



information

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A Bright Idea: Specify Concrete

Portland cement concrete pavements, paving blocks ("pavers"), and other precast elements are saving energy and lives due to their high reflectivity of light.

Public facilities like pavements, sidewalks, and parking facilities are brighter at night when they're constructed with portland cement concrete. That's because concrete's high albedo, or ratio of light reflected, means less light is needed to attain a like level of illumination when using other building materials.

Up to 27% of light falling on a portland cement concrete surface will be reflected, according to the University of Florida, compared to as little as 5% of light from blacktopped pavements and dark soil, and 8% from water (see chart). This unique feature can make concrete safer for users, and a real energy saver as well, researchers observe.

Albedo of different surfaces

Surface	Percent reflected
Clouds	50-55
Concrete	17-27
Crops, green	5-25
Forest, green	5-10
Meadows, green	5-25
Ploughed field	14-17
Road, blacktop	5-10
Sand, white	30-60
Snow, fresh fallen	80-90
Snow, old	45-70
Soil, dark	5-15
Soil, light (desert)	25-30
Water	8

Concrete provides high albedo for a construction material, making light go farther. (Source: University of Florida)

"Reflectivity [of pavement] is a safety factor in visibility at night, and this factor reduces the demand for electric lighting for streets," says the Center for Building Science, Energy & Environment Division, Lawrence Berkeley National Laboratory.

But there are aesthetic benefits to concrete's high reflectivity, too. Because outdoor lighting can be used to emphasize aesthetic features of structural or landscape architectural design, these features will stand out best when they're made of portland cement concrete.

And high-albedo concrete pavements, pavers, and other precast elements have the added quality of reflecting heat as well as light, thus reducing the "heat island" effect and higher temperatures endemic to urban areas (see EV19, *Shining a Light on "Cool Communities"*). The resulting lower overall temperatures can make a difference in the amount of electricity consumed in air conditioning and reduce smog formation, potentially improving air quality in urban areas.

Research shows that light fixtures with suitable directivity and efficiency can illuminate public spaces with minimal energy use, while reducing wasted light. Such stray light is the prime source of light pollution, a rapidly growing theme in environmental design and quality of life.

Lighting accounts for up to 25% of annual electricity usage in the United States, according to the U.S. Department of Energy. When combined with high-albedo concrete surfaces, the efficiency of lighting can be enhanced to the point that fewer fixtures are needed, with accompanying reductions in energy use and light pollution.





Brighter public areas

Lighting of streets and highways supplements vehicle headlights to enhance driving safety. Public benefits of lighting include improved traffic flow in congested areas, enhanced pedestrian safety, and improved police services. Lighting can lend an air of activity and confidence that can bolster business such as retail sales and office rentals.

In pedestrian areas—central business district streets and plazas, parking lots, parking garages, and around shopping malls—lighting enhances safety, and can help improve commerce and maintain property values.

For commercial districts and shopping malls, bright lighting can increase patronage and revenues without adding to cost. Because lighting actually does enhance security, the likelihood of incidents is decreased, leading to lower liability exposures, fewer losses and claims, and reduced negative publicity, according to the National Lighting Bureau. It can even lead to reduced insurance premiums and decreased personnel costs via a reduction in security patrols required.

From an architectural viewpoint, lighting can improve the appearance of a facility. For little, if any, additional investment, security/safety lighting can be used much as an artist uses paint, to selectively illuminate those aspects of a facility or its grounds that look more attractive. This can enhance the building's aesthetic appeal and neighborliness.

And in all instances, use of portland cement concrete in those structures will make

light perform better. Utilization of white aggregates, such as quartzite, and premium white cement, will make your structure stand out even more.

Light for safer roadways

Increasing the number of light standards or pylons along highways for brighter roadways can make driving more hazardous, due to the increased hazard of collision. But because use of concrete can make the same amount of light go farther, fewer standards may be needed, although they may need to be taller to augment their distribution pattern.

Research for Transport Canada (1977) found an approximately 40% drop in luminance levels under the same illumination conditions for concrete roads overlaid with bituminous asphalt.

The superior reflectance of concrete pavements was carved in stone, so to speak, with the 1983 release of American National Standards Institute (ANSI) publication RP-8, *Practice for Roadway Lighting* (revised 1993). This publication recognized the significant contribution of road surface reflectance to the performance of the roadway lighting system.

"The pavement surface in effect becomes part of the lighting system," says consulting illuminating engineer Richard E. Stark in the journal *Lighting Design + Application*, April 1986. "High-reflectance pavements require less illumination than low-reflectance surfaces."

The new standard embodied use of the newer luminance methodology—based on light



Concrete pavement reflects up to 27% of light. Black asphalt pavement reflects only 5% of light.

Illuminated pavements are safer pavements

Hard evidence supports the contention that illuminated pavements are safer pavements. The Wisconsin Department of Transportation found out the hard way, when in 1980 it curtailed lighting on 55 miles of Milwaukee expressways and 100 interchanges as a means of saving money.

The DOT cut out the lighting on Oct. 1, but amid immediate public outcry the governor ordered the lights back on only three weeks later. Data gathered by the DOT during the "lights out" period indicated a 6% increase in nighttime accidents, compared to the average of the same period in the three preceding years.

The number of reportable night accidents increased 14%; injury accidents increased 5%; the number of persons injured increased 50%; and interchange ramp accidents increased 35%. Yet another study showed a startling 77% increase in nighttime accidents over the immediately preceding 20 days, Sept. 10–30.

Earlier research from Canada during the Energy Crisis from December 1973 through March 1974 reflects these trends. As a result of the acute oil shortage, a large portion of street and highway lighting was switched off. Transport Canada's data show a dramatic increase in the accident rate for that period, of nearly 30% for motorways, 2% for rural roads, and nearly 11% for urban roads.

reflected from the pavement surface and toward the driver's eye—as opposed to the preceding luminance method, which only considered light falling on the pavement surface. The luminance method—while more complicated mathematically—is thought to better reflect real-world conditions. It originated in Europe and was adopted as a European standard in the early 1980s.

ANSI's standard classifies pavements into four categories, with portland cement concrete and asphalt with artificial brighteners added as the most reflective (R1), and asphalt with a very smooth surface as least reflective (R4).

This means that concrete pavements and structures allow the same lighting standard to be met with a smaller investment in equipment and wattage, resulting in a lower initial investment and lower energy and maintenance costs.

And new lighting technologies will make portland cement concrete even more attractive as a construction material. For example, a cost-effective application for prism light guides is tunnel and roadway lighting.

In Boston's Callahan Tunnel, 11,880 feet of "light pipe" is replacing linear fluorescent luminaires. The prism light guide provides drivers with uniform, linear light along the length of a tunnel while reducing lighting maintenance costs. High-reflectivity in the tunnel's interior makes light go farther, so to speak.

With the proprietary Lighted Guidance Tube (LGT), the leakage light from a prism light guide aids drivers traveling through hazardous roadways, such as construction work zones or sharp curves. The LGT can be mounted on con-

crete barriers to provide a continuous line of light, according to the Rensselaer Polytechnic Institute in its May 1998 quarterly publication, *Lighting Futures*.

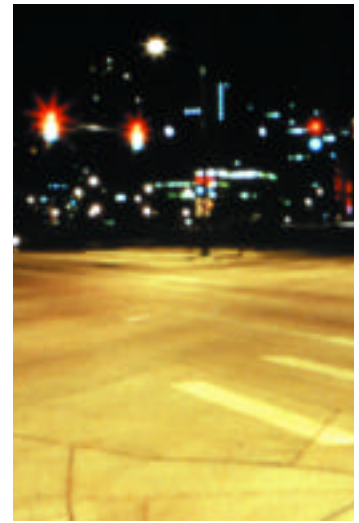
Reduce crime in parking facilities

Good lighting, coupled with a high-reflective surface, will do much to increase parking facility security, says Mary S. Smith, vice president of Walker Parking Consultants, writing under a grant of the American Institute of Architects.

Because parking facilities comprise a large volume of space with relatively low levels of activity, violent crime is more likely to occur in a parking facility than in other commercial areas, she says. But Crime Prevention Through Environmental Design (CPTED) concepts can be applied to parking facilities to enhance their safety.

An individual can be isolated in a parking area and targeted for an attack, which, in turn, attracts people with criminal intent. In particular, Smith notes, parking garages, which are either partially or fully enclosed and elevated above grade, offer much less natural surveillance—a primary focus of CPTED—than does an open single-level parking lot of the same capacity.

Thus it makes sense for parking facility owners and designers to specify adequate lighting and remote monitoring systems, and specify concrete as a building material to make that light go farther on dark nights, saving money and energy while making patrons safer.



Concrete parking lots are brighter—and safer—at night.

A Lexicon of Lighting

(Adapted from Shaflik and the International Dark-Sky Association)

Candela measures the luminous intensity of a lighting source. It's the basic unit of photometric quantity.

Full Cutoff Type Fixture is a luminaire or light fixture the housing of which doesn't allow any light dispersion or direct glare to shine above a 90-degree, horizontal plane from the base of the fixture.

Illuminance (or illumination level) is defined as the amount of light being transmitted upon a certain area. The SI unit for luminance is the lux, which is equal to one lumen per square meter.

Light Trespass is light from an artificial source that is intruding into an area where it is not wanted or does not belong.

Lumen is the unit of luminous flux produced by the source and is directly related to the candela. The lumen can be loosely interpreted as the amount of light emitted from a source with a certain intensity.

Luminance is the brightness of an object that has been illuminated by a source. The luminance of an object depends on its material characteristics and reflectance. For example, under the same luminance conditions a dark object will look less bright than a light object. Since luminance refers to the amount of light reflected back by an object, this object in effect acts as a new source. The unit of luminance is the candela per square meter.

Uplighting describes any light source that distributes illumination above a 90-degree horizontal plane.

Governments influence design

Municipal governments can have a major influence on parking garage design, and local officials can play a much stronger role in fostering security planning, Smith said, as reported by the International Dark-Sky Association (IDA).

"The single most important CPTED security feature is lighting," she writes. "Lighting fixtures selected for a parking facility must do more than just provide ample, glare-free lighting. As a key component of the security system, they must also be reliable, easy to maintain, able to withstand the elements, and protected from vandalism.

If local officials wish to encourage or mandate security in parking facilities, the single most effective thing they can do is to require good lighting," Smith says.

"Staining [coloring] concrete is a cost-effective method of increasing general brightness and creating a sense of well-being," Smith says, adding, "White stain on ceilings and beam soffits reflects light, thereby increasing uniformity."

Staining ceilings and beam soffits white may improve the lighting level of a particular design by as much as one level of service, she observes, adding, that a good quality concrete stain will last at least 10 years in these locations, but that paint creates the same brightness and requires increased maintenance.

White stain on walls seems to encourage graffiti, however, which tends to hurt the perception of security, she notes. Instead of white stain, anti-graffiti coatings may be used on walls to ease cleaning.

Choose luminaires wisely

Light pollution is a growing problem in urban areas, and one getting more attention from architects and planners. Common design sense—such as using the right kind of fixtures at the right location—is a primary means of limiting light pollution. Also important is appropriate local legislation, like that requiring billboard illumination to be aimed downward instead of upward.

"In many areas light pollution has become an important aspect of both planning and design," writes Carl Shaflik, P.E., in *Environmental Effects of Roadway Lighting*, August 1997. Shaflik is affiliated with the University of British Columbia, Department of Civil Engineering.

"Light trespass can be correctly equated to wasted energy," Shaflik writes, citing research undertaken by the International

Dark-Sky Association, which estimates that up to 30% of all roadway lighting is lost or misdirected from the intended source. This translates to over \$1 billion per year in lost energy in the United States alone, in addition to concomitant increases in air pollution from the wasted energy.

Luminaires are classified by their vertical light distribution, lateral light distribution, and the control of distribution above maximum candlepower, known as cutoff. Vertical and lateral light distributions apply primarily to the shape of the roadway area to be illuminated. Both of these distributions can be important when determining the amount of light trespass from a source.

Solutions to problems of light trespass are simple and inexpensive, Shaflik says. "Designers must take care to use luminaires with distributions suitable to the roadway. It is not necessary to apply an arbitrary 'safety factor' and overlight an area. And finally, the use of full-cutoff luminaires greatly increases the control of the stray light."

New, much improved light sources are now available that provide considerably more light per unit of energy, IDA says. "Most newer fixtures offer better light control, putting light where it is needed rather than wasting a great deal of the light produced by the lamp. Replacement of older fixtures and lamps with newer, improved ones can greatly improve efficiency."

Night and day, concrete's the one

By day, portland cement concrete pavement and products' high albedo means more solar heat can be reflected into the atmosphere, contributing to "cooler communities" and resulting in lower energy consumption and air pollution.

At night, that same high reflectivity makes for improved lighting, with safer roadways, parking garages and public places, and additional energy savings. And concrete can make for more attractive exterior displays, highlighting aesthetic architectural features.

Without a doubt, use of concrete for public spaces is a truly bright idea.

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Environmental Council
of Concrete Organizations

The Environmental Council of Concrete Organizations is a coalition dedicated to promoting the environmental benefits of concrete and its role in safe and sustainable construction.

ECCO members are companies, organizations, and individuals affiliated with the concrete industry. Together, they are committed to developing and disseminating information on the environmental benefits of concrete and concrete products.
