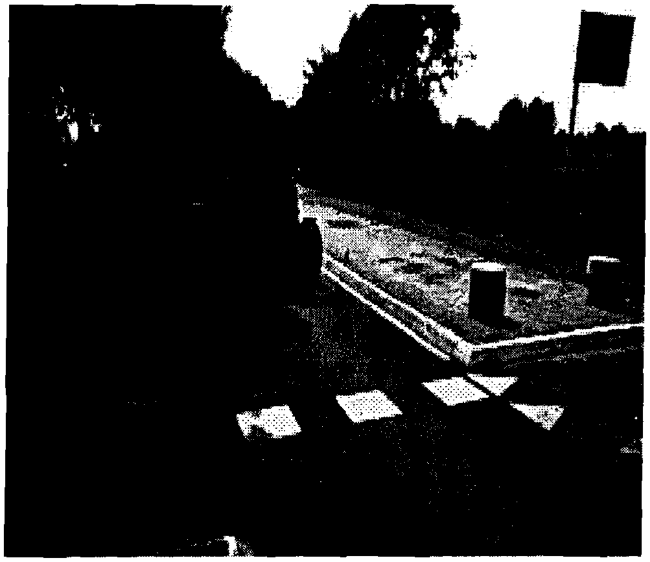
There are times when it is preferable that the at-grade crossing of a multi-use trail and a highway be at a location away from the influence of intersections with other highways. Controlling vehicle movements at such intersections is more easily and safely accomplished through the application of standard traffic control devices and normal Rules of the Road. Right-of-way should be assigned and sight distance should be provided so as to minimize the potential for conflict resulting from unconventional turning movements.

Special Note: By August 1996 the Department will publish a manual on trail/roadway intersections. Until then, the following guidance applies.

542.4 Crossing Angles

Junctions should cross at right angles wherever possible. If the pathway parallels a roadway, jughandle final approaches to the crossing point should be considered.

Bollards used to keep motorized vehicles off of the trail are dangerous to children and other living things. They can be hit easily and they focus attention away from the real danger (traffic). So don't put them in. Most motorists don't want to drive on the path, and there are better ways to deal with those who do, such as the tight curbing shown on the facing page. (Note fresh nick on bollard and child being assisted)



Dutch trail crossing employs double set of medians, one for bicyclists, the other for motorists. The medians and tight geometrics force low speed approaches by both groups, creating near ideal crossings of lower volume roadways. The Davis, California crossing (previous page) can be easily converted to one similar to the above.

Waiting. *Significant trail crossings should be designed with pleasant waiting areas with benches, water and other features back from the trail. Children sometimes arrive before their parents. An out of the way place to rest and wait benefits all*

542.5 Motorist Advance Warning

Advance warning signs of all crossings should be in advance of the intersection by at least twice the minimum stopping distance for that intersection.

542.6 Bicyclist Advance Warning

Changes in surfaces can alert the bicyclist to upcoming intersections. Brick or stone (or concrete cut into asphalt) inserts across the path are one method. Bright red edge striping or a change in the surface color is another. Changing the asphalt mix to a coarser grade would give a rougher surface suggesting a slower speed to be used. A speed bump or a change to a loose surface is not recommended. A pullout near the intersection can help with navigation, and act as a resting and gathering point for riders.

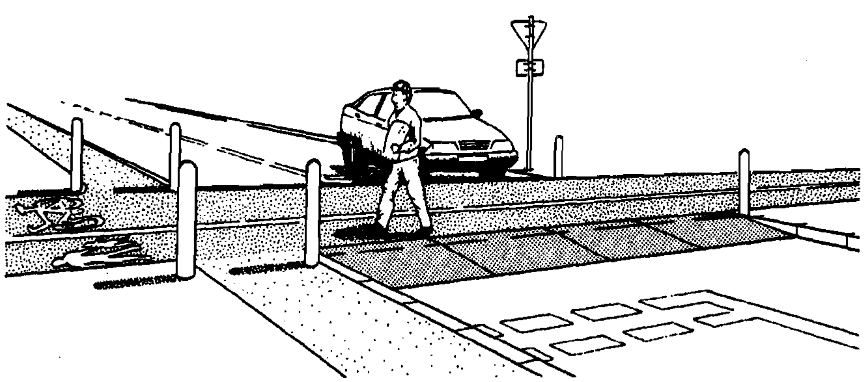
542.7 Motorist Turns

Intersection design should limit turning speeds so that motorists do not exceed 10 mph (15 km/h) for right turns and 20 mph (30 km/h) for left turns. At crossings of high volume multi-lane arterial highways where signals are not warranted, consideration should be given to providing a median refuge area for bicyclists and pedestrians.

Bicyclists, elderly adults, and mobility disabled all need median cuts as well as cuts through channelized islands (See illustration, top left).

***Priority Backwards.** Two minor dirt roads serving about 30 houses cross here. The homes generate no more than 100 auto trips a day.. Meanwhile, there are over 2000 trail users. The designer assigned the through movement to the minor traffic. Bicyclists quickly learn that the signs are "crying wolf". This leads to disregard for this and other stop signs by trail users. It also creates confusion among motorists, most of whom stop for trail users.*

***Below:** This British design solves many operational (stop sign) problems. In many cases the bicyclist and pedestrian deserve and require precedence over motor traffic. Assigning the through movement to the motorist, no matter what the respective volumes, not only sets the wrong tone, it creates unsafe movements of autos, pedestrians and bikes. Note that the use of this speed table forces a low speed motorist crossing. This design is appropriate when motorized crossings are under 1000 ADT, and when speeds are at or below 30 mph on approach.*



543 - Who Has The Right-of-Way?

A common mistake at an intersection is to assign the through priority to the wrong traffic. Some designers assume that because the bicyclist has more to lose if hit by an auto, then the bicyclist should stop at virtually all intersections, including driveways and even sidewalks. This assumption is incorrect. It can lead to unsafe practices, confusion, and increase the potential for a bad crash.

The *Manual on Uniform Traffic Control Devices*, and the principles of law in the *Uniform Vehicle Code* are clear on who should yield to whom: MUTCD, 2B-5 - Warrants for Stop Sign:

"Where two main highways intersect, the STOP sign or signs should normally be posted on the minor street to stop the lesser flow of traffic".

> **"Where two main highways intersect, the STOP sign or signs should normally be posted on the minor street to stop the lesser flow of traffic."**

Another common operations error is to stop traffic in both directions when there is a clear majority of movement "just to be safe". This also leads to confusion. Four-way stops can be applied when there are similar volumes of traffic in each direction, or other special conditions. However, 4-way stops are even more tricky with trails than they are with roadways. There is a general tendency for motorists at 4-way stops to over-yield to bicyclists, again creating unsafe expectations and practices. At times a motorist motions one bicyclist on in one direction, starts up, only to be confronted by a bicyclist coming the other direction.

When in doubt, stick with the general warrants in the MUTCD under stop controlled intersections. These warrants and practices are well tested and proven. The principles apply to bicyclists much better than the "I'll protect the bicyclist by having them stop" engineering approach.

544 - Trails Crossing Roadways Research

The University of North Carolina Highway Safety Reserarch Center (HSRC) studied 60 Florida trail intersections to learn essential principles to retrofit these intersections and to apply the same principles to future trail crossings. A copy of the full study can be obtained by writing to the *Florida Department of Transportation Maps and Publications Office (Price $8).*

544.1 Key Findings

The following conclusions are reached and have applications statewide.

544.2 Four Way Stops

Four-way stops are ineffective and can constitute a hazard. Motorists tend to stop, and bicyclists rarely do. This creates a false sense of security that can lead to a collision.

544.3 High Speed Roadways

Assignment of right-of-way is critical. For higher speed crossings of 40 and greater right-of-way is always assigned to the motorist.

544.4 Medium Speed

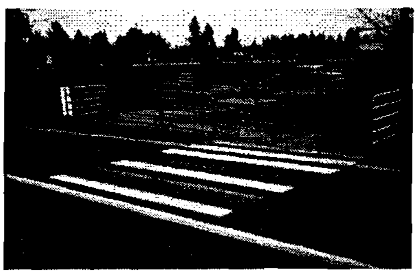
Right-of-way can be assigned to trail users when their volumes are highest and motorist speeds are at 30 mph. Use traffic calming to further slow the speed of motorists.

544.5 Low Speed Roadways

Right-of-way can be assigned to trail users when their volumes are highest and motorist speeds are 20 mph or less without using traffic calming.

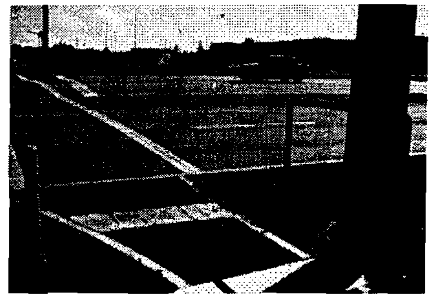
544.6 Solutions to Common Intersection Crashes

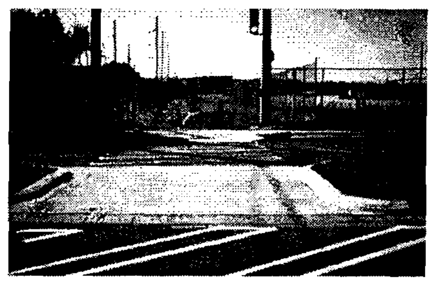
- Provide adequate stopping sight distances for motorists and trail users.
- Reduce conflict speeds by controlling the approach speed for either or both the trail user and motorist.
- Turning conflicts are reduced by placing the trail crossing as close to the intersection as possible.
- Medians are helpful, even on 2-lane roads, to act as a traffic calming feature, and to separate conflicts in time and place.
- Trail crossings should be at 90 degrees. But, when needed, it is possible to skew the crossing to 75 degrees and still only add 4% to the crossing distance.
- Properly placed overpasses on trails will be well used, especially if at-grade crossings are complex, require excessive waits, or poze high speed conflicts.
- Signal cycles must be responsive to bicyclists, and should not require an excessive wait.



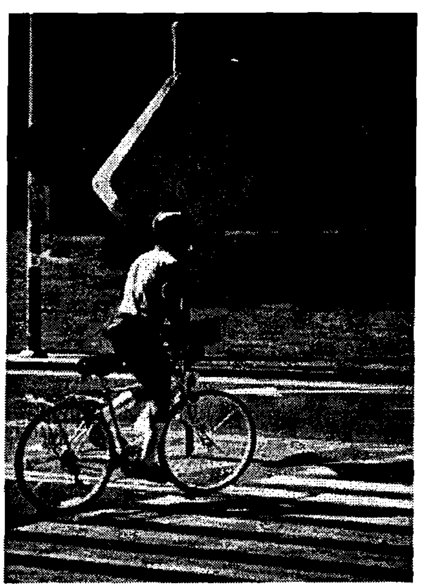
545 - Median Refuge

A refuge is a place in the middle of a 2-lane road, and especially multi-lane highways, where bicyclists and pedestrians can wait safely before crossing the next lane of traffic. A refuge allows a trail user to cross one direction of traffic at a time without waiting until both directions are clear. A refuge separates conflicts and simplifies the crossing procedure. The refuge can be simply a cut in the existing median or a structure can be built specifically as a refuge. Although they can be used on 2-lane roadways, they are especially helpful on multi-lane roadways.





Median details. *Top left, clockwise: (1) Davis goes under, but connects to the street, (2) Hitching post helps bicyclist wait, (3) Wide median aids Orlando bicyclists, Ringling Art Museum rotates new art into median twice a year, (4) Signs are helpful, but make sure they don't create a sight distance problem, (5) Portland forces pedestrians and bicyclists to look at the train that will hit them first, (6) median construction detail from Denmark.*



545.1 Minimum Width

The minimum median width to meet the needs of bicyclists should be 10 feet (3 m). If large numbers of bicyclists can be anticipated, a storage space of 3.6-4.0 meters is preferred.

545.2 Median Opening

The median opening may be angled 45 degrees toward the approach traffic. This forces bicyclists to stop for the second search, and orients them to look directly into the source of danger.

545.3 Median Lighting, Signing

Lighting should be used for median crossings. W11-1 advanced warning and warning signs should be used for the motorist approach, and approach speeds should be regulated and further constricted by design, when practicable.

545.4 Trail Termination

When multi-use trails terminate at existing roads, it is important to integrate the path into the existing system of roadways. Care should be taken to properly design the terminals to transition the traffic into safe merging or diverging situations. Appropriate signing is necessary to warn and direct both bicyclists and motorists regarding these transition areas. Care must be taken so wrong way riding is discouraged.

545.5 Warnings

Multi-use trail intersections and approaches should be on relatively flat grades. Stopping sight distances at intersections should be checked and adequate warning should be given to permit bicyclists to stop before reaching the intersection, especially on downgrades.

545.6 Median Ramps/Cuts

Ramps for curb cuts at intersections should be the same width as the multi-use trails. Curb cuts and ramps should provide a smooth transition between the multi-use trails and the roadway.

Self illuminated trail crossing signal. Can also be set to flashing when activated by trail user, and to call added attention to signals (Orlando).

***What's Wrong Here?** The crosswalk was placed too far in. Keep the crosswalk within 2 feet of the intersection to avoid this risk.*

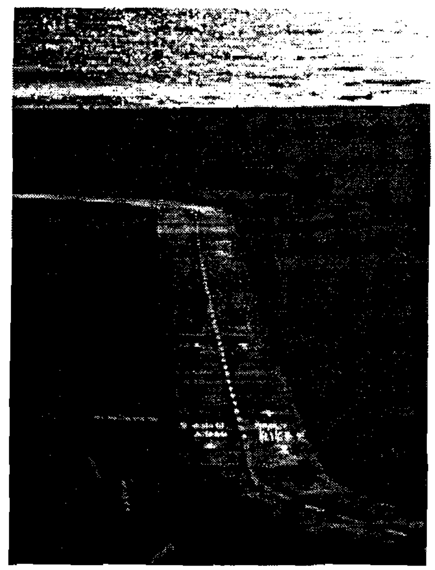
546 - Bicycle Crossing Signals

Often multi-use trails intersect busy roads and thus need signals. Instead of traffic lights, a flashing bicycle crossing signal can be used. This signal can be a pedestrian crossing signal that has been modified for cyclist use. The signal actuation mechanism should be mounted beside the path approximately 4 feet (1.3m) above the ground. This allows the cyclist to activate the signal without dismounting. Another method of activating the signal would be a detector loop in the trail. At some crossing locations, where optimum progression is not a factor, the designer may consider giving the multi-use trail user a "hot response" or immediate call, to encourage bicyclists with the shortest possible wait. This feature increases the number of trail users that wait for the signal.

547 - Staircases

Staircases can pose a problem for cyclists if the bicycle has to be carried up or down the staircase. A simple solution is to build concave or trough type ramps on either side of the staircase. These ramps allow bicyclists to roll their bicycles up or down the staircase without having to carry them. Each ramp should be at least 6 inches (150 mm) wide. Preferably there should be two ramps; one for ascending and the other for descending. A concave ramp is preferred as it will help keep the bicycle wheels centered on the ramp.


(1)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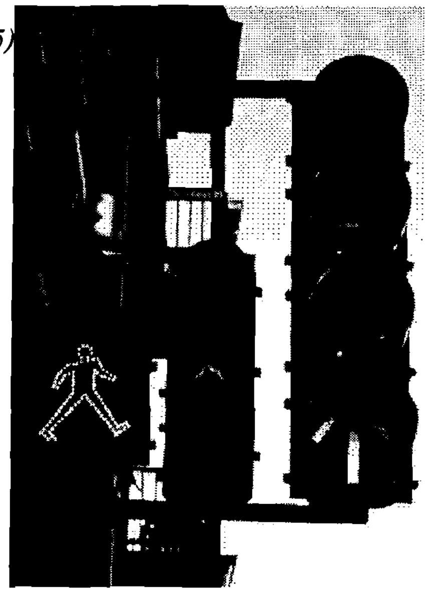
(5)


(4)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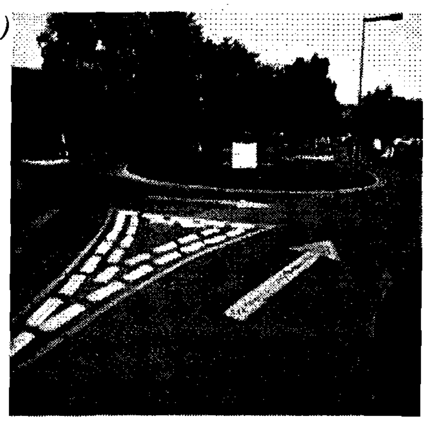
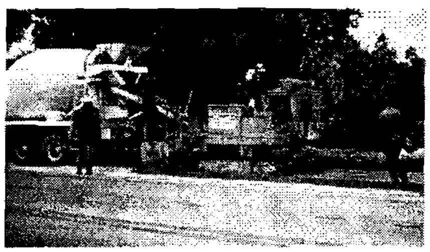
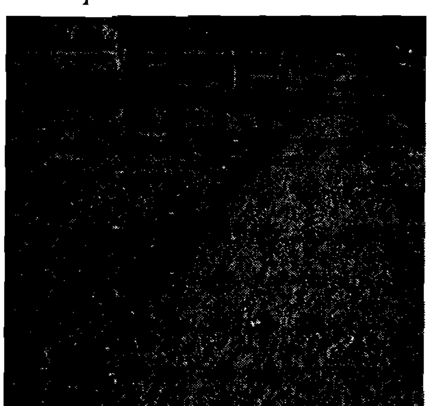


Staircases, Signals, signs and markings

Top, right: (1) This Japanese staircase is a helpful solution to top deck parking (2) Pedestrians on the Santa Monica Bike Path behave as expected, walking on pavement vs sand, (3) arrows provide directionality through roundabout, (4) pavement markings indicate bicycling side and direction, and (5) Canadian signal confirms Bike Xing.



Above, (1) pavement 20 years later, (2) new concrete will last over 50 years with low maintenance, (3) no matter what type of surface, it must be above grade, not below, as shown here, (4) hardened soil promotes lower speed movement.



550 - Signing and Marking

Adequate signing and marking are essential on multi-use trails. They alert bicyclists to potential conflicts and convey regulatory messages to both bicyclists and motorists at highway intersections. In addition, guide signs, such as those indicating 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.

550.1 Use of Centerline and Edgeline

A designer should consider a 6 inch (150 mm) wide yellow centerline stripe to separate opposite directions of travel. This is particularly beneficial in the following circumstances:

- For heavy volumes of bicycles
- On vertical and horizontal curves with restricted sight distance
- On unlighted paths where night time riding is expected

Edge lines can also be very beneficial where nighttime bicycle traffic is expected. The desire to omit lines for aesthetic reasons is common, but is contrary to operations and safety needs.

550.2 Marking Materials

General guidance on signing and marking is provided in the MUTCD. Care should be exercised in the choice of pavement marking materials. Some marking materials are slippery when wet and should be avoided in favor of more skid resistant materials. Adding grit to thermoplastic increases skid resistance.

560 - Pavements

Designing and selecting pavement sections for multi-use trails 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.

560.1 Pavement Loads

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 on multi-use trails will be substantially less than highway loads, trails must 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.

560.2 Motor Vehicle Loading

Special consideration should be given to the location of motor vehicle wheel loads on the path. When motor vehicles are driven on multi-use trails, their wheels will usually be at or very near the edges of the trail. Since this can cause edge damage that, in turn, will result in the lowering of the effective operating width of the trail, adequate edge support should be provided. Edge support can be either in the form of stabilized shoulders or additional pavement width. Constructing a typical pavement width of 12 feet (3.6 m), 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. Second, the additional construction can cost less than constructing shoulders because the separate construction operation is eliminated.

560.3 Preparation

It is important to construct and maintain a smooth riding surface on multi-use trails. Multi-use trail pavements should be machine-laid. Soil sterilants should be used where necessary to prevent vegetation from erupting through the pavement. On portland cement concrete pavements, transverse joints, necessary to control cracking, should be saw cut to provide a smooth ride. Normally this joint should be spaced at twice the pavement width, i.e. 10 feet (3.0m) wide equals 20 feet (6.0m) space. On the other hand, 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.

560.4 Driveways, Crossings

At unpaved highway or driveway crossings of multi-use trails, the highway or driveway should be paved a minimum of 10 feet (3.0 m) on each 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. In areas where climates are extreme, the effects of freeze-thaw cycles should be anticipated in the design phase.

560.5 Materials

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. In some low-use areas, limestone screens, or other porous materials have proven economical.

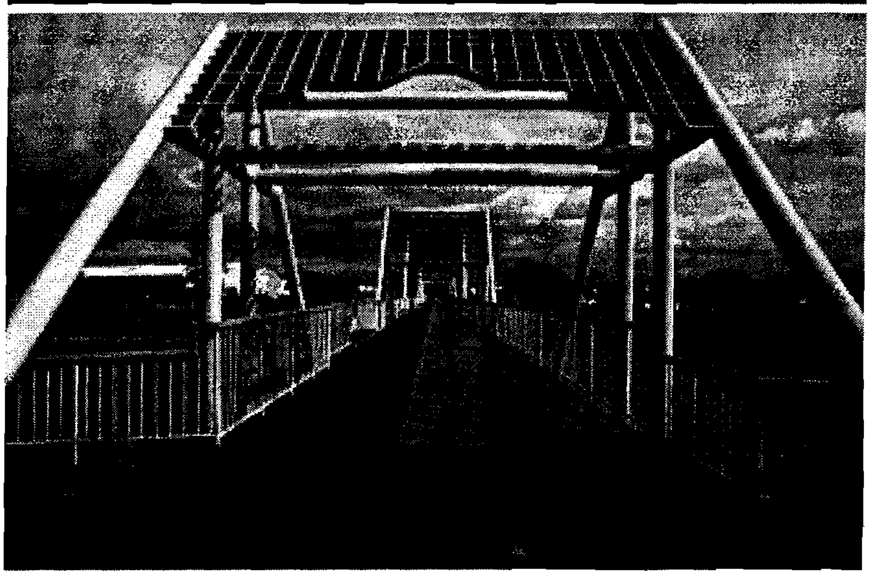
Good quality pavement structures can be constructed of asphaltic or portland cement concrete. Because of wide variations in soils, loads, materials and construction practices, it is not practical to present specific or recommended typical structural sections that will be applicable statewide. Decisions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

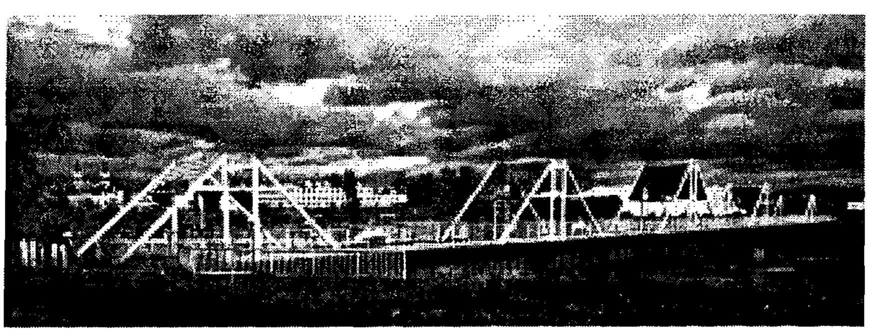
570 - STRUCTURES

An overpass, underpass, small bridge, drainage facility or facility on a highway bridge may be necessary to provide continuity to a multi-use trail.

570.1 Width

On new structures, the minimum clear width should be the same as the approach width of the paved multi-use trail; and the desirable clear width should include the minimum 2 foot (0.6 m) 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. 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 multi-use trails. Similarly, vertical clearance may be dictated by occasional motor vehicles using the path. Where practical, a vertical clearance of 10 feet (3 m) is desirable for adequate vertical shy distance.





Bridge designs to support maintenance and emergency vehicles can be prohibitively expensive. Barriers to prevent motor vehicle crossings, and alternate access should be provided to keep bridge costs affordable.

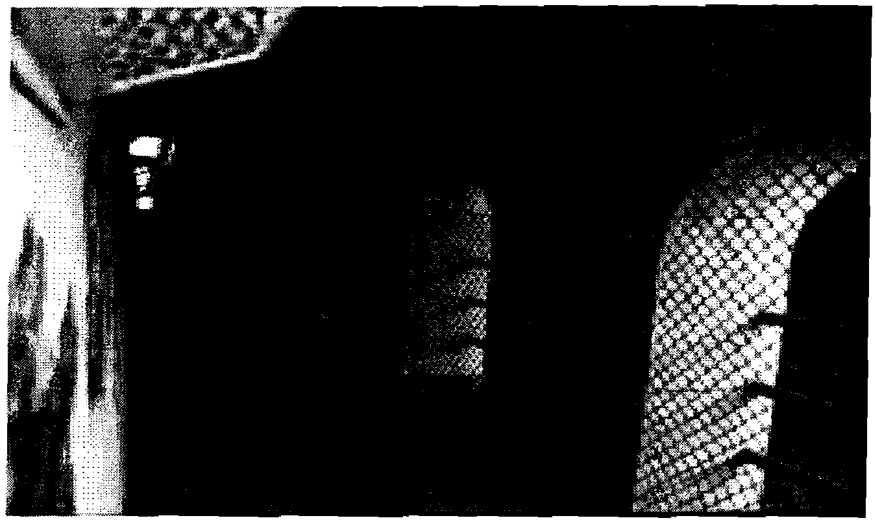
570.2 Railings, Fencing, Barriers

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

Bridges combine function and form. *This Dutch bicycle pedestrian bridge is a structural and architectural work of art. Light, color, shape and separation of movement work in harmony. Center and below: Spokane, Washington converted a railroad bridge to a landmark. For a few bucks more residents for the next century can take delight in the skyline. Note function of decking.*

570.3 Bridges

Bridges designed exclusively for bicycle and pedestrian 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.



570.4 Retrofitting Bridges

Where it is necessary to retrofit a multi-use trail onto an existing highway bridge, several alternatives should be considered in light of what the geometrics of the bridge will allow.

♦ One option is to carry the multi-use trail across the bridge on one side. This should be done where:

♦ The bridge facility will connect to a multi-use trail at both ends,

♦ Sufficient width exists on that side of the bridge or can be obtained by widening or restriping lanes and

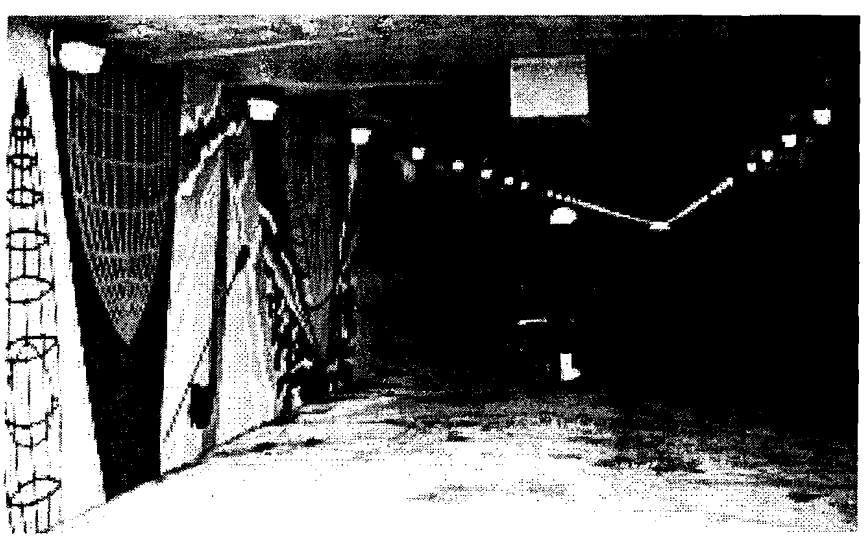
♦ Provisions are made to physically separate bicycle and pedestrian traffic from motor vehicle traffic as discussed above.

A second option is to provide either wide curb lanes or bicycle lanes over the bridge. This may be advisable where:

♦ The multi-use trail transitions into bicycle lanes at one end of the bridge, and

♦ Sufficient width exists or can be obtained by widening or restriping.

Because of the large number of variables involved in retrofitting bicycle facilities onto existing bridges, compromises in desirable design criteria are often inevitable. Therefore, the width to be provided is best



***Dark and Scary Places?** They don't need to be. The rail yard underpass tunnel in Missoula, Montana (above) can be a frightening place. In contrast, the Mercer Island, Washinton tunnel is enjoyed by hundreds of bicyclists a day. The tunnel was built wide enough to get a police cruiser into. The tunnel is monitored by the same staff that monitor the auto tunnel below. Police can be inside the tunnels within minutes. Good lighting, art on the entrance approaches, and the video security have eliminated all graffiti. There has never been an attempted crime in the six years since the tunnel was first opened.*

determined on a case-by-case basis, after thoroughly considering all the variables.

570.5 Tunnels

Tunnels are often considered less successful than bridges for reasons of security, confinement, drainage and other factors. The problems associated with tunnels can often be mitigated in large part by splitting the elevation change with the roadway to be crossed, submerging the tunnel half way and raising the roadway the other half. If a multi-lane highway is being crossed, a skylight can be used to flood the tunnel with light at midsection.

580 - Other Trail Features

581 - Drainage of Trail

The recommended cross slope of 2% adequately provides for drainage. Sloping in one direction instead of crowning is preferred and usually simplifies the drainage and surface construction. A smooth surface is essential to prevent water ponding and ice formation.

581.1 Intercepting Water

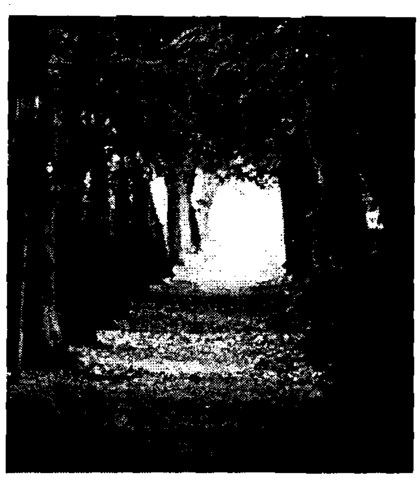
Where a multi-use trail is constructed on the side of a hill, a ditch of suitable dimensions should be placed on the uphill side to intercept the hillside drainage. Such ditches should be designed so that no undue obstacle is presented to bicyclists. Where necessary, catch basins with drains should be provided to carry the intercepted water. Drainage grates and manhole covers should be located outside the travel path of bicyclists. To assist in draining the area adjacent to the multi-use trail, the design should include considerations for preserving the natural ground cover. Seeding, mulching, sodding of adjacent slopes, swales and other erodible areas should be included in the design plans.

582 - Lighting

Fixed-source lighting reduces crashes along multi-use trails and at intersections. In addition, lighting allows the bicyclist to see the trail direction, surface conditions and obstacles. Lighting for multi-use trails is important and should be considered where riding at night is expected. Trails receiving night-time usage commonly serve college students or commuters.

582.1 Intersection Lighting

Lighting is essential at highway/trail intersections. Lighting should also be considered through underpasses or tunnels, and when night-time security could be a problem. Depending on the location, average maintained horizontal



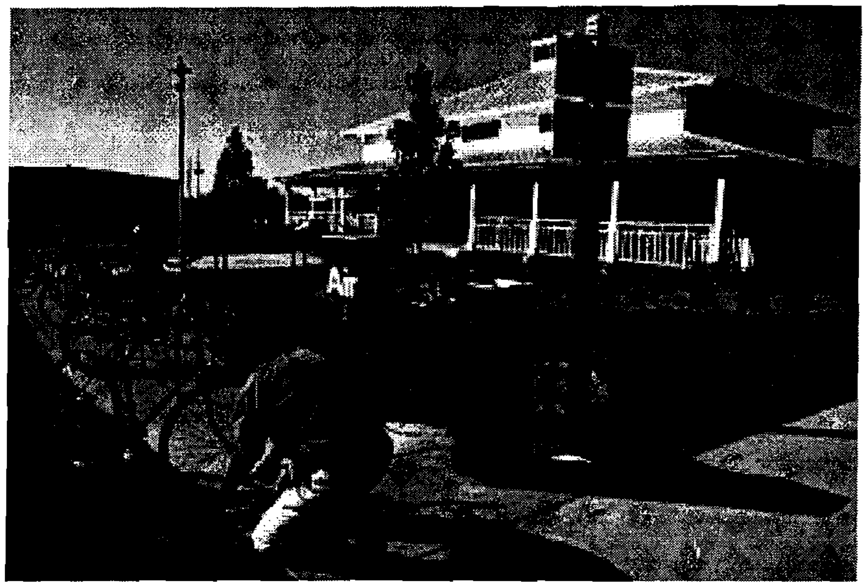
Left: Drainage details are essential. A 32-year old woman became a paraplegic here when her wheel dropped into the channel. By carrying the pipe through the recovery area (AASHTO standard for any roadway) she would have maintained stability. Right: European trail lighting.

Left: Vancouver, Washington development with inset trail lighting.

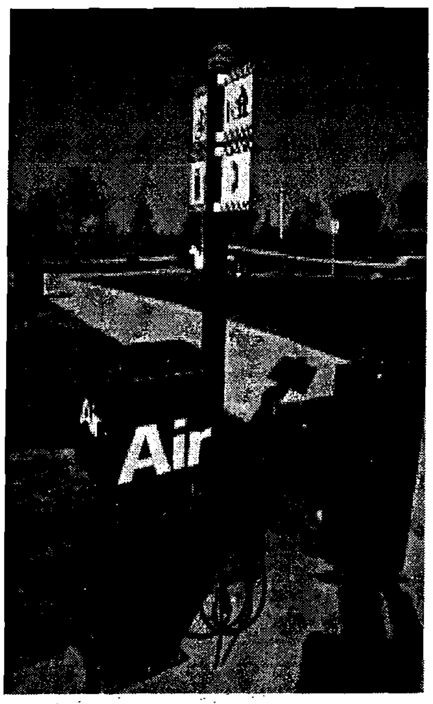
Plenty of Seating Please. *Place seats or benches wherever a sixty-ish person walking your trail would like to rest. Water, restrooms, shady picnic spaces, bike repair shops, telephones, and markers all make more sense after you've walked and ridden your trail a dozen or so times. Provide frequent places to rest (every 400 m). Rest areas are best placed in a combination of scenic spots and near intersections or other activity centers.*

illumination levels of 0.5 to 2.0 foot-candles (5-22 lux) should be considered. Where special security problems exist, higher illumination levels may be considered. Light poles should meet the recommended horizontal and vertical clearances. Luminaries and poles should be at a scale appropriate for a multi-use trail. Lighting should be placed wherever there is signage and accessible electricity. This is particularly important for warning signs. All intersections should be lit far enough back from the intersection in order to allow the bicyclist and motorist enough time to see the intersection and act appropriately. The effect of incidental lighting on the path and on cyclists also needs to be considered. The most common example occurs when a path parallels a road. The lights of

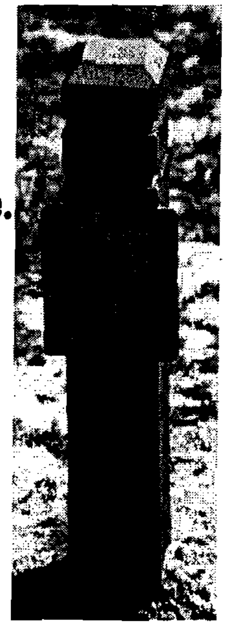
583 - Orange Blossom Trail's "Mother of all Trailheads"

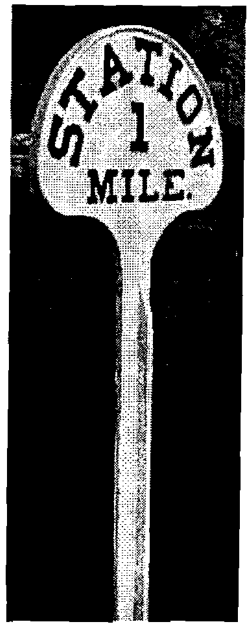


It's the ***"Mother of All Trailsheads"****, claims author Dan Burden. Orlando area designers deserve special praise for thinking through all details, from the shaded southern plantation style porch complete with rocking chairs, to the water bottle spickot on the backside of the drinking fountain, to the porous parking lot for autos, to the nicely worded temporary trail end. It's all there. An inspiration to all present and future trail designers.*

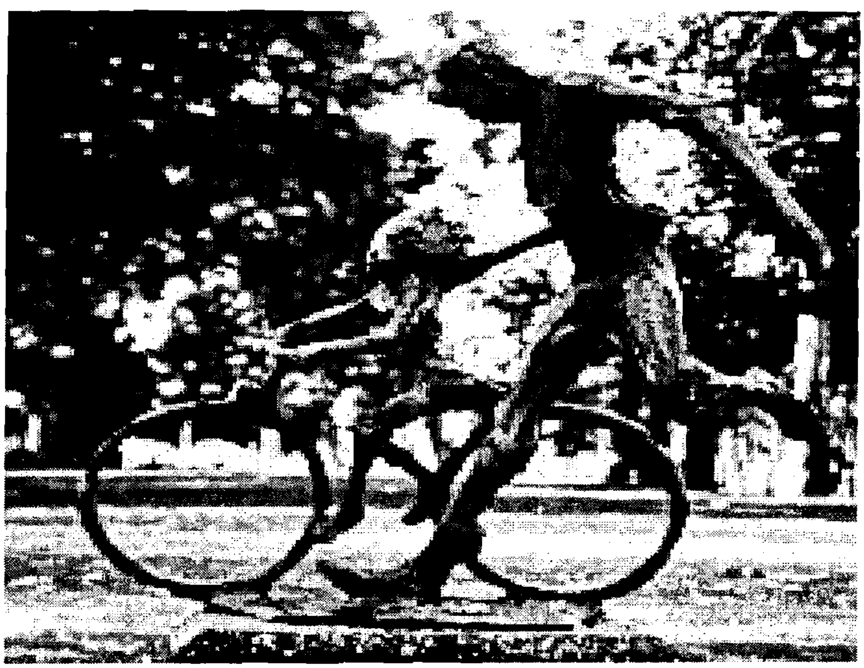


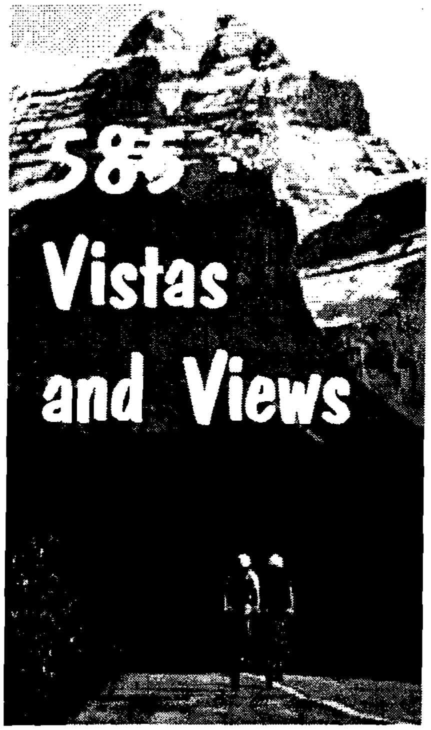
584 - Navigational aids, public art, trash cans and other things of importance.

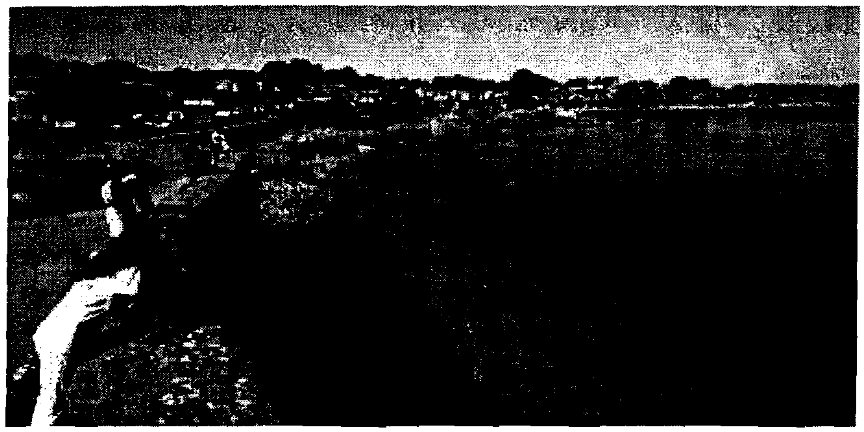


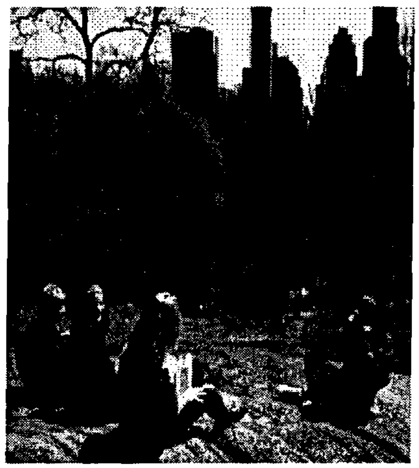


OK....so it doesn't look like a technical manual anymore. We need ways to protect and preserve, to celebrate, to navigate, Public spaces are supposed to be fun, inviting, clean and respectful of the land. There are many details the designer must pay special attention to, including making room for public art, and separating the trash.



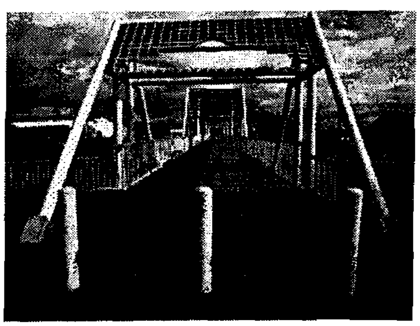


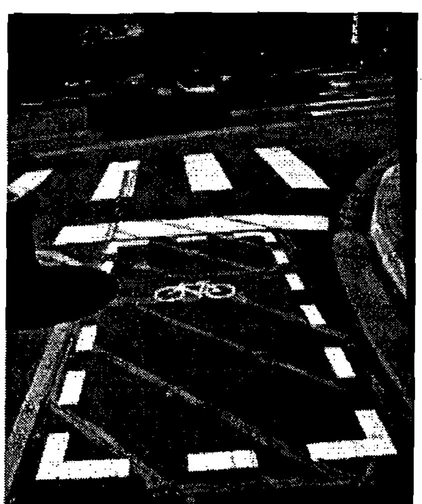




Without the view it's not a trail. It doesn't require mountains or an ocean to be grand -- the plains, waterwas, canals and swamps work just fine. The designer must define protect and preserve places of grandeur. Places like (Upper left, clockwise) (1) Banff National Park, Alberta; (2) Monteray Peninsula, California; (3) Portland, Oregon's Freeway Park, or (4-5) Seattle's Lake Washington (6-7) This majestic view along Santa Barbara, California's coast was paid for and dedicated by adjacent property owners. Center: Central park's many hiking and bike trails offer numerous spots for picnicking and reflecting back on city life.

Avoid Ballords. How did these gouges (above and below) get here? Most likely each scar created scars on the rider. Use signing, tight corners and medians to keep autos out (They don't want to be there anyway). Design them so that emergency vehicles can go over the curbing or over the top.





The lights of oncoming traffic will shine directly on bicyclists. This can cause momentary blindness that is dangerous on a curving path or in the face of oncoming bicycle traffic. In this case low level path lighting is recommended. The designer should keep in mind that in certain areas lighting is prone to high levels of vandalism.

590 - TRAIL HEADS AND REST STOPS

Any long multi-use trail or trail network needs rest stops. These should be at intermediate points, scenic lookouts, or near amenities such as restaurants, convenience stores, beaches, picnic areas, parking lots, etc. Any rest stop should be away from the path so bicyclists can pull off the path and not block traffic. A rest stop should have, at a minimum, a bench, shade, parking rack, and trash receptacle. In addition, water fountains and washroom facilities should be included at one or more rest stops on the pathway.

591- Restriction of Motor Vehicles

Multi-use trails often need some form of signing, curbing, or other physical barrier at highway intersections to prevent unauthorized motor vehicles from using the facilities. When using medians, trail medians, separators or islands, use permanently reflectorized materials for nighttime visibility and paint a bright color for color to improve daytime visibility. Advanced chevron markings and a center line should also be used to alert the bicyclist approaching the intersection. Curbing with tight radii leading up to the roadway can often prevent motorists from attempting to enter the path. Medians should be set back from the intersection 25' (8m) to permit bicyclists to exit the roadway fully before navigating the reduced pathway width.

An alternative method of restricting entry of motor vehicles is to split the entry way into two 5-foot (1.5 m) sections separated by low landscaping. Operators of emergency vehicles know they 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.

592 - Mixed Uses

Bicycles and pedestrians do not mix well in a restricted space. Due to the complexity of mixed-use bicyclist, in-line skaters and other pedestrian movements, separate bicycle and pedestrian paths should be considered as a design option in portions or the full length of a multi-use trail. Otherwise additional width, signing and striping should be used to minimize conflicts.

592.1 Sidewalk Pathways

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

Similarly, pedestrians often have difficulty predicting the direction an oncoming bicyclist will take. At intersections, motorists are not often 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.

Bicyclists riding on sidewalks can be expected in residential areas with young children. With lower bicycle speeds and lower motor vehicle speeds, potential conflicts are somewhat lessened, but they still exist. This type of bicycle sidewalk use is generally accepted, but it is inappropriate to sign a sidewalk as a multi-use trail or bicycle route, if to do so would prohibit bicyclists from using an alternate facility that might better serve their needs.

Commercial district sidewalks pose extreme risk to the bicyclist, pedestrian and motorist. Many communities do not permit such riding. The designer must use care to create alternate bicycling environments such as bicycle lanes or bicycle boulevards. Rear access into shopping plazas and malls also reduces the frequency of bicyclists using commercial sidewalks.

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. Increased speed increases the potential for conflicts with motor vehicles at intersections, as well as with pedestrians and fixed objects.

592.2 Motors Not Permitted

Mopeds are not permitted on multi-use trails. All terrain vehicles and other motorized vehicles are normally kept out by peer pressure (self-policing). New electric bicycles, and any other motor-assisted vehicles are also excluded.

When that is insufficient, cops on bikes, naturalists and others are empowered to enforce the law to prohibit motorized use.

592.3 Equestrians

Using the same trail for bicycles and horses creates an unsatisfactory and possibly dangerous mix. Horses startle easily and may kick out suddenly, if they perceive bicyclists as a danger. A multi-use trail and 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 a less than adequate surface for both. Separate portions of the R-O-W should be used for equestrian needs.

Section 6 600 - Supplemental Facilities, Laws and Operations

601 - Parking

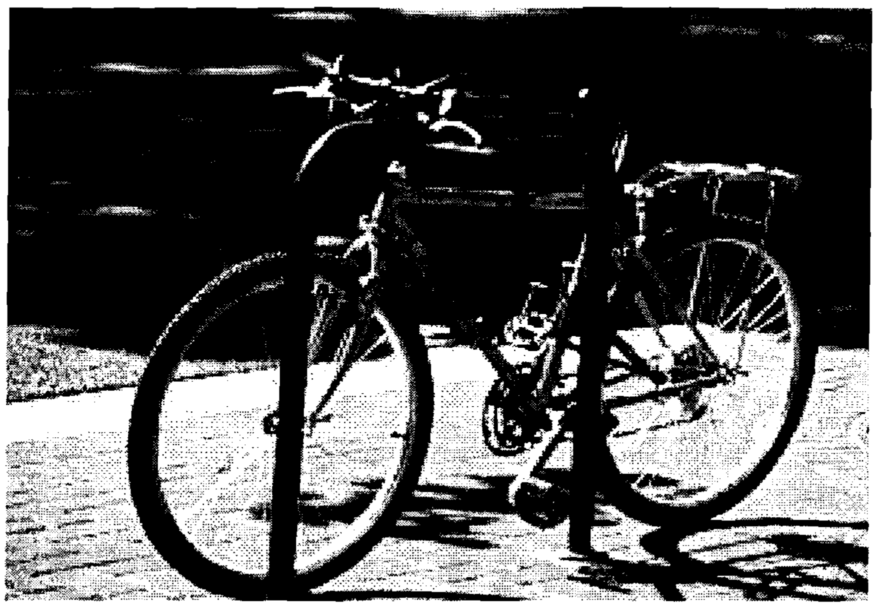
Provision for bicycle parking facilities is perhaps the most important link in a comprehensive bicycle facilities system. This is an essential element in an overall effort to promote bicycling. If parking is not available, the incentive to use bicycles as a means of transportation is seriously undermined.

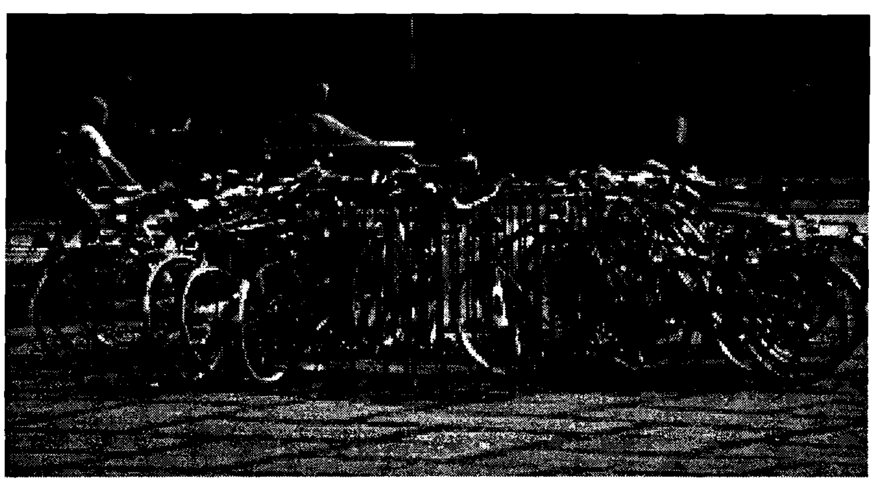
601.1 Need For Parking

Where adequate parking is not provided or properly designed and located, bicyclists will lock their bicycles to the nearest available object, whether it is a tree, a post, a parking meter or a handicap hand-rail. This random parking is undesirable, as it can damage the object, produce bicycle clutter, interrupt the normal pedestrian flow and be potentially dangerous to pedestrians.

Single racks can be simple. One of the best is the simple hitching post, which offers ample locations for locking the bike, or simply resting the bike when seating is nearby.

This Danish circular rack is one of the most space conscious and attractive. Parking should be kept in public view, under lighting when available, and near all rest stops, attractions and scenic views.





601.2 Planning Details

Several factors should be considered when planning and providing bicycle parking facilities:

- Care should be given in selecting bicycle parking locations to ensure that bicycles will not be damaged by motor vehicles.

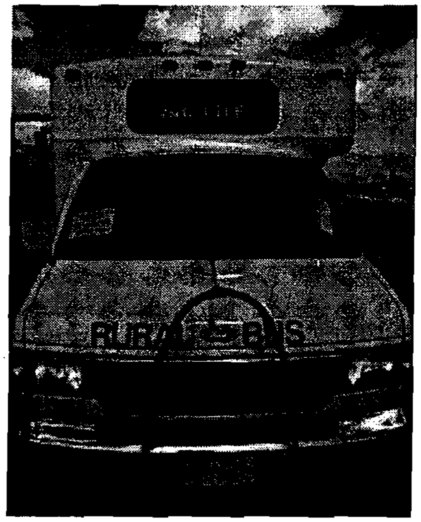
- Facilities should be designed so that people parking their bicycles will not disturb other parked bicycles.

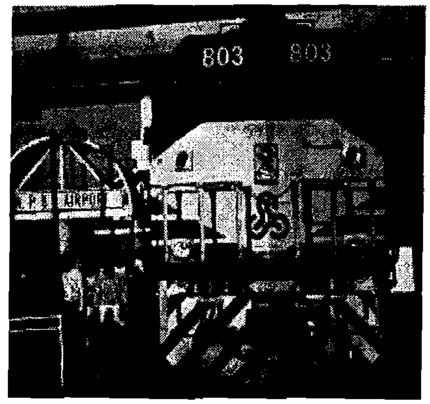
- Facilities should be able to accommodate a wide range of bicycle shapes and sizes including tricycles and trailers if used locally.

- Facilities should be simple to operate. If possible, signs depicting how to operate the facility should be posted.

Bicycle parking facilities should be provided at both the trip origin and trip destination sites and should offer protection from theft, vandalism and other damage. The amount of security needed to prevent theft should be evaluated for each area. Often racks or lockers perform best when in clear view of the main entry where any tampering would be noticed. Racks placed as little as 50 feet (15 m) out of view may go completely unused. Signs should be used to indicate the placement of bicycle parking.

620 - Transit Links, by land and water





Getting There. *Trails work better when you don't need lots of auto parking. Consider a long term investment in land, water, rail and air transportation. Today there are many trails that have limited ways to get there. Even when there are buses or trains, there may not be a way to transport bicycles.*

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 use differ, and will affect their placement and protection.

Long-term parking is needed at locations such as employment centers, transit or subway stations and multi-family dwellings. Facilities should be provided which secure the frame, both wheels, and accessories. These facilities should 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 the main entrance of shopping centers and outside office buildings for visitors and couriers. It is also needed at 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 facilities should be designed so that they will not damage bicycles. Bent rims are common with racks that only support one wheel.

630 - Other Supplementala Facilities

In addition to bicycle parking facilities, there are several other improvements that complement multi-use trails and roadway improvements. For example, on long, uninterrupted multi-use trails, turnouts or rest areas may be provided.

Provisions should be considered for interfacing bicycle travel with public transit. Improvements can include racks on buses, buses converted to carry bicycles aboard, or programs which allow bicycles on rapid rail facilities.

Printing and distributing bicycle route maps is a highly beneficial and relatively 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. In addition, maps can provide information on Rules of the Road, bicycle safety tips, and interfacing with mass transit.

640 - Operation and Maintenance

The agency responsible for the control, maintenance and policing of bicycle facilities should be established prior to construction. Thje 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 increase risk to those who do ride. Trail users should be encouraged to report trails and roadways needing maintenance.

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 a higher level of maintenance than other highways.

For multi-use trails, attention should be given to maintaining the full paved width and not allowing the edges to unravel. 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 multi-use trails should have a regular schedule of mowing. If winter warrants snow removal it should be in the form of plowing, since deicing agents and abrasives can damage bicycles.

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.

650 - LAWS AND OTHER PRINCIPLES

Bicycle programs must reflect applicable state laws and ordinances. Bicycle facilities must not encourage or require bicyclists, pedestrians, or motorists to operate in a manner inconsistent with the adopted rules of the road as described in Chapter 11 of the Uniform Vehicle Code (UVC).

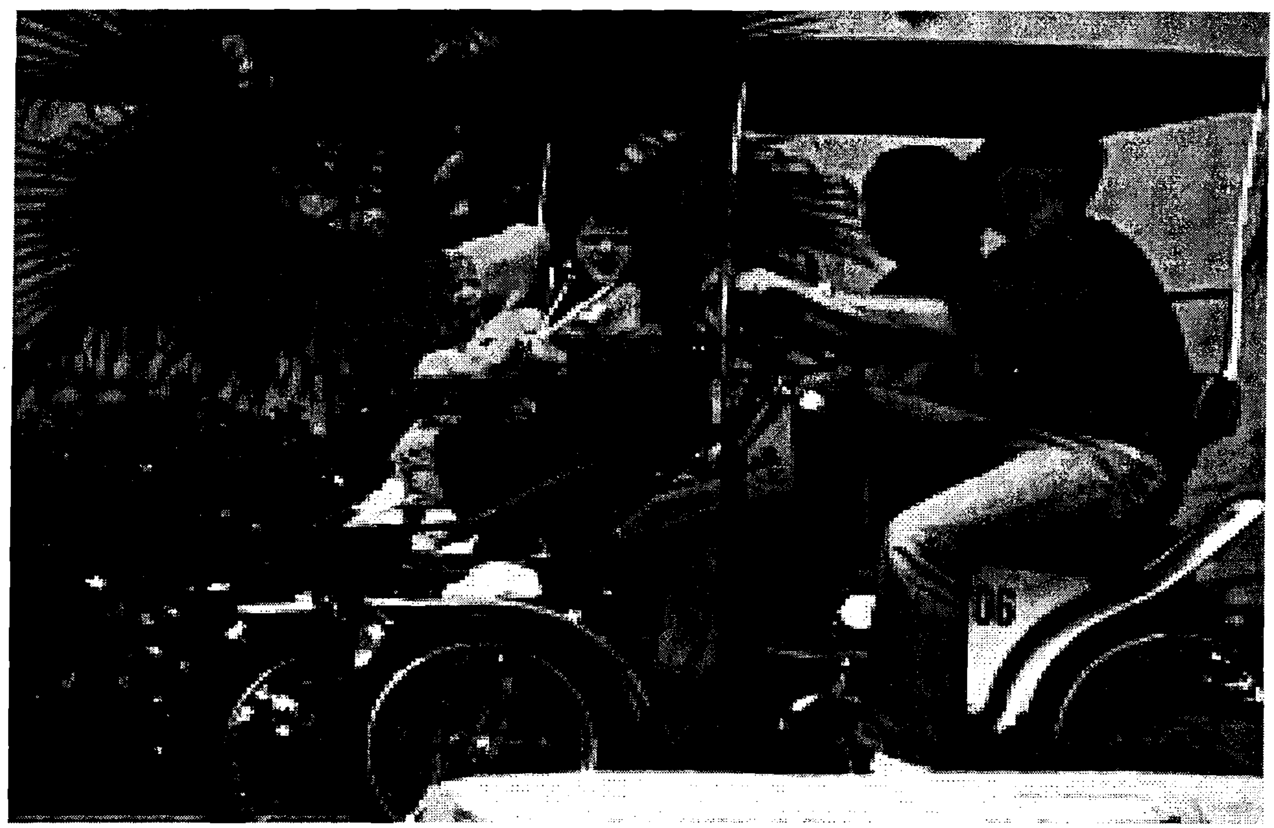
The UVC and state and local laws and ordinances should be reviewed before decisions are made on the type of facilities desired.

The design of trails and bicycling facilities is a relatively young science. A successful trail typically calls for a multi-disciplinary team of engineers, planners, architects, environmentalists, trail users, neighbors and other stakeholders.

Design should be an interactive and fun process. We hope and trust that this guide has given you new ideas and enough basics to advance the state of the art.

Happy Trails!

. . . Dan Burden



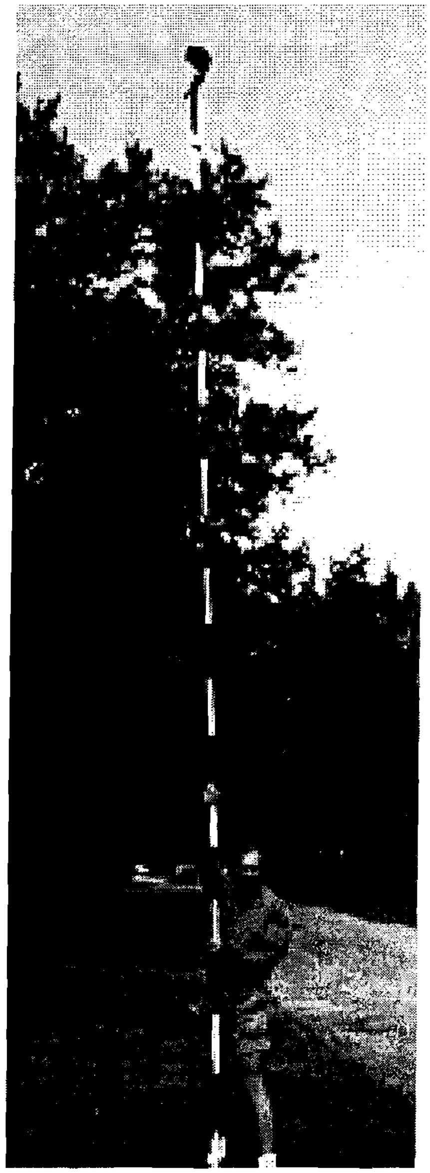
How This Book Was Created

The Writing

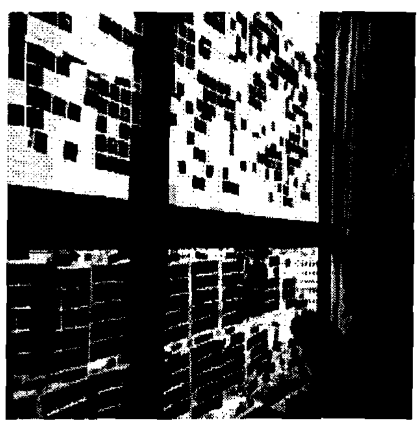
It began on my fiftieth birthday, January, 1994, a gift to myself. I wanted to be true to all who came before me. And so I started by assimilating the well read 1991 AASHTO *Guide For Development of Bicycle Facilities.* I took many thoughts from the Canadian Cycling Associations' *Cycle Planning Manual.* And then, I wrote ideas and images that had accumulated over the years.

The Editing

Pity the 100 or so people I asked to contribute through editing. I have never been a writer. Prolific, but never a writer. More than a dozen of North America's best bicycle facilities planners and designers contributed excellent ideas and helpful criticism. An FDOT task force was formed, which included the State Design Engineer and State Roadway Engineer, a trusted traffic operations engineer, a district coordinator, state trails coordinator, and others. Staff helped condense the editing into one document, and then we began the laborious task of making connected thoughts out of the many. My wife, Lys, worked many dozens of hours doing preliminary and final editing; putting real grammer, flow and style in the document.



Trade secrets. *How to obtain aerials when the boom trucks are asleep. Pictured below, an 80 (24.4 m) square foot light "table" was used.*



The Photography

Then came the fun. I poured through over 67,000 photographs that I had collected over the past fifteen years in 17 countries and nearly all 50 states. I looked for clues of what designs had done well, as well as designs that failed.

During the spring and early summer of 1995 I read and reread nine books that helped me decide what were the most critical visual and verbal statements related to design. This included books like Christopher Alexander's *Pattern Language* and *The Timeless Way of Building.* I bought a super computer (Dell Pentium 90, with 1.85 G of memory, a 4 meg video card, 32 megs of ram and a .26 dot pitch 17" screen). I bought a Polaroid SprintScan 35 slide scanner. I bought and practiced for weeks on Adobe's Photoshop 3.0. I practiced and relearned my Aldus PageMaker 5.0 skills.

The Layout

And then, in a crash 16 day period starting the 4th of July weekend, 1995, I worked nearly round the clock until the final layout was complete. I drew upon my experience as a college yearbook editor, and what I had learned studying under *National Geographic* photo editors. It was fun. What a swell birthday present.

Section 7

Appendix

Contents