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Part 2 – Design

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Roadways and Interchanges

Chapter 10

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CONTENTS

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Roadways and Interchanges — Chapter 10

The primary purpose of this chapter is to serve as the basis for the design of fixed lighting for highways and interchanges. This chapter deals entirely with lighting design and does not give advice on construction. Its purpose is to provide recommendations for the design of new continuous lighting systems for highways and interchanges. It is not intended for application to existing lighting systems until such systems are completely redesigned. It has been prepared to advance the art, science, and practice of highway lighting in North America.

In those circumstances where there is any doubt as to whether the provision of new or updated roadway lighting would provide a benefit at a particular location, a decision should be made based on a study of local conditions. In the United States, the *AASHTO Lighting Design Guide* provides guidance for warranting. In Canada, The TAC *Guide for the Design of Roadway Lighting* includes guidance for warranting. Once a decision has been made to provide lighting, this Recommended Practice may be referred to for guidance in designing an appropriate roadway lighting system.

This chapter contains lighting design considerations and criteria specific to lighting for highways and interchanges. Included in this chapter are coverage of roadway classifications and pavement classifications.

Streets are covered separately in **Chapter 11** because of the potential presence of pedestrians and bicyclists. Because of the special considerations inherent in their design, intersections, including roundabouts, are covered in **Chapter 12**, railway crossings in **Chapter 13**, underpasses and tunnels in **Chapter 14**, and toll plazas in **Chapter 15**.

In addition, several types of off-roadway applications and facilities are covered in **Chapter 16**, parking facilities in **Chapter 17**, roadway sign lighting considerations in **Chapter 18**, and temporary and work zone lighting considerations in **Chapter 19**.

10.1 Roadway Lighting – General

10.1.1 The Purpose of Roadway Lighting. The principal purpose of roadway lighting is to allow accurate and comfortable visibility at night of possible hazards in sufficient time to allow appropriate action. For the driver of a motor vehicle, this will mean time to stop or to maneuver around an obstacle. Good lighting has been shown to significantly reduce the proportion of accidents that occur at night, especially on urban freeways and on major streets.

The benefits of lighting should be considered against the drawbacks: engineering, capital, and maintenance costs; energy use; appearance—particularly of overhead wires, but sometimes also of poles—the added fixed-object hazard of poles; and spill light on adjacent residential or commercial property (e.g., outdoor dining) and into the nighttime sky. Thus, lighting is “good” when it is economical in equipment, energy and maintenance costs, and meets a proven or reasonably predictable need, with minimum adverse effects. This document has been developed to provide guidance to experienced engineers in designing such lighting.

10.1.2 Highway Lighting vs. Street Lighting. Two different types of roadway lighting systems are defined in this Recommended Practice: highway lighting and street lighting.

Highway lighting (see, for example, **Figure 10-1**) refers to lighting that is provided for freeways, expressways, limited access roadways, and roads on which pedestrians, cyclists, and parked vehicles are generally not present. The primary purposes of highway lighting are to help the motorist remain on the highway and help with the detection of obstacles within and beyond the range of the vehicle’s headlights.

Street lighting (see, for example, **Figure 10-2**) refers to lighting that is provided for major (arterial), collector, and local roads, where pedestrians and cyclists are generally present during hours of darkness. The primary purposes of street lighting are to help the motorist identify obstacles, provide adequate visibility of pedestrians and cyclists, and assist in visual search tasks, both on and adjacent to the street. Street lighting is covered in **Chapter 11**.

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Figure 10-1. Typical highway lighting installations. (Images courtesy of Paul Lutkevich, WSP)

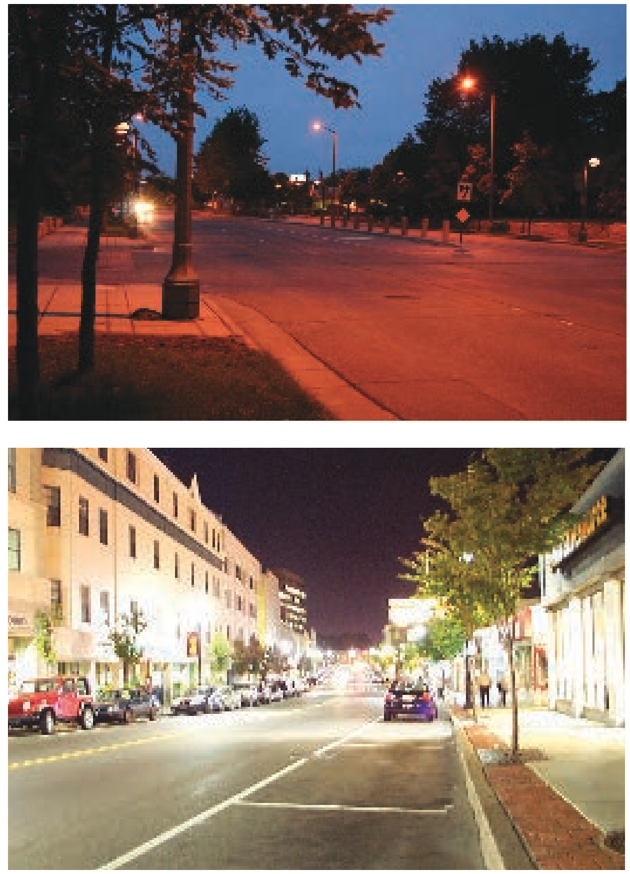

Figure 10-2. Typical street lighting installations. (Top image courtesy of Rick Kauffman; right image courtesy of Paul Lutkevich, WSP)

10.2 Classifications and Definitions

The terms used in this document might be used and defined differently by other documents, zoning bylaws, building codes, and agencies. For lighting design purposes, the classification for an area or roadway should best fit the descriptions contained within this document and not those of other sources.

10.2.1 Highway Classifications.

Freeway: A divided highway with full control of access.

Freeway A: Roadways with great visual complexity and high traffic volumes. This type of freeway will usually be found in major metropolitan areas in or near the central core, and will operate at or near design capacity through some of the early morning or evening hours of darkness.

Freeway B: All other divided roadways with full control of access.

Expressway: A divided highway with partial control of access.

Isolated Interchange: A grade-separated roadway crossing with one or more ramp connections between the crossing roadways, which is lighted and is not part of a continuous roadway lighting system.

Median: The portion of a divided roadway physically separating the traveled ways for traffic in opposite directions.

10.2.2 Pavement Classifications. The calculation of either pavement luminance or Small Target Visibility (STV) requires information about the directional surface reflectance characteristics of the pavement. Studies have shown that most common pavements can be grouped into a limited number of standard road surfaces having specific reflectance characteristics. These data have been experimentally determined and presented in r-tables. (See **Section 3.1.5** for a description of the pavement classifications and **Section 3.3.1** for the r-tables.)

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10.3 Design Considerations

10.3.1 Visual Task. An effort should be made to completely understand the visual task in a given setting.[1] Too often, the designer thinks only in terms of the driving task. When designing for areas of congestion or significant interest, allowance needs to be made for the myriad tasks that may be present. On a highway, these could include detecting wildlife approaching the road, spotting hazards or obstructions on the road, dealing with traffic tie-ups, reading signs, and other possible driving tasks. The recommendations included in this Recommended Practice are for typical situations. If the designer notes unusual situations when considering these items, then reasonable engineering judgment should be applied when applying the recommendations in this document.

10.3.2 Glare, Light Trespass, and Sky Glow Issues. Roadway lighting systems are under increasing scrutiny from various sectors of the public. While the public is not usually aware of specific design requirements of roadway lighting systems, observations of glare, light trespass, and sky glow are widely perceived and might be subject to criticism. Lighting designers should become familiar with these issues and be prepared to design a lighting system that meets the needs of the client or owner, while also considering the possible effects of the lighting system on the environment.

These issues are discussed in detail in **Chapter 4** and in **Chapter 11, Section 11.4.5**.

10.3.3 Impact of Headlights. Headlights are the primary system intended to assist drivers with seeing objects on and along the road. The ability of headlights to provide for detection of objects at higher vehicle speeds may not be adequate. It is known that at higher speeds the safe stopping sight distance can exceed the visual detection distance provided by low-beam headlights.[2,3,4] (See **Chapter 3, Section 3.1.8** for additional information.)

10.3.4 Spectral Considerations. The spectral content of street and highway lighting products is varied and, to a limited extent, controllable. Luminaires are available with many different blends of spectra; from nearly monochromatic yellows and reds to combinations of red, blue and green that appear as white light to many observers. Designers may select the spectral content of luminaires to achieve effects of color in the environment of their projects.

As anticipated in RP-8-14,[5] the U.S. Federal Highway Administration (FHWA) sponsored research by the Virginia Tech Transportation Institute (VTTI)[6] to evaluate the effects of changing spectral content in overhead street and highway luminaires on driver performance. The Roadway Lighting Committee, after review of this research, concluded that varying spectral content of overhead luminaires does not affect driver performance, as represented by detection of potential hazards.

IES TM-12-12 and *The Lighting Handbook*, 10th ed. (IES 2011) had introduced mesopic adjustment factors as potentially relevant to street and highway lighting calculations. The Roadway Lighting Committee considered the possibility that driver performance may vary with changes in spectral content of overhead lighting. After considering the results of the VTTI research, the Roadway Lighting Committee determined that the under realistic driving conditions, the driver is primarily photopically adapted, and therefore mesopic adjustment factors are not appropriate for street and highway lighting calculations at posted speeds of 40 km/h (25 mi/h) and higher. Therefore, calculations for street and highway luminance and illuminance are to remain based on the photopic luminous efficiency function without adjustment for spectral content.

The luminance levels in **Table 10-2 (Section 10.5.2)** were developed for roadway locations in the direct line of sight of the observer, and thus are to be interpreted as photopic levels only.

The reader is referred to **Chapter 2, Section 2.5.4 Spectral Effects and Mesopic Vision** for additional information.

10.4 Design Issues

Several major issues affect driver vision differently in rural compared to urban areas, and on limited access vs. uncontrolled access roads. These include differences in speed and levels of background luminance. Because of the increase in vehicular traffic and the level of traffic control, a motorist's rate of travel is typically slower in urban areas. The higher levels of background lighting found in urban areas can augment roadway luminance and illuminance provided by lighting systems, but can also produce glare and distraction. Thus, off-road light sources can either assist or disorient drivers.

10.4.1 Curves and Steep Grades. The visual problem in driving increases on curves and steep grades. Sharper-radius curves and steeper grades can require closer spacing of luminaires in order to achieve

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the desired light levels and uniformities. The modern computer programs that are available allow the designer to adjust and refine the pole spacing on curves and grades as required, to ensure that the lighting criteria are satisfied throughout.

10.4.1.1 Luminaire and Pole Location. The geometry of abrupt curves, such as those found on traffic interchanges and many roadway areas, requires careful analysis. Poles should be located so as to provide adequate clearance behind the guiderail or any natural barrier, if such exists.

10.4.1.2 Luminaire Orientation on Curves. Proper horizontal orientation of luminaire supports and poles on curves is important to ensure a balanced distribution of the light flux on the pavement. This can be achieved by ensuring that the luminaire is oriented at 90 degrees to the tangent of the curve (see **Figure 10-3**).

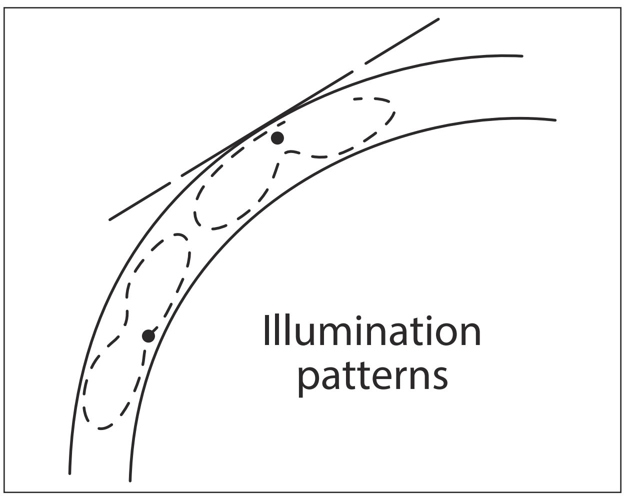

Figure 10-3. Luminaire orientation on curves.

10.4.1.3 Luminaire Orientation on Steep Grades. When luminaires are located on steep grades, it might be necessary to orient the luminaire (a "roll" adjustment) so that the light pattern from the luminaire is centered about the axis of the luminaire. This is accomplished by levelling the luminaire to the grade of the road. This ensures better uniformity of light distribution and keeps glare to a minimum (see **Figure 10-4**).

10.4.2 Highway Interchanges. A continuous lighting system will usually provide sufficient surrounding illuminance to reveal the features of the entire scene so that drivers will know where they are and where they are going at all times. An inadequately lit interchange can lead to confusion for the driver, by giving misleading clues due to a random placement of the luminaires (see **Figure 10-5a**).

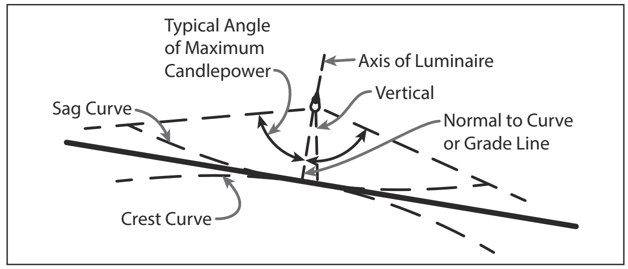

Figure 10-4. Luminaire orientation on steep grades.

When continuous lighting of the entire interchange area is not provided, it might be desirable to extend the limits of the conflict area to include site-specific areas of complexity, such as intersections, points of access and egress, curves, and steep hills. In these cases, lighting should extend beyond the conflict areas. **Figures 10-5a, 10-5b** and **10-5c** show examples of these types of interchanges. The reasons for this are:

- The eyes of the driver, adapted to the level of the lighted area, need about one second to adjust to the changes in the lighting upon leaving the lighted area, to maintain vision during the period of dark adaptation. Lighting transition, however, should be beyond the end of the maneuver area.
- Traffic merging into a highway from an access road is often slow in accelerating to the speed on the highway. The lighting along this area for a distance beyond the access point extends visibility and facilitates the acceleration and merging process.
- Diverging traffic lanes should be given careful consideration because motorists are most likely to become confused in these areas.

10.4.3 High-Mast Lighting. High-mast lighting has been employed in several jurisdictions as a means of providing both partial and continuous highway illumination (see, for example, **Figure 10-6**). Such systems consist of poles that range in excess of 20 meters (66 ft) in height and can consist of clusters of 3 or more luminaires that are usually located in a symmetrical fashion on supporting brackets that are fastened onto a ring. This type of highway lighting system can be ideal for providing illumination of freeways, parking lots, rest areas, and toll plazas, particularly where the poles can be safely mounted on concrete medians or in grass or dirt medians of sufficient width.

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