

# **HIGHWAY DESIGN MANUAL**

## **Chapter 12 - Highway Lighting**

**Revision 24**

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**CHAPTER 12  
HIGHWAY LIGHTING**

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**12.1 INTRODUCTION**

The lighting industry and governmental agencies have published guides, handbooks, and standards which describe and detail highway lighting design practices. Rather than repeat all of the detailed information in these publications, this chapter provides an overview of permanent highway lighting design which is consistent with these publications and refers to them as necessary. However, Regional experience and Department policy is stated where it may differ from the guidance presented in these other publications. References are provided throughout the text to provide the source for further discussion.

Refer to Engineering Instructions 95-3 "Requirements for Maintenance and Protection of Traffic During Nighttime Construction" and 95-5 "Lighting for Nighttime Operations-Special Specifications" for temporary highway lighting requirements for nighttime work zones and a special specification for lighting for nighttime operations.

**12.2 WARRANTS AND POLICY**

Warrants and policy for highway lighting are presented in the "Policy on Highway Lighting" issued by the Traffic Engineering and Safety Division (TE&S). Questions regarding warrants and policy should be directed to TE&S.

Prior to preliminary or detailed design, the designer should review and subsequently discuss the "Policy on Highway Lighting" with all municipalities and electric utilities involved. This discussion should establish:

1. The locality's consent to assume the operational and maintenance costs for lighting (except for parkway lighting in Region's 8 and 10).
  - a. Design should not begin without the municipality's consent to maintain and operate the lighting system.
  - b. Refer to Chapter 14 of this manual for guidance on, and an example of, the necessary resolution and agreement to be obtained by the Region from the municipality.
2. Any preferences for equipment selection or placement, thus allowing the designer to accommodate the municipality's needs with regard to aesthetics, maintenance, agreements with utilities, etc.

**12.3 DESIGN**

A design should provide a safe, energy efficient, and economical lighting system which will produce the desired visibility. This will involve selecting the appropriate light source (lamp), luminaire type, mounting height, luminaire position (spacing and transverse location), and pole offset from the traveled way.

Guidance regarding lighting system continuity, such as when to extend lighting across a bridge when only one approach is lit, and where to begin and end lighting installations, is presented in the "Policy on Highway Lighting".

### 12.3.1 **Criteria**

There exists two criteria and corresponding procedures (methods) for roadway lighting design, illuminance and luminance. The illuminance criterion and procedure is recommended for roadway (conventional and high mast) and walkway/bikeway lighting systems. The luminance criterion and procedure is not used for Department designs. Chapter 6 of the "Roadway Lighting Handbook" discusses the advantages and disadvantages of these two methods.

Highway lighting designs should provide values (lighting levels) for average maintained horizontal illuminance and uniformity of illuminance (illumination), commonly called the uniformity ratio, recommended in "An Informational Guide for Roadway Lighting". The Federal Highway Administration (FHWA) has adopted this publication, in section 625.5 of the Federal-aid Policy Guide (FAPG), as a guide to be used to promote good lighting design. Recommendations are provided for:

1. Roadways
2. Tunnels and underpasses
3. Rest areas
4. Guide signs
5. Pedestrian ways and bicycle lanes

Note: Average maintained horizontal illuminance is the average level of horizontal illuminance on the traveled way, in lux, when the output of the lamp and luminaire is diminished by the maintenance factors. (See section 12.3.2.1.) Refer to section 12.3.2.3 for a definition of the uniformity ratio.

Refer to the "Roadway Lighting Handbook", the "American National Standard Practice for Roadway Lighting", or "An Informational Guide for Roadway Lighting" for a complete glossary of the terms used in this Chapter.

### 12.3.2 **Illuminance Procedure**

The illuminance procedure for conventional and high mast lighting design is briefly discussed in sections 12.3.2.1 and 12.3.2.2 respectively. A complete discussion is presented in:

1. "Roadway Lighting Handbook", Chapter 6, and
2. "American National Standard Practice for Roadway Lighting", Appendix B (this also includes the procedure for calculating walkway and bikeway illuminance).

Computer software is available from major lighting manufacturers which will calculate lighting levels based on the design parameters entered (see sections 12.3.2.1 and 12.3.2.2). This software will enable designers to evaluate and refine their designs more readily. The computer printout, or written calculations, for the final design should be filed in the project files.

### 12.3.2.1 Conventional Lighting

This type of lighting design includes the selection, and subsequent specification on the plans and/or proposal, of the following items as a minimum:

1. Light source type,
2. Light source size and mounting height,
3. Luminaire type and location, and
4. Luminaire spacing and arrangement.

These items may be fixed or predetermined due to local preference or existing conditions. The relationship between these variables and the average maintained horizontal illuminance is defined by the spacing formula (see section 12.3.2.1D). Before any design is progressed, the designer should review the field conditions, and check with localities and electric utilities to establish any needs.

After determining items one through four above, which are discussed further in sections 12.3.2.1 A-D, the average maintained horizontal illuminance (see section 12.3.2.1D) and uniformity ratio (see section 12.3.2.3) should be calculated to ensure that the design values recommended in "An Informational Guide for Roadway Lighting" have been achieved.

Once it has been determined that the design will provide the desired lighting levels, an estimate of the length of the pole, and mass of the pole, arm, and luminaire, (provided in a manufacturer's data catalog) should be made. As most lighting system designs will utilize an aluminum light standard (pole) and arm mounted on a breakaway transformer base (aluminum), it is desirable to limit the length of the pole to under 16.75 m, and the combined mass of the pole, arm and luminaire to under 450 kg. (The 16.75 m criterion is based on available hardware limitations. The mass restriction is intended to limit the potentially serious consequences should a pole fall on a vehicle.) Designs which result in a pole length in excess of 16.75 m or a mass in excess of 450 kg should be redesigned to utilize a lower mounting height, and therefore a lighter and shorter pole, in order to maintain the safety feature provided by using a breakaway base.

#### A. Light Source Type

High pressure sodium (HPS) lamps are the Department's preferred type of light source.

**HIGHWAY LIGHTING****B. Light Source Size and Mounting Height**

150 W, 250 W, or 400 W lamps are generally recommended.

The luminaire should be mounted at a minimum height of 9 m above the roadway surface to provide an economical design. However, this may not be feasible when the luminaire is to be supported by a utility pole. Higher mounting heights (12 to 15 m) in conjunction with higher output lamps should result in an increased spacing between luminaires, and therefore fewer poles, which is desirable. A safer design will be provided due to the reduction in the total number of poles.

The following are commonly used lamp size and mounting height combinations:

1. A 150 W lamp mounted at a height of approximately 9 m.
2. A 250 W lamp mounted at a height of 12 m.
3. A 400 W lamp mounted at a height over 12 m and up to 15 m.

**C. Luminaire Type and Location**

Luminaire selection should be based on the roadway width or desired area to be lit and the lateral location of the luminaire relative to the roadway. Luminaires are classified based on their light distribution pattern, and should be specified using the following light distribution classification standard developed by the Illuminating Engineering Society of North America (IES):

1. Vertical - short, medium or long (medium is generally recommended),
2. Lateral - type I, II, III, IV or V (type II or III is generally recommended depending on the width of the area to be lit), and
3. Control of light distribution above maximum candlepower - cutoff, semi-cutoff, or non-cutoff (semi-cutoff is generally recommended).

Refer to Appendix E of the "American National Standard Practice for Roadway Lighting" or Chapter 4 of the "Roadway Lighting Handbook" for an explanation of luminaire classification.

The luminaire should be located adjacent to the area to be illuminated (such as over the edge of the traveled way adjacent to the shoulder). When placement of the luminaire near the roadway is not possible due to clear zone requirements and limited availability of required mast arm length, consider:

1. A different type (III instead of II) of luminaire and larger lamp size,

2. A luminaire placed at a higher mounting height or a combination of higher mounting height and higher lamp wattage or,
3. A luminaire mounted on a short arm ( or no arm) similar to a floodlight, i.e., an offset luminaire.

**D. Luminaire Spacing and Arrangement**

Luminaires should be spaced as far apart as practical to minimize the total number of poles necessary and increase roadside safety. If the luminaire is to be supported by a utility pole, spacing will be fixed and this will influence the type of luminaire and lamp size needed. Where scheduled bus service is provided, luminaire spacing should be coordinated with bus stop and bus shelter placement to provide increased illumination in these areas of pedestrian activity.

Luminaire spacing may be determined using computer software as mentioned in section 12.3.2 or by the following formula. Regardless of the method used, the designer will have to determine appropriate values for some of the variables upon which the luminaire spacing is determined.

$$S = \frac{(LL)(CU)(LLD)(LDD)(EF)}{(Eh)(W)}$$

where:

- S = luminaire spacing, in meters,
- LL = initial lamp lumens (see note 1), based on size and type of lamp,
- CU = coefficient of utilization (see note 2),
- LLD = lamp lumen depreciation factor (see note 3),
- LDD = luminaire dirt depreciation factor (see note 3),
- EF = equipment factor. A value in the range of 0.95 to 0.90 is commonly used.
- Eh = average maintained horizontal illuminance (in lux), from section 12.3.1
- W = lighted roadway width (in meters).

Refer to Chapter 6 of the "Roadway Lighting Handbook" or Appendix B of the "American National Standard Practice for Roadway Lighting" for a complete discussion of the terms in the luminaire spacing formula and an example problem.

Note 1: Provided in the manufacturer's lamp product data sheet. The data should correspond to a particular lamp/luminaire combination rather than consist of general information for a luminaire type.

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Note 2: It is not necessary to calculate the CU if the computer software is used. If needed, the CU is determined from utilization curves provided by luminaire manufacturers.

Note 3: The product of LLD, LDD, and EF is referred to as the light loss factor (LLF). The software may ask for a value of LLF rather than LLD, LDD, and EF. LLD and LDD are dependent on the maintenance schedule established by the municipality and/or the utility. Values for LLD and LDD are available in the Manufacturer's lamp product data sheet. EF represents anticipated losses due to the differences in equipment performance between laboratory data and field performance.

Poles may be located in the median and/or off to the side from the traveled way. A median placement should be considered only if the pole is to be mounted on concrete median barrier, and both the maintaining agency and Region feel that maintenance will not pose an unacceptable level of safety or an unacceptable level of service (LOS) if lane closing is needed for maintenance. Poles may be arranged on one side, staggered, and/or placed on opposite sides of the roadway, the choice of which will depend on achieving the most efficient lighting configuration.

#### 12.3.2.2 High Mast Lighting

High mast lighting (HML) consists of several luminaires mounted on a single luminaire support (mast). If proper light control can be achieved, and there is no objectionable light spillage or affect on adjacent residents, this type of system should be considered for interchanges and rest area locations.

Advantages of HML include:

1. Increased roadside safety, as the mast is located well outside the roadside clear zone, and
2. Increased visibility of the roadway and roadside area.

Disadvantages include:

1. Unwanted light "spilling over" to adjacent residences, and
2. Reluctance of agencies to accept maintenance responsibility.

The advantages and disadvantages of high mast lighting should be discussed with the locality and utility company, and the decision made jointly whether to progress this type of design. This discussion should identify any community concerns with environmental issues and identify system maintenance considerations to achieve a balanced final design.

The section on high mast lighting in Chapter 6 of the "Roadway Lighting Handbook" and Appendix B, section B.5, of the "American National Standard Practice of Roadway Lighting" provides a complete discussion on HML including:

1. An example problem which illustrates the procedure to determine the number of luminaires per mast and mast location, and
2. Potential mast locations which will provide the greatest degree of roadside safety.

After reviewing the above mentioned references, the designer should contact manufacturers of high mast lighting to seek their assistance in determining luminaire selection and mast location.

As with a conventional lighting design, HML design includes the selection and subsequent specification on the plans and/or proposal of the following items as a minimum:

1. Light source type. High pressure sodium (HPS) lamps are the Department's preferred type of light source.
2. Light source size and mounting height. Several 400 W or 1000 W lamps, mounted at a height of approximately 30 m, is a recommended initial design in the absence of any previous experience with HML. The exact number of luminaires and final mounting height will be determined by analyzing and refining the initial design until the lighting levels recommended in "An Informational Guide For Roadway Lighting" are obtained.
3. Luminaire type. The type V luminaire is generally the most efficient as it will provide a circular uniform light pattern. Floodlights should be avoided unless the failure of one luminaire will not produce an unacceptable lighting level. Where more light control is desired to reduce spill light, either the type V with modified optics that will provide an asymmetrical light distribution or, a type IV luminaire should be evaluated.
4. Mast spacing and location. Masts should be spaced and located to provide recommended lighting levels for the area to be lit. Refer to section 12.5.2 for additional guidance.

### 12.3.2.3 Uniformity Ratio

The uniformity ratio is a means of defining the quality of illumination and is calculated using the following formula:

$$\text{Uniformity Ratio} = \frac{\text{Average Maintained Horizontal Illumination}}{\text{Minimum Maintained Illumination}}$$

If software is not used to progress the design, the minimum point of illumination is determined by inspection using the isolux diagram contained in the photometric data for the particular luminaire selected.

## **12.4 EQUIPMENT**

Selecting lighting equipment is discussed in detail in Chapter 4 of the "Roadway Lighting Handbook". The designer should determine if the locality or utility have any specific equipment needs or preferences prior to equipment selection.

The type of equipment used to support a luminaire located on a structure should generally be the same as that used for the approaching roadway. Luminaires recessed into concrete walls or incorporated into bridge rail are not recommended due to the maintenance difficulties (dirt accumulation, lens cracking , etc.) associated with these types of installations.

### **12.4.1 Luminaires**

A luminaire consists of a lamp together with the components designed to distribute the light (reflector and refractor), to position and protect the lamp, and to connect the lamp to the power supply.

If a luminaire is to be mounted or remounted on existing utility poles, the designer may only have to provide the appropriate pay items necessary to coordinate the work. Some maintaining agencies include the cost of new arms, luminaires and any other equipment necessary to locate or relocate the luminaires in their agreement with the municipality. The designer should ensure that the equipment supplied by others will provide lighting levels and uniformity consistent with the recommendations provided in "An Informational Guide for Roadway Lighting".

### **12.4.2 Luminaire Supports**

Luminaire support design and specification should be consistent with the "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals". FHWA has adopted this publication in the FAPG, section 625.4, Standards, policies and standard specifications, to be followed in the design of structural supports.

#### **12.4.2.1 Conventional Lighting**

The luminaire support consists of a foundation, base, pole, and arm.

### A. Foundation

Aluminum and fiberglass poles should be supported by means of a cast-in-place or precast concrete foundation, designed in accordance with the reference mentioned in Section 12.4.2. Wooden poles are not normally provided with a separate foundation as they are supported by direct embedment into the soil.

Regardless of the type of foundation, the best information possible concerning the foundation soil conditions should be obtained from the Regional Geotechnical Engineer. A local subsurface investigation may be necessary in areas where weak, organic and/or plastic deposits are believed to be present.

The Regional lighting engineer should be consulted to determine if any Regional foundation details have been developed. At locations where the standard sheets are not applicable or the geometric or soil conditions are unusual, the Regional Geotechnical Engineer should be consulted.

### B. Base

The base, or method by which a pole is to be supported, is dependent on the material used to construct the pole and consideration for roadside safety. Bases may be of the breakaway, anchor, or direct embedment type.

Aluminum poles shall be supported by a breakaway transformer base (aluminum) regardless of whether the pole is located within or out of the clear zone. (Situations for which a breakaway base may not be provided, and therefore an aluminum anchor base (non-breakaway) is provided, are discussed later in this section.) The added expense of providing a breakaway base is minor, the added safety benefit is desirable, and its use increases the probability that the pole and arm will be reusable with only the replacement of the luminaire. If a breakaway base were not provided, the vehicle would impact the pole, thus making replacement of the pole and luminaire necessary. This would be a more expensive and time consuming activity.

It is desirable to have the side slope prior to the breakaway base be 1:6 or flatter. This is to ensure that the vehicle will impact the base at an acceptable height, which will allow the base to fail in shear, as intended, versus in bending. In addition, the height above ground of any portion of the anchor bolts or foundation should not exceed 100 mm. This is to prevent the bottom of a vehicle from snagging the foundation or base. Refer to section 4.2 and 4.5 of the "Roadside Design Guide" for a more complete discussion of the breakaway base concept.

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A aluminum anchor (non-breakaway) type base may be considered:

1. In urban areas or where pedestrians and bicyclists may be hit by falling poles and mast arms after a vehicular impact. The designer shall weigh the relative risks involved between potential pedestrian(s)/bicyclist(s) injury caused by the falling pole versus potential driver injury caused by hitting a fixed object.
2. On structures where the pole is located behind bridge rails.

Fiberglass poles may be supported by direct embedment or by a fiberglass anchor type base. The maintaining agency should be contacted to determine any preferences. The materials requirements section of Departmental specifications developed for this type of pole, or base, should state whether or not the pole, or base, should meet the specification for breakaway supports found in the "Standard Specifications for Structural Supports for Signs, Luminaires and Traffic Signals". Poles should be located laterally from the edge of traveled way based on the materials requirements (breakaway versus non-breakaway).

A separate base is not necessary for wooden poles directly embedded (non-breakaway) in the ground as the pole and base are one unit.

**C. Pole**

An aluminum, wood, or fiberglass pole may be specified. See Section 12.4.2.1B for a discussion of the type of base applicable for the type of pole selected.

Aluminum poles are preferred and should be specified.

Wood poles have limited application. They are acceptable in downtown urban areas when used in conjunction with utility pole lighting where short gaps must be filled in, and may be required on historic parkways. The Regional Environmental/Landscape Group should be contacted to determine the applicability of wood poles on historic parkways.

Fiberglass poles also have limited application. Some communities find them more aesthetically pleasing. They should be specified only when the maintaining agency deems them acceptable.

### D. Arm

The arm supports the luminaire closer to the roadway, or over the roadway, while allowing the pole to be placed a distance from the traveled way. To maintain aesthetics and continuity, the designer should specify an arm type (single arm, truss, or davit) similar to existing adjacent lighting, and length required to achieve the correct light levels and pole positioning.

### 12.4.2.2 Ornamental (Decorative) Lighting

Ornamental or decorative lighting is defined as any lighting equipment specified to replicate a historic period or provide a more decorative appearance, such as within a city, on a bike path or for a historic parkway. A special specification is necessary to provide pay item(s) for this type of work as it is not covered in the standard specifications.

Any ornamental lighting provided at the request of a locality and not associated with a historic program, such as historic parkways, should be treated as a betterment. The locality should be requested to pay the additional cost of providing a decorative pole and arm, versus a conventional light pole with associated arm.

Any ornamental or decorative lighting system design should be coordinated with the Regional Landscape/Environmental Group.

### 12.4.2.3 High Mast Lighting

Support for a HML installation consists of a foundation, pole (mast), and head frame assembly with luminaire ring and lowering device. The first two items are discussed below:

#### A. Foundation

Dead and live load reactions, horizontal shear, uplift and overturning moments should all be taken into consideration when designing foundations. The foundation and anchoring system should be designed for loads equal to, or greater than, the maximum loads that the pole is designed for.

#### B. Mast

The pole length specified is to be based on the mounting height of the luminaires, determined during design, and is the difference in elevation between the foundation and luminaires.

## 12.5 CONFIGURATION

Refer to Chapter 5 of the "Roadway Lighting Handbook" for a complete discussion on luminaire and luminaire support placement.

### 12.5.1 Pole (Light Standard) Placement - Conventional Lighting

The preferred pole location is on the right hand side in the direction of travel. However, if poles are required in areas where they are likely to be struck, or on ramps with insufficient width of embankment to provide for a pole outside the deflection distance of the guiderail, the pole should be placed on the inside of the curve. Median installations should be avoided on freeways, unless the maintenance agency and the designer feel that servicing activities will not present an unacceptable level of safety, or service, during maintenance.

#### 12.5.1.1 Lateral Offset

The designer should provide the appropriate lateral clearance (refer to Chapter 2, Section 2.6.9), if applicable, and clear zone (refer to Chapter 10). In addition, where sidewalks are present or proposed, the pole should be placed to allow continuous passage as discussed in Chapter 18 and the Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities, Section 14, Public Rights-of-Way.

#### 12.5.1.2 Longitudinal Spacing

The longitudinal spacing between poles will be established during the design procedure. Appurtenances along the highway, and highway geometrics, influence the final luminaire support location. Some recommendations follow:

1. To avoid being struck, poles in the area of exit ramps should not be placed within 50 m of the physical gore,
2. Poles should be placed approximately 25 m from each fascia to provide light under structures without underbridge lighting and to reduce the shadowing effect due to the bridge, and
3. Poles should be placed no closer than 15 m in front of lighted overhead signs, or 10 m where overhead signs are not lighted.

### 12.5.2 Luminaire Support Placement - High Mast Lighting

The criteria for spacing and locating the support for the luminaires is somewhat different than for conventional lighting. While the common concern for roadside safety should be adhered to, HML is an area type of lighting system which allows the designer more latitude in placing the support

farther from the roadway. Masts should not be placed in narrow medians if possible. They are difficult to construct as part of the concrete median barrier system and hazardous to maintain. The exact location of the high masts should be specified only after the number and type of luminaires necessary to meet the design criteria has been determined.

Using a plan of the area to be lighted, the designer should:

1. Identify potential support locations which would provide the greatest degree of roadside safety, and
2. Provide the area to be lit with the desired lighting levels.

Additional factors which should be considered when locating the supports are discussed in the high mast systems section of the "Roadway Lighting Handbook", Chapter 6.

## **12.6 HARDWARE**

The design of a highway lighting system also includes electrical design. The electrical design includes specifying the method by which electricity will be supplied to the luminaires (by connection to wires on utility poles, separate underground power connection with or without a distribution cabinet, etc.), and the source of electricity or power (secondary or other).

The maintaining agency or utility company may have a preference for or require that they provide some or all of the components discussed in this section. The designer generally will not have to specify pay items for work provided by others as the cost of this work is included in the maintenance agreement with the municipality. Refer to sections 12.6.1 through 12.6.6 when pay item selection is necessary.

Refer to Chapter 7 of the "Roadway Lighting Handbook" for additional discussion regarding the topics discussed in this section.

### **12.6.1 Electrical Distribution**

Electricity is usually supplied by connection to existing utility poles which supply "secondary" power to other commercial users. When "secondary" power is insufficient to energize the proposed lighting installation, as may be the case with continuous parkway or expressway lighting, the designer may have to provide transformer(s) to convert the higher voltage provided by the utility company to a voltage suitable for use in the lighting system branch circuits. Discussion of the electrical design (transformers, controller cabinet wiring) necessary for these larger systems is beyond the scope of this Chapter. Designers should seek the assistance of the utility company, maintaining agency, and Regional Utility Engineer when specification of transformers, and lighting control system equipment is a necessary part of the total lighting system. The point of service(s) where the utility will provide electricity for distribution to the luminaires should also be discussed, and if possible determined, at this time.

All electrical distribution equipment (controller cabinets and other electrical boxes) should be specified for placement in the safest location within the roadside area (such as behind and beyond the deflection distance of guiderail).

#### 12.6.1.1 Luminaire and Arm Attachment to Utility Poles

The designer will generally need to provide fewer pay items for an installation on wood utility poles as compared to providing a distribution system with associated controller cabinet, etc. Electrical distribution to luminaires on wood poles is usually provided by wiring from the luminaire to existing overhead wires and the luminaire is switched on and off by means of a photoelectric control mounted on the luminaire. Refer to section 12.6.6 for further discussion regarding photoelectric controls.

#### 12.6.1.2 Luminaire and Arm Attachment to Light Standards (Pole)

Distribution for this type of system consists of the utility company bringing in power to a specified location for subsequent distribution via branch circuit(s). These circuits distribute the electricity from the point of service, or distribution equipment, and are established by the specification of conduit, cable, wire, pullboxes, etc. The designer should specify service pole and distribution equipment locations which are outside the clear zone, placed behind and beyond the deflection distance of guiderail, and in a location where they are not susceptible to being hit by errant vehicles. The extent of the electrical design necessary for the distribution system will be dependent on the magnitude of the highway lighting system.

#### 12.6.2 **Wire**

In the absence of utility company, maintaining agency, or locality requirements, wire size and type should meet minimum requirements of the National Electric Code (NEC).

Wire should be sized separately:

1. For each branch circuit based on voltage drop criteria presented in NEC Article 210-19a FPN No. 4. and,
2. From the pole base to the luminaire (usually 10 or 12 AWG).

Refer to Chapter 7 of the "Roadway Lighting Handbook" for an example of how to determine wire size based on voltage drop.

#### 12.6.3 **Conduit**

Underground wiring is generally installed in conduit, and specified as separate items! wire and conduit. Direct burial cable, which consists of cable enclosed in a polyethylene conduit, is preferred by some.

The type of conduit specified should be appropriate for the roadway environment. Galvanized steel is generally specified for underground installations and when the conduit is to be exposed to the weather. Polyvinyl chloride (PVC) conduit may be specified for installation in non-rocky soils, and where there is reasonable certainty that it will not be damaged by construction equipment.

Conduit shall be large enough to meet the requirements (31% full for 2 conductor, 40% for 3 conductor) found in Chapter 9 of the National Electric Code (NEC).

Consideration should be given to the installation of spare conduit for future lighting maintenance needs or plans for traffic systems management strategies such as Information for Motorist (INFORM) variable message signs (VMS).

#### 12.6.4 **Pullboxes**

Cast-in-place concrete or precast concrete pullboxes should be provided at major junction points, at utility service points if required by the utility company, and at other locations as required by the project.

The pull box size will be dependent on the number and size of entering/leaving conduit or cable and what work is required within the box.

#### 12.6.5 **Junction Boxes**

A junction box should be considered for each luminaire support located on a bridge, to accommodate conduit and wire installation and connection. The dimensions and any installation details shall be included in the plans.

#### 12.6.6 **Photoelectric Control**

A photoelectric control (PE) should be specified as the means to switch the luminaire(s) on and off. Control may be provided at each luminaire, or by central control, locating the PE at the luminaire closest to the electrical control unit serving multiple circuits. The designer should consult with the maintaining agency and locality to establish any preferences.

Individual luminaire control is normally preferred for installations on utility poles, park-and-ride lots, and other minor lighting systems.

When it is desired to turn all of the circuits on and off with one PE, as with longer and more numerous circuits for lighting entire sections of an expressway, a contactor must be provided within the central controller. The contactor is needed due to the limited number of volt-amps that a photoelectric control can handle. The various circuits are connected to the contactor which in turn is connected to a photoelectric control. This arrangement limits the number of amps reaching the photoelectric control to an acceptable level. When this arrangement is used, a reverse contactor should also be provided for within the control box to energize the circuits should the PE fail.

## **12.7 TUNNELS AND UNDERPASSES**

Refer to the "Policy on Highway Lighting" for daytime and nighttime lighting policy and warrants. The lighting design should provide for the lighting levels and uniformities recommended in "An Informational Guide for Roadway Lighting". This reference and the "American National Standard Practice for Tunnel Lighting" discuss other factors, such as the selection and placement of luminaires, which the designer should consider.

### **12.7.1 Tunnels**

To achieve good visibility before entering, after leaving, and while within a tunnel, the designer should take into account the surroundings in which the tunnel is located as well as the characteristics of the tunnel itself. The designer should read the publications mentioned in section 12.7 and progress the design consistent with that guidance.

### **12.7.2 Underpasses**

Lighting can be provided from "wall packs" mounted on abutments and piers, or by "pendant" or "flat" lights, mounted over the travel lanes. The maintenance agency should be consulted to establish any preference.

Some recommendations when designing underpass lighting are:

1. For luminaires mounted over the travel lanes, an initial design may include a 70 W high pressure sodium lamp with type V, short, semi-cutoff luminaire(s),
2. Avoid placing the luminaire below the bottom flange of girder type bridges or other types of bridges that have flush bottom surfaces, unless there is available additional vertical clearance above the required minimum vertical clearance to accommodate the luminaire, and
3. Poles adjacent to an underpass should be located at a distance away (approximately 25 m) from the entrance and exit point of the underpass to allow the light from the lamp and luminaire to penetrate the underpass. This is very important at short underpasses where supplemental underbridge lighting is not required.

**12.8 PARK-AND-RIDE FACILITIES AND REST AREAS**

Refer to the "Policy on Highway Lighting" for park-and-ride facility and rest area lighting policy and warrants.

**12.8.1 Park-and-Ride Facilities**

The recommended design values referred to in section 12.8.2 are applicable to the design of park-and-ride facilities, with the exception of design values for platforms and shelters which are contained in the "Guide for the Design of Park-and-Ride Facilities".

**12.8.2 Rest Areas**

Refer to "An Informational Guide for Roadway Lighting" for recommended design values for:

1. Entrance and exit gores,
2. Interior roadways,
3. Parking areas, and
4. Activity areas

**12.9 GUIDE SIGN LIGHTING**

The criteria for lighting overhead guide signs are as follows:

1. The preferred light source is metal halide.
2. Position the luminaire(s) externally, 300 mm below and 1200 mm in front of the sign panel. Minimum vertical clearance requirements should be determined from the NYSDOT "Geometric Design Policy for Bridges". (150 mm of additional vertical clearance should be provided to avoid damage to the luminaire assembly.)
3. Provide an illumination gradient of 2:1 max. (refer to manufacturer's literature for a further discussion of this concept).
4. Luminaire shields should be specified to prevent light from shining into the eyes of traffic flowing toward the sign as well as in the opposite direction.

The designer should consult with lighting manufacturers to seek their recommendation regarding lamp size and spacing. Refer to "An Informational Guide for Roadway Lighting" for recommended lighting levels and the "Recommended Practice for Roadway Sign Lighting" for additional discussion.

### 12.10 LIGHTING REPORT

The designer should prepare a lighting report and retain it in the project files for future use when roadway modifications require revision to the lighting system. In addition, the report will document and provide a means for reviewing the basis for the design, performed consistent with the guidance in this chapter, as it progresses from inception to final design.

A lighting report should be submitted, or made available, with the Preliminary Plans, Advance Detail Plans, and Final Plans for review within the Region. Prior to submitting the preliminary report, the lighting criteria, determined based on the recommendations given in section 12.3.1, should be agreed to within the Region. The purpose of this step is to establish and agree upon the lighting levels (design criteria) before preliminary design work begins.

Designers should consider sending a copy of the lighting report to the utility company and municipality for review and comment. Continued coordination with these agencies should prevent problems associated with electric service connection, assumption of maintenance responsibility, or other issues which may be difficult to resolve late in project development or construction. A written reply from these agencies may be useful to document their concurrence with the design. It is important that these organizations are satisfied with those aspects of the design for which they will become responsible for servicing or maintaining. This correspondence with the utility and municipality should be added to the project file.

#### 12.10.1 Preliminary Lighting Report

The preliminary lighting report should establish the basic components of the lighting system and identify them in sufficient detail so that the system can be laid out and completed during design Phase V (Advanced Detailed Plans). The designer should include the following information:

1. Light source type,
2. Light source size and mounting height,
3. Luminaire type and location,
4. Luminaire spacing and arrangement,
5. Power supply point(s),
6. Hardware, and
7. Calculations (manual or computer printouts) which verify that the items selected in 1 through 4 above, satisfy the lighting design criteria.

#### 12.10.2 Advanced Lighting Report

The advanced lighting report should build upon and resolve the comments made regarding the preliminary lighting report. Design tasks performed leading up to and reflected in the advanced lighting report should include:

1. Energy consumption and cost calculations (if requested by the maintaining agency or utility),
2. Voltage drop calculations performed to determine cable (wire) size,
3. Other determinations necessary to bring plans/report up to this stage of development.

### 12.10.3 **Final Lighting Report**

The final lighting report should build upon and resolve the comments made regarding the advanced lighting report.

## 12.11 PLANS AND SPECIFICATIONS

Accurate and complete plans and specifications are a necessary part of the contract documents to help reduce disputes which may occur during construction and prevent the necessity to utilize the changed conditions clauses in the contract (see section 109-16 of the Standard Specifications).

### 12.11.1 **Plans**

The lighting plan and details should provide the information necessary for a contractor to bid and construct the lighting system. As a minimum, the following plan sheets should be provided:

1. Roadway Lighting Plan - provide the location of proposed and existing features such as:
  - a. edges of pavement, shoulder and curb,
  - b. luminaire supports and spacing, and
  - c. all other lighting facilities (conduit, cables, jacking, pole numbering, controller, power supply, and pullboxes).
2. Table of Luminaire Installation - either on the plan or on a separate sheet, specify the details associated with each luminaire installation. Indicate:
  - a. luminaire number (corresponds to number on plan),
  - b. location by station,
  - c. lateral offset of luminaire support (pole), (indicate what control line is used to measure offset),
  - d. foundation elevation,
  - e. foundation type (refer to foundation details, etc.),
  - f. pole type (refer to pole details, etc.)
  - g. luminaire type and lamp size, IES distribution type, voltage requirements,
  - h. luminaire mounting height.

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3. Wiring Details - provide details for:
  - a. circuit wiring,
  - b. transformer base wiring, and
  - c. controller wiring.
4. Pole Foundation Details - provide:
  - a. special installation details for cut or fill locations, and
  - b. dimensional requirements of foundation and conduit placement.
5. Pole Details - provide requirements for:
  - a. general configuration
6. Miscellaneous Details - show limits of clearing and grubbing existing trees in the path of light and in the vicinity of the luminaire.

**12.11.2 Specifications**

Designers should use either the Department's standard specifications found in Section 670 of the "Standard Specifications", or when these specifications do not satisfy the designer's needs, write or use previously written special specifications. Designs in Region 11 are progressed based on New York City Department of Transportation Division of Street Lighting approvals, standards, specifications and the New York City Electrical Code. Pay items have been developed, or should be developed when necessary, with the Region 11 pay item number prefix, which are based on the City of New York Specifications, Compiled 1970 for use in New York State Department of Transportation Contracts (Gray Book).

Specification pay items with corresponding quantities, or notes referring to separate agreements with utilities or municipalities regarding payment for work to be performed by them, shall be provided for all aspects of the work to be performed by the contractor.

Refer to Chapter 21 section 21.3 for further guidance regarding specifications.

**12.12 REFERENCES**

1. Policy on Highway Lighting, December 1979, Traffic Engineering and Safety Division, New York State Department of Transportation, State Campus, Albany, N.Y. 12232.
2. An Informational Guide for Roadway Lighting, 1984, American Association of State Highway and Transportation Officials, Suite 225, 444 North Capitol Street, N.W., Washington, D.C. 20001.
3. Roadway Lighting Handbook, December 1978, U.S. Department of Transportation, Federal Highway Administration, Offices of Research and Development, Office of Traffic Operations, Washington, D.C. 20590.
4. Roadway Lighting Handbook Addendum to Chapter Six, September 1983, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. 20590.
5. American National Standard Practice for Roadway Lighting, July 1983, Illuminating Engineering Society of North America, 345 East 47th Street, New York, N.Y. 10017.
6. Roadside Design Guide, 1989, American Association of State Highway and Transportation Officials, Suite 225, 444 North Capitol Street, N.W., Washington, D.C. 20001.
7. Americans With Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG), December 1993, Landscape Architecture Bureau, New York State Department of Transportation, State Campus, Albany, N.Y. 12232.
8. Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 1994, American Association of State Highway and Transportation Officials, Suite 249, 444 North Capitol Street, N.W., Washington, D.C. 20001.
9. American National Standard Practice for Tunnel Lighting, 1987, Illuminating Engineering Society of North America, 120 Wall Street, Fl.17, New York, N.Y. 10005.
10. Guide for the Design of Park-and-Ride Facilities, 1992, American Association of State Highway and Transportation Officials, Suite 249, 444 North Capitol Street, N.W., Washington, D.C. 20001.
11. Geometric Design Policy for Bridges, July 1993, Structures Design and Construction Division, New York State Department of Transportation, State Campus, Albany, N.Y. 12232.
12. Recommended Practice for Roadway Sign Lighting, 1983, Illuminating Engineering Society of North America, 345 East 47th Street, New York, N.Y. 10017.

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