DIVISION OF TRAFFIC OPERATIONS
CALIFORNIA DEPARTMENT
OF TRANSPORTATION

Traffic Operations Manual

Chapter 205 Lighting and Sign Illumination Systems

Part 1 Roadway Lighting

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Section 1 Introduction

This document is the culmination of extensive research and effort by Caltrans staff to develop guidelines for roadway lighting designs. The purpose of this document is to provide a comprehensive source of information on Caltrans policies for roadway lighting within the State Highway System (SHS) and assist Caltrans roadway lighting designers in preparing uniform and standard designs of roadway lighting facilities. This includes guidance on the following:

- Installing uniform lighting within the SHS (including freeways, conventional highways, expressways, intersections, walkways and bikeways, roundabouts, park and ride lots, bus stops, and railroad crossings).
- Standardizing lighting structures.
- Adjusting luminaire spacing and light fixture characteristics for a more uniform lighting distribution or to protect environmentally sensitive areas.
- Evaluating lighting levels using computer-based lighting software.
- Updating Caltrans' lighting practices and standards.

The illumination requirements in this document are based on lighting industry practices and recommendations, including standards set by the Federal Highway Administration (FHWA) and the *American National Standards Institute/Illuminating Engineering Society of North America Recommended Practice for Design and Maintenance of Roadway and Parking Facility Lighting* (*ANSI/IES RP-8-22*) guidelines.

This document supersedes the 2021 *Caltrans Roadway Lighting Manual* and does not constitute a standard, specification, or regulation and is not a substitute for engineering knowledge, experience, or judgment. Field and economic conditions may call for variation from this publication's requirements and may be subject to approval by designated levels of management in the district. Caltrans shall not be liable for any claims in connection with the use of this document including without limitation: liability arising from third-party claims, liability related to the quality of calculations or the safety or quality or structures, liability for scheduling delays or re-design, liability related to the retrofitting or re-working of structures, or any other similar liability.

It is important to note that fulfillment of lighting warrants may or may not justify upgrading or modifying a lighting facility, so the following factors should be considered:

- Safety (vehicle, pedestrian, bicyclist activity, or accident history).
- Budget, project scope, level of improvement, or schedule.
- Service connection feasibility (right-of-way and easements).
- Policies and manuals (such as Caltrans Director's Policy 37 – Complete Streets, and FHWA guidelines such as Proven Safety Countermeasures).
- Recommendations from subject matter experts and stakeholders.

Section 2 Lighting Procedures

The design of roadway lighting should comply with the policies and standards that are referenced or summarized in the latest versions of the following publications:

- Caltrans *Standard Plans, Standard Specifications, and Contract Item Codes*.
- Caltrans *Construction Contract Development Guide*.
- Caltrans *Highway Design Manual (HDM)*.
- Caltrans *Plans Preparation Manual*.
- Caltrans *Project Development Procedures Manual (PDPM)*.
- Caltrans *Electrical Systems Design Manual*.
- *California Manual on Uniform Traffic Control Devices (CA MUTCD)*.
- Caltrans *Local Highway Safety Improvement Program Guidelines*.
- Caltrans *Standard Environmental Reference (SER)*.
- Caltrans *Traffic Safety Systems Guidance*.
- *National Cooperative Highway Research Program (NCHRP) Annual Report*.
- *FHWA Lighting Handbook*.

Topic 1 Project Development

General requirements for developing lighting projects are noted in the Caltrans *PDPM*. The cost of lighting on federal aid highway projects is eligible for federal participation under certain conditions.

This document should be used for new or modified lighting facilities within the SHS.

The *FHWA Lighting Handbook* describes recommendations for roadway lighting and requirements for federal aid eligibility. This document is in substantial conformance with the *FHWA Lighting Handbook* to ensure federal aid eligibility.

For scoping and programming purposes, lighting warrants and the scope of lighting facilities should be addressed in the safety analysis and documented in the Project Initiation Document (PID). The Caltrans *PDPM* and the project manager should be consulted to determine specific reporting requirements.

The following data is used to warrant lighting and should be included in the PID or Project Report when applicable:

- **Traffic Counts** – Pedestrian, bicyclist, and vehicular traffic counts should be measured during hours of darkness. Pedestrian traffic counts should be shown on each crosswalk for the same periods as the vehicular count.

- **Vehicle Speed** – This indicates the posted speed limit or the 85th percentile speed of vehicles on approaches to the intersection.
- **Electrical Service** – This is a statement on the availability of electrical service. Where the cost of establishing electrical service is excessively high due to line extension, consider alternate sources of power or deferring the installation.
- **Other Data**:
  - Location map.
  - Condition diagram showing existing conditions.
  - Summary of crashes and the crash diagram.
  - Figure 4C-101 (CA) (Traffic Signal Warrants Sheet [sheets 1 to 5]), Figure 4C-102 (CA), or Figure 4C-103 (CA) from *CA MUTCD*.
  - Table 4C-1, Table 4C-2, Table 4C-3, and Table 4C-4, and Figure 4C-102 (CA) from *CA MUTCD*.
  - Improvement diagram showing existing and proposed lighting, channelization, and other proposed improvements. This may be combined on a single plan.
  - Environmentally sensitive areas that may need special consideration in lighting design.
  - Cost estimate.
  - Explanation of conditions to be improved by the lighting.
  - Traffic study forecasting future traffic volumes.

Topic 2 Lighting Standards

General

Lighting standard types within the SHS are shown in the Caltrans *Standard Plans*. Exceptions can be made in the event where a local agency uses a different type of lighting standard and has one of the following:

- Existing lighting that is being replaced due to state highway construction.
- A preference to include their roadway lighting into a state highway project. Long-term maintenance of the local agency's preferred lighting is covered in Section 2, Topic 5 "Lighting by Local Agencies and Others."

Standard Types

The type of standards for lighting installations are provided in the Caltrans *Standard Plans*. Modifications to lighting standard types, other than what is shown in the Caltrans

Standard Plans, require approval or a special design from the Special Designs Branch within the Division of Engineering Services.***Type 15 and Type 15D Standards***

Type 15 and 15D standards are typically installed at intersections, highways, and expressways. Type 15 and 15D standards may be mounted on structures in lieu of Type 21 standards where a lower mounting height is desired.

A 12-foot luminaire mast arm is normally used on a Type 15 standard, but lengths of 6, 8, 10, and 15 feet are also available. Aside from the 15-foot luminaire mast arm, the same lengths are also available for a Type 15D standard.

Type 21 and Type 21D Standards

Type 21 and 21D standards are typically installed on structures, barriers, and retaining walls.

A 12-foot luminaire mast arm is normally used on a Type 21 standard, but lengths of 6, 8, 10, and 15 feet are also available. Aside from the 15-foot luminaire mast arm, the same lengths are available for a Type 21D standard.

Types 30, 31 and 32 Standards

Type 30, 31, and 32 standards are typically installed on freeway diverge and merge points at on-ramps and off-ramps.

Type 30 standards have a slip base by default and are used when the standard cannot be placedTypical luminaire mast arm lengths for Type 30 standards are 15 feet, but lengths of 6, 8, 10, and 12 feet are available.

Type 31 standards only have a 20-foot luminaire mast arm and should be placed a minimum of 20 feet from the edge of traveled way. If a Type 31 standard is installed on the freeway or expressway, it needs to have a slip base within the clear recovery zone (CRZ).

Type 32 standards only have a 30-foot luminaire mast arm and should be placed a minimum of 30 feet from the edge of traveled way.

High Mast Lighting

The use of high mast lighting systems may be considered where regular lighting standards are difficult to install and maintain. Section 2, Topic 1 "Project Development" applies whether high mast or conventional lighting standards are used.

The following factors should be taken into consideration when selecting between conventional and high mast units:

- Location. This type of lighting should not be used in substantially developed residential areas to prevent lighting intrusion.
- Installation and maintenance costs.

- Traffic volume.
- Possibility of light pollution.
- Increase in environmental impacts, such as sensitive species or habitat.

Conventional lighting often requires lower installation costs on non-interchange roadway segments, while high mast lighting is less expensive for interchange areas due to reduced conduits and conductors, requiring fewer lighting fixtures and poles.

Maintaining high mast lighting also costs less because it involves less extensive lane closures.

Lighting Standard Placement

Refer to the figures within the applicable sections of this document for examples of typical installations.

Placement of lighting standards should comply with the latest Caltrans *HDM*, Chapter 300, Topic 309.1, "Horizontal Clearances for Highways."

Foundations

The foundation and installation details for lighting standards are shown in the Caltrans *Standard Plans*.

Lateral (Set Back)

Luminaires should not extend beyond the edge of traveled way, and lighting standard foundations should be as far from the right or left edge of the pavement as conditions permit. Exceptions to this are cut or fill slopes that are steeper than 4:1 in which foundations should be placed as shown in the Caltrans *Standard Plans*. On curved freeway ramps, lighting standards should be located on the inside of the curve. Lighting standards within sidewalks should be placed at the back of the sidewalk, when feasible, and maintain a clear pedestrian through zone that meets or exceeds Americans with Disabilities Act requirements. Refer to *HDM* standards and Design Information Bulletin-94 Complete Streets: Contextual Design Guidance.

Longitudinal

Adjust luminaire spacing to achieve required lighting levels in the conflict area using lighting software based on the roadway classification, traffic volumes, application, and environmental resources protection.

Structures

On structures and retaining walls, lighting standards should be located at least 5 feet from the structure expansion joints or hinges. Care should be taken in locating

standards on lower roadways or structures to avoid creating glare to vehicles on a higher structure.

Slip Bases

Slip bases should be installed on lighting standards that are within the CRZ. Refer to Caltrans *HDM* and Caltrans *Traffic Safety Systems Guidance* for guidance on slip base and breakaway poles. Slip bases may be installed on Type 15, Type 30, and Type 31 standards. Exceptions to this policy are that slip bases are not used under signal standards with lighting or under lighting standards located in any of the following areas:

- On or behind structures, retaining walls, or sound walls.
- Behind guard rails or barrier railing.
- In sidewalk areas.
- At or near pedestrian facilities where there is a potential for pedestrians to be impacted by a pole knockdown.

Topic 3 Utility Coordination

For new and modified service connections, the local electric utility must be contacted to determine the location and type of service during the design stage. Lighting facilities for local agencies require a separate service equipment enclosure and the local agency is responsible for the service utility fees.

Topic 4 Financing

General Policy

Installation, operation, and maintenance of roadway lighting facilities within the SHS are financed by Caltrans. When other public agencies or independent owners request decorative or nonstandard equipment, the division of responsibility should be delineated in the Electrical Maintenance Agreement. See Chapter K, Part K.09.1 "Painted/Decorative Standards and Poles, and Painted Hardware" of the *Maintenance Manual* for more information for public agencies. A cooperative maintenance agreement delineates the division of responsibility for independent owners.

At intersections where Caltrans shares ownership with another agency, the operational cost for lighting facilities is also shared.

When roadways outside of the SHS (such as frontage roads and intersections) are affected by Caltrans' road construction, warranted (see Section 3, Topic 1 "Freeway Interchange Lighting Warrants" and Section 4, Topic 1 "Conventional Highway and Expressway Lighting Warrants") roadway lighting facilities serving roadway construction may be installed at Caltrans' expense when the local agency, or others, agree to ownership, maintenance, and operational expenses.

Installation, operation, and maintenance of lighting facilities not meeting warrant criteria (see Section 3, Topic 1 "Freeway Interchange Lighting Warrants" and Section 4, Topic 1 "Conventional Highway and Expressway Lighting Warrants"), when requested by local agencies, or others, are financed at the requestor's expense and may require additional measures, such as cooperative and maintenance agreements. Such lighting must not detract from the effectiveness of existing state lighting or interfere with the safe movement of traffic.

Topic 5 Lighting by Local Agencies and Others

Where a local agency or others propose to install lighting within the SHS, an encroachment permit is required. Lighting may be installed at the intersection of a state highway and private driveway under an encroachment permit. For more information regarding encroachment permits, refer to the Caltrans *Encroachment Permits Manual*. Caltrans will review the lighting system design. Such lighting shall not detract from the effectiveness of existing state lighting or interfere with the safe movement of traffic.

Lighting for temporary construction may be installed on wood poles, however, all lighting installation must comply with CRZ requirements. When higher average illuminance luminaires are added to a modified lighting system, replacing all existing luminaires with new luminaires should be considered. The installation may be performed by a local agency, a contractor, or an electric utility. When lighting facilities are installed or modified, the Electrical Maintenance Agreement must be coordinated with the District Maintenance Agreements Liaison.

A cooperative agreement or joint use maintenance agreement between Caltrans and a local agency identifies the responsibility for the costs associated with installing, upgrading, maintaining, and operating lighting within the SHS.

Topic 6 Reconstruction of Existing Facilities

General Policy

Existing lighting facilities within the SHS that are affected by state construction are replaced at Caltrans' expense, using salvaged materials when possible.

The reconstruction of existing lighting facilities that are owned by a private utility company is the responsibility of the utility company and will be handled by the Division of Right of Way.

Existing lighting facilities within the SHS, when owned by a local agency or others, that are affected by state construction, are reconstructed at the expense of the owner unless prior rights can be established.

When a local agency requests to have an existing continuous lighting system within the SHS reconstructed to an improved standard or a new lighting system, the cost to Caltrans is limited to its share of the lighting where lighting is warranted (see Section 3,

Topic 1 "Freeway Interchange Lighting Warrants" and Section 4, Topic 1 "Conventional Highway and Expressway Lighting Warrants").

Topic 7 Lighting Levels

The lighting levels recommended are based on illuminance, instead of luminance, for field verification purposes and are obtained from the *ANSI/IES RP-8* publication. See *ANSI/IES RP-8* for the luminance to illuminance conversion for R2 and R3 class asphalt roadway surfaces and pavement classifications.

The lighting levels on roadways should be determined by type, classification, and pedestrian or bicyclist volumes.

The luminaire mast arm length is based on the geometric design of a roadway. The luminaire mast arm length and height will affect the photometric lighting intensity.

Refer to the appropriate tables in applicable sections of this document for the average maintained illuminance, uniformity ratio, and lighting levels.

Roadway lighting installations must:

- Have a clear purpose.
- Be directed to where it is needed while keeping in mind light pollution and environmental impact, as well as other applicable considerations.
- Have illuminance levels that are not higher than necessary.
- Be controlled and operational only during hours of darkness, except for facilities that require continuous lighting.

Roadway lighting luminaires should have a correlated color temperature (CCT) of 3,000 kelvins. Lower CCT should be considered in areas with no pedestrian or bicyclist traffic.

Topic 8 Lighting Area

Additional conflicts can be identified by experts, supplementing the guidelines outlined in this topic.

Conflict Points

A conflict point is a point where a driver decides which travel lane to follow. The following are examples of different types of conflict points:

- **Diverge Point** – Where a single travel lane divides to form two or more separate travel lanes.
    - Example: The diverge point on a freeway is when a lane divides to form a through lane and an off-ramp lane. The beginning of the exit ramp gore is the diverge point.

- **Merge Point** – Where two or more travel lanes combine to form a single travel lane.
    - Example: The merge point on a freeway is where the on-ramp lane narrows to 9 feet wide to form a single lane with the through lane on the freeway.
- **Crossing Point** – Where distinct movements intersect.
    - Example: Left-turn movement at an intersection over a crosswalk.

Conflict Areas

A conflict area is an area that encompasses all conflict points on a roadway that is used for lighting analysis.

Intersections

The conflict area for intersections is defined by the area bounded by the crosswalks. Where there are no crosswalks, the conflict area is defined by the area normally bounded by crosswalks.

Topic 9 Plans, Coordination, and Processing

General

The requirements for submitting plans, specifications, and estimates are noted in the Caltrans *PDPM* and the Caltrans *Construction Contract Development Guide*.

Structure

The designer should coordinate with the Division of Engineering Services, Office of Structure Design to coordinate with a structure engineer for the exact location of luminaires and pull boxes, foundation details, and conduit routes through the bridge structure to ensure proper design is included for all structures within the project limits.

Topic 10 Environmental Coordination

Coordination between the design and environmental processes should begin early in project development and continue through construction. The project development team (PDT) must identify and address potential environmental lighting impacts and ensure the project complies with applicable state and federal laws and regulations including avoiding/minimizing impacts or developing mitigation for unavoidable impacts.

Lighting impacts may include disturbances to bird nesting, sensitive wildlife habitats, or locations within a coastal zone or historic district. The designer should consult with their district's environmental and biology offices and review the Caltrans *SER* for potential lighting mitigation measures.

Potential lighting avoidance, minimization, or mitigation measures include at least one of the following:

- Utilizing roadway lighting analysis software to perform lighting level analysis in areas of concern such as environmentally sensitive areas.
- Reducing CCT of proposed lighting fixtures. Current Caltrans standard specifications require a nominal CCT of 3,000 kelvins. Designers are to document changes in their project design files.
- Lowering luminaire mounting heights. Consult Headquarters Division of Engineering Services if non-standard lighting standards are used.
- Adjusting lighting levels, color spectrums, and fixture placement per environmental sensitive areas.
- Installing luminaire light shields.
- Considering other alternatives that address illumination needs in environmentally sensitive areas, such as hyperreflective roadway striping.

Section 3 Freeway Lighting

This section includes warrants criteria, design criteria, and recommended lighting levels for freeway lighting. Freeway lighting may include one or more of the following:

- Interchange lighting, including ramps, mainlines, cross streets, gore areas, and intersections at ramp termini.
- Areas with potential conflict points.
- Points of access, means of egress, curves, steep hills, and major, collector, or local intersections.

Topic 1 Freeway Interchange Lighting Warrants

Freeway interchange lighting is warranted when one of the following is met:

- The total sum of the average daily traffic (ADT), ramp traffic entering and leaving the freeway within the interchange area exceeds 5,000 under urban conditions, 3,000 under suburban conditions, and 1,000 under rural conditions. These numbers refer to the total sum of ADT for the typical four ramps that are at an interchange. Where the number of ramps connecting with the freeway is less than four, this total sum of ADT may be reduced proportionately.
- ADT on the freeway exceeds 25,000 for urban conditions, 20,000 for suburban conditions, and 10,000 for rural conditions.
- Where a combination of sight distance, horizontal or vertical curvature of the roadway, channelization, or other factors indicate a visibility improvement with the installation of lighting.

Freeway Interchange Lane Lighting

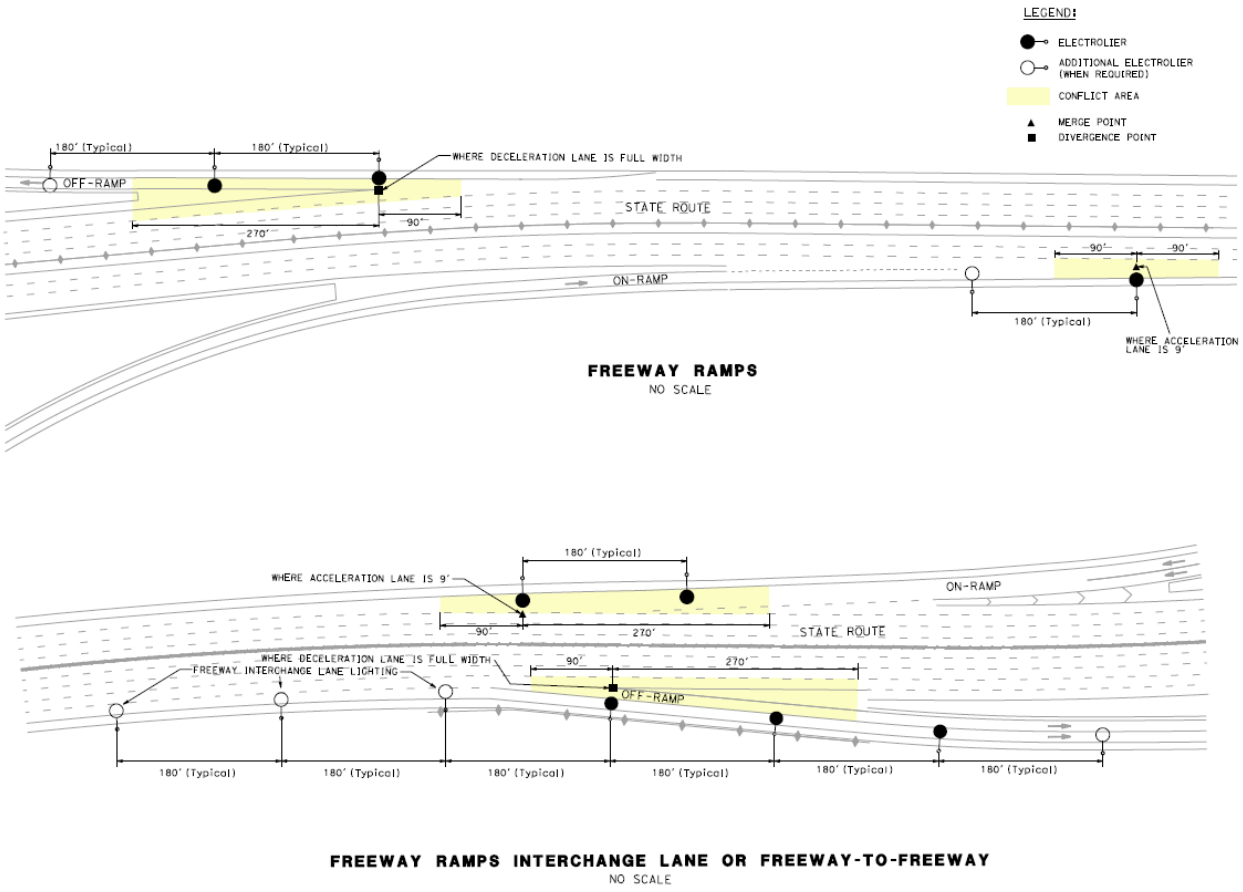
Freeway interchange lanes include the acceleration lanes (entrance ramps), deceleration lanes (exit ramps), or any auxiliary lanes that starts from an entrance ramp and ends at the next exit ramp. Continuous lighting for freeway interchange lanes is warranted when the lane is 1.5 miles or less. The recommended lighting levels for freeway interchange lane lighting are shown on Table 205-1.

Table 205-1 Recommended Lighting Levels for Freeway Interchange Lanes

Min E_{avg} (fc)	Max Uniformity E_{avg}/E_{min}
0.8	3.5

Figure 205-1 shows the typical luminaire placement for freeway ramps, interchange lanes, and freeway-to-freeway.

Figure 205-1 Freeway Ramps, Interchange Lane, and Freeway-to-Freeway



Freeway Ramp and Surface Street Intersection Lighting

Lighting at the intersection of a freeway ramp and a surface street within the SHS is warranted (see Section 3, Topic 1 "Freeway Interchange Lighting Warrants") when any of the conditions in freeway interchange lighting warrants are satisfied.

Additional luminaires may be installed when justified by geometrics, traffic patterns, background ambient lighting, lighting analysis, or freeway ramp traffic volumes.

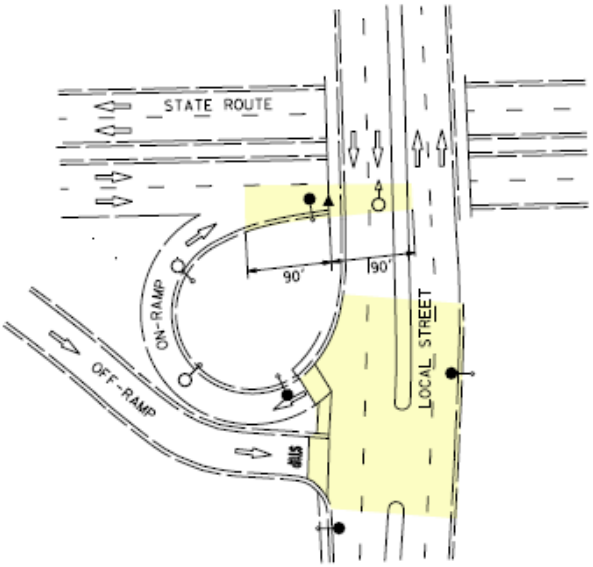
Table 205–2 shows the recommended lighting levels for freeway ramps and surface streets.

Table 205-2 Recommended Lighting Levels for Intersections and Roundabouts

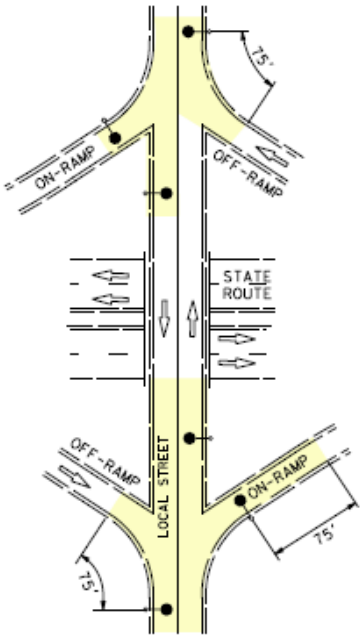
Roadway Intersection Classification	Ped/hr (During Hours of Darkness) Min E_{avg} (fc)			Max Uniformity Eavg/Emin
	≥ 100	11 to 99	≤ 10	
Major/Major	3.2	2.4	1.7	3.0
Major/Collector	2.7	2.0	1.4	3.0
Major/Local	2.4	1.9	1.2	3.0
Collector/Collector	2.2	1.7	1.1	4.0
Collector/Local	2.0	1.5	0.9	4.0
Local/Local	1.7	1.3	0.7	6.0

Figure 205-2 shows typical luminaire placement on freeway partial clover and diamond interchanges.

Figure 205-2 Freeway Partial Clovers and Diamond Interchanges[1]



PARTIAL-CLOVER INTERCHANGE
NO SCALE



DIAMOND INTERCHANGE
NO SCALE

LEGEND:
- ELECTROLIER
- ADDITIONAL ELECTROLIER (WHEN REQUIRED)
- CONFLICT AREA
- MERGE POINT
- DIVERGENCE POINT
- SOFFIT OR WALL PACK LUMINAIRE

Footnote: [1] Refer to Section 5.2.1 of the FHWA Lighting Handbook.

Freeway On-Ramps and Off-Ramps

This portion includes general requirements for installing lighting on freeway on and off-ramps.

The minimum lighting areas for freeway on-ramps and off-ramps include the following:

- Diverge point (typically two or three luminaires are placed):
  - **Longitudinal Boundary** – Starts 90 feet upstream of the diverge point and ends 270 feet downstream of the diverge point.
  - **Lateral Boundary** – Starts at the right-side edge of the lane and ends at the left-side edge of the lane. This area is typically 24 feet wide.
- Merge point (typically one or two luminaires are placed):
  - **Longitudinal Boundary** – Starts 90 feet upstream of the merge point and ends 90 feet downstream of the merge point.
  - **Lateral Boundary** – Starts at the right-side edge of the lane (where lane tapers to 9 feet) and ends at the left-side edge of the lane. This area is typically 21 feet wide.

Luminaires at freeway on-ramps and off-ramps are placed a maximum of 180 feet apart. The luminaire spacing may be adjusted to achieve recommended lighting levels.

The recommended lighting level for freeway ramps are shown in Table 205-1. Refer to Figure 205-1 for typical luminaire placement.

The longitudinal lighting area for on-ramps and off-ramps is extended when traffic volumes meet the freeway traffic volume (during one hour of darkness). Table 205-3 shows ramp volume requirements.

Table 205-3 Recommended Extended Conflict Area for High-Volume Freeways

Freeway Traffic Volume (During One Hour of Darkness)	On-Ramp or Off-Ramp Volume (VPH)	Off-Ramp Longitudinal Area (ft)	On-Ramp Longitudinal Area (ft)
> 75,000	> 300	+90 downstream	+90 upstream
> 150,000	> 700	+180 downstream	+180 upstream

The recommended lighting levels for high-volume freeways are shown in Table 205-1.

Freeway Ramp Meter

For freeway on-ramps with ramp metering and more than one lane, a minimum of one luminaire should be placed within 70 feet downstream of the limit line.

Topic 2 Freeway-to-Freeway Connections

Freeway-to-freeway connections warrant lighting to warn drivers of the following:

- Additional lanes that have been added or reduced from the freeway.
- Merging traffic.
- Navigate curvature of connector to improve the visibility and perception.

The recommended lighting level for freeway-to-freeway connections are shown in Table 205-1. Refer to Figure 205-1 for typical luminaire placement on freeway-to-freeway connections.

Topic 3 Local Streets Within Limits of Freeway Projects

General Policy

Lighting of local streets that are within the limits of Caltrans' road construction outside of the SHS may be installed when the local agency agrees to ownership, cost of maintenance, and one of the following criteria is met:

- Lighting is proposed to be installed by the local agency within five years after construction of the freeway is completed. Illumination levels must be coordinated with the local agency. The following should be considered for future lighting installations:
  - Conduits and other equipment in and under paved areas.
  - Provisions for future structure lighting as stated in Section 5, "Structure Lighting."
- Continuous roadway lighting already exists. The overall illumination uniformity should be approximately equal to the existing illumination levels. Existing illumination standards should be considered to ensure uniformity.
- Lighting is owned by a private utility company. Coordinate equipment location to ensure uniform lighting levels. Equipment that will be in or under paved areas within the freeway project limits must be installed by Caltrans.

Topic 4 Lighting for High-Occupancy Vehicle and Express Lanes

Lighting should be considered on high-occupancy vehicle and express lanes at the diverge and merge points. The division of responsibility for lighting should be delineated in the managed lanes maintenance and operations agreement. Refer to Table 205-1 for recommended lighting levels.

Section 4 Conventional Highway and Expressway Lighting

The purpose of conventional highway and expressway lighting is to illuminate conditions that are unusual, as well as illuminate the paths of travelers that may benefit from additional lighting.

Conventional highway and expressway lighting levels may be higher than freeway lighting levels due to the potential conflict points at intersections and driveways.

Topic 1 Conventional Highway and Expressway Lighting Warrants

Lighting on conventional highways and expressways is typically installed at intersections with traffic signals, flashing beacons, stop controls, yield controls, pedestrian hybrid beacons, and locations where lighting is warranted.

Continuous Lighting

Continuous lighting is a lighting system designed to provide a uniform level of illuminance throughout a specified section of roadway. Continuous lighting is warranted in the following conditions:

- At pedestrian or bicycle paths.
- When a crash summary indicates that both the following conditions exist:
  - At least 30% of crashes have occurred at night over the last 5 years.
  - High vehicle speeds (greater than 45 miles per hour) or high-volume roadway sections, as determined by engineering judgment, with pedestrians or bicycle facilities.
- Where a combination of sight distance, horizontal or vertical curvature of the roadway, channelization, or other factors indicate a visibility improvement with the installation of lighting.
- When a Complete Streets need is identified in the Complete Streets Decision Document (CSDD). The CSDD process will require coordination with Traffic Operations and Electrical Units to determine the necessity of lighting. The CSDD will document the justification for the lighting decision.

Table 205-4 shows the recommended lighting levels for continuous lighting on conventional highways and expressways.

Table 205-4 Recommended Lighting Levels for Conventional Highways and Expressways

Roadway Classification	Ped/hr (During Hours of Darkness)	Min E_{avg} (fc)	Max Uniformity E_{avg}/E_{min}
Major (3,500 or higher ADT)	≥100	1.67	3.0
	11-99	1.25	3.0
	≤ 10	0.83	3.5
Collector (1,501 to 3,499 ADT)	≥ 100	1.11	3.0
	11-99	0.83	3.5
	≤ 10	0.56	4.0
Local (100 to 1,500 ADT)	≥ 100	0.83	6.0
	11-99	0.70	6.0
	≤ 10	0.42	6.0

Crosswalks

Crosswalk lighting is warranted at controlled pedestrian crossings (such as pedestrian hybrid beacons). The crosswalk and areas between limit lines should be illuminated.

Crosswalk lighting may be warranted at pedestrian actuated crossings (such as rectangular rapid flashing beacons) or multilane crossings where vehicle volumes exceed 10,000 average annual daily traffic. One or two luminaires should be placed near the crosswalk. When two luminaires are placed, they should be at opposite ends of the crosswalk.

Refer to Table 205–2 and Table 205-5 for recommended lighting levels for conventional highways and expressways, as applicable.

Table 205-5 Recommended Lighting Levels for Controlled Pedestrian Crossings (Conventional Highways and Expressways)

Roadway Classification	Min E_{avg} (fc)	Max Uniformity E_{avg}/E_{min}
Major (3,500 or higher ADT)	0.8	3.0
Collector (1,501 to 3,499 ADT)	0.6	4.0
Local (100 to 1,500 ADT)	0.4	6.0

Intersections

Lighting is warranted at intersections on conventional highways and expressways under the following circumstances:

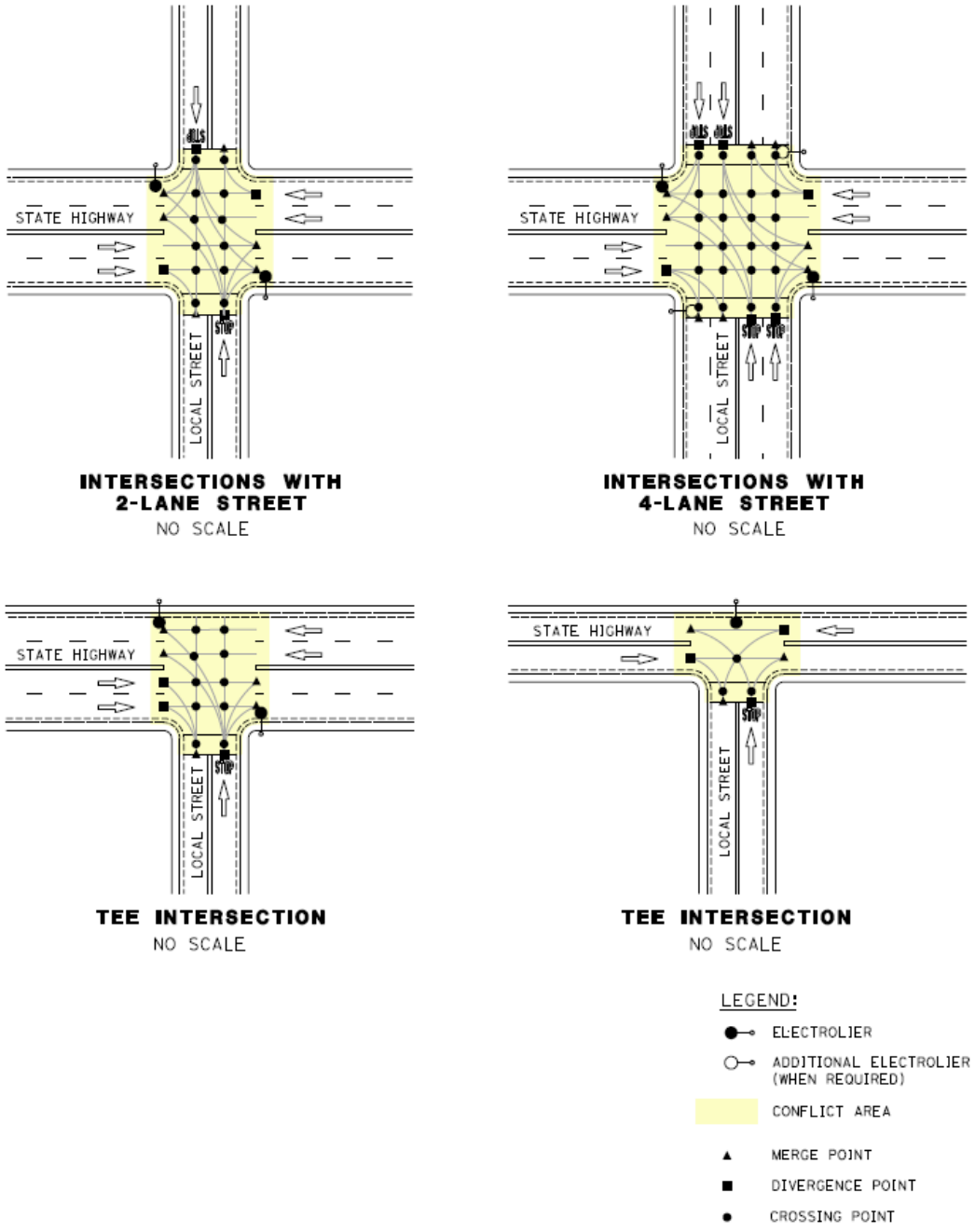
- Warrant 1, Condition A (Minimum Vehicular Volume) and Condition B (Interruption of Continuous Traffic) (see Figure 4C-101 [CA] Traffic Warrants Sheet Worksheet [Sheet 1 of 5] of the *CA MUTCD*) are satisfied.
- Warrant 4, Part 1, Section B (Pedestrian Volume) (see Figure 4C- 101 [CA] Traffic Warrants Sheet Worksheet [Sheet 3 of 5] and Figures 4C-7 and 4C- 8 from *CA MUTCD*) is satisfied for one hour of darkness.
- When 4 or more nighttime crashes have occurred in a consecutive 12-month interval within the last 5 years.
- When 6 or more nighttime crashes have occurred in a consecutive 24-month interval within the last 5 years.
- At traffic signals. A minimum of one luminaire should be placed at each corner to illuminate the crosswalk and the area normally bounded by the crosswalk. The lighting level emphasizes the middle of the intersection to all turning and oncoming vehicles.
- At regulatory stop signs with flashing beacons.
- Where a combination of sight distance, horizontal or vertical curvature of the roadway, channelization, or other factors indicate a visibility improvement with the installation of lighting. Factors that constitute visibility improvement should be included in the PID.

Luminaires should be placed on the downstream side of the intersection. The luminaire position notifies drivers about the perimeter of the intersection, past the approaching limit line, as well as the surrounding geometrics of the area.

The recommended lighting levels for intersections and isolated intersections are shown in Table 205-2 and Table 205-5, as applicable.

Figure 205-3 shows the typical luminaire placement on roadway intersections.

Figure 205-3 Roadway Intersections



Section 5 Special Lighting Applications

This section provides guidelines for special lighting applications. These applications may vary depending on factors such as funding, right-of-way, availability of electric power, and the surrounding climate. Special lighting applications include the following types:

- Walkways and bikeways.
- Roundabouts in roadways without continuous lighting.
- Railroad grade crossings.
- Mobility hubs (also known as park and ride lots).
- Bus stops.
- Signs.
- Chain on and off areas.
- Falseworks.
- Tunnels.
- High masts.
- Temporary.

Topic 1 Walkways and Bikeways

Lighting can help improve visibility for drivers, pedestrians, and bicyclists using highways, walkways, and bikeways.

Lighting for walkways and bikeways is warranted when a Complete Streets need is identified in the CSDD. Lighting may be warranted when the walkway or bikeway has 100 or more combined pedestrians and bicyclists per hour during hours of darkness.

Pedestrian scale lighting standards with luminaire heights of 10–25 feet require a special design and should be used for walkways and bikeways. The project engineer must coordinate with the Office of Design and Technical Services within the Division of Engineering Services.

Table 205-6 shows the recommended lighting levels for walkways and bikeways.

Table 205-6 Recommended Lighting Levels for Walkways and Bikeways

Vehicle and Ped or Ped only	Ped/hr (During Hours of Darkness)	Min E_{avg} (fc)	Max Uniformity E_{avg}/E_{min}
Vehicle and Ped	≥ 100	1.9	4.0
Ped Only	≥ 100	0.9	4.0
Vehicle and Ped	11-99	0.5	4.0
Ped Only	11-99	0.4	4.0
Vehicle and Ped	≤ 10	0.3	6.0
Ped Only	≤ 10	0.2	10.0

Topic 2 Roundabouts in Roadways Without Continuous Lighting

Lighting is warranted at roundabouts. The purpose of roundabout lighting is to achieve the following:

- Bring awareness to the change in roadway geometry and channelization for traffic approaching the roundabout.
- Improve the visibility and perception of conflict points that are due to the circulatory roadway for traffic within the roundabout.

Roundabout lighting design criteria includes the following:

- When continuous roadway lighting already exists, the overall illumination uniformity of the roundabout should be approximately equal to the existing illumination levels. Existing illumination standards should be considered to ensure uniformity.
- When continuous roadway lighting does not already exist, lighting should be provided on each approach. The conflict area should be extended from the circulatory roadway along each approach a minimum of 270 feet.
- Illumination should be provided on the approach nose of the splitter islands, at conflict points where traffic is entering the circulating stream, and at conflict points where the traffic streams separate to exit the roundabout.
- Crosswalks and bicycle ramps must be included in the conflict area. Lighting

standards should be placed a minimum of 10 feet upstream from the crosswalk to provide positive contrast.

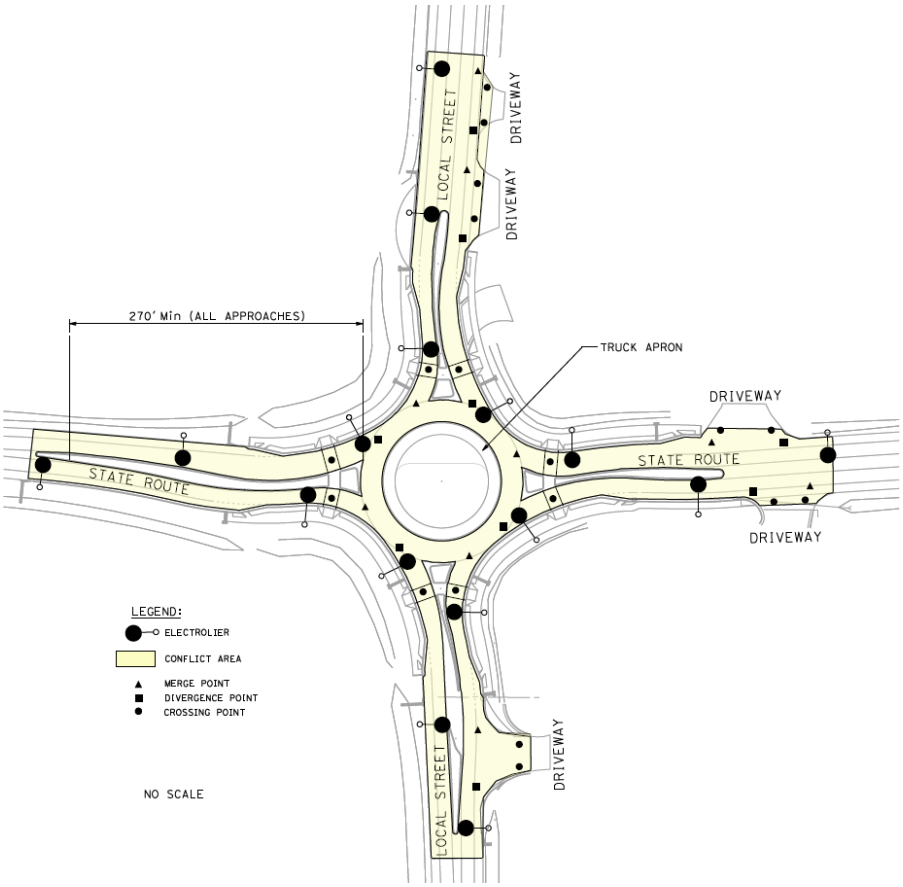
The recommended lighting levels for roundabouts and isolated roundabouts are shown in Table 205-2 and Table 205–7, as applicable.

Table 205-7 Recommended Lighting Levels for Roundabouts in Roadways Without Continuous Lighting

Ped/hr (During Hours of Darkness)	Min E_{avg} (fc)	Max Uniformity E_{avg}/E_{min}
≥ 100	1.7	6.0
11-99	1.3	6.0
≤ 10	0.7	6.0

Figure 205-4 shows the typical luminaire placement for roundabouts.

Figure 205-4 Roundabouts



Topic 3 Railroad Grade Crossings

The purpose of railroad grade crossing lighting is to illuminate the conflict area of railroad crossings. For additional information, refer to the *CA MUTCD*.

Conflict areas in railroad grade crossings include the shoulders, up to 100 feet in front of the crossings in both directions. Lighting poles should adhere to the following restrictions:

- Not be located closer than 33 feet from the railroad right-of-way to avoid falling onto the tracks if knocked down.
- Not block the visibility of the traffic signals used to warn drivers of approaching trains.

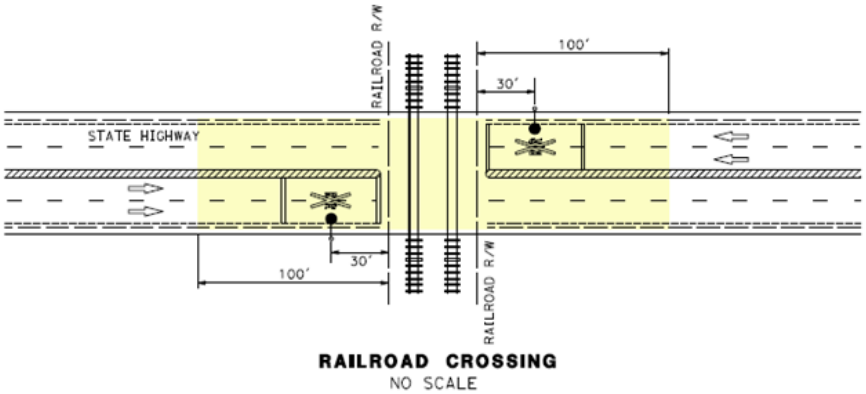
Designers should be familiar with road geometrics, including sidewalks, bikeways, signage, underground and overhead utilities, and railroad geometrics and crossing features.

Lighting may be warranted at railroad grade crossings when one of the following conditions exist:

- Railroad operations are conducted during hours of darkness.
- Railroad crossings are blocked for long periods of time.
- A combination of sight distance, horizontal or vertical curvature of the roadway, channelization, or other factors indicate a visibility improvement with the installation of lighting.
- A crash summary indicates that motorists often fail to detect trains or traffic control devices during hours of darkness.

The recommended lighting levels for railroad crossings are shown in Table 205-2 and Table 205-5, as applicable.

Figure 205-5 shows the typical luminaire placement in railroad crossings.**Figure 205-5 Railroad Crossings**



Topic 4 Mobility Hubs (Also Known as Park and Ride Lots)

Lighting for park and ride lots is warranted and should be provided based on the recommended lighting levels shown in Table 205-8.

Table 205-8 Recommended Lighting Levels for Park and Ride Lots

Min E_{avg} (fc)	Max Uniformity E_{avg}/E_{min}
0.2	20.0

Topic 5 Bus Stops

Bus stops warrant lighting. In particular, bus stops within state routes, areas between interchanges, and park and ride lots, should be illuminated. At locations within an interchange area where both a special ramp for buses and a bus stop are provided, a minimum of one luminaire should be provided. Illumination should be provided at bus turnouts, passenger loading areas, passenger benches, shelters, and crosswalks.

Lighting design should include bus turnouts, passenger loading areas, passenger benches and shelters, and crosswalks.

The responsibility for lighting at bus stops may be shared with the transit agency. The designer should consider illuminating bus stops with shelters, as they may result in higher passenger usage.

The recommended lighting levels for bus stops are between 2–3 footcandles.

A co-operative agreement or joint use maintenance agreement between Caltrans and the transit agency should ensure that the operations and maintenance of lighting at bus stops are proportionally shared by the jurisdictions.

Topic 6 Overhead Signs

In general, new overhead sign panels have ASTM Type XI retroreflective sheeting that will not require lighting.

However, lighting for overhead signs may be warranted when one of the following circumstances occur:

- A sign is skewed with an angle greater than 25 degrees and is not legible when illuminated by vehicle headlights.
- A sign is adjacent to another sign that requires, or has, sign lighting.
- A sign is located along a horizontal curve with a radius of 880 feet or less in a rural

area, or a radius of 2,500 feet or less in an urban area.

- A sign has vertical sag curves 1,000 feet or closer to overhead sign panels if determined the curve limits vehicle headlight illumination of signs.
- The sign is in an area where poor visibility exists due to weather conditions.

The sign lighting equipment, number of luminaires, and installation details can be found in the Caltrans *Standard Plans*.

Topic 7 Chain On and Off Areas

The purpose of having lighting at chain on and off areas is to improve visibility for the traveling public. Increasing the lighting levels and lighting uniformity can improve visibility for motorists. Lighting should illuminate pedestrians along the roadside immediately adjacent to traffic.

Table 205-9 shows the recommended lighting levels for chain on and off areas.

Table 205-9 Recommended Lighting Levels for Chain On and Off Areas

Min E_{avg} (fc)	Max Uniformity E_{avg}/E_{min}
3.0	3.0

Topic 8 Falsework

Lighting is warranted for walkways and bikeways through or under falsework. The faces of all falsework and forms located within or adjacent to the traveled way should be illuminated on the approach sides during the hours of darkness. Refer to Caltrans Standard Specifications, Section 48-2, "Falsework" for more details on falsework lighting.

Table 205-10 shows the recommended lighting levels for falsework.

Table 205-10 Recommended Lighting Levels for Falsework

Illumination Area	Min E_{avg} (fc)	Max Uniformity E_{avg}/E_{min}
Pavement	0.6	4.0
Portal	1.0	4.0
Walkway or Bikeway	2.0	4.0

Topic 9 Tunnels

Tunnels should have sufficient illumination during the day so that vehicles inside the tunnel are visible to approaching motorists. Interior walls and ceilings of tunnels that are to be lighted should be painted or tiled in a light color. Concrete surfaces to be painted should have a Class 1 finish. Tunnels less than 300 feet long normally do not require daytime lighting, but interior walls and ceilings should be painted.

Tunnel lighting consists of lighting for the tunnel approach and roadway inside the tunnel.

Day and night lighting is warranted for tunnels when one of the following criteria is met:

- A tunnel has vertical or horizontal curves that may obstruct visibility.
- A tunnel is over 300 feet long.
- A tunnel has walkways or bikeways.

If tunnel lighting is used, it must conform to the following requirements:

- Be a light-emitting diode type.
- Be addressable for remote monitoring and control.
- Be continuously dimmable from 10 percent to maximum output.
- Comply with the current version of *ANSI/IES RP-8*.

Designers must coordinate with the Division of Engineering Services on tunnel lighting facilities at a minimum of three months prior to project delivery. Designers should provide all required forms and supporting documents (such as layouts, cross sections, and photos).

Topic 10 Temporary Lighting

The same illumination requirements apply whether a condition is temporary or permanent.

Temporary lighting systems use existing or temporary lighting standards and poles to mount luminaires, may include high-mast lighting, and usually require the installation of standard roadway luminaires. Installing a temporary lighting system allows for uniform luminaire spacing at high mounting heights, resulting in uniform lighting with low glare.

Temporary roadway lighting is warranted when one of the following is met:

- Abrupt changes in the roadway alignment, including lane reductions.
- Presence of medium or high pedestrian or bicyclist activity.
- At locations with high traffic volumes.
- Presence of a fixed roadway lighting system in the work area (existing light levels should be maintained, possibly augmented).

- Work area location is identified as having documented operational concerns, such as a higher-than-average nighttime crash rate.

Maintain required illumination during all construction activities, except when shutdown is permitted to allow for alterations or final removal of the system per the project engineer. Site preparation, widening, drainage, guardrail installation, or other work can easily impact existing conduit runs or luminaire locations. Also, temporary changes, such as project-related merging, or changed alignment due to traffic control, may benefit from additional temporary illumination.

Section 6 Structure Lighting

Designers must consult with the Division of Engineering Services, Structure Design, Office of Electrical, Mechanical, and Water and Wastewater, as applicable, for lighting at the following locations:

- Exclusive pedestrian and bicyclist structures.
- Roadway undercrossings and overcrossings.
- Transportation-related facilities including:
  - Safety roadside rest areas.
  - Commercial vehicle enforcement facilities (truck inspections).
  - Toll plazas.
  - Agriculture inspection facilities.
  - Maintenance stations.
  - Transportation labs.

Conduit on structures should be run either parallel to, or at, right angles to the structure girders. A variation of ±15 degrees is acceptable. Except for sidewalk joints, a conduit expansion fitting should be installed at each structure joint, hinge, or abutment where a longitudinal movement of 0.5 inches or greater may occur. Where a lateral movement of 0.25 inches or greater may occur, an expansion-deflection fitting should be installed. Details for placement of expansion fittings and expansion-deflection fittings can be found in the Caltrans *Standard Plans*.

Topic 1 Exclusive Pedestrian and Bicyclist Structures

General Policy

Lighting for exclusive pedestrian and bicyclist structures is warranted outside the SHS where the local agency agrees to assume ownership and cost of maintenance. Lighting is required to be installed on exclusive pedestrian and bicyclist structures within the SHS. The designer should coordinate with Headquarters Division of Design and the Office of Design and Technical Services within the Division of Engineering Services.

Exclusive Pedestrian and Bicyclist Undercrossings

Exclusive pedestrian and bicyclist undercrossings (no vehicular traffic) 300 feet or longer require daytime and nighttime illumination. Exclusive pedestrian and bicyclist undercrossings shorter than 300 feet only require nighttime illumination.

Table 205-11 shows the recommended lighting levels for pedestrian and bicyclist undercrossing.

Table 205-11 Recommended Lighting Levels for Pedestrian and Bicyclist Undercrossing

Pedestrian and Bicyclist	Min E_{avg} (fc)	Max Uniformity E_{avg}/E_{min}
Daytime	9.3	3.0
Nighttime	3.7	3.0

Exclusive Pedestrian and Bicyclist Overcrossings

Exclusive pedestrian and bicyclist overcrossings (no vehicular traffic) require nighttime illumination. The location of the proposed overcrossing may require special consideration for lighting levels due to environmentally sensitive areas, such as rivers, creeks, and wetlands. Lighting installed on the overcrossing may produce glare that should be shielded from spreading to the structure where light can be a distraction for motorists using the highway and frontage road. Consider limited hours of lighting or user-actuated lighting design to minimize unnecessary emissions when the bridge is not in use. Table 205-12 shows the recommended lighting levels for pedestrian and bicyclist overcrossings.

Table 205-12 Recommended Lighting Levels for Pedestrian and Bicyclist Overcrossings

Min E_{avg} (fc)	Max Uniformity E_{avg}/E_{min}
0.5	4.0

Topic 2 Roadway Undercrossing

General Policy

Lighting on roadway undercrossing is warranted when one of the following criteria is met:

- When it is used for acceleration lanes, deceleration lanes, weaving areas, bikeways, and walkways.
- When it is part of local street lighting, as stated in Section 3, Topic 3 "Local Streets Within Limits of Freeway Projects."

Provisions for future undercrossing lighting facilities may be provided when warranted as

stated above. The project engineer must coordinate with the Division of Design and the Office of Design and Technical Services within the Division of Engineering Services.

Undercrossings that are less than 300 feet and have physical configurations that do not substantially limit the driver's ability to see objects ahead do not warrant daytime lighting but may warrant nighttime lighting.

Undercrossings that are 300 feet or longer warrant daytime and nighttime lighting. Refer to Table 205-12 for walkway or bikeway lighting levels. See the applicable roadway classification and table for recommended roadway lighting levels.

Topic 3 Transportation-Related Facilities

Lighting design for new transportation-related facilities and major renovations should be designed and constructed to exceed 15 percent of the applicable version of Building Energy Efficiency Standards, California Code of Regulations Title 24, Part 6. The controls for interior and exterior lighting should meet all the mandatory and perceptive requirements of Building Energy Efficiency Standards, Code of Regulations, Title 24, Part 6.

Section 7 Luminaires

This section covers luminaire types.

Topic 1 Roadway Luminaires

Utility company-owned semi-cutoff type luminaires should have a light shield when applicable per Section 2, Topic 7 "Lighting Levels."

Table 205-13 Comparison of Roadway Luminaires

Old Luminaires	New Luminaires	Typical Application
Roadway 1	Intersection Large A Intersection Large B Intersection Large C Intersection Medium A Intersection Medium B Intersection Medium C Intersection Small A Intersection Small B Intersection Small C Roadway 11	Conventional Highways and Expressways
Roadway 2	Roadway 12	Freeways

Topic 2 Soffit Luminaires

Soffit luminaires should be placed at or near the edge of traveled way.

Topic 3 Wall Pack Luminaires

Wall pack luminaires are designed to be surface mounted on vertical surfaces. A right-angle bracket allows for the mounting of wall pack luminaires to a horizontal surface, such as the bottom slab of a box girder.

Section 8 Lighting Software

Lighting software applications have replaced the old technique of using the Isofootcandle templates. The lighting industry is using lighting design analysis software that allows for importing roadway computer-aided design and drafting (CADD) files. These CADD files typically contain roadway properties on different layers (for example, edge of pavement, road shoulder, stationing, structures, curbs, and sidewalks). Using lighting software is required to ensure that the recommended lighting levels are met. In addition, it calculates and provides a visualization of the lighting distribution.

Topic 1 Lighting Design Using Software Applications

The basic steps for using lighting analysis software applications for roadway lighting design include the following four steps:

1. Perform an initial assessment to become familiar with the project location and the specific design requirements.
2. Select the types of fixtures and poles to be used in the appropriate category.
3. Determine lighting pole placements for constructability and maintainability.
4. Perform lighting analysis to ensure conformance with the applicable lighting levels. Verify that a minimum of three Illuminating Engineering Society (IES) files from manufacturers listed on the Caltrans Authorized Materials List meet the lighting levels. Luminaires should be evaluated at 0.9 light loss factor and calculation point spacing of 6 x 6 feet. Intersection and Roadway 11 luminaires have been authorized based on mounting heights of 34 feet. Roadway 12 luminaires have been authorized based on mounting heights of 40 feet.

Designers will utilize roadway CADD files and the lighting manufacturers' photometric files to calculate lighting levels for a roadway segment or an intersection. These photometric files are files with an IES file extension. The IES files include the photometric characteristics produced for each luminaire.

Topic 2 Software Applications and Validation

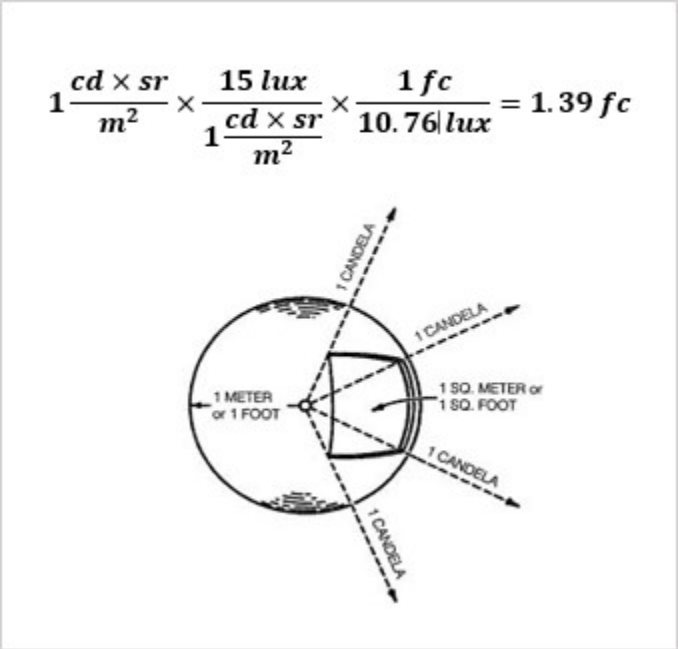
Field lighting measurements should be taken for a lighting project once it is installed and over time as the system ages. Caltrans should periodically validate luminaire photometrics, ensuring that the luminaires comply with the designed lighting levels and lighting uniformity.

Refer to the most current version of *ANSI/IES RP-8* for detailed instruction on how lighting measurements should be conducted in the field.

Topic 3 Relationship Between Candelas, Lumens, Lux, and Foot-Candles

The conversion factor is 1 candela per meter squared to 1.39 foot-candle. The calculation is shown in Figure 205-6.

Figure 205-6 Calculation for a Foot-Candle



A uniform point source (luminous intensity or candlepower = 1 candela) is shown at the center of a sphere of unit radius whose surface has a reflectance of zero. The illuminance at any point on the sphere is 1 lux (1 lumen per square meter) when the radius is 1 meter, or 1 footcandle (1 lumen per square foot) when the radius is 1 foot. The solid angle subtended by the area A, B, C, D is 1 steradian. The flux density is therefore 1 lumen per steradian, which corresponds to a luminous intensity of 1 candela as originally assumed. The sphere has a total area of 4 (or 12.57) square units (square meters or square feet), and there is a luminous flux of 1 lumen falling on each unit area. Thus, the source provides a total of 12.57 lumens.