



PDHonline Course C620 (6 PDH)

Complete Parking Lot Design

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Complete Parking Lot Design

PAVEMENT, DRAINAGE, LIGHTING, STRIPING, SIGNAGE, BARRIERS, LANDSCAPING AND MAINTENANCE

INTRODUCTION

- **PARKING LOT DESIGN**
- **HANDICAPPED ACCESSIBLE PARKING**
- **FLEXIBLE PAVEMENT SYSTEM**
- **SIDEWALKS AND RAMPS**
- **SHUTTLE BUS STOPS**
- **SECURITY**
- **DRAINAGE**
- **LIGHTING**
- **STRIPING AND MARKING**
- **PARKING BARRIERS**
- **LANDSCAPING**
- **MAINTENANCE AND REPAIRPARKING LOT DESIGN**

General

Great parking lots are safe, attractive, drain efficiently when it rains and are screened from residential areas. Striping and signage indicating regular and handicapped parking spaces, as well as direction of traffic flow, should be clearly marked. Safe pedestrian walkways, including easy access for wheelchairs, need to be separate from the traffic-flow areas. Landscaping that offers shade and visual relief while maintaining good sight lines is beneficial. In areas where it snows, good parking-lot planning also demands setting aside holding areas where snowplows can pile snow without blocking parking spaces or the flow of traffic.

Parking lot design involves many considerations. All too often the only consideration for the design is developing a sufficient parking area to meet the required number of vehicles based on adjacent occupancy. Local regulations will dictate many of the planning and design decisions made by the planner or designer. This class presents ideas and methodologies for many concepts that could be inconsistent with these local requirements. Often, these ordinances are a minimum requirement and consideration can be given to other concepts.

Good parking lot will maximize the total number of parking spaces in the space available with the following considerations:

- The parking layout should provide continuous flow of traffic through the lot.
- There must be safe pedestrian movement from parking to buildings.
- The design should allow for appropriate landscaping of the parking areas without conflicting with site lighting.

Pedestrian and Vehicular Circulation

Circulation patterns should be as obvious and simple as possible. All likely pedestrian routes should be considered in the design phase to eliminate “short cuts” which will eventually damage landscaped areas.

All site facilities and amenities should be accessible to people with disabilities. Circulation systems should be designed to avoid conflicts between vehicular, bicycle, and pedestrian traffic. Pedestrian circulation should take precedence over vehicular circulation.

Where pedestrian circulation crosses vehicular routes, a crosswalk with yellow striping in plastic paint, speed bumps, or signage should be provided to emphasize the conflict point and improve its visibility and safety. Circulation routes should focus upon main entries and exits

and also identify secondary access points. All elements of the site design should accommodate access requirements of emergency service vehicles.

Access to Parking Areas

All off-street parking spaces should be accessible without backing into or otherwise re-entering a public right-of-way, unless it is physically impossible to provide for such access. When an off-street parking area does not abut a public street, there should be an access drive not less than 24 feet in width for two-way traffic, connecting the off-street parking area with a public street.

Handicapped Accessible Parking Spaces

The location, size, and number of handicapped parking spaces should conform to the latest building codes, state and federal laws. Handicapped accessible parking spaces should be located on the shortest accessible route of travel to an accessible facility entrance. Where buildings have multiple accessible entrances with adjacent parking, the accessible parking spaces must be dispersed and located closest to the accessible entrances.

An accessible route must always be provided from the accessible parking to the accessible entrance. Ideally, an accessible route would not have curbs or stairs, and be at least three (3) feet wide, with a firm, slip-resistant surface.

Accessible parking spaces should be at least 102 inches wide. Parking access aisles should be part of an accessible route to the building or facility entrance. Two accessible parking spaces may share a common access aisle. Parked vehicle overhangs should not reduce the clear width of an accessible route.

Driveway Entrance Design

The location of driveways is based upon many factors, including the location of individual property lines and available street frontage, requirements of internal site design, number of vehicles expected to use the driveways, and traffic safety. Generally, the farther from an intersection a driveway can be located, the less it will affect the through traffic and the less delay it will cause to vehicles using the driveway.

Driveway approaches should be constructed so as not to interfere with pedestrian crosswalks. Driveways should be constructed a minimum of three (3) feet from any obstruction such as a street light or utility pole, fire hydrant, traffic signal controller or telephone junction box. Driveway entrances should be designed to accommodate all vehicle types having occasion to enter the lot, including delivery and service vehicles.

Parking Lot Layout

Drives that do not allow parking within the driveway right-of-way are normally 24' for two-way traffic and 12' for one-way traffic. For drives serving thirty (30) or fewer vehicles and where parking is not provided on either side, the width for two-way drives can be reduced to twenty-two (22) feet. Aisle widths are dependent upon traffic flow (one or two-way), angle of parking and whether or not parking is on both sides of the aisle. See Figure 1 for examples.

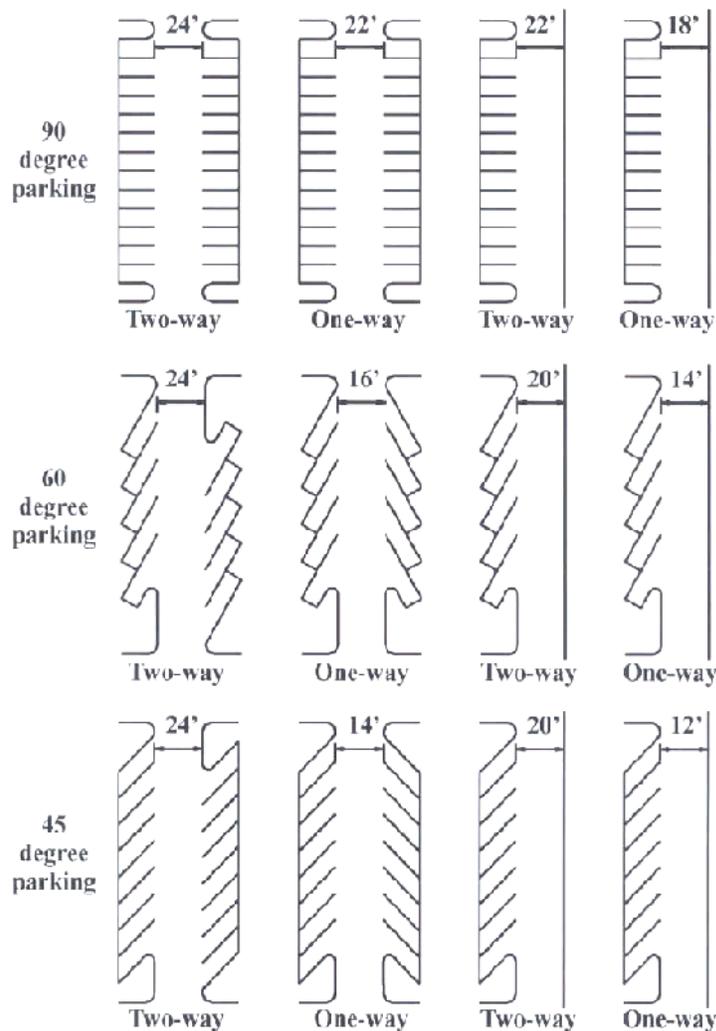


Figure 1
PARKING LOT AISLE WIDTHS

DRIVEWAY

Dimensions

All parking spaces, exclusive of access drives or aisles, should consist of a rectangular area not less than eight and one-half (8½) feet wide by eighteen (18) feet in length except that parallel parking stalls should be ten (10) feet by twenty (20) feet. For parking dimensions refer to Figure 2 and Table 1 below:

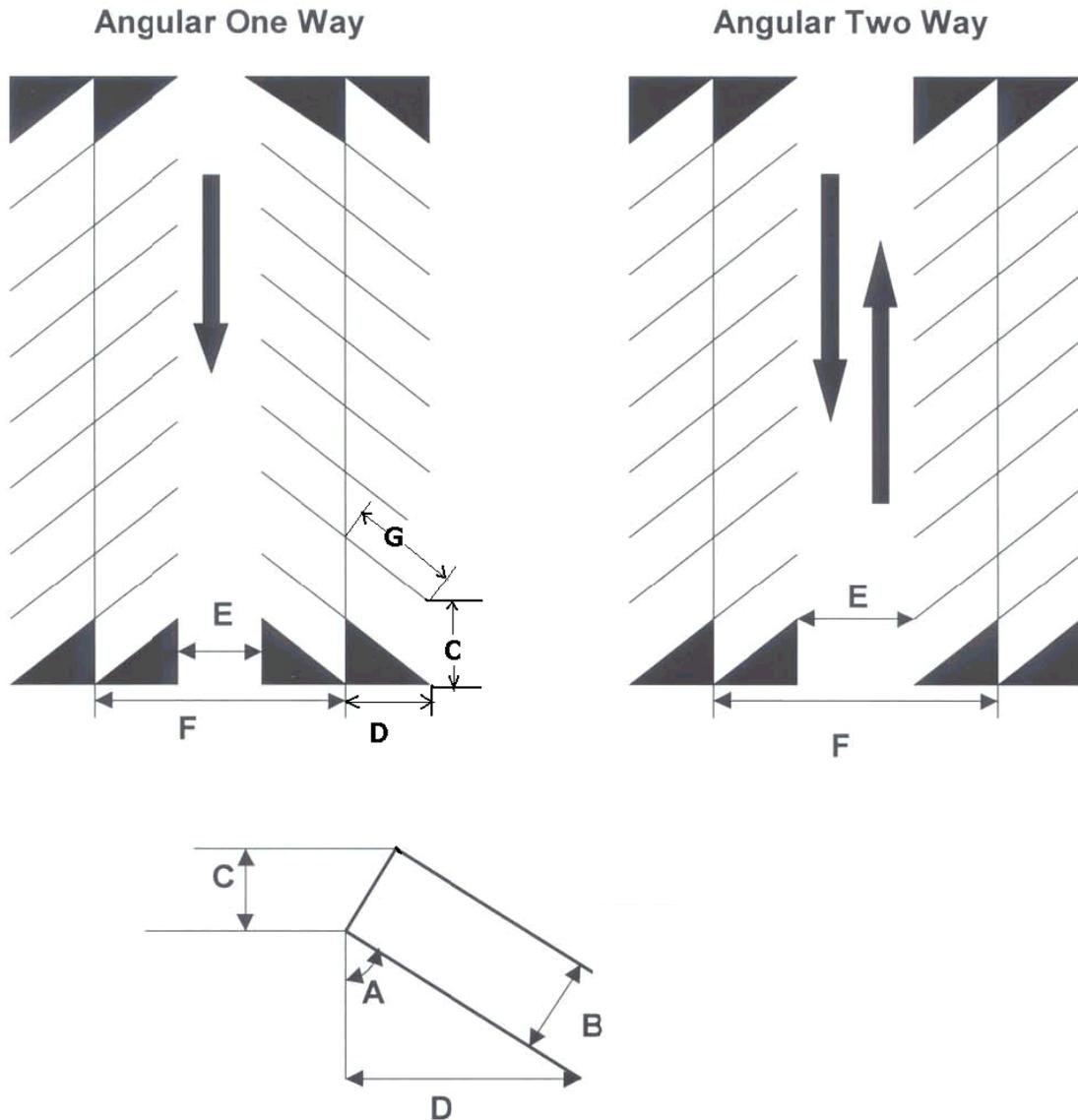


Figure 2
ACCEPTIBLE PARKING
DESIGNS

Angle	Dimensions				One Way Traffic		Two Way Traffic	
	Stall Width (ft.)	Curb Length (ft.)	Stall Depth (ft.)	Stripe Length (ft.)	Aisle Width (ft.)	Section Width	Aisle Width (ft.)	Section Width
A	B	C	D	G	E	F	E	F
30	8.5	17	16.4	32.7	12	44.7	24	56.7
45	8.5	12	18.7	26.5	14	51.4	24	61.4
60	8.5	9.8	19.8	22.9	16	55.6	24	63.6
90	8.5	8.5	18	18	22	58	24	60

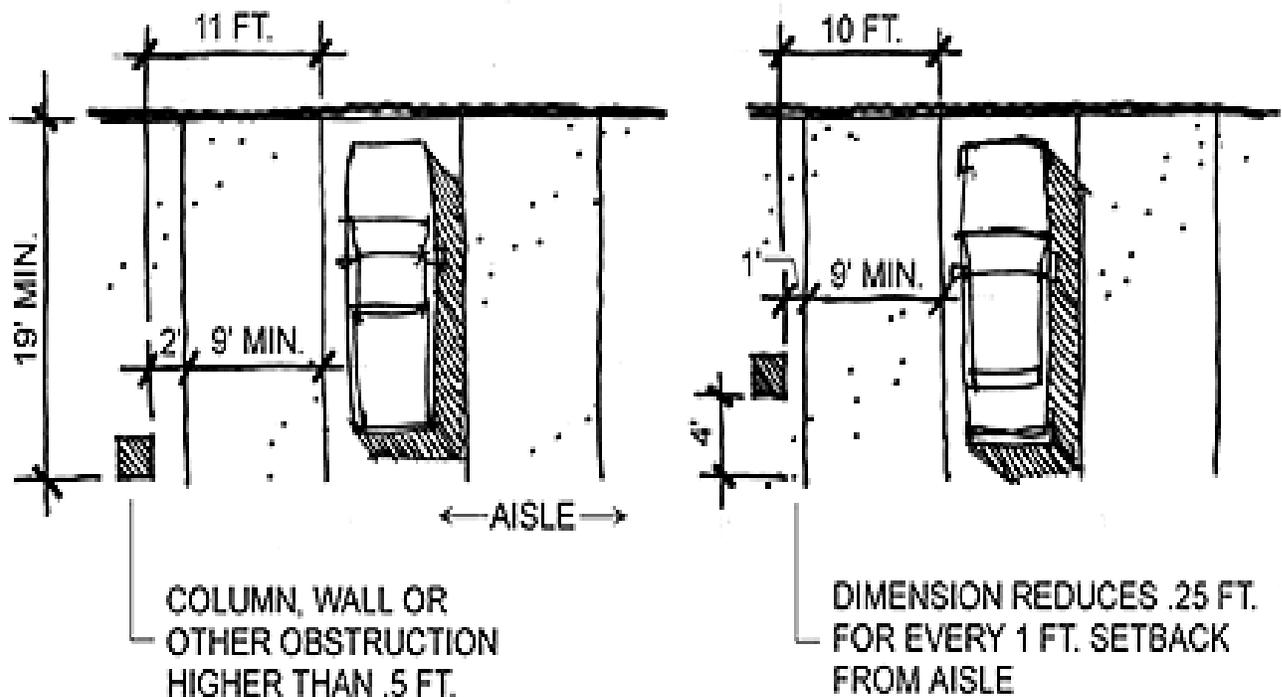
Table 1



Figure 3
PERPENDICULAR (90°) PARKING
SPACES

The following exceptions to the minimum standards apply:

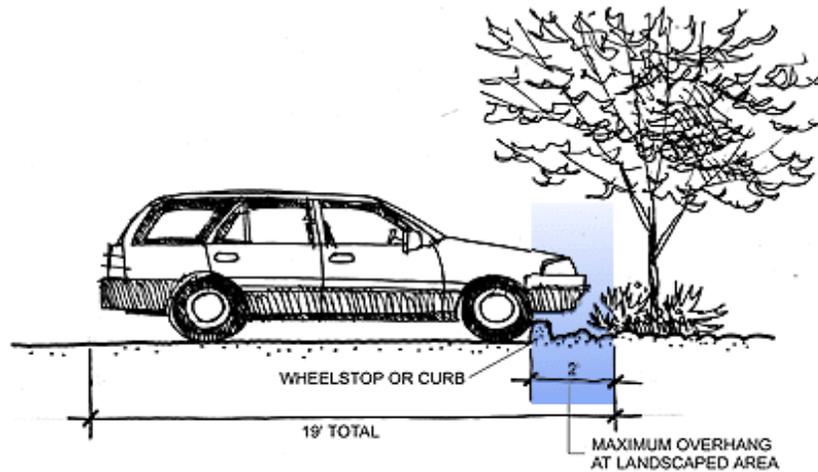
Spaces Near Obstructions. When the side of a parking space adjoins a wall, column, or other obstruction that is taller than 0.5 feet, the width of the parking space should be increased by 2 feet on the obstructed side, provided that the increase may be reduced by 3 inches for each 12 inches of unobstructed distance from the edge of a required aisle, measured parallel to the depth of the parking space. (See Figure 5)



Spaces Near Obstructions

Figure 4

Planter Overhangs. When a parking space abuts a landscape island or planter, the front 2 feet of the required parking space length may overhang the planter, provided that wheel stops or curbing is provided. (See Figure 5)



Reduction for Planter Overhangs

Figure 5

All new parking lots should be constructed with perimeter curbs wherever feasible. These curbs should be constructed of reinforced concrete and should be either monolithic or lay down depending upon the location and function of the curb. See Figure 6 for an example of a 6" monolithic concrete curb with gutter.



Figure 6

MONOLITHIC CURB ALONG PERIMETER OF PARKING LOT

Grading

Grading on new project sites should blend with the contours of adjacent properties. Proposed cut and fill slopes should be rounded off both horizontally and vertically. When designing a grading plan, balancing the cut and fill is highly encouraged when it does not result in further damage to the natural topography. Where the site plan results in substantial off-haul or infill, a mitigation plan may be required to address the impacts and clean-up of off-site construction activities. To prevent soil compaction and significant root damage, grading under the drip line of trees should be avoided.

Marking and Signage

Signs displaying the international access symbol should be provided at each accessible parking space. The signs should be displayed on fixed mountings in an area where they are not hidden from view. Pavement marking symbols may be used to supplement signs. Spaces intended for van parking should be marked accordingly.

Number of Spaces

Parking stalls for disabled persons should be provided in each parking lot in accordance with the Table 2:

Number of Spaces for Disabled	
Total Spaces in Lot	Required Accessible Spaces
1-25	1
26-50	2
51-75	3
76-100	4
101-150	5
151-200	6
201-300	7
301-400	8
401-500	9
501-1000	10

Parking lots with more than 1,000 spaces should have 2% of total capacity (20 spaces), plus 1 for each additional 100 spaces over 1,000.

Table 2

Access Ramps

Ramps must be provided at curbs or other raised barriers to provide access to the accessible routes leading from the parking lot. Ramps must be 48" wide and ramp grades cannot exceed 1:12. Handrails must conform to the latest requirements in the Architectural Barriers Act.

Thickness Design For Parking Lots

Design thicknesses given in this section are minimum values calculated on the volume and type of traffic that will use the facility and on the load-supporting capability of the underlying soils. Special truck lanes are sometimes required to expedite traffic to loading areas, trash dumpster sites, and equipment areas. Design thicknesses for these lanes or pavement areas should be increased. Drainage problems are also a major cause of pavement failures. Their significance warrants a special section on drainage that should be reviewed before selecting a pavement design either from this guide or from any other source.

Design Procedure

Tables 3 through 6 can be used directly to select design thicknesses for a number of design input factors. To use the tables, appropriate traffic and subgrade classes must be selected as follows.

Design Steps

The following steps can be used to determine a pavement thickness.

1. Using the number of parking spaces to be marked, select the traffic class (less than 50 spaces, 50 to 500, more than 500, or industrial) to be used. Determine if any areas will receive heavy truck traffic.
2. Using soil data from the project, select a subgrade class (good, moderate, or poor). If no soil information is known, use the poor classification for the subgrade.
3. Using the selected traffic class and subgrade class, select a design thickness from Tables 3, 4, or 5. Use Table 6. to design heavily-loaded areas.

Design Example

1. A new department store wishes to place a 350-car parking lot in front. A truck loading zone and dumpster site will be placed in back.
2. No soil data is known, so the engineer selects the poor soil classification.

3. The total full-depth asphalt design thickness selected from Table 3 and 4 for the parking lot is 6-11/2 inches; the base course is 5 inches, and the surface course is 1-1/2 inch. The total full-depth asphalt design thickness selected from Table for the truck loading zone and approaches is 8 inches; the base course is 6 inches and the surface course is 2 inches.

Pavement Thickness Tables

The pavement thickness for parking lots should be in accordance with the following tables:

Thickness Chart: Parking Lots with Less Than 50 Spaces

A. For Asphalt Concrete Base Pavements				
		Thickness in Inches Asphalt Concrete		
Traffic Class (Spaces)	Subgrade Class CBR	Base	Surface	Total
I(<50 spaces)	Good 9	3.0	1.0	4.0
	Moderate 6	3.5	1.0	4.5
B. For Untreated Aggregate Base Pavements				
Design Criteria		Thickness in Inches		
Traffic Class	Subgrade	Untreated Aggregate Base	Asphalt Concrete Surface	Total
I (<50 spaces)	Good 9	4.0	3.0	7.0
	Moderate 6	4.0	3.0	7.0

Table 3

Thickness Chart: Parking Lots with More Than 50 Spaces

		Thickness in Inches Hot Mix Asphalt		
Traffic Class (Spaces)	Subgrade Class CBR	Base	Surface	Total
II	Good 9	3.0	1.0	4.0
III (500 & Above spaces)	Good 9	3.5	1.5	5.0
	Moderate 6	4.5	1.5	6.0
B. For Untreated Aggregate Base Pavements				
Traffic Class	Subgrade	Untreated Aggregate Base	Asphalt Concrete Surface	Total
II (50-500 spaces)	Good 9	4.0	3.0	7.0
	Moderate 6	6.0	3.5	9.5
III (500 & Above spaces)	Good 9	6.0	3.0	9.0
	Moderate 6	8.0	3.5	11.5

Traffic Level ¹	Subgrade Class				
	Poor CBR ≤ 5 R ≤ 28	Fair CBR <u>6-9</u> R <u>33-41</u>	Good CBR 10-19 R 43-52	Excellent CBR ≥ 20 R ≥ 53	
Hot Mix Asphalt over Aggregate Base Course, inches					
Light	Up to 10,000 ESALs	2.5/13.0	2.5/8.5	2.5/6.0	2.5/4.0
	10-50,000 ESALs	3.5/16.0	3.5/11.0	3.5/6.0	3.5/6.0
Moderate	50-100,000 ESALs	4.0/17.0	4.0/12.0	4.0/6.0	4.0/6.0
	100-250,000 ESALs	5.0/18.0	4.5/13.0	4.5/6.0	4.5/6.0
Heavy	250-500,000 ESALs	5.5/12.0	5.5/9.5	5.5/6.5	5.5/6.0
	500-1,000,000 ESALs	6.0/23.0	6.0/15.5	6.0/7.0	6.0/6.0
Full Depth Asphalt, inches					
Light	Up to 10,000 ESALs	6.0	5.0	4.0	4.0
	10-50,000 ESALs	7.5	5.5	4.5	4.0
Moderate	50-100,000 ESALs	8.0	7.0	5.5	4.5
	100-250,000 ESALs	9.0	7.5	6.0	5.5
Heavy	250-500,000 ESALs	10.5	8.5	7.0	6.0
	500-1,000,000 ESALs	11.5	9.5	7.5	6.5
<ol style="list-style-type: none"> 1. inch = 25 mm 2. Excellent subgrade conditions are ideal for full depth asphalt; However, a minimum of 100 (4 inches) of HMA is recommended. In some areas, aggregate is needed to provide material to fine grade and to provide a smooth surface to pave on. 					

Table 5

Heavily-Loaded Areas

The pavement for entrances, frontage roads, trash dumpster sites, and delivery truck parking, as well as the approach areas to these spaces, must be increased in thickness to prevent pavement failure caused by the weight and dynamic loading. These areas should be constructed with full-depth asphalt in a thickness that will support this special type of pavement loading. Failure to provide this strengthening can result in severe pavement failure. The pavement thickness for these areas should be in accordance with the following Table 6.

Thickness Chart: Heavily-Loaded Areas in Parking Lots

		Thickness in Inches			
	Subgrade		Base	Surface	Total
	Class	CBR			
I-III (Up to 20 heavy trucks per day)	Good	9	4.0	2.0	6.0
	Moderate	6	5.0	2.0	7.0
	Poor	3	6.0	2.0	8.0

Table 6

Note: Untreated aggregate base courses are not recommended for industrial parking lots or for parking areas for heavy trucks.

Industrial Parking Lots

Industrial parking lots and those designed primarily for trucks require a thicker design than the other lots described. Because of heavy loads associated with trucks it is not recommended that untreated aggregate base courses be used. The pavement thickness for truck lots should be in accordance with the following table 7.

Thickness Chart: Heavily-Loaded Areas in Parking Lots

		Thickness in Inches			
Traffic Class (ADT)	Subgrade		Base	Surface	Total
	Class	CBR			
IV (20 to 200 trucks per day)	Good	9	5.5	2.0	7.5
	Moderate	6	6.5	2.0	8.5
	Poor	3	6.5	3.0	9.5

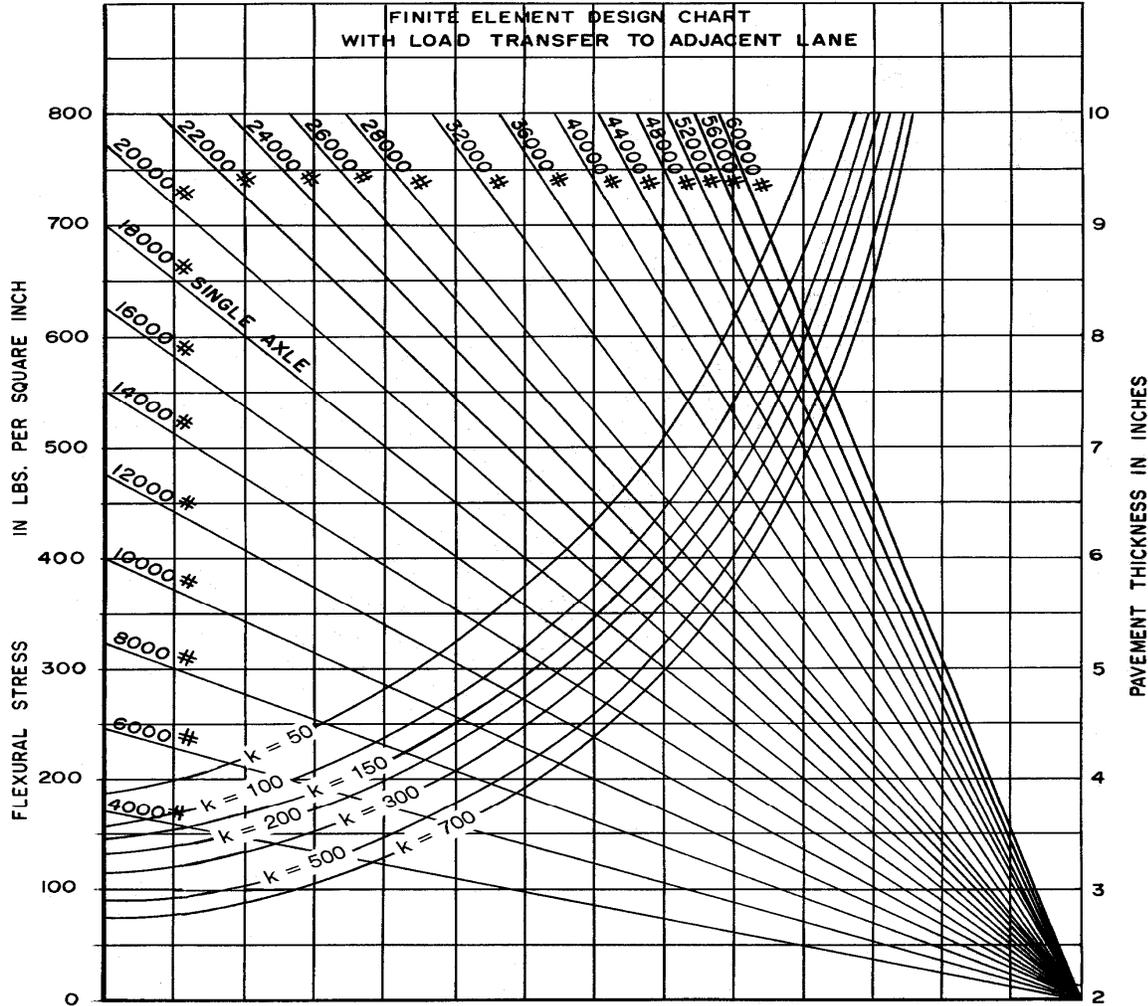
Table 7

Concrete Paved Parking Lots

The basic idea in design is that parking lots are subjected to higher loads than floors but those loads are mostly static (or low speed) so flatness and smoothness are not as critical as for streets and highways. With a parking lot, a good sub-base, the proper thickness, drainage, and traction are more important.

Parking lots are usually designed in accordance with ACI 330R, Guide for Design & Construction of Concrete Parking Lots, although the design method shown in that document is actually based on the Portland Cement Association's thickness design method.

The nomograph shown here will yield a design thickness knowing the subgrade reaction (k), the expected loads (how heavy the vehicles will be), and the number of load repetitions expected over the 20-year pavement life.



The pavement designer can use this nomograph and an iterative technique to come up with the pavement thickness based on the sub-base strength and the anticipated loads.

A few things to remember about design of concrete parking lots:

- An important consideration is that there is more to the parking lot than just pavement. Parking lots include slabs, joints, curbs, light poles, and drainage facilities and all of these need to work together.
- For cars and light trucks, a 4-inch pavement is generally acceptable. For bigger delivery trucks, the pavement will need to be 5 or 6 inches thick. This is dependent on the subgrade, the total number of load repetitions, and the weight of the vehicles.

- Concrete parking lots are typically placed directly on the existing soil rather than on a compressed subgrade. The important thing is to get the compaction of the subgrade uniform so that some areas don't sink and crack the pavement.
- Parking lots generally drain simply to the edge of the pavement or into gutters. Sometimes drains are located within the paving area. In either case, pavements should slope a minimum of 1% (1/8 inch/foot), however 2% (1/4 inch/foot) is better. 6% is the maximum slope in areas where cars park. Slope of entrances to the parking lot should not exceed 8% to prevent cars from dragging.

Jointing in a concrete parking lot is no different than for any slab on grade. See a complete description of joints. Parking lots should be isolated from any buildings, drains, or light post foundations by installing isolation joints. Contraction joints should be continuous (not staggered), in square panels, and spaced at the intervals shown in Table 8 below.

Spacing of contraction joints according to ACI 330	
Pavement thickness, in.	Maximum distance between joints, ft.
4	10
5	12.5
6	15

Table 8

- Reinforcement is generally only for shrinkage in a concrete parking lot. If, for any reason, the contraction joints are spaced farther than recommended in the table 8, reinforcement might be specified to hold cracks together. Similarly, dowels at joints to transfer the vertical loads between panels are unnecessary unless very heavy loads are anticipated as for heavy truck traffic.
- The exception to the rule about no dowels or reinforcement is tie bars. To prevent the first section of slab from moving away from the parking lot, the first joint in from the edge of the pavement should be tied to the rest of the pavement with tie bars. Tie bars should be ½ inch in diameter, 24 inches long, and spaced at 30 inches on center.
- The edges of parking lots should be thickened if cars will park close to the edge. Edges can be thickened by using an integral curb or by thickening the bottom (see diagram).
- Parking lots can be given just about any exterior decorative treatment, although large lots would be expensive to stamp or texture. Integral color is a good option and may keep the lot looking a little cleaner.

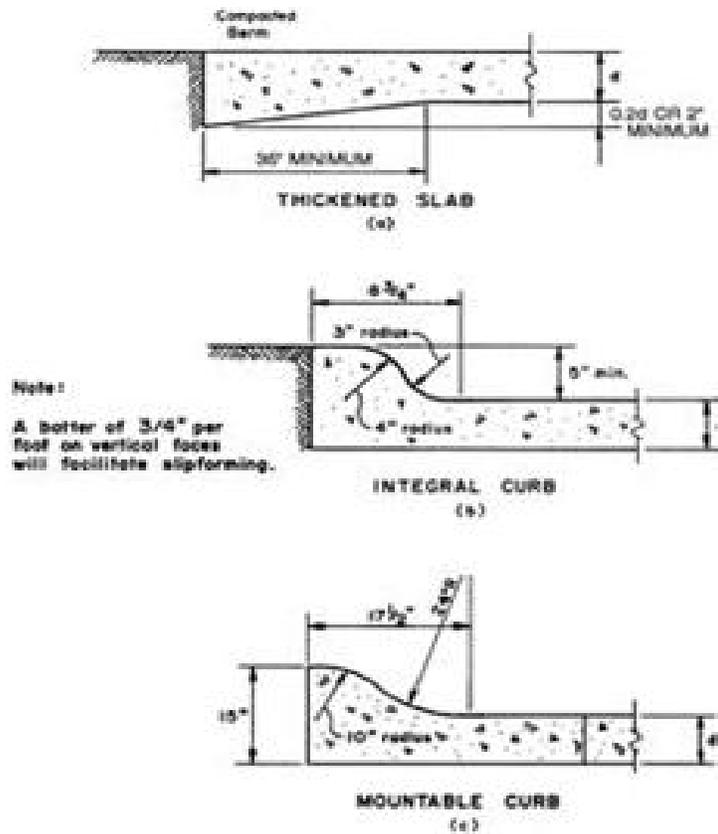


Figure 7

Testing

Following are the tests required for each component of the flexible pavement system:

SUB BASE TESTING	METHOD	WHEN
Optimum Lime Content Determination		Prior to Lime application
Proctor (Moisture & Max Density)	ASTM D 698	After application of lime
Field Density	ASTM D 2922 ASTM D 3017	During application
Depth Check		After application
Field Sieve Analysis		As applicable

BASE COURSE TESTING	METHOD	WHEN
Proctor (Moisture & Max Density)		After application
Field Density	ASTM D 2922 ASTM D 3017	During application
Depth Check		As required

CONCRETE TESTING	METHOD	WHEN
Concrete Cylinders	ASTM C31	Beginning of concrete placement

HMAC TESTING	METHOD	WHEN
Bulk Specific Gravity		Beginning of placement
Extraction/Gradation		Beginning of placement
Maximum Theoretical Density		Beginning of placement
Molded Specimens		Beginning of placement
Field Density	ASTM D 2922	During placement

Table 9

One set of tests should be conducted for every 1000 tons of asphalt applied, with a minimum requirement of one set of tests per day.

Sidewalks And Ramps

Sidewalks

Sidewalks should be constructed according to the following criteria:

Sidewalks should be 6'-0" wide, 5" thick, with ¼" per foot transverse slope, be installed on a compacted 2" thick sand base cushion, and reinforced with 6/6 -10/10 welded wire mesh. Walks designated as fire lanes must be at least 6" thick.

The sidewalk should extend above the adjacent finished grade 2". The concrete for the sidewalk should consist of sand and gravel aggregate mix producing a minimum compressive strength of 3,500 psi at the end of a 28-day curing period.

The sidewalk sub-grade should be compacted and consolidated to 85% of maximum dry density. The welded wire fabric should conform to ASTM A185. Sidewalk curves should be formed true and smooth.

New sidewalks should be doweled into existing sidewalks with 12" long smooth No. 4 dowels, with one end greased and thimble, spaced at 12" o.c., with a ½" expansion joint.

Doweled 1" expansion joints in the sidewalk should be located at every 42 feet. Dowels should be 18" long smooth No. 4 dowels, spaced at 12" o.c., with one end greased and thimble.

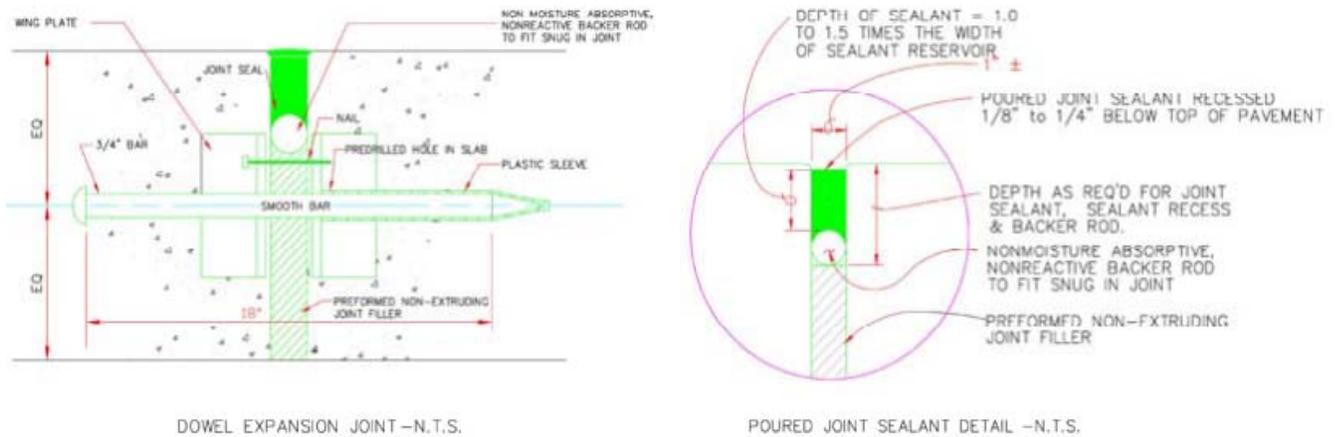


Figure 10

DOWEL TYPE EXPANSION JOINT

Joint dowel bars for expansion joints should be Grade 60 plain steel bars, as specified under ASTM A615. Cut bars true to length, with the ends square and free of burrs. The 1" expansion joints for sidewalks should be formed as follows:

The joint filler should be polyethylene closed-cell expansion joint filler material, install to a depth of 1" below the walk surface. Prior to applying joint sealant, clean the joint and prime joint with primer. Do not prime expansion joint filler material.

Apply one-component polyurethane self-leveling sealant, conforming to ASTM C920, Type S, Grade P, Class 25, Use T or M, in the upper 1/2" depth of the joint, over the joint filler material.

Control (contraction) joints in the sidewalk should be cut through 1/4 of the slab thickness and have both sides edged and tooled. The layout of the control joints should be indicated in the drawings or described in the project specifications.

All edges and joints should be rounded to a minimum of 1/4" radius with an approved tool. Horizontal surface of edging tool should not exceed 2" in width and should not depress into sidewalk more than 1/16".

All sidewalk surfaces should have a textured, non-slip broom finish free from trowel marks, except for the edging tool.

All sidewalks should be cured with liquid-type membrane-forming curing compound complying with ASTM C309. Curing compound should be applied in accordance with manufacturer's recommendations.

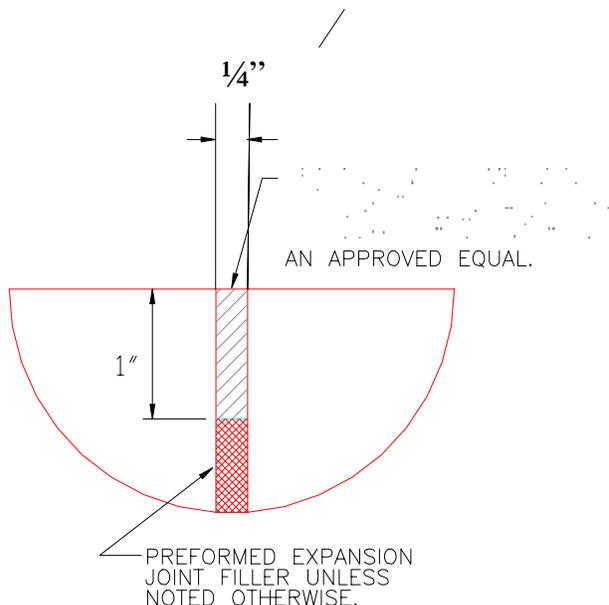


Figure 11
SEALED EDGE ISOLATION JOINT

Access Route

Provide at least one accessible route within the boundary of the parking lot from public transportation stops, handicapped accessible parking and accessible passenger loading zones, and public streets or sidewalks to the accessible building entrance they serve.

Location: Accessible routes should be located so that pedestrians are not required to wheel or walk behind parked vehicle or in traffic lanes.

Width: The minimum clear width of an accessible route should be 48". If a person in a wheelchair must make a turn around an obstruction, the minimum clear width of the accessible route should be as shown in Figure 12.

Passing Space: If an accessible route has less than 60" clear width, then passing spaces at least 60" by 60" should be located at reasonable intervals not to exceed 200 ft. A T-intersection of two walkways is an acceptable passing place.

Surface Textures: Ground surfaces along accessible routes including walks, ramps, and curb ramps, should be stable, firm, and slip-resistant. Sidewalks and walkways should be constructed of concrete or similar materials. Soft or loose materials such as sand, gravel, bark, mulch or wood chips are not suitable.

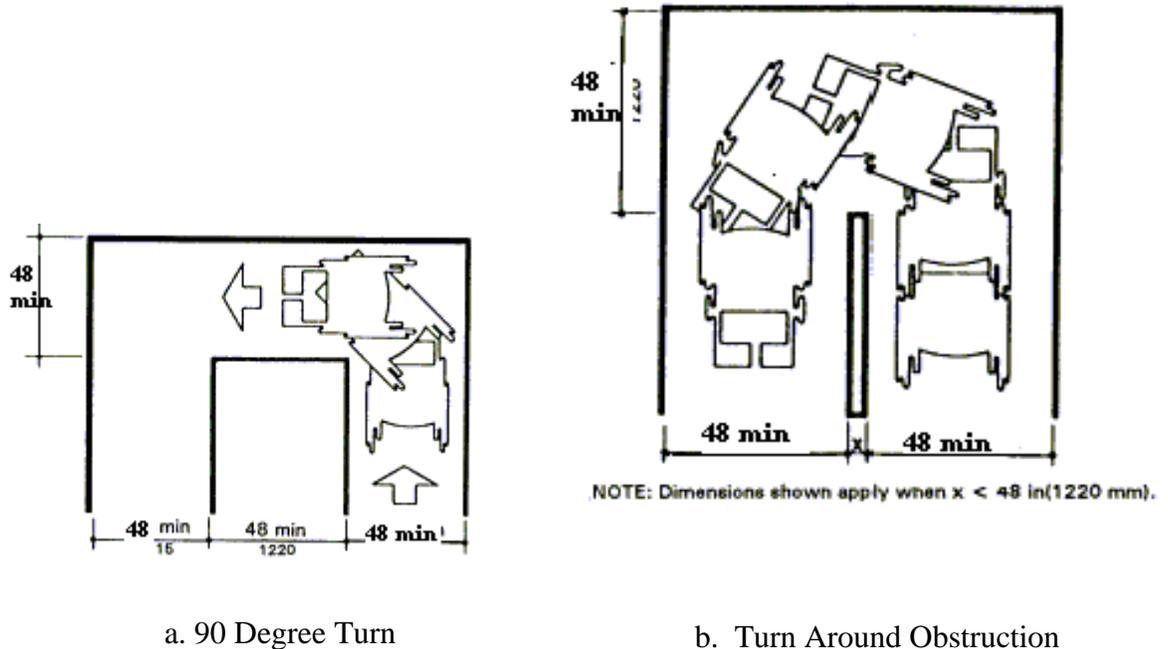


Figure 12
ACCESSIBLE ROUTE

Slope: An accessible route with a running slope greater than 1:20 is a considered a ramp. Nowhere should the cross slope of an accessible route exceed 1:50.

Change in Levels: Changes in levels along an accessible route up to ¼” may be vertical and without edge treatment (See Figure 13). Changes in levels between ¼” and ½” should be beveled with a slope no greater than 1:2 (See Figure13).

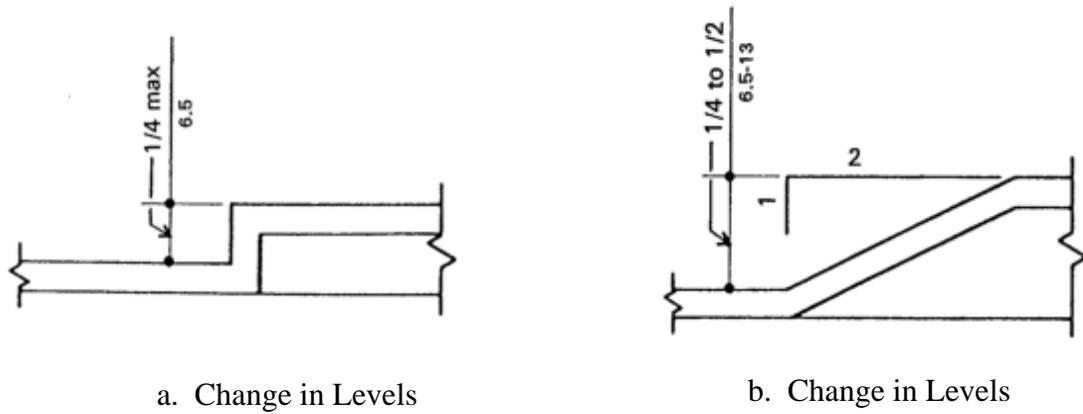
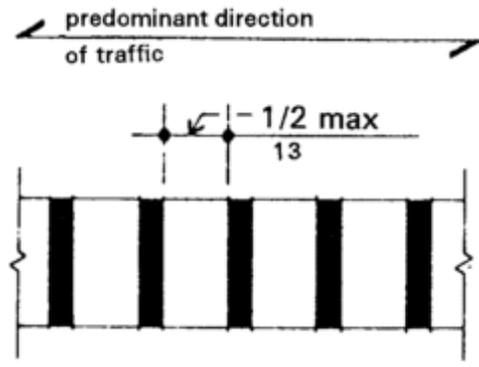


Figure 13
ACCESSIBLE ROUTE

Gratings: If gratings are located in walking surfaces or along accessible routes, then they should have spaces no greater than 1/2" wide in one direction. If gratings have elongated openings, then they should be placed so that the long dimension is perpendicular to the dominant direction of travel.



GRATINGS

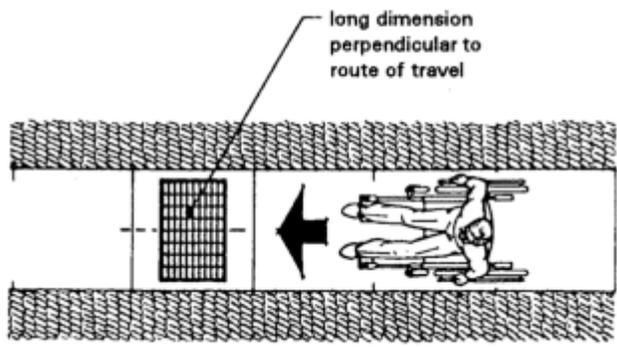


Figure 14
GRATING ORIENTATION

Curb Ramps

Curb ramps must conform to the following standards:

Slope: The slope should be measured as shown in Figure 15. Transitions from ramps to walks, gutters, or streets should be flush and free of abrupt changes. Maximum slopes of adjoining gutters, road surface immediately adjacent to the curb ramp, or accessible route should not exceed 1:20.

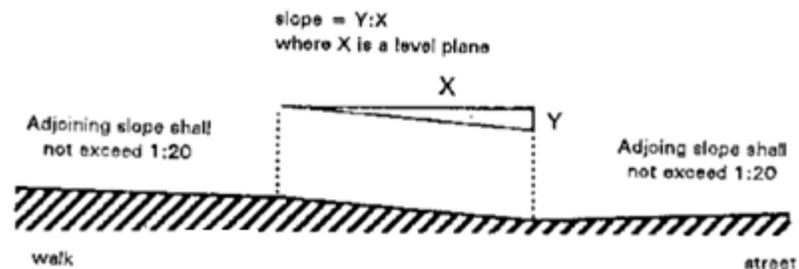


Figure 15
MEASUREMENT OF CURB RAMP SLOPES

Width: The minimum width of a curb ramp should be 36", exclusive of flared sides.

Surface: Surfaces of curb ramps should be stable, firm and slip-resistant with a broom finish. Textures should consist of roughened concrete with grooves extending the full width and depth of the curb ramp. Surfaces that are raised, etched, or grooved in a way that would allow water to accumulate are prohibited.

Built-up Curb Ramps: Built-up curb ramps should be located so that they do not project into vehicular traffic lanes or into spaces that would interfere with persons entering or exiting parked or standing vehicles (See Figure 16).

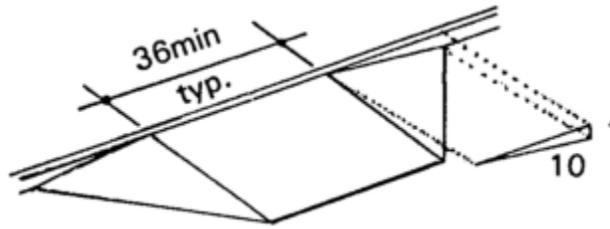


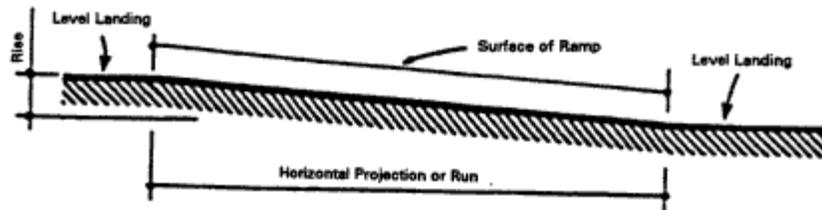
Figure 16
BUILT-UP CURB RAMP

Ramps

Any part of an accessible route with a slope greater than 1:20 should be considered a ramp. Ramps should be constructed according to the following criteria and should conform to all Federal ADA and local requirements.

Slope and Rise: The least possible slope should be used for any ramp. The maximum slope of a ramp in new construction should be 1:12. The maximum rise for any run should be 30" (See Figure 17).

Clear Width: The minimum clear width of a ramp 30 feet or less in length should be 44".



Slope	Maximum Rise		Maximum Horizontal Projection	
	in	mm	ft	m
1:12 to < 1:16	30	760	30	9
1:16 to < 1:20	30	760	40	12

Figure 17
COMPONENTS OF A SINGLE RAMP
RUN AND SAMPLE RAMP DIMENSIONS

Landings: Ramps should have level landings at bottom and top of each ramp and each ramp run. It should be at least as wide as the width of the ramp run leading to it.

The landing length should be a minimum of 60" clear.

If ramps change direction at landings, the minimum landing size should be 60" by 60".

Handrails: If a ramp run has a rise greater than 6" or a horizontal projection greater than 72", then it should have handrails on both sides. Handrails are not required on curb ramps. Handrails should have the following features:

1. Handrails should be provided along both sides of ramp segments. The inside handrail on switchback or dogleg ramps should always be continuous. Ramps in excess of 176" width should have intermediate handrails spaced a maximum of 176" on center.
2. If handrails are not continuous, they should extend at least 12" beyond the top and bottom of the ramp segment and should be parallel with the floor or ground surface (See Figure 18).
3. The *nominal* diameter or width of the gripping surfaces of a handrail should be 1-1/2", or the shape should provide an equivalent gripping surface.
4. If handrails are mounted adjacent to a wall, the space between the wall and the handrail should be 1-1/2". Handrails may be located in a recess if the recess is a maximum of 3" deep and extends at least 18" above the top of the rail.
5. Handrails should be black painted steel.

Cross Slope and Surfaces: The cross slope of ramp surfaces should be no greater than 1:50.

Edge Protection: Ramps and landings with drop-offs should have curbs, walls, railings, or projecting surfaces that prevent people from slipping off the ramp. Curbs should be a minimum of 2" high.

Outdoor Conditions: Ramps approaches should be designed so that water will not accumulate on walking surfaces.

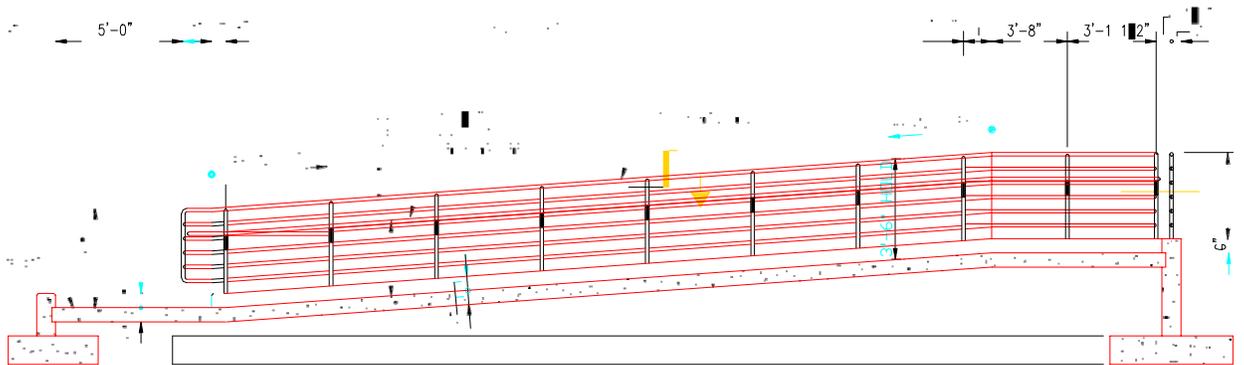


Figure 18
ADA RAMP AND HANDRAILS



Figure 19
ADA RAMP AND SIDEWALK AT LOT

Barrier Gates

Barrier gates are a means of increasing security by restricting use of parking spaces to those individuals with pre-approved permission to park in a specific lot. Gates can be a two-way gate system or a single card gate with a separate controlled egress. (See Figure 20).

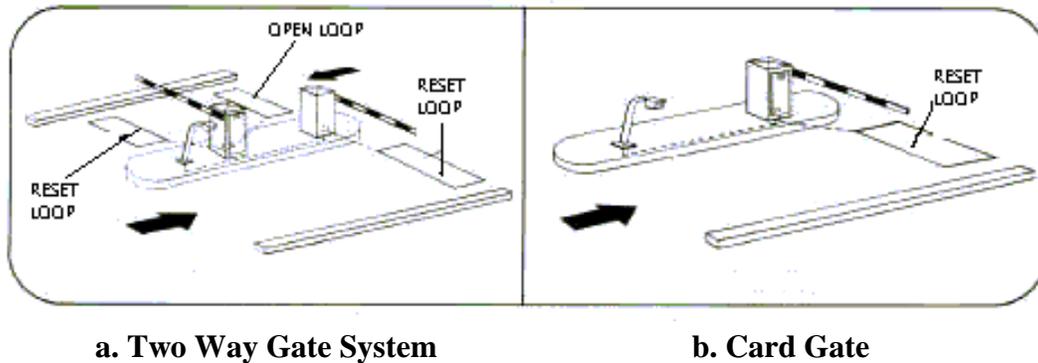


Figure 20

PARKING LOT GATE SYSTEMS

DRAINAGE

General

All parking lots shall be designed to develop proper site drainage, directed at the disposal of all storm water accumulated on the site. Parking lots which contain an area of 2,500 square feet or more; and which are located within 150 feet of an existing storm sewer or other drainage way, including an open channel or creek, should be designed to direct storm water runoff into such storm sewers or drainage ways. The parking lot should be graded and surfaced such that storm water runoff from the site is collected on the site by a parking lot drainage system and carried to the storm sewer system, and not allowed to discharge through the driveway entrances and exits onto the public way. Proposed finished elevations of the parking lot must be indicated on appropriate plans. The site drainage design must not restrict flows that could occur during a 100-year flood condition.

Proper Drainage

Laboratory testing and practical experience have demonstrated the dramatic reduction in the ability of a soil to resist stresses in the presence of excess moisture. For this reason, one of the most important functions of a pavement is to provide a seal over the underlying soil or sub grade. Although the pavement itself absorbs much of the traffic-induced stress, invariably some of this pressure is ultimately transmitted to the soil foundation. If there is excess moisture in this soil, it may be unable to resist the applied loads. The load will eventually exceed that which the pavement can tolerate, and a local failure will result.

Excess moisture can be prevented by proper drainage. Properly designed inlets and culverts should efficiently remove storm water from the parking lot surface. Where necessary, subsurface drains should be used to collect and dispose of groundwater before it can reach the sub grade. Evidence of poor drainage, which includes ponding or standing water that does drain from the surface of a parking lot, is an unacceptable consequence of poor parking lot construction.

Pipes

All drainage pipes shall be constructed of PVC or Reinforced Concrete Pipe. Pipes shall be designed for free flow and a minimum velocity of 3.0 fps at peak design flow.

Storm Drain Manholes, Junction Boxes and Cleanouts

Manholes are required at:

1. Any change in horizontal or vertical alignment of underground drainage pipe. Minor horizontal curvature in pipe less than 15 degrees may be allowed, (without manholes or cleanouts), depending on pipe size, street alignment, degree of curvature and reason. Maximum joint deflection shall be per manufacturer's recommendation.
2. All connections.
3. All changes in pipe size.
4. At least every 500 feet.

Standard catch basins, junction boxes, or cleanouts may be used in place of manholes for pipe not larger than 18 inches in diameter and with a depth less than 4.0 feet. Avoid placing manholes within a parking space. Wherever possible manholes should be located behind the curb or in drive lane.

Inlets and Catch Basins

Inlets and catch basins are required at:

1. All low spots and shall be connected to a storm drainage facility.
2. At least every 500 feet of gutter length.

Monolithic Curb, Inlet and Catch Basin

Open Channels

All existing ditches and other open channels feeding a pipe with a diameter greater than 36 inches shall remain open channel except at road crossings. Where possible, ditches shall be located along or adjacent to lot lines. For reasons of maintenance and safety, bank slopes shall be 4:1 or flatter. The maximum allowable design velocity is 7 fps.

The minimum allowable design velocity is 3 fps. The installation of a concrete lined low-flow channel may be required to achieve minimum velocity. The normal maximum depth for an open ditch is 4 feet outside of road rights-of-way and 2 feet adjacent to the roadways.

Green Considerations

Porous Asphalt

Porous asphalt pavements offer developers and planners a new tool in their toolbox for managing storm water runoff. These pavements, used mostly for parking lots, allow water to drain through the pavement surface into a stone recharge bed and infiltrate into the soils below the pavement. Such pavements have been proving their worth since the mid-1970s, and recent changes in storm water regulations have prompted many consulting engineers and public works officials to work with them.

What Porous Asphalt Can Do

Porous asphalt pavements are of great interest to site planners and public-works departments. With the proper design and installation, porous asphalt can provide cost-effective, attractive pavements with a life span of more than twenty years and at the same time provide storm-water management systems that promote infiltration, improve water quality, and many times eliminate the need for a detention basin. The performance of porous asphalt pavements is similar to that of other asphalt pavements. And, like other asphalt pavements, they can be designed for many situations.

The technology is simple. The secret to success is to provide the water with a place to go, usually in the form of an underlying, open-graded stone bed. As the water drains through the porous asphalt and into the stone bed, it slowly infiltrates into the soil. The stone bed size and depth must be designed so that the water level never rises into the asphalt. This stone bed, often 18 to 36 inches in depth, provides a tremendous sub base for the asphalt paving.

Special features such as the underlying stone bed are more expensive than conventional construction, but these costs are more than offset by the elimination of many elements of standard storm-water management systems. On those jobs where unit costs have been compared, a porous asphalt pavement is generally the less-expensive option. The cost advantage is even more dramatic when the value of land that might have been used for a detention basin or other storm-water management features is considered.

Even after twenty years, porous pavements can show little if any cracking or pothole problems. The surface wears well. Porous asphalt retains its ability to handle rain water for many years. In a study of a porous pavement system constructed at the Pennsylvania State Visitor center, researchers found that the system had maintained a consistent infiltration rate. During a 25-year precipitation event, there was no surface discharge from the stone beds.

Appearance of These Pavements

While slightly coarser than standard asphalt, porous asphalt pavements are attractive and acceptable. Most people parking on a porous asphalt parking lot will not notice (or believe) that it is porous. The surface of a porous asphalt pavement is smooth enough to meet requirements of the Americans with Disabilities Act (ADA).

An added advantage to porous asphalt is that it does not necessitate proprietary ingredients. It does not require the contractor to have special paving equipment or skills. With the proper information, most asphalt plants can easily prepare the mix and general paving contractors can install it. The available data indicate a very high removal rate for total suspended solids, metals, and oil and grease.

Environmental Benefits

Because of the open structure of the pavement, porous asphalt offers a “cooler” pavement choice. By replenishing water tables and aquifers rather than forcing rainfall into storm sewers, porous asphalt also helps to reduce demands on storm sewer systems. In areas where storm-water impact fees are imposed by local governments, such fees may be reduced by using porous asphalt.

Planting Strategies

Vegetation is an effective and attractive way to reduce runoff, and smaller parking lots free up more space for landscaping.

Leaves, stems and branches intercept rainwater, which then evaporates. A significant amount of storm water can evaporate from beds of tall grasses, wildflowers, shrubs, and trees. Furthermore, deep-rooted prairie plants create channels that help encourage infiltration. They also hold up to a half-inch of storm water on their leaves and in the thatch they create. Shallow-rooted turf grass is not nearly so effective; substitute deep-rooted perennial plantings for sod wherever possible.

Even if extensive perennial planting is not possible, include trees to canopy paved areas. In addition to intercepting rainwater, the summer shade they provide helps to reduce the urban heat island effect and make parking lots more pleasant places to be.

Infiltration

Planted areas can also be designed specifically to accept runoff of parking areas, providing temporary storage and on- site infiltration

Advantages

1. Less paving means lower development and maintenance costs.
2. Grasses, wildflowers, shrubs and trees hold water that is then evaporated, reducing runoff.

3. Channels created by deep roots encourage infiltration.
4. Shade from trees helps reduce the urban heat island effect and make the area more comfortable for people.
5. Planting native vegetation creates wildlife habitat.
6. A variety of vegetation creates a more interesting and aesthetically pleasing environment.
7. Trees shade impermeable surfaces, keeping storm water cool and reducing urban heat island effect.

Limitations

1. Municipalities may have firm parking requirement that do not encourage innovation.
2. Space allocated for parking lot in a given development may not be sufficient to include significant planted areas.
3. Soil type may limit infiltration and/or planting success.
4. Use the most space-efficient stall configuration for the site
5. In larger commercial parking lots, design 30 percent of the spaces for compact cars.
6. Use pervious surfacing in summer spillover parking areas.
7. If soils are suitable, drain parking lot runoff into infiltration islands using curb cuts or flat curbs.
8. If soils are unsuitable, excavate to a depth of 3 feet and fill with a planting soil mix.
9. Plant native or vigorous nonnative perennials rather than turf grass over as much of non-paved surfaces as possible. See the Plant List that follows.

Aim to have canopy trees at maturity cover at least 50 percent of paved surfaces. Since tree height and spread will generally be smaller than normal in parking lot growing conditions, compensate by planting more trees closer together.

Irrigation systems are usually necessary for parking lot island plantings, unless sufficient runoff is directed into them.

Construction

To avoid compaction, do not drive on planting areas during construction. After construction, loosen soils in planting areas to a depth of 24 inches, to a maximum compaction of 85 percent standard proctor density. Till the upper 10 inches of soil.

Maintenance

1. Planted areas must be weeded monthly during the first two to three years. After that, weeding once or twice a growing season may suffice.

2. Regular watering will be necessary during dry spells. Limit irrigation to a maximum of two inches per week.
3. During winter plowing, push street snow away from swales whenever possible in order to avoid accumulation of road salt and sand.

Rainwater Gardens Plant List

Source: Fred Rozumalski, Barr Engineering

Mesic-Dry Soils (Sunny)

Native

Butterfly Flower *Asclepias tuberosa*

Gold'

Purple Prairie Clover *Dalea purpureum*
Foerster'

Purple Coneflower *Echinacea purpurea*

Bee balm *Monarda fistulosa*

Little Bluestem *Schizachyrium scoparium*

Spiderwort *Tradescantia bracteata*

Non-Native

Yarrow 'Coronation Gold' *Achillea 'Coronation*

Feather Reed Grass *Calamagrostis 'Karl*

Daylily

Blazingstar 'Kobold'

Silverfeather Grass

Garden Phlox

Black-Eyed Susan

Hemerocallis spp.

Liatris 'Kobold'

Miscanthus sinensis

Phlox paniculata

Rudbeckia fulgida

Mesic-Dry Soils (Shady)

Native

Wild Columbine *Aquilegia canadensis*

Wild Geranium *Geranium maculatum*

Obedient Plant *Physostegia virginiana*

Jacob's Ladder *Polemonium reptans*

Solomon's Seal *Polygonatum biflorum*

Zig Zag Goldenrod *Solidago flexicaulis*

Canada Violet *Viola canadensis*

Non-Native

White Comfrey

Tufted Hair Grass

Bigroot Geranium

Daylily

Hosta 'Royal Standard'

Tigerlily

Symphytum grandiflorum

Deschamsia caespitosa

Geranium macrorrhizum

Hemerocalis spp.

Hosta 'Royal Standard'

Lilium tigrinum

Wet Soil (Sunny)

Native

Giant Hvssop *Agastache foeniculum*

Canada Anemone *Anemone canadensis*

Marsh Milkweed *Asclepias incarnata*

New England Aster *Aster novae-angliae*

Turtlehead *Chelone glabra*

Joe-Pye Weed *Eupatorium maculatum*

Obedient Plant *Physostesia virginianum*

Boneset *Eupatorium perfoliatum*

Queen of the Prairie *Filpendula rubra*

Blueflag Iris *Iris versicolor*

Great Blue Lobelia *Lobelia siphilitica*

Switchgrass *Panicum virgatum*

Mountain Mint *Pycnanthemum*

Tall Meadow Rue *Thalictrum dasycarpum*

Culvers Root *Veronicastrum virginicum*

Golden Alexander *Zizia aurea*

Non-Native

Joe-Pye 'Gateway'

Daylily

Siberian Iris

Tigerlily

Switchgrass 'Heavy Metal'

Eupatorium
'Gateway'

Hemerocalis spp.

Iris sibirica

Lilium tigrinum

Panicum virgatum
Metal'

Plant List

Wet Soils (Shady)

Native

Cardinal Flower	<i>Lobelia cardinalis</i>
Ostrich Fern	<i>Matteuccia struthiopteris</i>
Virginia Bluebells	<i>Mertensia virginica</i>
Sensitive Fern	<i>Onoclea sensibilis</i>

Non-Native

Pink Turtlehead	<i>Chelone layonii</i>
Daylily	<i>Hemerocalis spp.</i>
Obedient Plant	<i>Physostegia virginiana</i>

Shrubs (Sunny)

Black Chokeberry	<i>Aronia melanocarpa</i>
Red-Osier Dogwood	<i>Cornus sericia</i>
Bush Honeysuckle	<i>Diervilla Jonicera</i>
Annabelle Hydrangea 'Annabelle'	<i>Hydrangea arborescens</i>
Pussy Willow	<i>Salix discolor</i>
High Bush Cranberry	<i>Viburnum trilobum</i>

Shrubs (Shady)

Black Chokeberry	<i>Aronia melanocarpa 'alata'</i>
Red-Osier Dogwood	<i>Cornus sericia</i>
Bush Honeysuckle	<i>Diervilla Jonicera</i>
Annabelle Hydrangea 'Annabelle'	<i>Hydrangea arborescens</i>

Trees (consider soils when making selections)

Autumn Blaze Maple	<i>Acer x freemanii 'Jeffersred'</i>
Black Ash	<i>Fraxinus nigra 'Fallgold'</i>
Seedless Green Ash	<i>Fraxinus pennsylvanica 'Marshall's Seedless'</i>
Swamp White Oak	<i>Quercus bicolor</i>
Kentucky Coffeetree	<i>Gymnocladus dioica</i>

LIGHTING

Purpose

Parking lot lighting is vital for traffic safety, for protection against assault, theft and vandalism; for convenience; and for comfort to the user. Lighting on parking lots can be designed to provide the minimum lighting necessary to ensure adequate vision and comfort while being arranged so as not to cause visual interference on public thoroughfares or encroach on the visual privacy of adjacent building occupants.

Criteria

Lighting systems are to be designed to conform with Illuminating Engineering Society of North America (IESNA) requirements, to the International Dark-Sky Association (IDA) recommendations, and to the following criteria:

General: All parking lot lighting will utilize a standard luminaire and pole height.

Illumination Level within the Parking Lots: Illumination levels at any point across the parking lot must not be greater than 6.0 foot-candles in the horizontal plane, and must not exceed 0.5 vertical foot-candles. All points across the interior of the parking lot should have an illumination level greater than 3.0 foot-candles. Illumination in low traffic areas should not fall below the 2.5 foot-candles level.

Illumination Level Beyond Parking Lot Perimeter: Illumination attributable to a parking lot lighting system should not exceed 0.50 horizontal foot-candles beyond the perimeter of the parking lot.

Illumination Level at High Traffic Areas: Illumination levels at entrances, exits, loading zones and collector lanes of parking areas should be greater than twice the illumination of the adjacent parking area or the adjoining street, whichever is greater.

Uniformity Ratio: The illumination uniformity ratio should not exceed 3:1, average to minimum, or 4:1 maximum to minimum. The use of unnecessarily high wattage lights can actually lead to a less secure environment by creating dark pockets just outside the range of the lights.

Glare Control: Lighting should be designed to protect against glare onto public rights-of-way that could impair the vision of motorists and adversely impact adjoining properties. Lighting adjacent to buildings and/or residential districts must be arranged so that the luminaires have a sharp cutoff at no greater than 78 degrees vertical angle above nadir. Not more than five (5) percent of the total lamp lumens can project above 78 degrees vertical.

Spillover: In the ideal case, all exterior light would be shielded from adjacent properties by existing vegetation, thick evergreen vegetated buffers, berms, walls or fences, and/or the use of directional lighting, lighting shields, special fixtures, timing devices, appropriate light densities, luminaries, and mountings at established heights. A design objective for parking lots is for outdoor lighting to be designed and located such that the maximum illumination measured in foot-candles at the property line should not exceed

0.5 onto adjacent residential sites and 1.0 onto adjacent commercial sites and public rights-of-way.

Orientation: The intent of parking lot lighting is to minimize or eliminate light directed upward. Light emitted at angles of 80 degrees higher (where straight down is 0 degrees) fails to produce useful illumination on horizontal surfaces in open areas. At these high angles light produces significant glare, light pollution, and energy waste. Light above 90 degrees is totally wasted and produces undesirable sky glow.

Placement: The placement of light poles within raised curb planter areas is encouraged, but conflicts with parking lot trees, which can obscure the lighting, should be avoided. The distance separating lights will be determined by the geometry of the parking lot and the requirement to satisfy illumination levels.

Luminaires

Mounting Height: The mounting height is measured from the finished grade or surface and includes the total height of the luminaire, pole, and any base or other supporting structure required to mount the light. Parking lot luminaires should be designed, located and mounted at heights no greater than 33-feet above grade for cutoff lights (See Figure 21)

Pole bases: Raised light pole bases should be attractively designed. A typical standard is a 2 ft. diameter, cylindrical concrete base set 8.0 ft. below and 2.5 ft. above grade. The top of the base must be finished in a slight convex shape to prevent water pooling at the base of the light pole. (See Figure 22 for details).

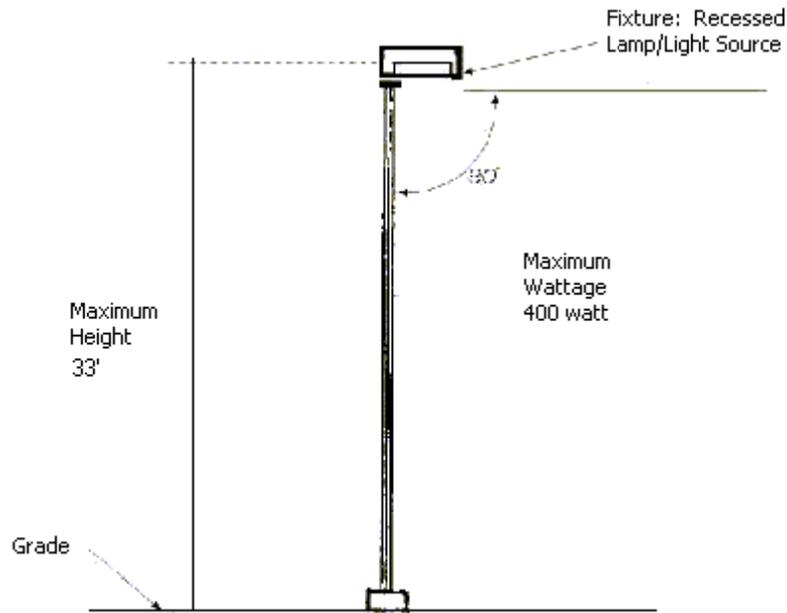


Figure 21
CUTOFF LIGHT FIXTURE

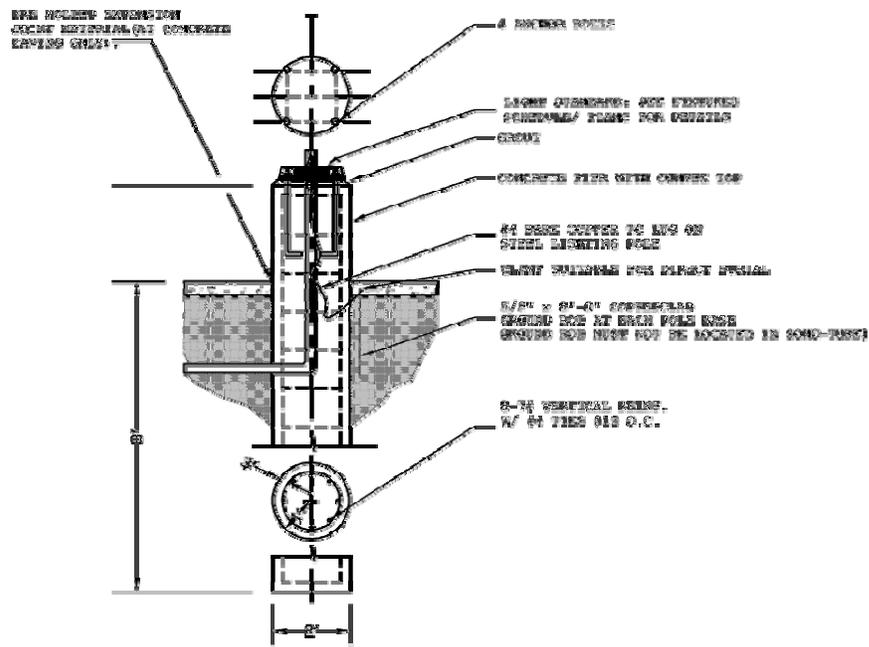


Figure 22
LIGHT STANDARD POLE BASE



REBAR, ELECTRICAL CONDUIT



Figure 23
CONCRETE LIGHT POLE BASE WITH ANCHOR BOLTS

Interior Coating: Interior pole shaft surfaces should be mechanically cleaned and coated at the base end for a length of approximately 2.0' with a zinc rich epoxy powder. The coating should be electrostatically applied and cured in a gas fired convection oven by heating the steel substrate to a minimum of 350 degrees and a maximum of 400 degrees F.

Exterior Coating: All exterior surfaces should be coated with either Urethane or Triglycidyl Isocyanurate (TGIC) Polyester Powder to a minimum dry film thickness of 2.0 mils for Urethane Powder and 3.0 mils for TGIC Powder. The coating should be electrostatically applied and cured in a gas fired convection oven by heating the steel substrate to a minimum of 350 degrees and a maximum of 400 degrees F.

MARKING AND STRIPING

Layout

The project design drawings must include a detailed and accurately scaled parking lot layout clearly showing the location of parking spaces and aisles.

Marking

The construction documents should include the parking spaces to be marked on the project design drawings, and should conform to the following criteria:

1. Each required parking space should be identified by surface markings and should be maintained in a manner so as to be readily visible and accessible at all times. Such markings should be arranged to provide for orderly and safe loading, unloading, parking and storage of vehicles.
2. One-way and two-way access into parking facilities should be identified by directional arrows. Any two-way access located at any angle other than 90 degrees to a street should be marked with a traffic separation stripe the length of the access. This requirement does not apply to aisles.
3. Markings that are required to be maintained in a highly visible condition include striping, directional arrows, lettering on signs, lettering in handicapped-designated areas, and field color.



Figure 24
ACCESSIBLE SPACE MARKING

4. Each loading space should be striped or permanently designated by other suitable methods and permanently posted with a sign restricting its use to loading.
5. Parking spaces should be permanently marked with striping in accordance with all federal, state and local standards. As a minimum lines, should be located along the sides and, unless curbing is present, at the head of parking stalls. Lines should be four (4) inches wide and should extend the full length of the space.

6. "YIELD" markings should be painted in yellow letters a minimum of 36" high at the end of each parking row as it intersects either a drive lane or another parking row that has priority flow for traffic.

Striping

Striping should be one consistent color, semi-permanent, reflective traffic paint with reflective glass beads to enhance visibility. If oil based paint is utilized then a single coat is sufficient. If water base paint is utilized then two coats are required with the second coat being applied at least two months after the first. Stop signs and crosswalks should be painted with rubber (plastic) paint with reflective glass beads to enhance visibility.

Parking spaces will be striped white except at the end of each row of parking or at handicapped accessible aisles. These lines will be painted yellow. All cross walks, no parking areas and access walks will be striped in yellow. All lines must be 4" wide.

Re-striping

When an existing parking lot is re-striped, the re-striping must provide accessible parking spaces as required by the ADA Standards for Accessible Design.

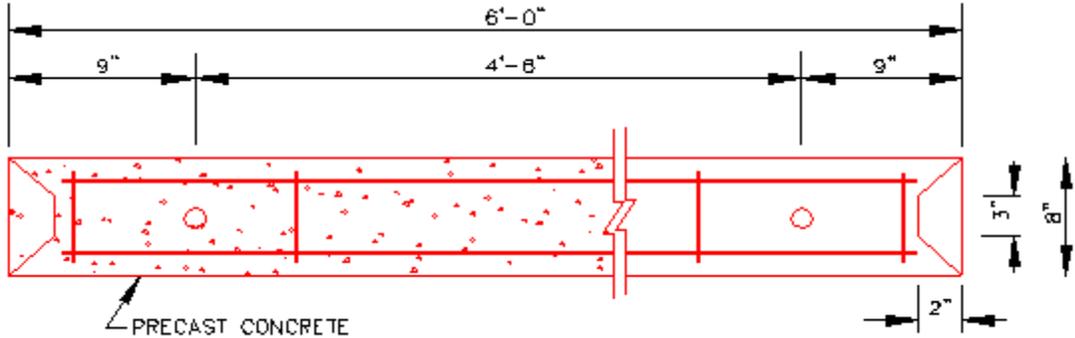
PARKING BARRIERS

Purpose

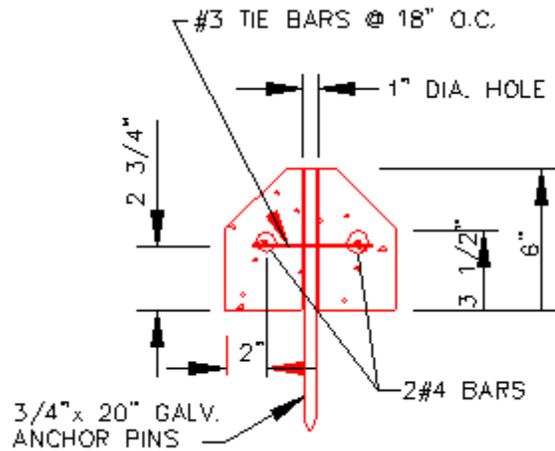
All parking areas and spaces should be provided with bumper barriers, wheel stops, or wheel stop curbing designed to prevent parked vehicles from extending beyond the property lines, damaging adjacent landscaping, walls or buildings, or overhanging sidewalk areas. Each handicapped accessible parking space without a curb stop should be furnished with a parking barrier. Barriers should not block the access aisles between handicapped accessible spaces.

Approved Barriers (Wheel Stops)

Prefabricated concrete parking barriers, where used, should be a minimum of 6” wide, 6” high, and 6 feet long (See Figure 25). Prefab barriers must be firmly and permanently anchored a minimum of 12” below the pavement with galvanized anchor pins (See Figure 26).



**Figure
25
PRE-CAST CONCRETE PARKING
BARRIER**



**Figure
26
PARKING BARRIER
ANCHORS**

Location

Barriers should be located to contain the parking within the approved parking lot. When a concrete curb is used as a barrier for perpendicular or angle parking, it should be offset at least two (2) feet from the edge of the parking lot to allow for the front overhang of the vehicle.

Painting/Marking

All parking barriers (wheel stops) should be painted white except for the following:

- Yellow – No Parking / Tow Away Zones
- Red – Emergency Vehicle / Fire Zones
- Blue – Handicapped Parking
- Black Letters – Denote Reserved Spaces (usually with a space number)

Benefits

Properly placed barriers protect structures and landscaping from vehicle damage. Bumpers encourage drivers to pull all the way into a parking space. This ensures adequate clearance behind the vehicle for other traffic. Bumpers along a centerline of a double row of parking can prevent drivers from taking unsafe short cuts through a parking lot.

LANDSCAPING OF PARKING AREAS

General Guideline

Vehicular parking areas should be both functionally and aesthetically pleasing. The overall goals of implementing these requirements are to enhance, beautify, and improve the environmental and climatic impact of surface parking lots and to minimize the vast, barren character of existing and future parking areas while providing efficient parking, vehicular circulation and safe pedestrian access. Large canopy trees should dominate the parking areas for shade and shrubs along the perimeter should be provided for screening. Additional information is included in the discussion of environmental issues.

Numerical Requirements

The parking lot design should include, at a minimum one (1) tree for every ten (10) parking spaces, rounding up or down in the case of a fraction to the nearest whole number, and in no case should be less than one (1) tree. Required trees must be located in the interior of, or an area adjacent to the parking lot. For parking lots with more than 20 parking spaces, a minimum of five percent (5%) of the total interior parking lot area should be landscaped (excluding perimeter landscaping).

In addition to the parking lot tree requirements described above, shrubs should be planted along the perimeter of all parking surfaces so that the parking lot is screened from all adjacent public streets, exclusive of driveway entrances, pedestrian walkways and visibility triangles. Shrubs should be maintained at a height of no more than 36 inches or less than 18 inches as measured from the surrounding soil line. The number of shrubs required should be equal to the total number of street trees required multiplied by ten (10). No less than 75 percent of the shrubs required should be planted along the perimeter of the parking surface adjacent to the public street. A minimum 10'-0" wide landscaped area, exclusive of sidewalks and utility easements, should be provided between the parking lot and street right of way to accommodate the required screening shrubs.

Design Requirements

Landscape islands should be created to comply with the above numerical requirements, to provide shade canopy and to break up the visual monotony of large asphalt covered areas. The requirements are as follows:

- Landscaped terminal islands should be provided at the end of each parking row. Terminal islands should contain at least one (2) trees and should be the approximate size of two (2) parking spaces.

- Additional intermediate islands should be created when the maximum number of parking spaces between terminal islands is greater than twenty (20). (See Figure 27)
- All landscaped islands should be a minimum of 250 sq. ft.
- All landscaped islands should be provided with raised concrete curbs to prevent vehicular intrusion.

Additional Considerations

- No tree should be planted closer than three (3) feet to a curb.
- All new trees should have a minimum caliper of 4" at installation.
- All required landscaped areas should be provided with a permanent and adequate means of irrigation and should be adequately maintained.
- Each island and screening buffer zone should be planted with ground cover or sodden lawn in addition to canopy trees.
- Large canopy shade trees are required for terminal islands and must be suitably sized, located and maintained to provide a clear trunk height of seven (7) feet at maturity to allow for unobstructed sight lines. A combination of canopy and ornamental trees that add color and variation may be planted in perimeter areas.
- Where canopy trees are located along the perimeter with screening shrubs, sight lines should be maintained between the underside of the canopy and the top of the shrubs for security. (See Figure 28)
- All landscaping should be arranged so as not to obscure traffic signs or fire hydrants, or obstruct drivers' sight distance within the parking area and at driveway entrances.
- Preserve existing trees where possible, especially native species.
- No new parking lot or sidewalk paving or curbs should encroach within the drip line of existing trees. No equipment, dirt or construction materials should be stockpiled within the drip line of existing trees.

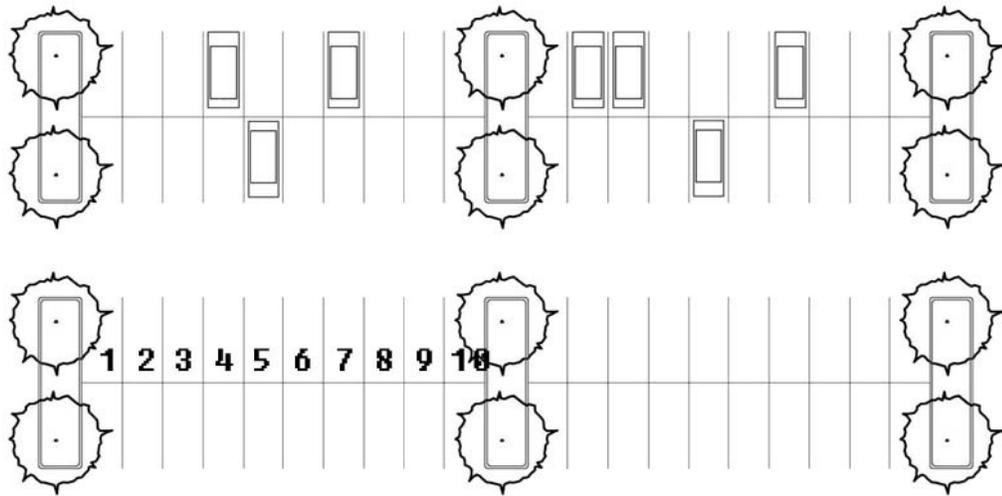
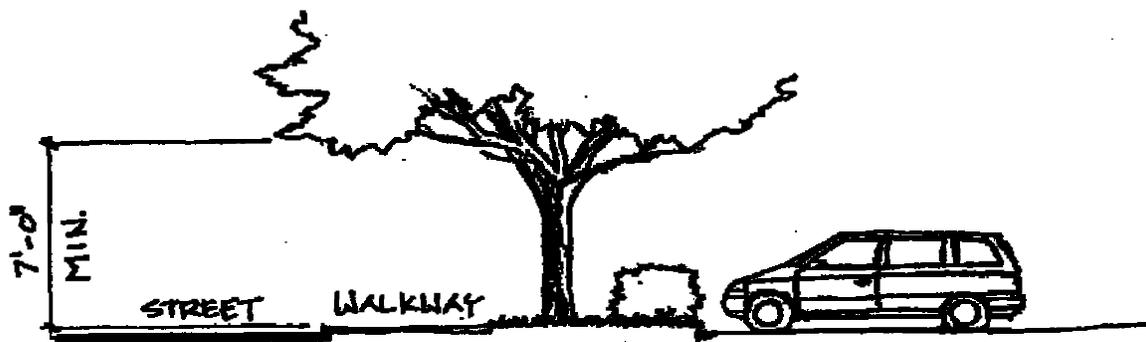
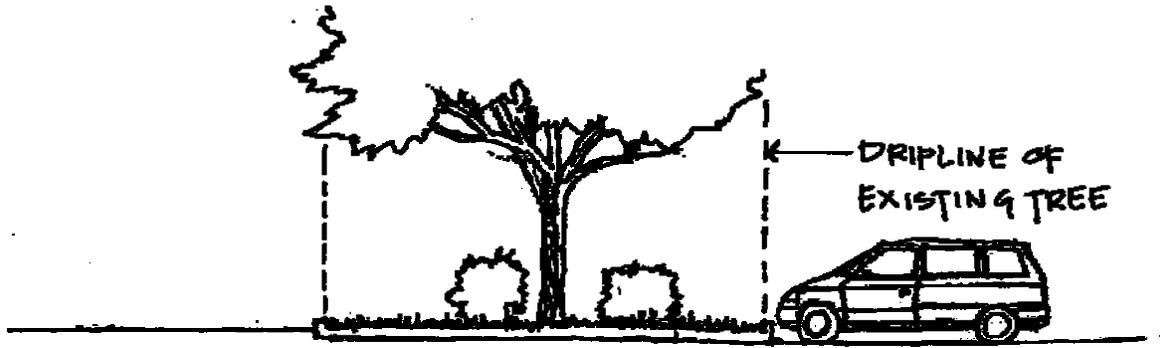


Figure 27
PARKING

Minimum Clearance for Sight
Lines





Vehicular Encroachment at Existing Trees

Figure 28
LANDSCAPING OF PARKING AREAS

MAINTENANCE AND REPAIR

Introduction

All pavements require maintenance. They need this attention because stresses producing minor defects are constantly at work. These stresses may be caused by traffic loads, temperature fluctuations, or by changes in moisture content in the soil. Regardless of the cause, the result is the same. Without timely maintenance the pavement ultimately deteriorates. Preventive maintenance means the early detection and repair of minor defects, before major corrective action is necessary. It is the only proper way to care for a parking lot.

Proper Drainage

For the maintenance of parking lots, moisture and drainage have three implications.

1. First, a properly functioning drainage system can eliminate a number of future maintenance problems.
2. Second, surface repair of a pavement defect caused by poor drainage will merely be a temporary solution, since it treats only the symptom, not the cause.
3. Third, the most important repairs are those that will stop water from getting beneath the pavement surface. These repairs can prevent even larger maintenance expenditures in the future.

Inspection and Evaluation

The key to successful maintenance is careful planning and programming of the work to be done. The first step in planning is a periodic evaluation of all parking areas and access roads in the system.

The parking lot should be thoroughly inspected at least twice a year for surface condition, structural strength, and drainage. The inspection should be done on foot rather than from a slow-moving vehicle. This enables the inspector to notice very small cracks and defects. Subtle signs of future trouble, such as mud or water on the pavement, can be detected and recorded.

In all cases of pavement distress, it is important to determine the cause(s) of the difficulty. This will facilitate repairs that will both correct the defect and prevent its recurrence. Time and money spent for such repairs are well invested, since the same repairs will not have to be repeated in the future.

When the inspection has been completed, there should be a record of problem areas, as well as an idea of the general condition of the pavement.

When these inspections reveal minor defects they should be repaired immediately, before they deteriorate into pavement failures requiring major maintenance expenditures.

Pavements in need of maintenance or repair can exhibit any or all of these conditions:

1. Raveling. This is the progressive separation of aggregate particles in a pavement from the surface downward. Usually, the fine aggregate comes off first and leaves little "pock marks" in the pavement surface. As the process continues, larger and larger particles are broken free, and the pavement soon has the rough and jagged appearance typical of surface erosion. Raveling can result from lack of compaction during construction, construction during wet or cold weather, dirty or disintegrating aggregate, poor mix design, or extrinsic damage to the pavement.
2. Alligator Cracks. These are interconnected cracks forming a series of small blocks resembling an alligator's skin or chicken wire. In most cases, alligator cracking is caused by excessive deflection of the surface over unstable sub grade or lower courses of the pavement. The unstable support usually is the result of saturated granular bases or sub grade. The affected areas are usually not large. They can cover entire sections of a pavement, and when this happens, it usually is due to repeated heavy loadings exceeding the strength of the pavement.
3. Upheaval. Upheaval is the localized upward displacement of a pavement due to swelling of the sub grade or some portion of the pavement structure. Upheaval may also be caused by the swelling effect of moisture on expansive soils.
4. Pot Holes. These are bowl-shaped holes of various sizes in the pavement, resulting from localized disintegration of the pavement under traffic. Contributory factors can be improper asphalt mix design, insufficient pavement thickness, or poor drainage. Also, potholes may simply be the result of neglecting other types of pavement distress.
5. Grade Depressions. Depressions are localized low areas of limited size that may or may not be accompanied by cracking. They may be caused by traffic heavier than that for which the pavement was designed, by settlement of the lower pavement layers, or by poor construction methods. A depressed, cracked area frequently denotes a plastic failure in the base or sub grade. A cracked area without permanent deformation often indicates an elastic movement in the pavement structure.
6. Effects of Tree Roots. This is either an upheaval situation in which the growth of the tree roots pushes the pavement up or a depression due to the trees removing moisture from the soils under the pavement. Treatment of these areas should be coordinated

with the Campus Grounds Department.

Corrective Actions

These are some typical cases of pavements requiring maintenance, and the proper methods of correcting the deficiencies.

Pavement in Good Condition. Typically, a pavement in good condition might exhibit fine cracking, and some raveling of the fine aggregate; the ordinary effects of some wear and tear.

The remedy for this condition is the application of a light seal coat, such as a fog seal or an emulsified asphalt slurry seal. Seal coating should consist of two coats of coal tar asphalt sealer with eight pounds per gallon of concentrate sand aggregate and 5% latex additive. Seal coat should be allowed to cure for a minimum of 24 hours before re-stripping and marking.

All newly paved lots should be seal coated within 12 months of completion and every three years thereafter to maximize the life of the pavement.

Pavement in Fair Condition. Such a pavement is characterized by random cracks of up to 13 mm (1/2 in.) in width, and raveled aggregate. Seal these cracks by:

1. If needed, rout out the crack to the sealant manufacturers' specifications for width to depth ratio. Clean the crack using wire brushing, high-pressure air, sandblasting, hot air blasting, or high-pressure water. This is a key step to crack sealing or filling. If the crack is not thoroughly cleaned the sealant will not adhere to the sides. Thoroughly dry the crack before sealing.
2. After removing the old sealant and/or cleaning the cracks, check them for depth. Generally if they are over 19mm (3/4 in.) deep a backer rod is used to conserve sealant. The backer rod should be a compressible, non-shrinking, non-absorbent material with a melting point higher than the sealant temperature. The backer rod should be about 25% wider than the crack so it doesn't slip down, or float out after installing the sealant.
3. Immediately before applying the sealant, inspect the cracks to ensure they are clean, dry and any backer material is properly installed. If the cracks have been left unsealed for any period of time, clean them out with compressed air before sealing them.
4. The sealant should be applied from the bottom to the top of the crack to prevent air bubbles from forming and creating a weak spot in the sealant. Use a sealant

kettle that has an injection wand for the best results. To prevent tracking the sealant should be left about 3 to 6 mm (1/8 to 1/4 in.) below the top of the crack. Use a squeegee to remove any excess sealant on the pavement surface.

Pavement in Poor Condition. This pavement may display random cracks, raveled aggregate, depressions, alligator cracks, potholes, and perhaps upheaval. Repairs these areas by:

1. First, the areas of local distress -- areas containing alligator cracks, potholes, and upheavals -- should be repaired. This is accomplished by constructing a Full-Depth asphalt patch.
2. Following the repair of local distress, cracks should be filled.
3. Depressed areas should be restored to the proper cross-section by applying a leveling or wedge course. This is an asphalt layer of variable thickness, specifically intended to eliminate irregularities in the contour of an existing surface prior to an overlay.
4. Finally, an asphalt overlay or slurry seal should be applied.

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