How to:

Build better parking areas of concrete

Major attention to layout and design must be backed up by good construction practices

Have you ever entered the parking area of a large shopping center and felt like an enemy intruder amid army tank-and-artillery-type maneuvers—automobiles and trucks darting chaotically, crisscrossing traffic aisles, swarming and attacking, all converging on you in an attempt to reach the exit or entrance? Or have you ever driven through a battle-worn parking lot, its surface riddled with potholes, and found it easier to dodge the bumps of the pavement by driving in the gullies? These are examples of the frustrating, often hazardous effects of poorly designed or poorly constructed parking areas—driving traps or parking jungles to which the innocent motorist is undeservedly and unnecessarily subjected through lack of good design and construction.

DESIGN OF AREA

Designing a parking area is not a step-by-step process. The designer cannot plan the parking area and then arbitrarily attach it to the adjoining street with an entrance and exit. A parking area, like any architectural structure, has many mutually influencing (and often mutually opposing) elements that must be integrated to give the best functioning and best appearing design. There are no simple steps to follow, but there are guidelines.

Entrances and exits

Entrances and exits should promote safe, smooth traffic flow. They should minimize any of the parking area's traffic impact on adjacent streets. Therefore entrances and exits should always be at least 50 feet from an intersection. Left turns should be allowed only onto two-way streets that have little traffic, and it should be remembered, if left turns are unavoidable, that entering a parking area from a highly traveled street is much easier than exiting onto the same street. Design should prevent outbound and inbound cars from blocking one another and, if needed, a buffer space should be provided in case several cars are waiting to enter or exit. Above all, entrances and exits should blend with the traffic aisles inside the parking lot to avoid traffic congestion and confusion.

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Generally one entrance and exit is needed for every 75 parking spaces. If cars will be constantly coming and going, separate entrances and exits will be necessary for smooth, continuous traffic flow. However, if most cars will either be entering or leaving at the same time, as at employee parking lots, a common entrance-exit lane may be satisfactory.

If there is control equipment such as a card lock or ticket machine to regulate parking in the lot, then there should be a sufficient turning radius—24 feet minimum—for the motor vehicle to reach it easily. Also, to allow easy entry for a range of vehicles and to prevent damage to car underbodies, a single access lane should be at least 9.5 feet wide, and its slope should be no more than 12 percent.

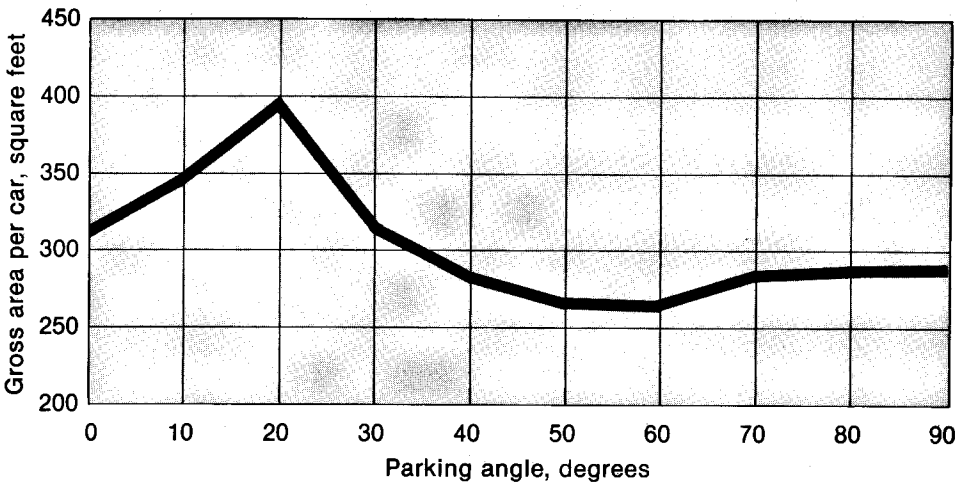


Figure 1. *Average gross area required for parking one car at various parking angles. (This includes area for aisles and lost space.)*

Drainage

The drainage system should have adequate capacity to handle runoff without ponding during normal storms. Water should be carried away from areas where drivers and passengers must walk; it can be drained toward the area between a double row of cars or to the center of a traffic aisle. Areas around exits and entrances also should be designed for good runoff.

Stalls and aisles

The size of vehicle that uses the parking area and the level of convenience allowed the user determine the stall width, stall angle, and aisle width to be selected.

A convenient size stall for easy self parking of a large size car is 9x19 feet. Assuming such vehicles are centered in their stalls, 9 feet allows only about 1½ feet on each side to open the long, thick car doors. A stall width greater than 9 feet is a convenience well appreciated by short-term parkers, shoppers, visitors and executives. If there is a relatively constant number of parkers with vehicles significantly different in size, laying out different size stalls may be advantageous. Compact car stalls, for instance, are normally 7.5x15 feet. It is expected that by 1990 the average car size will be only 5.5x15 feet. By then car stalls 8x17 feet should be adequate for cars, though not for campers and vans.

The angle at which a parking stall is pointed away from the traffic aisle is referred to as the stall angle. Its selection is based on the available space, the desired convenience and the gross area that can be allowed each car (see Figure 1). A parking stall angle of 60 degrees is often chosen since it offers a compromise between the convenience afforded by small stall angles and the space conservation provided by large ones. Table 1 lists the advantages and disadvantages of different stall angles.

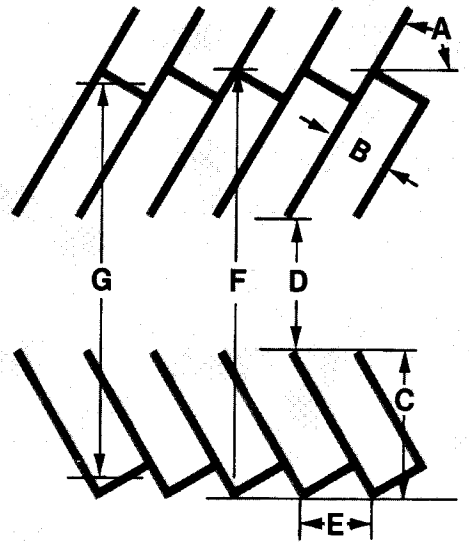
Once the stall size and stall angle have been chosen, the optimum aisle width can easily be determined (see Table 2). Wider stall sizes and smaller stall angles permit the use of narrower aisle widths. Therefore, a stall angle of 90 degrees requires a wide aisle for turning;

Table 1. Advantages and disadvantages of various stall angles

Stall angle	Advantages	Disadvantages
90 degrees	Required two-way aisles give broad range of vision	Less convenient to enter stall; requires 90-degree turn from direction of aisle travel, which takes more time and room
	Allows traffic to move two ways in aisles	Gives greater potential for accidents
	Allows use of dead end aisle where desirable	Makes it difficult to encourage one-way traffic flow where desired
	Parkers usually drive all the way into the stall	May require more total area
45 to 90 degrees	Uses one-way aisle, aids traffic flow	May have many dead spaces
	Saves space because stalls overlap in double rows	Parkers sometimes do not drive all the way into stalls
	45-degree stalls in double rows can be overlapped in either direction (see Figure 2)	Traffic aisles may seem narrow
	Stalls can be narrower since doors open ahead of or behind the adjacent car	
Less than 45 degrees	Smaller turn is required from the direction of aisle travel	Parkers sometimes do not drive all the way into stalls
	Uses one-way aisle, aids traffic flow	Will have many dead spaces
	Stalls can be narrower since doors open ahead of or behind the adjacent car	Inefficient in use of total area available

Table 2. Relation of optimum aisle width and other dimensions to stall angle and size

Dimensions in feet						
A	B	C	D	E	F	G
Stall angle, degrees	Stall width	Vehicle projection for 19-foot stall length	Optimum aisle width	Curb length per car	Width for double aisle, wall to wall	Width for double aisle, overlap center to overlap center
	8.0	8.0	12.0	23.0	28.0	—
	8.5	8.5	12.0	23.0	29.0	—
0	9.0	9.0	12.0	23.0	30.0	—
	9.5	9.5	12.0	23.0	32.0	—
	10.0	10.0	12.0	23.0	32.0	—
	8.0	14.0	11.0	23.4	39.0	31.5
	8.5	14.5	11.0	24.9	40.0	32.0
20	9.0	15.0	11.0	26.3	41.0	32.5
	9.5	15.5	11.0	27.8	42.0	33.1
	10.0	15.9	11.0	29.2	42.8	33.4
	8.0	16.5	11.0	16.0	44.0	37.1
	8.5	16.9	11.0	17.0	44.8	37.4
30	9.0	17.3	11.0	18.0	45.6	37.8
	9.5	17.8	11.0	19.0	46.6	38.4
	10.0	18.2	11.0	20.0	47.4	38.7
	8.0	19.1	14.0	11.3	52.2	46.5
	8.5	19.4	13.5	12.0	52.3	46.5
45	9.0	19.8	13.0	12.7	52.5	46.5
	9.5	20.1	13.0	13.4	53.3	46.5
	10.0	20.5	13.0	14.1	54.0	46.9
	8.0	20.4	19.0	9.2	59.8	55.8
	8.0	20.7	18.5	9.8	59.9	55.6
60	9.0	21.0	18.0	10.4	60.0	55.5
	9.0	21.2	18.0	11.0	60.4	55.6
	10.0	21.5	18.0	11.5	61.0	56.0
	8.0	20.6	20.8	8.5	61.2	58.5
	8.5	20.8	19.5	9.0	61.1	58.2
70	9.0	21.0	19.0	9.6	61.0	57.9
	9.5	21.2	18.5	10.1	60.9	57.7
	10.0	21.2	18.0	10.6	60.4	57.0
	8.0	20.1	25.0	8.1	65.2	63.8
	8.5	20.2	24.0	8.6	64.4	62.9
80	9.0	20.3	24.0	9.1	64.3	62.7
	9.5	20.4	24.0	9.6	64.4	62.7
	10.0	20.5	24.0	10.2	65.0	63.3
	8.0	19.0	26.0	8.0	64.0	—
	8.5	19.0	25.0	8.5	63.0	—
90	9.0	19.0	24.0	9.0	62.0	—
	9.5	19.0	24.0	9.5	62.0	—
	10.0	19.0	24.0	10.0	62.0	—



this is wide enough for two-way traffic. All other stall angles need only one-way aisles.

The capacity and convenience of the parking area depends largely on how well the stalls and traffic aisles are laid out. This is probably best accomplished by using templates of the size and angle of stall selected and experimenting on a scale drawing of the proposed site. The scale drawing should show key obstacles such as fire hydrants and light poles, and it should indicate the nature of traffic on adjacent streets: one- or two-way, number of lanes, speed of traffic, and nearby intersections.

For maximum capacity parking, irregular parking areas that are curved or triangular should be avoided. Rectangular parking areas are the most space-efficient. Likewise, to take advantage of the lot dimensions, traffic aisles should parallel the lot's longest side, and the perimeter of the parking area should be lined with stalls. Traffic aisles should always be kept on the inside, serving stalls on either side.

Sharp turning angles like a U-turn around a single row of cars should be avoided since sharp angles cause backup maneuvering that congests the traffic flow. A safe, smooth passage from entrance, to stall, to exit should be the prime consideration in planning traffic aisles.

CONCRETE PAVEMENT DESIGN

Most cracks, breaks and spalls observed in concrete parking areas are not, as they are frequently assumed to be, due to concrete that is not thick enough, but rather because the pavement was detailed improperly. In the National Road Test, a $27-million test project sponsored by the American Association of State Highway Officials, 3½-inch concrete pavement withstood 1,000,000 axle loads of 6000 pounds each without any indication of a loss of serviceability. Most parking areas are subjected almost entirely to the loads of large numbers of automobiles—about 2000-pound axle loads. Thus, if constructed properly, parking areas to be used only by automobiles need be only 4 inches thick—5 inches thick for medium weight trucks (see Figure 2).

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Such pavements will handle occasional overloads. For consistently heavier loads, thicker pavement is needed.

Guidelines for joints and steel

The most economical and most serviceable detailing of concrete parking areas is unreinforced pavement jointed at 10-foot centers in both directions for 4-inch-thick pavements, and at 12.5-foot centers for 5-inch pavements. Pavements of 6-inch or greater thickness should be jointed to form 12.5-foot-wide longitudinal strips which are also jointed transversely at intervals of 15 to 20 feet. The resulting panels should be capable of transferring vertical loads across joints to the surrounding four panels by keyed joints, or aggregate transfer, as discussed below. Wood boards left in place as joints do not permit load transfer and each corner of the panel becomes a cantilever that can easily break under a heavy load. If board joints are desired for their visual effect, the board depth should not exceed one-fourth the pavement thickness.

Load transfer may be achieved by paving in 20- or 25-foot-wide lanes, using keyed construction joints between lanes. A longitudinal joint is then formed or sawed longitudinally to divide each lane into two 10- or 12.5-foot widths. Transverse joints should be made by forming dummy joints with fiber inserts or by sawing. Joints should be at least one-fourth the depth of the slab to cause the slab to subsequently crack below the joints and not elsewhere. These joints provide relief for normal shrinkage, and for thermal and curling stresses, while the aggregate interlock below the joints provides the necessary load transfer.

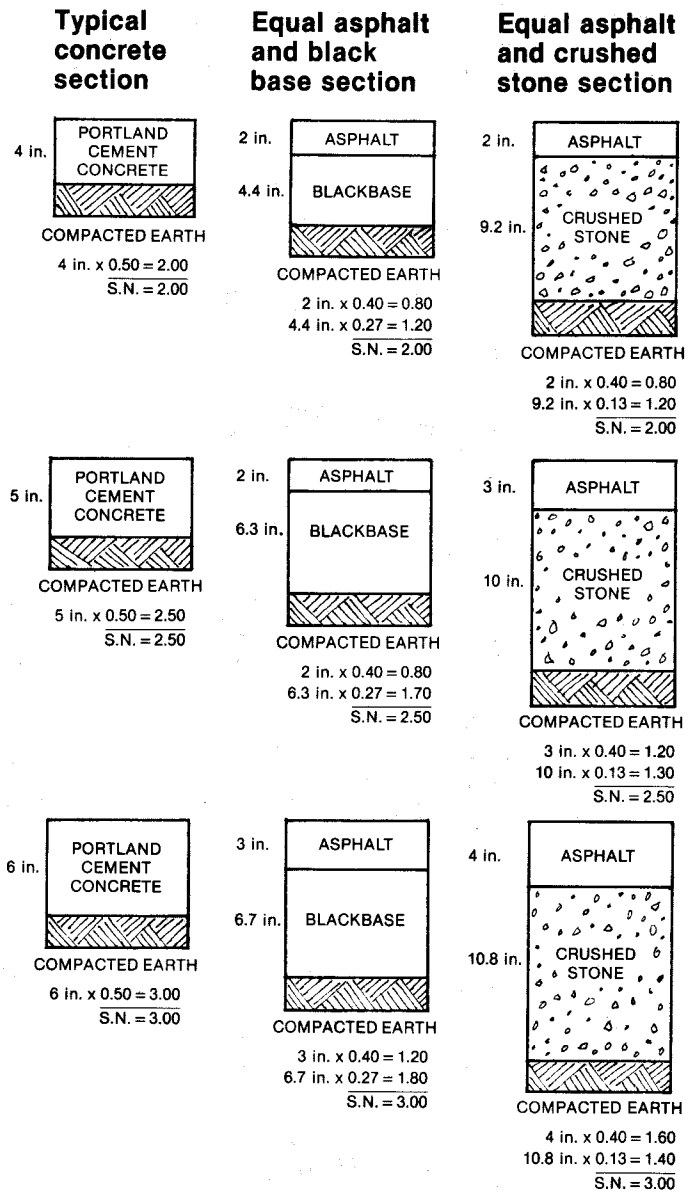
Isolation joints are needed to separate the pavement slab from fixed objects such as drop inlets, light standards and buildings. Failure to provide isolation joints where needed inevitably cracks the pavement.

When to use distributed steel

With closely spaced joints, steel is not needed, but if large panels are desired and pavement economy is not a major factor, distributed steel may be used to hold any eventual cracks tightly together. Steel in pavements is not used in sufficient quantities, or placed in the most favorable position, to add strength. Instead it is used in relatively small amounts placed near the top surface to minimize the sizes of cracks. It should be positioned at about one-third the slab thickness below the surface, but no less than 2 inches, and it should never be continued across joints.

Only the amount of steel required to hold cracks together should be used. A 6-inch-thick pavement having 30-foot-square panels, for example, requires 6x6—W2.0xW2.0 welded wire fabric weighing 30 pounds per 100 square feet and a 7-inch slab with 40-foot-square panels requires 6x6—W2.9xW2.9 fabric weighing 42 pounds per 100 square feet.

When large panels with distributed steel are used, load transfer devices such as lugs or smooth dowels must be used at transverse joints. These devices should *not* be used in both longitudinal and transverse joints. Such a practice causes cracking because it does not permit the lateral movement between panels that is needed with changes of temperature or moisture. When lugs or dowels are used it is extremely important that they be accurately aligned or they will cause cracking and spalling.



GUIDE FOR ESTIMATING STRENGTHS OF PAVEMENTS

MATERIAL	EQUIVALENT STRENGTH PER INCH OF PAVEMENT
BLACKTOP	0.40
BLACKBASE* (Varies between 0.16 and 0.33)	0.27
CRUSHED STONE BASE	0.13
PORTLAND CEMENT CONCRETE	0.50

SOURCES: American Association of State Highway Officials
* Illinois Department of Transportation Design Manual

Figure 2. *Typical sections for parking area pavement. Structural numbers (S.N.), calculated as shown, give equivalent strengths for typical pavement sections. (Comparison prepared by American Concrete Pavement Association.)*

Concrete mix proportioning

Finally, the proper concrete for parking areas should have a minimum 28-day compressive strength of 3500 psi, a slump of no more than 4 inches, and a minimum cement content of 520 to 540 pounds per cubic yard for

mixes with ¾- to 1-inch maximum-size aggregate. In areas exposed to a number of freeze-thaw cycles annually or to use of deicers, it is advisable to have a 28-day compressive strength of 4000 psi, a minimum cement content of 560 pounds per cubic yard and an air content of 6 ± 2 percent.

PAVING AND MARKING

It is beyond the scope of this article to give a step-by-step procedure for placing and finishing the concrete. Such information is given in other published articles and special tips are given in the article beginning on page 243. Nevertheless, it is worth emphasizing the need for the following practices.

- Moisten the subgrade immediately before placing concrete.

DESIGN MEMO

Don't underestimate space needs. Almost twice the area of each car must be alotted to provide for traffic aisles, space between cars and entrance and exit lanes.

Allow extra space near fixed objects to permit opening car door.

Match stalls to vehicles. Compact cars and motorcycles need less room than standard cars. Estimate the number of each and plan accordingly.

Provide convenience as necessary. Shoppers need more room for loading and unloading than tenants, and tenants need more than workers. Plan accordingly.

Avoid irregular shapes. Try for rectangular parking areas.

Use space to best advantage. Keep traffic aisles to inside, lining the perimeter with stalls.

Simplify maneuvering. Avoid sharp turns. Make entrances and exits a continuation of traffic aisles.

Use dead spaces for bicycles, motorcycles, landscaping or benches.

Consider special users, particularly the handicapped and the elderly, but also delivery vehicles, visitors and others.

TIPS

- On steep slopes or hillsides, fit lot into the natural landscape.
- Beautify lot area with textured concrete panels.
- Use ornamental planters, bushes, trees and concrete masonry walls to screen or visually break up parking areas.
- Use concrete patterns to define crosswalks, courts and turnarounds.
- Consider simple decorative finishes to define areas—for example, provide texture by brooming.
- If specially decorative effects are wanted, use exposed aggregate concrete—or different shades and patterns for walks, curbs, bumper stops and individual parking places.
- Use colored or white concrete in areas where personal security or electricity savings are important.
- Do not overfinish the pavement. A bullfloat finish is usually adequate. Where a textured surface is wanted, follow the bull floating with a burlap drag.
- Cure the fresh concrete the equivalent of 7 days at 50 or more degrees F. Applying liquid membrane-forming curing compound is usually the most economical method.
- After curing close pavement to cars for an additional 3 days and trucks for 7 days before initial use.

Marking and signing

The value of marking lines on the pavement and installing signs highly visible above automobile roof level is immeasurable for the efficient operation of a parking area. Stalls, aisles and access lanes should all be marked. Experience has shown that double lines between stalls, establishing a stall width of 7 feet and a painted island of 1.5 to 2 feet between adjacent stalls, encourages parkers to center their cars in the stalls. This minimizes the amount of unusable or tight space caused by cars offset in parking stalls—as well as reducing the number of nicks, dents, and scrapes inflicted on polished car bodies by doors opening and banging. Areas too small for the average 9x19-foot stall might be marked for compact cars, and completely unusable areas can be crosshatched or landscaped.

All traffic aisles should be marked with arrows at their beginning, end, and at any intersection, and one-way aisles should have signs indicating the direction of traffic. Entrances and exits, too, should be clearly marked by both signs and pavement arrows for incoming and for outgoing patrons.

Conclusion

Following these guidelines should produce economical parking areas that endure, conserve space and promote safe, smooth traffic flow. And, due primarily to good design and construction, they should put a much needed crimp in the business of auto body shops. CC