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ENGINEERING AND DESIGN

DESIGN OF RECREATION AREAS AND FACILITIES—ACCESS AND CIRCULATION

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
OFFICE OF THE CHIEF OF ENGINEERS

DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, D.C. 20314

DAEN-CWE-BU

Manual
No. 1110-2-410

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Engineering and Design
DESIGN OF RECREATION AREAS AND FACILITIES
ACCESS AND CIRCULATION

1. Purpose. The purpose of this manual is to present data compiled from experience and research that should be useful in the design of access and circulation to recreation sites, areas and facilities.

2. Applicability. This manual is applicable to all field operating activities having civil works design responsibilities.

3. Discussion. Access and circulation to and through park and recreation areas have distinctive characters and play a major role in influencing the public's enjoyment of recreation resources. Each segment of the facility should be compatible with the environment and the recreation scene through which it passes. Using this philosophy, this manual presents basic design considerations for all portions and modes of access and circulation to and about recreation areas and facilities. It sets out specific design considerations which when applied can eliminate confusion and duplication of design effort. An attempt is made to present the most efficient, practical and time tested designs. Additional guidance is given in the form of construction details and by illustrations of existing design solutions. The illustrations were selected for their soundness and completeness for meeting the public need for recreation facilities.

FOR THE COMMANDER:

JAMES W. RAY
Colonel, Corps of Engineers
Chief of Staff

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CHAPTER 1

INTRODUCTION

1-1. Purpose. The purpose of this manual is to present data compiled from experience and research that may be useful to Corps of Engineers personnel concerned with design of access and circulation to recreation sites, areas and facilities. The material presented in this manual is intended as design guidance for obtaining an end product which results in safe, useable, economical recreation developments and accessible to all.

1-2. Applicability. This manual is issued for the guidance of Division and District Engineers having responsibility for the design and construction of recreation developments at Civil Works projects.

1-3. References.

a. TM 5-818-2

b. TM 5-820-3

c. TM 5-820-4

d. TM 5-822-2

e. TM 5-822-4

f. TM 5-822-5

g. TM 5-822-6

h. EM 1110-2-1906

i. Office of the Chief of Engineers, Standard Pavement Joint Curb and Gutter - Vehicular Rigid, Standard Drawing No. 40-17-02 dated 5 March 1962.

j. American National Standards Institute (ANSI) D 6.1-1978, "Manual on Uniform Traffic Devices", U.S. Department of Transportation, Federal Highway Administration, 1978.

k. Architectural Graphic Standards, 6th Edition, The American Institute of Architects, 1970.

l. The American Association of State Highway and Transportation Officials (AASHTO), 341 National Press Building, Washington, D.C. 20004:

(1) A policy on Geometric Design of Rural Highways, 1965.

(2) A policy on Design of Urban Highways and Arterial Streets, 1973.

1-4. Scope. This manual presents basic design considerations for all portions and modes of access and circulation to and about recreation areas and facilities. It sets out specific design considerations which when applied can eliminate confusion and duplication of design effort. An attempt is made to present the most efficient, practical and time tested designs. Additional guidance is given in the form of construction details and by illustrations of existing design solutions. The illustrations were selected for their soundness and completeness for meeting the public need for recreation facilities.

1-5. Discussion. Public use and enjoyment of recreation resources at Corps projects depends upon many factors. Whether the visit is by automobile, boat, or on foot access and circulation to and through park and recreation areas have a distinctive character and play a major role in influencing the recreating experience. The design and location of park access and circulation roads, parking areas, boat ramps, walks, steps, and trails must be in accordance with the philosophy of how a person views the park and can be as significant as participation in its activities. This philosophy of design aids in insuring that Corps projects become places to which people go for a special kind of experience, rather than merely places to get away from everyday activities. Within recreation lands, no road or other circulation system should be designed only as a connecting device to link points of interest. Every segment of every recreation access facility should relate to the environment and the recreation scene through which it passes in a meaningful way. Access and circulation in recreation areas should, to the extent possible, constitute an enjoyable and informative experience in itself. Directness of route of recreation roads should not be the overruling factor in selection of alignment. This manual covers the various means of access to recreation sites, areas and facilities. Special chapters cover road design; parking areas; roadside facilities; boat launching ramps; walks, steps and ramps; trails; and park entrances.

CHAPTER 2

ROADS

2-1. Application. Recreation roads are designed and built primarily to support and provide recreation experiences. A large percentage of recreation visitors are sightseers and roads are primary recreation facilities for them. National policy places emphasis on safety, aesthetics, and accessability to the physically handicapped in design of public facilities. Road designers must be sensitive to and routinely incorporate these features in Corps designs. Designers should be familiar with and follow the general road design standards set out in this manual. The road terminology used in this chapter is that of the American Association of State Highway and Transportation Officials, AASHTO (formerly AASHO). Design of a park road should be accomplished by an interdisciplinary team of professionals.

2-2. Controls.

a. Topography and Physical Features.

(1) General. Special knowledge and concern for protection of the resources and aesthetics of the area through which the access road passes and of the area where the recreation facilities are to be developed are essential tools of the recreation road designer. A complete knowledge of topography, physical features, and recreation facilities is required and the best location for each has to be determined prior to detailed design of the access and circulation road. Information regarding topography, land use and physical features, together with traffic data form the major design controls. The other design controls discussed below depend largely on these controls. Since topography and land use have such a pronounced effect on road geometrics, information regarding these features should be obtained in the early stages of planning and design. Photogrammetry at the proper scale and contour interval is most helpful.

(2) Types of Topography (Terrain). General topography types are established here for classifying terrain for common understanding in their application to design needs. Classification pertains to the general character of the specific route corridor. Classification is established here in terms of difficulty the design vehicle would encounter when a recreation road is placed on that terrain. Level terrain would not cause the design vehicle towing heavy loads to reduce to speeds below those of passenger cars on any section of the road. In general, rolling terrain causes vehicles towing heavy loads to reduce to speeds below those of passenger cars on some sections of road.

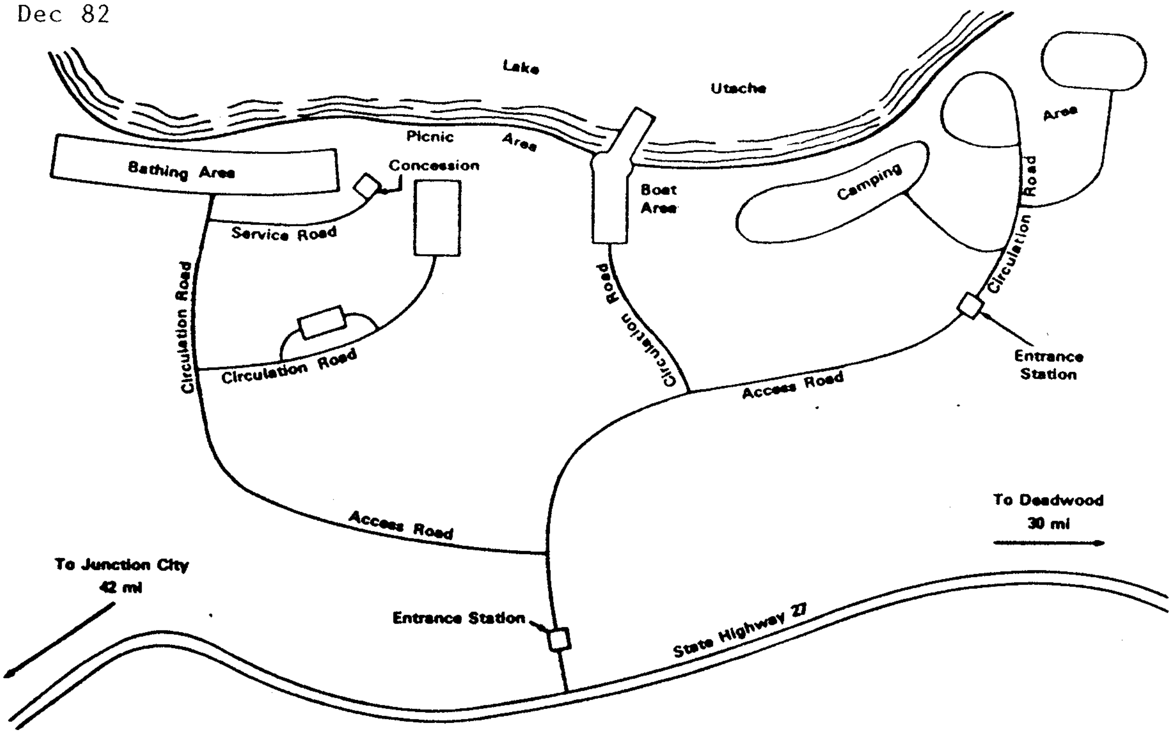


Figure 2-1 Schematic of typical recreation road pattern showing three main types of roads serving a recreation site.

Mountainous terrain may cause some vehicles towing heavy loads to operate at crawl speeds. Definitions of terrain classifications are as follows:

(a) Level terrain is that condition where sight distances are generally long or could be made to be so without major changes to the natural environment.

(b) Rolling terrain is that condition where the natural slopes consistently rise above and fall below the roadway grade line and where occasional steep slopes offer some restrictions to horizontal and vertical alignment.

(c) Mountainous terrain is that condition where longitudinal and transverse changes in the elevation of the ground with respect to the roadway are abrupt.

b. Road Classifications. Recreation road classifications are set out here for convenience of reference and to set the stage for good park road design. The recreation road is divided into three major types. These are: access road (the transition between high speed roads, and the park area) circulation road (an integral part of the recreation site or area), and the service road (the link between the high speed, access, or circulation road and special services provided by the park manager and the Government concessionaire). Figure 2-1 shows the different roads serving a recreation site with most of the outdoor recreation activities.

(1) Access Road. An access road is a road which permits vehicles to move between an existing public thoroughfare and the recreation site or area. These roads should be environmentally pleasing to serve as approaches to recreation areas. Access roads outside park boundaries may be designed more like highways, while access roads within park boundaries should be designed as recreation roads. In either case the impact on the environment should be as slight as feasible. Access roads may be two-way, two-lane roads and in some instances dividing of the lanes might become a practical application.

(2) Circulation Road. A circulation road is a road which connects with an access road or other circulation road and leads to and through recreation use areas and facilities. Circulation roads may be two-way.

(3) Service Road. The service road is used primarily for maintenance and supply vehicles within recreation areas. Service roads may also serve as public hiking/biking trails and firebreaks. Normally they will be one lane wide. Turnarounds and passing lanes should be provided where needed or as required.

c. Traffic.

(1) Importance of Traffic Data. The design of a road or any part thereof should be based upon factual data, among which are those relating to traffic. All data should be considered jointly. Cost, quality of foundations, availability of materials, and other factors have important bearing on the design, but traffic indicates the service for which the road is being built and directly affects the geometric features of design such as width, alignment, grades, etc. Traffic information serves to establish the "loads" for geometric road design.

(2) Design Traffic. The quantity of traffic for recreation roads will be derived by analyzing the road system for distribution of traffic generated by the park design load. The design load will be based on visitation anticipated on a normal weekend day during the principal recreation season with full development. The design load (vehicles perday) will be used for each recreation road classification as outlined

below in the similar way as Average Daily Traffic count is used in highway design. Design traffic will not be based on the unusually heavy traffic on a holiday weekend such as the 4th of July or Labor Day. It should be recognized that some congestion and overloading will occur on holiday weekends. The mix of vehicle types (ratio of SU:P-see paragraph 2-2d (2)) should also be estimated for each road.

d. Vehicle Characteristics.

(1) Vehicle Characteristics. The physical characteristics of vehicles including their size, maneuver patterns and the various types of vehicles used by recreationists are positive controls in geometric design. Some recreation vehicles might seem at a glance to have unique characteristics, i.e., a 30-foot long motor home. The length, width, wheelbase and turning radius are all similar to commercial trucks or buses. The motor home (RV) is used extensively for outdoor recreation experiences and are used for extended vacations rather than the weekend recreation visit. These and other trends must be studied and verified from time to time and perhaps for each major project to be sure the right design data are selected.

(2) Design Vehicle. This is a selected motor vehicle, the weight dimensions and operating characteristics of which are used to establish road design controls to accommodate vehicles of a designated type. For purposes of design, the design vehicle should be one with dimensions and minimum turning radius larger than those of almost all vehicles in its class. The heaviest and largest travel units using recreation roads are school buses, motor homes and maintenance and construction oriented vehicles such as dump trucks. Generally, their loaded weights will not exceed 10,000 pounds (total weight). A single unit truck (SU), as described in AASHTO "A Policy on Geometric Design of Rural Highways", 1965, best fits this class. (See Figure II-9 of above referenced AASHTO Policy). The SU Design Vehicle should be used for access roads, circulation roads, and service roads which will be used by buses, motor homes and/or maintenance trucks. Other roads which will be used only by passenger cars and light pickup trucks may be designed based on Design Vehicle P (See Figure II-3 of above referenced Policy for definition).

e. Capacity. Capacity will seldom govern design of recreation roads. For two-way traffic, two lanes of appropriate width will almost always accommodate traffic for Corps parks. In those rare instances where two 12' wide lanes would be inadequate, a proposal to provide more than two-lanes must be thoroughly justified in a feature design memorandum on the basis of AASHTO capacity data and approved by the Division Engineer. One-way roads of more than one lane will also require the same justification and Division Engineer approval.

f. Safety. It is imperative that the Corps' recreation roads be designed to provide safety to park participants. This should be accomplished by applying the design data set forth herein with sound professional judgment to recreation road needs.

g. Cost. Road construction consumes a large percentage (25 percent and more) of funds available for providing recreation facilities and also for project maintenance. Considerable design effort is necessary in getting the most road for the dollar initially, while at the same time giving full consideration to recreation and environmental values, maintenance, safety and life cycle cost.

2-3. Elements of Design.

a. Design Speed. The design speed of a roadway is defined as "the maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design features of the highway govern" (AASHTO, 1965). Design speed should be selected with respect to the character of the terrain and the level of roadway which is to be constructed. Current design standards are generally based on design speeds ranging between 30 and 80 miles per hour. For recreational roadway systems, however, 20 to 30 mile per hour designs should be considered far more suitable and economic. The use of a reduced design speed may provide for the reasonable reduction of other design parameters related to the design process, e.g. sight distances.

(1) General. Table 2-1 through 2-3 give the design speed for access and circulation roads as discussed in road classifications set out in paragraph 2-2.

Table 2-1
SUGGESTED DESIGN SPEEDS (MPH)
Access Roads Outside Park Boundaries Longer Than One Mile
Connecting a Public Road*

Type of	Traffic Brackets for Design Control-Vehicles Per Day (VPD)					
Terrain	0-50	50-250	250-400	400-750	750-1000	over 1000
Level	40	40	50	50	50	50
Rolling	30	30	40	40	40	40
Mountainous	20	20	20	30	30	30

*Design speeds for this type of access road should adhere to the principles of recreation road design rather than highway design standards. Design speeds should be selected which will begin to make the transition from highways to recreation roads. There is no need to use design speeds greater than that which will be permitted on this type of road by legal or regulatory speed limits.

Table 2-2
SUGGESTED DESIGN SPEEDS (MPH)
Short Access Roads Outside Park Boundaries and
Access Roads Within Park Boundaries

Reaches of Significant Length through Undeveloped Lands	Reaches through Developed Access Areas and Sites
40 mph maximum	20 mph maximum

Table 2-3
SUGGESTED DESIGN SPEED (MPH)
Circulation Roads

Reaches of Significant Length through Undeveloped Lands	Reaches through Developed Areas and Sites
30 mph maximum	20 mph or less

(2) Service Roads. Use the maximum suggested design speed that terrain permits economically. The suggested range of design speeds is from 20 to 40 mph with a maximum of 15 mph through developed sites and areas.

b. Sight Distance.

(1) Passing sight distance. Provision of the minimum passing sight distances indicated in Table 2-4 is secondary to fitting the road to the terrain, preservation of natural resources, minimizing earthwork and safety of recreation users scattered in sites and areas. The distances traversed by recreation roads are relatively short and do not merit much effort or cost to provide safe passing sight distances; however, when passing is not permitted, "No Passing" signs and markings should be provided in accordance with American National Standards Institute (ANSI) D6.1-1978, "Manual on Uniform Traffic Control Devices-For Streets and Highways". Passing sight distance need not be provided on recreation roads except that it should be at least considered on long access roads outside parks.

(2) Stopping sight distance. Minimum safe stopping distance for access roads should be provided as indicated in Table 2-4. Adjustments might have to be made in the case of circulation roads where integrity of site values (recreation values) might be compromised. Posting of safe speeds might be the designers choice in these cases remembering that

Table 2-4

MINIMUM SIGHT DISTANCES IN FEET

Design Speed, mph	20	30	40	50
Stopping sight distance				
Minimum Stopping Sight Distance, feet	150	200	275	350
K Value for:*				
Crest vertical curve	16	28	56	85
Sag vertical curve	24	35	55	75
Desirable Stopping Sight Distance, feet	150	200	300	450
K Value for:*				
Crest vertical curve	16	28	65	145
Sag vertical curve	24	35	60	100
Passing sight distance:				
Passing distance, feet 2-lane	--	--	1500	1800
K Value for:*				
Crest vertical curve	--	--	686	985

*NOTE: K value is a coefficient by which the algebraic difference in grade may be multiplied to determine the length in feet of the vertical curve which will provide minimum sight distance.

generally speeds on circulation roads are below 30 mph. Figure 2-2 shows data for stopping sight distances at intersections for wet pavements with increases and decreases for percent grade. Professional judgment should be applied in mountainous terrain and terrain between mountainous and rolling as to whether minimum stopping sight distance should be provided. Proper signing might have to suffice in lieu of extreme grading to attain engineering integrity of the road design.

The need for sight distance across the inside of horizontal curves must not be neglected where there are sight obstructions such as walls, cut slopes, wooded areas, buildings, etc.

(3) Measuring sight distance. Criteria for measuring distance, both vertical and horizontal, are as follows: for stopping sight distance, height of eye, 3.75 feet and height of object 0.5 foot; for passing sight distance, height of eye, 3.75 feet and height of object, 4.5 feet.

(4) Special application of passing sight distance. Passing sight distance is not given for design speeds of 20 and 30 mph because where

factors indicate that speed that slow is required on recreation roads, passing is undesirable and design data is not needed. Roads designed for 20 and 30 mph are circulation roads inside developed areas with activity facilities nearby, i.e. picnicking and camping.

(5) Special application of minimum sight distance. Where crest vertical curves and horizontal curves occur at the same location in rolling terrain, greater than minimum sight distance should be used in the design to assure that the horizontal curve is visible as drivers approach. When this condition occurs in mountainous terrain proper signing of safe speed and extent of horizontal curve should be used to indicate safe driving conditions and speed.

c. Horizontal Alignment.

(1) Design philosophy. Long tangents should not be used in park road design. The horizontal and vertical alignment should respect the terrain, so that the road is laid lightly on the land. In deciding upon road location, maximum emphasis should be given to interpretive and scenic values. The design and location of roads, trails, walks and overlooks should be interrelated to permit the visitors to enjoy the park visit more thoroughly with as much freedom as possible in the manuver of their automobiles, pedestrian travel and other forms of park travel. Heavy

Minimum Stopping Sight Distance for Wet Pavements									
Highway Design Speed	Assumed Speed For Wet Condition	Minimum Stopping Sight Distance For Wet Pavement. Grades To 2%		Correction for Stopping Sight Distance for Wet Pavement					
				Decrease For Upgrade			Increase For Downgrade		
		Computed	Rounded	+3%	+6%	+9%	-3%	-6%	-9%
M.P.H.	M.P.H.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
30	28	176	200		10	20	10	20	30
40	36	263	275	10	20	30	10	30	50
50	44	369	350	20	30		20	50	
60	52	491	475	30	40		30	80	

Figure 2-2. Minimum Stopping Sight Distance for Wet Pavement

earthwork in cut and fill sections should be avoided. In effect the road should be molded to the terrain through which it is passing. Monotony is relieved, and maximum advantage is taken of park values by changes in elevation and by developing viewpoints and overlooks, as well as by providing close-range views of near scenes. Curving alignment offers constantly changing views of the scenery.

(2) Layout. Curving or winding alignment is preferred for recreation roads. Park roads should be aligned with curves, often compound, and connected with relatively short tangents or spirals, or both. Figure 2-3 shows curving alignment for recreation roads. It is desirable to use tangents, curves and spirals to define the alignment of highways

Figure 2-3 Curving Alignment for Recreation Roads

with appreciable traffic; however, for recreation roads with low traffic, the alignment can be (a) "eyeballed" or (b) driven in with a passenger vehicle or light pickup truck. When either method (a) or (b) is used for determining alignment, it should be staked and referenced (and/or witness staked) in the field with appropriate notation provided on the plans and as-built drawings. The alignment for such minor roads can be sketched on the plans and the measured length shown for bidding and payment. Deflection angles at points of intersection of up to five degrees may be used without horizontal curves inside parks. Recreation roads should be aligned to best accommodate the design of supporting facilities such as boat launching ramps, camping facilities, picnic facilities, overlooks, beaches, and their attendant parking facilities. Recreation roads should be located to preserve the integrity of the scenic values of the project, e.g., reservoir shoreline, bogs and natural rock outcroppings.

(3) Roads in reservoir areas. Generally roads should be located outside areas that are likely to be affected by shoreline erosion. When such areas cannot reasonably be avoided, shoreline protection (i.e., riprap) should be included. Access roads to camping areas that can be flooded, particularly when rapid pool rises can be expected, should be high enough that they will provide safe egress once the danger of rising water is readily apparent.

(4) Maximum curvature. Depending on the maximum superelevation value selected by the designer, the maximum curvature for different design speeds is shown in Table 2-5.

(5) Superelevation. Where ice and snow are factors, a superelevation rate of about 0.08 is a logical maximum to minimize slipping across the road when stopped or when attempting to start from a stopped position. From Table 2-5 above, it can be seen that there is little to be gained in greater permissible maximum degree of curve by increasing the maximum "e" above 0.08. Greater rates of superelevation tend to cause excessive inward friction required to drive slowly around the curve, a condition resulting in erratic vehicle operation. For this reason, it is recommended that a maximum superelevation rate of 0.08 normally be used. Where low speed operation will prevail, a low maximum rate of superelevation is appropriate. For additional guidance on standards for superelevation, follow the practice of the local highway department or AASHTO policy for rural roads. The extent and nature of applying superelevation in recreation road design should be tempered with the knowledge of the need for the road to be open during extreme winter conditions and the actual posted speed intended. Roads in camping areas are subject to not more than 15 mph posted speeds. Many other park areas need to have 15 mph speeds posted. The need for superelevation should be tempered with this knowledge. Road designers need to become fully informed as to how the area served by the road will be managed.

(6) Superelevation runoff. Superelevation runoff is the length of roadway needed to accomplish the change in cross slope from a normal crown section to a fully superelevated section. Minimum lengths of runoff are shown in Table 2-6. Adjustments in design runoff lengths may be necessary for smooth riding, surface drainage, and good appearance. For low speed center-crowned roads, removal of the adverse crown in the outside lane to provide a "shed" transverse grade sloping to the inside of the curve may be adequate for the runoff required. On curves with spirals the superelevation runoff is effected on the spiral. On curves without spirals, from 60 to 80 percent of the length of runoff should be located on the tangent. Smoothly rounded edge of pavement profiles are the desired end in design of superelevation runoff, rather than exactness in fitting the above guide values. For additional design details, follow the practice of the local highway department or AASHTO policy.

(7) Minimum desirable radii. Figure 2-4 shows minimum desirable radii for very low speed (5-10 mph), low design traffic recreation road curve.

(8) Pavement widening on Curves. Pavement widening need not be provided at horizontal curves in recreation roads with radii to the inside edge of surface greater than 100 feet because of the local nature of the roads, reduced vehicle operating speeds, relatively low traffic volumes and the absence of large commercial trucks. Because recreation roads should curve to fit the terrain it is more desirable in rolling to mountainous rough terrain from the standpoint of vehicle operation, constructability and appearance to make the normal road surface width about two feet wider than the practicable minimum than to widen first on one side and then the other. In level terrain flatter curves can be used. It is significant to note that the AASHTO makes no recommendation for widening for local roads. Widening should only be provided in recreation roads when it is crucial to safe vehicle operation. Also, see paragraphs 2-4b and 2-4d for extensive design data for pavement widening of recreation roads. In the unusual instances where widening on curves must be used, follow the standard of the local highway department or the design policies of the AASHTO.

(9) Design without superelevation. Frequently in parks with considerable irregularity in terrain, the distance between reverse curves will be too short to permit adequate runout of superelevation for a reversal in the cross slope of the road surface. The use of superelevation in extremely curving roads as opposed to normal center crown cross sections adversely affects constructability and control of grading. Some park road designers prefer to design circulation and service roads, where terrain and soils permit, with the cross slope

Table 2-5

MAXIMUM DEGREE OF CURVE AND
MINIMUM RADIUS FOR DIFFERENT VALUES
OF MAXIMUM SUPERELEVATION

Design Speed	Maximum e*	Minimum Radius (Rounded)	Max. Degree of Curve (Rounded)
MPH		Feet	Degrees
20	.06	115	50.0
30	.06	275	21.0
40	.06	510	11.5
50	.06	830	7.0
20	.08	110	53.5
30	.08	250	23.0
40	.08	460	13.0
50	.08	760	8.0
20	.10	100	58.0
30	.10	230	25.0
40	.10	430	14.0
50	.10	690	9.0
20	.12	95	63.0
30	.12	215	27.0
40	.12	400	15.0
50	.12	640	9.0

*Note: e = rate of roadway superelevation, foot per foot.

approximately parallel to the natural cross slope of the existing ground (without roadside ditches). In no case should the cross slope be less than ¼-inch per foot nor more than ½-inch per foot. Omission of superelevation may be permitted provided that after roads have been constructed, but before they are opened to the public, the maximum safe speed for negotiating curves is determined and posted with signs.

Table 2-6

MINIMUM LENGTH FOR SUPERELEVATION
RUNOFF FOR 2-LANE PAVEMENTS

Superelevation Rate Foot per foot	L-Length of runoff in feet for design speed, MPH, of:			
	20	30	40	50
.02	50	100	125	150
.04	50	100	125	150
.06	50	110	125	150
.08	50	145	170	190
.10	50	180	210	240
.12	50	215	250	290

Preferably this should be accomplished in cooperation with the state highway department. See the discussion of use of the ball bank indicator on page 154 of AASHTO, "A Policy on Geometric Design of Rural Highways", 1965. If the safe speed cannot be determined in connection with the state highway department, it will be determined by other suitable means, such as test driving in a vehicle typical of the design vehicle. When a passenger car is used it should be towing a rather long heavy trailer and when an SU type vehicle is used it should have a rather high center of gravity. If the maximum safe speed for negotiating a curve is determined to be less than the established speed limit (established in cooperation with the appropriate enforcement authority) for the reach of road, appropriate warning signs should be installed. ANSI D6.8 sign 2C-5 Curve Sign (W1-2), 2C-7 Reverse Curve Sign (W1-4), or 2C-8 Winding Road Sign (W1-5) as appropriate should be used at the top of the sign assembly. A 2C-35 Advisory Speed Plate (W13-1) should be mounted on the same assembly just below the appropriate curve warning sign to indicate the maximum safe speed for negotiating the curve or curves.

d. Vertical Alignment - Profiles.

(1) Design philosophy. Profile and horizontal alignment go hand in hand. A good profile cannot be established on an alignment which has not been wisely designed to most advantageously traverse the terrain. In usual road design the profile is established with the objective of

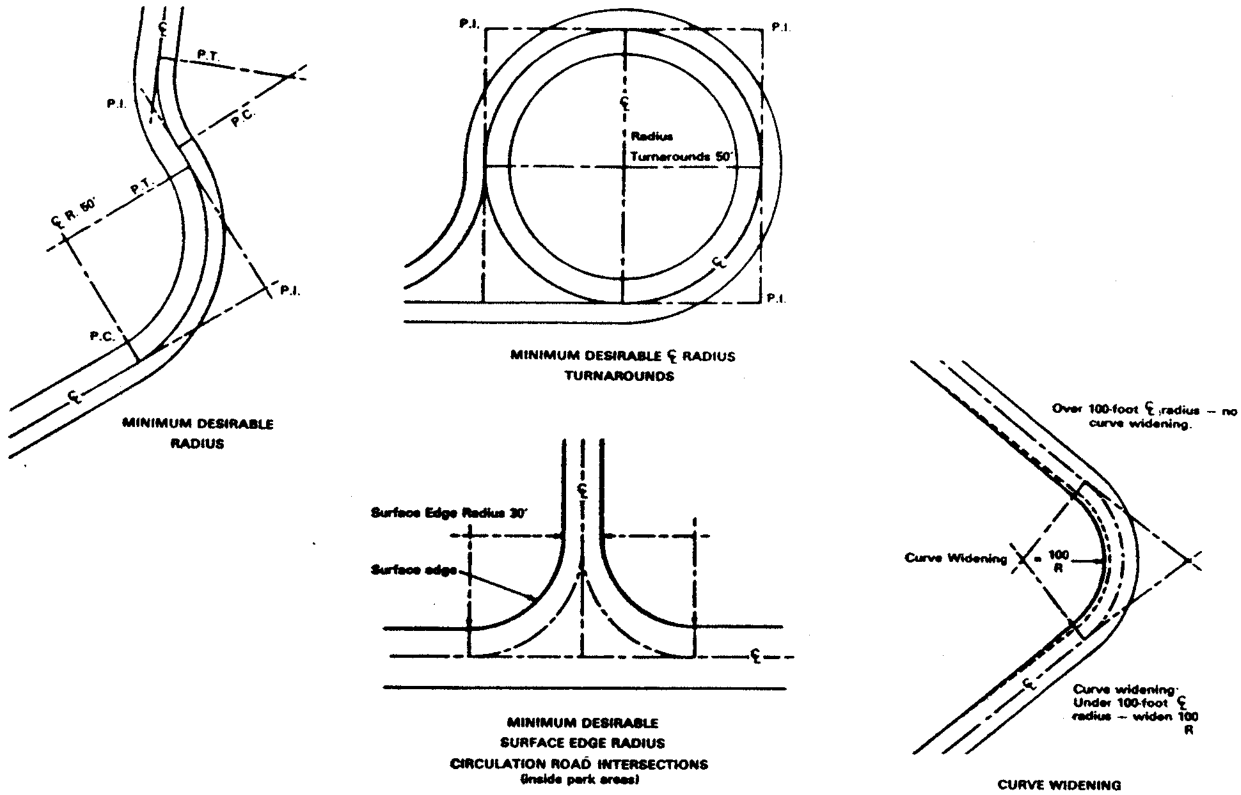


Figure 2-4 Minimum Desirable Radii for Recreation Roads

balancing cut and fill within economical haul distance. Recreation roads are different. For a traffic way that blends and flows with the terrain as well as provides a smooth transition from the paving to the roadside for errant vehicles, the vertical alignment should follow the existing grade as closely as possible. When suitable borrow material is economically available, consideration should be given to building the roadbed slightly above natural ground rather than trying to balance cut and fill. Often this will provide better drainage, create less disturbance of the environment, be less costly, and create less problems from an erosion control standpoint. All borrow areas used in this manner should be located to provide the least disturbance to the environment, preferably out of the view of visitors. When economically feasible, borrow should be taken below the elevation of a conservation or permanent pool. In mountainous terrain it may be necessary to exceed the desirable maximum grades because the cost of doing otherwise would be prohibitive and the environment severely harmed. When it is necessary to exceed the desirable maximum grades, the reaches should be kept as short as feasible and combinations of steep grade and horizontal curves should be avoided, as much as possible. Consideration should be given to the dangers that steep grades pose when traversed by light vehicles towing trailers.

Steep grades are particularly undesirable for gravel-surfaced roads because they are unsafe when wet and the gravel tends to be washed away. Figure 2-5 illustrates good vertical alignment of roads in park areas.

Figure 2-5 Vertical Alignment of Roads

(2) Maximum grades. Table 2-7 shows the desirable maximum grades for different types of terrain and design speeds in percent.

Table 2-7

MAXIMUM GRADES*

Type of Terrain	Design Speed MPH			
	20	30	40	50
Flat	7	7	7	6
Rolling	10	9	8	7
Mountainous	12	10	10	9

*Note: For roads with design traffic below 250 or where terrain is such that the grades shown would require cut and/or fill that would be excessive for a park road, grades of relatively short lengths may be increased up to 150 percent of the values shown while observing the cautions in paragraph 2-3d(1) above.

(3) Vertical curves. Vertical curves are used to effect gradual change between tangent grades. They should be simple in application and should result in a design which is safe, comfortable in operation, pleasing in appearance, and adequate for drainage. The major control for safe operation on crest vertical curves is the provision of minimum stopping sight distances for the design speed. In any design the sight distances should be consistent with the terrain and conservation of the environment. Considerations of comfort require that vehicular rate of change of grade be kept within tolerable limits. This is most important in sag vertical curves where gravitational and vertical centrifugal forces act in the same direction. Appearance also should be considered. A long curve has a more pleasing appearance than a short one which may give the appearance of a sudden "break" in the profile due to the effect of foreshortening. Simple parabolic curves should be used on recreation roads. Vertical curve data including K values are given in Table 2-4 under paragraph 2-3b(2) above, entitled Minimum Sight Distances in Feet. In recreation road design, minimum sight distances might be the rule instead of the exception and provision of prescribed appropriate markings and signs in accordance with ANSI D6.1-1978 can provide the proper safety precautions.

(4) Grades at intersections. Where intersections occur on road sections with moderately steep grades, it is desirable to reduce the gradient through the intersection in all legs of the intersection. Such a profile change is beneficial for all vehicles making turns and reduces potential hazards.

e. Combination of Horizontal and Vertical Alignment. Design of a recreation road is an art in three dimensions embodying many controls and elements, all interrelated. The following are excerpts from the AASHTO "A Policy on Geometric Design of Rural Highways", 1965 and are applicable to recreation road design, but with more emphasis on environmental values and less emphasis on efficiency in moving traffic rapidly.

"COMBINATION OF HORIZONTAL AND VERTICAL ALINEMENT"

"Horizontal and vertical alinement should not be designed independently. They complement each other, and poorly designed combinations can spoil the good points and aggravate the deficiencies of each. Horizontal alinement and profile are among the more important of the permanent design elements of the highway, for which thorough study is warranted. Excellence in their design and in the design of their combination increase utility and safety, encourage uniform speed, and improve appearance, almost always without additional cost.

"ALINEMENT COORDINATION IN DESIGN"

"Coordination of horizontal alinement and profile should not be left to chance but should begin with preliminary design, during which stage adjustments can be readily made. While a specific order of study for all highways cannot be stated, a general procedure applicable to most facilities can be outlined.

"The designer should utilize working drawings of a size, scale, and arrangement so that he can study long, continuous stretches of highway in both plan and profile and visualize the whole in three dimension. Working drawings should be of sufficiently small scale, generally 1 in. = 100 ft. or 1 in = 200 ft., with the profile plotted jointly with the plan. A continuous roll of plan-profile paper usually is suitable for this purpose.

"After study of the horizontal alinement and profile in preliminary form, adjustments in each, or both, can be made jointly to obtain the desired coordination. At this stage the designer should not be concerned with line calculations, other than known major controls. The study should be made largely on the basis of a graphical analysis. In doing so the use of splines, highway curve templates, ship curves, and straightedges are convenient in projecting both the horizontal alinement and the grade line. The criteria and elements of design covered in this and the preceding chapter should be kept in mind. For the selected design speed the values for controlling curvature, gradient, sight distance, superelevation runoff length, etc., should be available and checked graphically. Design speed may have to be adjusted during the process along some sections to conform to likely variations in speeds of operation where noticeable changes in alinement characteristics may occur. All aspects of terrain, traffic operation, and appearance can be considered and the horizontal and vertical lines adjusted and coordinated before the costly and time consuming calculations and the preparation of construction plans to large scale are started.

"The coordination of horizontal alinement and profile from the viewpoint of appearance can be accomplished visually on the preliminary working drawings. Generally this results in a satisfactory product when done by an experienced designer. This means of analysis may be supplemented by models of perspective sketches at locations where the effect of certain combinations of line and grade are questionable."

f. Drainage and Erosion Control. The importance of good drainage, both surface and subsurface cannot be overemphasized. Inadequate drainage, erosion control and overloading are the three greatest causes of road failures. Some general guidance for the design of drainage and erosion control design is given in the following sub-paragraphs.

(1) Design drainage structures to blend into the surrounding landscape rather than intrude upon it. Also use drainage grates that will not divert bicycle wheels when passed over. See Figure 2-6.

(2) Avoid long ditches along roadways which tend to accumulate large flows and require big ditch sections. The use of subdrains, catch basins, water bars, drainage dips, free draining embankment slope protection, slope seeding and outsloping road surfacing should be considered in the design.

(3) To the extent feasible, use natural materials such as stone for velocity and erosion control to avoid the high velocities of concrete chute structures. More specific guidance on roadway ditch design is presented in paragraph 2-4e and on drainage structure design in paragraph 2-6.

g. Landscape Development. Landscaping should be used for aesthetics, erosion control and to aid safety of drivers and pedestrians. Landscaping of recreation roads can be accomplished by vegetation, by shaping land forms, and by location of the road itself. Landscape development should be an element of the recreation road design.

Figure 2-6 Special Provision for Drainage

h. Roadside Turnouts, Driveways and Roadside Controls. These functional elements need to be considered in the design of recreation roads. Their frequency, location in relation to scenic features and recreation facilities, where they occur in relation to traffic volume and the safety of the user, and how well they serve the recreationist for enjoyment in the park visit are all important considerations in roadside control. The efficiency and safety of a recreation road depend greatly upon the amount and character of roadside interference most of which originates in recreation vehicle movements to and from the park and areas within the park. Overlooks and vistas, intersecting roads leading up to specific activity areas, off-road parking access, the camping spur, fee collection and check-in stations are examples of the roadside functional elements to be considered.

i. Utilities. Utilities such as power lines, telephone, water, gas and sewerage mains, which occupy or cross the road right-of- way, should be considered in location and design of the road. Normally, on new construction, no utility should be situated under any part of the pavement, except where it must cross the road. For such cases the utility should be placed in a pipe sleeve. Preferably underground utilities should be located outside the roadway to avoid any disturbance to traffic during utility maintenance activities.

j. Signs and Markings. Signs and markings are directly related to the design of the road and are features of traffic control and operation which the designer must consider in geometric layout of the work. Signs on project lands should be in accordance with EP 310-1-6, Chapter 4, Signage. Signs not on project lands should be coordinated with the appropriate state, county, or local authority. In addition signs, markings, and other traffic control devices pertaining to recreation roads should be provided in accordance with the Manual on Uniform Traffic Control Devices for Streets and Highways, ANSI D6.1-1978, U.S. Department of Transportation, Federal Highway Administration. Signs required to properly direct and warn drivers should be provided for public safety. Center line markings, no passing markings and pedestrian and cycle crossing markings are also stressed. Also see discussion on signing and marking as geometric design elements in AASHTO "A Policy on Geometric Design of Rural Highways", 1965 for additional guidance.

k. Lighting. Normally, lighting will not be provided except to improve safety at particular hazards or for security reasons. Hazards which would require lighting should be avoided to the extent possible by prudent road design and recreation facility management techniques and practices. Low nighttime traffic volumes generally prevailing in parks and low speed operation imposed in developed sites and areas should usually obviate the need for lighting of roads. When lighting is necessary, luminaries should be placed on standards high enough to minimize the effect of glare and to prevent vandalism. Standards should be located back of the horizontal obstruction clearance. Lighting in developed areas for roads should be coordinated with any other lighting, such as for campgrounds. Break-away standards should be used along roadways. For additional discussion of lighting, see AASHTO policy.

2-4. Cross Section Elements.

a. General. The design elements covered in this paragraph are illustrated on Figure 2-7 and the terms used conform with those on the illustration. The desirable range of rate of normal cross slopes is given in Table 2-9.

b. Width.

(1) Access roads. The minimum surface widths should be as given in Table 2-8. The widths given in the table have been adjusted from normal designs. These adjustments are made for the following reasons. First, the surfaced lanes of recreation roads are increased to provide a greater margin of safety and to reduce maintenance of the pavement edge and/or the shoulder at the pavement edge. This widening helps distracted drivers to maintain control of the many types of recreation vehicles especially those pulling trailers. Second, the park area can be considered a destination point and drivers need a wider pavement for safe operation of vehicles under congested conditions. Third, it is important in the interest of safety to paint a white stripe along the very edge of the pavement or one to two feet inside from that edge depending on the amount of pavement widening. See Figure 2-8.

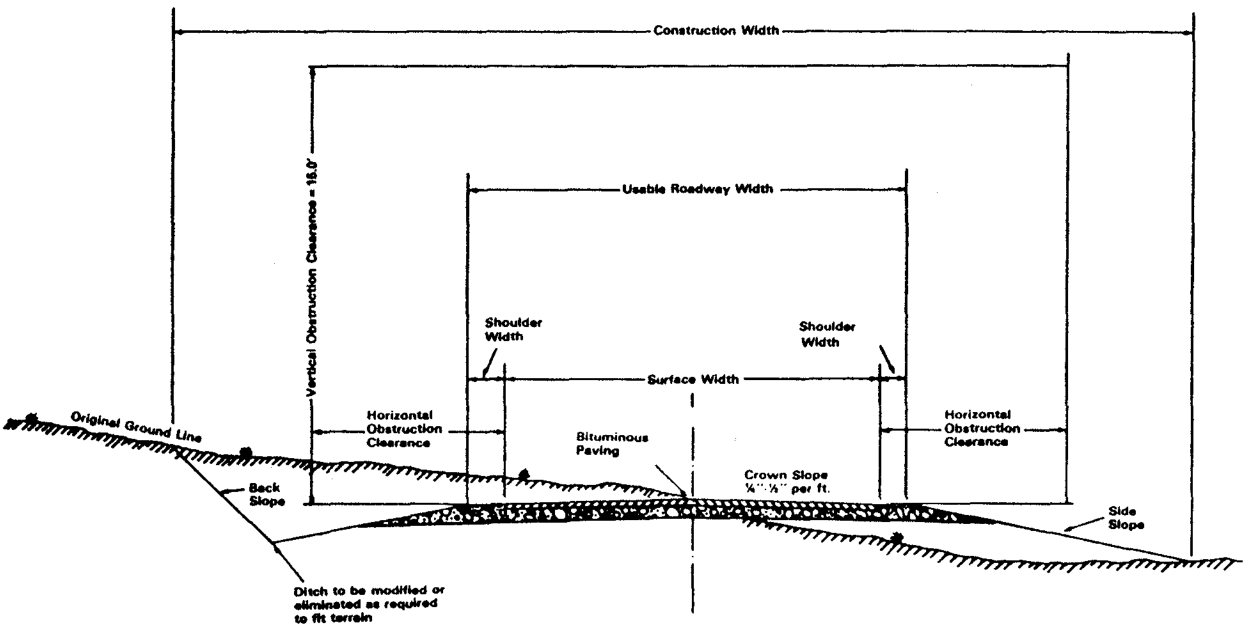


Figure 2-7 Cross Section elements for recreation roads

(2) Circulation Roads.

(a) Two-way circulation roads. Surface width should normally be 22-feet. Roads with design traffic of over 250 VPD and when design vehicle SU is used, surface width may be 24-feet wide. Where design vehicle P is applicable and design traffic is less than 250 VPD, 18-foot wide surface may be used. Minor short circulation roads and loops may also have 18-foot wide surface. When in doubt, use 20-foot surface.

(b) One-way circulation roads. Surface width should be 12-feet except for long roads with very sharp curves, through large campgrounds, where width should be 14-feet wide.

(3) Service roads. When surfaced, the surface width should be 10 feet. The type of surfacing provided should meet the need of access to the service facility (including O&M requirements). Surfacing of service roads might be economical for short distances to aid erosion control and other drainage problems.

Table 2-8

MINIMUM SURFACE WIDTH - TWO LANE ACCESS ROADS

	Surface Width in Feet for Design Traffic of:				
Design Speed, MPH	VPD (Vechicles per day) Less Than 50	VPD 50-250	VPD 250-400	VPD 400-750	Over 750 VPD with peaks
20	22	22	24	24	24
30	22	24	24	24	24
40	22	24	24	24	26
50	22	24	24	24	26

Table 2-9

NORMAL PAVEMENT CROSS SLOPES

Surface type	Cross Slopes	
	Inch per foot	Foot per foot
High	1/8-1/4	.01-.02
Intermediate	3/16-3/8	.015-.03
Low	1/4-1/2	.02-.04
Unsurfaced	1/2-1	.04-.08

c. Curbs. There are few applications of curbs in design and construction of recreation roads. They should be used only when needed for one or more of the following purposes. (1) to control drainage, (2) to confine vehicles to the pavement, or (3) to direct or channelize traffic. When curbs are used they should be designed in accordance with paragraph 3.3.3.3 of TM 5-822-2. In addition to the designs shown in CE Standard Drawing No. 40-17-02 the following designs may also be used: (1) extruded or slip-formed asphaltic concrete or Portland cement curb, (2) when direction of drainage is away from the curb, a free standing, partially buried more or less rectangular shaped wall type concrete, masonry or reinforced concrete curb with the exposed traffic side slightly battered away from the road surface, (3) pre-cast wheel stops and (4) a low flat, cast in place curb on grade, more or less rectangular in cross section with its width at least twice its height. Where a barrier only is needed, logs, railroad ties, masonry walls or other equivalent material may be used so long as it does not impose an increased hazard to vehicles.

d. Shoulders.

(1) Access roads outside park boundaries. Shoulders on access roads outside park boundaries should be designed to the standards of the highway agency who will be responsible for the operation and maintenance of the constructed roadway. All other access roads (those inside park boundaries) should be designed in accordance with the data given below.

(2) Access roads and circulation roads inside park boundaries. Because of the purpose and nature of the recreation road and the mood generated by the terrain, shoulders for those roads inside park boundaries serve modified purposes. The purpose of shoulders for this type of road is needed to protect pavement edge and provide transition between the pavement and fill or cut slopes. Temporary storage of disabled vehicles is not important on the usually short length of road, because of the slow speed of traffic, and the length of time, both weekly and daily the road is in use. Disabled vehicles can be tolerated better in recreation areas, therefore, complete off-the-road temporary vehicle storage is not critical. Preservation of the natural resources becomes very important in recreation areas and must be dealt with while designing park roads.

(3) Importance and functions. Because recreation areas attract many types of vehicles, it seems prudent to reduce the usual road shoulder for recreation roads and increase the pavement width according to the design speed and extent of use. An additional characteristic of the recreation road, i.e., curving alignment, also adds credence to the reduction of shoulder width and increasing pavement width principle. Pavement widening is practiced for the ordinary highway at curves. Shoulders on all recreation roads should be stabilized to provide lateral support for the pavement, facilitate drainage of the pavement (both surface and subsurface), reduce maintenance cost, and provide greater safety for visitors. See the discussion on importance of stabilizing shoulders beginning on page 238 of AASHTO, "A Policy on Geometric Design of Rural Highways, 1965. The stablization need not be extended at full depth for

the entire shoulder width. A feathered edge cross slope may be used for all or part of the shoulder width. A shoulder material that will provide stabilization and support a stand of grass is desirable. Shoulder stabilization to provide traffic support and support the growth of vegetation may require some additional cost but it is justified in climates that will sustain growth. The shoulder design should provide sufficient depth to allow root development and to sustain the vegetation. Placing a thin layer of soil over a sterile base course on the shoulder is not desirable for traffic support or for sustaining vegetation. See the discussion on turfed shoulders on page 239 of the AASHTO policy referred to above. For trafficability of shoulders give appropriate consideration to camping and boat trailers of considerable weight on small wheels.

(4) Shoulder width.

(a) Access roads and circulation roads. Shoulders for access and circulation roads for most recreation areas should be 2 feet. In some cases a greater width might be required for safety.

(b) Service Roads. Surfaced roads should have 1-1/2 feet wide shoulders.

(c) Shoulder with guard rail. Where a guard rail is used the shoulder should be increased 1 to 2 feet to permit setting the guard rail farther from the edge of the surface. Figure 2-8 shows a typical example of good shoulder width with a guardrail on an access road.

(5) Shoulder cross slopes. The desirable range of cross slopes is given in Table 2-10 for types of shoulder surfaces.

e. Slopes, Drainage Ditches, Channels and Erosion Control. These should be designed for minimum grading and clearing, safe and pleasing roadsides, and to present the least difficulty in erosion control. See discussion of these design elements in AASHTO policy. There is a conflict between two desirable features for ditches and slopes. These are:

(1) Slopes should be relatively flat and ditches shallow for safety and to blend with the terrain.

(2) The total width of the construction cross-section should be narrow to reduce clearing and minimize the scar caused by construction. This requires judgment to develop a good overall design. In cut sections it is recommended that the sideslopes be 6:1 (6 horizontal on 1 vertical)

and the backslope 3:1 (3 horizontal on 1 vertical). With these slopes, unforeseen ditch erosion is more likely to cut into the backslope which is more desirable than cutting into the sideslope. In rock cuts the backslope may be as steep as the rock characteristics permit. Minimum ditch depth to be shown on typical sections for cut should be 1 foot in soil and 6 inches in rock. These ditch depths should be measured from top of subgrade at shoulder points or edge of additional pavement to bottom of ditch. Consideration for deeper minimum depth ditches should be based on the following: (a) where necessary to intercept subsurface drainage or seepage; (b) in the northern latitudes where heavy snowfall

Table 2-10

SHOULDER CROSS SLOPES

	Shoulder cross slope (No Pavement edge curbs)	
Type of surface	Inch per foot	Foot per foot
Bituminous	3/8-5/8	.03-.05
Gravel or crushed stone	1/2-3/4	.05-.06
Turf	1	.08

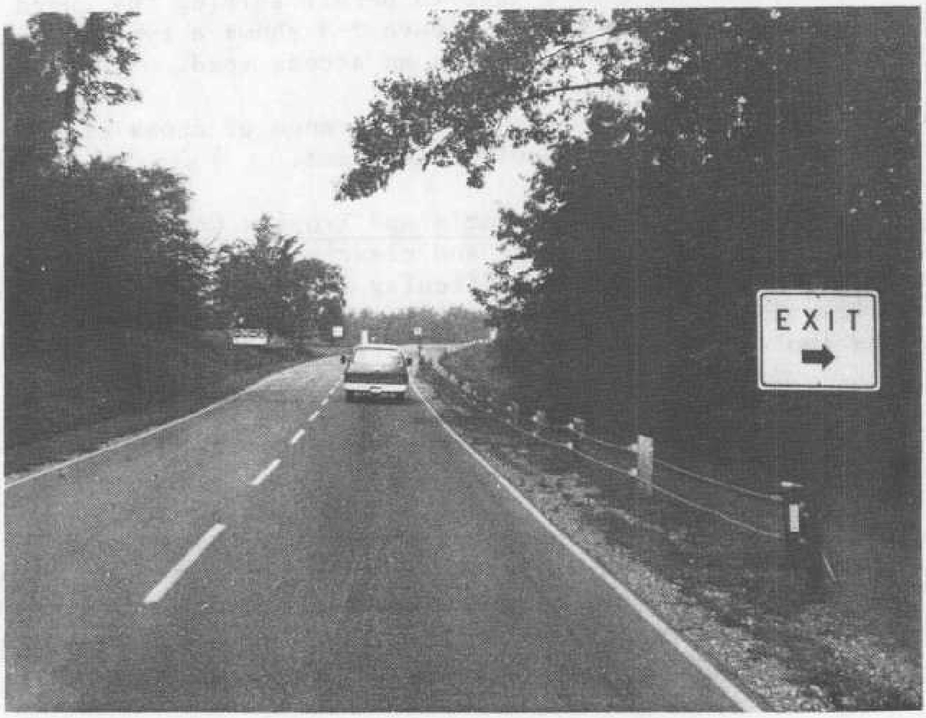


Figure 2-8 Cross Section Showing Pavement Striping, Shoulder and Guardrail

tends to block ditches, impeding runoff so as to cause damaging saturation of the pavement or subgrade; and (c) where deeper ditches will reduce overall cost where freezing governs pavement design thickness. Ditches should be routed and slopes warped where feasible to save desirable trees and other landscape features. Ditch bottoms should be sized and graded to carry runoff at non-erosive velocities when feasible. When erosive velocities will occur, erosion control measures should be provided. Fill side slopes should be 4:1 or flatter for rolling terrain. It is generally accepted that side slopes of 4:1 are reasonably safe and very often can be provided at less cost than the cost of guardrail. General Motors Proving Grounds tests indicate that side slopes 6:1 provide insurance against overturning even under adverse conditions. Interceptor ditches, dikes or terraces should be provided where needed to intercept runoff and conduct it away from slopes at non-erosive velocities. Roadside ditches on the upstream side of roads should be relieved with culverts across the road at intervals spaced so as to prevent excessive erosion of the upstream ditches. Ditches and channels should be designed for hydraulic efficiency by customary Corps hydraulic design criteria to accommodate runoff. Proper erosion control measures should be provided as needed, designed in accordance with customary Corps criteria. Drainage and erosion control should be designed in accordance with TM 5-820-4, Drainage and Erosion Control; Drainage for Areas Other Than Airfields. Additional sources of information on recreation road drainage and erosion control are the various state highway manuals and the Soil Conservation Service design. These aids may be used when they are more suitable for the prevailing conditions.

f. Grading. Design of grading should give consideration to roadside safety and aesthetics. Transitions between slopes, and slopes and natural ground should be rounded and warped as required for safety and to blend with the surroundings. Vegetation can usually be restored even though it may take considerable time and expense, but unsightly land forms left at the end of construction usually are difficult and costly to correct. See Figures IV-3 and IV-4 of AASHTO, "A Policy on Geometric Design of Rural Highways", 1965 for rounding of typical cross sections. Figure 2-9 shows minimum grading for a recreation road. Grading should be as light as feasible.

g. Obstruction Clearance. Obstruction clearance is the distance to be provided, measured from the edge of the (paved) road surface, which should be free of obstructions hazardous to vehicles if struck by them. Obstructions include structures, trees, poles, utility features, and standards which are not of yielding, break-away or frangible type including sign supports. Again recreation road classification must be given full consideration in determining application of the guidance set out here. As classification of the road and the intended use thereof meets with the activity area, i.e., picnicking and camping, obstruction clearance becomes less and less important and integrity of the environment begins to have stronger demands on how obstruction clearance is applied.

Figure 2-9 Grading for Recreation Roads in Activity Areas

(1) Horiz ntal. The horizontal clearance is measured as shown on Figure 2-7 from the edge of the road surface. In the obstruction clearance width, the maximum slope (shoulder or side slope) should not exceed 6:1 (6 horizontal to 1 vertical). Metal beam guardrail or other highway department standard devices may be required at places along the higher speed (40 mph or more) access road to protect vehicles where ususual conditions or economics restrict the clearance that can be provided. Maintenance of the integrity of obstruction clearance along roads inside activity areas must be judged on the merits of safety involved and serving park aesthetics at the same time. Abrupt changes in type of road (from 40 to 50 mph access road to 20 or 30 mph circulation road) thus causing hazardous conditions should be avoided because of the abrupt changes in horizontal obstruction clearance that could occur. Minimum horizontal obstruction clearances should be as given in Table 2-11.

(2) Vertical. For roads which will be used only by passenger cars (Design Vehicle P) the minimum vertical clearance should be 10'. For roads designed for Design Vehicle SU the vertical clearance should be 15'.

h. Crosswalk. Pedestrian walks crossing roads (cross walks) should be signed and marked in accordance with ANSI 6.1-1978, particularly paragraphs 3B-13 and 2C-33. Chapter 5 of this manual, gives a discussion on walks and Chapter 6 discusses trails and trail crossings of roads.

Table 2-11

MINIMUM HORIZONTAL OBSTRUCTION CLEARANCE*

Road Classification	Design Speed (MPH)		
	20 or less	30	40 or more
Access	10'	10'	16'
Circulation	Edge of widened Pavement +2'	Edge of widened Pavement +4'	-
			-
Service	-	-	-

*On a case by case basis there may be times when these distances should be waved in the interest of park aesthetics. Users should enjoy the surroundings within a park with caution since both safety and pleasure are to be served.

i. Guardrails and Delineators.

(1) General. Guardrails are used where vehicles accidentally leaving the highway would be subjected to hazard. Generally, such hazards are fixed objects along the pavement edge, fills on steep grades, long through fills, or fills on sharp curvature, but other points equally hazardous are along water courses, bodies of water, escarpments, along deep ditches in cuts (particularly with rock exposed) and similar locations. The more dangerous points along a highway are obvious from the plans, but the overall need for guardrails is best determined by field inspection as the grading nears completion. Installation should be made before the highway is opened to traffic.

(2) Guardrails on fills. The need for guardrails on fills is definitely related to the slope. Generally they may be omitted where it is practicable to provide slopes of 4:1 (four horizontal to one verticle) or flatter because a driver, forced onto such a slope, has a chance of regaining control of his vehicle. In some cases it is economical to flatten embankment slopes to 4:1 or less instead of constructing guardrail, provided right-of-way is available. For roads that must be

constructed on difficult terrain (mostly rolling to mountainous) depth of fill criteria should be followed. The park road designer must be sensitive to terrain conditions as the road type passes from access to circulation to the point of users destination in an activity area or facility. When considering fill slopes and drainage ditch design needs comparative cost studies of guardrail versus flatter side slopes should be made. See discussion in AASHTO, "A Policy on Geometric Design of Rural Highways", 1965. Savings in maintenance cost and for safety can be reasons for increasing the fill depth at which it is economical to flatten slopes rather than use guardrail. However, where there is an accident prone situation, even with flat slopes, there usually is reason for guardrails. With headwalls, interceptor drainage channels, trees, or other objects present on the flat slopes, the hazard is not greatly different from that on steep slopes.

(3) Other hazards to be protected by guardrail. While guardrails largely are used on fill sections, their need is recognized at abrupt changes in road cross section, at approaches to structures, or at drainage pickup points, even in cut sections to provide the essential delineation or warning. In such instances, delineators generally are more suitable, with guardrails being only infrequently required.

(4) Choice between guardrail or delineator. The choice of providing guardrails or delineators largely is a matter of the hazard involved. Guardrails are designed to resist impact by deflecting the vehicle so that it continues to move at reduced velocity along the guardrail. Any abrupt stop of a vehicle is dangerous and guidepost or projection on guardrails which might snag a moving vehicle is not desirable. The sudden stop may be more hazardous than the alternative. Delineators are especially desirable in areas subject to fog. Reflector surfaces or buttons on them greatly improve their visibility at night, when it is needed most.

(5) Delineators. Delineators should be designed so as not to resist impact. They are less costly than guardrail, but should not be used in lieu of guardrail where vehicles need structural restraint to prevent them from leaving the road. Locations frequently are encountered where many drivers are confused regarding the direction of the road, particularly at night. Delineators generally are used at such places. In general, horizontal curves can be outlined sufficiently by delineators on the outside of curve only. They should be continued for some distance on tangents at the ends of the curve.

(6) Location. Except at turnouts, guardrails and delineators should be located at a constant distance from the edge of pavement to avoid possible confusion in inclement weather as to their location. They should be located somewhat back from the usable pavement line and at about the same elevation. When guardrail is used it is desirable for a

short distance on the traffic approach end to sweep it outward and downward and tie it into the ground in order to lessen possible direct end impact and to provide a full view to the driver.

(7) Visibility. To be fully effective, guardrails and delineators should be highly visible and well maintained with reflector buttons or reflectorized material. Such highly visible treatments are good warnings for hazardous situations and add measurably to the comfort and ease of riding along the roadway. This factor alone may in many instances provide the reason for their provisions.

(8) Designs. Guardrail and delineators should be of designs customarily used by the state highway department, however, consideration should be given to the use of treated timber when wood meets the restraining needs. See Figure 2-8. When the roadway section requires more sure guardrail holding capacity, metal, concrete, or masonry wall types should be considered. Delineation and quasi guardrail devices, such as guideposts, boulders or other objects which would in themselves be hazards if struck by vehicles should not be used.

2-5. Intersection Design Elements.

a. General. An intersection is the point where two or more roads join or cross. Each segment of road radiating from an intersection is called leg. An intersection is an important part of a highway since much of the efficiency, safety, speed, cost of operation, and capacity is influenced by it. An intersection must handle through traffic as well as turning movements. Intersection design should give consideration to such features as alignment, sight distance, pavement width, grades, superelevation, and curbed channelization islands.

b. Sight Distance. The operator of a vehicle approaching an intersection should be provided unobstructed view of the entire intersection. All intersections for Corps recreation roads should be controlled intersections, i.e., STOP and YIELD signs should be provided at all intersections. Figure 2-2 shows design data for desirable sight conditions at the intersection of recreation and public roads.

c. Minimum Designs for Sharpest Turns (Fillet Radii).

(1) General. Where it is necessary to provide for turning vehicles within minimum space, as at unchannelized intersections, the minimum turning paths of the design vehicles apply. The paths of concern are the minimum attainable at low speed, less than 10 mph, which are a little above the minimum paths of nearly all vehicles in each class and, consequently, offer some leeway in driver behavior. Layouts patterned to fit these design vehicle paths are considered satisfactory as minimum designs. In the design of the edge of pavement for the minimum path of a

given design vehicle, it is assumed that the vehicle is properly positioned within the traffic lane at the beginning and end of the turn, i.e., 2 feet from the edge of pavement on the tangents approaching and leaving the intersection curve.

(2) Minimum radius for inner edge of pavement surface or fillet.

(a) Design vehicle P (passenger car). The minimum radius should be 30 feet.

(b) Design vehicle SU (Single unit truck or bus). The minimum radius should be 50 feet. In any design permitting the SU design vehicle to turn on its minimum path without swinging wide, the front overhang swings out 12 feet from the edge of tangent pavement on the far end of the turn, the vehicle fully occupying a 12-foot land on the crossroad. With 10- or 11-foot lanes, the vehicle would encroach on an adjacent lane. To preclude this, edge of pavement radii larger than the minimum indicated would have to be used.

(3) Additional minimum edge of pavement designs. It is emphasized that the radii prescribed herein are minimums and may be increased within a reasonable limit. For additional design information see AASHTO "A Policy on Geometric Design of Rural Highways", 1965. Table 2-12 gives minimum radii for intersection turns at various angles.

d. Speed Change Lanes. Speed change lanes would rarely be justified except where the access road to recreation land intersects a road or highway of a state, county or city system. They are not justified for an intersection with a public road or highway unless it is travelled by relatively large numbers of vehicles at relatively high speeds. For additional guidance refer to AASHTO, "A Policy on Design of Urban Highways and Arterial Streets, 1973.

e. Traffic Control Devices. All recreation road intersections should be provided with traffic control devices in accordance with the Manual on Uniform Traffic Control Devices for Streets and Highways, ANSI D6.1-1978. The minimum control should be erection of right-of-way assignment signs, either STOP or YIELD. Where needed STOP AHEAD or YIELD AHEAD signs should be erected. Cross Road Sign (W2-1, W2-2, W2-3), T Symbol Sign (W2-4) and Y Symbol Sign (W2-5) should also be used as appropriate on roads with design speeds in excess of 30 mph which are assigned the right-of-way at the intersection; i.e., STOP or YIELD signs installed on the other road leg or legs at the intersection. Intersections are about the most dangerous places on roads and deserve careful design efforts. Where traffic justifies, curbs and/or islands may be used to channelize traffic and they should be designed in accordance with local state highway department criteria or AASHTO policy. Also consult, ANSI 6.1-1978.

Table 2-12

MINIMUM EDGE OF PAVEMENT DESIGNS FOR TURNS AT INTERSECTIONS*

Design vehicle	Angle of turn	Simple curve radius
	degrees	feet
P	30	100
SU		100
P	45	100
SU		75
P	60	40
SU		60
P	75	35
SU		60
P	90	30
SU		50
P	105	**
SU		**
P	120	**
SU		**
P	135	**
SU		**
P	150	**
SU		**
P	180	**
SU	U-Turn	**

*Fillet radii
**Use minimum radii of 30' for vehicle P, and 50' for vehicle SU.

2-6. Drainage Structurces.

a. Hydraulic Design Frequency. Culverts should be designed to pass the runoff for hydraulic frequencies of 2 to 10 years. Minor bridges should be designed for hydraulic frequencies of 5 to 25 years. Major bridges (these will rarely be constructed in parks) should be designed for frequencies of 25 to 50 years. Selection of the design frequency should be influenced by consideration of the effects of traffic interruption, potential damage from runoff exceeding design runoff, and the importance of the road and structure size (See TM 5-820-4).

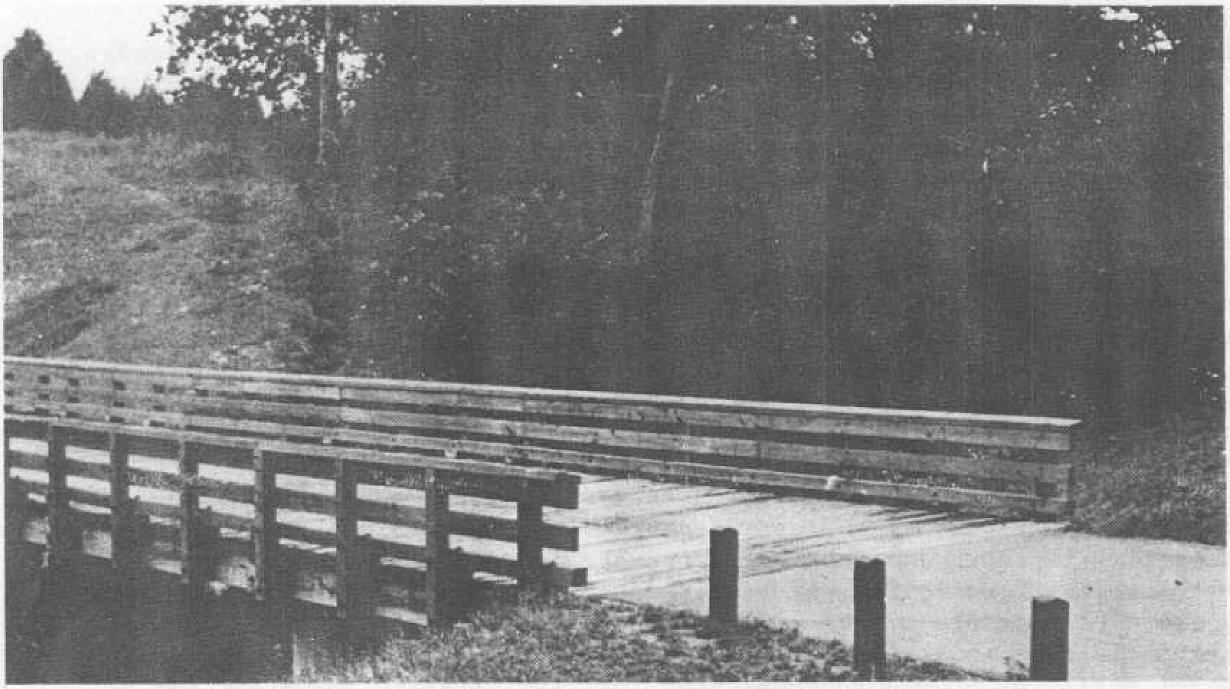
b. Culverts. Ditches should be relieved frequently to avoid carrying runoff for long distances in roadside ditches. In locating structures, the natural drainage pattern should be preserved as much as feasible. Contractor's option for use of reinforced concrete or corrugated metal for pipe culverts should be permitted where feasible. Careful attention should be given to proper setting of the outfall invert. Outfall protection and/or energy dissipaters should be provided where outfall velocities can be erossive (See TM 5-820-3).

c. Bridges. Bridges when required should be designed as economically as possible consistent with good architecture and protection of park aesthetics. H-15 loading will usually be adequate for recreation roads. Clear width of bridges should normally be equal to full roadway width including shoulders in accord with national policy on bridge safety. To provide access to isolated or low intensity use park areas, one-lane bridges may be provided in two-lane roads with appropriate warning signs. Bridges constructed of timber, masonry or native materials may be used. To save design effort for both reinforced box culverts and bridges, use of state standard designs is recommended. Furthermore, contractors tend to bid lower when standard state designs and specifications are used. Figure 2-10 is a typical bridge design for park area roads with low traffic volumes.

d. Improvised Structures. Nonstandard structures such as concrete slab ditch crossings, military field type expedient structures, log bridges, and other improvised structures may be used on minor circulation, service, and vehicular trail roads. Personnel should be alert for the possibility of using materials salvaged from the reservoir area.

e. Drop Structures. Liberal use of simply designed drop structures will help avoid deep and steep ditches (See TM 5-820-3).

f. Omission of Structures. On minor circulation roads and service roads, structures may be omitted with surface runoff conducted over the road by dips or sheet flow when soil conditions, paving materials, and terrain indicate that expensive maintenance problems would not be created by so doing. Dips may be paved or stabilized when needed. Low water crossings may also be advantageous in some instances.



2-7. Pavement Design Considerations.

a. Optional Designs. Use one of the following at the option of the District Engineer, advising in the appropriate D.M. which method was used:

(1) Follow the guidance in TM 5-822-2 to determine class of road based on anticipated design traffic used as average annual vehicles per day. Follow the guidance in TM 5-822-5 for design of flexible pavements using the design index for the anticipated traffic for design of surfaced access, circulation and service roads. For most roads a design index of two will be adequate. On a few roads, such as the main access road to a large park with extremely high visitation a design index of three or higher may be justified, but such roads will be rare. Where feasible, field CBR's (California Bearing Ratio) under existing pavements in similar soils should be considered in selecting the design value. Regardless of how the design CBR is selected, the object is to design for the actual field post-construction condition of the subgrade under the pavement. Usually flexible pavements will be less costly, but this depends on the economics of the project area. When rigid pavement is less costly or when it is to be used for short sections subject to frequent inundation it should be designed in accordance with TM 5-822-6.

(2) As an alternate to the above method, the state or local highway department design may be used. The design will be under secondary road criteria for roads with design traffic of 1000 vehicles per day and primary highway criteria for roads with design traffic over 1000 vehicles per day. It should be considered in designing under this method that highways are designed to support significant (not greater than 10%) numbers of commercial truck loads which may not be present on park roads.

b. Use of Local Materials. Maximum use of local materials and state specifications is encouraged. Specifications for base and sub-base materials should permit the contractor to exercise ingenuity in locating, producing, processing, and laying of base and sub-base courses. Specific requirements for bases and sub-bases such as abrasion and soundness may be waived where materials have demonstrated satisfactory performance in existing roads. Some examples of such materials are iron ore gravel, pit run gravels, caliche, sandshell and pit run quarry stone crushed on the roadway. When it is proposed to use such materials at a project, advance discussion with Division Engineer Office, Foundation and Materials Branch personnel is recommended.

c. Surface Course. Bituminous surface courses maybe placed as full-depth, directly on a prepared subgrade or on a 4-inch (minimum) base course. Bituminous surface treatments should not be placed directly on lime stabilized soils. Consideration should be given to use of asphaltic concrete when plants are located within economical haul distance and when life cycle cost indicates it is competitive with surface treatments. Gravel surfacing should be considered for light traffic roads and for all service roads.

d. Additive Stablization. Cement, lime, or bitumen - is recommended for roads and parking areas below the elevation of the 5-year frequency pool.

e. Upgrading of Local Materials. In designing pavements, full consideration should be given to upgrading locally available materials for base and sub-base courses with lime, cement, or bitumen.

f. Asphalt Emulsions. Designers should become familiar with and give consideration to the use of anionic and cationic asphalt emulsions in design of surface treatments.

g. Plastic Soil Binder. Materials used for open-surface, traffic bound pavements should contain sufficient plastic soil binder. Plasticity index (PI) range between 6 and 12 is preferred. Where suitable materials cannot be located or produced within economical haul distance which have PI within the preferred range, a range from 4 to 15 may be considered. Strength design is not required for open-surfaced roads. Such roads should be designed as all-weather easily maintained roads. The possibility of future surfacing should be considered in design.

h. Soil Stabilization. Stabilization should be designed following guidance in TM 5-822-4 or the design procedure of the state highway department of the state in which the road is located.

i. Pavement Design for Frost Conditions. The need for pavement design for frost conditions should be determine based on criteria in TM 5-818-2. If design for frost conditions is found to be necessary, pavement should be designed in accordance with TM 5-818-2. In making the determination of necessity consideration should be given to practices of the highway department of the state in which the project is located. In northern latitudes road paving costs can often be reduced by using free draining materials daylighted to drain. Roadside ditches in some cases can be cut deep enough to facilitate lateral drainage so that damaging freezing under the pavement surface will not occur.

j. Compaction. Compaction requirements should normally be based on modified density (AASHTO policy; ASTM, D 1557, or CE Modified Compaction Test, EM 1110-2-1906). The following minimum compaction requirements are suggested:

	Modified	Standard
Base Courses	100%	105
Sub-base Courses	95% to 100%	100-105
Top 6 inches Subgrade	90% to 95%	95-100
Fills	90%	95

k. Blanket Pavement Design. Blanket type pavement design sections will normally be used because of their superior performance. When trench design sections are used, the reasons should be given in feature design memorandums. Trench type sections generally should not be used in impervious soils.

2-8. Landscape Planting and Development.

a. General. Landscape development, to be effective, should begin with an analysis of the existing vegetation along the proposed route, looking for and directing the possibilities for conserving all desirable landscape features and scenic values. In order that the natural features of the route may be preserved, attention should be given during the preliminary design stage to the landscape existing and to that of the post construction. The ultimate recreation landscape development should be visualized in three dimensions; horizontal and vertical alignment and cross sectional elements. Each of these so coordinated as to produce a facility that will be attractive and be part of the recreation experience. All of the above elements of design when coordinated with landscape development should produce the best road in the best interest of the user and its cost of construction and maintenance.

b. Selective Thinning and Tree Protection.

(1) Trees to be preserved. Existing vegetation outside of the areas staked for clearing and grubbing should be appraised for preservation. Precaution should be taken for the protection of all desirable vegetation from damage during construction operations. Trees which do not interfere with sight distance nor create a hazard to roadway users and are on the edge of the construction limits should be given special protection during construction. Existing trees that provide shade, frame views, or have other values, should be saved on roadside borders where there is adequate clearance from the edges of pavements. For low speed circulation roads and loops inside activity areas, trees can be preserved right up to the pavement edge. The guidance given here amplifies that given in paragraph 2-4g, obstruction clearance. Figure 2-11 demonstrates landscape preservation and development inside activity areas. In some cases tree walls (to protect trees within cuts) and tree wells (to protect trees within fill sections) might be considered to preserve trees of outstanding character and value (Historical or cultural values). Specie tolerance to road conditions should also be evaluated.

(2) Trees to be removed. Existing vegetation (particularly trees) outside the limits of clearing which are determined to be in poor or unsatisfactory condition horticulturally, should be removed. Every effort should be made to save diseased or partially deteriorated trees and other vegetation by applying the best horticultural practices.

c. Planting Design. Landscape planting for recreation roads should serve specific purposes. Because trees and shrubs create a third dimensional effect in the recreation road cross section special design considerations are needed. Before planting plans are prepared each recreation road should be analyzed to determine (1) the purposes for which planting may be needed; and (2) the controls governing the feasibility of planting and influencing the planting design.

(1) Planting purposes. Planting of recreation roadsides should be designed to serve one or more of the following purposes:

(a) Protecting slopes from erosion.

(b) Screening traffic from recreation areas and facilities including accaustical control.

(c) Providing advance warning to traffic along road way approaches to structures.

(d) Guiding traffic by indicating need for turning movements.

(e) Reduce maintenance through elimination of mowing.

(f) Increase aesthetic values by framing desirable views and roadway structures, blending new construction areas into the natural surroundings, and providing variety and interest of the roadside especially between areas of cut and fill.

(g) Enhance the recreation facilities.

(h) Delineate roadway alignment where delineation by natural conditions do not exist.

(i) Provide shade at scenic overlooks.

(j) Supplement existing vegetation at the tree edge to improve the appearance of the areas.

(k) Glare and reflection control.

(l) Modification of climate.

(m) Wildlife habitat.

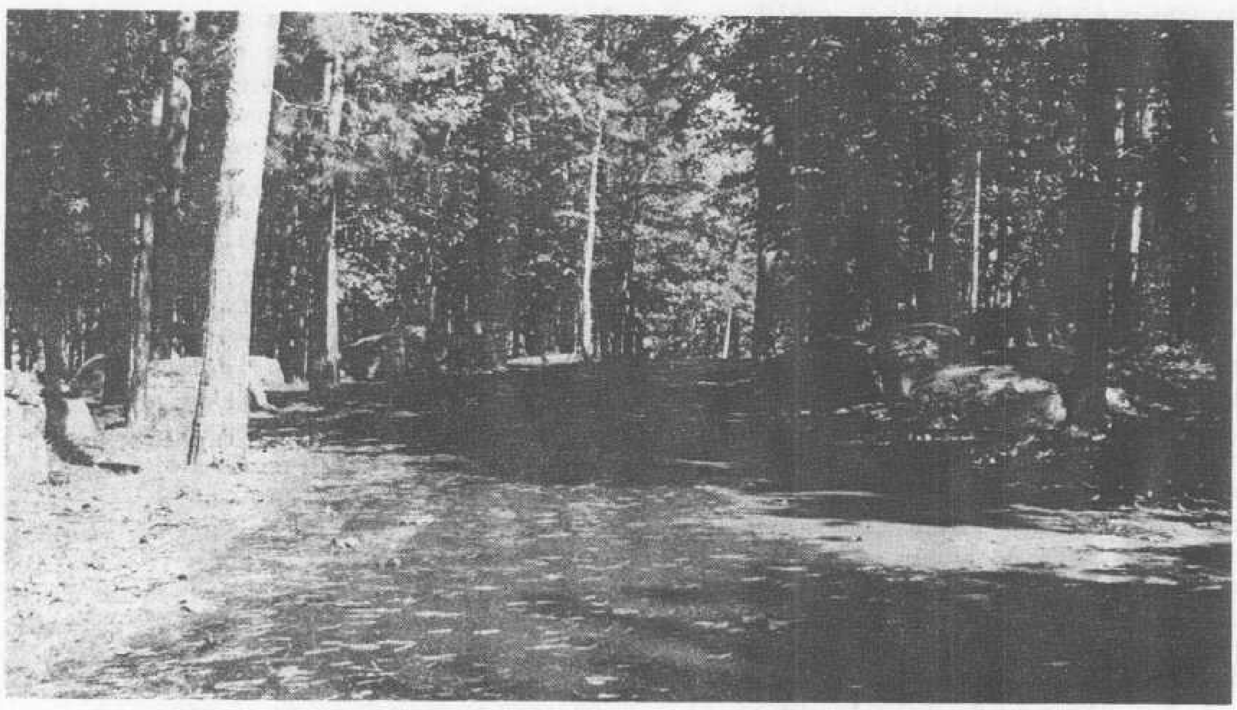


Figure 2-11 Preservation of Landscape Features

(2) Planting controls. Limitations of the existing surroundings, planting clearances, scale, and future maintenance should be considered in the design of planting.

(a) Existing surroundings. Appropriate planting should be designed to tie the recreation road into its environment in keeping with (1) the character of the surrounding terrain and existing vegetation, and (2) the planned recreation use. Existing trees and other natural growth conserved during construction should be supplemented as necessary. New plantings may be justified in open areas, on cut and fill slopes and in recreation use areas. Such planting should be naturalistic and similar to existing growth. Trees and shrubs should usually be arranged in natural groupings in keeping with the recreation setting and the open countryside.

(c) Planting clearances. Horizontal clearances for recreation roadsides is given in paragraph 2-4g (1) however, certain design philosophy regarding specific relationships of recreation roads, planting clearances and user facilities enhancement should be considered in the design of roadside plantings. Since shade is one of the amenities recreationists seek in the outdoors, trees and shrubs along roadways should be planted to meet the requirement of safety of the motorist and park user and enhance the facilities being used and the roadway scenic values. Trees and shrubs should not be planted close to drainage structures where blockage could occur. All plantings of trees and shrubs along recreation roads should take into consideration ultimate spread of plants so that when fully grown, there will be no interference with signs, overhead clearance, and integrity of roadway safety. Some allowance can be made for maintenance which is necessary along most roadways.

(d) Types and scale. Generally the types of plant materials which are effective in recreation road planting are: (1) high-headed medium-growing trees (deciduous and evergreen), (2) small flowering trees, and (3) medium and small shrubs, vines or turf grasses. Of this group, small flowering trees may be the most important group of plant material for use in the recreation area. There is a plus if they have outstanding fall foliage and visible fruit. Small flowering trees can be used to tie the scale of the road to the scale of the recreation area better than any other plant type. Shrub type materials are best used only in mass plantings. Low-growing shrubs may be desirable at selected points to reduce mowing and to relate the road to wooded areas. The scale of planting should be related to the road, structures, and the recreation area and facilities. Species of trees and shrubs native to the local area should be used if possible. Wildlife values to be obtained should be considered in addition to aesthetics and other values. Plant material should be in accordance with the American Nursery Growers Standards and should be inspected by a qualified expert prior to planting.

(e) Maintenance. During the process of selection, arrangement, and application of plants, the designer should give consideration to maintenance capabilities of the park manager. Reduction of mowing should be an objective of the roadside planting design. Slopes where possible should be planted with ground cover and permitted to acquire natural vegetation. Plant-bed outlines adjacent to planned turf areas should be designed with low sweeping lines to permit ease of mowing. Except to the extent required for safety, slopes should not be mowed, not only for economy, but also mowing prevents natural development of indigenous woody plant growth. Degree of mowing should also be considered (three mowings per recreation season might suffice). This type of information should be set out in the design process.

2-9. Miscellaneous Considerations.

a. Clearing and Grubbing. These items should be held to the minimum feasible. Plans and specifications should clearly define the limits of clearing and grubbing. The limits should be marked in the field by the Government or the contractor prior to beginning clearing operations. The plans and specifications should indicate who will do the marking. If the limits are marked by the contractor, they should be approved by the contracting officer before beginning clearing operations. Any necessary haul roads or contractor work areas should be similarly handled. Haul roads should traverse permanent road alignments and already cleared areas as much as feasible. Haul roads should be laid out along curving alignments so that the scar they cause will be less apparent than if straight lines are used. The plans and specifications should require the contractor to operate his equipment within the limits of clearing. Reasonable provisions should be included in the technical provisions to discourage the contractor from damaging vegetation or land forms outside the authorized limits of clearing. Clearing for roads should not extend beyond the toe of fills or the top of backslopes in cuts. Where necessary to save particularly desirable tree or group of trees, the lanes of two-lane roads may be split apart, leaving a median between to contain the trees. Grubbing should not be permitted beyond the bottom of the ditch in cuts or beyond the edge of subgrade preparation in fills. Selective clearing and underbrushing may be omitted from construction contracts because it is costly to perform and difficult to get done satisfactorily by contract because overclearing usually results. Refinements in clearing often can best be accomplished later by Government personnel such as summer hires.

b. Top Soil Stripping. Stripping should be just deep enough to assure that the amount of roots and other organic material not removed will be too small to cause construction of a poor subgrade. This amount of stripping can usually be obtained with light blading with a motor patrol and windrowing laterally to the limits of clearing. After grading is completed, the windrowed material, if suitable, may be pulled back and spread on the slopes.

c. Borrow Areas. These should be subject to the approval of the contracting officer. They should be located in areas where they are concealed from view or blended in with the natural surroundings. Borrow areas located within the park should be located as remote as economically feasible from developed areas or future developed areas and preferably out of view of most of the visitors. The location of borrow areas should be shown on the plans to permit bidders to estimate haul cost. Borrow areas should be graded at the end of operations to drain and blend naturally with establish vegetation. Borrow areas should be within the conservation pool when possible.

d. Finishing Rock Cuts and Fills. Finish of rock cuts should be controlled by specifying tolerance, instead of requiring 6 to 8 inches of undercutting below subgrade and backfilling with a suitable material. Specifications should require contractors to save sufficient suitable material for topping out and finishing rock fills. Erosion resistant rock slopes should not be flattened merely to provide areas flat enough to grow turf. Steep bare cut banks can present interesting geological exposures which may enhance the landscape by providing contrast between the paved road surface, turfed foreslopes and the greenery beyond the backslopes.

e. Payment for Grading. The discussion given here on payment for grading is directed toward providing information on a possible alternative for payment of grading work for park roads. There is an advantage to paying for road grading by the station. Roads that must be constructed in moderately rolling to flat terrain, grading work could be accomplished by motor grader instead of heavier equipment. This type of grading is especially needed inside the activity area, i.e., near the picnic area and camping loop roads. When payment is by the station, the incentive to the contractor is to do as little grading as he can. When payment is by the cubic yard, experience has shown in some localities, the incentive to the contractor is to do as much grading as he can. There is a disadvantage to payment by the station in that bidders cannot determine the amount of work as closely as they can when payment is by the cubic yard. However, it is considered that a little higher cost is justified to preclude over-grading and to obtain park-like roads. When payment is by the cubic yard, quantities and earthwork balance points should be shown on the plan-profile sheets. Payment by the cubic yard should be used for heavy grading (moderately rolling to mountainous terrain) in fairness to both the bidder and the Government; however, heavy grading should be avoided as much as possible in parks.

f. Maintenance and Restoration. As standard materials run short, there will be an increasing emphasis on the development of more economical maintenance and restoration techniques. Unfortunately, the variability of climates and geology makes generalization concerning the cost effectiveness of such techniques quite indefensible. Maintenance techniques must be evaluated on a site and project specific basis.

g. Planning and Design Techniques. Increased costs and environmental concerns require roadway planners and engineers to investigate and more thoroughly evaluate the consequences of road location decisions. Three techniques, primarily using a combination of computers and revised field design techniques, are discussed here.

(1) Topometrics. A technique using topometrics has been developed to assist the planner or engineer in efficient evaluation of alternative routes. Topometrics is the process whereby numeric information is obtained from topographic maps by measuring three-dimensional differences of coordinates. The topometric process translates graphic position into a format that lends itself to numeric methods of analysis.

(a) The system which uses desk top computers with digitizers, plotters, printers and specially designed software routines offers a low cost, readily available route evaluation system. The system allows the user to evaluate routes based on horizontal alignment, earthwork and mass diagram computations. The technique allows the user to participate in an interactive process that allows him to see the results of basic decisions, make desired changes and carry out many more design cycles than are possible with manual methods. Alternative route evaluation can be conducted at a rapid rate, up to 1,000 feet per minute, depending on map scale. The system provides a quantitative output enabling the user to easily evaluate cost, safety and aesthetic factors.

(b) In addition to evaluating such factors as cost and safety, the planner or engineer may address other more subtle considerations. Route aesthetics are a function of the total amounts of material moved, depths of cut and fill, exposure of cut and fill slopes, road suitability, and proximity to sensitive areas such as recreation sites, viewing points and scenic overlooks. Unacceptable routes can be identified and eliminated and the most economic and environmentally promising routes can be scheduled for field verification.

(2) Computer aide design system. The U.S. Forest Service utilizes a computer-aided design system called the Forest Service Road System (FSRDS). The FSRDS is a comprehensive set of interrelated computer programs for processing road designs from the initial traverse to construction earth work quantities. Though somewhat complex and developed primarily for design of lengthly low-class road systems, portions of the FSRDS have possible applicability to design of Corps recreation area roads.

(a) The FSRDS is a "computer-aided" system in which the user is relieved of the repetitive computational tasks associated with roadway design. The user is allowed the luxury of considering more imaginative concepts and thus generate better designs.

The complete FSRDS system contains over 30 interrelated design programs and provides the user with data on which to make a decision as to his next course of action.

(b) Although FSRDS will handle the design of any individual type of road, it was primarily developed for the evaluation of low volume roads. There are several individual programs within the system that allow efficient design of low volume roads. The design modules require minimum inputs of profile grade, slope selection information, template information and earthwork compaction factors. The computed output for each roadway station includes: (1) grade elevations; (2) average side slope; (3) topography limits, the distance left and right of baseline centerline that the design template can be moved; (4) limits of cut and fill, how far the template can be shifted left and right of base-line centerline based on maximum cut and fill height; (5) daylight offset; (6) self balanced offset; and (7) approximate station by station quantities.

(c) The Forest Service has used FSRDS for more than 15 years and has great confidence in the system's efficiency and effectiveness as a tool for helping the roadway designer and the on-the-ground land manager make decisions concerning road design and construction. The Forest Service has found that the system allows the user to fit the road to the ground with minimum impact and still consider cost, safety and aesthetics factors.

(3) Field design. The Forest Service has also investigated techniques involving field design of forest roads. Although the technique is primarily suitable for the design of low standard roads, the concepts may have application to Corps recreation road planning, design and construction, particularly local, sublocal and service roadways.

(a) Prior to development of the field design methodology, the Forest Service used the conventional P-line, L-line survey-design methodology. This conventional method of roadway design involves the establishment of roadway slope stakes through the use of a preliminary survey of the road line (called a P-line survey), an office design from the P-line data, and an additional survey of the designed roadline (called a location or L-line survey) to establish a line from which to stake the roadway slope. The road is then slope staked and referenced prior to construction. The field design methodology essentially eliminates the initial P-line survey, or actually consolidates the P-line survey office design and L-line into one continuous process.

(b) Development of the field design methodology has been evolutionary rather than revolutionary. For design of low class roads, the Forest Service reports substantial savings in manpower and design efforts. In one case, survey and design of a 3.5 mile low type road was accomplished in 12 days. Conventional P-line methods were estimated to require 3 months. The field design methodology is generally estimated to require from 10 to 15 percent of the effort required for conventional design.

(c) The field design methodology has not only resulted in manpower savings but has produced aesthetically pleasing roadways with minimal impact on the land. Greater environmental impact has been found when conventional office design techniques are utilized. In test cases, field designed roads were found to be indistinguishable from those that are conventionally designed.

CHAPTER 3

ROADSIDE FACILITIES

3-1. Application. Many roads which provide access to day and overnight recreation use areas traverse terrain with high scenic value. These scenic views can be near the road or at great distances therefrom. Scenic views should be made available to the project visitor by providing a full stop overlook and by creating vistas which could be full stop or drive-by in nature. The turnout for sanitary dump station is another type of roadside facility provided for recreationists. The entrance station is covered in Chapter 8, this manual. Planning reports set out the need for a roadside facility. That report should also determine how large, how many visitors will be accommodated, and the general location of such facilities.

3-2. Controls. Safety of all highway users is the main controlling factor in designing roadside facilities. Recreationists that use the roadside facility should be able to maneuver their vehicles off the main roadway into the roadside facility without increased danger and the safety of other users. Generally, vehicles should not have to cross traffic or stop on the roadway before turning into the roadside facility and from the roadside facility back onto the main road. For example, a trailer dump station should be sited along the out-bound lane.

3-3. Design Considerations. These data for the design of roadside overlooks and vistas should be used to enhance the recreationists visit. Each site is different and application of the data should be supplemented with the experience of the park designer. The advice of the experienced park manager, road designer and landscape architect should be sought when collecting information and data required for the design of roadside facilities. Another roadside facility to be considered here is the sanitary station for self contained trailers and Recreation Vehicles that need to dump stored wastes. Sanitation and safety of the user are to be emphasized for this type of facility design.

a. Overlooks. To meet safety requirements the access road should be field staked so that a complete analysis of the site can be made of the existing conditions. Sites which are densely wooded or those dominated by extreme rock outcropping should not be intensely developed by heavy grading.

(1) Location. Overlooks and their support facilities should be sited on gently sloping terrain. The area where the entrance, exit and parking facilities will be located should not exceed 7 percent grades and

the section of roadway passing the potential site should not exceed 5 percent grade. These selected grades are guides to the designer to avoid dispoilment of the site that is providing the opportunity to view the scenic beauty beyond the access point. Grades of the road providing access to the general area might be as great as 15 percent, but the road grade at the site and the terrain on which the overlook is developed should be close to the 5 percent grade. The total scenic values of the overlook site should be preserved at all cost even to the extent of abandoning the overlook development and looking elsewhere for a more suitable site.

(2) Site development. The overlook facilities should be set in the existing vegetation and geological assets of the site. The parking area should not occupy the dominant elevation of the site. The dominant elevation should be reserved for development of the viewing area from a standing or sitting position. Precipitous dropoffs should be made safe by the provision of appropriate railing. The railing should protect the very young and the very old but at the same time provide a height which protects the wheelchair visitor and permits normal and comfortable access to the views afforded other visitors. Appropriate shelter should be provided for protection from hot sun and rain, to house interpretive media, and to afford picnicking capabilities if needed.

(3) Clearing and grading. These two operations should be controlled at the design stage by very carefully locating the overlook facilities on those parts of the site where the smallest amount of existing vegetation, particularly trees and shrubs, would be destroyed. Parking areas should be designed around existing trees to the extent feasible. A landscape architect should be involved in the design of the clearing and grading of the overlook site. Grading should be accomplished to meet natural grades of the site and only that amount of natural soil or rock be removed to allow for sound construction procedures. Foundation preparation should be limited to that required for development of each facility. Clearing and trimming of vegetation to open visual channels should be designed in accordance with paragraph 3-3b(2)(a), vista clearing.

(4) Facilities. It should not be misconstrued that every overlook will contain all of the facilities included in this chapter. Some overlooks could contain more. The designer, confronted with a specific site, is the only person who can determine the total development which can be accommodated by the conditions of the site and still meet the needs for the visitor as set out by the planner.

(a) Access road. Ingress and egress should be provided under the design data given in Chapter 2 of this manual for road intersections. The design of the road should follow the data set out in Chapter 2 for circulation roads.

(b) Parking areas. Attractive gates should be provided to restrict vehicle access and visitor use to designated use periods. Short circulation roads from the main roadway are acceptable. The design of the road to the overlook should protect the environment. Elements of parking area design are given in Chapter 7 of this manual. Parking areas for automobiles should be developed with 90 degree head-in spaces. This is the safest parking manuver where come and go traffic is a high percent of the total traffic. If pull-through parking can be developed with no apprecible expense to the environment (requires additional space) then it too should be considered. Parking for busses and cars with trailers should be provided if possible.

(c) Walks. This feature of the overlook should be designed in accordance with Chapter 5 of this manual. The designer should make certain that provisions for the handicapped visitors are considered in the early design stage.

(d) Interpretive media. Several techniques can be used to interpret particular portions of a scene viewed from an overlook. These are: audio, visual, and a combination thereof. The designer should seek the advice and help of experienced technicians in the specialized field of providing outdoor graphics.

(e) Signs. Traffic regulating signs guide potential visitors to roadside facilities and in and out of parking areas. Additional signs, as needed, to meet visitor needs should be developed according to the site demands. Facilities for the handicapped including parking areas should have proper signs. Special scenic overlooks, unique ecological and aesthetic features should be given appropriate attention by signs and outdoor graphic descriptions.

(f) Landscaping. Land forms and scenic values should be complemented and protected at roadside facilities. The introduction of exotic plant species should usually be avoided. Native species, including grass species are preferred. Planting plans should usually have a naturalistic character.

b. Vistas. The main considerations in the design of vistas are the location, the extent and nature of clearing, and roadside safety. Vistas may be designed for moving vehicles or stoped vehicles. Clearing will be different for each. Vistas are popular points for taking interesting photographs. For this reason light requirements, foreground, and framing potential should be considered.

(1) Location. Vistas should be developed along roads having a gradient, horizontal and vertical alinement, vehicle speed, deceleration time, stopping distance and sight distance which are amenable to park visitors enjoyment of a vista development. Vistas should not be located on sharp curves, at the end of a tangent leading into the curve, nor at right angles to tangents where the motorist has to turn his eyes beyond the desirable maximum of 45 degrees from the road centerline. Generally, vistas should be located on the right hand viewing side of traffic where the assumption is made that the view would be most important to inbound traffic inside the park area.

(2) Site development. The vista can be designed to afford a view of the scenery beyond by clearing only the underbrush and low hanging branches or fully clearing of all obstructions which would rinder a full view of the scene beyond. Each of these developments and the various degrees of development between requires different standards. The park manager, landscape architect and planner can contribute to the extent and nature of the development for specific sites.

(a) Vista clearing - for moving vehicle. The determination of the extent of clearing for a vista providing a view from a moving vehicle requires a time space study. Time is as important as cleared space; they both should be related to the driver's viewing point. A vista clearing should create a flash impression to the car occupants. Clearings need to be large enough to allow adequate viewing time, but small enough to hold attention for a short period of time. Clearing length will change with vehicle speed. Usually three to five seconds allowable attention and viewing time requires 150 to 200 feet of clearing length at 30 mph. Slope of ground surface away from the roadway and depth of the vegetation from the roadway to sloping terrain also plays a role in determining the extent and nature of clearing and the location of the vista. Corridors of deep vegetation, greater than twenty feet, will require an angular finished cut edge as compared to vegetation depth consisting of only a few minor trees and dense understory.

(b) Vista clearing for stopped vehicle. Time is no factor to the viewing qualities of a park visitor in a stopped vehicle. Available space to provide pull-off parking at vantage points, including the need of the angular cut of the finished tree and shrub line, are factors which have to be dealt with in site development design of this type of vista. Also, for this type of vista, consideration should be given to a design of understory clearing and lower limb removal. However, this type of vista requires safe parking of the vehicle off the main roadway.

Understory vegetation should be removed which will limit vegetative growth to two feet. Low hanging limbs that interfere with the view should be totally removed or that portion of a limb that causes interference to the viewer. Such trimming should provide a maximum overhead clearance of seven feet. Partial limb removal (leaving a limb stub) should not be practiced. The total length of clearing parallel to the road and/or parking area should be controlled by the depth of the tree cover which causes the visual barrier and the extent of the scene to be viewed. Clearing for visual access to the scene beyond the obstruction should not exceed fifty feet along the edge of the pull-off. Tapering of the tree and shrub line edge should be used to increase the exposure of the scene to the viewer. Vista clearing for stopped vehicles is shown on Figure 3-1.

(c) Vehicle pull-off. The entrance for a vista pull-off should begin fifty feet ahead of the starting point of the vista clearing line and the exit should end fifty feet beyond the opposite vista clearing line. A short deceleration lane should be provided so that the vehicle can leave the roadway in a safe manner and come to a stop in the parking position opposite the vista clearing. The pull-off should be a minimum of 16 feet wide through the parking area and the access and exit lanes should be a minimum of 10 feet wide. The entire vista area should be separated by a traffic island a minimum of two and one half feet wide. Figure 3-2 is a sketch of a typical vistas pull-off.

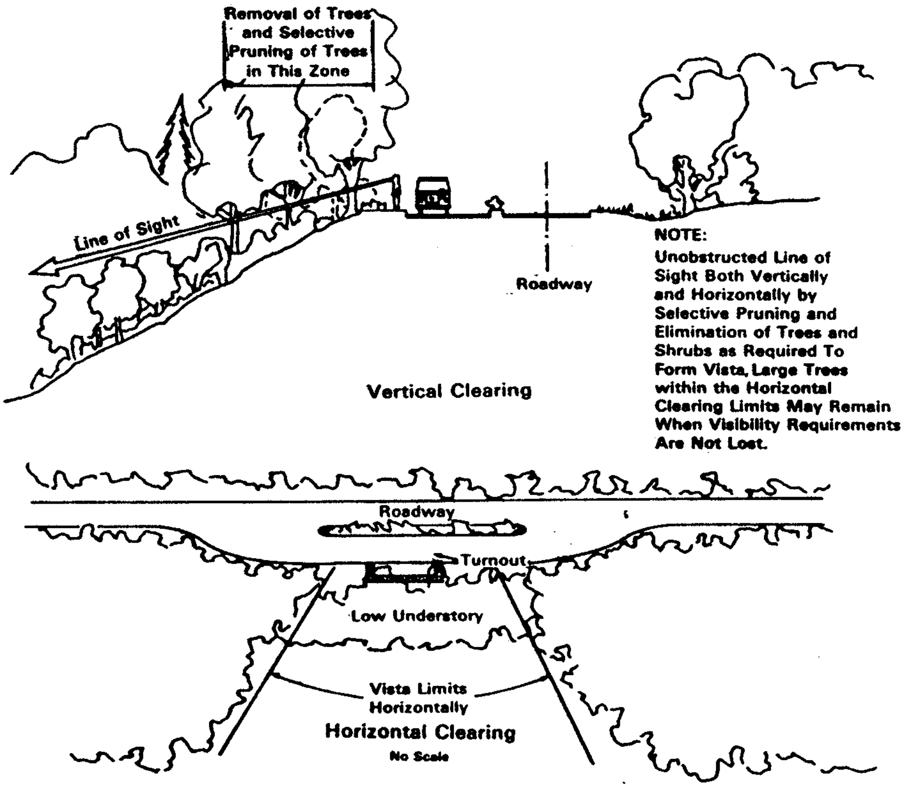


Figure 3-1 Vista Clearing

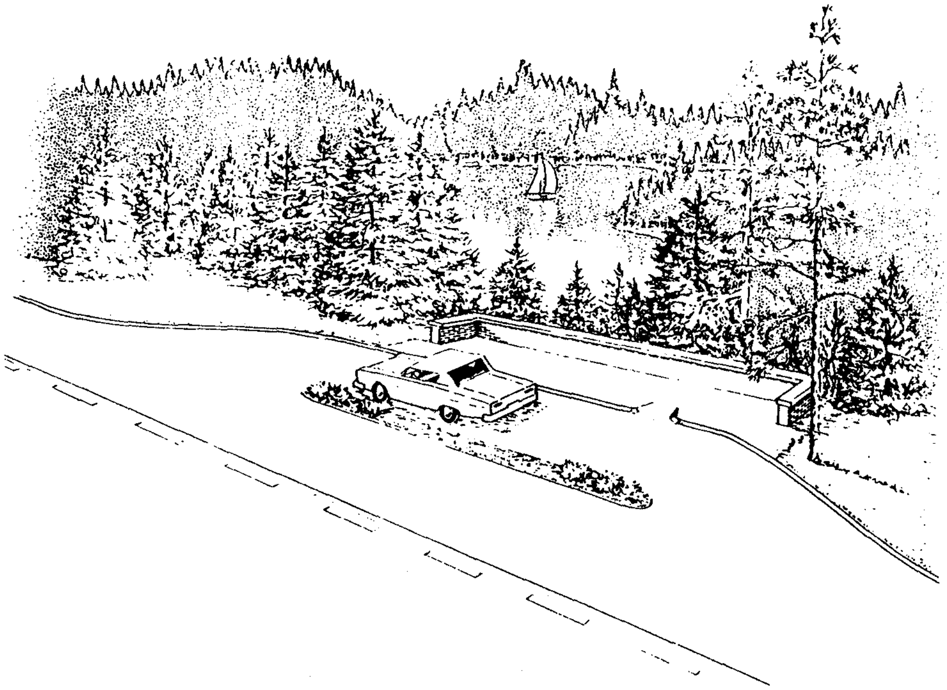


Figure 3-2 Parking for Vistas

(d) User amenities. Vistas usually need no additional facilities except a solid waste receptacle. It should be anchored to a post or other perment structure.

(e) Landscaping. The vista should be enhanced where needed with a selective planting. Plants should be native species that require minimum establishment and maintenance. No attempt should be made to maintain grasses in lawn form. The area should be kept open to provide safety to users from the standpoint of poisonous snakes that might inhabit the area.

(f) Signs. Standard highway markers for scenic overlooks should be used to direct the potential user to the vista site. Additional signs might be needed to give the visitor indepth knowledge of the views.

c. Turnout for Sanitary Dump Station. The sanitary dump station is required for disposal of the wastes from boats and/or mobile camping facilities. The station is usually not manned when located in relation to camping and non-marina related boating areas. Back up of users can occur at peak times and this occurance should be part of the overall design.

(1) Location. A site that is somewhat remote to other park users and with some screening (natural when possible) from view of passerbys should be the prime criteria. The facility should be located along the outbound lane of the access road serving the camping and boating areas. Otherwise a secluded site either within the immediate vicinity of the

camping area or the boating area should be made part of the design criteria.

(2) Access drives. A typical site design for a dump station is shown in Figure 3-3. The radii, road widths and unit parking position at the station are considered minimum and provides the flexibility for the vehicle to return to the activity area or to turn onto the outbound land of the road. Adjustments should be made in length of entrance driveway and of radii to fit terrain and existing vegetation conditions. A queuing lane along the road before reaching the turnout might be needed for some areas.

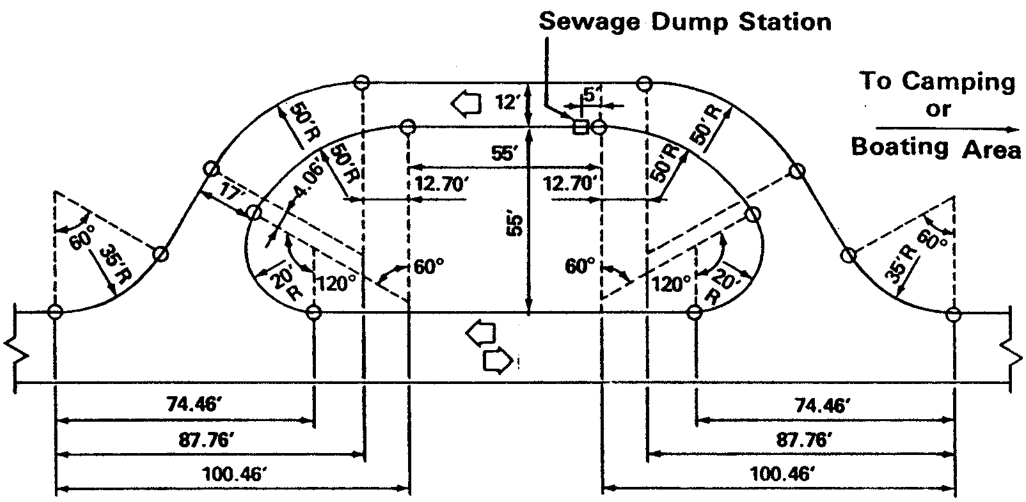


Figure 3-3 Minimum Dump Station Access Drive

(3) Water supply and waste handling.

(a) Water supply. A small quantity of water (coin operated 10 minute metered supply) should be available to the user for washing down the holding tank, pipe connection, and the concrete drain area of the station. A water supply of 5 to 10 gallons per minute usually will be sufficient for the station. The water should be potable giving a safety factor over the possibility that children passing the area might be tempted to drink from the water supply. The metered operation also provides some margin of water conservation. The water supply and waste drain might be connected to the park water supply system and sanitary system. This could be a determinating factor for station location due to economics in cost of piping.

(b) Wastewater. The dump station can be connected to a sanitary sewer, be connected to a large holding tank which would be pumped and the waste truck-hauled to a treatment facility at some other part of the project or off-project site. The waste could also be treated on site by a septic tank system or lagoon system. Generally on-site package plants should not be used for dump station wastes.

(4) Signs. A traffic regulating sign should be posted along the road to warn of the type of traffic ahead and a sign that directs users to the station.

(5) Landscaping. Planting should be minimal and mainly to provide the screening of the facility. Grassed areas should be used for landscape restoration and erosion control.

CHAPTER 4

BOAT RAMPS

4-1. Introduction. This chapter deals with the design of ramps used for launching boats from trailers. Appurtenant structures, such as docks, mechanical boat launching areas and marinas are not covered here. The number of ramps and lanes and the general location should be determined and set out in planning reports.

4-2. Application. Boat launching ramps are needed for access to water bodies for pleasure boating, fishing, water skiing, sailing, hunting, scuba diving, underwater exploration, operation, maintenance and water patrol personnel. Ramps serve various needs such as the small fisherman's 'Johnboat' in a remote part of the water body to large luxury cabin cruisers and hydro racing craft.

4-3. Controls. Characteristics of boat, trailer, and vehicle; extent, duration, and frequency of water level fluctuations; current velocities, waves, and prop wash control the design of boat ramps. Lake and river topography above and below the water surface; planform, type, and layering of soils and rock; and flood flows are critical considerations which must be addressed in developing proper boat ramp design. Also, many drainage areas are locations of landslides or geologically recent and transitory land forms which are quite susceptible to failure and erosion processes. Safety in launching and retrieving the boat and providing for the handicapped also control boat ramp design.

4-4. Design Considerations.

a. Characteristics of Boat, Trailer and Vehicle.

(1) Boat. Data on types and sizes of various boats are given in American Institute of Architects, "Architectural Graphic Standards", dated 1971.

(2) Boat trailer. The greatest weight of the loaded boat trailer is assumed to be 9600 pounds for a craft 28 feet long. This weight is the assumed maximum for ramp design. The total weight of some vehicles using the ramp might equal or exceed the above maximum. Generally, however, this should not influence the design of the ramp since most ramp surfacing must withstand heavy wave action.

(3) Vehicle. The vehicles which carry boats or tow boat trailers limit the steepness of grade of the launching ramp because of their power, traction and braking ability. Their turning radii place limitations on layout for maneuverability. Their traction requires a

rough ramp finish because mud and slime tend to accumulate on surfaces. Their underside clearance limits affect permissible break over angles of grade profiles. Ramps should be steep enough in grade to permit the vehicle to back far enough down the ramp to permit launching without submerging exhaust pipe ends or rear wheel bearings and brakes.

b. Topography and Physical Conditions.

(1) Fluctuation of water level. Precipitation and operations result in water level fluctuations at Corps projects. These fluctuations are set out in lock and dam operation and reservoir regulation plans. Wetter or dryer than normal years may result in variations from the normal reservoir regulation and should also be considered when designing boat ramps.

(2) During the planning phase general locations for boat ramps should be determined. Bank or shore area excavation should slope toward the water at grades which will conform, as much as feasible, to ramp grades thus avoiding excessive cuts or fills and thus fit in smoothly with the surroundings. There should be sufficient area at gentle grade near the top of ramp for turning and parking. The ramp site should be easily accessible. Sites where construction scars would adversely affect views from the water should be avoided.

c. Soil Stability. Care should be taken in siting ramps so that there is no unaddressed significant risks from landslides, rockfalls or bank failures. Site specific sampling, testing, and analysis to determine conditions at each ramp site should be conducted to verify location suitability. Fluctuations in river and lake levels, seepage conditions, and effects of excavation and fill placement and construction of structures should be evaluated.

4-5. Geometric Design.

a. Access. The approach to the ramp from both the main access road and the parking facility seems to work best by means of a one way circulation system. There have been instances where unoriented visitors have mistakenly driven down a ramp thinking that it was an extension of the road. Therefore, the circulation road should have an alignment that requires a definite turn at or just prior to its intersection with the ramp (See Figures 4-1 and 4-2).

b. Parking. Parking facilities for vehicles pulling trailers at boat ramps should be pull through type parking. The spaces should be 10 feet wide by 42 feet long. The angle of the parking may vary to suit existing conditions but it should be remembered that all inside turning radii should be a minimum of 15 feet.

c. Length and Width. The optimum length and width of a ramp will vary depending upon the physical conditions of a given site.

(1) The width may vary as follows:

Ramp Length	Lane Width
Under 50 feet	12 feet
50 feet to 75 feet	14 feet
over 75 feet	16 feet

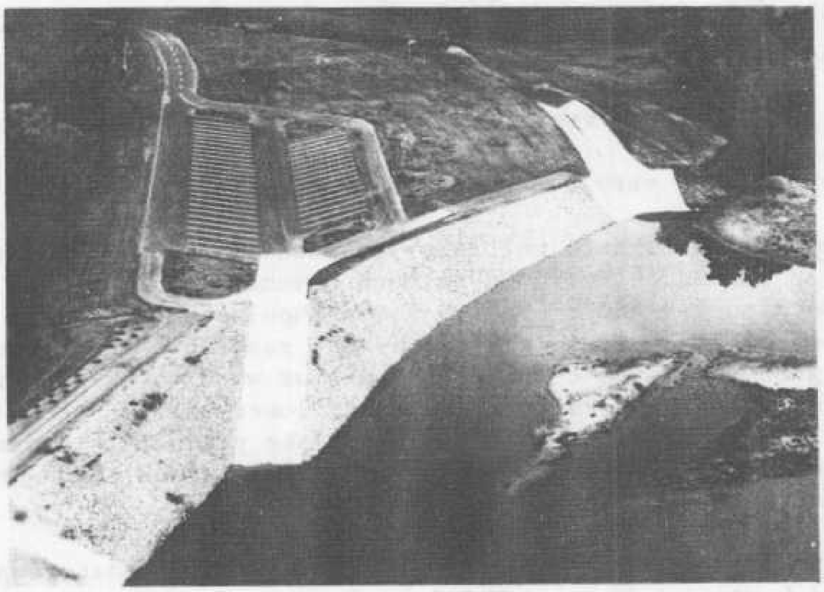


Figure 4-1 Access, Circulation, and Parking at a Boat Ramp

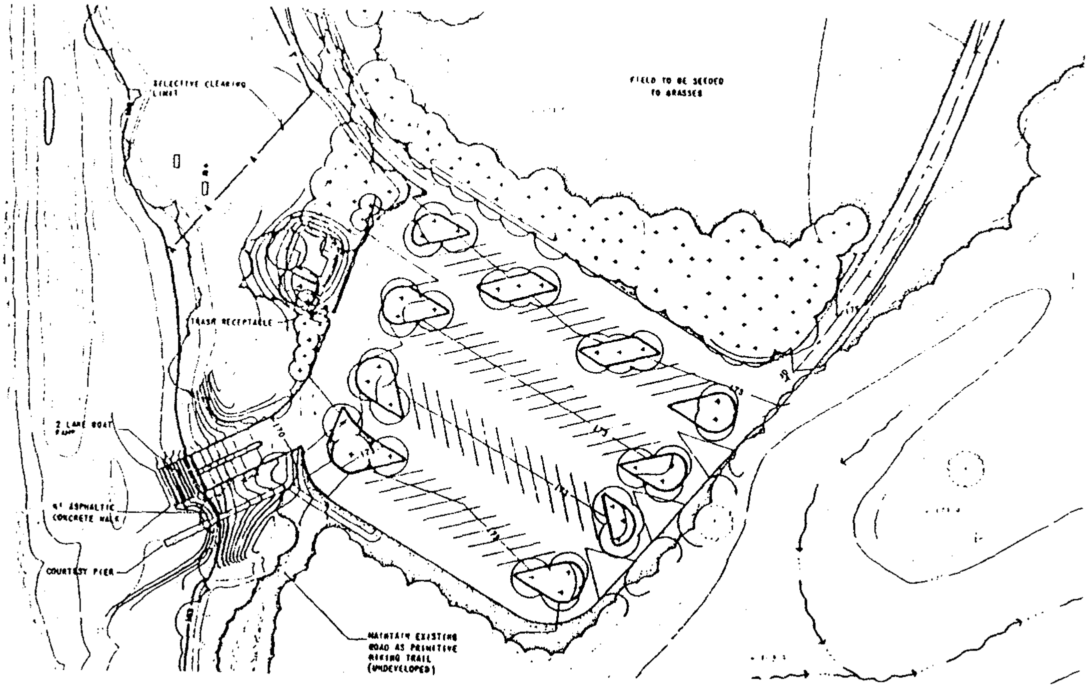


Figure 4-2 Access, Circulation, and Parking at a Boat Ramp

(2) The length will vary depending on pool elevation and ramp grade.

(a) Pool elevation. Where multiple-lane concrete ramps are needed, one or more lanes should be designed to meet demands for launching at low pool levels. Both public and operation needs should be met. Ramp length for various types of lakes is determined by the reservoir regulation plan. The designer should be completely familiar with the regulation plan prior to designing boat ramps. Upper and lower limits are to be established for each ramp designed for use at lake projects. Ramps serving launching into streams or rivers should meet annual high and low water flow conditions.

1. Upper limit. The upper limit to be considered in boat ramp design for Flood Control Lakes and Multiple Purpose Lakes is the 5-year frequency flood pool elevation. This elevation is stated in feet above mean sea level. The upper limit for Navigation Lakes is 3 feet above the normal operating pool. Appropriate allowance should be made for backwater effects.

2. Lower limit. The lower limit water elevation to be considered for design of boat ramps at the various types of lakes are:

(a) Flood control lakes. A minimum of four feet below the permanent pool.

(b) Multiple-purpose lakes. Four feet below the 10 year drawdown.

(c) Navigation lakes. A minimum of four feet below the normal operating pool.

(b) Grade.

1. Ramp grades should be a minimum of 12 percent and maximum of 16 percent. Grades of 14 percent are preferable. A straight line grade from top to bottom is not necessary when changes in grade will better fit the terrain. Care should be taken when changing the grade to assure that vehicles and trailers will not drag the surface at the break over points. This is particularly important at the top of ramps where the access pavement meets the ramp. The break over angle at the point of beginning of the ramp or at any other change of ramp grade, should not exceed 7 degrees. When conditions require an angle greater than 7 degrees a vertical curve should be used to prevent dragging of the surface. Transverse grade should be flat for ease of construction. (See Figure 4-3). When there are requirements for ramps at locations with existing terrain having a grade less than 12 percent a combination of ramps, boat channels, and boat turning basins, may be used if siltation is not a problem.

2. Each ramp should have a minimum of one 75-foot diameter vehicular turnaround or equivalent supplemented with additional turnarounds at a 150 foot interval on a continuously sloping ramp. Vehicular turnarounds may overlap for multiple ramps. Turnarounds should permit vehicles to drive head first down the ramp, turn around and back the trailers into the water for boat launching. An additional access level (road, not a turnaround) should be provided for dangerously long ramps (300 feet or more). The additional access road should be provided at the mid point of the ramp.

d. Shoulders. Ramp shoulders should be stabilized with rock to prevent erosion and to provide support to errant vehicle wheels going off the pavement. Either graded riprap or quarry run rock may be used for this purpose. Rock should be sized for the anticipated wave action or current as the case may be using customary Corps of Engineers criteria. To prevent trailer wheels from dropping into holes in the rock or people from stepping into them and incurring injury, the surface of the rock should be chocked and grouted as necessary. Grouting also prevents loss of rock due to vandalism and theft. Chocking and grouting both reduce the effectiveness of the riprap shoulder protection by interfering with dissipation of wave energy in the interstices of the rock. For this reason the rock size should be increased over the size that would be used otherwise. The thickness of quarry run rock should be increased similarly. The "Typical Transverse Section" on Figure 4-3 shows a detail for rock protection of a ramp without curbs. Figure 4-4 shows details for rock protection of ramps with curbs.

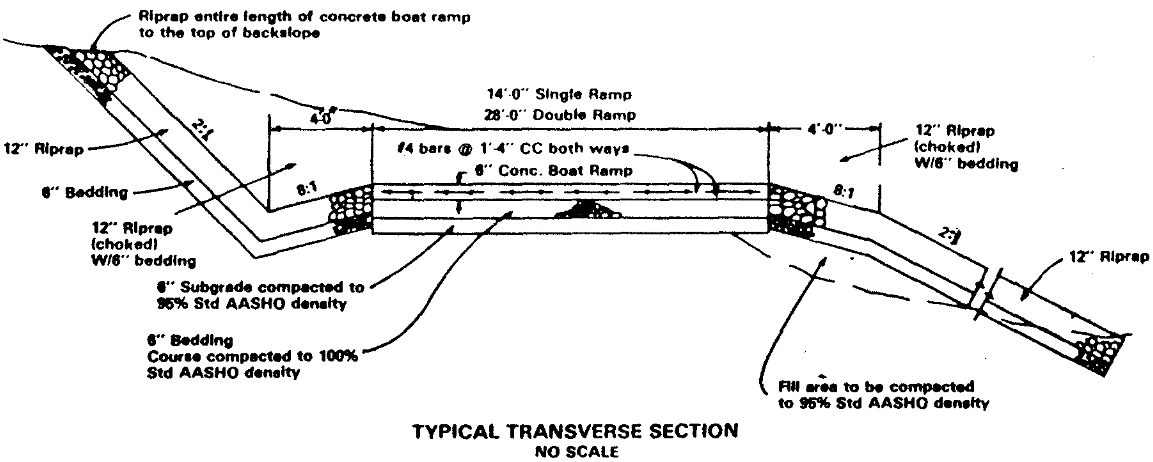


Figure 4-3 Rock protection details for boat ramp without curbs

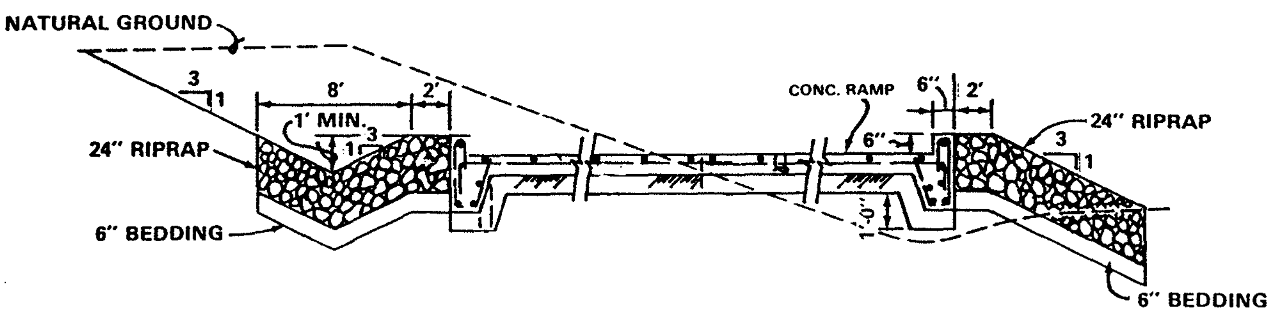


Figure 4-4 Rock protection details for boat ramp with curbs

e. Curbs. Single lane ramps should be designed with curbing to provide a margin of safety to drivers inexperienced in backing vehicles with trailers. Curbs integral to pavement are preferred.

f. Surface. Permanent ramps should be surfaced with reinforced or prestressed concrete. Ramps should have a minimum concrete thickness of 6 inches, a 6 inch bedding course compacted to 100 percent density, and a subgrade compacted to 95 percent density. The surface should be grooved in a herringbone pattern, down sloped from the center of the ramp to the outside edge. Figure 4-5 shows surface finish for concrete ramps. Asphaltic concrete has been a troublesome surface for ramps because of the slick, caused by algae, that can form just above and below the water surface and sediments deposited on the ramp on the water side.

4-6. Drainage and Erosion Control. Surface runoff should be directed away from ramps at intervals which will eliminate erosion of ramp shoulders or carry debris onto the ramp. Particular attention should be given to turning the runoff in roadside ditches of ramp access roads away from the ramp. Interceptor and diversion ditches and dikes or levees may be used where needed for protecting boat ramps from erosion by surface runoff. Riprap is also used to protect the ramp from erosion by wave attack. Boat launching ramps can easily be damaged by erosion. When it is necessary to locate ramps where they are exposed to heavy wave action, breakwaters should be included in the design for erosion control and to make launching and recovery safer and easier. The effect of breakwaters on siltation must be considered when breakwaters are made a part of the design of the boat ramp. Ramps constructed where relatively high stream velocities are anticipated, such as on river navigation projects, can be constructed on rockfills above the existing grade in order to avoid future undercutting and siltation. Weep holes should be provided for draining the subgrade of ramps constructed on soil subgrades that are without a free draining base.

4-7. Markers and Signs. A suitibly sized sign with launching and retrieval instructions should be provided. Directional signs should be used to direct traffic to and from ramps and parking areas. Warning signs should be used as appropriate. Directional pavement markings may be used as needed to indicate traffic flow and movements. These markers and signs should conform with the latest ANSI standards. The water areas, turning basins and channels related to the launching of boats should be marked according to standard navigation markings.

4-8. Landscaping. Good sight distance should be maintained in the immediate vicinity of the ramp particularly the access and the upper turnaround areas. The zone where vehicles leave the ramp to proceed to the parking area should also be maintained for good visibility. Grasses and low growing shrubs (3 feet at maturity) should be used in the vicinity of the ramp where visibility should be maintained.

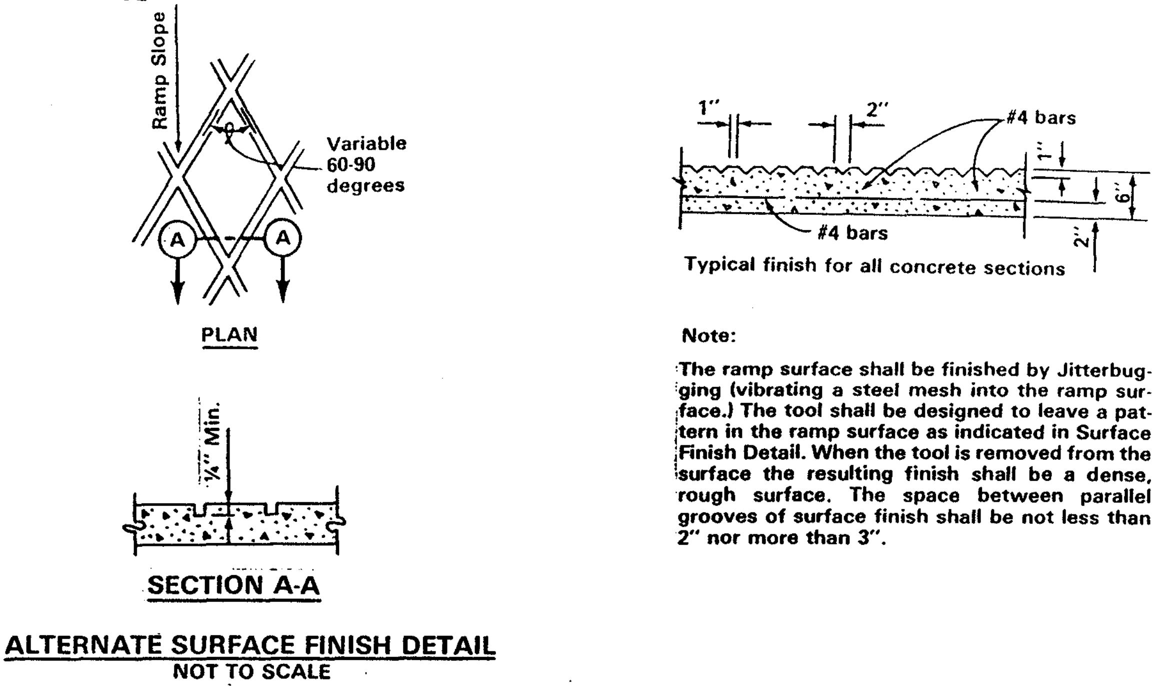


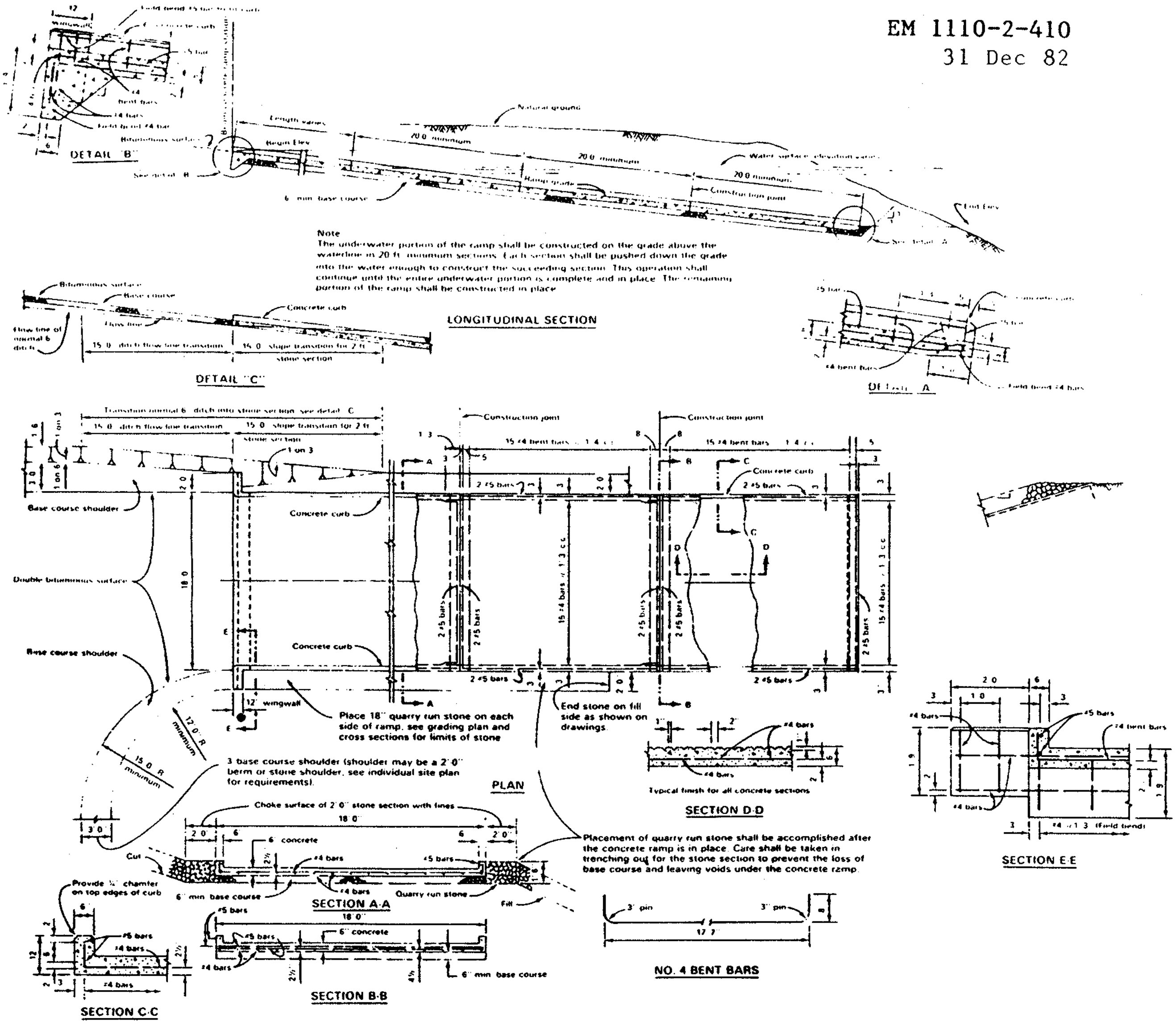
Figure 4-5 Concrete surface finish for boat launching ramp

4-9. Lighting. High pressure sodium lighting on wooden poles should be used for night lighting of boat ramps. Lighting level should be one candle power over one lane, turn-around and tie-down area.

4-10. Temporary Ramps. These may be constructed when the situation warrants until permanent ramps can be constructed. Temporary ramps should be of expedient design and conform to the foregoing standards of this chapter as nearly as is reasonable except grade when stone and gravel or other loose material is used that could impair traction of the vehicle. Grades should be reduced to 11 percent. Suitable materials are steel mats, crushed stone and gravel or earth materials stabilized by additives. Precast concrete planks or other suitable bearing material should be used for extending existing ramps during periods of extreme drawdown elevations.

4-11. Ramps For Existing Impoundments. Where additional ramps are required for existing impoundments and it is not feasible or economical to permit construction in the dry, ramps may be constructed on the bank and shoved into the water on a temporary base course. Figure 4-6 shows details for such a ramp with side curbs.

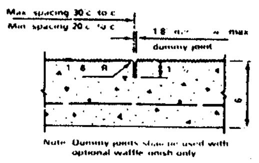
4-12. Plank Ramps. Precast reinforced or prestressed concrete plank ramps may be used for permanent boat launching ramps in areas where they are sheltered from wave or current attack. They also may be used to extend existing ramps during periods of extreme drawdown.



DATA FOR CONSTRUCTION OF CONCRETE LAUNCHING RAMP

SITE LOCATION FOR RAMP	PERCENT OF GRADE	BEGIN RAMP STATION	BEGIN RAMP ELEVATION	END RAMP ELEVATION	TOTAL ACTUAL LENGTH OF RAMP
Toad Suck Ferry West	14.0%	[illegible] 07 37	274.0	249.0	206 87
Dam Site 9 North	14.0%	1 98 14	290.0	261.0	206 87

NOTES:
1. The top surfaces of the ramps may be given a waffle grid finish at the contractor's option in lieu of the grooved finish shown on the plan, see specifications. Where a waffle finish is used, transverse dummy joints shall be applied as shown by the joint detail, this drawing.
2. The concrete in each section to be pushed shall be cast on heavy building paper, roofing felt or other approved material to faciliate sliding.
3. Each section shall cure a minimum of 7 days before performing any pushing operation.
4. Sections may be combined or lengthened to faciliate construction upon approval by the Contracting Officer.
5. Alternate construction methods may be used, as approved by the contracting officer.



DUMMY JOINT DETAIL

REINFORCING NOTES
1. All splices shall overlap a minimum of 30 bar diameters.
2. The slab sections in the concrete ramp are not sufficiently reinforced to support themselves.
3. Dimensions for reinforcing bars are to the center of bars.

Figure 4-6 Boat ramp design for wet placement

4-13. Mechanical Boat Launching Devices. Mechanical devices may be substituted for ramps on grade for launching boats up to 25-foot length where steep banks make ramp on grade construction impracticable or to aid the physically handicapped. The selection of mechanical boat launching devices should be guided by manufacture's literature and factory representatives.

4-14. Loading Piers. Only fixed piers which are integral to the launching ramp are covered here. There are many types of fixed piers which function over a varying range of lake levels. The main design problem is to meet the varying water levels. The floating type loading pier is used for more widely varying water levels, greater than 10-15 feet. The fixed pier as discussed here is used for lesser varying pool levels. The fixed pier integral to the launching ramp can be designed with treated wood timbers, concrete cribbing, steel cribbing or a combination of these materials. The pier should be a minimum of 6 feet wide. To meet moderate varying water levels (less than 10 feet) the pier should be alternately ramped (maximum 8.3 percent slope) and flattened to meet the next water level. The number of ramps in the stepping down process will be determined by the lake level fluctuations to be accommodated. Hand railing should be made part of the design to accommodate the physically handicapped. The cribbed area can be filled with rock and gravel and finished with roughened surface concrete. Wind and wave studies should be used to determine the overall design requirements. Figure 4-7 shows an example of the fixed loading pier integral with the boat ramp. Figure 4-8 shows a boat access dock facility for the handicapped.

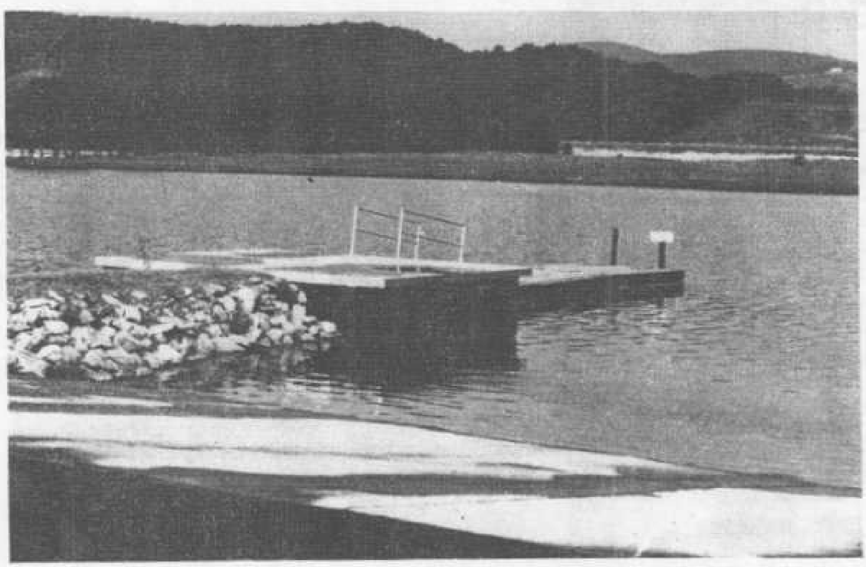


Figure 4-7 Fixed loading pier integral with boat ramp

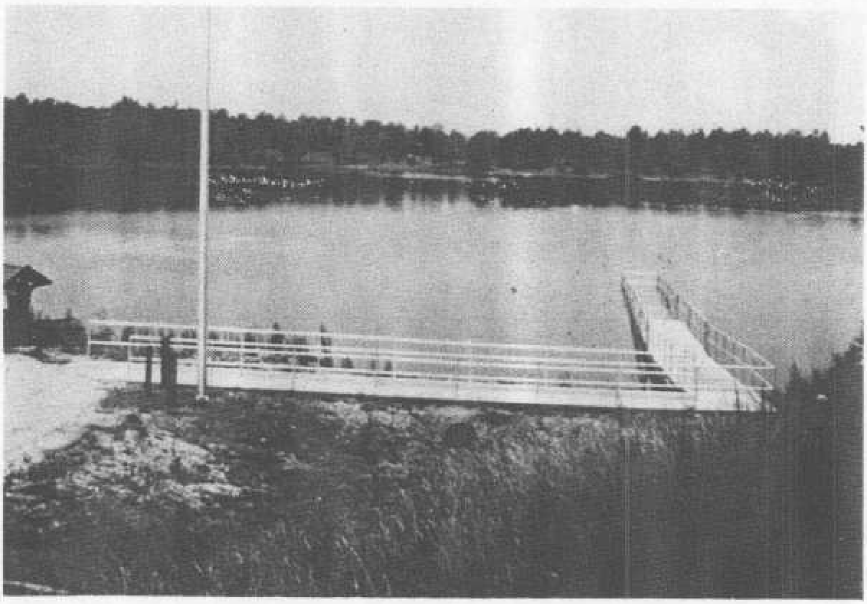


Figure 4-8 Dock facility for the handicapped park user

4-15. Access to Water For Non-Trailered Boats. This paragraph discusses the design of water access facilities for boats placed in the water by hand from the top of a car or trailed object other than a boat trailer. This facility consists of a graded section of shoreline no steeper than 3 on 1 (three horizontal to one verticle), stabilized with rock to withstand erosive forces and accessible from a gravel surfaced road. The grade section and its protection should be designed to meet water levels under the same design standards for ramps as given in paragraph 4-5d(1).

CHAPTER 5

WALKS, STEPS, AND RAMPS

5-1. Applicability. Walks, steps, and ramps provide for convenient and safe pedestrian access and circulation from parking areas, to comfort stations, bathhouses and other facilities as needed. Walks, steps, and ramps also, where it is desirable, channelize pedestrian traffic, and protect relatively fragile environments from damage by foot traffic. Walks, steps and ramps should serve the handicapped visitor as required. Not all outdoor recreation areas and facilities will be amenable to providing ramping in lieu of steps. However every effort should be made to make representive parts of recreation areas accessible to all users. Walks and ramps can usually, when studied with knowledge of existing topography, make representive parts of a area accessible.

5-2. Controls.

a. Function. Function establishes the need for walks, steps, and ramps and controls the width, layout and materials.

b. Climate. This affects the need for walks (the need being greater in humid climates), grade, drainage and materials. Icing affects grades and may make canopies necessary over ramps and steps in walks at entrances to buildings.

c. Preservation of Environmental Values. Construction of walks detracts from the natural appearance of a site or area. On the other hand, construction of walks tends to channelize pedestrian traffic so that widespread damage to ground cover and soil compaction is decreased. Environmental considerations influence good design of grade, alignment and aesthetics of walks. Examples: In desert areas where ground cover is sparse and the ground is not too rough, walks may not be needed. In areas where ground cover is lush and can stand a great deal of foot traffic, walks may not be needed for some facilities.

d. Topography and Physical Features. These considerations affect walk design in much the same way that they affect road design. Layout, grade, drainage and erosion control will be heavily influenced by topography and physical features. The need for steps and/or ramps in walks is dictated by terrain and the using public. Alignment may be affected by the need to route walks around rather than through desirable features.

e. Constructability and Maintainability. These controls impact most heavily on materials, grades, drainage and erosion control measures.

f. Safety. The safety of visitors should be of uppermost concern. Safety considerations must be incorporated into the design of grade, surface, drainage, location, width, steps, ramps, guards, handrails, lighting and all other features of design.

5-3. Physically Handicapped. Each recreation area offers a different challenge to the designer to provide access for the handicapped. Handicapped needs should be identified in the early stages of design so that facilities may be provided as the need warrents. It will usually not be possible to make each recreation facility, i.e., picnic unit, camping unit, or trail accessible to the physically handicapped; however, a sufficient number should be made accessible with similar freedom of choice as non-handicapped visitors. More specific information on which and how many recreation facilities are to be provided for handicapped use is furnished and will be periodically updated in the Manual on Design for the Physically Handicapped. In addition design criteria for walks, ramps, guards, handrails, etc., can be found in that manual. Guidance to designers of outdoor recreation facilities for the handicapped can only be generalized because the limitations of handicapped visitors is highly variable. Some handicapped recreationist with only slight disabilities can in fact use many recreation facilities without modifications. On the other hand, facilities for the visitor in a wheel chair may require extensive adjustments.

5-4. Design Considerations. Walks, steps, and ramps for outdoor recreation areas should be designed in accordance with standards in the following subparagraphs.

a. Walks.

(1) Width. Pedestrian lanes are considered to be 2 feet wide. Walks with low traffic such as to individual picnic or camp sites should be 2 feet wide. Walks with moderate traffic (i.e. from parking area to facilities), and this will cover the majority of walks, should be 4 feet wide. Walks with heavy traffic (i.e. visitor centers) may be increased in width by multiples of 2 feet based on traffic analysis and design judgement to provide 6 feet, 8 feet, etc., widths. Figure 5-1 illustrates walk design adjacent to parking facilities.

(2) Location and layout. A general rule for walk design which should be observed to the extent feasible is that pedestrian and vehicular traffic should be separated. The location and layout of walks should be based on an analysis of facilities to be served, traffic, terrain, and physical features so as to best serve the public. Directness of route is of primary importance; otherwise, people will make cuts using shorter routes. Hesitant designers have often thought that it

would be ideal if walk construction could be deferred until after recreation facilities are in use and then built where people have established paths. In some instances, it may be necessary to place walks adjacent to roads. Walks adjacent to recreation access roads should be located well back of ditch lines, guideposts, and guardrails. Where there is no ditch or fill of consequence, the maximum distance available should be allowed between the walk and the outside edge of the road. Circulation roads, can sometimes be use for pedestrians as well as vehicles particularly in campgrounds. Vehicle speed should be posted at 15 mph. For aesthetic, purposes, long walks should usually be designed

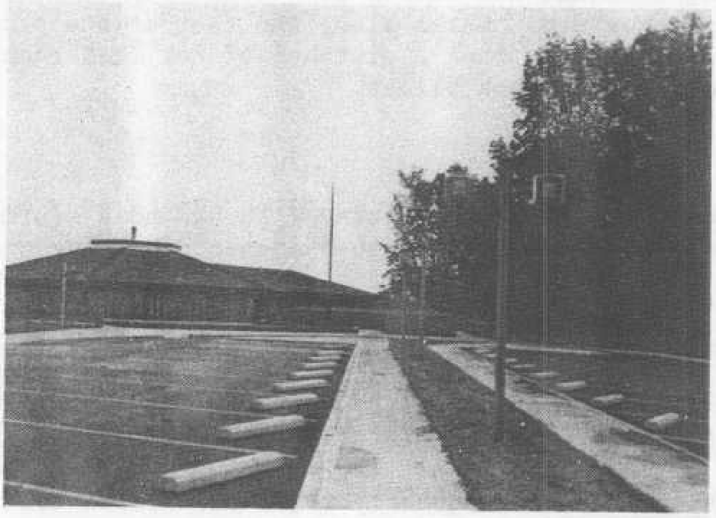


Figure 5-1 Walk adjacent to parking area

with curvilinear alignment. However, the use of curving alignment should not unduly increase the length of a walk from point to point. Right angle turns in walks, except very short ones, will almost always be shortcut. Where right angle changes in walk direction must be used a fillet of three feet minimum radius should be constructed on the inside of the turn. Walks through wooded areas should be routed so as to obviate removal of or damage desirable trees. Limbs overhanging walks should be pruned no more than to provide a horizontal clearance of 1' from the edge of walks and 7' vertical clearance above walks. It should be kept in mind that a walk system that looks great on paper may not be so on the ground. Accordingly, the design should usually be staked out and checked in the field before construction begins.

(3) Grade. The grade of walks should follow the natural grade of the ground as nearly as possible. The finished grade adjacent to walks should be 1 inch below walk grade to allow for turf growth. A transverse slope of 1/4 inch per foot should be provided for drainage. Longitudinal grades should not be greater than 10 percent in locales where there will be significant use during freezing weather, or 15 percent in non-freezing locales. Steps in walks are generally undesirable but should be used where longitudinal grades exceed 15 percent. Transverse grade of ground adjacent to walk edges should not exceed 25 percent for the first 3 feet unless handrails are provided. Walks along the foot of steep cut banks should be set out from the cut bank a distance of not less than 5 feet to provide safety from possible rock slides.

(4) Surface.

(a) Asphalt concrete. Surface thickness should be a minimum of 1 inch and a base course of 2-1/2 inches to 5 inches depending on soil conditions.

(b) Portland cement concrete. The concrete surface should be a minimum of 4" with a strength of 3000-3500 pounds. For most sites a leveling course of gravel or sand should be provided, the thickness of which should be determined on the basis of soil conditions.

(5) Drainage structures. Frequently walks must cross drainage courses and it will be necessary to provide drainage structures to pass the water under the walk. For small runoff rates pipe culverts are most suitable. Where head height is limited a battery of pipe culverts may be used. Metal arch pipes reduce head height requirements. Small reinforced concrete box culverts may be used instead of pipe culverts if cost is competitive and appearance is improved. Masonry or timber culverts may similarly be used. Culvert ends should be covered and extended for 3 feet from the edge of the walk for safety. For larger drainage courses foot bridges should be used.

b. Steps. When steps are used they should be grouped together, rather than spaced as individual steps. Not less than three risers should be used per group of steps. Ramping should be applied to grade changes requiring fewer than three risers. All step groups should be provided with handrails. Risers should normally be 5 inches and tread width 14 inches. When all steps are to be used frequently in nighttime hours, lighting should be included in the design. Steps should be built into the slope and have a foundation that goes below frost level. They may be constructed of various material, such as stone, brick, concrete, and wood or a combination of these.

c. Ramps. Ramps in walks should be used in lieu of steps in recreation areas for safety of visitors when the extent of change in elevation will permit. The maximum slope for ramping is 20 degrees, 15 degrees is the preferred maximum. Positive drainage should be provided transverse by tilting the ramp wearing surface on a 1 percent slope to the downhill side of the walk. Ramps should be protected from surface drainage which could cause deterioration of the ramp or its foundation. The design criteria for ramps, guards and handrails for the handicapped is given in manual for design for the pysically handicapped. A use of ramps for access is shown in Figure 5-2.

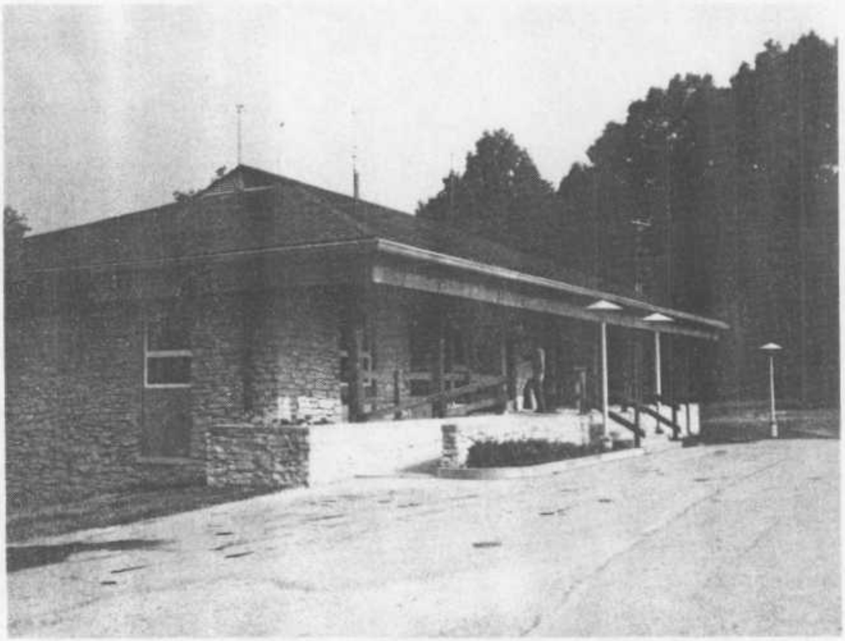


Figure 5-2 Access Ramp to Visitor Center

CHAPTER 6

TRAILS

6-1. Foot Trail.

a. Application. The purposes for providing trails in recreation areas are for visitor's enjoyment, education, and excercise. In addition, trails may also support fire control and special administrative access. The needs of the elderly, the very young, and the physically and mentally handicapped must be considered early. Their need for outdoor experiences may be even greater than that of other visitors. Often minor modifications in existing trails, and more sensitive design of new ones, can provide handicapped persons with a joyful and memorable experience instead of one that is frustrating and/or hazardous. Trails may be designed with one or many disabilities in mind. Special trails for the visually and physically impaired should not conflict with other trail users. They should be designed to permit an interchange of trail experience with other users. It is difficult to design a trail for both the blind and the wheelchair user. Wheelchairs bog down or slip on trail surfaces such as pine needles or gravel which are often a tactile delight to the blind.

b. Controls. Flexible design standards should be applied to the various types of foot trails. A careful analysis is required of each type describing volume of use, kinds of users, mood desired, guided or self-guided, seasonal or time-of-day restrictions, and limitations needed because of topography or administrative constraints.

c. Design Considerations.

(1) Surface.

(a) Natural. Where terrain permits, the surface of most hiking trails should receive little improvement except for that made naturally by those walking on it. Some steep slopes may require grading and/or water barriers (bars). Any areas where the existing surface is unsatisfactory the unsuitable surface should be excavated and the trail surfaced with wood chips, gravel, sands, slag, or other aggregates less than one inch in diameter. Depth of fill may vary up to six inches according to the soil and its trafficability. A soil sterilant might be needed to control difficult to maintain vegetative species, such as poison ivy and briered plants on some tread surfaces. Some areas which receive especially heavy traffic may need to be paved.

(b) Surfaces for special use. Surfaces of trails to be usable by the handicapped need special treatment. Where possible, trails for the

Figure 6-1 Scenic trail with paved surface

blind should have a natural surface such as pine needles, gravel or wood chips. All trails for the blind (whether natural or paved surface) should have a contrasting surface material at its edges to indicate the edge to the blind user. The contrasting color of the trend surface and edging will aid the partially blind. Generally, a concrete trail with turf edges or an asphalt trail with a light colored gravel edge will serve both purposes. All trail surfaces designed for the wheelchair user should be paved with non-slip brushed concrete or asphalt. Expansion joints should be minimized as well as expansion joint filler which extends above the surface. The best paving material is sealed asphalt since there are no expansion joints to worry about. Very hard asphalt should be used to prevent wheelchair wheels or crutches from sinking in during hot weather. A solid surface extending 1 foot beyond each side of the trail should provide lateral support as well as the contrasting strip needed by the blind and partially blind. Figures 6-1 and 6-2 show a scenic trail with paved and unpaved surfaces.

(2) Drainage. Drainage must be considered with all trail types. Drainage is one of the most important items in trail construction and is often the most neglected. A study of the precipitation and runoff characteristics as well as the soil characteristics of a locality should be made to properly determine the methods best suited for disposing of drainage water. The problem can often be solved by diverting water from the trail at suitable intervals before it builds up an erosive force. Methods used are described below:

(a) Outslope. The tread is sloped 2 to 4 percent to the downhill side.

Figure 6-2 Scenic trail with unpaved surface

(b) Grade dips. Sections of trail where a shorter segment (not over 5 feet to 6 feet) has been built with a grade slightly adverse to the prevailing trail grade.

(c) Water bars. Water bars can be made with 6 inches to 8 inches diameter peeled log or timber laid at a 30 to 45 degree angle to the trail and fastened to heavy stakes, posts, or steel pins. The grade above the water bar should be flush with the top of the water bar. Figure 6-3 shows water bars in place for protection of the trail surface. Immediately above the water bar, the outer edge of the trail should be sloped downward to permit water release. A combination of the above methods usually provides the best drainage and is preferred to culverts and bridges. In extreme cases drainage ditches, culverts, and catch basins may be needed, but care should be taken in then selection to blend into the surroundings. In addition, some grate patterns can be hazardous to persons using crutches, canes or wheelchairs.

(3) Gradient. The rate of grade should not be steeper than 15 percent with 6 percent considered a general grade. Short sections of the trail may have steps and grades exceeding 15 percent. See the Manual on Design for the Physically Handicapped gradients for handicapped users.

Figure 6-3 Water Bars

(4) Length and alignment. The trail length may vary depending on its use and purpose. It may be short, perhaps 1/2 mile, or it may extend for many miles and incorporate both urban and rural characteristics. There are two basic types of trail alignment (a) simple one-way loops with common start and finish points and (b) linear trails along parkways, rivers, etc., which require hikers to make transportation arrangements at the end of the trail. Trails made accessable to physically handicapped should provide flat areas for resting (turnouts) at 100 foot intervals along the steeper lengths of the trail. Trails for the handicapped should be 1/10 of a mile to 1 mile long. The trails should avoid an excessive number of sharp turns or right angles.

(5) Width. Some variation according to the flora and terrain is appropriate. As a general guide, the trail should be sufficiently wide that the route will be clearly obvious as one looks along the trail. A long distance back country trail should have an actual width of around 24 inches. Figure 6-2 illustrates a back country trail. Where an existing route, such as an old logging road is incorporated into a trail the width may vary. The width for shorter trails, such as those confined to campgrounds should be from 3 to 5 feet. The three foot width would be suitable for one-way loop trails. Heavily used trails and those which may be used periodically for maintenance and emergency vehicles should be a minimum of 8 feet.

(6) Clearance. Clear trees, brush, rocks and ground litter only to a sufficient width and height to provide an unobstructed passage for

hikers and backpackers. Excessive clearing is not desired. The clearing height on hiking trails should be not greater than 8 feet. Horizontal clearance should be a maximum of 2 feet on both sides of the trail.

(7) Maintenance. All trails will require occasional maintenance work to keep them in good condition. Care should be taken during the design of a trail to insure that maintenance costs will be as low as possible. Clearing should be done on an annual basis to keep the trails clear of briars, tree sprouts and other undesirable growth. Late spring or early summer is the best time for this type of maintenance as winter blowdowns can also be removed. To discourage the use of shortcuts across graded switchbacks, rocks, logs, or other physical barriers may be placed in the shortcut. Excess soil from initial construction should be stockpiled at appropriate locations (out of sight) for possible future maintenance requirements.

(8) Signs. Signs should be kept to a minimum, but the trail should be adequately marked to warn, restrict, or inform the using public. The trail name should be prominently displayed at the entrance. Signs should be low profile and compatible with surrounding landscape. Standard wooden and metal materials can be used; most metal types will be more resistant to vandalism than wood. Vandalism will be the most severe in the first 500 feet of the trail, the more expensive displays and signs should be located beyond that zone, if possible. Care should be taken in the placement of all directional and interpretive signs. The lower eye level (approx. 45 inches) of wheelchair visitors should be considered. Signs for the blind can be made with routed or raised letters or with braille. Actually a combination of the two is preferred. Many of the partially blind can read bold print (letters 18 pt. or larger-3/16 inch). Experts in education of the blind and the physically handicapped should be consulted.

(9) Safety. All standard precautions must be taken. Bridges and steep steps should have handrails; fences or some type of barrier should be placed along bluff edges. Visitors should be adequately warned of hazards that may exist such as - poison ivy, poisonous snakes, falling rock, adverse weather conditions, wild animals, etc. Hikers should be especially aware of the dangers of forest fires and the safety precautions that must be taken with campfires. During periods of extremely high fire danger, trails may have to be closed and provision for closure should be part of the design. Wherever possible, topography should be fairly level for 3 or 4 feet on the downhill side of trails as a safety factor for to wheelchair users. In places where this is not possible or in places potentially dangerous to the handicapped, curbing 4

inches high should be installed. Guardrails or handrails 32 inches off the ground may be substituted for curbing. Handrails should be provided on at least one side of all ramps, bridges and steps. Manholes, and drain inlet grates should be kept off all trails. But, if grating cannot be avoided, the openings in the grates should not exceed one half inch. Methods have been developed to guide the blind such as cord strung along one side of the trail with, knots or markers on the cord to identify the location of displays and signs, and kickboards set along the edge of the trail surface. The kickrails can enable the blind to follow the trail through simple shoe contact with the rail. These methods can alternate from side to side depending upon location of interpretive markers. A simple 3 inch wide, white line painted on the trail surface can enable the partially blind to follow a trail safely. Facilities should be available for emergencies that might occur on the trail and routes should be laid out for emergency vehicles to reach the trail. Figure 6-4 shows details for providing guidance to the blind on trails. Special attention should be given to trail crossings at park roads. Caution signs along the trail and road should be made part of the design.

(10) Support facilities.

(a) Sanitary. Heavily used trails may require toilet facilities. When required, they are usually best located adjacent to a trail entrance and/or parking area. Trash receptacles should also be provided near the entrance and parking area. When trash receptacles are not provided on the trail, appropriate signs should be posted at the entrance.

(b) Primitive camping. Primitive camping areas should only be provided on long distance cross-country trails. Generally, backpackers are most interested in minimal development of campsites. Such facilities can include a drilled well with hand pump, a fire ring, a picnic table, and a pit toilet. The camping areas should be small, with space cleared to accommodate no more than ten tents.

(c) Potable water. It is not essential to provide water on shorter trails, but it would be an appreciated facility, especially at the trail's end. Potable water should always be available, at least at the beginning and end, on longer trails. A well or spring 5 gpm unfailing water supply is satisfactory for hiking trail use. Design potable water facilities in accordance with state public health standards.

(d) Parking area. Ample vehicle parking should be provide at trail head and ending. If natural barriers do not exist, posts, boulders, or some other physical barriers should be used to restrain vehicles from entering hiking trails.

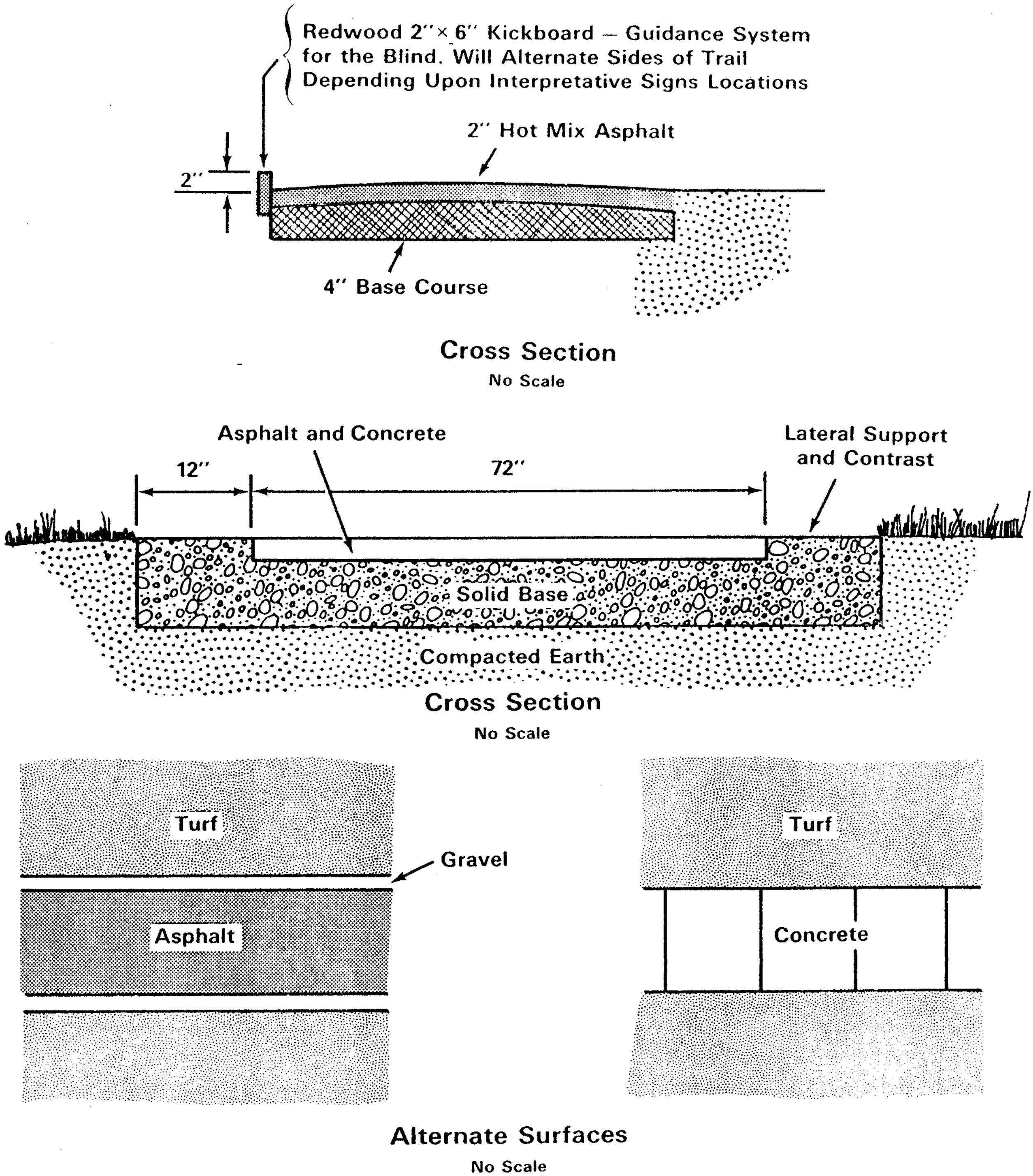


Figure 6-4 Methods of providing guidance to the blind

6-2. Bike Trails.

a. Application. Bicycle trails can be made part of a multipurpose trail near urban areas. Where possible, an effort should be made to tie into existing metropolitan trails. In larger, busier parks the biker's safety may justify a separate trail system.

b. Controls. Volume of use, average age of users, safety, separation of bicycles and autos, speed, and seasonal limitations control the design of bike trails. Type of equipment and specialized users (handicapped) also need to be kept in mind when designing bike trails.

c. Design Considerations.

(1) Surface. A paved surface is essential. It is a common misconception that bike trail surfaces do not require heavy load-carrying capabilities. Actually, bicycles have a highly concentrated weight in a very small area and thus the load capacity of the surface should be comparable to that of an automobile. The surface should also be capable of supporting light maintenance vehicles. A bituminous surface is the most popular with bikers because of the smooth ride it provides. Proper attention must be given to the subbase for bicycle trails for good drainage and support for the pavement. The surface thickness can vary depending upon soil stability and material availability. The accepted standard is 2 inches of bituminous over a 4-inch aggregate base with a

Figure 6-5 Bicycle Trail

compacted subgrade. Where good soil drainage exists the base can be stabilized earth, soil cement, or aggregate. Full depth asphalt can be used instead of aggregate, with a 3 to 6-inch thickness depending on the quality of the subgrade. Roadway mix can be used provided it is dense graded. Concrete is an alternative surfacing to bituminous. For a bike-path there should be a 4 inch concrete surface over a 4 inch aggregate base. Though this surface is the most durable it also has some disadvantages: (a) it is expensive, and (b) there is some riding discomfort due to expansion joints.

(2) Drainage. To provide proper runoff of excess water, the crown of the surface should slope 0.02 foot to 0.03 foot per foot. In addition to drainage ditches, culverts may be needed for cross drainage. In extreme cases catch basins may be needed. Positive drainage of the subgrade of the area prepared for the base course is also essential to good design.

(3) Gradient. Bicycle trails should follow the natural contour wherever possible. Weather conditions, physical energy, and bicycle characteristics are factors which can limit the slope and number of grades used. Under ideal conditions the maximum gradient for a long (1500 feet) uphill slope should not exceed 2 percent. For short segments (less than 300 feet) 5 percent can be negotiated. Gradients are no problem to experienced bikers. The design of bike trails should not, however, be influenced by the experienced bikers abilities only. The occasional biker should also be considered.

(4) Length and alignment. It is difficult to establish a precise minimum or maximum length because this is dependent upon many factors. Short recreational loops range from 3 to 10 miles. Touring trails can be much longer. A bike trail should blend into the environment. Taking advantage of the topographic features of an area will provide a diversity of scenery and riding experiences. Figure 6-5 shows an example of a bicycle trail, while figure 6-6 shows a multipurpose trail.

(5) Width. With ideal shoulder conditions, a standard width of 4 feet for one-way and 8-feet for two-way traffic is acceptable. A 2-foot shoulder on both sides is ideal. Pavement spreaders can spread a minimum 8-foot section and is the most cost effective method of surfacing when an 8-foot path or near that width is required.

(6) Clearance. Bike trails should have a horizontal clearance of 2 feet beyond pavement or improved shoulder and a vertical clearance of 9 feet.

(7) Stopping sight distance. For safe operation, the bike trail should have a minimum sight distance for safe stopping. Design values for safe stopping sight distance may be computed using the same

Figure 6-6 Multi-purpose trail

methodology as is used for roadways. Table 6-1 is based on a coefficient of skid resistence of 0.25 (based on a bike with good brakes and a single wheel in contact with a paved surface) and a perception-reaction time of 2.5 seconds.

Table 6-1 Stopping Sight Distances for Downhill Gradients

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

(8) Curvature. Within the aforementioned criteria for designing park trails, minimum radii for curvature should be incorporated into the design. If this is not possible, adequate signing and marking should be used to indicate the sharp curve ahead. Some superelevation should be included in the design for all curves, however little information is available as to what the rate should be. A general design value of .05 has been used. Table 6-2 considers a curve where little or no superelevation is used, therefore where more than token superelevation is provided the radii may be reduced.

Table 6-2 Design Radii

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

(9) Design speed. Design speed should be considered in the layout for bike trails even in parks. The goal in parks is not to reduce travel time but to insure safe and enjoyable operation. Most bicycle riders travel at speeds of 7-15 mph with 10 mph as typical. On an interesting or scenic segment of a trail the speeds will probably be slower. On moderate or steeper slopes design speed becomes an important consideration. Speeds can easily build up to 15 mph on moderate slopes while speeds of 20 mph and higher should be considered for long moderate slopes or steep slopes. Bicyclists should be reminded of possible hazards ahead as well as the scenery. Many objects, such as tree branches, turtles, and slick leaves can present hazards to the biker.

(10) Maintenance. Ease of maintenance of the bicycle trail is a critical consideration. Pavement protection from erosion is important in the design of bike trails.

(11) Signs. Signs on bikeways are needed for three purposes: (a) regulating bike movement, (b) warning bicyclists of potential hazards, and (c) providing direction and information. Directional signs are especially important where trails cross or follow existing roadways for short segments. The standard bicycle symbol should be used for marking and distinguishing the trail location. Standard metal and wooden materials can be used; most metal types will be more resistant to vandalism than wood. Also, stenciled signs can be painted on the bikeway surface.

(12) Safety. Safety should be designed into all bike trails. Inadequate trail width, poor trail maintenance (tree debris and erosion deposits) and inadequately constructed shoulders have been identified as the leading causes of accidents on bike trails.

(13) Support facilities.

(a) Sanitary. Bike trails should be routed near existing public restrooms and trash receptacles should be provided at appropriate locations. Provision of sanitary facilities should be considered along isolated trails or isolated segments of longer trails.

(b) Potable water. Potable water should be provided on longer trails. Well water with 5 gpm supply is sufficient.

(c) Parking area. Many users transport their bicycles from home and will need ample room to park vehicles and unload. Scattering parking and access points to the bikeway will help diffuse cyclists along the entire route. It also enables cyclists to plan trips of varying length and scenic interest. Parking lots should provide for ample circulation of traffic and avoid congestion.

(d) Bike racks. There are many different types of racks and lockers, ranging from standard bar racks to coin and key operated models. Choice of suitable parking equipment must be based on security needs, unit costs, location and the number of anticipated users. Standard designs for bike racks are given in, "Architectural Graphic Standards."

6-3. Riding Trails.

a. Application. Horseback riding trails may be needed in both the urban and rural setting, but usually are more in demand in urban areas. Horseback riding trails are best developed on terrain that is well drained. Fire lanes can often be developed as a dual use trail.

b. Controls. Safety of rider and horse, isolation from other recreation use, (particularly that use where extreme noise could be dangerously distracting to the horse), and demand for facilities control design of riding trails.

c. Design Considerations.

(1) Surface. The natural surface should be used wherever possible. Sand or wood chips may be used in areas of concentrated use. Grade for good transverse drainage to avoid puddling of water. Soils subject to wearing depressions where water could collect should have subdrainage and be reinforced with gravel and finished with sand surfacing.

(2) Drainage. Provide drainage to prevent erosion and excessive wear on trail. On flat terrain subsurface water is often as much of a problem as surface water. Where relocation is not a viable solution, ditching to draw water from the trail area (lower the water table) is a possibility. The need for culverting and bridging of streams should also be considered in the design.

(3) Gradient. Grades in excess of 10 percent are difficult and costly to maintain. If grades in excess of 10 percent (maximum 20 percent) are to be used they should be limited to short sections (less than 100 feet).

(4) Length and alignment. Trails can range from 1 to 20 miles depending upon availability of land, needs of the user, and management capabilities. The alignment should, in general, fit the topography of the area. On flat terrain, the trail should curve and wind to provide diverse experiences. The trails should run through points of scenic, historic or recreational interest. Avoid steep grades, poor drainage areas and conflict with motorized vehicles. The following corridor types are preferred: ridge lines, shorelines of streams and lakes, canals and logging or rural dirt roads.

(5) Width. Width should be 2 to 3 feet minimum and 6 to 8 feet maximum. The larger width will only be needed in dense traffic areas.

(6) Clearance. The horizontal clearance should be 2 feet beyond the sides of the tread. The minimum vertical clearance should be 10 feet.

(7) Maintenance. Segments of the trail susceptible to erosion or bogging have to be checked regularly. Clearing around the tread area is an annual requirement. Maintenance should be considered during the design of the trail.

(8) Signs. Directional signing is needed at trail heads, points of interest, trail crossings, and at areas of unsafe conditions. Mileage markers are desirable on longer trails.

(9) Safety. Care should be taken during the design to relate the difficulty of the trail to the user's experience. Hazards, such as cliffs, ledges, dead timber, and streams should usually be avoided.

(10) Support facilities.

(a) Sanitary. Heavily used trails should have toilet facilities provided, usually adjacent to the trail entrance or parking area. Trash receptacles should not be needed on trails, but should be provided near the entrance and parking area.

(b) Potable water. Potable water in the quantity of 5 gpm should be provided. Provisions must be made for watering horses; stream, pond or lake water can be utilized where available. Generally water should be available at the trails end and beginning.

(c) Parking area. Parking should be provided near the trail's entrance for cars and trailers. Ample space should be allowed for the loading and unloading process.

(d) Hitch racks. Hitch racks should be provided at the trail's start and finish and at most popular stopping points along the trail.

(e) Concessions. Concessions should be provided on an as needed basis.

(f) Loading and unloading ramp. A 30 inch ramp height will meet most users needs. Ramp slope should be no greater than 10 percent.

6-4. Off-Road Vehicles (ORV).

a. Application. Off-road vehicles are in abundant use today. The provision of multipurpose ORV trails has become an important recreation design consideration. Specific areas and facilities are required for the use of off-road vehicles.

b. Controls. Sufficient buffer area is a major consideration in the design of the off-road vehicular recreation area. This is imporant in order to maintain visual and noise separation from other recreation users and adjacent landowners. Access to the area should be limited to one entrance. Safety of participants is of utmost importance. Monitoring use, reducing fire hazards, and controlling dust are also important design considerations.

c. Design Considerations. Before designing off-road vehicle trails, local enthusiasts and experts should be consulted. The people who are going to use the trail should have an input with regard to desired degree of difficulty, support facilities and regulations as well as overall layout and design. In appropriate parts of the country, nearly any kind of trail can serve as a snowmobile trail during the winter months. With motorcycles being the most popular ORV, most of the following standards are for motorcycle trails alone, although many of them could be applied to other types of ORV (See Figure 6-7).

Figure 6-7 Off-road recreation vehicle trail

(1) Drainage. Water bars or diversion ditches should be provided to control runoff water. Low areas should have permanent positive drainage structures. Wet trail surface and the opposite extremely dry, dusty conditions, should be anticipated and drainage and dust control provided accordingly.

(2) Gradient. Variations in the terrain are a major attraction to the ORV users. Slopes up to 45 percent are easily negotiated by an experienced motorcycle operator. The primary contoll for grade is the ability of the soil to tolerate deterioration and erosion cause by the interaction of the elements and the user vehicle.

(3) Length and alignment. Length is not important as even very short trails can be made very challenging and enjoyable for the ORV user. The ORV trail can be 1/2 mile, 3 miles, or longer. For safety, ORV trails should utilize one-way, loop alignment. Some cross-country snowmobile trails may have a linear alignment with two-way traffic which must be wider than 6 feet. Simply mowing or "bushhogging" loops in a grass or weed field can provide the ideal place for younger more inexperienced motorcyclists and minibikers.

(4) Width. Width for motorcycle trails can vary between 1 to 6 feet. As the width is narrowed the rider's challenge is intensified.

(5) Clearance. Motorcycles and snowmobiles require a standard clearance of 6 feet horizontally and 7 feet vertically. Four wheel drive vehicles will require 10 feet horizontal clearance and 9 feet vertical clearance.

(6) Signs. Trail rules, trail layout, and hours of operation should be prominently displayed at the trail entrance. A minimum number of directional signs should be provided along the trail route to maintain the desired flow of traffic. Signs should be low profile and placed to reduce vandalism and to reduce hazards for errant drivers.

(7) Safety. Safety reminders should be posted prominently to guide the users conduct on the trail. Trails should be varied, allowing the user to operate safely at his/her level of skill. Areas for beginners should include more gradual slopes and smoother surfaces. Man-made obstacles at difficult sections of a trail can enhance safety in some cases by forcing riders to operate at slower speeds. Safety equipment, such as; helmets, gloves, pads, leather pants and boots should be mandatory. Additional guidance on ORV safety practices can be obtained from the National Safety Council.

(8) Support facilities.

(a) Sanitary. Heavily used trails should have toilet facilities easily accessible usually adjacent to a trail entrance and/or parking area. Trash receptacles should also be provided near the entrance and parking area.

(b) Potable water. A water well at the parking area yielding 5 gpm is sufficient for water supply.

(c) Parking area. Parking should be provided near the trail's entrance for vehicles and trailers. Space should be allowed for the loading and unloading process. Several smaller parking areas should be considered rather than one large one. Riders should be channeled from the parking area to the trail through a controlled point (usually one entrance).

(d) Camping and picnicking. Camping and picnicking facilities should be considered for ORV trail users.

(e) Loading and unloading ramp. A ramp should be provided where the level of anticipated use is such that the ramp could aid in relieving congestion at the staging area. A height of 24 inches should be used to meet both trailer and truck bed heights.

6-5. Physical Fitness Trails.

a. Application. In urban areas there is a demand for a facility where the people can compress a great amount of physical exercise into a small area and do it in a short amount of time. Actually the need for this type facility is great in rural areas as well. The entire country is becoming "health conscious" and the popularity of these facilities is rapidly increasing.

b. Controls. Physical fitness trails are limited by safety, terrain, climate, and the needs of the user. Input from professionals in physical education as well as medical doctors should be sought in the design of the more elaborate physical fitness trails.

c. Design Considerations.

(1) Surface. The surface can be grass, cinders, 3/8 inch gravel or asphalt, depending on the amount of traffic anticipated and the budget. If gravel is applied, a 2 inch base of 3/4 inch gravel should be topped with at least 2 inches of 3/8 inch gravel and rolled to the desired compaction. Cinders may be applied over 3/4 inch gravel instead of 3/8 inch gravel. For foot traffic only, a 2 inch rock base and a 2 inch asphalt top are sufficient. If trucks or tractors will run over the trail, a 4 inch base should be used under asphalt.

(2) Drainage. The trail should be crowned so water will run off slowly.

(3) Gradient. A level grade is desired for most jogging trails. The use of any grades greater than 2 percent must be given careful consideration. Where space is limited the use of short uphill grades can offset the shortness of a trail and maintain a desired level of difficulty. Figure 6-8 shows a well used physical fitness trail.

(4) Length and alignment. The length of these trails can range from 1/4 mile to 2 miles. Regimented exercise trails should have a single start/finish point with a one-way, loop design. Trails designed only for jogging may be for two-way traffic and have more than one starting point.

(5) Width. Trails, for jogging should be 6 feet wide allowing for 2 people to run side by side and to allow for two-way traffic.

Figure 6-8 Physical fitness trail

(6) Clearance. Physical fitness trails should have a horizontal clearance of 2 feet beyond tread width on both sides and a vertical clearance of 8'.

(7) Signs. The trail should have adequate signs to regulate and inform the using public. Signs should be low profile and compatible with the surrounding landscape. Standard wooden or metal materials can be used but metal types are more resistant to vandalism than wood.

(8) Safety. Handrails should be provided on bridges and steps. Consideration should be given to providing lighting for trails where there is a demand for nighttime use.

(9) Support facilities.

(a) Sanitary. Heavily used trails should be provided with toilet facilities and trash receptacles at trail access points and parking areas.

(b) Potable water. Potable water is especially appreciated on physical fitness trails and should be provided where the volume of use can justify the expense.

6-6. Cross Country Ski Trails.

a. Application. Trails for skiing are in demand where the winter season is especially long and proper conditions prevail.

b. Controls. Ski trails should not be used for other wintertime activities, such as snowmobiling, snowshoeing or tobogganing. These activities compact the snow, crush the skier's groove to an icy sheet, and reduce control and safety for the skier. Weather conditions certainly are the main controlling factor. Ready availability of project land also will be a constraint for long distance trails and ski facility development.

c. Design Considerations.

(1) Surface. The actual ground surface requires very little attention, but to provide optimum conditions for the skiers the surface of the snow itself should be groomed regularly. To maintain optimum surface conditions for the skiers a track setting device should be used after each snowfall. The most economical track setters are volunteer ski tourers who set the track or groove by "breaking trail" or skiing each of the trail routes. A second method of track setting is to pull a track-setting sled over the trail with a snowmobile of 40 hp or more. The snowmobile also compacts the fresh snow. A regular snow tractor of 80 hp or more can pull heavier track-setting sleds capable of making a double set of tracks. Such a tractor is also often used for grooming snowmobile trails.

(2) Drainage. Good drainage design should be provided to prevent erosion of the ground surface during the spring thaw and heavy rains.

(3) Gradient. The trail should be about one-third flat, one-third uphill, and one-third downhill to provide interest and variety. Generally, a 15 degree or less slope is suitable for novices and general use, while short, 40 degree maximum slopes challenge advanced skiers. The trail should start out fairly level for about 100 yards. This gives skiers a chance to get accustomed to snow conditions and apply a different wax to skis, if necessary. If the terrain provides a chance to climb, then the skier can glide downhill on returning. If the terrain drops away, it means a climb back to the parking area, sometimes unwelcomed after several hours on the trail.

(4) Length and alignment. There are no limitations on maximum length. These trails should be no less than 2 miles in length. One hour's activity may be all a skier can tolerate before resting. The well conditioned, advanced skier may travel 6 miles, and the intermediate skier about 3 miles, while the beginning skier may be content with about 1 mile, in an hour's time. Trails should be laid out in connected loops, giving skiers a choice of distance they wish to cover. A system of cloverleaf configurations - mostly for one-way traffic - allows the intermediate and experienced skier to determine the distance that can be traveled in a given time. If possible, avoid placing trails on open, unshaded south or west facing slopes.

(5) Width. The trail should be at least 5 to 6 feet wide, where possible, to permit skiing side by side, as well as snow grooming machines.

(6) Clearance. Because snow buildup elevates the skier and the grooming machines, trees along the trail should be trimmed up to at least 10 feet in height to provide vertical clearance.

(7) Signs. Generally, signs with dark backgrounds and white lettering show up best against the snow. Trail head signs depicting the entire trail system, should be placed at the start of the trail, or near the parking area. This helps the skier become familiar with locations of rest stops, sanitary facilities, warming shelters, and the degree of difficulty of the routes. A code to explain trail difficulty ratings should be on this sign. Direction at junctions help keep the skier on the chosen trail, especially when color-coded or otherwise marked to indicate trail difficulty. Such signs help keep the novice off a trail beyond his or her ability. Signs can also state the distance back to the trail head. General information signs may caution the skier about a steep hill, upcoming bridge, direction of travel, or a bypass around a difficult section.

(8) Safety. Local cross-country ski touring club members should be consulted for safe trail layout. If possible, ski trails should avoid crossing roads, not only because of the potential accident hazard, but also because the road surface can damage the skis.

(9) Support facilities.

(a) Sanitary. Heated restrooms with flushing facilities is preferable, but it is possible to make do with temporary, self-contained comfort stations or properly maintained vault toilets. Trash receptacles should not be needed on trails but should be provided near the entrance and parking area. Signs should be posted at the entrance, stating that no receptacles will be available on the trail and that the skiers should "Pack it in and Pack it out".

(b) Potable water. It is not essential to provide water on shorter trails; however, potable water should always be available, at least at the beginning and end, on longer trails. A hand pumped well yielding 5 gpm is sufficient.

(c) Parking area. A parking area cleared of snow can serve as a staging area for groups of skiers.

(d) Rest stops. Rest stops may consist of maintained primitive windbreaks and fire pits. Trash receptacles could also be provided where the area is accessible to maintenance vehicles.

CHAPTER 7
PARKING

7-1. Introduction. Parking facilities must be provided at Corps areas to accommodate many and varied types of vehicles. The size of the facilities range from one parking space to several hundred. The cost of construction and impact on the site is usually considerable. For these reasons and others, it is important that these guidelines be followed as a matter of course.

7-2. Location.

a. Function.

(1) The parking lot or space should be located convenient to the area or facility it serves.

(2) Dead - end parking lots should be avoided.

(3) Provide vehicular/pedestrian separation where possible, and especially in large parking lots.

(4) When very large numbers of cars must be accommodated, use several small lots rather than one large parking lot if possible.

b. The terrain may place very real limitations on the location of a parking facility.

(1) Parking facilities should be developed on relatively level land to avoid excessive cut and fill. In order to accommodate the required number of cars it may be necessary to terrace for large parking lots.

(2) Grades not exceeding 6 percent parallel with the axis of parked vehicles and 8 percent transverse are permissable. Lesser grades are desirable.

(3) Drainage should flow to the naturally lower edge of a lot rather than the center.

(4) Erosion control measures should be provided to combat the increased quantity and acceleration of runoff.

(5) Preservation of the existing natural vegetation to the greatest extent possible should be one of the highest design priorities for parking facilities. Plans and specifications should clearly define the limit of clearing. To this end, it may even be necessary to limit the type and size of equipment allowed for clearing.

7-3. Layout. This paragraph is devoted to providing dimensional and geometric design guidelines for typical parking spaces and areas at Corps projects.

a. On-road parking, in any significant quantity, should be avoided. It reduces the traffic carrying capacity of the roadway, and it is usually unsafe and aesthetically displeasing. An acceptable use for on-road parking would be the small amount provided at a washhouse within a camping area. In this case, the low traffic volumes and vehicular speeds minimize the potential hazards. Also, by minimizing the site disturbance, the environmental and aesthetic aspects are less likely to suffer damage. When on-road parking is used, follow the guidelines in sub-paragraph b.(1)(a) & (b) below, and

(1) Increase 90-degree parking stall length by 4 feet,

(2) Increase 60-and 45-degree parking stall length by 2 feet, and

(3) Increase parallel parking width by 2 feet.

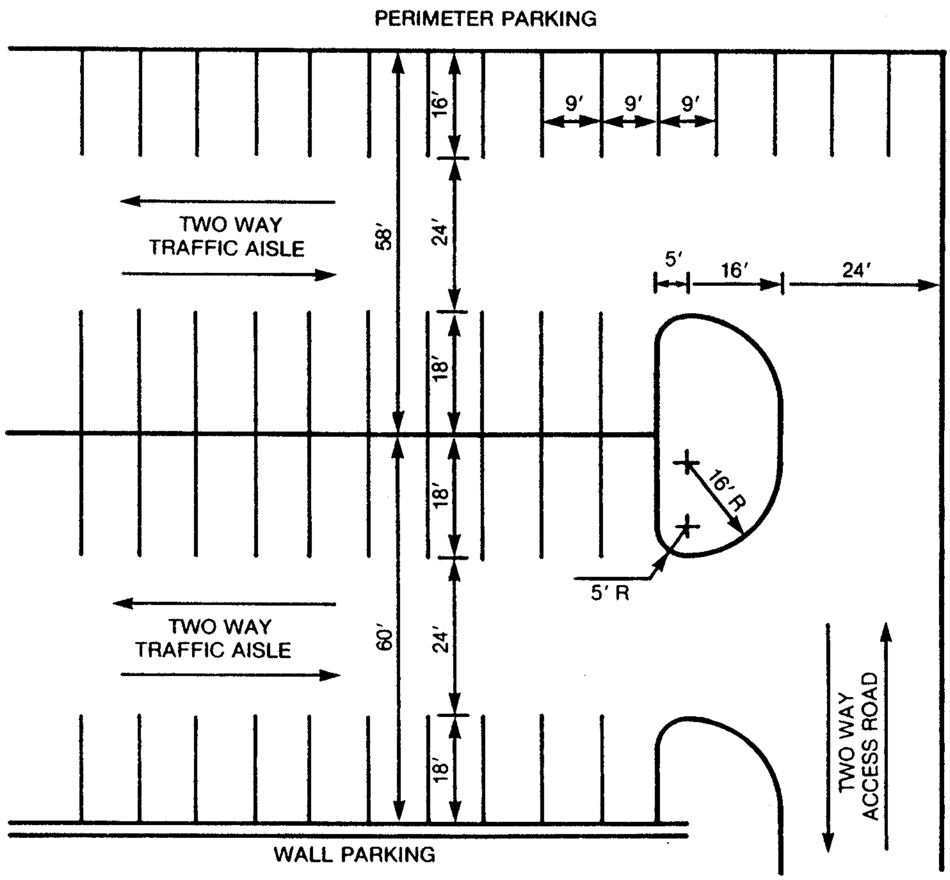


Figure 7-1 90-Degree Parking

b. Off-road parking is the preferred type of parking for most uses at recreation areas. It promotes safety, benefits vehicular circulation, and provides a pleasant and convenient transition between the roadway and the primary recreation activity.

(1) Mass parking is used for various size concentrations of day use recreationists at such diverse areas and facilities as beaches, picnic areas, and visitor centers to overlooks and comfort stations.

(a) Head-in parking is the predominent type of parking used in mass parking facilities. It is intended to be used by single unit passenger vehicles (for design guideline on parking vehicles with trailers see Chapter 4 Boat Ramps paragraph 4-5). Typical layouts with stalls arranged at 90 degrees, 60 degrees, and 45 degrees are illustrated in figures 7-1 through 7-3.

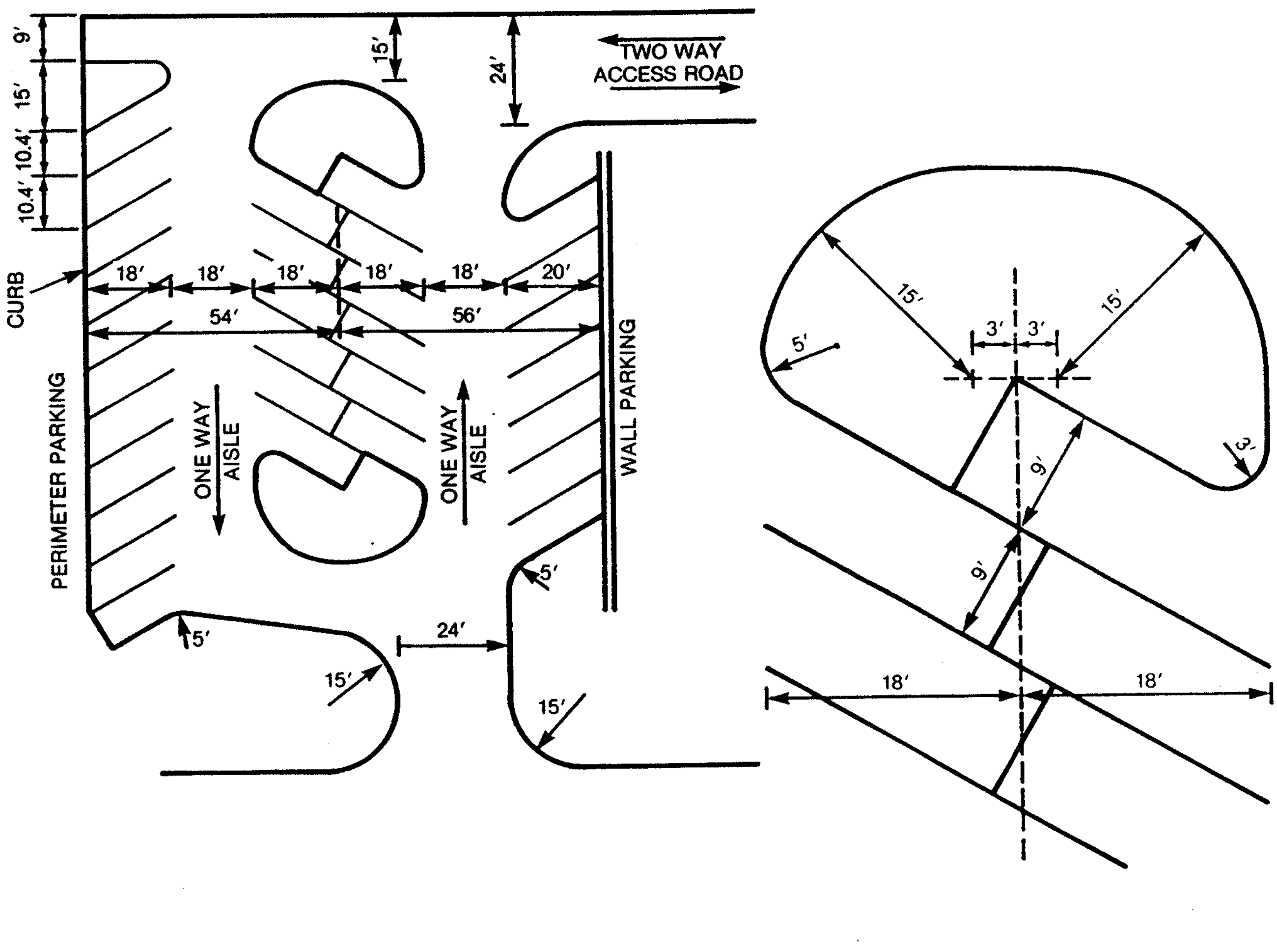


Figure 7-2 60-Degree Parking

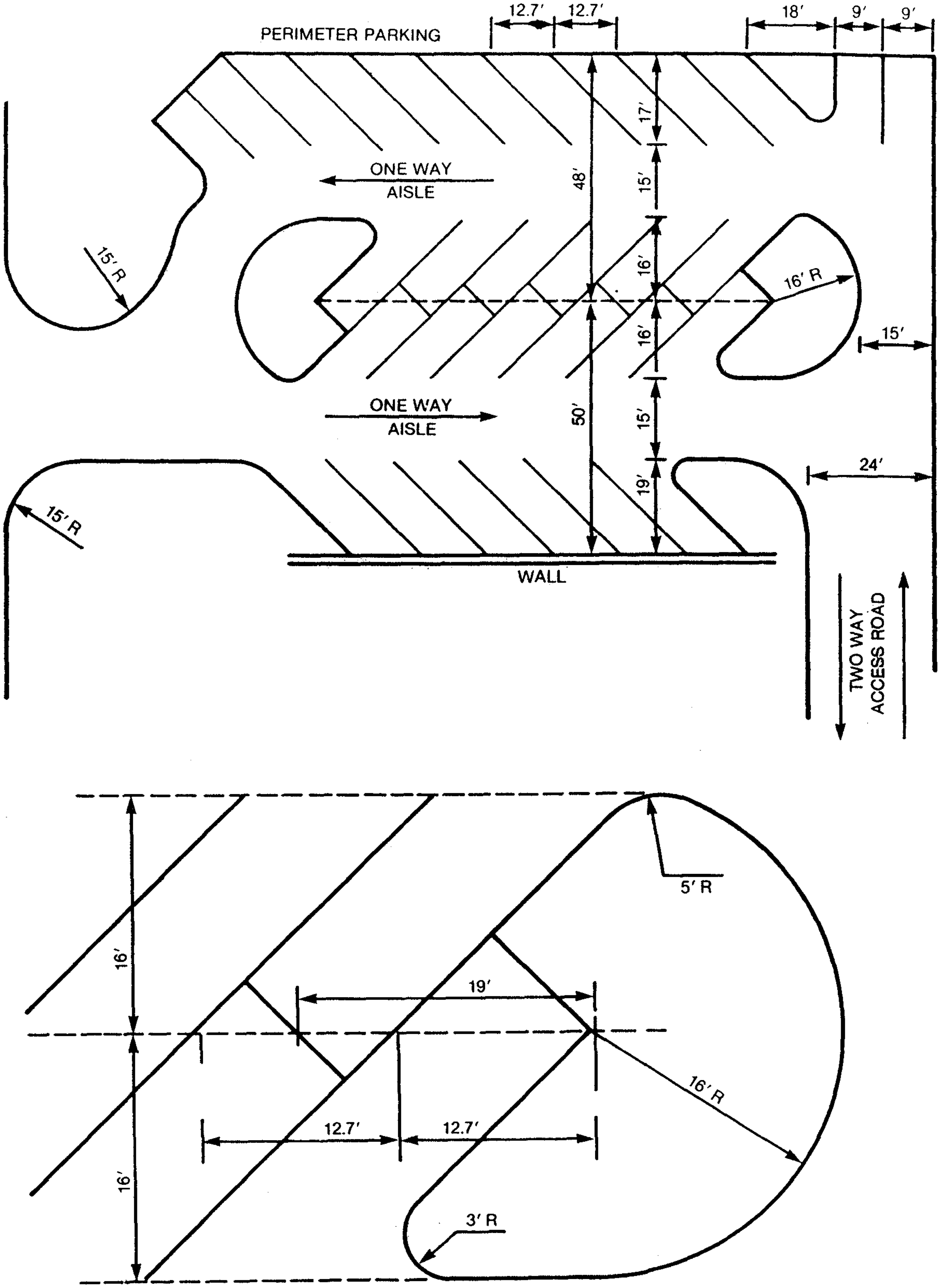


Figure 7-3 45-Degree Parking

(b) Parallel parking can be used very effectively where the terrain dictates a long and/or narrow parking facility. Typical layouts for Parallel parking are illustrated at figure 7-4. Parallel parking, on one side of an aisle only, is often the best choice for parking at an overlook. It is possible to utilize parallel parking on one side of an aisle and head-in parking on the opposite side to provide for the occasional bus or vehicle with a trailer that otherwise may be difficult and costly to accommodate. For bus or vehicle/trailer parking modify the typical parallel parking details in figure 7-4 so that:

1. The length for 1 bus or vehicle/trailer space will equal 2 regular spaces and

2. Increase the width of the stall by 2 feet

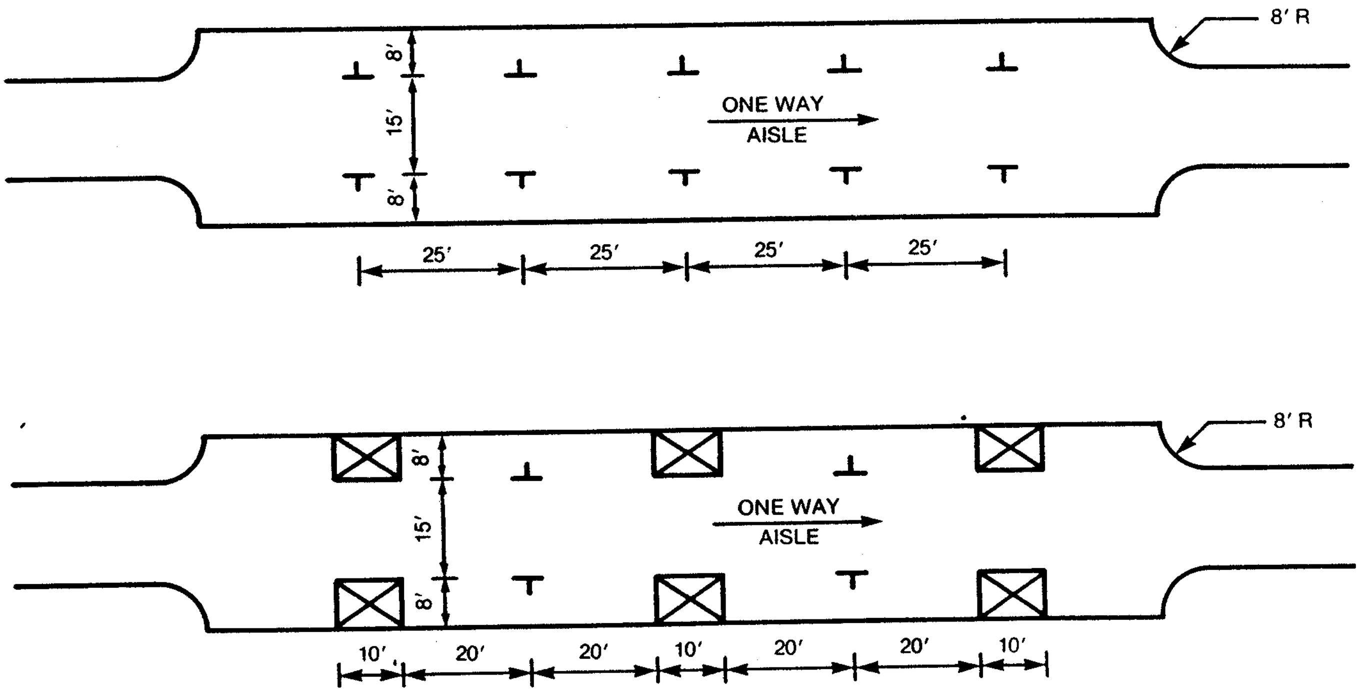


Figure 7-4 Parallel Parking

(2) Single vehicle parking is used primarily for individual camping sites and, to lesser extent, for short stops at signs or markers.

(a) Spurs are the preferred arrangement for parking at individual camp sites. Figure 7-5 illustrates a typical camp site spur.

(b) Pull-offs for a single vehicle should seldom have to be used. Overlooks, Vistas, historical markers, and the like, usually should be designed for parking more than one vehicle. However, a pull-off for a brief stop is sometimes essential. Figure 7-6 shows a typical pull-off parking space.

c. Terminal parking is the type of parking facility that is usually developed at the end of an access, circulation, or local road, when these roads terminate at an activity site such as an overlook, a picnic area, or a boat launch facility. Basically, the layout guidance in subparagraph b. above should be followed for the design of terminal parking. Figure 7-7 illustrates a simple terminal parking facility that can be used very effectively at an overlook or a small picnic area.

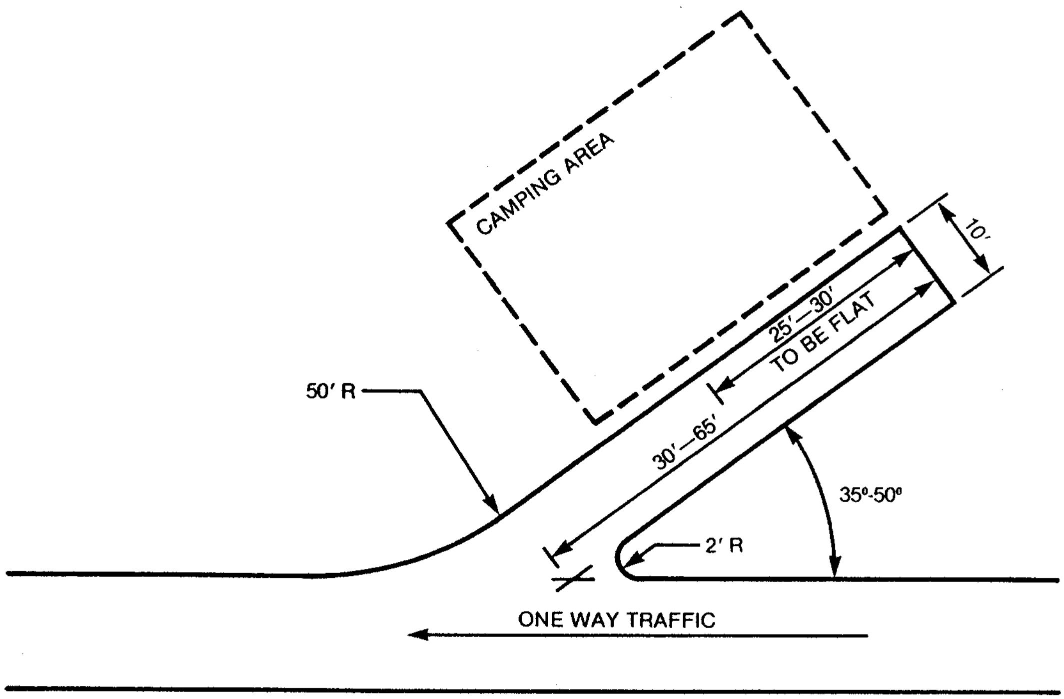


Figure 7-5 Spur Parking

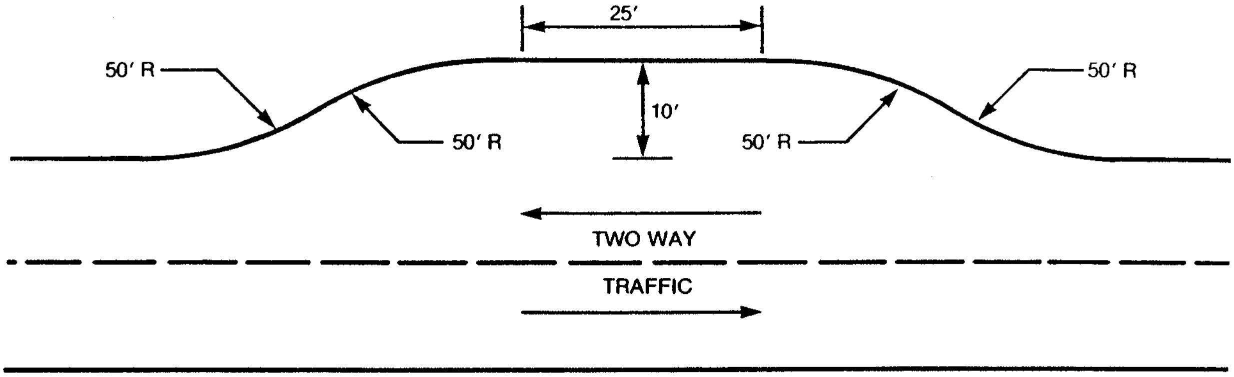


Figure 7-6 Pull-off Parking

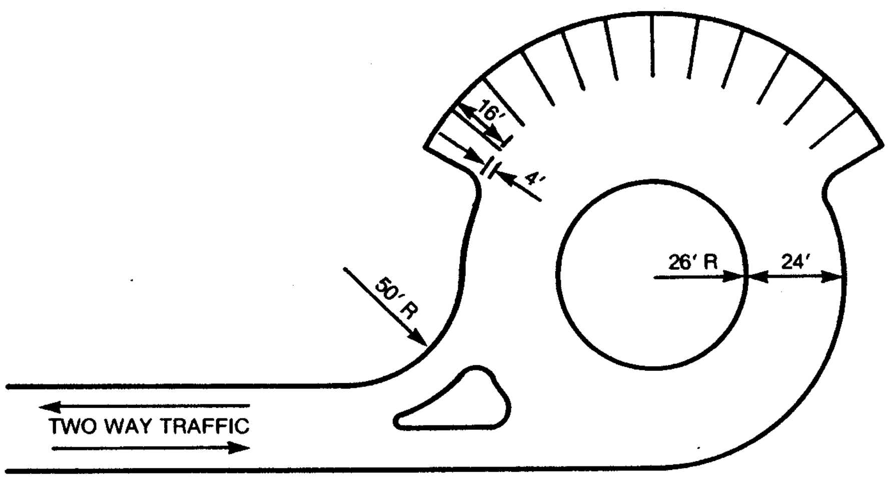


Figure 7-7 Terminal Parking

7-4. Details.

a. Entrances and Exits for parking facilities should be located at least 100 feet from road intersections. A greater distance is preferred. To minimize conflicts with access or circulation road traffic, entrances and exits should be kept to the minimum needed for peak-hour requirements. Except where a large volume of bus or recreational vehicle traffic is anticipated, the minimum inside turning radii for entrances and exists should be 15 feet. For bus and recreational vehicle use, increase the inside radius to 30 feet.

b. Motorcycle and Bicycle parking should be provided within parking lots as needed. Corners of parking lots can be used efficiently for this purpose.

c. Surfacing for parking facilities should be determined on the basis of utility, life cycle cost, aesthetics, and maintenance and operation considerations. From the standpoint of utility and maintenance it is usually desirable to pave parking facilities. It is generally most economical to pave parking facilities at the same time and with the same material used for adjacent recreation roads. When economic or other considerations do not justify paving the parking facility, consideration should be given to paving only the vehicle aisles of multiple lane parking areas and using a surface such as gravel for the parking spaces. This technique can also be used to reduce run-off and thereby aid in erosion control.

d. Curbing should be used when it is necessary to contain drainage and/or channel traffic. Continuous cast in place concrete curbing is easiest to maintain but is more costly initially than some other materials such as asphaltic concrete, railroad ties, and logs. Curbing precludes the need for other wheel stop measures. However, curb cuts and ramps for the physically handicapped are required.

e. Trees can be used very effectively in islands in parking lots to provide shade and relieve visual monatony. Planted earth berms may be used to screen and control the adverse visual impact of parking lots from both adjacent roadways and recreation areas.

f. Traffic Channelization Islands should be used to help define vehicular circulation and to releave visual monotony, especially in large parking areas. Islands separating bays should be a minimum of 12 feet wide and vary to greater dimensions to accommodate existing terrain. Intermediate islands, at least 9 feet wide, should be used in large parking lots. In general, there should be not more than 18 parking spaces in a row without providing intermediate islands. Intermediate islands can and should be used in irregular patterns to help provide an informal character and to preserve existing trees when possible.

CHAPTER 8

PARK ENTRANCE

8-1. Application. The park entrance helps the visitor make the transition from the access road to the facilities provided inside the park. Persons arriving at the park for the first time should be able to obtain the information they need to use and enjoy the park, its surroundings, and its facilities. The entrance should control the hours the park is available for use. The park entrance facility should not be confused with nor be developed as a visitor's center, overlook area, or interpretive sign area. The park entrance station is a completely separate park management facility. The area can be used for collection of user fees for the total park, or only portions of the park, such as camping area.

8-2. Controls. Safety of the park user, point of public contact and information and control of the times the park is open for use, are the main controls in the design of park entrances. The entrance station provides safety in that it slows or stops traffic so that the transition from the access road to the park can take place in the mind of the driver of the vehicle entering the park area. The entrance is also an aid for the visitor in that information is available concerning the visitor's destination in the park and how to get there. Because the entrance station can control the hours the park is open to the public, visitor safety and park management are enhanced.

8-3. Design Considerations.

a. Location. Entrances are generally located at the point where the access road enters the park or controlled area, thus providing a single point of control. This single factor is becoming more and more important to park managers concerned with the safety of park visitors, reduction of vandalism, and providing the public with services it needs. In addition the entrance should be located on a site that requires little grading.

b. Park Entrance Area. Access road pavement and shoulder widths at entrances must often be increased for safe maneuvering of vehicles and for possible temporary stopping to read information signs. Space for these manuevers must meet the needs of widely varying types of vehicles (buses, recreation vehicles cars with trailers, and the single family car). Besides the gate with complete fencing, a park entrance sign, flag pole, gate attendant shelter (enclosed or open) parking, water supply, and toilet facilities should be considered in the design of the area. Figure 8-1 shows a typical entrance to a recreation site.

c. Entrance Closures. The fence and gate structure is an important element of park entrance design. This element should be aesthetically pleasing blend in with the environment and be in harmony with the project theme.

d. Signs. Signs at park entrances should be of the highest quality and present a good Corps image. Again, the signs at entrances should blend in with the environment and reflect the project theme.

e. Approach Road. The access road should begin the transition for the visitor from highway speed to the lower speed recreation road inside the entrance. A warning sign with words, "Park Entrance Ahead" should be provided for the entrance. Paragraph 2C-2 of the Manual of Uniform Traffic Control Devices, ANSI D6.1-1978, should be used as guidance for the design and placement of this and other warning signs. The approach road should meet the stopping sight distance of 450 feet inbound, and 300 feet outbound. Pavement width of 24 feet for the above stopping sight distances and 4 foot shoulders are considered minimum. An additional inbound lane should be considered for important park entrance developments. Other traffic control devices that should be provided are; double yellow line for inbound and outbound zones and posted speed signs. In open range states, cattle guards might be needed. This type of device should be placed well in advance of the station area (500 feet minimum distance from entrance gate area).

Figure 8-1 Typical entrance station to a recreation site