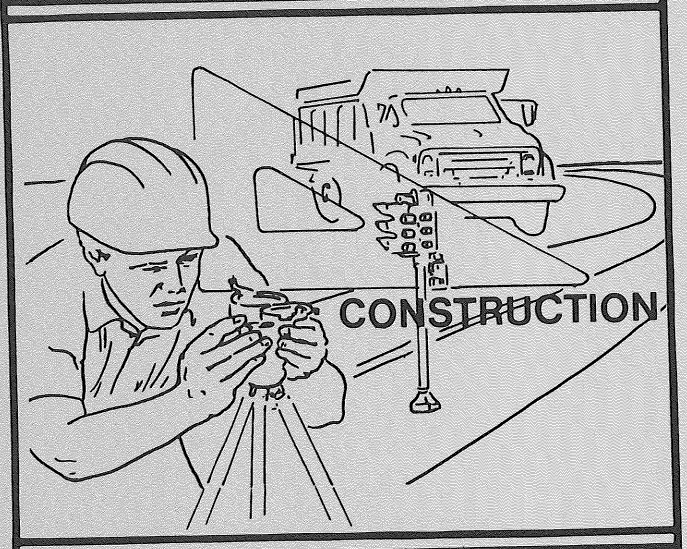

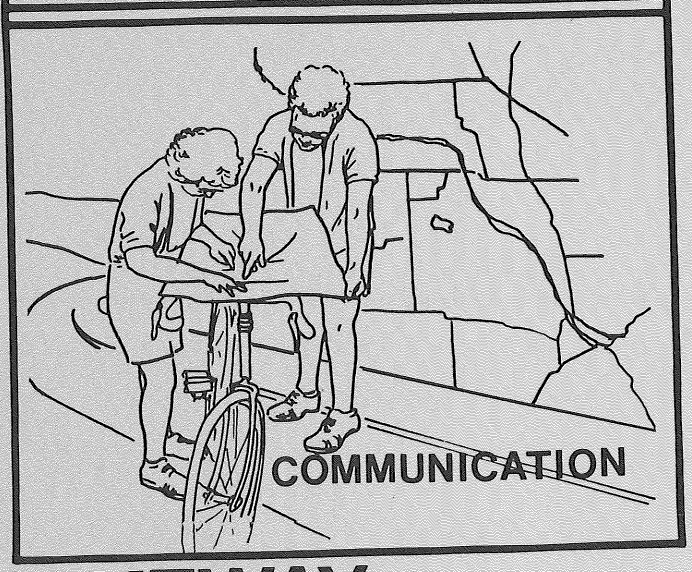

BIKEWAY DESIGN MANUAL

State of Minnesota
Department of Transportation

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I. INTRODUCTION

In order to increase the mileage of public roads that provide an acceptable level of service with available funds and to maximize fully the value of existing roadways for bicyclists, Mn/DOT has adopted bikeway design standards. Because more flexibility is provided, these standards will permit improvements to be made which will result in greater uniformity of highway geometrics over major lengths of roadway. These standards are based on the relationship between the characteristics of the road design (bicycle driving area) to the average daily motorized traffic. Although these bikeway standards have been developed and should be used to the maximum extent possible, as with most engineering projects, the designer should use engineering judgement in the application of the standards.

II. DEFINITIONS

The definition of each of these standards is as follows:

A. RURAL DESIGN BIKEWAY

Rural design refers to any section of public road that has shoulders and ditches. The relationship between the road design and the traffic volume is particularly critical. Shoulder surface and width (in addition to lane width and the number of lanes) are significant factors because shoulders may be the operational area for cyclists by preference (if paved and clear of debris) or serve as an emergency escape lane.

B. MUNICIPAL DESIGN BIKEWAY

Municipal design refers to all other public road sections within corporate limits. A municipal design roadway generally has curb and/or gutter on one or both sides of the road. Bicyclists usually do not have shoulders to ride on and parked vehicles present obstacles. Parking maneuvers, open car doors and the obstruction to vision that a parked car presents, have a negative influence on urban cycling. Therefore, the relationship of the bicycle driving area to traffic takes into account the road design and the design of the parking area (diagonal, parallel, no parking and various combinations).

C. OFF-ROAD BIKEWAYS

An off-road bikeway refers to a travel corridor separated from the road structure, and specifically designed for non-motorized transportation. Bikeways of this design are often times implemented when a roadway cannot be enhanced to an acceptable level, and when a suitable parallel route is not available. Also, this design is often used as a recreational corridor through public lands. The designer should be aware of off-road bikeways in his project study area so as to provide for safe access to and from such facilities relative to his project.

III. DETERMINATION OF APPROPRIATE STANDARD

Determination of the appropriate standard to use on a project, requires three basic evaluations. First, the major section of the route that the proposed project lies within must be identified and evaluated to determine what probable improvements will be made within the foreseeable future. Secondly, the project must take into account the current and anticipated travel needs of the cyclist, land use data and system continuity. Thirdly, the project standards are selected to be compatible with the rest of the major bikeway section.

A. MAJOR BIKEWAY SECTION IDENTIFICATION

A major bikeway section is defined as a principal travel route used by cyclists. A route of this stature is the "backbone" of a bicycling network, which may encompass all three bikeway designs along its length and may serve a significant portion of a community, county, region or have a significant influence on long distance travel. Ideally the design selected could vary minimally to avoid surprising the motoring and cycling public by a change in standards that could result in accidents.

It is not possible to specify the length of a major bikeway section, nor would it serve any beneficial purpose. The length varies depending on the service area of the route and the presence (or lack thereof) of suitable alternate routes. It is critical, however, to understand fully the principal destination of cyclists, and the road design at either end of the project termini, so as to provide a total picture of the travel options available and the impact of project design.

B. EVALUATION OF ROADWAY FOR BICYCLE TRAVEL NEEDS

Once the project termini of the bikeway section have been determined, existing and anticipated conditions may be analyzed. The road under study must be rated (using the appropriate design table) to determine whether or not it is currently providing a safe level of service to the cycling population. If the road is rated "unsatisfactory" or "poor", a similar analysis of parallel routes should be conducted. If there are no suitable parallel routes, it is necessary for the designer to study the options for upgrading this particular section to a "fair" or "good" level.

The second level of study involves transportation planning with the respective agency to determine land use proposals, principal travel trends and the population served by the proposed project. Project termini should

render a logical "beginning" and "ending". Due to limited funds the opportunity may or may not present itself to complete a desired link at a later date.

1. Determine appropriate standard

a. No build - The no-build option would be used when:

– the present road design and traffic volume render an acceptable service level ("good" or "fair" rank)

– the service area is comparatively limited (although the section under study may rank "poor" or "unsatisfactory")

– an acceptable parallel road or off-road bikeway is available to the majority of the same destinations as the section under study.

b. Minimal level - An investment of this nature would provide either better communication to travelers through the signing of an acceptable route or through the placement of special informational signs to cyclists; or through the construction of a bituminous shoulder of relative dimension to the inplace aggregate shoulder (not less than 4' unless under extenuating circumstances). The minimal level of effort generally should be avoided if it renders less than a fair rating unless geometrics and financing of the project prohibit such a design. Generally speaking projects constructed at minimal level render a travel corridor of greater perceived safety -- this design should be the exception to the standard whereby the objective is a fair rating.

c. Moderate level - The moderate level standard would render a "fair" rating without major alteration to the existing road geometrics/drainage structure, etc. This standard is the norm, whereby the achievement of a "fair" rating would produce a travel corridor acceptable to the average cyclist's skills and needs. Motorized traffic along roads rated fair mix well with non-motorized traffic through the implementation of this standard.

d. Major level - Often times projects involving the entire roadway (i.e., new road construction, overlay projects, etc.) should take into account the travel needs of cyclists. The review process is the same as presented previously (i.e., road analysis, parallel suitable routes, service areas) yet the problem of retrofitting a provision for bikeways is not present. As with all transportation investments, a thorough investigation must be conducted to determine how to best serve the traveling public with available funds.

2. Evaluate the probability of implementing the proposed project. The probability of implementing the project should be studied in conjunction with those agencies and local units of government directly impacted. Construction schedules should be flexible, yet provide enough guidance to the implementing agency to provide for a well-coordinated operation. Therefore, the designer and administrator responsible for the project should require input from all affected parties at an early stage of project development to avoid last minute decision-making.

3. Evaluate the probability of implementing adjacent improvements. The probability of implementing the improvements on the rest of the major bikeway segment should then be evaluated. A rough estimate of the cost to accomplish these improvements should be made. Then considering the severity of the deficiencies compared to the need for improvements on other roads (and off-road bikeways) and considering the probable long-range funding capability, a decision should be made on whether or not these desirable improvements are likely to be accomplished in the foreseeable future.

C. MINOR ROUTE EVALUATION

A minor route is a road or off-road bikeway that serves as a tributary to the major bikeway route. The service area is significant at a local level, and serves to support the principal travel corridor. Minor routes function as collectors from cities, parks, commercial/residential areas to the major bikeway system. Normally minor routes are existent "good" or "fair" roads, however if these routes are rated "poor" or "unsatisfactory", the design should not exceed the present or proposed standards of the major bikeway route design (or desired design).

Because there are several combinations of conditions that will be encountered when evaluating proposed projects, it is important for the designer to get the "big picture" of the proposed project area and surrounding vicinity to provide design continuity (an acceptable level of standards at a minimum cost).

(1) Ideally the standards used should produce a uniformly consistent "rating" level while minimizing the variance in design so as to not confuse motorists or cyclists. Anticipation and predictability of the design of a travel corrridor often times can minimize the potential for accidents.

(2) All crossings of public roadways should be done at intersections at specially marked areas. This is a particular concern when designing off-road bikeways because of the lack of driver reaction time to an unexpected cyclist maneuver.

IV. BIKEWAY DESIGN TABLES

The first step in the evaluation of a proposed project is an analysis of the road design and the volume of motor vehicles (ADT). The following tables provide the designer with an understanding of his present situation and enables him to progress to determine design options. Depending upon the review of the service area, the probability of project implementation, review of abutting section, and funding, the appropriate design level can be determined. In the tables:

– Road sections currently rated "good" or "fair" will generally not be eligible for shoulder or off-road construction.

– If a suitable parallel road or off-road bikeway exists, funding from Mn/DOT will be denied.

– Off-road design will be considered if shoulder construction cannot enhance the road to "good" or "fair" status.

V. DESIGN CRITERIA

A. DESIGN SPEED

Curvature, superelevation, gradient and width of traveled way are geometric features which affect the speed at which a bicyclist can travel safely and with comfort. In addition, factors such as traffic, the type of bicycle, physical condition of the rider, wind, surface condition, also affect the speed the cyclist will travel. Although speed of over 30 mph is attainable, the average cyclist travels at much lower speeds.

Speed bumps intended to cause cyclists to slow down in advance of intersections etc. shall not be used because they may cause a cyclist to fall and result in injuries. The design speed is normally determined by the speed of the highway or street. These design speeds are generally adequate for cyclist's use.

For off-road bikeways, the design speed should be 20 mph. For long downgrades, longer than 500 feet and steeper than 4 percent, a design speed of 30 mph should be used at the downhill end.

B. CURVATURE

On-road bikeways will have curvature as dictated by the highway. Since these curves are designed to accommodate motor vehicles, they are generally adequate for bicyclists.

For off-road bikeways, the minimum radius of curvature must be consistent with the design speed of the facility. The following design values are applicable where only standard cross-slope (.02 foot per foot) is provided:

Design Speed mph	Design Radius feet
10	15
15	35
20	70
25	90
30	125

Where more than standard cross-slope is provided see Figure A for curve radii.

C. SUPERELEVATION

As with curvature, superelevation on shared roadway facilities the highway superelevation or shoulder slope will govern and be more than adequate for cyclists.

However, with off-road bikeways, some superelevation should be provided on all curves, .05 foot per foot should be used as the general design value and .02 foot per foot as the absolute minimum value (the minimum rate of cross slope required for drainage). In some cases, a rate of superelevation greater than .05 foot per foot may be advantageous; however, pedal clearance must be considered when increased super is used. A straight .02 foot per foot cross slope is recommended for tangent sections.

D. GRADES

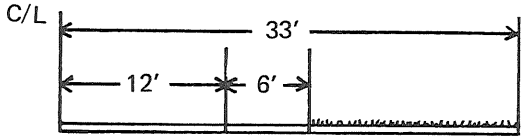
The grade which a bicycle can be expected to negotiate is dependent upon the length of the grade, characteristics of the bicyclist (age, weight, condition, etc.), characteristics of the bicycle (type of cycle, gear ratios, weight, tires, etc.), wind velocity, air resistance and road surface. As all of these determinants are variable, it is not possible to specify definite design grades. Generally speaking, the amount of energy required to use a bicycle route will affect the usage of the route and, thus, grades should be kept to a minimum.

The grade for on-road bikeways is generally adequate for cyclists, with little or no room for design change since it is a part of the road structure.

Desirably, a grade of 5% should not be longer than 100 feet and a grade of 2% should not be longer than 500 feet. Grades of 5% for over 300 feet and 2% for over 1,500 feet should be avoided. Grades should be minimized even at the expense of having to provide added curvature or travel distance, within the practical limits for the site. The designer is offered some latitude in selecting profile grades for off-road bikeways but this is not the case for on-road bikeways.

USING THE BIKEWAY DESIGN TABLES

To evaluate the suitability of a road for bicycle transportation:



- Refer to appropriate table (Rural, 2 way, undivided).
- Locate thru lane width column (12').
- Locate shoulder surface and width line (⩾ 4' unpaved).
- Enter ADT value to determine the suitability of the road for bicycle transportation.

To attain a rating of "Fair", locate ADT value in "Fair" column, and correlate this information with the shoulder surface and width design. In this example, a design of 4' paved shoulders would be required to provide a "Fair" rating.

If a "Fair" rating cannot be attained, further research may be necessary to assess alternative suitable parallel routes or an off-road bikeway.

Rural Design 2 WAY/UNDIVIDED

shoulder surface and width	10' thru lane width							11' thru lane width							12' thru lane width						
	GOOD	G/F	FAIR	F/P	POOR	P/U	UN-SAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UN-SAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UN-SAT.
⩽ 3' unpaved	⩽ 252 ADT	253 ADT	254 – 417 ADT	418 – 423 ADT	424 – 580 ADT	581 – 592 ADT	⩾ 593 ADT	⩽ 315 ADT	316 – 317 ADT	318 – 521 ADT	522 – 529 ADT	530 – 725 ADT	726 – 740 ADT	⩾ 741 ADT	⩽ 378 ADT	379 – 380 ADT	381 – 625 ADT	626 – 634 ADT	635 – 870 ADT	871 – 888 ADT	⩾ 889 ADT
⩾ 4' unpaved	⩽ 302 ADT	303 – 304	305 – 500	501 – 507	508 – 696	697 – 711	⩾ 712	⩽ 378	379 – 380	381 – 625	626 – 634	635 – 870	871 – 888	⩾ 889	⩽ 453	454 – 457	458 – 750	751 – 761	762 – 1044	1045 – 1066	⩾ 1067
⩽ 3' paved	⩽ 1585 ADT	1586 – 1599	1600 – 2625	2626 – 2666	2667 – 3653	3654 – 3733	⩾ 3734	⩽ 1982	1983 – 1999	2000 – 3282	3283 – 3333	3334 – 4566	4567 – 4666	⩾ 4667	⩽ 2378	2379 – 2399	2400 – 3938	3939 – 3999	4000 – 5479	5480 – 5599	⩾ 5600
4' paved	⩽ 1812 ADT	1813 – 1828	1829 – 3000	3001 – 3047	3048 – 4174	4175 – 4266	⩾ 4267	⩽ 2265	2266 – 2285	2286 – 3750	3751 – 3809	3810 – 5218	5219 – 5333	⩾ 5334	⩽ 2717	2718 – 2742	2743 – 4500	4501 – 4571	4572 – 6261	6262 – 6399	⩾ 6400
5' paved	⩽ 1898 ADT	1899 – 1916	1917 – 3244	3245 – 3298	3299 – 4661	4662 – 4776	⩾ 4777	⩽ 2372	2373 – 2395	2396 – 4055	4056 – 4123	4124 – 5826	5827 – 5970	⩾ 5971	⩽ 2846	2847 – 2874	2875 – 4865	4866 – 4948	4949 – 6991	6992 – 7164	⩾ 7165
6' paved	⩽ 1992 ADT	1993 – 2012	2013 – 3530	3531 – 3595	3596 – 5275	5276 – 5423	⩾ 5424	⩽ 2490	2491 – 2515	2516 – 4412	4413 – 4494	4495 – 6594	6595 – 6779	⩾ 6780	⩽ 2988	2989 – 3018	3019 – 5295	5296 – 5393	5394 – 7913	7914 – 8135	⩾ 8136
7' paved	⩽ 2097 ADT	2098 – 2119	2120 – 3871	3872 – 3950	3951 – 6076	6077 – 6274	⩾ 6275	⩽ 2621	2622 – 2649	2650 – 4839	4840 – 4938	4939 – 7595	7596 – 7843	⩾ 7844	⩽ 3145	3146 – 3178	3179 – 5807	5808 – 5925	5926 – 9114	9115 – 9411	⩾ 9412
8' paved	⩽ 2212 ADT	2213 – 2237	2238 – 4286	4287 – 4383	4384 – 7165	7166 – 7441	⩾ 7442	⩽ 2765	2766 – 2797	2798 – 5380	5381 – 5479	5480 – 8956	8957 – 9302	⩾ 9303	⩽ 3318	3319 – 3356	3357 – 6429	6430 – 6575	6576 – 10,747	10,748 – 11,162	⩾ 11,163
9' paved	⩽ 2342 ADT	2343 – 2370	2371 – 4800	4801 – 4923	4924 – 8728	8729 – 9142	⩾ 9143	⩽ 2927	2928 – 2962	2963 – 6000	6001 – 6153	6154 – 10,910	10,911 – 11,428	⩾ 11,429	⩽ 3513	3514 – 3555	3556 – 7200	7201 – 7384	7385 – 13,091	13,092 – 13,714	⩾ 13,715
10' paved	⩽ 2488 ADT	2489 – 2519	2520 – 5455	5456 – 5614	5615 – 11,163	11,164 – 11,851	⩾ 11,852	⩽ 3109	3110 – 3149	3150 – 6819	6820 – 7017	7018 – 13,954	13,955 – 14,814	⩾ 14,815	⩽ 3731	3732 – 3779	3780 – 8182	8183 – 8421	8422 – 16,745	16,746 – 17,777	⩾ 17,778

Rural Design 2 WAY/UNDIVIDED

10' thru lane width

shoulder surface and width	GOOD	G/F	FAIR	F/P	POOR	P/U	UN-SAT.
≤3' unpaved	≤ 252 ADT	253 ADT	254–417 ADT	418–423– ADT	424–580 ADT	581–592 ADT	≥ 593 ADT
≥4' unpaved	≤ 302 ADT	303–304	305–500	501–507	508–696	697–711	≥ 712
≤3' paved	≤ 1585 ADT	1586–1599	1600–2625	2626–2666	2667–3653	3654–3733	≥ 3734
4' paved	≤ 1812 ADT	1813–1828	1829–3000	3001–3047	3048–4174	4175–4266	≥ 4267
5' paved	≤ 1898 ADT	1899–1916	1917–3244	3245–3298	3299–4661	4662–4776	≥ 4777
6' paved	≤ 1992 ADT	1993–2012	2013–3530	3531–3595	3596–5275	5276–5423	≥ 5424
7' paved	≤ 2097 ADT	2098–2119	2120–3871	3872–3950	3951–6076	6077–6274	≥ 6275
8' paved	≤ 2212 ADT	2213–2237	2238–4286	4287–4383	4384–7165	7166–7441	≥ 7442
9' paved	≤ 2342 ADT	2343–2370	2371–4800	4801–4923	4924–8728	8729–9142	≥ 9143
10' paved	≤ 2488 ADT	2489–2519	2520–5455	5456–5614	5615–11,163	11,164–11,851	≥11,852

11' thru lane width

shoulder surface and width	GOOD	G/F	FAIR	F/P	POOR	P/U	UN-SAT.
≤3' unpaved	≤ 315 ADT	316–317 ADT	318–521 ADT	522–529 ADT	530–725 ADT	726–740 ADT	≥ 741 ADT
≥4' unpaved	≤ 378	379–380	381–625	626–634	635–870–	871–888	≥ 889
≤3' paved	≤ 1982	1983–1999	2000–3282	3283–3333	3334–4566	4567–4666	≥ 4667
4' paved	≤ 2265	2266–2285	2286–3750	3751–3809	3810–5218	5219–5333	≥ 5334
5' paved	≤ 2372	2373–2395	2396–4055	4056–4123	4124–5826	5827–5970	≥ 5971
6' paved	≤ 2490	2491–2515	2516–4412	4413–4494	4495–6594	6595–6779	≥ 6780
7' paved	≤ 2621	2622–2649	2650–4839	4840–4938	4939–7595	7596–7843	≥ 7844
8' paved	≤ 2765	2766–2797	2798–5380	5381–5479	5480–8956	8957–9302	≥ 9303
9' paved	≤ 2927	2928–2962	2963–6000	6001–6153	6154–10,910	10,911–11,428	≥11,429
10' paved	≤ 3109	3110–3149	3150–6819	6820–7017	7018–13,954	13,955–14,814	≥14,815

12' thru lane width

shoulder surface and width	GOOD	G/F	FAIR	F/P	POOR	P/U	UN-SAT.
≤3' unpaved	≤ 378 ADT	379–380 ADT	381–625 ADT	626–634 ADT	635–870 ADT	871–888 ADT	≥889 ADT
≥4' unpaved	≤ 453	454–457	458–750	751–761	762–1044	1045–1066	≥1067
≤3' paved	≤ 2378	2379–2399	2400–3938	3939–3999	4000–5479	5480–5599	≥ 5600
4' paved	≤ 2717	2718–2742	2743–4500	4501–4571	4572–6261	6262–6399	≥ 6400
5' paved	≤ 2846	2847–2874	2875–4865	4866–4948	4949–6991	6992–7164	≥7165
6' paved	≤ 2988	2989–3018	3019–5295	5296–5393	5394–7913	7914–8135	≥8136
7' paved	≤ 3145	3146–3178	3179–5807	5808–5925	5926–9114	9115–9411	≥9412
8' paved	≤ 3318	3319–3356	3357–6429	6430–6575	6576–10,747	10,748–11,162	≥11,163
9' paved	≤ 3513	3514–3555	3556–7200	7201–7384	7385–13,091	13,092–13,714	≥13,715
10' paved	≤ 3731	3732–3779	3780–8182	8183–8421	8422–16,745	16,746–17,777	≥17,778

Rural Design 2 WAY/DIVIDED

shoulder surface and width		10' thru lane width							11' thru lane width							12' thru lane width						
		GOOD	G/F	FAIR	F/P	POOR	P/U	UN-SAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UN-SAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UN-SAT.
⩽ 3′	unpaved	⩽ 511 ADT	512 – 515 ADT	516 – 855 ADT	856 – 868 ADT	869 – 1202 ADT	1203 – 1228 ADT	⩾ 1229 ADT	⩽ 639 ADT	640 – 644 ADT	645 – 1069 ADT	1070 – 1085 ADT	1086 – 1502 ADT	1503 – 1536 ADT	⩾ 1537 ADT	⩽ 767 ADT	768 – 773 ADT	774 – 1283 ADT	1284 – 1302 ADT	1303 – 1802 ADT	1803 – 1843 ADT	⩾ 1844 ADT
⩾4′	unpaved	⩽ 614 ADT	615 – 618	619 – 1026	1027 – 1042	1043 – 1442	1443 – 1474	⩾ 1475	⩽ 767	768 – 773	774 – 1283 –	1284 – 1302	1303 – 1802	1803 – 1843	⩾ 1844	⩽ 920	921 – 928	929 – 1539	1540 – 1563	1564 – 2163	2164 – 2211	⩾ 2212
⩽ 3′	paved	⩽ 3244 ADT	3245 – 3274	3275 – 5455	5456 – 5544	5545 – 7707	7708 – 7887	⩾ 7888	⩽ 4055	4056 – 4093	4094 – 6819	6820 – 6930	6931 – 9634	9635 – 9859	⩾ 9860	⩽ 4865	4866 – 4912	4913 – 8182	8183 – 8316	8317 – 11,560	11,561 – 11,830	⩾11,831
4′	paved	⩽ 3707 ADT	3708 – 3742	3743 – 6234	6235 – 6336	6337 – 8808	8809 – 9014	⩾ 9015	⩽ 4634	4635 – 4678	4679 – 7793	7794 – 7920	7921 – 11,010	11,011 – 11,267	⩾ 1,268	⩽ 5560	5561 – 5614	5615 – 9351	9352 – 9504	9505 – 13,211	13,212 – 13,521	13,522
5′	paved	⩽ 3887 ADT	3888 – 3926	3927 – 6761	6762 – 6881	6882 – 9897	9898 – 10,158	⩾10,159	⩽ 4859	4860 – 4907	4908 – 8451	8452 – 8602	8603 – 12,372	12,373 – 12,698	⩾12,699	⩽ 5830	5831 – 5889	5890 – 10,141	10,142 – 10,322	10,323 – 14,846	14,847 – 15,238	⩾15,239
6′	paved	⩽ 4086 ADT	4087 – 4129	4130 – 7385	7386 – 7529	7530 – 11,295	11,296 – 11,636	⩾11,637	⩽ 5107	5108 – 5161	5162 – 9231	9232 – 9411	9412 – 14,118	14,119 – 14,545	⩾14,546	⩽ 6128	6129 – 6193	6194 – 11,077	11,078 – 11,294	11,295 – 16,942	16,943 – 17,454	⩾17,455
7′	paved	⩽ 4305 ADT	4306 – 4353	4354 – 8136	8137 – 8311	8312 – 13,151	13,152 – 13,617	⩾13,618	⩽ 5382	5383 – 5442	5443 – 10,170	10,171 – 10,389	10,390 – 16,439	16,440 – 17,021	⩾17,022	⩽ 6458	6459 – 6530	6531 – 12,204	12,205 – 12,467	12,468 – 19,727	19,728 – 20,425	⩾20,426
8′	paved	⩽ 4550 ADT	4551 – 4604	4605 – 9057	9058 – 9275	9276 – 15,738	15,739 – 16,410	⩾16,411	⩽ 5688	5689 – 5755	5756 – 11,321	11,322 – 11,594	11,595 – 19,673	19,674 20,512	⩾20,513	⩽ 6825	6826 – 6906 –	6907 – 13,585	13,586 – 13,913	13,914 – 23,607	23,608 – 24,615	⩾24,616
9′	paved	⩽ 4825 ADT	4826 – 4885	4886 – 10,213	10,214 – 10,491	10,492 – 19,592	19,593 – 20,645	⩾20,646	⩽ 6031	6032 – 6106	6107 – 12,766	12,767 – 13,114	13,115 – 24,490	24,491 – 25,806	⩾25,807	⩽ 7237	7238 – 7328	7329 – 15,320	15,321 – 15,737	15,738 – 29,388	29,389 – 30,967	⩾30,968
10′	paved	⩽ 5134 ADT	5135 – 5203	5204 – 11,708	11,709 – 12,075	12,076 – 25,946	25,947 – 27,826	⩾27,827	⩽ 6418	6419 – 6504	6505 – 14,635	14,636 – 15,094	15,095 – 32,433	32,434 – 34,782	⩾34,783	⩽ 7701	7702 – 7804	7805 – 17,561	17,562 – 18,113	18,114 – 38,919	38,920 – 41,739	⩾41,740

Municipal Design: 2 LANE/2 WAY/UNDIVIDED

Parking Use		10' thru lane width							11' thru lane width							12' thru lane width						
		GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.
	N-N	⩽ 1133 ADT	1134–1142 ADT	1143–1875 ADT	1876–1904 ADT	1905–2609 ADT	2610–2666 ADT	⩾ 2667 ADT	⩽ 1416 ADT	1417–1428 ADT	1429–2344 ADT	2345–2380 ADT	2381–3261 ADT	3262–3333 ADT	⩾ 3334 ADT	⩽ 1699 ADT	1700–1714 ADT	1715–2813 ADT	2814–2857 ADT	2858–3914 ADT	3915–3999 ADT	4000 ADT
	P-N	⩽ 1110 ADT	1111–1119	1120–1838	1839–1866	1867–2557	2558–2613	⩾ 2614	⩽ 1387	1388–1399	1400–2297	2298–2333	2334–3196	3197–3266	⩾ 3277	⩽ 1665	1666–1679	1680–2757	2758–2799	2800–3835	3836–3919	⩾ 3920
	P-P	⩽ 1087 ADT	1088–1097	1098–1800	1801–1828	1829–2505	2506–2559	⩾ 2560	⩽ 1359	1360–1371	1372–2250	2251–2285	2286–3131	3132–3199	⩾ 3200	⩽ 1631	1632–1645	1646–2700	2701–2742	2743–3757	3758–3839	⩾ 3840
	D-N	⩽ 1087 ADT	1088–1097	1098–1800	1801–1828	1829–2505	2506–2559	⩾ 2560	⩽ 1359	1360–1371	1372–2250	2251–2285	2286–3131	3132–3199	⩾ 3200	⩽ 1631	1632–1645	1646–2700	2701–2742	2743–3757	3758–3839	⩾ 3840
	P-D	⩽ 1065 ADT	1066–1074	1075–1763	1764–1790	1791–2453	2454–2506	⩾ 2507	⩽ 1331	1332–1342	1343–2204	2205–2238	2239–3066	3067–3133	⩾ 3134	⩽ 1597	1598–1611	1612–2644	2645–2685	2686–3679	3680–3759	⩾ 3760
	D-D	⩽ 1042 ADT	1043–1051	1052–1725	1726–1752	1753–2400	2401–2453	⩾ 2454	⩽ 1302	1303–1314	1315–2157	2158–2190	2191–3000	3001–3066	⩾ 3067	⩽ 1563	1564–1577	1578–2588	2589–2628	2629–3600	3601–3679	⩾ 3680

N-N: No parking either side
P-N: Parallel parking one side, no parking one side
P-P: Parallel parking both sides
D-N: Diagonal parking one side, no parking one side
P-D: Parallel parking one side, diagonal parking one side
D-D: Diagonal parking both sides.

Municipal Design: 2 LANE/2 WAY/DIVIDED

Parking Use	10' thru lane width							11' thru lane width							12' thru lane width						
	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.
N-N	< 2317 ADT	2318 – 2339 ADT	2340 – 3897 ADT	3898 – 3960 ADT	3961 – 5505 ADT	5506 – 5633 ADT	> 5634 ADT	< 2896 ADT	2897 – 2923 ADT	2924 – 4871 ADT	4872 – 4950 ADT	4951 – 6881 ADT	6882 – 7042 ADT	> 7043 ADT	< 3475 ADT	3476 – 3508 ADT	3509 – 5845 ADT	5846 – 5940 ADT	5941 – 8257 ADT	8258 – 8450 ADT	> 8451 ADT
P-N	< 2271 ADT	2272 – 2292	2293 – 3819	3820 – 3881	3882 – 5395	5396 – 5521	> 5522	< 2838	2839 – 2865	2866 – 4773	4774 – 4851	4852 – 6744	6745 – 6901	> 6902	< 3406	3407 – 3438	3439 – 5728	5729 – 5821	5822 – 8092	8093 – 8281	> 8282
P-P																					
D-N	< 2224 ADT	2225 – 2245	2246 – 3741	3742 – 3801	3802 – 5285	5286 – 5408	> 5409	< 2780	2781 – 2807	2808 – 4676	4677 – 4752	4753 – 6606	6607 – 6760	> 6761	< 3336	3337 – 3368	3369 – 5611	5612 – 5702	5703 – 7927	7928 – 8112	> 8113
P-D																					
D-D																					

N-N: No parking either side
P-N: Parallel parking one side, no parking one side
P-P: Parallel parking both sides
D-N: Diagonal parking one side, no parking one side
P-D: Parallel parking one side, diagonal parking one side
D-D: Diagonal parking both sides.

Municipal Design: 2 LANE/1 WAY

Parking Use		10' thru lane width							11' thru lane width							12' thru lane width						
		GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.
	N-N	⩽ 1186 ADT	1187 – 1197 ADT	1198 – 2028 ADT	2029 – 2061 ADT	2062 – 2913 ADT	2914 – 2985 ADT	⩾ 2986 ADT	⩽ 1483 ADT	1484 – 1497 ADT	1498 – 2534 ADT	2535 – 2577 ADT	2578 – 3641 ADT	3642 – 3731 ADT	⩾ 3732 ADT	⩽ 1779 ADT	1780 – 1796 ADT	1797 – 3041 ADT	3042 – 3092 ADT	3093 – 4369 ADT	4370 – 4477 ADT	⩾ 4478 ADT
	P-N	⩽ 1163 ADT	1164 – 1173	1174 – 1987	1988 – 2020	2021 – 2855	2856 – 2925	⩾ 2926	⩽ 1453	1454 – 1467	1468 – 2484	2485 – 2525	2526 – 3568	3569 – 3656	⩾ 3657	⩽ 1744	1745 – 1760	1761 – 2980	2981 – 3030	3031 – 4282	4283 – 4388	⩾ 4389
	P-P	⩽ 1139 ADT	1140 – 1149	1150 – 1946	1947 – 1979	1980 – 2797	2798 – 2865	⩾ 2866	⩽ 1423	1424 – 1437	1438 – 2433	2434 – 2474	2475 – 3496	3497 – 3582	⩾ 3583	⩽ 1708	1709 – 1724	1725 – 2919	2920 – 2969	2970 – 4195	4196 – 4298	⩾ 4299
	D-N	⩽ 1139 ADT	1140 – 1149	1150 – 1946	1947 – 1979	1980 – 2797	2798 – 2865	⩾ 2866	⩽ 1423	1424 – 1437	1438 – 2433	2434 – 2474	2475 – 3496	3497 – 3582	⩾ 3583	⩽ 1708	1709 – 1724	1725 – 2919	2920 – 2969	2970 – 4195	4196 – 4298	⩾ 4299
	P-D	⩽ 1115 ADT	1116 – 1125	1126 – 1906	1907 – 1938	1939 – 2738	2739 – 2805	⩾ 2806	⩽ 1394	1395 – 1407	1408 – 2382	2383 – 2422	2423 – 3423	3424 – 3507	⩾ 3508	⩽ 1672	1673 – 1688	1689 – 2859	2860 – 2907	2908 – 4107	4108 – 4208	⩾ 4209
	D-D	⩽ 1091 ADT	1092 – 1101	1102 – 1865	1866 – 1896	1897 – 2680	2681 – 2746	⩾ 2747	⩽ 1364	1365 – 1377	1378 – 2332	2333 – 2371	2372 – 3350	3351 – 3432	⩾ 3433	⩽ 1637	1638 – 1652	1653 – 2798	2799 – 2845	2846 – 4020	4021 – 4119	⩾ 4120

N-N: No parking either side
P-N: Parallel parking one side, no parking one side
P-P: Parallel parking both sides
D-N: Diagonal parking one side, no parking one side
P-D: Parallel parking one side, diagonal parking one side
D-D: Diagonal parking both sides.

Municipal Design: 3 LANE/1 WAY

Parking Use	10' thru lane width							11' thru lane width							12' thru lane width						
	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.
N-N	⩽ 1868 ADT	1869–1886 ADT	1887–3309 ADT	3310–3370 ADT	3371–4946 ADT	4947–5084 ADT	⩾ 5085 ADT	⩽ 2335 ADT	2336–2358 ADT	2359–4137 ADT	4138–4213 ADT	4214–6182 ADT	6183–6355 ADT	⩾ 6356 ADT	⩽ 2801 ADT	2802–2830 ADT	2831–4964 ADT	4965–5056 ADT	5057–7418 ADT	7419–7627 ADT	⩾ 7628 ADT
P-N	⩽ 1830 ADT	1831–1849	1850–3243	3244–3303	3304–4847	4848–4983	⩾ 4984	⩽ 2288	2289–2311	2312–4054	4055–4129	4130–6058	6059–6228	⩾ 6229	⩽ 2745	2746–2773	2774–4864	4865–4955	4956–7270	7271–7474	⩾ 7475
P-P	⩽ 1793 ADT	1794–1811	1812–3177	3178–3235	3236–4748	4749–4881	⩾ 4882	⩽ 2241	2242–2264	2265–3971	3972–4044	4045–5935	5936–6101	⩾ 6102	⩽ 2689	2690–2716	2717–4765	4766–4853	4854–7121	7122–7322	⩾ 7323
D-N	⩽ 1793 ADT	1794–1811	1812–3177	3178–3235	3236–4748	4749–4881	⩾ 4882	⩽ 2241	2242–2264	2265–3971	3972–4044	4045–5935	5936–6101	⩾ 6102	⩽ 2689	2690–2716	2717–4765	4766–4853	4854–7121	7122–7322	⩾ 7323
P-D	⩽ 1756 ADT	1757–1773	1774–3111	3112–3168	3169–4649	4650–4779	⩾ 4780	⩽ 2194	2195–2216	2217–3888	3889–3960	3961–5811	5812–5974	⩾ 5975	⩽ 2633	2634–2660	2661–4666	4667–4752	4753–6973	6974–7169	⩾ 7170
D-D	⩽ 1718 ADT	1719–1735	1736–3045	3046–3101	3102–4550	4551–4677	⩾ 4678	⩽ 2148	2149–2169	2170–3806	3807–3876	3877–5687	5688–5847	⩾ 5848	⩽ 2577	2578–2603	2604–4567	4568–4651	4652–6825	6826–7016	⩾ 7017

N-N: No parking either side
P-N: Parallel parking one side, no parking one side
P-P: Parallel parking both sides
D-N: Diagonal parking one side, no parking one side
P-D: Parallel parking one side, diagonal parking one side
D-D: Diagonal parking both sides.

Municipal Design: 4 LANE/ 2 WAY/ UNDIVIDED

Parking Use	10' thru lane width							11' thru lane width							12' thru lane width						
	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.
N-N	⩽ 2317 ADT	2318 – 2339 ADT	2340 – 3897 ADT	3898 – 3960 ADT	3961 – 5505 ADT	5506 – 5633 ADT	⩾ 5634 ADT	⩽ 2896 ADT	2897 – 2923 ADT	2924 – 4871 ADT	4872 – 4950 ADT	4951 – 6881 ADT	6882 – 7042 ADT	⩾ 7043 ADT	⩽ 3475 ADT	3476 – 3508 ADT	3509 – 5845 ADT	5846 – 5940 ADT	5941 – 8257 ADT	8258 – 8450 ADT	⩾ 8451 ADT
P-N	⩽ 2271 ADT	2272 – 2292	2293 – 3819	3820 – 3881	3882 – 5395	5396 – 5521	⩾ 5522	⩽ 2838	2839 – 2865	2866 – 4773	4774 – 4851	4852 – 6744	6745 – 6901	⩾ 6902	⩽ 3406	3407 – 3438	3439 – 5728	5729 – 5821	5822 – 8092	8093 – 8281	⩾ 8282
P-P	⩽ 2224 ADT	2225 – 2245	2246 – 3741	3742 – 3801	3802 – 5285	5286 – 5408	⩾ 5409	⩽ 2780	2781 – 2807	2808 – 4676	4677 – 4752	4753 – 6606	6607 – 6760	⩾ 6761	⩽ 3336	3337 – 3368	3369 – 5611	5612 – 5702	5703 – 7927	7928 – 8112	⩾ 8113
D-N	⩽ 2224 ADT	2225 – 2245	2246 – 3741	3742 – 3801	3802 – 5285	5286 – 5408	⩾ 5409	⩽ 2780	2781 – 2807	2808 – 4676	4677 – 4752	4753 – 6606	6607 – 6760	⩾ 6761	⩽ 3336	3337 – 3368	3369 – 5611	5612 – 5702	5703 – 7927	7928 – 8112	⩾ 8113
P-D	⩽ 2178 ADT	2179 – 2198	2199 – 3663	3664 – 3722	3723 – 5175	5176 – 5295	⩾ 5296	⩽ 2723	2724 – 2748	2749 – 4578	4579 – 4653	4654 – 6468	6469 – 6619	⩾ 6620	⩽ 3267	3268 – 3298	3299 – 5494	5495 – 5584	5585 – 7762	7763 – 7943	⩾ 7944
D-D	⩽ 2132 ADT	2133 – 2152	2153 – 3585	3586 – 3643	3644 – 5065	5066 – 5183	⩾ 5184	⩽ 2665	2666 – 2690	2691 – 4481	4482 – 4554	4555 – 6331	6332 – 6478	⩾ 6479	⩽ 3197	3198 – 3328	3329 – 5377	5378 – 5465	5466 – 7597	7598 – 7774	⩾ 7775

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P-N: Parallel parking one side, no parking one side
P-P: Parallel parking both sides
D-N: Diagonal parking one side, no parking one side
P-D: Parallel parking one side, diagonal parking one side
D-D: Diagonal parking both sides.

Municipal Design: 4 LANE/ 2 WAY/DIVIDED

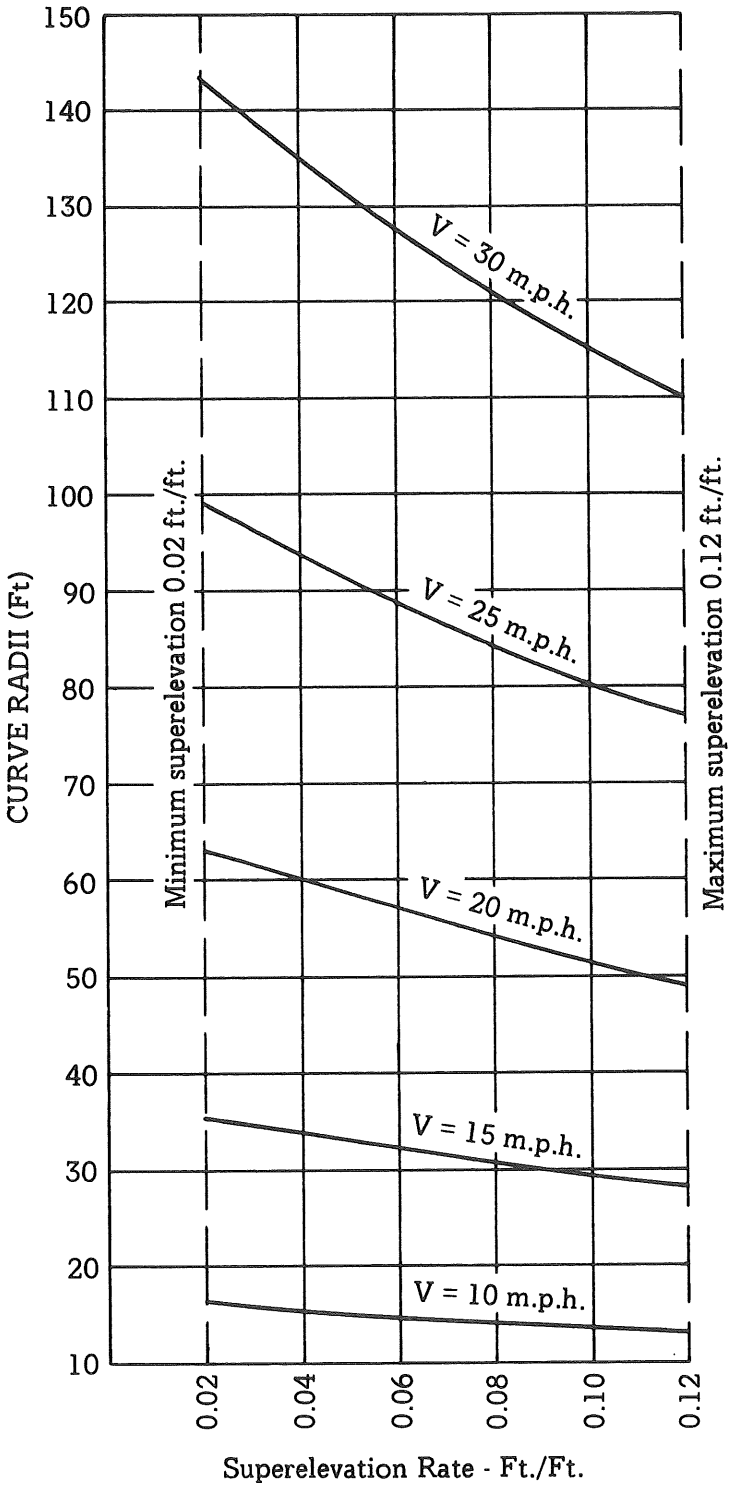
Parking Use	10' thru lane width							11' thru lane width							12' thru lane width						
	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.
N-N	⩽4744 ADT	4745–4790 ADT	4791–8109 ADT	8110–8247 ADT	8248–11,651 ADT	11,652–11,940 ADT	⩾11,941 ADT	⩽5929 ADT	5930–5988 ADT	5989–10,136 ADT	10,137–10,309 ADT	10,310–14,564 ADT	14,565–14,925 ADT	⩾14,926 ADT	⩽7115 ADT	7116–7185 ADT	7186–12,163 ADT	12,164–12,371 ADT	12,372–17,476 ADT	17,477–17,910 ADT	17,911 ADT
P-N	⩽4645 ADT	4646–4690	4691–7940	7941–8075	8076–11,408	11,409–11,691	⩾11,692	⩽5806	5807–5863	5864–9924	9925–10,094	10,095–14,260	14,261–14,614	⩾14,615	⩽6967	6968–7035	7036–11,909	11,910–12,113	12,114–17,112	17,113–17,537	⩾17,538
P-P																					
D-N	⩽4554 ADT	4555–4598	4599–7784	7785–7917	7918–11,185	11,186–11,462	⩾11,463	⩽5692	5693–5748	5749–9730	9731–9896	9897–13,981	13,982–14,328	⩾14,329	⩽6831	6832–6898	6899–11,676	11,677–11,876	11,877–16,777	16,778–17,194	⩾17,195
P-D																					
D-D																					

N-N: No parking either side
P-N: Parallel parking one side, no parking one side
P-P: Parallel parking both sides
D-N: Diagonal parking one side, no parking one side
P-D: Parallel parking one side, diagonal parking one side
D-D: Diagonal parking both sides.

Municipal Design: 4 LANE/ 1 WAY/DIVIDED

Parking Use		10' thru lane width							11' thru lane width							12' thru lane width						
		GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.	GOOD	G/F	FAIR	F/P	POOR	P/U	UNSAT.
	N-N	⩽2554 ADT	2555–2580 ADT	2581–4616 ADT	4617–4705 ADT	4706–7059 ADT	7060–7272 ADT	⩾7273 ADT	⩽3192 ADT	3193–3225 ADT	3226–5770 ADT	5771–5882 ADT	5883–8824 ADT	8825–9090 ADT	⩾9091 ADT	⩽3830 ADT	3831–3870 ADT	3871–6924 ADT	6925–7058 ADT	7059–10,589 ADT	10,590–10,909 ADT	⩾10,910 ADT
	P-N	⩽2503 ADT	2504–2529	2530–4524	4525–4611	4612–6918	6919–7127	⩾7128	⩽3128	3129–3161	3162–5654	5655–5764	5765–8648	8649–8909	⩾8910	⩽3754	3755–3793	3794–6785	6786–6917	6918–10,377	10,378–10,690	⩾10,691
	P-P	⩽2452 ADT	2453–2477	2478–4431	4432–4517	4518–6777	6778–6981	⩾6982	⩽3064	3065–3096	3097–5539	5540–5647	5648–8471	8472–8727	⩾8728	⩽3677	3678–3716	3717–6647	6648–6776	6777–10,165	10,166–10,472	⩾10,473
	D-N	⩽2452 ADT	2453–2477	2478–4431	4432–4517	4518–6777	6778–6981	⩾6982	⩽3064	3065–3096	3097–5539	5540–5647	5648–8471	8472–8727	⩾8728	⩽3677	3678–3716	3717–6647	6648–6776	6777–10,165	10,166–10,472	⩾10,473
	P-D	⩽2400 ADT	2401–2425	2426–4339	4340–4423	4424–6636	6637–6836	⩾6837	⩽3000	3001–3032	3033–5424	5425–5529	5530–8295	8296–8545	⩾8546	⩽3600	3601–3638	3639–6508	6509–6635	6636–9953	9954–10,254	⩾10,255
	D-D	⩽2349 ADT	2350–2374	2375–4247	4248–4329	4330–6495	6496–6690	⩾6691	⩽2937	2938–2967	2968–5308	5309–5411	5412–8118	8119–8363	⩾8364	⩽3524	3525–3561	3562–6370	6371–6494	6495–9742	9743–10,036	⩾10,037

N-N: No parking either side
P-N: Parallel parking one side, no parking one side
P-P: Parallel parking both sides
D-N: Diagonal parking one side, no parking one side
P-D: Parallel parking one side, diagonal parking one side
D-D: Diagonal parking both sides.



plot of: $\frac{V^2}{gR} = \frac{\tan \theta + f}{1 - f \tan \theta}$

Where: V = velocity, ft./sec.
g = acceleration due to gravity, ft./sec.^{2}
R = radius of curvature, ft.
f = coefficient of friction on dry pavement = 0.4 (based on maximum 20° lean)
$\tan \theta$ = superelevation rate, ft./ft.

Figure A

CURVE RADII AND SUPERELEVATIONS

E. SIGHT DISTANCE

To insure safe and efficient operation, bicycle facilities should be designed so that adequate sight distance is provided for safe stopping, on crest vertical curves and horizontal curves.

1. Safe Stopping Sight Distance

Design values for stopping sight distance may be computed in the same manner as for a highway. Generally, there is no problem in attaining adequate stopping sight distances on bicycle lanes and shared roadways because the roadway alignment usually has been designed to accommodate motor vehicle speed that are equal to or greater than bicycle speeds. There are exceptions, however, and the stopping sight distance factor should be checked in locating such bicycle facilities.

STOPPING SIGHT DISTANCE
FOR DOWNHILL GRADES

Design Speed mph	Grade (%) 0% feet	5% feet	10% feet	15% feet
10	50	50	60	70
15	85	90	100	130
20	130	140	160	200
25	175	200	230	300
30	230	260	310	400

These values are based on a coefficient of skid resistance of 0.25, perception-reaction time of 2.5 seconds, height of eye of 3.75 feet and an object height of 6 inches. The height of an adult bicyclist's eye will normally be greater than 3.75 feet but a lower object may be pertinent.

2. Sight Distance at Crest Vertical Curves

In order to provide a better sense of bikeway continuity and riding quality, the use of vertical curves is recommended where changes in grade are encountered. Sight distances at grade crests can be checked using the following equations:

$$L = \frac{AS^2}{750} \quad \text{when } S < L$$

$$L = 2S - \frac{750}{A} \quad \text{when } S > L$$

Where S = sight distance in feet (based on design speed)
L = length of vertical curve (in feet)
A = algebraic difference in grades in percent

The equations are based on a height of eye of 3.75 feet and a height of object of zero inches. A minimum height of object is used here because such things as gravel on a surface can be dangerous to a cyclist.

Figure B gives sight distance values for various vertical curve lengths, algebraic differences in grade and speed.

3. Sight Distance at Horizontal Curves

Where a high embankment or wall is on the inside of a curve the sight distance for a bicyclist may not be sufficient. To check the horizontal sight distance for bicyclist, the bicycle has to be positioned 6 feet further to the right than a motor vehicle. Figure C provides values and formulas for sight distance on horizontal curves.

F. WIDTHS AND CLEARANCES

The surfaced or operating width required for a bikeway is one of the primary considerations of design.

The minimum dimensions should include space required for the cyclist, allowance for lateral clearance to obstructions, and allowance for clearance to other hazards. The typical bicycle and rider dimensions are given in Figure D. In addition to the physical space taken up by the bicycle and rider the following maneuvering allowances and clearances are generally accepted:

Type of Clearance	Desirable Distance feet
Maneuvering Allowance	
– handlebars to edge (for wobble)	1.0
– between bicycles (regardless of direction)	2.5
– between bicycles and pedestrians	2.5
– between bicycles and motor vehicles	4.0 (minimum)
Lateral Clearance (static obstructions)	
– parked cars	2.0
– curb drop-off	2.0
– utility poles, trees, hydrants, fences, railings, etc.	2.0
– soft shoulders	1.5
– sloped drop-off	1.0
– raised curb	1.0
Vertical Clearances	8.5 (10' desirable)

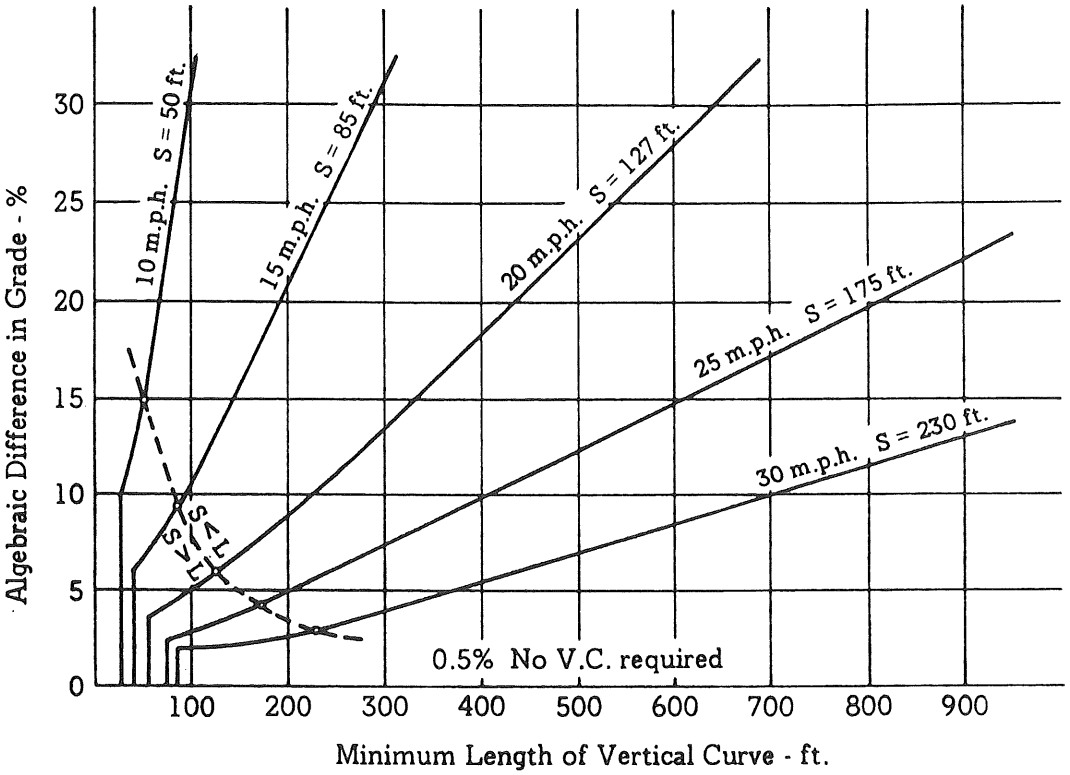
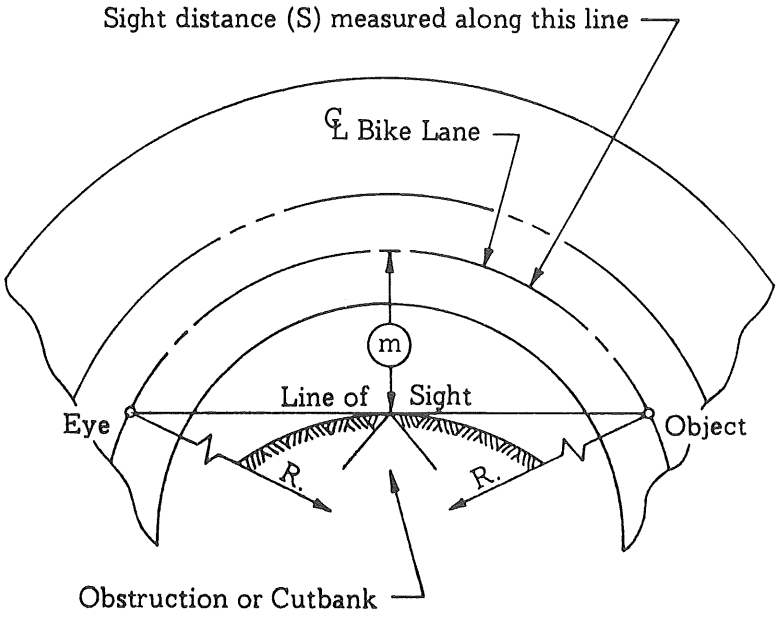


Figure B

SIGHT DISTANCES FOR CREST VERTICAL CURVES



S = Sight distance in feet
R = Radius of ℄ inside lane in feet
M = Distance from ℄ inside lane in feet
V = Design speed for S in M.P.H.

Angle is expressed in degrees

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

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

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

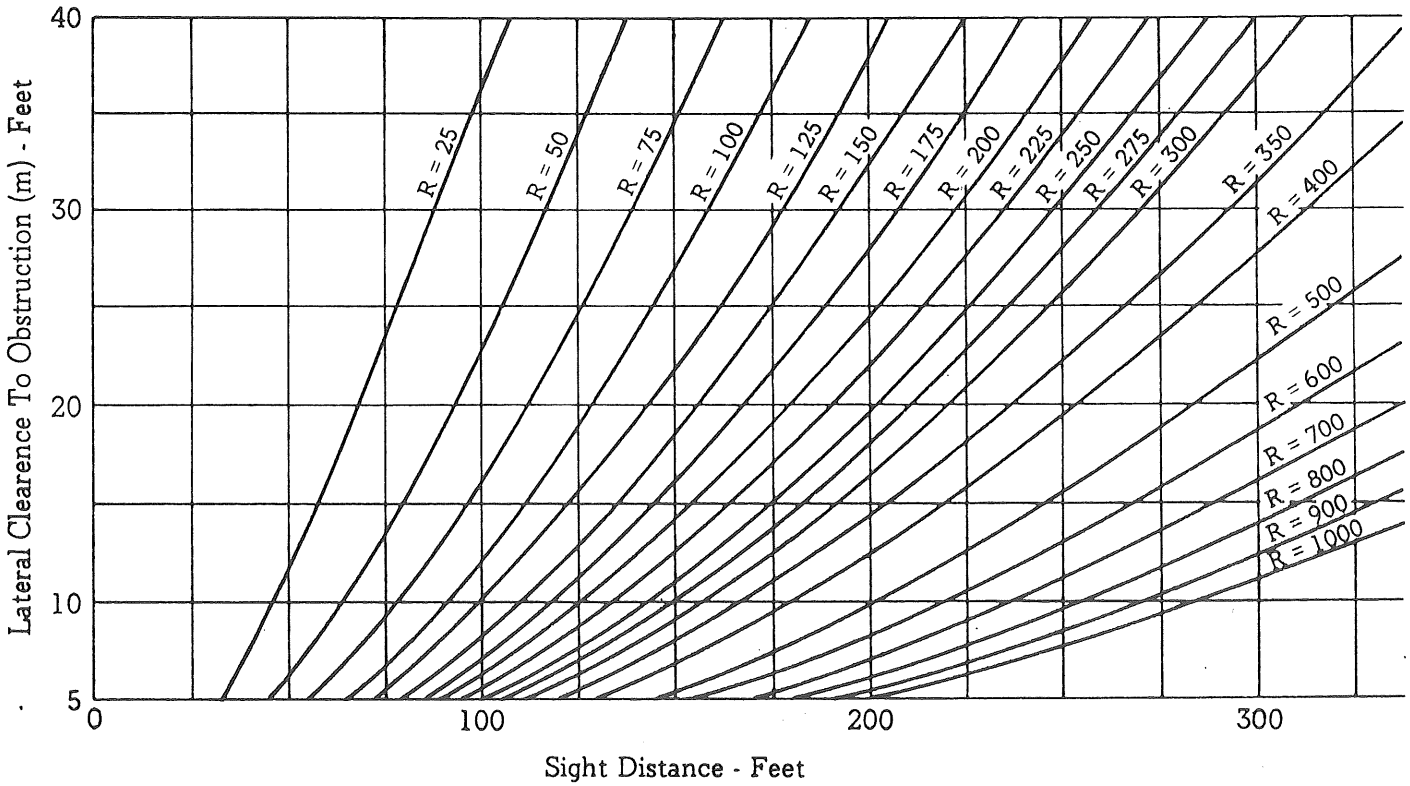
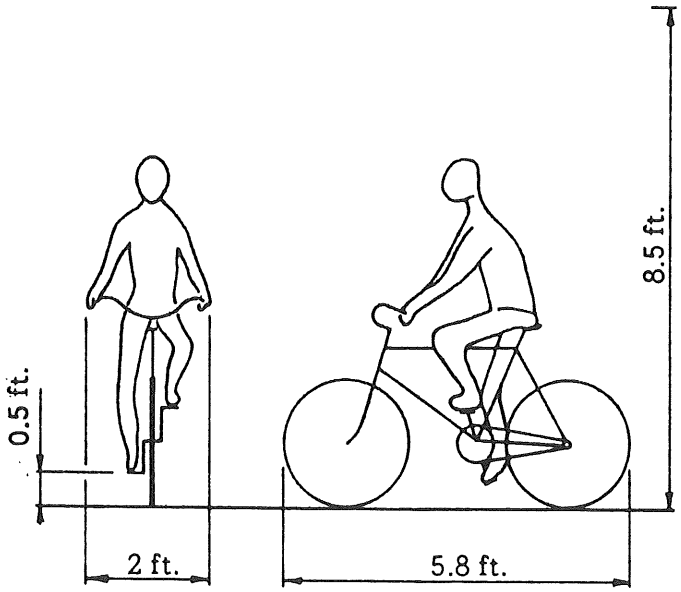


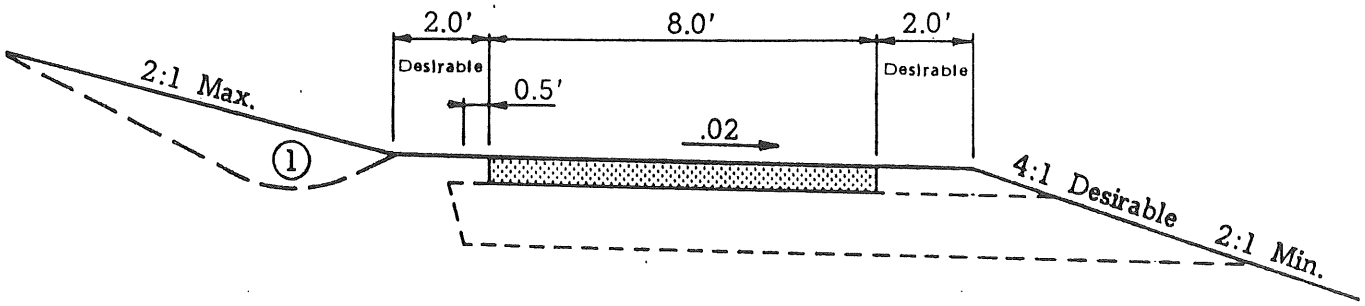
Figure C

LATERAL CLEARANCES ON HORIZONTAL CURVES



TYPICAL BICYCLE & RIDER DIMENSIONS	
CHARACTERISTICS	DIMENSION (Feet)
Width	2.00 (handlebar width)
Length	5.75
Height	7.40 minimum
Vertical Pedal Clearance	0.50

FIGURE D



(1) Ditch if required for drainage

NOTE:
The bikeway width should be maintained across bridges and through underpasses.

FIGURE E

1. On road

Bicycle travel shall be in the same direction as adjacent motor vehicle traffic in compliance with the uniform vehicle code. A minimum width and lateral clearance will depend on the location of the lane within the roadway and parking conditions. The bikeway design tables provide widths for various roadway conditions. The gutter section of a curb and gutter should normally not be considered as a part of the bicycle lane since the joint between the gutter and roadway surface can be very hazardous to a cyclist.

2. Off-road Bikeways

The cross section of an off-road bikeway can be determined from the widths and clearances presented. The minimum widths based on the number of lanes are as follows:

Number of Lanes	Minimum Paved Width feet
1	4.0
2	8.0

In addition, a minimum two foot graded area on each side of the bikeway should be provided adjacent to the paved surface. See Figure E on page 27. It should be emphasized that the minimum width and clearances are for bicycle needs and are not sufficient to accommodate maintenance and emergency vehicles (pickups, mowers, ambulances, etc.). Accordingly, the minimums may have to be adjusted, as necessary, to provide for these considerations. In addition to the widths provided above, additional widths should be provided for sharp curves and where steeper grades are necessary. On steep grades, additional width is necessary due to increased speed and needed room for maneuverability. On sharp curves, less than 100 foot radius, additional width may be needed due to bicycle lean. The following values are recommended for widening:

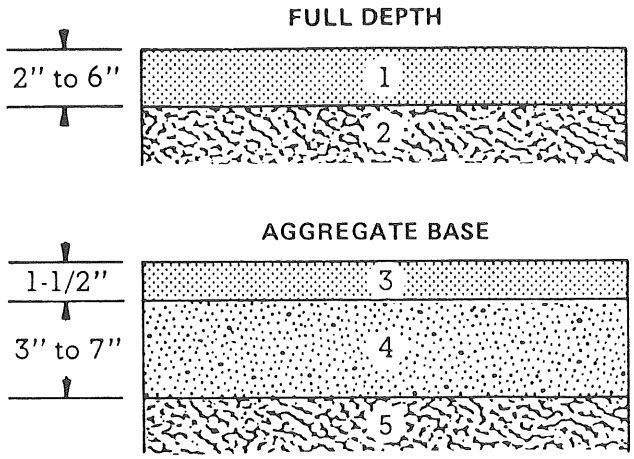
Radius feet	Additional Paved Width feet
0-25	4
25-50	3
50-75	2
75-100	1
100+	0

G. STRUCTURAL SECTION

For bike routes and lanes the inplace surfaced structure is normally adequate. When a roadway with unpaved shoulder is to be surfaced for a bike lane, standard Mn/DOT shoulder designs should be specified.

The structural section of an off-road bikeway should be designed in the same manner as a highway, with consideration given to the quality of the subsoil and the anticipated loads the bikeway will experience. Principal loads will normally be from maintenance and emergency vehicles. These vehicles should be restricted to less than 4 or 5 ton axle loads, especially in the spring.

Bituminous surfacing is recommended. Figure F provides typical surfacing designs for full depth bituminous and aggregate base sections.



1. Spec. 2331 Wearing Course (Full Depth)
2. Compacted Subgrade
3. Spec. 2331 Wearing Course
4. Class 5 Aggregate Base
5. Compacted Subgrade

FIGURE F
TYPICAL OFF-ROAD DESIGN SECTIONS

The lighter sections should be used only in granular subsoils.

- Topsoils and other organic soils should be removed.
- A 1 foot subcut should be provided for uniformity and compaction.
- Granular subgrades may require a minimum 1 inch Class 1 stabilizing aggregate, especially in the full depth bituminous section.
- Consideration should be given to increasing the asphalt content by 1 to 2% to provide increased pavement life.

Subgrade and surfacing recommendation should be requested from a Materials or Soils Engineer.

H. CLEAR ZONE (distance from bikeway to traveled way)

For on-road bikeways refer to the bikeway design tables to assess the road suitability for bicycle travel. The tables will also enable "pretesting" of shoulder widening and surfacing. Bike traffic must flow the same direction as adjacent motor vehicle traffic. Two-way bike traffic on one-side of the road is not permitted.

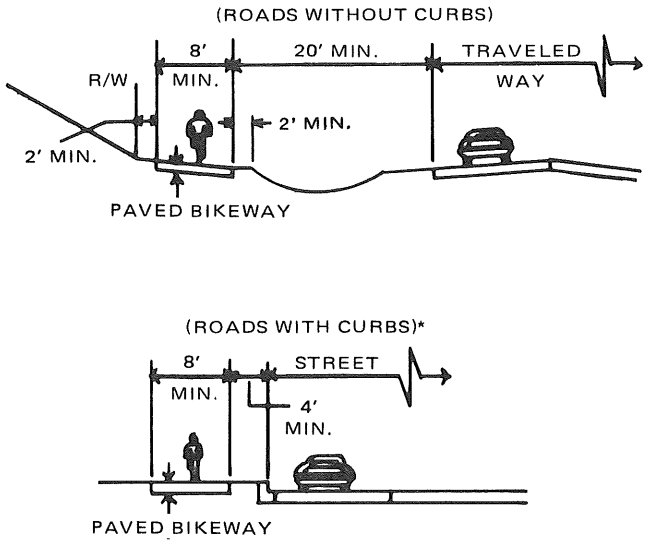
For off-road bikeways, there are two categories: roads without curbs and roads with curbs. The proper set back from the traveled way is an important consideration for the designer because operation of the facility is dependent upon adequate separation from each respective travel mode (motor vehicle, bike, pedestrian) and stationary objects (poles, signs. . .). See Figure G.

I. DRAINAGE

For bike routes and lanes the existing roadway drainage is normally adequate. However, on curb and gutter sections a check of ponding depths should be made and corrective action proposed if depths are significant. This may entail improved grate designs or wider bike lanes.

On off-road bikeways, the surface of the bikeway should have a cross-slope of two percent for the proper drainage. Sloping in one direction usually simplifies longitudinal drainage design and surface construction, and accordingly, is the preferred practice. Ordinarily, surface drainage from the path will be adequately dissipated as it flows down gently sloping terrain. However, when the bikeway is constructed on the side of a hill, a drainage ditch of suitable dimensions may be necessary on the uphill side to intercept the hillside drainage. See Figure H. Culverts or bridges are necessary where a bikeway crosses a drainage channel. Sizing of the required waterway opening should be determined by a hydraulics engineer. Minimum culvert size used for bikeway drainage should be 18 inch diameter.

Drainage inlet grates on bikeways shall have openings narrow enough and short enough to assure bicycle tires will not drop into the grates regardless of the direction of bicycle travel. Where it is not immediately feasible to replace existing grates with standard grates designed for bicycles, 1 inch x 1/4 inch steel cross straps should be welded to the grates at a spacing of 6 inches to 8 inches on center, to reduce the size of the openings. See Standard Plates 4151 and 4152 for acceptable designs of grates.



*PROVIDES ROOM FOR SIGNS, POLES, ETC.

FIGURE G

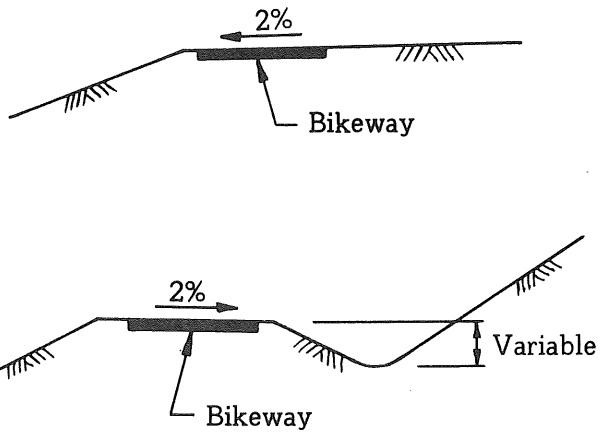


FIGURE H

J. AT-GRADE RAILROAD CROSSINGS

Whenever it is necessary to cross railroad tracks with a bikeway, special care must be taken to assure that the safety of bicyclists is protected. The bikeway crossing should be at least as wide as the approaches of the bikeway. Whenever possible, the crossing should be straight, and at right angles to the rails. For on-road bikeways, where a skew is unavoidable, the shoulder should be widened, if possible, to permit bicyclists to cross at right angles. (See Fig. I). Special construction and materials should be considered to keep the flangeway depth and width to a minimum. Pavement should be maintained, so ridge buildup does not occur next to the rails. In some cases, timber plank crossings can be justified, and can provide for a smoother crossing. Where hazards to bicyclists cannot be avoided, appropriate signs should be installed to warn bicyclists of the danger. For off-road bikeways, it is also desirable to cross at 90°, see Fig. J. When it is not possible to cross at 90° the bikeway should be widened to allow the cyclist to cross at as close to 90° as possible, see Fig. K.

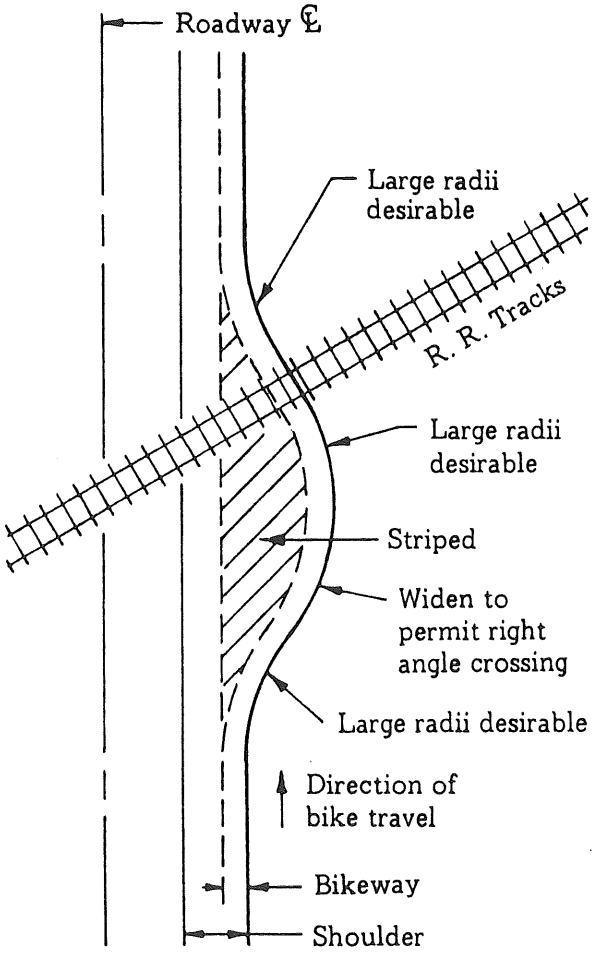


FIGURE I

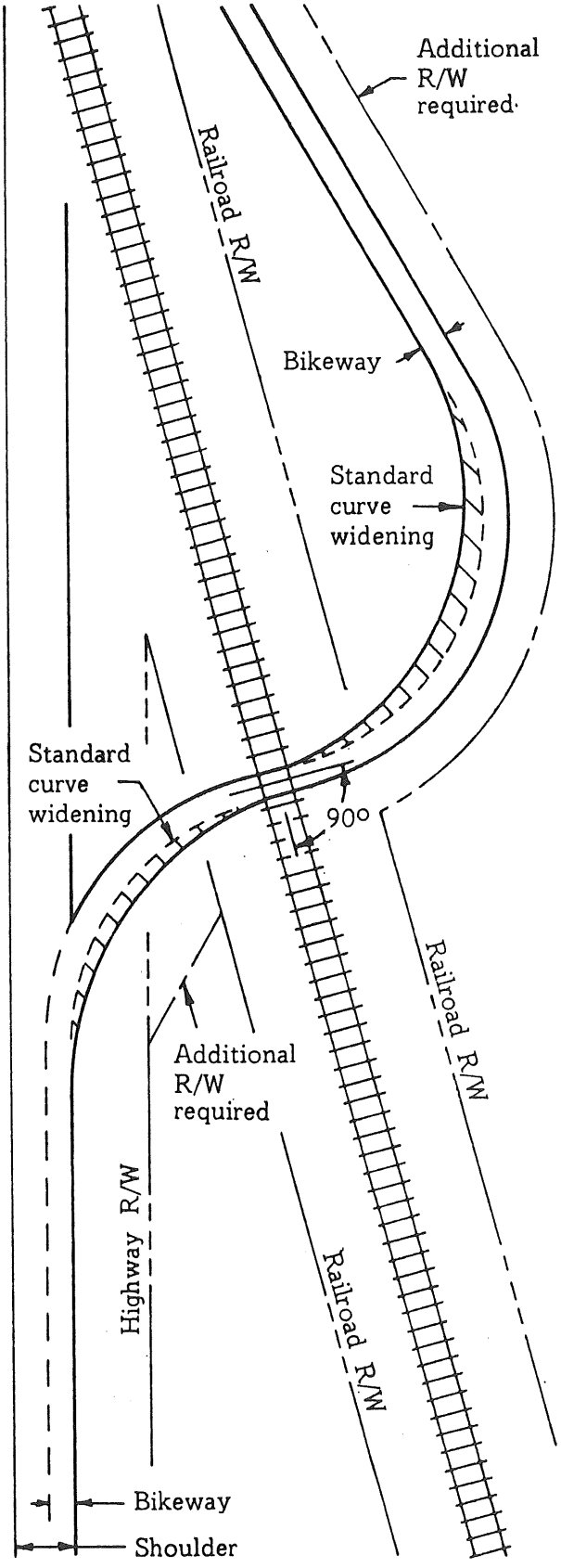
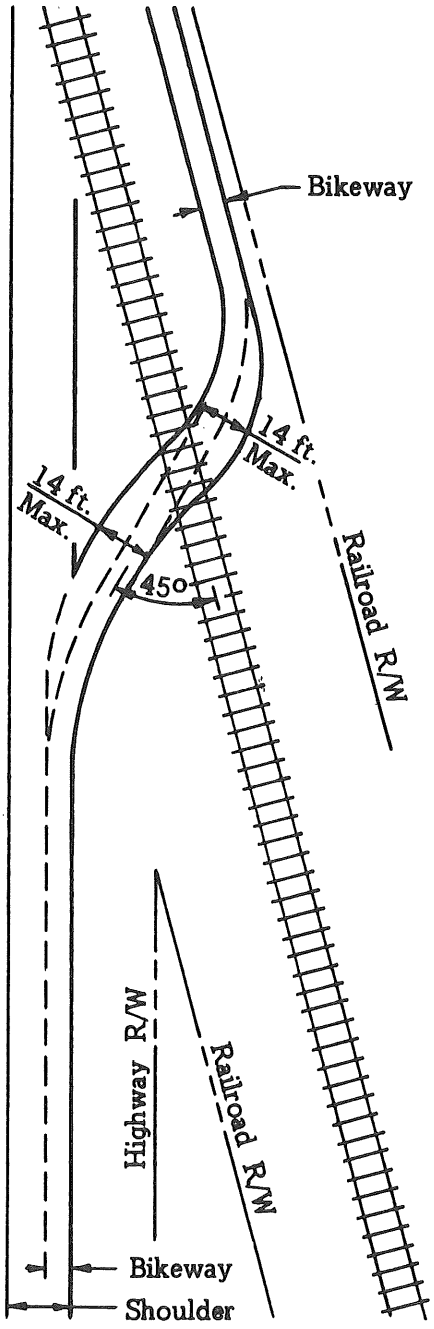


FIGURE J
90° CROSSING (Most Desirable)



Additional width to 14 feet to be provided at railroad crossing to allow cyclist to choose his own crossing route.

FIGURE K
45° CROSSING (Less Desirable)

K. BRIDGES AND GRADE SEPARATIONS

1. General

Some type of grade separation should be provided wherever a combination of vehicular volumes and speeds and bicycle volumes would warrant some type of physical separation. Where these conditions exist, and provision of a grade separation structure would not be feasible, the bikeway should be rerouted. Experience has shown that structures designed for pedestrian live loads are satisfactory for bicycle loading.

2. Highway Bridges with Bikeways

Where off-road bikeways are located parallel to a highway, there are some conditions where it is necessary to carry the trails across a highway structure. On controlled access highways with high volumes of vehicle traffic, the bikeway should be carried outside of the normal bridge shoulder and separated from the shoulder by a physical barrier (concrete barrier, railing or fence).

On minor low-speed highways, where vehicular volumes are not great and the roadway shoulder is carried across the structure, the bridge shoulders can be utilized for the bikeway (one-way travel on roadway shoulders).

Sometimes, it is necessary to widen existing bridges to provide adequate width for bikeways. Where it is anticipated that a bikeway will be provided in the future, new bridges should be designed to include the appropriate width.

Bikeways on highway bridges must be carefully coordinated with approach bikeways, to make sure that all elements are compatible. For example, bicycle traffic bound in opposite directions is best accommodated by bike lanes on each side of a highway. In such cases, a two-way bikeway on one side of the bridge would normally be inappropriate, as one direction of bicycle traffic would be required to cross the highway at grade twice, to get to and from the bridge bikeway. Because of the inconvenience, many bicyclists will attempt to ride on the wrong side of the highway beyond the bridge termini. See Figure L for approach and bridge typical sections.

Consideration should be given to a bicycle pull-off abutting a bridge. In instances where the bridge is a crest, a pull-off area has the added advantage of an overlook for enjoyment of the scenery and other interesting features of the crossing.

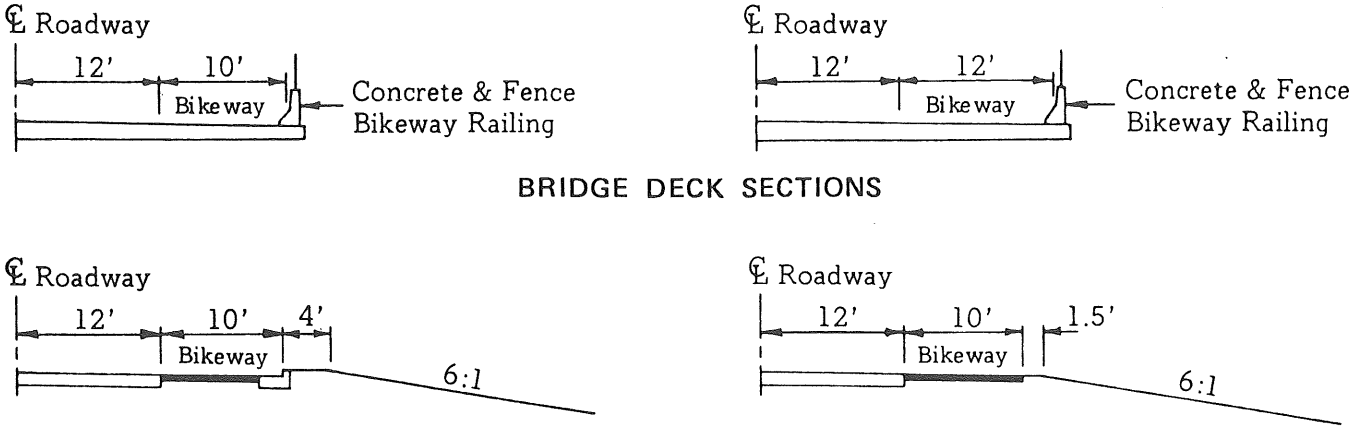
URBAN DESIGNS

See Bridge Design Manual - Fig. D 5-392.203

RURAL DESIGNS

See Bridge Design Manual - Fig. C 5-392.203

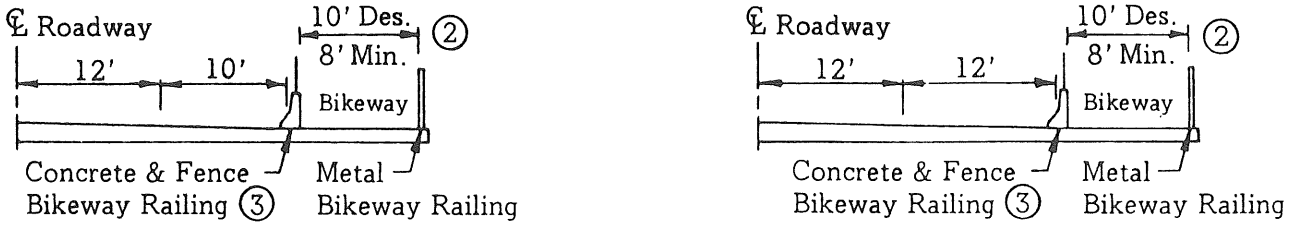
On Road Bikeways



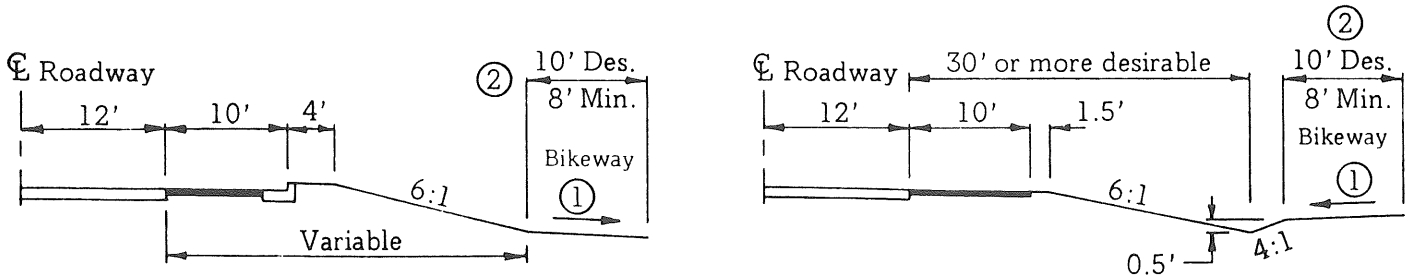
BRIDGE DECK SECTIONS

APPROACHING ROADWAY SECTIONS

Off Road Bikeways



BRIDGE DECK SECTIONS



APPROACHING ROADWAY SECTIONS

NOTES:

① .02 ft./ft. slope

② Minimum width. Includes provision for pedestrians.

③ If shoulder width is ⩾ 6' no fence is required on top of barrier.

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

FIGURE L

DESIGNS FOR BRIDGE DECKS WITH BIKEWAYS

The following criteria apply to a two-way bikeway on one side of a highway bridge:

a. The bikeway approach to the bridge should be by way of a separate two-way facility, for the reason explained above.

b. A physical separation, capable of taking vehicle impact shall be provided to offset the adverse effects of having bicycles traveling against motor vehicle traffic. The physical separation should be designed to minimize the fixed-end hazards to motor vehicles and cyclists, and if the bridge is an interchange structure, to minimize sight distance restrictions at ramp intersections.

Where there is a danger that the cyclist may fall onto an adjacent traffic lane, it is recommended that bikeway bridge railings or fences placed between traffic lanes and bikeways be at least 4.5 feet high, to minimize the likelihood of bicyclists falling over the railings. Standard bridge railings which are lower than 4.5 feet can be retrofitted with light-weight upper railings or chain link fence, suitable to protect bicylists. A fence should also be provided on retaining walls when a bikeway is located close to the top of the retaining wall.

The use of existing bridge sidewalks for bicycle traffic may be considered on existing bridges when the sidewalk is of sufficient width to accommodate the cyclists. In such cases, ramps should be installed at the sidewalk approaches. If approach bikeways are two-way, the sidewalk facility should also be two-way. Whenever the bridge sidewalk is utilized for a bikeway, a special effort should be made to remove obstacles that will be hazardous to bicycle travel. Whenever bicyclists are directed from bike lanes to sidewalks, curb cuts (see Standard Plate 7036) should be flush with the street to assure that bicyclists are not subjected to the hazards of a vertical lip crossed at a flat angle. Curb cuts should be wide enough to accommodate adults' tricycles and twowheel bicycle trailers.

3. Bridges for Bikeways

A bridge designed exclusively to carry bicycles over a natural barrier or across a highway should have a minimum width of 8 feet, particularly where two-way traffic is to be accommodated. The minimum clear width of the bridge shall be the paved width of the approach bikeway. If pedestrians are to use the structure, additional width is recommended. See Figure M.

In the design of the bicycle overpass, all of the bicyclist's requirements with respect to grade, turning radius, width, cross slopes and speed should be considered. The structure roadway should have a minimum width of 8 feet to allow adequate room for stopping and passing maneuvers. Ramp grades generally need to be steeper than elsewhere but, preferably, should not exceed 8.3 percent; desirably, they should be in the range of 5-10 percent. See Figure M. With these grades, bike speeds will increase on the downward movement. Precautions should be used to eliminate, where possible, hazards to the cyclists near the end of the ramp. The cyclist should also be warned, such as by signing, of the hazards of steep grades where they do occur. Parapet barriers should be designed to provide adequate side protection. Screens, similar to the type which is provided on pedestrian overpasses, should be used where incidents of dropped objects can be expected without such protection. Where the overpass is removed from other structures, the vertical clearance of the overpass over the roadway should be slightly higher than the minimum clearance required for vehicular structures due to the fact that bicycle structures are less resistant to impact if struck by an overheight vehicle. Generally, 17 to 22 feet are considered desirable. The structure, approach and appurtenances should be designed in such a manner that bicyclists are physically prevented from crossing the vehicular roadway at grade.

Bridge railings or fences and parapets, particularly at the sides of spiral ramps, should be at least 4.5 feet high to minimize the likelihood of bicyclists falling over the sides, or being catapulted over in the event of mishap.

4. Bikeways Under Bridge Structures

Figure N provides acceptable locations, separations and widths for rural designs. Figure O provides these same details for urban designs.

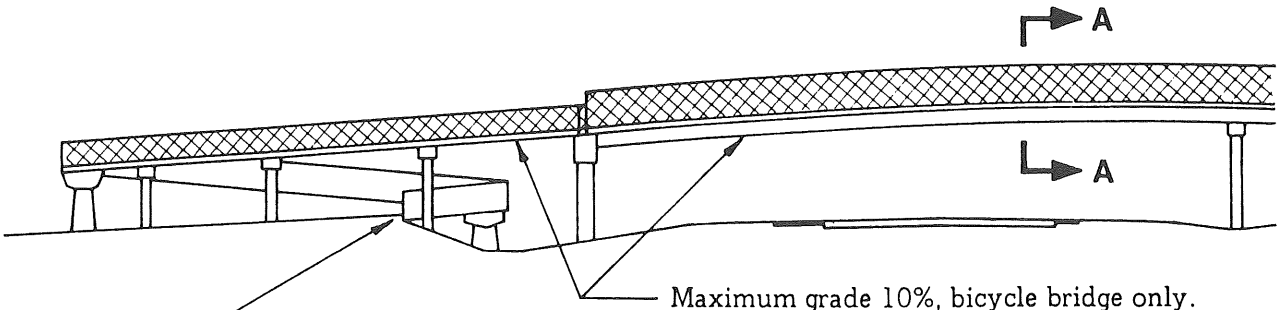
5. Underpasses

Generally, a bikeway underpass is a less desirable method of carrying the bikeway across a major highway than an overpass structure. An underpass has the disadvantages that unless it is well located and openly designed, it may be conducive to crime and vagrancy.

Contrary to the above statements, there may be times when an underpass may be the most desirable alternate. This may occur where the grade is uniform thru the structure and for a considerable distance at both approaches to afford a better view for safety's sake. Another instance might be when the highway to be crossed is on embankment and the cost of constructing an overpass would be excessive.

Underpasses may be constructed of cast-in-place or precast concrete box culverts, or arch-type steel or concrete pipe with the proper horizontal and vertical clearances.

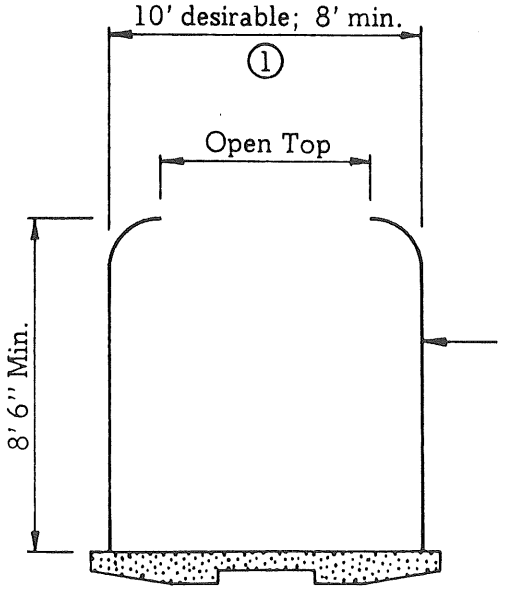
Of considerable concern in conjunction with any type of bicycle underpass is the possibility of attacks upon the bicyclist. Where an underpass is necessary, the designer should whenever possible, be selective as to location to facilitate safety. Approaches and grades should provide the maximum possible field and range of vision of the way



Maximum grade 10%, bicycle bridge only.
Maximum grade 8.33%, bicycle and pedestrian bridge using federal funds and required landings for handicapped pedestrians.

Check landing area for stopping sight distance requirements.
Avoid direct entry on to streets.

HALF ELEVATION



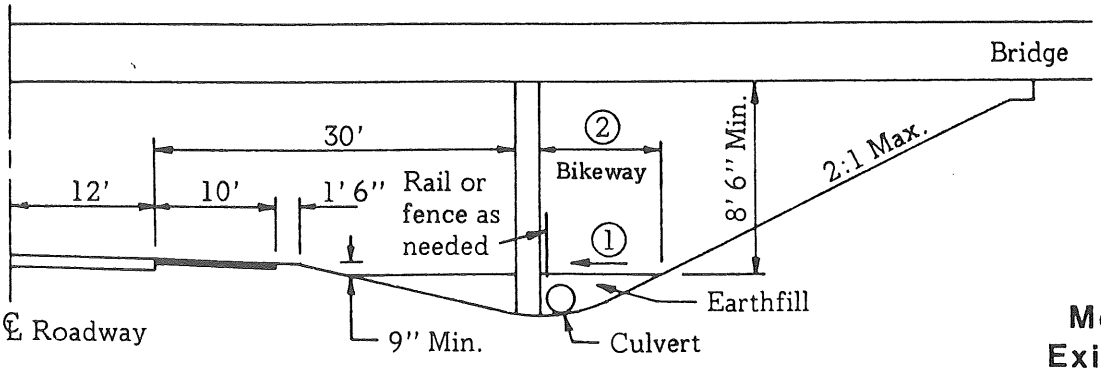
Chain Link Enclosure
See Bridge Details Manual, 5-397.201
Chain Link Enclosure For Pedestrian Bridges

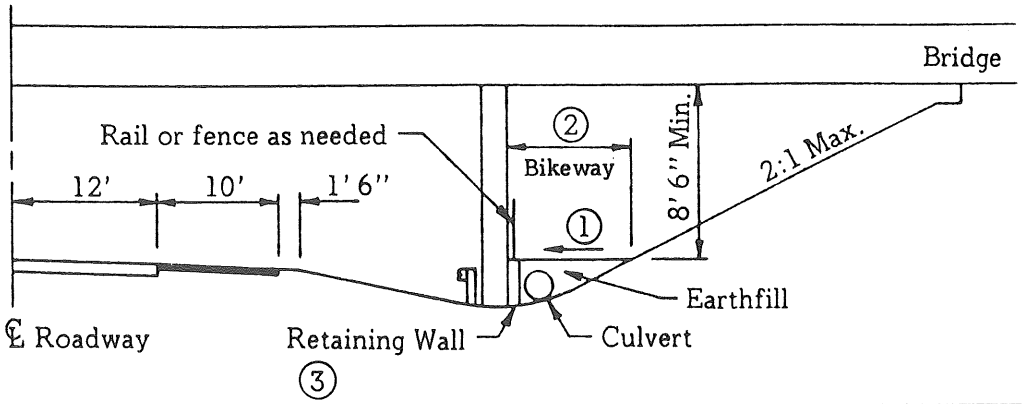
SECTION A-A

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

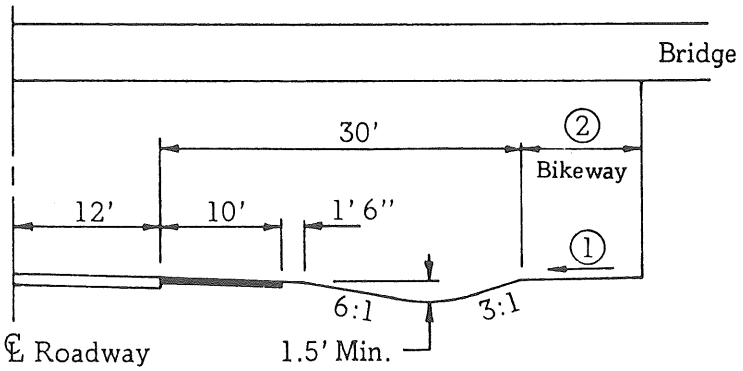
FIGURE M

SEPARATE BIKEWAY BRIDGE

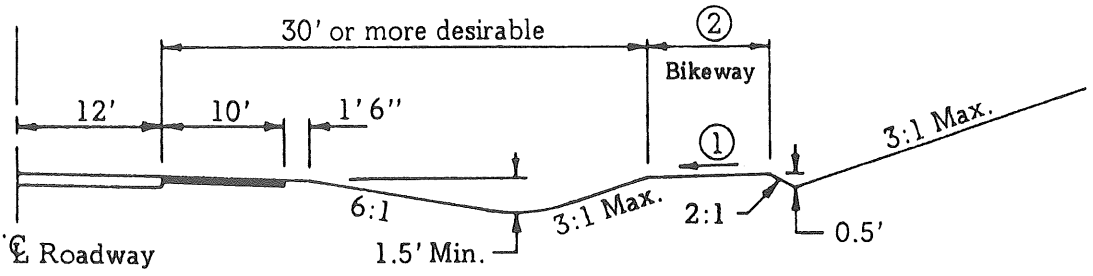




Modification Of Existing Facilities



Design For New Facilities



Approaching Roadway

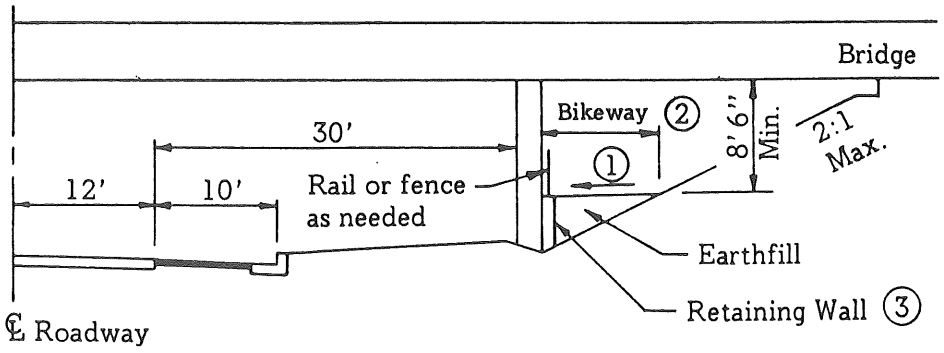
① 0.2 ft./ft. slope

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

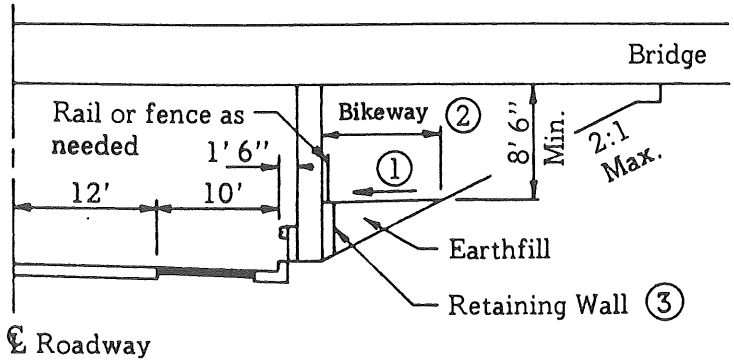
③ A barrier wall (Standard Plans 5-297.601 and .603) may be used between piers.

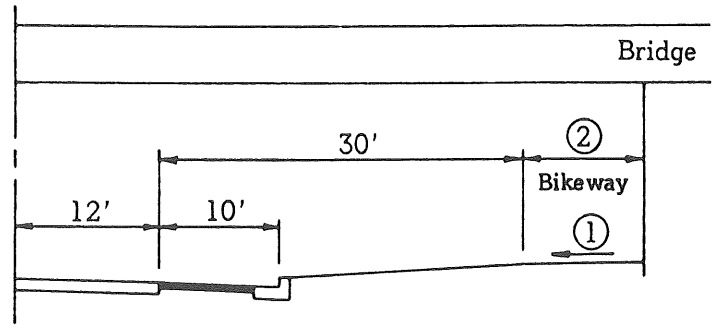
FIGURE N

OFF ROAD BIKEWAYS UNDER BRIDGE STRUCTURES - RURAL

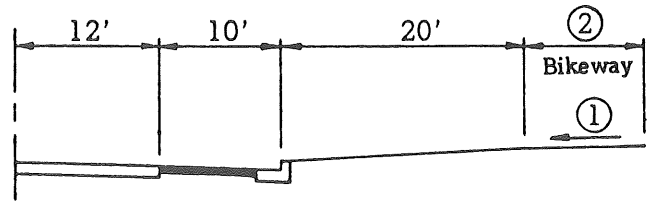


Modification Of Existing Facilities





Design For New Facilities



Approaching Roadway

(1) 0.2 ft./ft. slope

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

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

FIGURE O

OFF ROAD BIKEWAYS UNDER BRIDGE STRUCTURES - URBAN

ahead to the bicyclist. Fencing of both sides of the bikeway at each end of the underpass might serve as deterrent to undesirables. Where a bikeway is routed under a structure, fencing on the trail side between and adjacent to piers and abutments to screen out points of possible ambush might be in order. Where nighttime riding is expected, adequate lighting shall be provided under structures and in underpasses and as deemed necessary at approaches. In certain cases, lighting may be required on a daily 24 hour basis.

VI. INTERSECTION TREATMENT

A. INTRODUCTION

Safe movement of bicyclists through intersections is of paramount concern. A high percentage of bicycle-motor vehicle collisions take place at intersections. The cause of these accidents are numerous, but no one type seems dominant. A number of elements compound the basic fact that intersections are inherently points of significant traffic conflict. Among these are human error, basic conflict between behavior and expectations, and the fact that measures undertaken to improve motor vehicle flows and safety may conflict with bicyclist operational convenience and safety. It must be remembered that there is no single measure that will provide a primary solution to the intersection problem. Each intersection must be studied individually.

B. DESIGN APPLICATION

Statistics show that accident occurrence depends significantly on the age and/or experience of the bicyclist: adult vs. young children; the expert vs. the inexperienced. The bicyclist can be placed into three general categories: the young bicyclist, the average adult bicyclist, and the expert bicyclist. The young bicyclist is not old enough to possess a driver's license and thus the bicycle often become a major and inexpensive means of transportation. This category includes children under the age of 16. This group involved the highest percentage of bicycle/motor vehicle accidents. Most children's accidents occur when they are just "riding around". The average adult bicyclist includes adults and children over the age of 16. Usually, this class of riders prefer to use residential streets and off-road bicycle facilities, but will occasionally ride on major streets for a short distance. They ride only occasionally and may not be very skillful. The expert bicyclist consists of a small group which has extensive bicycle knowledge and skill. Included within this group are bicycle commuters and touring bicyclists.

Since the expert bicyclist can generally handle themselves in most traffic situations, the following design guide was developed primarily with the inexperienced cyclist in mind.

C. CONFLICTS INTERSECTIONS PRESENT

Conflicts between bicyclist behavior motorist expectation, relative to traffic behavior, is a significant cause of accidents at intersections. Some of these conflicts are:

1. The right turning motorist vs. the bicyclist

Bicyclist traveling on the right side of the roadway, either going straight through an intersection or turning right, often have a problem with right-turning motorists approaching the intersection in the same direction. The reasons for this are:

– Poor visibility to the right rear of a motor vehicle and limited target visibility of the cyclist.

– Lack of expectation on the part of a motor vehicle operator in the right hand travel lane for a "through" vehicle on his right.

– Poor driver perception of cyclist speed.

– Preoccupation of the motorist with cross-street traffic, particularly that coming from his left, or with pedestrian traffic in the crosswalk area.

– Motorist's expectation that cyclist will yield to a "bigger" vehicle.

– Failure to signal properly for the right turn.

– The mandatory right turn lane.

In the case of mandatory right turn lanes, where all road users have to turn right, bicyclists, often, violate the lane mandate. If he travels straight through in keeping to the right, he violates the law and causes difficulties to motorist observing him since the motorist expects him to turn. If the cyclist uses the left through lane to avoid the mandatory right turn lane, he must weave through the right turning traffic and this is a difficult thing for young cyclist to do. In the case of optional right turn lane, it is difficult for both the motorist and cyclist to recognize the intent of each other.

2. Left Turning Bicyclists

When making a left turn maneuver the difference between an experienced bicyclist and the inexperienced bicyclist shows up the most. The experienced bicyclist will tend to follow the same maneuver that motor vehicles use. The weaving movements necessary to cross to the center lane or left turn lane are difficult for the bicyclist and unanticipated by motorists. The tendency for bicyclists to "double-up" with turning vehicles, rather than fall in line, also creates sideswipe exposure. Opposing vehicles tend to not see or fail to grant right-of-way to turning bicycle.

The inexperienced bicyclist will generally prefer the two step approach. They will enter the intersection in the right lane and cross to the corner and then make another crossing to end up on the right lane of the cross street.

Some of the conflicts noted above are partially the result of physical facility provisions for bicyclists and laws and ordinances relating to bicycle operation.

D. POSSIBLE SOLUTIONS TO INTERSECTION PROBLEMS

As noted before, techniques to improve safety for the bicyclist will generally inhibit the experienced cyclist by routing bicycle lanes through intersections in such a way that the less experienced cyclist will be least exposed to conflict. Since the predominate use of bikeways falls into the less experienced class the two-step approach to making a left turn should be planned for the intersection.

Possible solution to the intersection problem can take three forms of approach:

– Designs can be implemented which channel the bicycle into specific and more desirable locations.

– The second approach is to improve the motorist's perception of the potential for cyclist-motorist conflict. This could best be done by advance warning through signs or markings at locations where heavy cyclist conflicts are expected.

– A third approach is to separate traffic flows either by signalization or grade separation.

E. SITE OF INTERSECTION & FIELD EVALUATION

Before reviewing specific ways of handling a bikeway through an intersection, one should do a field walk of it to get an idea of what type of conditions are present. In the review one should note some of the following:

– Is there good perceptual sight distance so both motorist and bicyclist can be seen? Are there any buildings, embankments, parked cars, or trees and bushes that are blocking the view?

– Note traffic control. If signals are present are there pedestrian indicators provided?

– Note if a curb is present. Are pedestrian ramps in place and are they safe?

– Note general cross section. If bikeway is involved, it will be desirable to know if ditches are adjacent to road. Is landing area for bicycles going to be a problem?

– Desirable to identify utilities present.

– Available traffic volume data.

– If intersection looks difficult, should bikeway be added to this road? Is there another alternative?

With the above data gathered, you now can properly evaluate the alternative designs.

F. ON-ROAD BIKEWAY TREATMENTS AT INTERSECTIONS

The following on-road bikeways treatments are appropriate at intersections under varying circumstances. No single treatment is universally recommended. Each intersection should be studied on an individual basis to determine the appropriate design.

1. Lane Continuation

The "lane continuation" treatment where the on-road bikeway is marked through the intersection may be appropriate only at intersections where the bikeway on major streets cross minor streets, particularly at "T" intersections and only where right turns from the major street to the minor street are minimal. The purpose is to provide more continuity of flow for the bicyclist. The solid stripe helps alert and remind vehicle (drivers) approaching on the minor, low volume, street and right turning motorist on the major street of the existence of the bike lane. See Fig. A.

2. Lane to Intersection

Bike lanes carried to the intersection are the recommended treatment when right turning motor vehicle traffic is extremely light or when traffic conditions make bicyclist weaving, to esablish normal postional relationships with motor vehicles for through and left-turn movements, more potentially hazardous than cross conflict with right turning motor vehicles. When this treatment is provided, left turning bicyclists should make two-stage turns. See Fig. B.

3. Lane Termination

"Lane Termination" treatment is normally employed under the same conditions as the broken stripe, except that space is unavailable to maintain a bike lane to the intersection. Whether "broken stripe" or "lane termination" treatment is employed, arbitrary setback distances from the intersection should not be specified as standard points for initiation of treatment. Each intersection should be individually assessed as to appropriate weaving distance required and lane termination or broken stripe initiation should be located accordingly. See Fig. C.

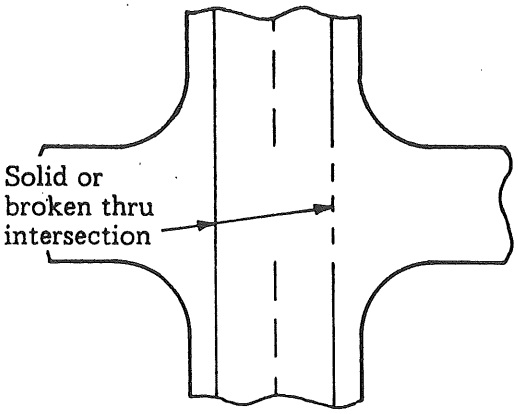


FIGURE A
LANE CONTINUATION

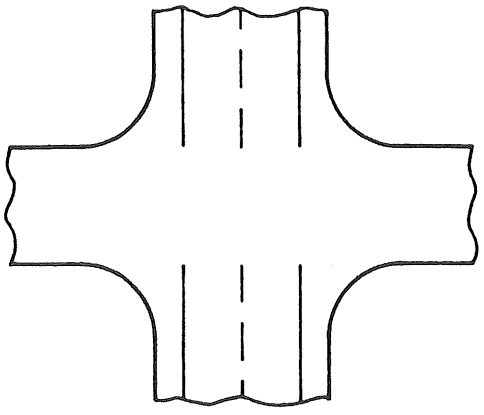


FIGURE B
LANE TO INTERSECTION

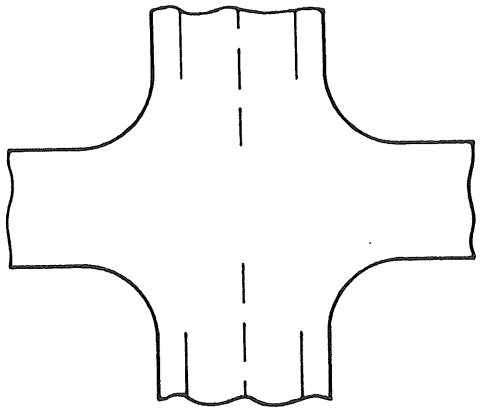


FIGURE C
LANE TERMINATION

This technique also has another application. If intersection proves too difficult to route a bikeway through it, a sign could be posted at end of stripe point directing bicyclist to walk bike to next bike lane. In such cases, it would be desirable if a sidewalk facility was available to make this connection.

G. ON-ROAD BIKEWAY TREATMENTS THROUGH INTERSECTION FEATURES

1. Right Turn Lanes

Minnesota State law requires the bicyclist to keep as close as practicable to the right-hand curb on edge of the roadway. Therefore, the bicyclist should be on the right edge of the right turn lane. This is not a desirable position, especially if the bicyclist is intending to go straight ahead, however, it is the safest location. To accommodate the bicyclist in the right turn lane, two methods are suggested:

– For low volume right turn lanes

Replace standard "RIGHT TURN LANE" sign (R3-X1) with "BEGIN RIGHT TURN LANE YIELD TO BIKES (R4-4). See Fig. D.

– For high volume right turn lane

Channel the bike lane onto the sidewalk or off road path and encourage bicyclists to behave as pedestrians at the intersection. See Fig. E. Placement of a stop sign for the cyclist at the crossing may cause confusion for the motorist and should generally not be used except for high traffic volumes (both turning motorists and bicycles). Bicyclists in an intersection cross-walk are considered the same as a pedestrian.

2. Channelized Free Turning Lanes

Channelized "Free" turning lanes pose problems similar to the right turning lanes. Recommended treatment at free turning lanes is indicated on Figure F. This involves the broken stripe treatment to encourage bicyclist weaving to the proper position relative to turning traffic, and a marked right-angle crossing to encourage bicyclists to make a pedestrian-like crossing if they are unable or unwilling to execute the weaving maneuver. For high speed turning lanes, the technique indicated on Figures G and H are recommended.

3. Right Turn on Red

Where "right turn on red" is permitted, the focus of right turning motorists toward cross traffic approaching from the left is intensified. The straight through bicyclist required to stop for the red light may find that vehicles turning right on red infringe into their storage area. Signs and markings along the bike lane can help to remind the drivers of the bicyclist presence.

4. Double Left Turn Lanes

Bicyclists should be encouraged to make left turns by the two-step method if a double left turn lane is present.

5. Two-Way Continuous Left Turn Lane

Bicyclists should be encouraged to make left turn by the two-step method.

6. Bypass Lane at "T" and Four-Way Intersections

The use of a bypass lane encourages vehicles to move around left turning vehicles. They present a problem to the bicyclist using the shoulder of the roadway, because usually the bypass lane uses what there is of the shoulder.

When a bikeway is added to roadway where bypasses are in use, it is strongly recommended that at least a four foot shoulder be added to the bypass lane. This additional width should also be striped to discourage vehicle encroachment into it.

H. OFF-ROAD BIKEWAYS AT INTERSECTIONS AND INDEPENDENT BIKEWAY CROSSING

Off-road bikeways normally carry two-way traffic. At intersections bicyclists face many of the same conflicts as they would if they were in a bike lane on the roadway. The problems associated with the bikeways relate largely to motorist expectation of entries to the crosswalk area as pedestrian rather than typical bicycle travel speeds. Also, two-way bikeways require one direction of crossing to be done contrary to normal vehicle operation. Safety with this type of crossing is dependent upon the bicyclist adopting a more pedestrian-like yielding posture to motor vehicles.

1. Treatment of Off-road Bikeways

Bikeways which run parallel to the roadway should be brought into the intersection to function like a crosswalk. (See Fig. I). The reason for this is to take advantage of the intersection traffic control and to avoid having the bicyclist passing between stopped vehicles waiting for signals to change. At low volume cross streets, it is acceptable to continue the parallel distance; however, the crossing should be identified and bicyclist must be required to stop or yield before entering the roadway.

2. Treatment of Off-road Bikeway at Independent Crossings

There is some evidence of high accident experience in isolated intersections of independent facilities with motor vehicle roadways. This appears to stem from four factors:

– Failure to establish proper sight clearance zones.

– Poor perception of or reaction to crossing signs and markings.

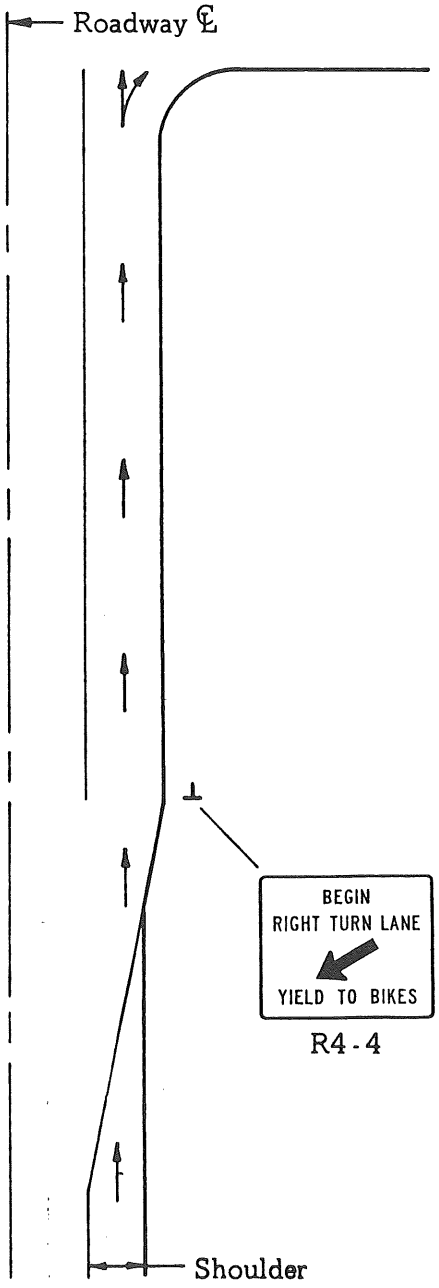


FIGURE D
LOW VOLUME RIGHT TURN LANE

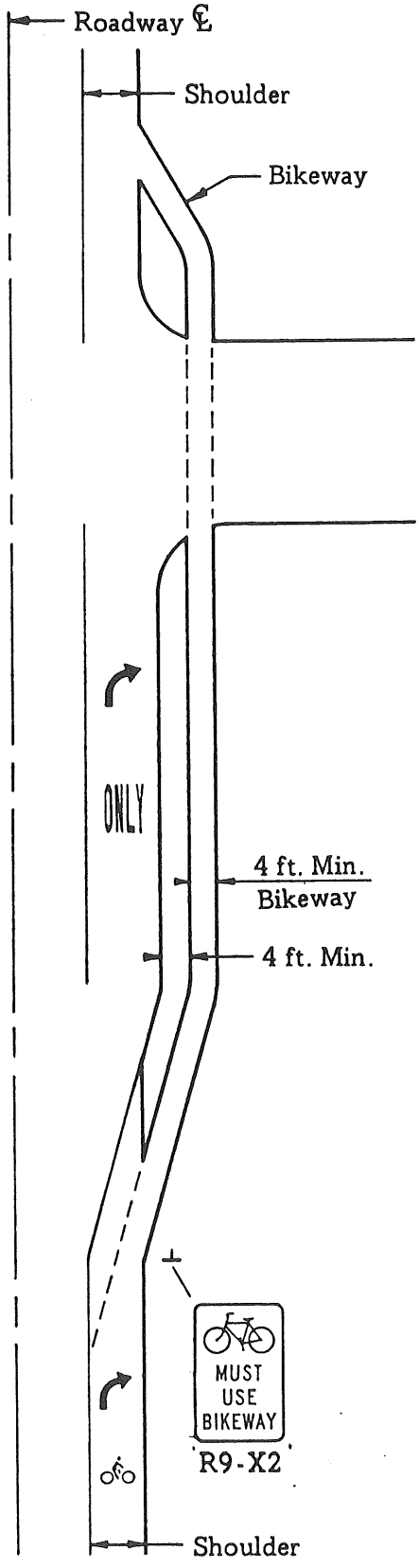


FIGURE E
HIGH VOLUME RIGHT TURN LANE

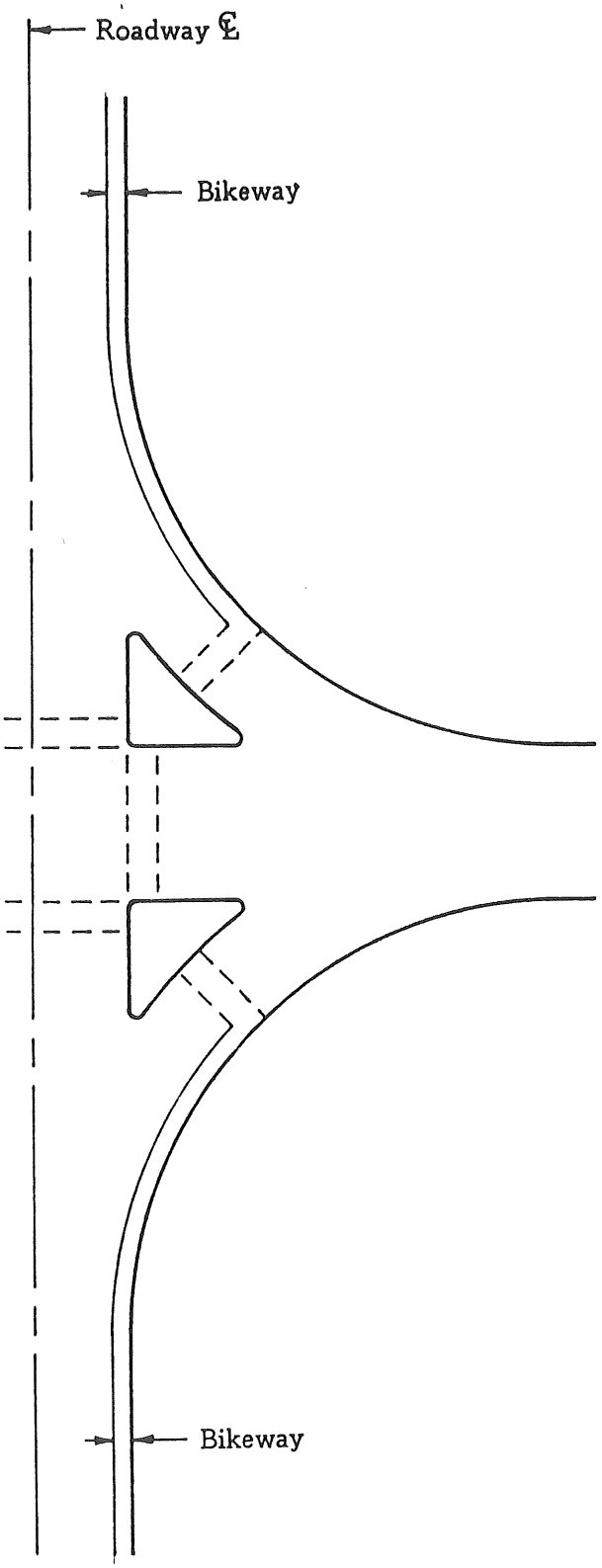


FIGURE F
LOW SPEED - LOW VOLUME TREATMENT

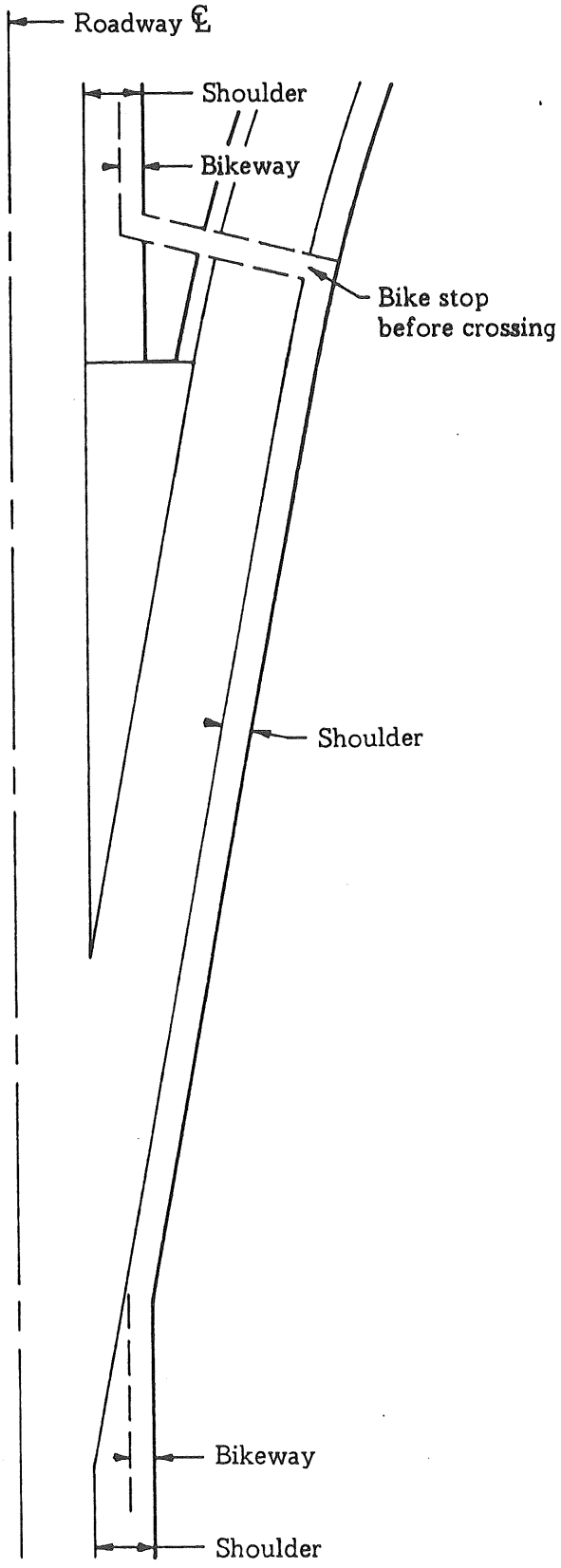


FIGURE G
HIGH SPEED - LOW VOLUME
BIKEWAY TREATMENT

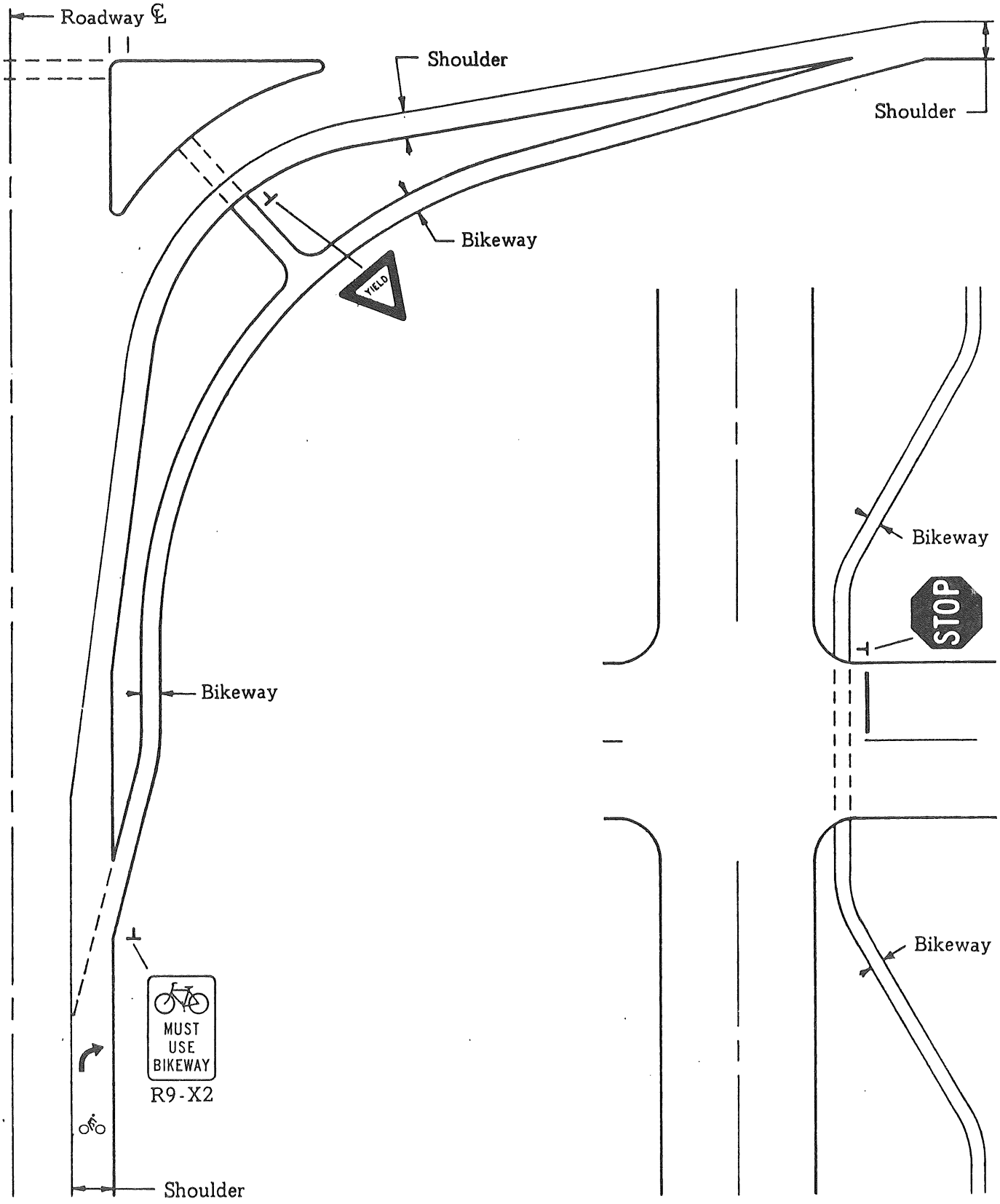


FIGURE H
HIGH SPEED - HIGH VOLUME
ON ROAD TO OFF ROAD TREATMENT

FIGURE I
OFFSET BIKEWAYS
INTERSECTION TREATMENT

– Motorist expectation of entries to the crossing at pedestrian speeds rather than at typical bike travel speeds.

– Cyclist disobedience of STOP or YIELD controls.

Independent off road bikeway crossings of roadways merit particular attention to design detail. Measures to alleviate some of the above problems include the following:

– Provide proper sight clearances. Sight clearance assessment must consider obstructions due to roadway cross-section profile (steep cuts or fills) as well as common obstructions such as foliage.

– Locate the crossing a minimum of 250 feet from any roadway intersection. If such separation is impossible, the crossing should be brought into the intersection and treated as a bikeway at an intersection.

– Align the crossing to intersect the motor vehicle roadway at right angles.

– Mark the crossing with "zebra" or "panda" pavement marking. "BIKE XING" signs should be placed on the motor vehicle approaches 250 to 750 feet in advance, with specific location depending upon roadway speed limit and proximity to adjacent intersections. Refer to MMUTCD.

– Place "STOP AHEAD" or "YIELD AHEAD" signs on the bikeway approach approximately 150 feet in advance of the crossing: further if downgrades make bicyclist speed in excess of 20 MPH likely.

– Provide a landing area on the bikeway for its approach to the roadway, so bicyclist can be seen by motorist and bicyclist can comfortably wait for a gap to cross.

VII. TRAFFIC CONTROLS FOR BIKEWAYS

A. INTRODUCTION

The purpose of this section is to inform individuals charged with the design, construction, and operation of bikeways of the basic concepts to consider on the use and application of traffic control devices. Further, the necessary official manuals are identified, which give standards on design and usage of traffic control devices. The Minnesota Traffic Laws concerning the operation of bicycles are listed for reference.

Signs and markings are the traffic control devices used most frequently to regulate, warn, and guide bicycle traffic. The installation of traffic signals are rarely needed solely for bicyclists.

Adequate signing is a critical requirement in successful bikeway design. Their proper use helps to warn bicyclists of hazardous conditions, establishes the right-of-way, excludes motor vehicles and/or pedestrians from the bikeway and warns motorists and pedestrians of the presence of bicycle traffic on shared facilities. However, too much signing is a nuisance and improper placement of signs can cause some significant problems, especially on bikeways parallel to the roadway. Stop or yield signs placed to control the bicyclist may in fact cause confusion for some vehicles on a through street. It becomes hard to determine to whom the stop sign applies. If that potential exists, consider the following alternates:

1) Paint crosswalk and remove stop or yield sign.
2) Add louvers to sign to shield it from highway.

Generally signing driveway entrances and commercial entrances should be avoided because of the potential confusion. Consult the District Traffic Engineer for assistance.

B. SIGNS

There are 3 main classifications of signs needed on bicycle facilities:

1. Regulatory Signs - give notice to the bicyclist of traffic laws or regulations.

2. Warning Signs - are used to warn bicyclists of conditions on, or adjacent to, bikeways and trails, steets, and highway that are potentially hazardous to them.

3. Guide Signs - Bike Route guide signs keep bicyclists informed of changes in route direction and reminds motorists of the presence of bicyclists. Destination and distance guide signs furnish additional guidance.

When signing at a roadway crossing, if the volume of the cross street is low, consider using the Yield sign instead of a Stop sign. Generally, bicyclists do not stop if traffic is not present and the Yield sign allows this practice.

C. PAVEMENT MARKINGS

Pavement marking lines are necessary to indicate separation of the lanes for motor vehicles and bicycles on streets and highways. Where bicycles and pedestrians share a common off-road bikeway, lines are marked to separate the two traffic flows. The frequent use of symbols and word messages stenciled in the bike lanes is a desirable method of supplementing and reinforcing sign messages.

D. SIGNALS

Traffic signals used solely for bicyclists will be rare; however, when signals are involved on the bike route, the following comments should be considered:

– Where a bikeway is a separate facility adjacent to the road, the bicyclist can be considered as a pedestrian at cross road intersections and pedestrian indications should be provided if not present at existing signals.

– Warrants used for motor vehicles are considered appropriate for use in determining the need for signals to serve bicyclists.

– Generally bicycles can cross intersections under the same signal timing arrangement as motor vehicles. But at signalized intersections of multilane streets, bicyclists may have difficulties crossing, if the clearance interval (amber interval plus optional all-red interval) is not of adequate duration. Extremely short clearance intervals should not be used.

– On-road bikeways will require engineering judgment to determine if clearance intervals should be modified to allow a more adequate clearance interval for bicyclists to clear the intersection.

– Clearance time required for bicycles should be evaluated as a standard practice for each signalized intersection along a bikeway. A bicyclist's speed, representative of bikers' ages and travel characteristics for each specific case, should be utilized in the calculations. The number of seconds required to cross a street can then be determined. To this figure will be added the amount of time necessary for the bicyclist to perceive, react and brake to a stop without entering the intersection.

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

– At low volume intersections utilizing semi-actuated controllers, it may be necessary to provide special "pedestrian type" detectors (pedestrian pushbuttons) for bicyclists because the motor vehicle detectors normally will not detect bicycles.

E. REFERENCES

The Minnesota Manual on Uniform Traffic Control Devices, Part IX Traffic Controls for Bicycle Facilities, should be reviewed to determine proper use and installation of traffic control devices. All traffic control devices installed must conform to this manual under the provisions of Minnesota Statutes 169.06.

The Standard Signs Manual Parts 1, 2, and 3 contain detail drawings of all approved traffic signs.

Both of the above-mentioned manuals are available from Mn/DOT Traffic Engineering Section, St. Paul, free of charge to all governmental road authorities in the State. Private firms may purchase the manuals at a nominal fee. Technical assistance on the use and application of traffic control devices on bikeways is also available from the Mn/DOT District Traffic Engineers and the Traffic Engineering Section staff.

F. LAWS

Listed below are pertinent sections of the Minnesota Motor Vehicle and Traffic Laws current as of 1981.

CHAPTER 169
MINNESOTA HIGHWAY TRAFFIC REGULATION

169.01 DEFINITIONS. Subdivision 1. Terms. For the purposes of this chapter, the terms defined in this section shall have the meanings ascribed to them.

Subd. 51. Bicycle. "Bicycle" means every device propelled solely by human power upon which any person may ride, having two tandem wheels except scooters and similar devices and including any device generally recognized as a bicycle though equipped with two front or rear wheels.

Subd. 62. Bicycle lanes and ways. The terms "Bicycle lane" and "Bicycle way" shall have the meanings ascribed to them in section 160.263.

169.06 SIGNS, SIGNALS, MARKINGS. Subdivision 1. Uniform systems. The commissioner shall adopt a manual and specifications for a uniform system of traffic-control devices consistent with the provisions of this chapter for use upon highways within this state. Such uniform system shall correlate with and so far as possible conform to the system then current as approved by the American Association of State Highway Officials. The adoption of the manual and specifications by the commissioner as herein provided is specifically exempted from the provisions and requirements of Minnesota Statutes section 15.0411 to 15.0422 and acts amendatory thereto.

Subd. 2. Placement and maintenance on trunk highways. The commissioner shall place and maintain such traffic-control devices, conforming to the manual and specifications, upon all state trunk highways as he shall deem necessary to indicate and to carry out the provisions of this chapter or to regulate, warn, or guide traffic. The commissioner may construct and maintain signs at the entrance of each city, which sign shall have placed thereon the name of the city, and the population thereof. The commissioner may construct and maintain other directional signs upon the trunk highways and such signs shall be

uniform. The commissioner may authorize variations from the manual and specifications for the purpose of investigation and research into the use and development of traffic control devices. When such authorized variation pertains to the regulation of traffic, notice of the intended regulatory purpose shall be published in a qualified newspaper of general circulation in the area where the research is being conducted.

No other authority shall place or maintain any traffic-controlled device upon any highway under the jurisdiction of the commissioner except by the latter's permission.

Subd. 3. Placement and maintenance by local authorities. Local authorities in their respective jurisdictions shall place and maintain such traffic-control devices upon highways under their jurisdiction as they may deem necessary to indicate and to carry out the provisions of this chapter or local traffic ordinances, or to regulate, warn, or guide traffic. All such traffic-control devices hereafter erected shall conform to the state manual and specifications.

169.222 OPERATION OF BICYCLES. Subdivision 1. Traffic laws apply. Every person operating a bicycle shall have all of the rights and duties applicable to the driver of any other vehicle by this chapter, except in respect to those provisions in this chapter relating expressly to bicycles and in respect to those provisions of this chapter which by their nature cannot reasonably be applied to bicycles.

Subd. 2. Manner and number riding. No bicycle shall be used to carry more persons at one time than the number for which it is designed and equipped, except (a) on a baby seat attached to the bicycle, provided that the baby seat is equipped with a harness to hold the child securely in the seat and that protection is provided against the child's feet hitting the spokes of the wheel or (b) in a seat attached to the bicycle operator.

Subd. 3. Clinging to vehicles. No person riding upon any bicycle, coaster, roller skates, toboggan, sled, skateboard, or toy vehicle shall attach the same or himself to any street car or vehicle upon a roadway.

Subd. 4. Riding on roadways. (a) Every person operating a bicycle upon a roadway shall ride as close as practicable to the right-hand curb or edge of the roadway except under any of the following situations:

(i) When overtaking and passing another vehicle proceeding in the same direction.

(ii) When preparing for a left turn at an intersection or into a private road or driveway.

(iii) When reasonably necessary to avoid conditions, including fixed or moving objects, vehicle, pedestrains, animals, surface hazards, or narrow width lanes, that make it unsafe to continue along the right-hand curb or edge.

(b) Persons riding bicycles upon a roadway shall not ride more than two abreast and shall not impede the normal and reasonable movement of traffic and, on a laned roadway, shall ride within a single lane.

(c) A person operating a bicycle upon a sidewalk, or across a roadway on a crosswalk, shall yield the right of way to any pedestrian and shall give an audible signal when necessary before overtaking and passing any pedestrian. No person shall ride a bicycle upon a sidewalk within a business district unless permitted by local authorities. Local authorities may prohibit the operation of bicycles on any sidewalk or crosswalk under their jurisdiction.

A person lawfully operating a bicycle on a sidewalk, or across a roadway or a crosswalk, shall have all the rights and duties applicable to a pedestrian under the same circumstances.

Subd. 5. Carrying articles. No person operating a bicycle shall carry any package, bundle, or article which prevents the driver from keeping at least one hand upon the handle bars or from properly operating the brakes of the bicycle.

Subd. 6. Bicycle equipment. (a) No person shall operate a bicycle at nighttime unless the bicycle or its operator is equipped with a lamp which shall emit a white light visible from a distance of at least 500 feet to the front and with a red reflector of a type approved by the department of public safety which is visible from all distances from 100 to 600 feet to the rear when directly in front of lawful lower beams of head lamps on a motor vehicle. No person may operate a bicycle at any time when there is not sufficient light to render persons and vehicles on the highway clearly discernible at a distance of 500 feet ahead unelss the bicycle and its operator is equipped with reflective surfaces that shall be visible during the hours of darkness from 600 feet when viewed in front of lawful lower beams of head lamps on a motor vehicle.

The reflective surfaces shall include reflective materials on each side of each pedal to indicate their presence from the front or the rear and with a minimum of 20 square inches of reflective material on each side of the bicycle or its operator. Any bicycle equipped with side reflectors as required by regulations for new bicycles prescribed by the United States consumer product safety commission shall be considered to meet the requirements for side reflectorization contained in this subdivision.

(b) No person shall operate a bicycle unless it is equipped with a brake which will enable the operator to make the braked wheels skid on dry, level, clean pavement.

(c) No person shall operate upon a highway any bicycle equipped with handlebars so raised that the operator must elevate his hands above the level of his shoulders in order to grasp the normal steering grip area.

(d) No person shall operate upon a highway any bicycle which is of such a size as to prevent the operator from stopping the bicycle, supporting it with at least one foot on the highway surface and restarting in a safe manner.

Subd. 7. Sale with reflectors and other equipment. No person shall sell or offer for sale any new bicycle unless it is equipped with reflectors and other equipment as required by subdvision 6, clauses (a) and (b) and by the regulation for new bicycles prescribed by the United States consumer product safety commission.

Subd. 8. Turning and lane changes. An arm signal to turn right or left shall be given continuously during the last 100 feet traveled by the bicycle before turning, unless the arm is needed to control the bicycle, and shall be given while the bicycle is stopped waiting to turn.

Subd. 9. Bicycle parking. (a) A person may park a bicycle on a sidewalk unless prohibited or restricted by local authorities. A bicycle parked on a sidewalk shall not impede the normal and reasonable movement of pedestrians or other traffic.

(b) A bicycle may be parked on a roadway at any location where parking is allowed if it is parked in such a manner that it does not obstruct the movement of a legally parked motor vehicle.

Subd. 10. Bicycle events. (a) Bicycle events, parades, contests, or racing on a highway shall not be unlawful when approved by state or local authoritities having jurisdiction over that highway. Approval shall be granted only under conditions which assure reasonable safety for all participants, spectators and other highway users, and which prevent unreasonable interference with traffic flow which would seriously inconvenience other highway users.

By agreement with the approving authority, participants in an approved bicycle highway event may be exempted from compliance with any traffic laws otherwise applicable thereto, provided that traffic control is adequate to assure the safety of all highway users.

169.305 CONTROLLED ACCESS REGULATIONS AND PENALTIES.

Subdivision 1.

(c) The commissioner of transportation may by order, and any public authority may by ordinance, with respect to any controlled access highway under their jurisdictions prohibit or regulate the use of any such highway by pedestrians, bicycles, or other nonmotorized traffic, or by motorized bicycles, or by any class or kind of traffic which is found to be incompatible with the normal and safe flow of traffic.

(d) The commissioner of transportation or the public authority adopting any such prohibitory regulation shall erect and maintain official signs on the controlled access highway on which such regulations are applicable and when so erected no person shall disobey the restrictions stated on such signs.

Subd. 2. Except for a driver of an authorized emergency vehicle in the course of performing his duties, no driver of a vehicle shall back the same upon the roadway or shoulder of any controlled access highway.

Subd. 3. Any person violating the provisions of this section or any order or ordinance promulgated or enacted by the commissioner of transportation or a public authority pursuant thereto is guilty of a petty misdemeanor.

160.263 BICYCLE LANES AND WAYS. Subdivision 1. Definitions. As used in this section, "bicycle lane" means that portion of a roadway set aside by the governing body of a political subdivision having jurisdiction over the road for the exclusive use of bicycles or other vehicles propelled by human power and so designated by appropriate signs and markings; and "bicycle way" means any path or sidewalk or portion thereof designated for the use of bicycles or other vehicles propelled by human power by the governing body of a political subdivision.

Subd. 2. Powers of political subdivisions. The governing body of any political subdivision may by ordinance:

(a) Designate any roadway or portion thereof under its jurisdiction as a bicycle lane.

(b) Designate any sidewalk or portion thereof under its jurisdiction as a bicycle way provided that the designation does not destroy a pedestrian way or pedestrian access.

Subd. 3. Designation of lane. A governing body designating a sidewalk or portion thereof as a bicycle lane under this section may:

(a) Designate the type and character of vehicles or other modes of travel which may be operated on a bicycle lane or bicycle way, provided that the operation of such vehicle or other mode of travel is not inconsistent with the safe use and enjoyment of the bicycle lane or bicycle way by bicycle traffic.

(b) Establish priority of right-of-way on the bicycle lane or bicycle way and otherwise regulate the use of the bicycle lane or bicycle way as it deems necessary.

(c) Paint lines or construct curbs or establish other physical separations to exclude the use of the bicycle lane or bicycle way by vehicles other than those specifically permitted to operate thereon.

The designating governing body may after public hearing, prohibit through traffic on any highway or portion thereof designated as a bicycle lane, except that through traffic may not be prohibited on a trunk highway. The designating governing body shall erect and maintain official signs giving notice of the regulations and priorities established under this subdivision, and shall mark all bicycle lanes and bicycle ways with appropriate signs.

Subd. 4. Speed on street with bicycle lane. Notwithstanding section 169.14, subdivision 5, the governing body of any political subdivision, by resolution or ordinance and without an engineering or traffic investigation, may designate a safe speed for any street or highway under its authority upon which it has established a bicycle lane; provided that such safe speed shall not be lower than 25 miles per hour. The ordinance or resolution designating the speed are erected along the street or highway, as provided by the governing body.

VIII. EROSION CONTROL DURING BIKEWAY CONSTRUCTION

There is a lot of data available regarding erosion on construction projects. Basically, on a unit area basis, construction is one of the highest sediment yielding activities known. Since bikeway construction is similar to roadway construction except on a reduced scale, most of the erosion control methods and devices used on roadway construction may also be used on bikeway construction.

Erosion, the resulting sediment and the deposition of that sediment can cause property damage, water quality problems and safety problems. Rill and gully erosion immediately adjacent to a bikeway represents a real safety hazard to any bicyclist who leaves the riding surface, and if the erosion is allowed to progress it may cause damage to the riding surface and/or other related structures. Therefore erosion control methods must be incorporated into the design, construction and maintenance of bikeways.

In general, bikeways that are part of the roadway or shoulder, will not necessitate any additional erosion control efforts other than those provided in normal road construction. An exception to this would be the construction of a rural roadway with a bikeway on the roadway shoulder. In order to provide additional protection against the formation of rills and gullies on the inslope adjacent to the bikeway it may be necessary to place a material such as wood fiber blanket, plastic netting over straw mulch or sod.

An off-road bikeway is completely separated from vehicular traffic with its own or sharing another facilities right-of-way, erosion control for its construction will often be independent from but in most respects similar to erosion control practices used on roadway construction. Therefore, an understanding of roadway erosion control methods and materials is needed. The remaining portion of this section will classify erosion control methods into three types, and give examples and references for each type.

Erosion control methods can be classified as temporary, permanent, and/or regulatory.

Temporary erosion control methods include such items as bale ditch stops, temporary flexible down drains, and temporary seeding (oats or rye). Temporary erosion control items are short life items which are intended to supplement but not perform in place of permanent erosion control measures.

Permanent erosion control methods include such items as riprap, culverts, aprons, sod, permanent turf establishment, sediment ponds, dams and shaping. Permanent erosion control items are long life items.

Information on permanent and temporary erosion control items may be found in the following:

1. Mn/DOT "Road Design Manual".

2. MHD "Erosion Prevention and Turf Establishment Manual"; 1970 by L.E. Foote, D. L. Kill and A. H. Bolland.

3. Mn/DOT "Standard Specification for Highway Construction"; current edition, sections 2105, 2575 and 3861 - 3885.

There are numerous regulatory methods by which to control erosion. Mainly these methods are geared towards reducing or limiting the amount of time which elapses between initial disturbance and project completion. An excellent example is the withholding of funds or payment with release of these funds being made in proportion to the amount of erosion control and turf establishment items which have been completed. Examples of regulatory

methods may be found in the Mn/DOT "Standard Specification for Highway Construction", current edition sections 1717, 1803, 2105 and 2575.

IX. VEGETATION CONTROL

Control of vegetation is generally considered to be the responsibility of maintenance forces, however, in order to provide better control it should also be considered during design and construction.

The following are examples of vegetation control methods which may be provided for or carried out during the design and construction of bikeways.

1. Placement of a general herbicide (such as Urox Liquid or Oxy Monobor-Chlorate) under asphalt paving. These herbicides will prevent vegetative growth from penetrating the asphalt paving for a number of years. It is quite common for thin bituminous surfaces with shallow subsurface treatment, such as walking trails, to be ruined by vegetation.

2. Requiring the contractor to control noxious weeds during construction. The following nine weeds have been designated noxious weeds on a state wide basis.

Canada Thistle	Sow Thistle
Bull Thistle	Musk Thistle
Plumeless Thistle	Wild Hemp
Poison Ivy	Leafy Spurge
Field Bindweed	

The Agricultural Weed Law of Minnesota requires the control of at least these nine weeds. In the preparation of plans and provisions for the construction of bikeways the responsibility for control of these noxious weeds during construction can be delegated to the contractor.

3. Selective vegetation removal should be required in order to remove low hanging branches and other vegetative growth which has encroached onto the bikeway. These encroachments may reduce the cyclist's sight distance and can cause personal injury to the cyclist.

X. MAINTENANCE

Maintenance of a bicycle facility, after it has been constructed, is an important factor for the successful operation and usage of the facility by cyclists. Poor maintenance resulting in the accumulation of sand, gravel, broken glass, branches, etc., on the facility or development of potholes, corrugations and other rough surface conditions will cause cyclists to avoid the facility. The result may be that the facility becomes a liability rather than an asset to the controlling agency. Therefore, the responsibility for maintenance of the facility must be established prior to construction. Normally, if the facility is located on the highway shoulder the maintenance of the facility will be the responsibility of appropriate highway agency. If the facility is separated from the roadway the maintenance of the facility will be the responsibility of the appropriate local or other governmental agency.

Although the designer is not responsible for maintenance, there are a number of factors that can be incorporated into the design which will facilitate the necessary maintenance operations. The following is a partial checklist of items to be considered during design:

1. Is the facility of sufficient width (especially off-road bikeways) to accommodate maintenance vehicles?

2. Is the structure thickness of the facility adequate to support maintenance or emergency vehicles?

3. Has access to the facility for maintenance or emergency vehicles been provided (especially on off-road bikeways)?

4. Has sufficient clearing or grubbing been provided for adequate sight distance and horizontal and vertical clearances?

5. Have adequate cross slopes, drainage structures and ditches been provided to insure good drainage?

6. Are designed plantings in locations that will not become a hazard or create sight distance problems in the future.

7. Have "maintainable" side slopes been planned?

8. Have driveways and intersecting roadways been paved beyond the bikeway (10 feet or more) to minimize amounts of gravel and dirt dropped on the bikeway by by crossing motor vehicles?

The above checklist is not a complete list but does give some of the items to be considered during the design stage. The designer may wish to contact maintenance personnel for additional items.

XI. BIKEWAY PLANS PREPARED BY LOCAL GOVERNMENTAL AGENCIES

Bikeway plans prepared by local governmental agencies for funding thru Mn/DOT programs will be processed by the State Aid Office and the Office of Environmental Services.

Plans for projects within cities of over 5,000 population shall be prepared (or reviewed) and signed by the City Engineer (if the bikeway is on a county road, the plan shall also be signed by the County Engineer). For other areas plans shall be prepared (or reviewed) and signed by the County Engineer. Official Mn/DOT contact will be with the city or county engineer. Plans shall then be submitted to the appropriate Mn/DOT District State Aid Engineer and thence to the Office of State Aid in St. Paul.

Plans must be approved before award of contract to be eligible for funding.

An engineer's estimate shall be submitted with the plans, consisting of a list of pay items, the unit price for each item, the extension for each item and the grand total.

Projects involving Federal Aid shall follow the regular federal aid programming sequence.

The purpose of a set of Construction Plans is to delineate the contemplated work with sufficient details of design, supplemented with tabulation of summary of quantities, in such a manner that it can be clearly interpreted by engineers and contractors. The originals serve as a permanent record of the project and must provide sufficient data to enable the contractor to make an intelligent bid and to perform the work as intended. Clarity and conciseness are essential so as to avoid misrepresentation. Unnecessary details should be avoided.

Plans shall be prepared in accordance with Mn/DOT Technical Manual sections 5-292.600, Mn/DOT State Aid Manual section 5-892.200 and the following:

A. GENERAL

1. All projects shall have a State Aid Project Number, this number may be obtained by calling the Office of State Aid. The project No. (e.g. S.A.P. 87-623-04) shall be shown on the lower right hand corner of all plan sheets.

2. Plan size shall be 8-1/2" x 11", 11" x 17" or 22" x 34". (We do not have facilities for processing any other sized plans). Plans that are 11" x 17" or 22" x 34" shall be on translucent material capable of making clear ozalid prints. Do not use "Stick Up" on final plans.

3. Plans shall include a legend showing conventional signs and symbols used in the plans.

B. TITLE SHEET shall include:

1. Description Block

a. Type of work; bicycle route, bicycle lanes or bicycle path.

b. Highway (CSAH or MSASH) number, or street name.

c. Project number.

d. Geographic location of each project - name, distance and direction from intersecting highways or towns.

e. Legal Description - land ties to extremities of each project.

f. Length of each project in feet and miles (indicating gross length, bridge lengths, exceptions and net lengths) carried to exact chained footage and to three decimal points in mileage. All bridges are considered exceptions if previously constructed.

2. Index maps shall clearly portray the project location and shall include:

a. Stationing and project number at beginning and end of project.

b. Distance and direction to at least one incorporated municipality.

c. Bridge number, stationing and length in feet and miles to each bridge.

d. Section, township and range.

NOTE: If a scale is shown, use a bar graph that will change when plan size is changed by reduction processing.

3. Index of Sheets. Title sheet shall be sheet number 1. Sheets shall be numbered consecutively.

4. Specification Reference (latest edition of Mn/DOT Standard Specifications for Highway Construction).

5. Present and Projected (20 Year) Average Daily Traffic of roadway for Bicycle Route and Bicycle Lane projects.

6. Standard Signature Block and Engineer's Certification Block.

7. For urban federal aid projects a FHWA approval block must be provided.

C. ESTIMATED QUANTITIES AND TYPICAL SECTION sheet shall include:

1. Statement of Estimated Quantities

a. Statement shall have separate quantity columns for participating and non-participating items. Where bikeway work is part of a regular State Aid project, bikeway items shall have a separate quantity column.

b. Numbers and wording of items shall be identical with those listed in the current Standard Specifications (and pay item description tape maintained by Mn/DOT central office, call Office of State Aid if any questions arise).

c. Work shall be paid for under the appropriate item designation, such as Common Excavation, Bituminous Material for Mixture, Wearing Course Mixture, etc. The use of Lump Sum payment in lieu of the regular items will normally not be permitted.

d. Equipment rental items explained by adequate notes. It is not permissible to provide equipment rental items for emergencies.

e. All items listed in the Statement of Estimated Quantities must be referred to elsewhere in the plans by notes, tabulation, sketch of detail, etc.

f. On projects involving federal funds (except R.S. projects), no proprietory item references shall be made unless justified by a public interest finding or unless at least 3 proprietory names are listed for each proprietory item.

g. List of Standard Plates applicable to project, including plates for standard barricades and current specification references.

3. Typical Sections of Bicycle Lane and Bicycle Trail projects shall show the following:

a. Width, thickness and type of surfacing and base materials.

b. Exact point representing profile grade.

c. Recovery area as specified in the design standards.

d. Topsoil material.

e. Rounded ditch bottoms and tops of backslopes on grading sections (except in rock cuts).

f. Enough information on typical section so that the quantities of each type of construction can be accurately computed and constructed.

D. PLAN AND PROFILE SHEETS

1. For "Bicycle Route" plans, a layout such as a plat large enough to clearly portray locations and types of signs and pavement markings may be adequate. Profile grades will usually not be required.

2. For "Bicycle Lane" plans, plan view layouts and profile grades will not be required where previously approved plans for these areas are on file in the State Aid Office. Where Plan and Profiles are not on file, a complete plan and profile shall be included in the plans.

3. "Bicycle Trail" plans shall include the following:

a. All pertinent topography.

b. All existing utilities, either aerial or underground. Projects involving Federal Aid funds shall include a "Public Utilities" chart if applicable.

c. All pertinent information concerning railroads adjacent to or crossing the project, including distances from highway, stationing and angles of intersection, grades, track elevation, etc.

d. All perinent information on bridges. (Bridge number, type, length and width curb to curb).

e. Indicate present and proposed right of way with conventional symbols and widths in feet. Show slope easements with conventional symbols and widths in feet. Permanent right of way shall be provided for all permanent structures.

f. All horizontal alignment shall be dimensioned to adjacent street or highways. All curves shall have horizontal curve data including superelevation.

g. Profile grades (contracted scale) showing proposed grades vertical curves and existing ground line.

h. Elevation tie to Sea Level Datum (U.S.C. & G.S.)

i. Drainage Structures

i. invert elevations (both inlet and outlet) for cross culverts, cattle passes, sewers and subsurface drains.

ii. Direction of Flow.

iii. End bevel of structural plate culverts.

iv. Class of RC Pipe and gage of metal pipe if other than standard.

v. Class of Bedding for R.C. Pipe if other than standard.

vi. Any structure carrying a 500 cubic feet per second or more design flood shall have the pertinent hydraulic data for the design flood shown in the plans.

vii. Due to maintenance considerations the minimum culvert size shall be 18 inch diameter.

viii. Indicate the direction of flow of all drainage with arrows. (This includes areas where there is natural drainage and areas where drainage structures are not required).

j. Stationing of corporate limits of municipalities.

k. Stationing of equations, exceptions and temporary connections.

l. All section corners, land ties, etc.

m. Grading quantities in agreement with those on cross sections and statement of estimated quantities.

n. Sources of selected material and locations of designated borrow pits and balances showing where selected material or borrow materials is to be placed.

o. All removal and construction items shall be shown as notes or in tabulation form. (Culverts, storm sewer, clearing and grubbing, sodding etc.).

p. All construction items not covered by Mn/DOT Standard Plates shall be detailed on appropriate plan sheets.

q. A scale which will not require crowding of topography and notes.

r. A "North" arrow on each plan and profile sheet.

E. CROSS-SECTION sheets are required for "Bicycle Trail" projects as follows:

1. Cross culverts, cattle passes and subsurface drains. This gives a better picture of the planned drainage and provides an opportunity to check the structures for strength classifications.

2. Side slope ratios and recovery area width.

F. FORCE ACCOUNT AGREEMENT PROJECT

Smaller projects can be processed as Force Account Agreement projects (see forms in State Aid Manual). This eliminates the contract letting procedures. The paragraph referring to Preliminary Engineering shall be deleted as this is not a participating item. Larger bicycle path projects should be constructed by the contract letting process. Force account agreements require the approval and signature of the city or county engineer, the district state aid engineer and the Director, Office of State Aid (the same as plans). Submit three signed copies. Force account agreements must be approved prior to construction to be eligible for funding.

G. SUMMARY

Plans for bicycle routes and bicycle lanes can be quite brief. The geographic location of the project shall be portrayed on the title sheet. Show a plat or plan view clearly showing project route. Types and location of signs shall be shown. Types of signs shall be referenced to the applicable Standard Sign Manual Sign Number. Striping location, types, quantities and details, if applicable, shall be shown. A tabulation of estimate quantities shall be included in the plans.

Plans for bicycle paths shall show the proposed alignment, grades, typical section and all other pertinent features. These items shall be in accordance with the bikeway engineering standards.