Less is More: Energy-Efficient Lighting Alternatives to Support Pedestrian Friendly Communities

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Rensselaer Polytechnic Institute
Less is More: Pedestrian Lighting Alternatives

Learning Objectives

Participants will be able to:

1. Identify novel approaches to pedestrian-friendly lighting.

2. Compare different alternatives to overhead street and area lighting.

3. Describe the impacts and potential benefits of new types of pedestrian lighting.

4. Analyze the visual, safety, economic and environmental impacts of new approaches to pedestrian lighting.
Background

Pedestrian fatalities were 11% of total vehicle crash fatalities nationwide

- In New Jersey, this percentage was 21% (NHTSA, 2006)

RP-8: Roadway Lighting (IESNA, 2014):

- Minimum vertical illuminance ($E_v$) is 10 lux for high pedestrian conflict areas with mixed pedestrian-vehicle use
- Minimum vertical illuminance ($E_v$) is 2 lux for medium pedestrian conflict

Increasing $E_v$ can provide better visibility of pedestrians (Hasson et al., 2002)

10 lux $E_v$ sufficient for pedestrian detection (Gibbons et al., 2006; Edwards et al., 2007)

But is an $E_v$ of ~10 lux all that we need to know?
LRC’s Approach to the Problem

- Photometric simulations
- Visual performance analyses
- Outdoor visibility experiment
- Develop performance specifications
- Real-world evaluations
Conventional Overhead Lighting

<table>
<thead>
<tr>
<th>Pedestrian location no.</th>
<th>Object luminance (cd/m²)</th>
<th>Background luminance (cd/m²)</th>
<th>Contrast</th>
<th>RVP</th>
<th>Vertical illuminance (fc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1</td>
<td>0.344</td>
<td>-0.709</td>
<td>0.946</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>0.15</td>
<td>0.135</td>
<td>0.114</td>
<td>0.635</td>
<td>0.3</td>
</tr>
<tr>
<td>3</td>
<td>0.25</td>
<td>0.198</td>
<td>0.261</td>
<td>0.878</td>
<td>0.6</td>
</tr>
<tr>
<td>4</td>
<td>0.25</td>
<td>0.374</td>
<td>-0.332</td>
<td>0.921</td>
<td>0.6</td>
</tr>
<tr>
<td>5</td>
<td>0.15</td>
<td>0.322</td>
<td>-0.535</td>
<td>0.937</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Overhead Lighting Set 15 ft. Ahead

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<th>RVP</th>
<th>Vertical illuminance (fc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1</td>
<td>0.420</td>
<td>-0.762</td>
<td>0.952</td>
<td>0.2</td>
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<tr>
<td>2</td>
<td>0.2</td>
<td>0.149</td>
<td>0.341</td>
<td>0.913</td>
<td>0.7</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>0.196</td>
<td>1.550</td>
<td>0.953</td>
<td>1.5</td>
</tr>
<tr>
<td>4</td>
<td>0.5</td>
<td>0.358</td>
<td>0.395</td>
<td>0.931</td>
<td>1.6</td>
</tr>
<tr>
<td>5</td>
<td>0.4</td>
<td>0.241</td>
<td>0.659</td>
<td>0.942</td>
<td>1.3</td>
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</tbody>
</table>
Bollard-Based Lighting

<table>
<thead>
<tr>
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<th>Contrast</th>
<th>RVP</th>
<th>Vertical illuminance (fc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.6</td>
<td>0.210</td>
<td>1.855</td>
<td>0.953</td>
<td>2.3</td>
</tr>
<tr>
<td>2</td>
<td>0.9</td>
<td>0.190</td>
<td>3.734</td>
<td>0.956</td>
<td>3.3</td>
</tr>
<tr>
<td>3</td>
<td>0.6</td>
<td>0.172</td>
<td>2.495</td>
<td>0.952</td>
<td>2.2</td>
</tr>
<tr>
<td>4</td>
<td>0.9</td>
<td>0.245</td>
<td>2.680</td>
<td>0.958</td>
<td>2.7</td>
</tr>
<tr>
<td>5</td>
<td>0.6</td>
<td>0.354</td>
<td>0.697</td>
<td>0.947</td>
<td>2.2</td>
</tr>
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</table>
Overhead lighting at the crosswalk location can result in reduced contrast of pedestrians or areas of transition between “negative” and “positive” contrast.

Bollard-level luminaires providing vertical illumination maintain “positive” contrast, without competing against vehicle headlights.
Outdoor Visibility Experiment

A: Headlights only

B

C

D

In-kind support: The Lighting Quotient
Results: Outdoor Visibility Experiment

A: Headlights only

B

C

D

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Performance Specification

• ≥10 lux vertical illuminance @ 3 ft. above ground within the crosswalk

• ≤1 lux vertical illuminance @ 5 ft. above ground to minimize glare

• “White” light to enhance brightness and contrast with existing overhead high pressure sodium illumination
Field Demonstration – Old Bridge, New Jersey

Exterior floodlight luminaires were modified to create bollard fixtures

U.S. Route 9 and Texas Road, Old Bridge, Middlesex County, NJ

Participation from individuals from NJDOT, NJ Transit, Old Bridge Police Department

Sponsor: New Jersey Department of Transportation

In-Kind Support: Philips Hadco
Field Demonstration – Slingerlands, New York

At roundabouts, pedestrian crosswalks appear in unexpected locations, and conventional overhead lighting does not enhance contrast of pedestrians.

LRC installed bollard-based crosswalk lighting in conjunction with landscape and low-level overhead “ecoluminance” lighting – 75% energy use reduction.

Sponsor: New York State Department of Transportation, New York State Energy Research and Development Authority
In-Kind Support: Forms + Surfaces

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Field Demonstration – Aspen, Colorado

Prototype light-emitting diode luminaires designed to meet the LRC’s performance specification were installed in a temporary demonstration in Aspen, Colorado.

Observations by city engineering staff and survey questionnaires of residents and tourists were very positive.

Sponsor: City of Aspen

In-Kind Support: 3M, Intrigue Lighting
Field Demonstration – Aspen, Colorado

1. I would feel secure while waiting to cross the street after dark \( (n=41) \)
2. I would feel secure while crossing the street after dark \( (n=41) \)
3. As a pedestrian, I can see vehicles approaching clearly after dark \( (n=40) \)
4. As a pedestrian, I can see other pedestrians clearly after dark \( (n=37) \)
5. I would be able to see pedestrians clearly while driving after dark \( (n=31) \)
6. Overall, the lighting is comfortable \( (n=37) \)
7. I like the color of the lighting \( (n=41) \)
8. I like the appearance of the light fixtures \( (n=40) \)
9. I could easily find objects dropped on the ground after dark \( (n=41) \)
10. Overall, the light fixtures would help me feel safe at night \( (n=37) \)

Sponsor: City of Aspen

In-Kind Support: 3M, Intrigue Lighting

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Field Demonstration – Schenectady, New York

Crosswalk bollard luminaires were modified to produce low intensity (<1 lux) in crosswalk until activated by push button.

Upon activation, luminaires produce three cycles of high and low intensity to serve as an alerting effect.

Installed luminaires in Schenectady, NY were judged favorably by observers from the city, Metroplex development authority, and by members of the public.

Sponsor: University Transportation Research Center
In-Kind Support: 3M, Intrigue Lighting
Metroplex Authority
Field Demonstration – Schenectady, New York

<table>
<thead>
<tr>
<th>Mean Responses (n=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would feel safe crossing here.</td>
</tr>
<tr>
<td>I would feel comfortable driving here.</td>
</tr>
<tr>
<td>The appearance is appropriate.</td>
</tr>
<tr>
<td>The lighting is glaring.</td>
</tr>
<tr>
<td>I can see pedestrians easily.</td>
</tr>
<tr>
<td>There are dark areas.</td>
</tr>
<tr>
<td>The lighting is bright.</td>
</tr>
<tr>
<td>I like the color of the lighting.</td>
</tr>
</tbody>
</table>

Sponsor: University Transportation Research Center

In-Kind Support: 3M, Intrigue Lighting, Metroplex Authority

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Bollard-based lighting system for crosswalks was judged to be promising for improving pedestrian safety

Found to be practical and acceptable by transportation, transit and public safety professionals

- Field tested in New Jersey, New York, Colorado

Visual performance analysis is a practical safety-related evaluation tool

Featured in transportation lighting guidance from Transportation Research Board, Minnesota Department of Transportation
Acknowledgments

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3M
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Rosa Capó
Ute Besenecker
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Thank you!

Questions?

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