Chapter 6

Lighting

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6 Lighting

6.1 ~~A~~ Introduction

The major reason for lighting streets and highways is to improve safety for vehicular and pedestrian traffic. Improvements in sight distance and reduction of confusion and distraction for nighttime driving can reduce the hazard potential on streets and highways. There is evidence indicating that highway lighting will produce an increase in highway capacity as well as improve the economic, safety, and aesthetic characteristics of highways.

Experience and technical improvements have resulted in improved design of lighting for streets and highways. Photometric data provide a basis for calculation of the illumination at any point for various combinations of selected luminaire types, heights, and locations. Lighting engineers can develop lighting systems that will comply with the requirements for level and uniformity of illumination; however, some uncertainties preclude the adoption of rigid design standards. Among these uncertainties is the lack of understanding of driver response and behavior under various lighting conditions. The design of lighting for new streets and highways, as well as improvements on existing facilities, should be accompanied by careful consideration of the variables involved in driver behavior and problems peculiar to particular locations.

Rights of way with pedestrian sidewalks and/or bikeways adjacent to the roadway should first address lighting requirements for the roadway to assure it is continuously illuminated. Additional lighting for a sidewalk or shared use path may be necessary if it is substantially set back from the roadway, at the discretion of the responsible/maintaining agency. Pedestrian sidewalks and/or bikeways should not be illuminated in lieu of lighting the adjacent roadway to avoid glare or potential lighting distractions to drivers.

See **Chapter 17 – Bridges and Other Structures,** **Section 17.3.6** ~~Section C.6~~ for structural requirements for lighting.

6.2 ~~B~~ Objectives

The objective for providing lighting is to improve the safety of roadways, sidewalks, and shared use paths and visibility of signs for road users (drivers, pedestrians, and bicyclists). The achievement of this objective will be aided by meeting these specific goals:

- Provide an improved view of the general highway geometry and the adjacent environment.
- Increase the sight distance to improve response to hazards and decision points.

- Eliminate "blind" spots unique to travel at night or in low light conditions.
- Provide a clearer view of the general situation during police, emergency, maintenance, and construction operations.
- Provide assistance in roadway, sidewalk or path delineation, particularly in the presence of confusing background lighting (i.e., surrounding street and other area lighting confuses the driver on an unlighted street or highway).
- Minimize glare that is discomforting or disabling.
- Reduce abrupt changes in light intensity.
- Avoid the introduction of roadside hazards resulting from improper placement of light poles, pull boxes, etc. (as covered under **Chapter 3 – Geometric Design** and **Chapter 4 – Roadside Design**).

6.3 ~~C~~ Warranting Conditions

Although precise warrants for the provision of roadway lighting are difficult to determine, criteria for lighting is established and should be followed for new and reconstruction projects and for improvement of existing facilities. The following locations should be considered as a basis for warranting roadway lighting:

6.3.1 ~~C.1~~ Criteria Based Upon Crash History

- Locations that, by a crash investigation program, have been shown to be hazardous due to inadequate lighting.
- Locations where the night/day ratio of serious crashes is higher than the average of similar locations.
- Specific locations that have a significant number of nighttime ~~night time~~ crashes and where a large percentage of these nighttime ~~night time~~ crashes result in injuries or fatalities.

6.3.2 ~~C.2~~ Criteria Based Upon Analysis and Investigation

- Locations requiring a rapid sequence of decisions by the road user.
- Locations where night sight distance problems exist, with consideration to headlight limitations (i.e., where vertical and horizontal curvature adversely affect illumination by headlamps).
- Locations having discomforting or disabling glare.

- Locations where background lighting exists, particularly if this could be distracting or confusing to the road user.
- Locations where improved delineation of the highway alignment is needed.

6.3.3 ~~C.3~~ General Criteria

- Roundabouts and signalized intersections.
- Urban streets, particularly with high speed, high volumes, or frequent turning movements.
- Urban streets of any category experiencing high nighttime ~~night time~~ volumes or speeds or that have frequent signalization or turning movements.
- Areas frequently congested with vehicular and/or pedestrian traffic.
- Pedestrian and bicyclist crossings (intersections or mid-block locations).
- Transit stops and hubs, passenger rail stations.
- Areas such as entertainment districts, sporting arenas, shopping centers, beach access points, parks, and other locations that generate higher volumes of pedestrian activity.
- Schools, places of assembly, or other pedestrian or bicyclist generators.
- High density land use areas.
- Central business districts.
- Junctions of major highways in rural areas.
- Rest areas/picnic shelters/trail heads/recreational facilities.
- Tunnels or undercrossings

6.4 ~~D~~ Types of Luminaires

Examples of common types of lighting are identified and discussed below. Other types of lighting may be desired and currently in use for specific applications.

- Light Emitting Diode (LED) – is currently the preferred light source for street lighting, primarily due to high energy efficiency, long lifespan, accurate color rendering, and widespread availability in the industry. ~~Light produced by~~ LEDs ~~lamps~~ generally have correlated color temperature (CCT) options from ~~of~~ 2700°K ~~4000°K~~ to 5000°K ~~6000°K~~, which range in appearance from a warm amber to ~~is~~ a bluish white ~~to bluish~~ color. Additionally, wildlife-sensitive color options are available per section 6.10. The average rated lifespan for LEDs can vary from 50,000 to 100,000 hours. ~~To provide sufficient lumen levels for roadway applications, m~~Most LED fixtures have an initial luminous efficiency ranging from ~~of around~~ 100 to 185 ~~75~~ lumens per watt.

- High Pressure Sodium (HPS) ~~Lamps~~ – was the industry standard for street lighting in prior decades, and it’s still sometimes seen on existing light poles. Light produced by HPS lamps has a correlated color temperature (CCT) around 2100°K, which is a warm amber ~~yellow~~ color. The average rated life for an HPS lamp is from 24,000 to 30,000 hours. HPS lamps have an ~~very high~~ initial luminous efficiency of over 100 lumens per watt.
- Metal Halide (MH) ~~Lamps~~ – is sometimes still used for overhead lighting of commercial parking lots, sports facilities, retail stores, and street lighting. Light produced by MH lamps has a CCT of 3800°K to 4000°K which is a white color. The average rated life of a MH lamp can vary from 9,000 to 20,000 hours. MH lamps have a high initial luminous efficiency of around 75 - 100 lumens per watt.

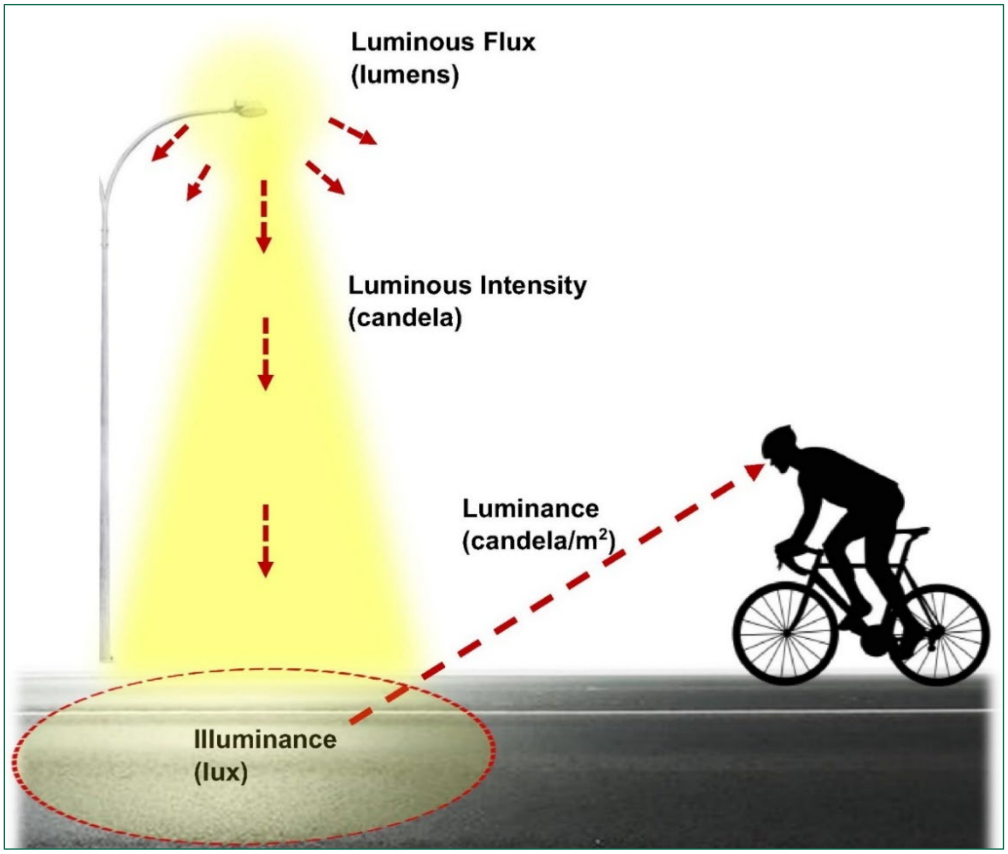
6.5 ~~E~~ Lighting Design Techniques

The two accepted methods for achieving ~~a~~ given lighting conditions are known as ~~either level of~~ illuminance ~~or~~ and ~~level of~~ luminance design. ~~Both methods of calculation are dependent upon light being reflected toward the observer’s eye. Horizontal illuminance is used for intersections and interchanges and includes a variable for surface type. Horizontal and vertical illuminance is the preferred method for pedestrian areas. The luminance method can be used for straight roadways and streets, based upon the appropriate choice of surface type~~.

The calculation for illuminance is the more straightforward method by comparison, so it’s the most common method. It offers flexibility to handle complex roadway geometry, intersections, and crosswalk design. By contrast, the luminance calculation method adds complexity by considering reflectivity of surfaces, so design software is typically only able to process linear roadway segments. Additionally, when considering the varying reflectivity of aging pavement along with the effects of dense vehicular traffic, luminance design may not always be practical.

Figure 6 – 1 Illuminance and Luminance illustrates how illuminance and luminance are measured. Illuminance is the measure of the amount of light flux falling on a surface and is measured in foot candles. Luminance is a measure of the amount of light flux leaving a surface and is measured in candelas per meter squared.

Figure 6-1 Illuminance and Luminance



Source: Florida Greenbook

6.5.1 ~~E.1~~ Illuminance

The horizontal illuminance method determines the amount of light falling on the horizontal roadway surface ~~or on vertical surfaces~~ from the roadway lighting system. Because the amount of light seen by the driver is the portion that reflects from the pavement towards the driver, and because different pavements exhibit varied reflectance characteristics, different illuminance levels are ~~ls are needed for each type of standard roadway surface~~ provided in **Table 6-2** (based on assumed pavement type in **Table 6 -1 Road Surface Classifications**). Illuminance is easily calculated and measurable and is not observer or pavement dependent.

Similarly, the vertical illuminance method determines the amount of light falling on a vertical plane, which is typically used for lighting requirements at crosswalks. This light is measured on the side of pedestrians visible to approaching vehicles, so it improves the positive contrast of pedestrians by supplementing vehicle headlights. In general, vertical illuminance is calculated for intersection crosswalks at a value equal to the average horizontal illuminance used for the intersection. This follows the intersection concepts of the ***AASHTO Roadway Lighting Design Guide (7th Edition)***. For additional vertical illumination levels at roundabouts and midblock crosswalks, see **Sections 6.12** and **6.13** of this Chapter.

6.5.2 ~~E.2~~ Luminance

The luminance method determines how “bright” the road surface is by determining the amount of light reflected from the pavement in the direction of the driver. It uses the reflective characteristics (R-classification) noted in **Table 6 – 1 Road Surface Classifications** for the standard roadway surface types and a specific observer position.

The R-classification system is a measure of the lightness (white to black) and specularity (shininess) of roadway surfaces. A system of pavement reflectance values divides the pavement characteristics into four categories: R1, R2, R3 and R4. These categories are based upon the ***American National Standard Practice for Roadway Lighting*** and have been adopted by **AASHTO** in their ***Roadway Lighting Design Guide***.

Table 6-1 Road Surface Classifications

Class	Q0*	Description	Mode of Reflectance
R1	0.10	Portland cement concrete road surface. Asphalt road surface with a minimum of 12% of the aggregates composed of artificial brightener or aggregates.	Mostly diffuse
R2	0.07	Asphalt road surface with an aggregate composed of minimum 60% gravel (size greater than 0.4 in.). Asphalt road surface with 10 to 15% artificial brightener in aggregate mix. (Not normally used in North America).	Mixed (diffuse and specular)
R3	0.07	Asphalt road surface (regular and carpet seal) with dark aggregates (e.g., trap rock, blast furnace slag); rough texture after some months of use typical highways).	Slightly specular
R4	0.08	Asphalt road surface with very smooth texture.	Mostly specular

* Q0 = representative mean luminance coefficient.

6.5.3 ~~E.3~~ Lighting Design Levels

The level of illumination for streets and highways should not be less than those shown in **Table 6 – 2 Illuminance and Luminance Design Values**. When adding supplemental lighting for pedestrian activity, ensure lighting is compatible with any existing lighting in the corridor and minimizes glare.

These levels are for the purpose of highway safety and do not apply to lighting levels required for crime reduction. Further information may be found in the ***AASHTO Roadway Lighting Design Guide (7th Edition)*** ***~~AASHTO Roadway Lighting Design Guide (2005)~~***.

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Table 6-2 Illuminance and Luminance Design Values

Roadway and Walkway Classification	Off-Roadway Light Sources	Illuminance Method					Luminance Method			Additional Values (both methods)
		Average Maintained Illuminance (Horizontal)				Illuminance Uniformity Ratio	Average Maintained Luminance			Veiling Luminance
		R1	R2	R3	R4		Lavg	Uniformity		
	General Land Use	(foot-candles) (Min)				avg/min (max) (6)	cd/m^2 (min)	Lavg/Lmin (max)	Lmax/Lmin (max)	Lv(max)/Lavg (max)(3)
Principal Arterials (partial or no control of access)	Commercial	1.1	1.6	1.6	1.4	3:1	1.2	3:1	5:1	0.3:1
	Intermediate	0.8	1.2	1.2	1.0	3:1	0.9	3:1	5:1	0.3:1
	Residential	0.6	0.8	0.8	0.8	3:1	0.6	3.5:1	6:1	0.3:1
Minor Arterials	Commercial	0.9	1.4	1.4	1.0	4:1	1.2	3:1	5:1	0.3:1
	Intermediate	0.8	1.0	1.0	0.9	4:1	0.9	3:1	5:1	0.3:1
	Residential	0.5	0.7	0.7	0.7	4:1	0.6	3.5:1	6:1	0.3:1
Collectors	Commercial	0.8	1.1	1.1	0.9	4:1	0.8	3:1	5:1	0.4:1
	Intermediate	0.6	0.8	0.8	0.8	4:1	0.6	3.5:1	6:1	0.4:1
	Residential	0.4	0.6	0.6	0.5	4:1	0.4	4:1	8:1	0.4:1
Local	Commercial	0.6	0.8	0.8	0.8	6:1	0.6	6:1	10:1	0.4:1
	Intermediate	0.5	0.7	0.7	0.6	6:1	0.5	6:1	10:1	0.4:1
	Residential	0.3	0.4	0.4	0.4	6;1	0.3	6:1	10:1	0.4:1
Alleys	Commercial	0.4	0.6	0.6	0.5	6:1	0.4	6:1	10:1	0.4:1
	Intermediate	0.3	0.4	0.4	0.4	6:1	0.3	6:1	10:1	0.4:1
	Residential	0.2	0.3	0.3	0.3	6:1	0.2	6:1	10:1	0.4:1
Sidewalks	Commercial	0.9	1.3	1.3	1.2	3:1	Use illuminance requirements			
	Intermediate	0.6	0.8	0.8	0.8	4:1				
	Residential	0.3	0.4	0.4	0.4	6:1				
Pedestrian Ways and Bicycle Ways(2)	All	1.4	2.0	2.0	1.8	3.1				

Notes
1. Meet either the Illuminance design method requirements or the Luminance design method requirements and meet veiling luminance requirements for both illuminance and Luminance design methods.
2. Assumes a separate facility. For Pedestrian Ways and Bicycle Ways adjacent to roadway, use roadway design values. Use R3 requirements for walkway/bikeway surface materials other than the pavement types shown.
3. Lv (max) refers to the maximum point along the pavement, not the maximum in lamp life. The Maintenance factor applies to both the Lv term and the Lavg term.
4. There may be situations when a higher level of illuminance is justified. The higher values for freeways may be justified when deemed advantageous by the agency to mitigate off-roadway sources.
5. Physical roadway conditions may require adjustment of spacing determined from the base levels of illuminance indicated above.
6. Higher uniformity ratios are acceptable for elevated ramps near high-mast poles.
7. See AASHTO publication entitled, “A Policy on Geometric Design of Highways and Streets” for roadway and walkway classifications.
8. R1, R2, R3 and R4 are Road Surface Classifications, defined in the AASHTO Roadway Lighting Design Guide and further described in Table 6.2.

6.6 F Uniformity of Illumination

To avoid vision problems due to varying illumination, it is important to maintain illumination uniformity over the roadway. It is recommended the ratio of the average to the minimum initial illumination on the roadway be between 3:1 to 4:1.

A maximum to minimum uniformity ratio of 10:1 should not be exceeded. It is important to allow time for the driver's eye to adjust to lower light levels. The first light poles should be located on the side of the incoming traffic approaching the illuminated area. The eye can adjust to increased or increasing light level more quickly. In transition from a lighted to an unlighted portion of the highways, the level should be gradually reduced from the level maintained on the lighted section. This may be accomplished by having the last light pole occur on the opposite roadway. The roadway section following lighting termination should be free of hazards or decision points. Lighting should not be terminated before changes in background lighting or roadway geometry, or at the location of traffic control devices.

It is also important to ensure color consistency when lighting a highway/pedestrian corridor. Mixing of different types of lighting may reduce the lighting uniformity. As we transition to LED, it is acceptable to have mixed lighting segments along the same corridor.

The use of spot lighting at unlit intersections with a history of nighttime crashes is an option.

Close coordination between the Engineer of Record and the responsible local governmental agency is essential.

6.7 G Bridge Underpasses and Overpasses

One of the criteria to be followed to determine requirements for underpass lighting is the relative level between illumination on the roadway inside and outside of the underpass. The height, width, and length of the underpass determines the amount of light penetration from the exterior.

The need for lighting of independent sidewalks or shared use paths should be evaluated on a project specific basis. Considerations include the likelihood of nighttime night time use, the role of the facility in the community's bicycle and pedestrian network, and whether alternatives are available for nighttime night time travel.

When lighting an underpass, use a wall-mounted luminaire that is attached to a pier, pier cap, or the wall copings underneath the bridge.

6.1.1 Daytime Underdeck Lighting

A gradual decrease in the illumination level from daytime level on the roadway, sidewalk or path into the underpass should be provided. Consider daytime lighting for vehicles in underpasses greater than 80 feet in length.

Supplemental lighting of sidewalks or shared use paths in roadway underpasses less than 80 feet in length should be considered. Sidewalks and shared use paths on independent alignments with little natural light should be illuminated, especially if the exit is not visible upon entry.

6.7.2 ~~G.2~~ Nighttime Underdeck Lighting

The nighttime illumination level of a roadway through an ~~in the~~ underpass ~~of the roadway~~ should be maintained near the nighttime level of the adjacent connecting ~~approach~~ roadway. Lighting of sidewalks or shared use paths ~~adjacent to roadways~~ in underpasses should also be considered. Sidewalks and shared use paths on independent alignments and open to travel during darkness should be illuminated. Due to relatively low luminaire mounting heights in underpasses, care should be taken ~~exercised~~ to avoid glare.

6.8 ~~H~~ Decorative Roadway Lighting

Decorative or architectural roadway lighting is acceptable provided it meets the minimum design criteria and the objectives contained in this Manual. Examples include architectural lighting posts, cross arms, wall brackets, bollards, and light fixtures.

6.9 ~~I~~ Correlated Color Temperature ~~Adaptive Lighting~~

Modern LED luminaires are available with different light color options, also known as correlated color temperature (CCT). Warm color temperatures are generally considered 3000°K or lower. This warm light appears more amber in color, and it more closely resembles the color of candlelight as CCT values become lower. Next, cool color temperatures are generally 4000°K or higher, and this lighting appears whiter with increased blue light content. This cooler light is generally more comparable to fluorescent lighting.

The preferred CCT for LED roadway lighting is 3000°K. As compared to high pressure sodium lights, 3000°K offers whiter light with improved color rendering. That said, 3000°K compares favorably to cooler LED options because it has reduced blue light content and lower discomfort glare for drivers. Additionally, organizations such as *©DarkSky International* prefer 3000°K or lower to help reduce skyglow and environmental impacts. Next, widespread public feedback has generally shown a preference towards 3000°K or warmer CCT, which tends to lower concerns with lighting as seen from homes and businesses. Last, for roadways with design speeds of 35 mph or less, an even warmer 2700°K CCT may be considered for aesthetic locations, including parks, campuses, downtown districts, tourist areas, and residential communities.

~~Some locations such as coastal roadways where sea turtles may be affected, may require lower lighting levels and different colors than what might normally be provided. FHWA's publication ***The Guidelines for the Implementation of Reduced Lighting on Roadways*** describes a process by which an agency or a lighting designer can select the required lighting level for a road or street and implement adaptive lighting for a lighting installation or lighting retrofit. This document supplements existing lighting guidelines.~~

6.10 ~~J~~ Wildlife-Sensitive Lighting

The lighting on some coastal roadways may affect wildlife, including sea turtles, and may require lower lighting levels, adjusting direction of luminaires, and different types and colors of lighting installations than what might normally be provided. Sea turtles and their habitat (nesting beaches) are afforded protection in accordance with ***Florida's Marine Turtle Protection Act (379.2431, F.S.)*** which restricts the take, possession, disturbance, mutilation, destruction, selling, transference, molestation, and harassment of marine turtles, nests or eggs.

The state of Florida developed the ***Model Lighting Ordinance for Marine Turtle Protection Rule (62B-55, F.A.C.)*** to guide local governments in creating lighting ordinances. Counties and municipalities in Florida that have passed ordinances prohibiting light from reaching the beach can be found on the Municipal Code Corporation web site. Coordinate with the local agencies in proximity to the project for additional requirements and guidance on providing permanent lighting or lighting in work zones.

Wildlife areas of concern can be determined by contacting the Florida Fish and Wildlife Conservation Commission (FWC) at ***MarineTurtle@MyFWC.com***. KMZ layers and Shape files illustrating areas where wildlife sensitive areas occur can be found on the ***FDOT's Office of Environmental Management "OEM Resources"*** web page, under Turtle Lighting.

An interactive map of wildlife sensitive areas can also be found in the ***Florida Geographic Data Library (FGDL)***, and will show areas of the state where wildlife sensitive lighting measures should be implemented. Use the key word "turtle" in the search function. ~~Direct links for download from the FGDL layers are:~~

- ~~***https://download.fgdl.org/pub/state/trtl_sen_light_jul20.zip***~~

- ***https://download.fgdl.org/pub/state/trtl_drksky_light_jul20.zip***

Additional information can be found on ***FWC's Sea Turtle Lighting Guidelines*** website.

For conventional lighting near a wildlife area of concern, incorporate the following design requirements:

1. Where feasible, orient luminaires away from the wildlife area of concern.
1.2. Use manufacturer's light shielding options to prevent light from reaching wildlife areas of concern.
2. Use Design lighting system using luminaires with that meet the following requirements:
a.3. The light source for the luminaires must be true red, orange, or amber light-emitting diodes (LEDs) with no more than 1.75% of the spectral power distribution below 560 nm.
   b. The optics must have an IP 66 rating.
   c. The luminaire mounting assembly must be a slip fitter type designed to accommodate a nominal 2 inch pipe size (2-3/8 inch O.D.) arm or a pole top mounting assembly designed to accommodate a 2-3/8 inch pole top tenon.
   d. Luminaires must have a IESNA light distribution curve (IES LM-79) designated by an EPA-recognized laboratory.
   e. Luminaires must meet a minimum pole spacing of 50 feet.

Further information on luminaires which meet the criteria for wildlife sensitive lighting may be found on the FDOT's ***Approved Product List (APL)*** in the Wildlife-Sensitive Conventional Lighting category or FWC's ***Certified Wildlife Lighting Guidelines***. The AGi32 lighting optimization tool, used in accordance with the settings shown in the FDOT ***Standard Specifications for Road and Bridge Construction, 992-2.4 Luminaires for Wildlife Sensitive Lighting***, may be used to design appropriately spaced lighting.

6.10.1 J.1 Work Zones in Wildlife Sensitive Areas

For night work along coastal roadways where sea turtles may be affected, incorporate the following for temporary lighting of work zone operations:

1. Direct all work zone lighting away from the beach to avoid illumination of or direct visibility from the beach.
2. Shield luminaires to avoid lighting areas outside of the immediate construction area.

6.11 ~~K~~ Overhead Sign Lighting

If the visibility of the sign due to roadway geometry or retro reflectivity of the sign sheeting is inadequate, overhead sign lighting should be provided. It is recommended that the level of illumination for overhead signs not be less than guidelines found in **Table 6 – 3 Illuminance ~~and Luminance~~ Levels for Sign Lighting**. See **Chapter 18 – Signing and Marking** for signage retroreflectivity requirements.

Table 6-3 Illuminance ~~and Luminance~~ Levels for Sign Lighting

Ambient Luminance	Sign Illuminance		~~Sign Luminance*~~	
	Footcandles	Lux	~~Candelas per Square Meter~~	~~Candelas per Square Foot~~
Low	5 - 10 ~~10 - 20~~	50 – 100 ~~100 - 200~~	~~22 - 44~~	~~2.2 – 4.4~~
Medium	10 - 20 ~~20 - 40~~	100 – 200 ~~200 - 400~~	~~44 - 89~~	~~4.4 – 8.9~~
High	20 - 40 ~~40 - 80~~	200 – 400 ~~400 - 800~~	~~89 - 78~~	~~89 – 178~~

~~Notes:~~
1. ~~Based upon a maintained reflectance of 70 percent for white sign letters.~~

Source: 2025 FDOT Design Manual Table 231.2.1 ~~AASHTO Roadway Lighting Design Guide (October 2005), Table 10 – 1 Illuminance and Luminance Levels for Sign Lighting.~~

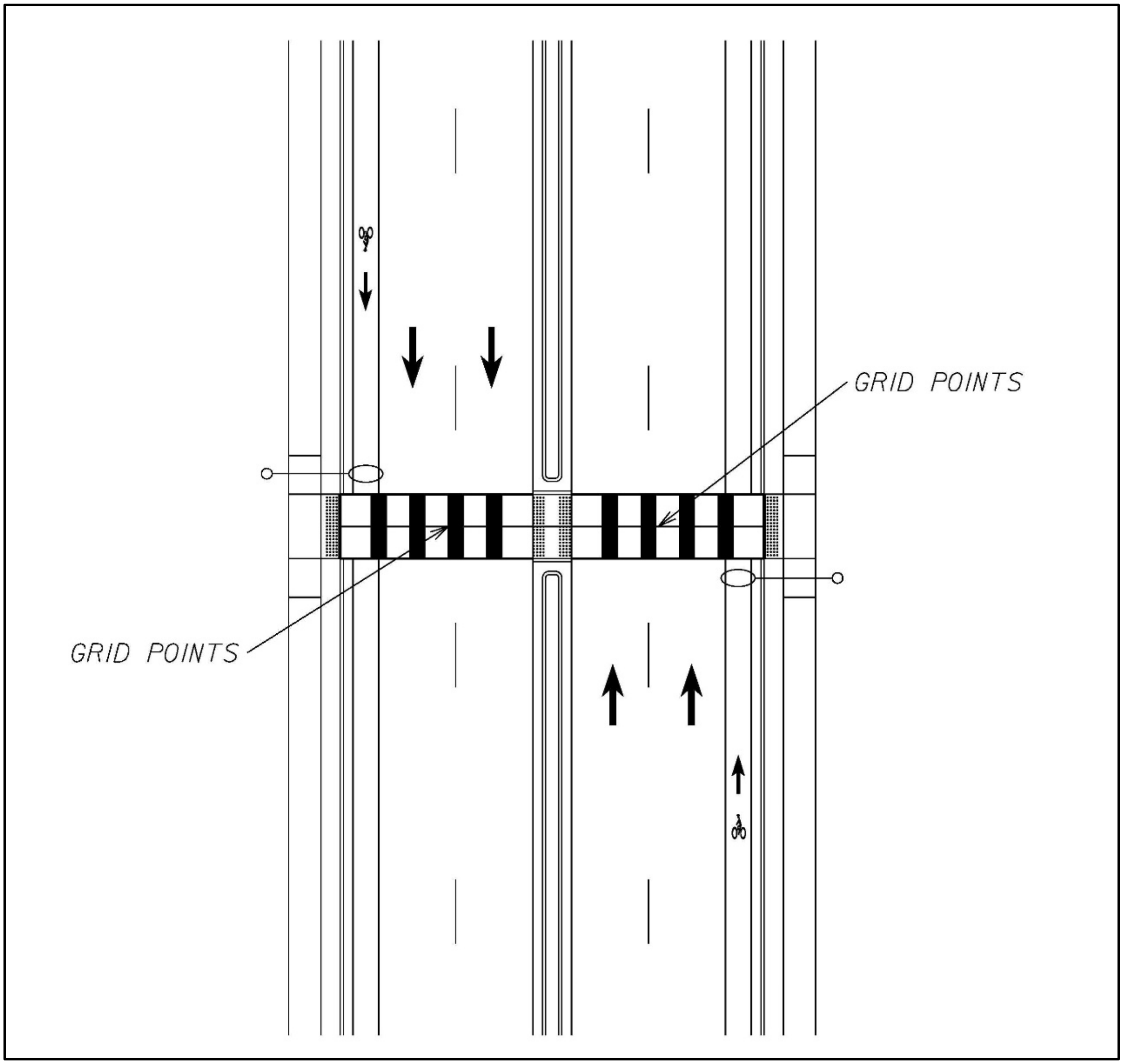
6.12 ~~L~~ Roundabouts

Roundabouts must ~~should~~ be supplemented with roadway lighting. Where pedestrians are expected, provide additional lighting of 1.5 ~~2.0~~-foot candles of maintained vertical illumination, measured at 5 feet from the road surface. Calculate the vertical illuminance for the crosswalk on each near side approach entering and exiting the roundabout.

6.13 ~~M~~ Midblock Crosswalks

At midblock pedestrian crossings, provide 2.0-foot candles of maintained vertical illumination, measured at 5 feet from the road surface. Calculate the vertical illuminance for the crosswalk on each near side approach.

Figure 6-2 Horizontal and Vertical Illuminance for Mid-Block Crosswalk



6.14 ~~N~~ Maintenance

A program of regular preventive maintenance should be established to ensure levels of illumination do not go below required values. The program should be coordinated with lighting design to determine the maintenance period. Factors for consideration include a decrease in lamp output, luminaire components becoming dirty, and the physical deterioration of the reflector or refractor. The maintenance of roadway lighting should be incorporated in the overall maintenance program specified in **Chapter 10 – Maintenance and Resurfacing**.

6.15 Light Poles

Light poles should not be placed in the sidewalk when adequate right of way is available beyond the sidewalk. Placement of lighting structures and achieved illumination may be limited by existing conditions such as driveways, overhead and underground utilities, drainage structures, and availability of right of way.

Light poles should not be placed so as to provide a hazard to errant vehicles. Non-frangible light poles should be placed outside of the clear zone. They should be as far removed from the travel lane as possible or behind adequate guardrail or other barriers. Light poles should be placed on the inside of the curves when feasible. Foundations or light poles and rigid auxiliary lighting components that are not behind suitable barriers should be constructed flush with or below the ground level.

The use of high mast lighting should be considered, particularly for lighting interchanges and other large plaza areas. This use tends to produce a more uniform illumination level, reduces glare, and allows placement of the light poles farther from the roadway. Additional emphasis lighting should be considered to illuminate specific and desired pedestrian crossings.

The placement of light poles should not interfere with the driver's sight distance or visibility of signs, signals, or other traffic control devices. In addition, the ***National Electrical Code (NEC)*** requires a working area for safety purposes around the poles. Further criteria regarding the placement of roadside structures, including light poles, is specified in **Chapter 4 – Roadside Design**.

6.16 ~~P~~ References for Informational Purposes

The publications referenced in this chapter can be obtained at the following web sites.

- Roadway Lighting, ANSI/RP-8-21

  https://blog.ansi.org/ansi-ies-rp-8-21-design-roadway-lighting/#gref

- Design Guide for Residential Street Lighting (2015), Illuminating Engineering Society

  https://www.ies.org/store/design-guides/design-guide-for-residential-street-lighting/

- AASHTO - Roadway Lighting Design Guide (7th Edition ~~October 2005~~)

  https://highways.dot.gov/safety/other/visibility/roadway-lighting-resources

- Guidelines for the Implementation of Reduced Lighting on Roadways

  PUBLICATION NO. FHWA-HRT-14-050 JUNE 2014
  http://www.fhwa.dot.gov/publications/research/safety/14050/14050.pdf

- The Lighting Handbook, 10th Edition, Illuminating Engineering Society (IESA)

  https://www.ies.org/store/lighting-handbooks/lighting-handbook-10th-edition/

- National Electric Code

  https://www.nfpa.org/