WEST BEND®
Driving Safety Throughout the Industry

Preventing Parking Lot Injuries: Slope, Condition, and Lighting Considerations

Parking Lot Surface Water Drainage and Slope

Surface area drainage is created by grading an area so that water collects and flows to a lower elevation away from where people walk. Regardless of surface characteristics, when it comes to surface drainage, slope is the most important factor to consider. For efficient drainage, paved surfaces should have a minimum one-percent slope. Gravel or aggregate areas should have a minimum slope of two percent.

To determine the slope, "shoot" the grade. Because slope is so important for drainage, a transit or level is good to have on hand to "shoot" grades. It's also the best way to find the absolute lowest spot in a potential drainage area. Exceeding the two percent standard by too much can cause erosion problems. Slopes of more than four or five percent will also be too steep in most situations.

Calculate the slope. Each foot of elevation over a 100-foot length is 1 percent. Therefore, it takes two feet of elevation change over each 100-foot length of a swale to create a two percent slope. If the distance is 10 feet, you'll need a fall of 0.2 feet (roughly two and a half inches) to create a two percent slope. Grade the area. Areas that'll be paved, such as driveways or parking lots, are easy to surface drain by simply grading them to slope away from structures and walkways and toward a lawn, storm sewer, or gutter.

As a general guideline, parking area surfaces should have a minimum slope of two percent or quarter inch per foot. This guideline may not be realistic when matching curb, gutter, pans, planters, ramps, etc. The parking lot needs to be designed to provide positive drainage. Pavement cross slopes of less than two percent are hard to construct without potential of "bird baths," which are undesirable depressions that allow water to pool. Parking areas also need to be designed to prevent water from accumulating at the edge. Runoff needs to be collected by gutters or curbs and channeled away from the lot. Also, curb and gutter cross sections should be built so that water flows within the designed flow line and not along the interface joints between the asphalt pavement and curb face.

To achieve adequate drainage on paved surfaces, a slope between two and five percent is recommended.

Concrete Parking Lots

Concrete parking lots are designed in accordance with ACI 330R, Guide for Design & Construction of Concrete Parking Lot recommendations. Here are some important concepts to understand about design of concrete parking lots:

1. There's more to a parking lot than just pavement. Parking lots include slabs, joints, curbs, light poles, and drainage facilities. All these components need to work together as a system.
2. For cars and light trucks, a four-inch pavement is generally okay. For bigger delivery trucks, the pavement will need to be five or six inches thick. This is dependent on the subgrade, the total number of load repetitions, and the weight of the vehicles driving on the surface.
3. Parking lots generally drain 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 one percent (one eighth inch per foot); two percent (one quarter inch per foot) is better; and six percent is the maximum slope in areas where cars park. Slope of entrances to the parking lot shouldn't exceed eight percent.

4. The pavement for truck lanes used for loading, deliveries, etc., must be increased in thickness to prevent pavement failure due to the weight associated with heavy truck traffic. These areas should be constructed with asphalt pavement thicknesses that will support this heavier pavement loading, typically a *minimum* of three inches of base asphalt under the surface course and more than a six to eight-inch aggregate subbase.

Sidewalk Slope
Sidewalks should be six feet wide with a quarter inch per foot (2%) transverse slope perpendicular to the direction of travel.

Parking Lot and Pavement Condition
Maintaining pavement is important to optimize water drainage. Pavement inspection is needed to assess the condition of the asphalt and determine needed corrective actions. Pavement in need of maintenance or repair can exhibit any, or all, of these conditions:

- **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 pockmarks in the pavement's surface. As the process continues, larger and larger particles break free, and the pavement 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.
- **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 is usually the result of saturated granular bases or sub grade. The affected areas usually aren't large. They can cover entire sections of a pavement, and when this happens, it's usually due to repeated heavy loadings exceeding the strength of the pavement.
- **Upheaval** – This 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.
- **Potholes** – 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.
- **Grade Depressions** – These are localized low areas of limited size that may or may not be accompanied by cracking. They may be caused by heavier traffic than the pavement was designed for, 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.
- **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.

Corrective Actions to Repair Asphalt
These are some typical cases of pavement condition and the proper methods of correcting issues.

Pavement in Good Condition
Typically, a pavement in good condition might exhibit fine cracking, and some raveling of the fine aggregate as the result of ordinary wear and tear. The remedy for this condition is an application of a light seal coat, such as a fog seal or an emulsified asphalt slurry seal. For parking lots, seal coating shall consist of two coats of coal tar asphalt sealer with eight pounds per gallon of concentrate sand aggregate and five percent latex additive. Seal coat should be allowed to cure for a minimum of 24 hours before restriping 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
Pavement with random cracks of up to 13 mm (1/2 inch) in width and raveled aggregate is considered to be in fair condition. Follow these steps to seal cracks.

If needed, rout out the crack to the sealant manufacturer's specifications for width to depth ratio. Then clean the crack using a wire brush, high-pressure air, sandblasting, hot air blasting, or high-pressure water. This is a key step to crack sealing or filling. If the crack isn't thoroughly cleaned the sealant won't adhere to the sides. Thoroughly dry the crack before sealing.

After removing the old sealant and/or cleaning the cracks, check them for depth. Generally, if they're over 19mm (3/4 inch) deep, use a backer rod 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 percent wider than the crack, so it doesn't slip down or float out after installing the sealant.

After ensuring the cracks are clean and dry and that any backer material is properly installed, apply the sealant working from the bottom of the crack to the top. This prevents air bubbles from forming and creating a weak spot in the sealant. For best results, use a sealant kettle that has an injection wand. To prevent tracking, the sealant should be left about three to six mm (1/8 to 1/4 inch) below the top of the crack. Use a squeegee to remove any excess sealant on the pavement surface.

Pavement in Poor Condition
Pavement in poor condition may display random cracks, raveled aggregate, depressions, alligator cracks, potholes, and perhaps upheaval. Follow these steps to repair pavement.

Start with areas of local distress, such as areas containing alligator cracks, potholes, and upheavals. To do this, construct a full-depth asphalt patch. Next, fill cracks as detailed in the previous section. Then, restore depressed areas 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. Finally, apply an asphalt overlay or slurry seal.

Parking Lot Lighting

Lighting systems are to be designed to conform to Illuminating Engineering Society of North America (IESNA) requirements, the International Dark-Sky Association (IDA) recommendations, and these 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 footcandles in the horizontal plane and must not exceed 0.5 vertical footcandles. All points across the interior of the parking lot must have an illumination level greater than 3.0 footcandles. Illumination in low traffic areas must not fall below the 2.5 footcandles level.
- **Illumination Level Beyond Parking Lot Perimeter –** Illumination attributable to a parking lot lighting system should not exceed 0.5 horizontal footcandles 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.
- **Illumination Uniformity Ratio –** The illumination uniformity ratio should not exceed three-to-one, average to minimum, or four-to-one maximum to minimum. The use of unnecessarily high wattage lights can 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. 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 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, fences, the use of directional lighting, lighting shields, special fixtures, timing devices, appropriate light densities, luminaries, and/or mountings at established heights. An objective for all parking lots is for outdoor lighting to be designed and located such that the maximum illumination measured in footcandles at the property line shall 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 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.
- **Control –** Lighting must be designed to interface with a control system such as photocells. Each lighting circuit must be equipped with a manual over-ride switch.

Necessary parking lot lighting is dependent upon the type of building or site that it supports as well as the surrounding area. The Illuminating Engineering Society of North America (IES) recommends light levels for basic parking lots and higher light levels for parking facilities where enhanced security is required. More light doesn't equal better quality. For example, most security cameras are rated for both very low and very high light levels but are limited by contrast ranges. Therefore, uniform lighting will aid in viewing images on the camera as well as those physically in the parking lot.

Equally important is the uniformity of lighting throughout the area. Uniformity of lighting is expressed as a ratio between the lowest light level reading and the average light level reading taken throughout the area. For example, if the average light level reading that you took was five fc, and the lowest light level reading that you took was one fc, the uniformity ratio would be five-to-one. A maximum uniformity ratio of three-to-one is recommended for most outdoor parking lot applications.

Lighting uniformity on the pavement surface must also be considered for safe vehicle and pedestrian interaction. Too much contrast between bright and darker areas makes it more difficult to see people and vehicles in the darker areas. The use of luminaires that distribute light evenly on the parking surface and lighting layouts with appropriate spacing, are crucial to the lighting design. Consequently, one-for-one replacement may not be an option when specific light levels and uniformity ratios are targeted. Factors such as trees and other elements on the site may affect the lighting design.

It's not uncommon to see uniformity ratios as high as 200:1. Typically, high light levels (20 to 30 fc) will be found directly under light fixtures. As you walk away from the light fixture light levels diminish, and at the midpoint between fixtures, it's not uncommon to see light levels of .1 fc or less. This lack of uniformity is usually caused by light fixtures that are spaced too far apart. The situation is complicated when trees or other types of landscaping are located between light fixtures.

There's much debate as to what constitutes "adequate" lighting in parking lots and other outdoor areas. Published standards show that acceptable light levels in parking lots can range from a minimum of .5 fc in low activity areas to a maximum of 5 fc for high-activity areas where pedestrian security is a concern. IESNA and other organizations recommend the following levels:

	Highest Activity Levels	Medium Activity Levels	Low Activity Levels
Typical activities	fast food restaurants gas stations convenience stores cultural/institutional facilities	community shopping centers hospital parking areas educational facilities banks, other services	local merchants industrial employee parking multi-family parking lots
Average maintained illumination levels	2.0 - 3.0 footcandles	1.0 - 2.0 footcandles	0.5 - 1.0 footcandles
Uniformity ratios	3:1 average/minimum (.66 f.c. minimum) 12:1 maximum/minimum (8.0 f.c. maximum)	3:1 average/minimum (.33 f.c. minimum) 12:1 maximum/minimum (4.0 f.c. maximum)	4:1 average/minimum (.125 f.c. minimum) 15:1 maximum/minimum (2.5 f.c. maximum)
Maximum light at property boundaries	0.5 footcandles	0.5 footcandles	0.5 footcandles