

Fundamentals of Lighting

Module 6

Lighting for Exteriors

For a PDF copy, send me an email to randy@rsltg.com



IES Lighting Handbook, 10th Edition

Recommended Practice Guides (RP):



RP-33-99



RP-8-00



RP-06-11



RP-22-11

International Dark-Sky Association:



www.darksky.org

Module 6: Introduction

Goals for Exterior Lighting:

• **Similar goals to Interior Lighting:**

- ✓ Create a comfortable and pleasant environment for the occupant.

• **Additional goals include:**

- ✓ Pedestrian safety
- ✓ Vehicular operation
- ✓ Safety/security
- ✓ Lack of intrusion into the nighttime environment



Exterior Lighting

Lighting the outdoor environment is different from lighting an interior space.

Outdoors, the universal standard reference is the daytime sun and sky.

The night outdoor environment presents the following design challenges.....



Exterior Lighting – Design Challenges

- Electric lighting cannot light the sky as the sun does.
- No single fabricated light source is as powerful as the sun



Exterior Lighting – Design Challenges

- At low light levels the eye works differently from the way it works at high daylight light levels.
- People experience different emotions at night. Lighting can affect these emotions, not only when viewing dramatic scenery, sporting events, and outdoor entertainment, but it also affects feelings of personal safety and security such as in a parking lot.



Exterior Lighting – Design Challenges

- Outdoor lighting can be seen at great distances, and nighttime visual clutter can be distracting and disturbing.



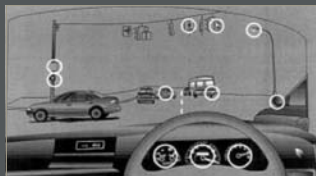
Exterior Lighting – Design Challenges

- Outdoor lighting can be seen at great distances, and nighttime visual clutter can be distracting and disturbing.



Exterior Lighting – Design Challenges

- Nighttime tasks, such as playing sports or driving automobiles, have very specific lighting requirements so people can perform these tasks safely and effectively.
- There is an expectation (or need) to control the light added to the outdoor environment.





Module 6: Metrics

Foot-candle = $\frac{\text{Candle Power}}{\text{Distance}^2}$

Exterior Lighting Metrics:

• **Horizontal illuminance** - important in areas, such as parking lots, sports fields, and roadways; generally given for a horizontal plane at the walking, playing, or driving surface.

$E = \frac{I}{D^2} \times \cos \theta$

• **Vertical illuminance** - important for visibility of a person or an object in areas such as pedestrian walkways

$E = \frac{I}{D^2} \times \sin \theta$

Module 6: Metrics

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Exterior Lighting Metrics:

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$E = \frac{I}{D^2} \times \cos \theta$

Cos (0 deg) = 1 Cos (45deg) = 0.707

• **Vertical illuminance** - important for visibility of a person or an object in areas such as pedestrian walkways - **ADD vertical surfaces...** such as building facades, people's faces and bodies, signs, structures, statues, and landscape features such as trees

* Surface luminance adds interest and depth to an outdoor scene and can be necessary for good outdoor visibility and security. It is important to see the *effect* of lighting, not the source.

$E = \frac{I}{D^2} \times \sin \theta$

Sin (0 deg) = 0 Sin (45deg) = 0.707

Module 6: Metrics

Illuminance and Luminance of Roadway Surfaces

- **Illuminance:** amount of light arriving upon a surface.
- **Luminance:** the amount of light reflecting from the surface and reaching the eye of the observer.
- **Photo (right):** *illuminance* is the same across the roadway surface. The *luminance*, is twice as high in the left lane as in the right lane because the surface reflectance is twice as high.



Seeing Light



We See Brightness / Luminance

Measures how easy something is to see, or how bright a surface is – **visibility or contrast with background**

Examples: backlit signage, a full moon, glowing wall, the contrast of steps

Measured in: Foot-Lamberts (US) or Candelas per meter squared (metric)

1 Foot-Lambert = 3.426 Candelas/m²



We do Not See Light Levels / Illuminance

Measures how much light there is, the light level to perform a task – **illumination**

Examples: emergency light level on the floor), on the desk, on a book

Measured in: Foot-Candles (US) and Lux (Metric)



Exterior Lighting – IES illuminance Levels

- Illuminance (in lux or foot-candles) is a measurement of light falling on a surface.
- Too often illuminance is the only metric used to design and evaluate exterior environments.

IESNA Lighting Design Guide		Outdoor 1			
OUTDOOR TASKS		Very important	Important	Essential important	Basic or not important or not applicable
Architectural Signage and Public Markers (see Bulletin and Public Notices, or Signs)	Very important	Important	Essential important	Basic or not important or not applicable	
Aluminum walkways – commercial areas Shopping mall walkways	Very important	Important	Essential important	Basic or not important or not applicable	300, 71, 20, 28
Building General illumination Construction work	Very important	Important	Essential important	Basic or not important or not applicable	10, 10, 10, 10
Building Exterior Construction work	Very important	Important	Essential important	Basic or not important or not applicable	10, 10, 10, 10



Summary of IES illuminance Levels

	Horizontal	Vertical
Bikeways	1 fc	2 fc
Building Entries	5 fc	3 fc
Gardens		
• General	0.5 fc	0.2 fc
• Paths, away from bldg	1 fc	0.3 fc
• Parks	5 fc	3 fc
Retail		
• Fast Food	10 fc	3 fc
• Car Dealer Lots	5 fc	3 fc
• Outdoor Malls	3 fc	3 fc



Roadways *depends on road classification and pavement material*

Reflectance

Surface Material Type:	Reflectance
Light Light Marble, White Plaster, Concrete, White/Cream Terra Cotta	70%-85%
Medium Light Tinted Stucco, Buff Sandstone, Buff Brick	40% - 70%
Medium Dark Medium Grey Limestone, Tan Brick, Sandstone	20% - 45%
Dark Red Brick, Brownstone, Stained Wood, Dark Grey Brick	10% - 20%



Module 6: Critical Design Considerations

Visibility

The actual **visibility** of a stationary object of a fixed size and uniform luminance is a function of the following criteria:

- Contrast between the luminance of the object and its immediate visual background.
- General adaptation level of that portion of the retina of the eye concerned with the object.
- Difference in eye adaptation between successive eye movements (transient adaptation).
- Size, shape and color of the object.
- Background complexity and the dynamics of motion.
- Visual capability of the observer.



Exterior Lighting – Luminance / Brightness

Often, the terms "brightness" and "luminance" are used interchangeably, but they have different meanings.

- **The Luminance** of a source or surface is the intensity of the source or surface in the direction of an observer – reflected light off a surface.
- **Brightness** is what an individual sees or perceives largely as a result of the luminance of the source or surface to the background.

The brightness of the two sources or surfaces with the identical luminance can appear different, if in different environments.



Module 6: Critical Design Considerations

Glare

- Glare (excessive differences in luminance) matters a great deal during nighttime outdoor lighting conditions
- Glare can impair the ability of a person to perform visual tasks.



Module 6: Critical Design Considerations

Glare

- In bright environments, the amount of light reaching a person's eye has less of an impact on the overall perception of glare.
- This is due to the level of eye adaptation caused by the bright environment.



Module 6: Critical Design Considerations

Glare

- In darker environments, the amount of light reaching someone's eye must be limited.
- This task can be accomplished with good optical control in the luminaire



- When luminaires do not have a great deal of optical control, more luminaires with lower lumen output lamps can be used to reduce glare



What is Glare?

Glare is not brightness. Glare is contrast.

- Glare can be a good thing... if controlled and minimized.



What is Glare?

Disability glare is caused by stray light scattered within the eye, which reduces the contrast of the retinal image.



What is Glare?

Discomfort glare from a light source produces a sensation of discomfort. It is caused by high contrast or a non-uniform distribution of luminance in the field of view.



Module 6: Critical Design Considerations

Light Trespass

- **Light trespass** - light that leaves the area for which the lighting system was designed and "trespasses" onto the property of abutters (right).
- **To minimize** - light must be controlled with a combination of luminaire optics, pole placement, and overall light levels.
- Curfews are also a good strategy in some applications



What is Glare?

Nuisance or annoyance glare has not been quantified, though research is ongoing. Essentially, nuisance glare occurs when light appears where it does not belong.



Module 6: Critical Design Considerations

Light Trespass

- Recommended Light Trespass Limitations: Zone E0 has no electric lighting

Environmental Zone	Pre-Curfew Limitations*	Post-Curfew Limitations*
E1	1.0 (0.10)	0.0 (0.00)**
E2	3.0 (0.30)	1.0 (0.10)
E3	8.0 (0.80)	3.0 (0.30)
E4	15.0 (1.50)	6.0 (0.60)

* Lux (footcandles) values on a plane perpendicular to the line of sight to the luminaire (s).

**Where safety and security are issues, nighttime lighting is needed. Such lighting should meet IESNA recommendations for the particular property being lighted. Lighting should be designed, however, to minimize light trespass



Module 6: Critical Design Considerations

Sky Glow

Sky Glow - The brightening of the night sky that results from the reflection of radiation (visible and non-visible), scattered from the constituents of the atmosphere (gas molecules, aerosols and particulate matter) in the direction of observation.

- Natural sky glow:** That part of the sky glow that is attributable to radiation from celestial sources and luminescent processes in the Earth's upper atmosphere.
- Man-made sky glow:** That part of the sky glow which is attributable to man-made sources of radiation (e.g., artificial outdoor lighting), including radiation that is emitted directly upwards and radiation that is reflected from the surface of the Earth.



Dark Skies Organization - www.darksky.org

Unwanted Light at Night

The topic of light trespass is somewhat subjective, because it often relates to un-measurable and indefinable factors. A typical example is the "light shining in my window" complaint. A simple solution to this problem is to shield the offending luminaire so that its luminance is not directed toward the complainant.

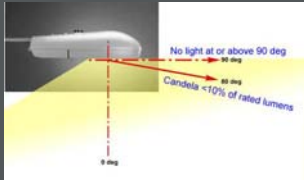
The following suggestions help control light trespass problems, including nuisance glare:

- Inspect areas adjacent to the lighting design location to identify and consider any potential problems involving residences, roadways, and airports.
- Select luminaires that have tightly controlled intensity distributions, using full cutoff reflectors and refractors.
- Contain light within the design area by carefully selecting, locating, mounting, and aiming (when appropriate) the luminaires.
- Use well-shielded luminaires (or select equipment that can be shielded) if a potential problem is found after installation.
- Keep floodlight aiming angles low so that the entire beam always falls within the intended lighted area during (and after) the design and installation process.
- Turn off outdoor lighting during times of low use.



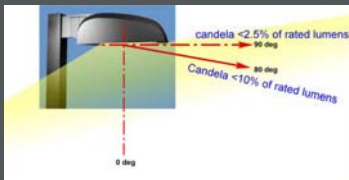
Vertical Classifications: Full Cut-Off

- Cut-off optics to control the light above horizontal – above 90 deg
- Reflector to redirect the light



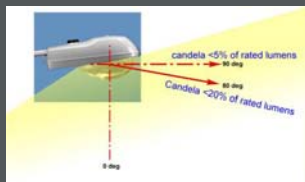
Vertical Classifications: Cut-Off

- Cut-off optics to control the light above horizontal – above 90 deg
- Reflector to redirect the light



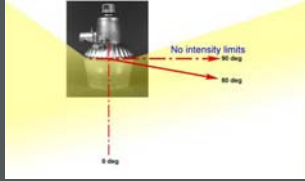
Vertical Classifications: Semi Cut-Off

- Cut-off optics to control the light above horizontal – above 90 deg
- Reflector and or Refractor to redirect the light



Vertical Classifications: Non Cut-Off

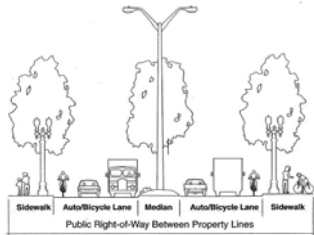
- Cut-off optics to control the light above horizontal – above 90 deg
- **Reflector** and or **Refractor** to redirect the light



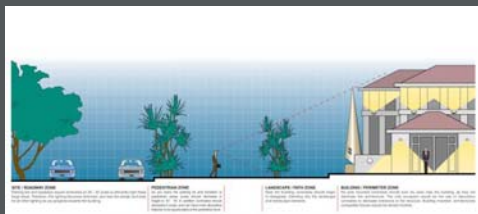
Module 6: Critical Design Considerations

Exterior Elements

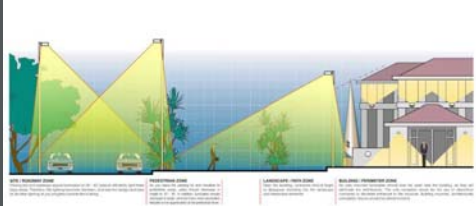
- Lighting designers first become familiar with all of the elements in the environment.
- Investigate applications and then coordinate the different elements with the design.
- Elements can consist of street furniture, signage, landscaping, parking, etc. as show, (right).



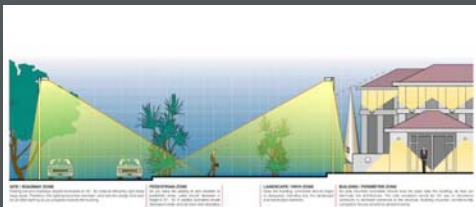
Roadway / Pedestrian Lighting



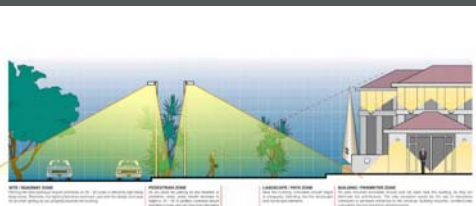
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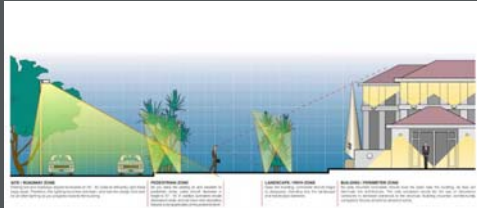
Roadway / Pedestrian Lighting



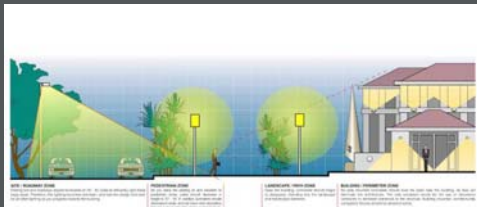
Roadway / Pedestrian Lighting



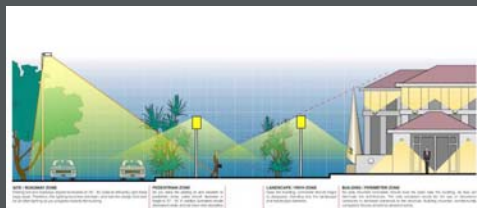
Roadway / Pedestrian Lighting



Roadway / Pedestrian Lighting



Roadway / Pedestrian Lighting



Module 6: Critical Design Considerations

Foliage

Luminaire placement should take foliage placement and foliage growth into account!



Module 6: Critical Design Considerations

Safety and Security

- Research has been performed on the relationship between safety and lighting.
- Most of that research has shown that providing lighting does increase safety and reduce accidents.
- The most dramatic safety impacts can be seen in the reductions of pedestrian and cyclist fatalities.



Module 6: Critical Design Considerations

Equipment Ratings

Equipment used in exterior environments should be suitable for those environments and should carry an Underwriter's Laboratory (UL) or Canadian Standards Association (CSA) label for the proposed use.

Luminaires should be UL rated for wet locations when necessary.



Module 6: Critical Design Considerations



Module 6: Critical Design Considerations

Materials

Luminaire Selection: When considering luminaires for a lighting design, assure they will hold up acceptably in the specific environment.

Considerations: The following materials and components must be considered during the design phase.



Module 6: Critical Design Considerations

Materials: Housings

- **Housings Materials** - exterior Luminaires are fabricated from a variety of materials, including aluminum, steel, stainless steel, cast iron, plastic, bronze and brass.
- **Corrosive environments** - salt, city and industrial air pollution require that lighting fixtures be fabricated from materials resistant to corrosion.
- **Finishes** - such as marine-grade polyester powdercoat paint, or hot-dip galvanized finish also prevent problems.



Corroded metal



Module 6: Critical Design Considerations

Materials: Lenses and Diffusers

Lenses for exterior luminaires are commonly fabricated from acrylic or polycarbonate plastic or from glass (right.) As with painted finishes, these materials can be susceptible to the impacts of environment, as well as the UV component in daylight or lamp sources.



Glass is not affected by UV light and actually blocks a significant amount of the UV light produced by fluorescent, halogen, or metal halide lamps or daylight.



Module 6: Critical Design Considerations

Materials: Lenses and Diffusers

Acrylic Plastic - somewhat affected by UV light, but DR Acrylic is more resistant and should be used if available (see photo, right). Acrylic is not susceptible to breakage but may shatter if vandalized in a very cold environment.



Polycarbonate Plastic (Polycarb) - is very resistant to breakage and is often used in areas where vandal resistance is important. It is, however, greatly affected by UV Light and will yellow significantly over time.



Module 6: Critical Design Considerations

Materials: Vandalism

Polycarbonate plastic - least breakable of the lensing materials. Should be considered if the luminaire has a lens that is accessible to vandals.



Shields - street lights that have a thick glass lens, which can be quite vandal resistant, will have the option of a plastic vandal shield, which fits below the lens and gives added protection.



Module 6: Critical Design Considerations

Light / Glare Controls

▪ **Beam control** - usually provided by a combination of the optics system (reflector and lamp) or by the lamp itself (e.g., PAR-Lamps). In some outdoor accent equipment, however, these optics may be variable.



▪ **Glare controls** - found inside the luminaire housing or outside the luminaire as an add-on and are fabricated from metal or plastic. Include louvers, cross baffles, or concentric louvers, which reduce the view of the lamp from various angles (right).

▪ **House-side shields** - shield the area of the "house" or building from unwanted light. Found primarily on street lighting equipment - but also flood lighting equipment.



Module 6: Critical Design Considerations

System Controls

To be most effective, lighting-system controls should always be automatic rather than being triggered by a typical on/off toggle switch.



Automatic controls - can be as simple as a time clock but may also include motion sensors, photosensors, and hookups to computer control systems.



Module 6: Critical Design Considerations

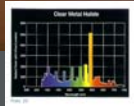
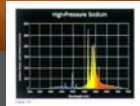
Spectral Effects

Spectral effects - the effects of different colored light sources on people's ability to see, have been undergoing much research and scrutiny in recent years.

Under low light levels (below 0.5 fc), we can see better under a light source that contains a short wavelength ("blue") light component (e.g. metal halide, left) than we can under a source without a blue-light component (e.g., high pressure sodium, right) as shown below.



Spectral Effects: HPS vs Metal Halide



Exterior Lighting – Community Response

Traditionally, street lighting has been the basic component of public outdoor lighting.

- In urban settings, it is the street lighting, along with traffic signals and signs, that organizes and defines the visual environment at night.



Exterior Lighting – Community Response

Public lighting systems can help define urban character and image.

- Lighting systems may illuminate for streets, roadways, sidewalks, pedestrian malls, pathways, bikeways, parks, monuments, buildings, structures, statues, fountains, and landscapes.
- A hierarchy of public lighting connotes the relative importance and character of cityscapes and enhances their information-giving value.



Exterior Lighting – Community Response

Special features and amenities of urban environments should be lighted to reveal their importance.

- Buildings and monuments can serve as markers or reference points to provide visual orientation.
- Urban landscape elements can act as visual anchors and serve as points of arrival for neighborhood residents.



Exterior Lighting – Community Response

Special features and amenities of urban environments should be lighted to reveal their importance.

- The streetscape or pedestrian spaces should appear consistent with the community theme, both day and night so the lighting equipment should be integrated into the daytime scenes



Project Example: Celebration Town Center, Florida



Project Example: Celebration Town Center, Florida



Project Example: Celebration Town Center, Florida



Project Example: Celebration Town Center, Florida



Project Example: Gateway Plaza, Los Angeles



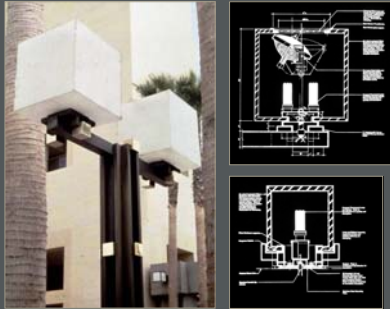
Project Example: Gateway Plaza, Los Angeles



Project Example: Gateway Plaza, Los Angeles



Project Example: Gateway Plaza, Los Angeles



Exterior Lighting - Equipment

Luminaire Classifications

Outdoor luminaires are classified by the manner in which they are

- Mounted
- Performance Classifications: **Roadway Lighting**
 - Horizontal Distribution, pattern on the ground
 - Vertical Distribution, Degree to which they provide cutoff (floodlights, by their beam patterns)
- Performance Classifications: **Structure Floodlighting**
 - Floodlight Distribution, by their beam patterns)



Exterior Lighting - Equipment

Pole or Post Mounted



Exterior Lighting - Equipment

Building or Ground Mounted



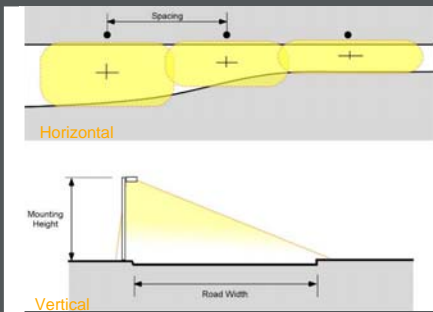
Exterior Lighting - Equipment

Ground Mounted for Object Lighting



Roadway / Pedestrian Lighting

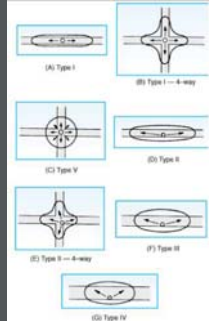
Luminaire Light Distribution



Roadway / Pedestrian - Equipment

Horizontal Distribution

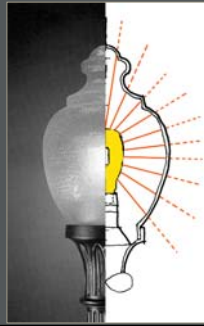
- The IESNA outdoor roadway luminaire classifications by horizontal intensity distributions are Type I, II, III, IV, and V.



Roadway / Pedestrian - Equipment

Horizontal Distribution

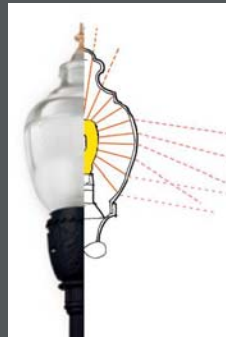
- Post or Pole Mounted with no control or optics
- **Bare Lamp** within a diffuser or enclosure to redirect the light
- Typically Type V
- "Non-Cutoff" vertical Type



Roadway / Pedestrian - Equipment

Horizontal Distribution

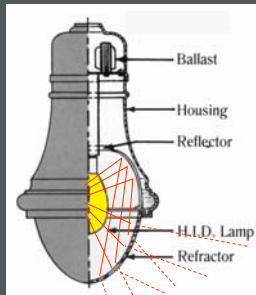
- Post or Pole Mounted with control optics
- **Reflector** to redirect the light
- Horizontal distribution can vary from Type I thru V
- "Non-Cutoff" vertical Type



Roadway / Pedestrian - Equipment

Horizontal Distribution

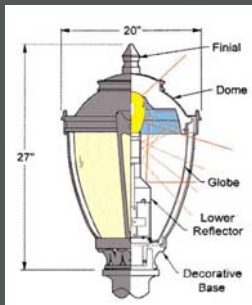
- Post or Pole Mounted with control optics
- **Reflector and Refractor** to redirect the light
- Horizontal distribution can vary from Type I thru V
- "Non-Cutoff" vertical Type



Roadway / Pedestrian - Equipment

Horizontal Distribution

- Post or Pole Mounted with cut-off optics
- **Reflector** to redirect the light
- Horizontal distribution can vary from Type I thru V
- "Semi-cutoff" vertical Type



Module 6: Exterior Lighting Applications

Roadway Lighting

Proper use of roadway lighting as an operative tool provides economic and social benefits to the public, including the following:

- Reduction in night accidents, attendant human misery, and economic loss
- Aid to police protection & enhanced sense of personal security
- Facilitation of traffic flow
- Promotion of business and the use of public facilities during the night hours



Module 6: Exterior Lighting Applications

Streets and Roads

- The road classification determines the appropriate levels of light and equipment positioning.
- In the past, roadway calculations were based primarily on horizontal illuminance calculations at the road.
- As driving speeds increased, the need to understand the driver's ability to see the road, any pedestrians, and other vehicles has made luminance calculations and illuminance calculations on vertical surfaces 1.5 meters above the road more important
- These calculations are very complex and include contrast issues, reflectance of road surfaces, and direction of traffic



Module 6: Exterior Lighting Applications

Pedestrian Areas Adjacent to Roadway

- **Sidewalks** are defined as paved or otherwise improved areas for pedestrian use, located next to the street (below left). The visibility issue is to provide enough light to see the curb and, if applicable, parked cars along the curb. In busy residential areas, the lighting needs to be appropriate to see a person or animal run out between the cars. **Levels of light are appropriately calculated for vertical illuminance, 1.5 meter above the grade.** Uniformity of light needs to be considered (below, left).
- Uniformity must also be considered (below, right).



Module 6: Exterior Lighting Applications

Pedestrian Walkways

- **Pedestrian walkways** - unlike sidewalks, do not necessarily run along the street
- **Examples** - skywalks (pedestrian overpasses), subwalks (pedestrian tunnels), and walkways giving access to parks, mid-block interiors, or midblock street crossings.



Module 6: Exterior Lighting Applications

Bikeways

- **Bikeways** - like walkways, can be either a part of or separate from roadways. When they are part of the roadway, they should be included in the lighting design for that roadway.
- **Goal** - to provide lighting for both navigating the path and seeing the other people on the path.



Module 6: Exterior Lighting Applications

Intersections

- Typically, about 50% of accidents in urban areas, excluding freeways, occur at intersections.
- The classification of intersections, and therefore the light levels required, is based on the classification of the streets creating the intersection.



Module 6: Exterior Lighting Applications

Roundabouts

- **Circular intersections** - where traffic is normally directed counterclockwise in one direction.
- **Lighting is calculated** - as illuminance on the horizontal plane at the roadway; however, when pedestrian access is included, calculations should also include vertical illuminance at 1.5 meters above grade.
- **Glare** - from on-coming headlights can be a real issue that should be addressed as well.



Module 6: Exterior Lighting Applications

Crosswalks

- **Crosswalks** – pedestrians must be seen at a distance by vehicle operators
- **Vertical lighting** - most important aspect for both for the vehicular operator, as well as for other pedestrians who want to be in a safe and comfortable environment.
- **Low-level lighting** - with a higher-than-normal light emittance - often placed adjacent to crosswalks between the on-coming traffic and the pedestrian.



Module 6: Exterior Lighting Applications

Tunnels

Tunnel lighting – is highly specialized and involves a large number of life/safety issues, including:



Tunnels are divided into three areas:

1. The threshold zone
2. The transition zone
3. Interior zone



Tunnel Lighting



Approach: The external roadway area leading to the tunnel.
Portal: The plane of entrance into the tunnel.
Threshold Zone: The first part of the tunnel where, during daytime, the highest level of the lighting is provided.
Transition Zone: The area where a transition is made from the high lighting level of the threshold to the lower lighting level of the interior.
Interior Zone: The innermost part of the tunnel where the lowest level of lighting is provided.
Note: Lengths of zones will vary with the design parameters.



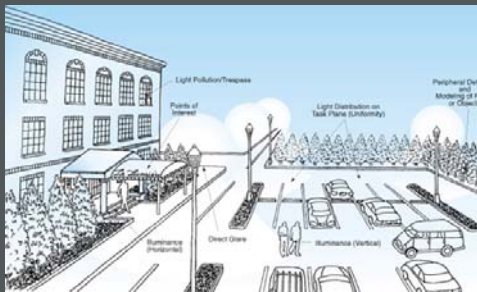
Module 6: Exterior Lighting Applications

Parking Lighting

- Parking lots are areas where vehicles and pedestrians mix
- The lighting system should meet the needs of both groups and, particularly, allow them to see each other clearly.



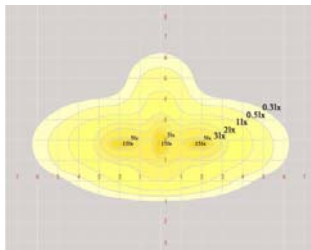
Parking Lot Lighting



Module 6: Exterior Lighting Applications

Parking Lot Lighting

- Uniform lighting of parking lots to appropriate horizontal illuminances requires detailed attention to the proper spacing of poles
- Proper spacing, in turn depends upon pole height and luminaire photometric distribution
- Uniformity is typically expressed as "max to min" or "average to min" values over the defined area.



Module 6: Exterior Lighting Applications

Enclosed Parking Structures

Reflectance of the structure itself is important and can noticeably affect the quality of the design.

As the quantity and uniformity of illuminance increases on the ceiling, walls and columns of the structure, the vertical and horizontal illumination throughout the space improves.



Module 6: Exterior Lighting Applications

Sports Lighting

- Good sports lighting design cannot be accomplished by approximation
- It typically requires calculations using sophisticated computer programs
- Avoidance of glare and light trespass are important factors in today's outdoor sports lighting designs
- Color rendition is another important factor, particularly when night time sports events are televised



Module 6: Exterior Lighting Applications

Sports Lighting

- **Goal** - to provide an appropriate luminous environment by controlling the luminance of the playing target (ball) and its background so the target will appear clear and sharp to the players, spectators, and television viewers.
- **Speed** - when the visual target must be observed at high speeds and at close range between players, higher illuminance is needed.
- **Higher levels of competition** - require higher levels of illuminance, as do the resulting requirements of increased speed and accuracy.
- **Spectators** - As capacity increases, the average observer is usually farther away from the visual target, so higher illuminance is again needed.
- **Computer calculations** - Perhaps more than any other type of exterior application, sports lighting should be field verified for light trespass



Module 6: Exterior Lighting Applications

Retail and Commercial Lighting

- **Applications** - range from car dealerships to gas stations to miniature golf courses.
- **Tasks** - Typically, projects can be sub-divided into tasks, such as display lighting, roadway lighting, or sports lighting.
- **Control strategies** - play an important role in the performance of security systems
- **Other issues** - spill light and ordinances and standards may be relevant, and every facility is likely to have path-ways, entrances and signage.



Module 6: Exterior Lighting Applications

Structures

Lighting of structures must be very carefully considered in order to create a balance between aesthetics, way-finding, and security, without creating glare or light trespass.

- **Goal** – to create visual focal points, reinforce circulation patterns in areas not adjacent to street lights, and to create a sense of security in areas where it is required.



Module 6: Exterior Lighting Applications

Structures Lighting - ATMs

- Proper design becomes essential when the safety and security of the public are at stake.
- Exterior ATMs need to be illuminated so that reading and writing tasks can be performed in an environment that is safe and secure.
- Illumination should not produce excessive glare to achieve these higher lighting levels, or place the ATM user "in the spotlight" and therefore potentially in harm's way.



Module 6: Exterior Lighting Applications

Structures Lighting

- Techniques for the lighting of structures and landscape lighting include flood lighting, grazing light, and highlighting and are very similar to interior lighting, except in terms of scale.
- Choice of the light source is based on energy use, ambient temperature, and maintenance characteristics.



Module 6: Exterior Lighting Applications

Structures Lighting



Bridge lighting using HPS and LED



Palace of Fine Arts using halogen and HPS

Module 6: Exterior Lighting Applications

Structures – Luminaire Placement and Color

- If lighting a structure to create high drama, and three-dimensional qualities or textural effects are needed, the luminaires will need to be located quite close to the subject
- Color choices of the light sources used for structure and landscape lighting are based on how the objects are to be perceived.
- Recently, LED, luminaires have become more predominant in structural, landscape and accent lighting schemes due to typically long life characteristics and the possibility of color changing as a feature



Structure Lighting

Criteria for Building Floodlighting: It is assumed that careful thought has been given, and cost analysis carried out, to determine whether floodlighting the structure is desirable and will be of benefit.

From a design guideline point-of-view, the following should be considered:

1. What features of the building might best be highlighted?
2. Should the entire structure be highlighted, or only a portion of it?
3. From what angles can these illuminated portions be seen? *To justify the lighting, worthwhile viewing points (such as from expressways, streets, bridges, overlooks, or cetera) should exist.*
4. How bright should the lighting be? What portions should be brightest?
5. What color should the light be? *Is it desirable to change the color of the building at night? A mock-up of the light source can determine the appropriate lamp for the project.*
6. And the primary question-what appearance should the building have at night? *The intensity and type of light are of secondary importance since these are merely the tools employed to achieve the end result.*

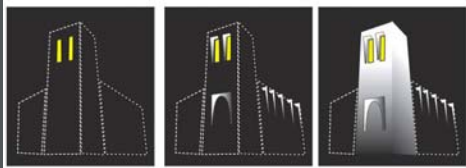


Structure Lighting

Concepts for Illumination

There are three basic types of building illumination:

- **Internal** - the illumination of interior surfaces visible from the exterior to create a glow from windows
- **Immediate** - the illumination of architectural features
- **Far** - floodlighting of entire facades



Structure Lighting

Internal Lighting – Examples

- Illuminate interior apertures (windows, entries, archways)



Structure Lighting

Immediate Lighting – Examples

- Illuminate architectural features (window frames, buttress, arches)



Structure Lighting

Far Lighting – Examples

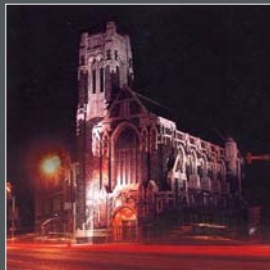
- Illuminate surfaces (key facades, brighter at top)



Structure Lighting

Far Lighting – Examples

- Illuminate surfaces (key facades, brighter at top)



Basic Concepts for Illumination of 3D Objects

...irrespective of size, a three-dimensional artifact must be illuminated from several different directions:



Combination Key, Fill, and Back light

Light from multiple directions..

- renders a sculptures detail
- expresses depth by highlighting some areas while allowing others to fall into shadow
- different angles render material variations with lesser or greater emphasis



Key light only



Fill light only



Back light only



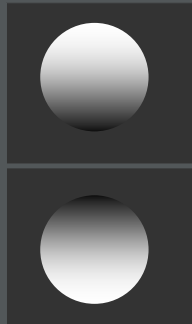
Basic Concepts in using Color for Illumination of 3D Objects

...using warm and cool sources for Key and Fill light not only increases sense of shape and depth of an object, but assist with defining direction of light.



Basic Concepts for Perception of 3D Objects

...the direction of light provides visual information about an objects shape:



Light And Shade:

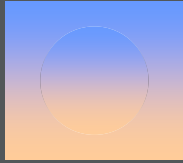
Highlights and shadows can provide information about an object's dimensions and depth.

Our visual system assumes the light comes from above, a totally different perception is obtained if the image is viewed upside down.

For more images, check out [this link](#)



Basic Concepts in using Color for Perception of 3D Objects

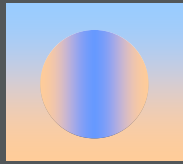


Cool Light And Warm Shade:

Color also can provide information about an object's dimensions and depth.

Our visual system assumes the light comes from above, we rely on our visual experience with nature to explain direction of light

Visual experience tells us warm light comes from the interior (warmth) and cooler light source comes from nature - daylight or day, moonlight or night



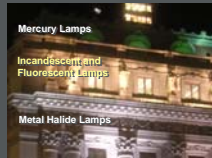
Moonglow



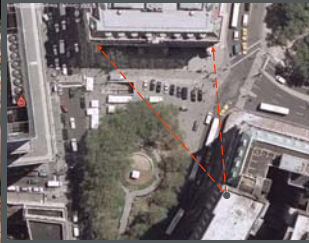
Project Example: US Customs House



Project Example: US Customs House



Project Example: US Customs House



Project Example: US Customs House



Project Example: US Customs House



Module 6: Exterior Lighting Applications

Landscape Lighting

- Highlighting plants, trees, and gardens is a way to extend the nighttime "view" from both residential and commercial structures.
- The color of the source and duration of highlighting becomes more important as the length of time the plants are highlighted extends.
- Note that trees, shrubbery and plants require a period of dark to finish the photosynthesis process that produces food.



Module 6: Exterior Lighting Applications

Landscape Lighting

Remember to position luminaires to minimize glare and to select appropriate system controls to turn the luminaires off after mandated curfews



Module 6: Exterior Lighting Applications

Conclusion

Exterior lighting requires the balancing of many critical aspects of lighting. These include:

- Minimum and average illuminance (both horizontal and vertical)
- Visibility considerations, including luminance, contrast, adaptation, background complexity, and the color, size, shape, and reflectance of the object(s) being illuminated
- The proper selection of light sources, luminaires and other lighting equipment for outdoor environments
- Minimization of glare, sky glow, and light trespass
- Achievement of the desired safety and security goals
- Achievement of energy use/energy savings goals
- Aesthetic considerations

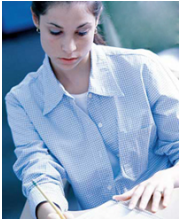


To achieve the desired results, here are some simple recommendations to keep in mind.

- Determine light levels using the appropriate IESNA document and use those as the illuminance goals.
- Glare is one of the most critical issues with exterior lighting systems. Select proper equipment and place it properly in order to minimize glare.
- In most designs involving pedestrian safety issues, whether adjacent to roadways or in parking areas, meeting vertical illuminance recommendations is the key to a successful installation.
- Exterior lighting systems must be integrated and coordinated with the natural and architectural environment. Design should always be performed in conjunction with the landscaping, civil, site, building, and utility design teams.



Module 6: Quiz Time!



Congratulations – you have concluded Module 6.

Now, it's time for the quiz.

Good luck!