Roadway Lighting Design

An Online Continuing Education Course for Engineers

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I. Introduction

The general purpose of roadway lighting is to provide improved visibility for the various users of the roadways and associated facilities.

"Users" refer to vehicle operators (automobiles, trucks, buses, motorcycles, bicycles), pedestrians and other citizens such as merchants and shoppers.

"Associated Facilities" refer to physical features along the roadway (barriers, bridge piers, ditches, curbs, channelization, etc.).

Roadway lighting on local streets provides pedestrian visibility as well as driver visibility. Lighting quality increases the comfort level and safety of the motorist. Lighting can be expected to reduce night crashes by approximately 30 percent.

A. Objectives of Roadway Lighting

- To supplement vehicle headlights, extending the visibility range beyond their limits both laterally and longitudinally.
- To improve the visibility of roadway features and objects on or near the roadway.
- To delineate the roadway ahead. To improve visibility of the surroundings.
- To reduce the apprehension of those using the roadway.

B. Visibility Requirements

Vision – The eyes are the primary source of information. As light decreases, vision and the detection of information are severally impaired or nonexistent. As light increases, vision and the detection of information are improved.

Contrast is the difference in brightness between the object and background. The ability to discern objects increases as the contrast level between the two increases. Drivers normally see objects in silhouette – a dark area against a bright background. This bright background can

cause a glare resulting in a reduction in the contrast level thereby partially or totally obscuring the details to be seen.

II. Analyzing Lighting Needs

The warrants for roadway lighting are in AASHTO's "An Informational Guide for Roadway Lighting". The manual contains a basic guide for highway lighting and contains design guidelines and warranting criteria.

A lighting justification analysis was created due to the energy crisis of the 1970's and based on recommendations of a research project; a lighting justification program was developed. It is used to calculate the cost benefit analysis of lighting. The FDOT Office of Traffic Operations in Tallahassee may be contacted for a copy of the program.

III. Lighting Equipment

A. Light Sources

There are three general types of light sources: LED, filament and arc-discharge.

Light Source	Type	Lumens	Life (hrs)
LED	LED	2-90	50,000
Filament Lamp	Incandescent	10-15	12,000
Discharge Lamp	Fluorescent	60-70	7,500-24,000
	Mercury Vapor	50-65	24,000
	Metal Halide	90-110	10,000-20,000
	High Pressure Sodium	125-140	24,000
	Low Pressure Sodium	180	18,000

LED (Light-Emitting Diode)

An LED roadway light is an integrated light that uses light emitting diodes (LED) as its light source. These are considered integrated because the luminaire and fixture are not separate parts. Most LED roadway lights have a lens on the LED panel, which is designed to cast its light in a rectangular pattern aiming most the light to the street side. The primary appeal of LED roadway lighting is energy efficiency compared to conventional roadway lighting fixture technologies. An LED fixture uses considerable less electricity than the traditional light fixtures. In addition, an LED fixture will have a longer life than the traditional light fixtures. This results in a reduction in maintenance cost. A disadvantage of LED lighting is increased glare.

Incandescent Lamp

The incandescent lamp has a filament that is an electrical resistance wire enclosed in a gas filled bulb. Current passing through the filament heating the filament to incandescence produces light. The gases are inert, usually nitrogen or krypton, which reduce evaporation of the filament and act as a thermal barrier.

Discharge Lamp

The discharge lamp produces light by exciting gases or metal vapors in a lamp or tube. Electrical potential is applied to electrodes. Gas is ionized and current flows between the electrodes. The lamps have a negative resistance and must have a ballast to maintain proper current level. The ballast regulates input power for the lamp.

Fluorescent Lamp - The fluorescent lamp produces light by a fluorescent coating on the inside of the tube which is activated by an ultraviolet energy generated by an arc.

Mercury Vapor - The mercury vapor lamp consists of an arc tube inside the outer bulb containing mercury vapor and electrodes. Light is produced from ionization of mercury vapor. Lamps may be clear or coated with phosphors to improve color rendition.

Metal Halide - Metal halide light is produced by a combination of metallic vapors. The lamp has excellent color rendition, but has a short lamp life.

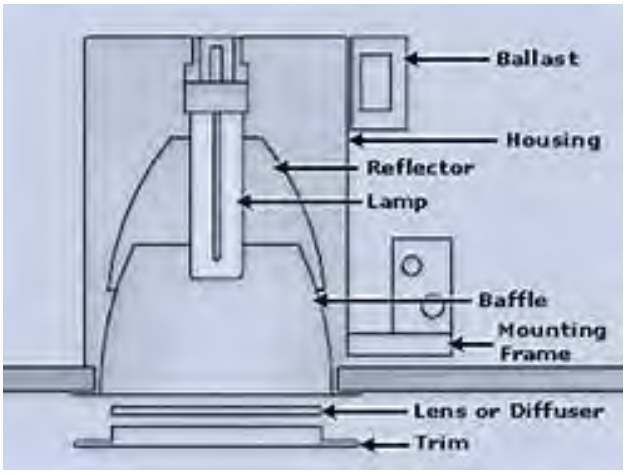
High Pressure Sodium - The high-pressure sodium lamp produces light from sodium vapor. The arc tube is normally filled with sodium, mercury and xenon. Xenon is used for starting the light and mercury for coloring. This lamp has no starting electrode and produces a high voltage pulse of 2,500 to 4,000 volts.

Low Pressure Sodium - The low-pressure sodium lamp is very efficient. However, it is monochromatic (single color only). It has a large physical size and the light is hard to control. It also has a lower lamp life.

B. Luminaries

The luminaire components consist of a housing of the ballast and optical assembly. The optical assembly components consist of the lamp, reflector and refractor. The lamp produces the light output for the luminaire. The reflector is mounted above the lamp inside the optical assembly. It reflects or redirects the light. The refractor is mounted below the lamp and in some luminaries, encloses the lamp cavity. The refractor is made of a transparent, clear material, glass or a strong plastic material. It has many prisms and is enclosed or open at the bottom.

The following illustration shows the components of a typical luminaire.



C. Luminaire Supports

Luminaire supports generally have frangible/breakaway bases. The breakaway criteria are covered in the AASHTO Specifications. The term "breakaway support" refers to all types of sign, luminaire and traffic signal supports that are design to yield when hit by a vehicle. The release mechanism may be a slip plane, plastic hinges, fracture elements, or a combination of these. Frangible/breakaway bases are safer in vehicular collisions since the light base will yield in the collision.

The standard pole is made of aluminum. However, in some locations they may be concrete or fiberglass. Joint use poles may combine the luminaire with signals or utilities on wood, concrete, or steel poles. All conventional height poles shall be breakaway unless bridge or barrier wall mounted. High mast poles are made of steel or concrete. These structures must be installed outside of the clear zone as they are not frangible/breakaway.

FDOT has developed an aluminum light pole standard for Conventional Lighting foundations. The standard provides details for 40, 45 and 50-foot luminaire mounting heights on poles mounted either at grade or on fills up to 25 feet in height, all of which accommodate fixture arm lengths of 8, 10, 12 and 15 feet. Standard Aluminum Light Poles have been designed for 110, 130, and 150 mph design wind speeds. High mast lighting (80 feet or greater) requires a foundation design in the plans.

D. Bracket Arm Types

Bracket arm types may consist of single member, truss, or davit. The length and rise may vary. The length is determined in the design of the lighting system and is measured to the center of the luminaire. The rise is the difference in elevation between the attachment at the pole and connection to the luminaire. The contractor usually calculates the rise because it depends on the length of the pole and mounting height required.

Single Member Bracket Arm

Truss Bracket Arm

Davit Bracket Arm

IV. Conventional Lighting

Conventional lighting consists of any number of mounting heights depending upon the desired lighting level. The standard FDOT mounting heights are 40, 45, and 50 feet. There is one luminaire per pole for conventional mountings. There can be two luminaries per pole if it is median mounted. The following table outlines the FDOT requirements for illumination levels and uniformity ratios for conventional lighting.

Table 7.3.1 Conventional Lighting – Roadways (FDOT PPM, Chapter 7)

Roadway Classificati…	…	Ratios	
			Max./Min.
Interstate, Expressway, i… & Major Arte…			10:1 or less
All Other Roac…			10:1 or less
* Pedestrian W… and Bicycle Lar…			10:1 or less

V. High mast Lighti…

High mast lighting consis… …eet or greater. The standard mounting height is 120 feet. There a… …several luminaries per pole. The number of luminaries depends on the light level required. The maximum number of luminaries per pole is 12 high mast or 16 flood. The luminaries are attached to a ring by cables and to a winch inside the pole base. The ring and luminaries lower to the ground by the winch for maintenance. Either a heavy-duty drill motor attaches to the pole to operate the winch or a previously installed electric motor lowers the ring. The following table outlines the FDOT requirements for illumination levels and uniformity ratios for high mast lighting.