Illuminating
ENGINEERING SOCIETY

IES RES-2-19

# IES Research Report: Lighting for Parking Facilities

IES RES-2-19

# IES Research Report:
# Lighting for Parking Facilities

Final Report prepared for the Illuminating Engineering Society

June 2018

Rajaram Bhagavathula, Ronald Gibbons, and Alejandra Medina-Flintsch

Center for Infrastructure-Based Safety Systems

Virginia Tech Transportation Institute

Published by the Illuminating Engineering Society, 120 Wall Street, New York, New York 10005.

Printed in the United States of America.

ISBN# 978-0-87995-000-2

## DISCLAIMER

**Acknowledgements**

Southern California Edison's Engineering Services group is responsible for implementing this project. This report was developed as part of Southern California Edison's Emerging Technologies and Codes & Standards Programs under internal project number ET17SCE1220. The Project Team conducted this lighting technology evaluation with overall guidance and management from the project collaborative team listed below. This project was co-funded by the Illuminating Engineering Society (IES).

**Energy Solutions** (Project Management)
Christopher Uraine
curaine@energy-solution.com
(510) 482-4420 x243

Michael McGaraghan
mmcgaraghan@energy-solution.com
(510) 482-4420 x242

**Southern California Edison** (Co-funder)
Randall Higa
Randall.Higa@sce.com
(606) 454-5545

David Rivers
david.g.rivers@sce.com
(626) 302-0827

**Illuminating Engineering Society** (Co-funder)
Brian Liebel, Director of Standards and Research
bliebel@ies.org
(917) 855-1065

Kevin Houser, Editor-in-Chief, Leukos
kwh101@psu.edu

**Virginia Tech Transportation Institute** (Principal Investigator)
Rajaram Bhagavathula
RBhagavathula@vtti.vt.edu
(540) 231-5209

Ronald Gibbons
rgibbons@vtti.vt.edu
(540) 231-1581

Alejandra Medina-Flintsch

# CONTENTS

# Executive Summary

**PROJECT GOAL –** The goal of this study was to understand the effects of lighting source types and light levels on the visual performance of pedestrians and drivers on the critical visual tasks in parking lots and garages. The results of this study will inform the lighting level recommendations for parking facilities in IES Recommended Practice (RP) documents.

**TECHNOLOGY DESCRIPTION –** In the current study, pedestrians' and drivers' visual performance and their perceptions of safety, comfort, and visibility were evaluated at a parking garage and at parking lots with asphalt and concrete pavements under three light source types (high pressure sodium luminaires, 3000-K light-emitting diode [LED] luminaires, and 5000-K LED luminaires) and at multiple light levels. Visual performance involved facial and hand recognition, wheel stop detection, detection of a side-facing pedestrian, and detection of a vehicle backing up from a parking spot. Perceptions of safety, comfort, and visibility were assessed by means of a questionnaire.

**PROJECT FINDINGS –** Results showed that in the parking garage, an increase in light level beyond 10 lux of average horizontal pavement illuminance did not result in a statistically significant increase in visual performance or perceptions of safety, comfort, and visibility. For parking lots of asphalt and concrete pavements, this plateauing was observed at the 2-lux light level. No statistical differences were observed between the light source types for the visual performance tasks, but the perceptions of safety, comfort, and visibility were highest for the 5000-K LED luminaires.

**PROJECT RECOMMENDATIONS –** The recommended light levels for parking lots should be revised to an average pavement illuminance of 2 lux, and those in the parking garage should be set at an average pavement illuminance of 10 lux, to ensure better visibility for all parking facility users.

# LIST OF FIGURES

# LIST OF TABLES

# 1.0 Introduction

Lighting in parking lots and garages increases the visibility and sense of security for its users. The recommended light levels in parking lots and garages are included in the Illuminating Engineering Society's Recommended Practice (RP-20) document for parking facilities. In the latest version (RP-20-14), the light levels recommended for parking lots were significantly higher than those mentioned in the previous version (RP-20-98). Some of the recommended illuminance levels are twice as high for parking lots with asphalt pavements and five times as high for parking lots with concrete pavements (see **Table 1**). The higher horizontal illuminance recommendations in RP-20-14 were likely based on consideration of a single critical task: detection of a non-painted concrete wheel stop on a concrete pavement. However, this critical task only accounts for the detection of trip hazards by pedestrians and ignores the other critical interactions between vehicles and pedestrians. Moreover, detection of a wheel stop whose texture and color are very similar to the surface on which it is placed requires a much higher luminance contrast. Higher luminance contrasts could be obtained by increasing the illuminance of the pavement in the parking lots (Adrian, 1989; Pretto & Chatziastros, 2006).

**Table 1. Increase in Recommended Maintained Horizontal Illuminance from RP-20-98 to RP-20-14**

| | Pavement Type | RP-20-98 | RP-20-14 | Increase in Illuminance |
|---|---|---|---|---|
| **Basic** | All | 2 lux | | |
| **Enhanced** | All | 5 lux | | |
| **Pre-curfew** | Asphalt | | 5 lux | 2.5 times |
| | Concrete | | 10 lux | 5 times |
| **Post-curfew** | Asphalt | | 2 lux | |
| | Concrete | | 2 lux | |

It is noteworthy, however, that an increase in illuminance will typically increase visibility only until a plateau is reached; beyond that plateau, any increase in illuminance will not result in an increase in visibility (Adrian, 1989; Bhagavathula, 2016; Bhagavathula, Gibbons, & Nussbaum, 2017; Rea & Ouellette, 1991). The additional illuminance can not only result in energy waste, but may also create conditions that increase discomfort glare and disability glare for parking lot users. In order to determine parking lot illuminance levels that increase visibility as well as parking lot users' perceptions of comfort, safety, and visibility, while still conserving energy and reducing glare, it is important to determine critical tasks that are realistic and account for all possible parking lot users and their interactions.

As noted, the two major users of parking facilities are pedestrians and drivers, and therefore the critical tasks for determining the lighting requirements for parking lots and garages should involve both types of user. There are three major tasks that involve both types of parking lot and parking garage users:

- Driver-pedestrian and other driver interactions
- Pedestrian and driver obstacle detection and navigation
- Pedestrian and driver perceptions of comfort, safety, and visibility

If these critical tasks were to be taken into consideration, lighting requirements for parking lots and garages could be developed to increase the visibility and perceptions of comfort, safety, and visibility for all users.

Crash statistics in parking lots have seldom been analyzed. In a study in Montgomery County, Maryland, pedestrian-vehicle crashes accounted for about 23% of the total crashes in a 5-year period (2004 to 2009). This data