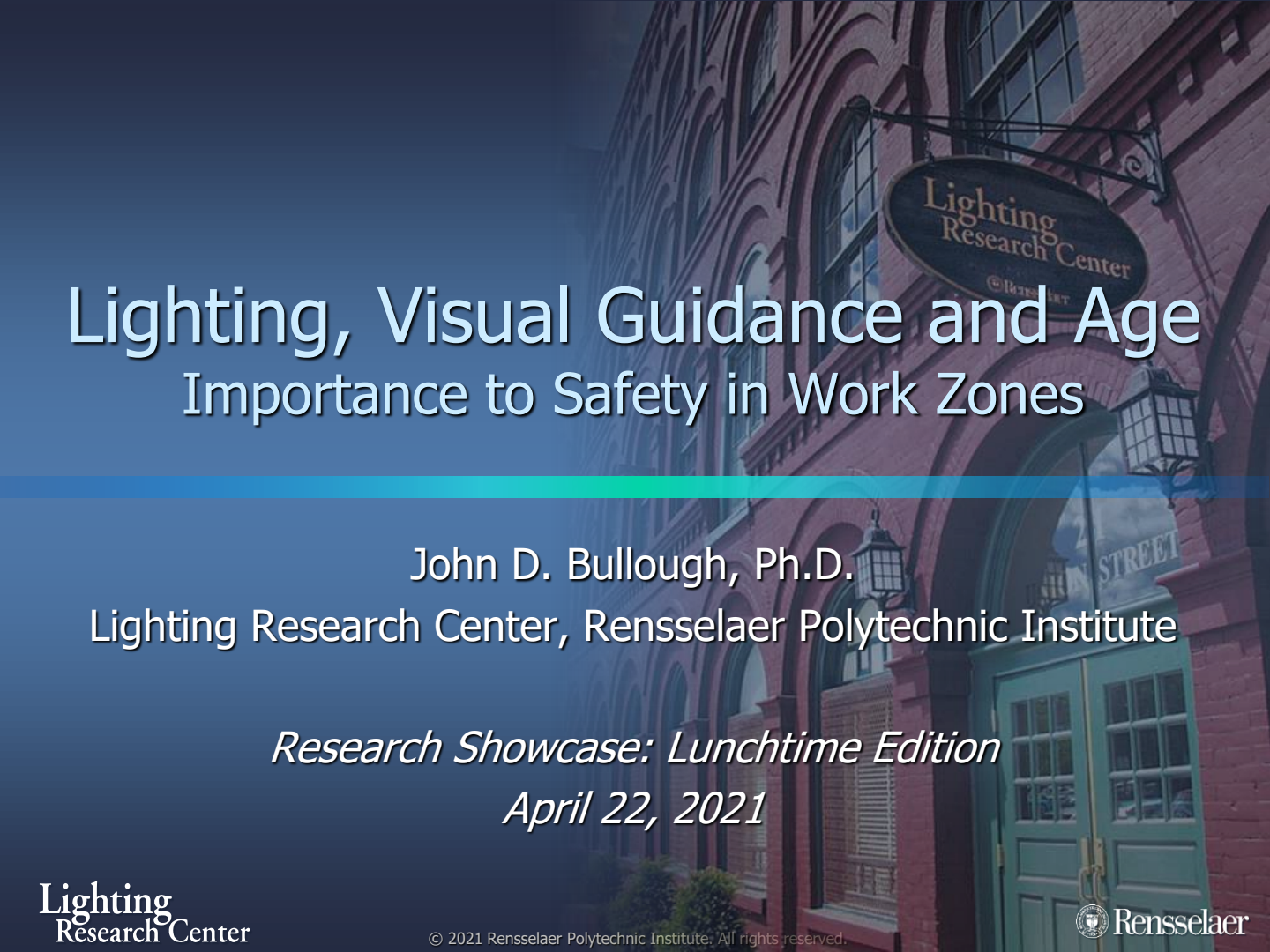


Lighting, Visual Guidance and Age

Importance to Safety in Work Zones

John D. Bullough, Ph.D.

Lighting Research Center, Rensselaer Polytechnic Institute

Research Showcase: Lunchtime Edition

April 22, 2021

Lighting Research Center

Rensselaer

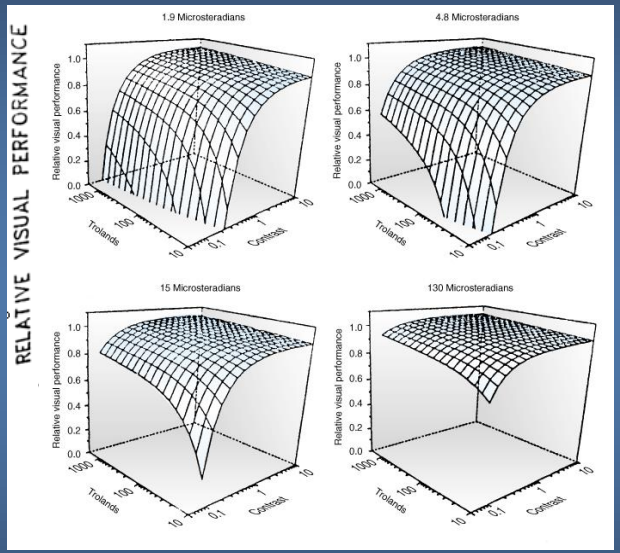
Background

Problems of Nighttime Work Zone

- Insufficient illumination for safe working and driving conditions
- Glare to workers and drivers
- Visual chaos
- Often these problems are exacerbated for older adults

Lighting and Visual Performance

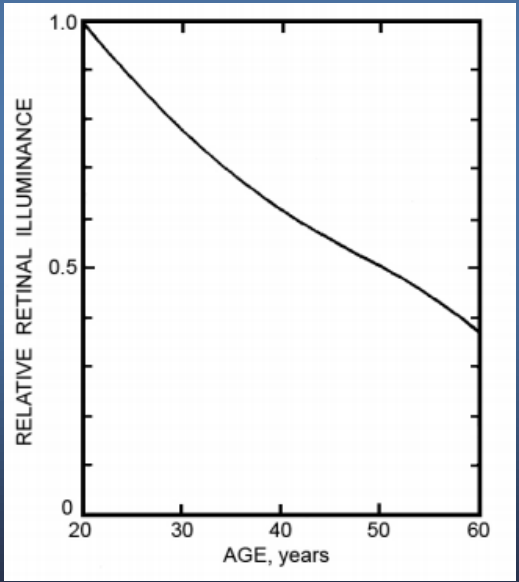
- Relative visual performance (RVP)
- Speed and accuracy of visual processing
- Depends upon:
  - Light level
  - Contrast between object and background
  - Size of object
  - Age of observer
- Plateau and escarpment



(Rea and Ouellette 1991)

Age and Optics of the Eyes

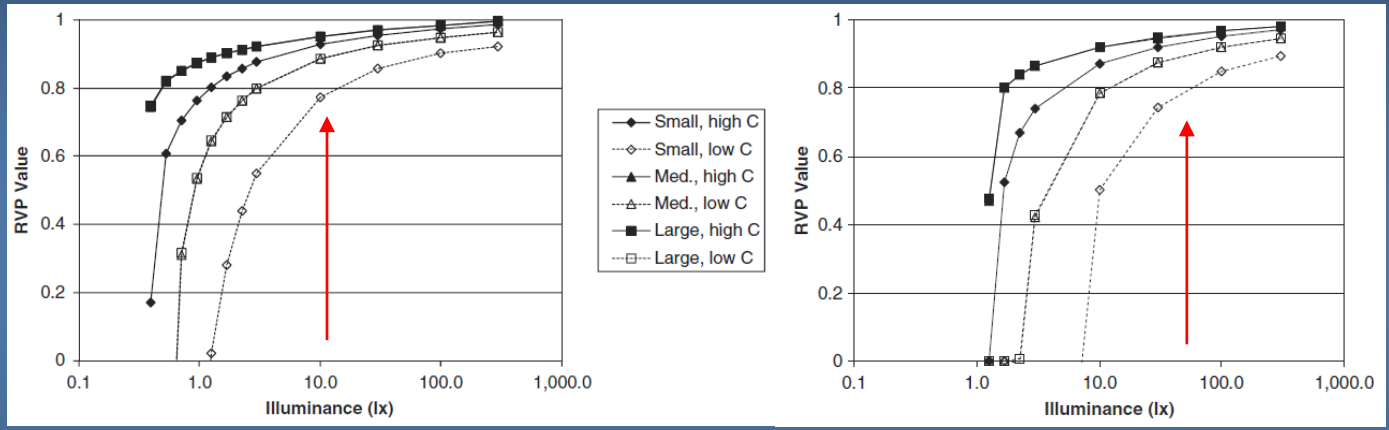
- As we age, the lenses of our eyes yellow and our pupils decrease in size, reducing the amount of light reaching the retina in the back of the eye



Task Illuminance and Visual Performance

- Ranging in:
- Size
  - Small: keyhole viewed from 3 ft
  - Medium: hand tool on ground viewed from 10 ft
  - Large: truck viewed from 100 ft
- Contrast
  - 0.2 (med./dark gray) to 0.8 (black/white)
- Light level
  - < 1 lux (0.1 fc) to 300 lux (30 fc)
- Observer age
  - 20 or 60 years

Impact of Lighting/Task/Age Parameters on Visual Performance

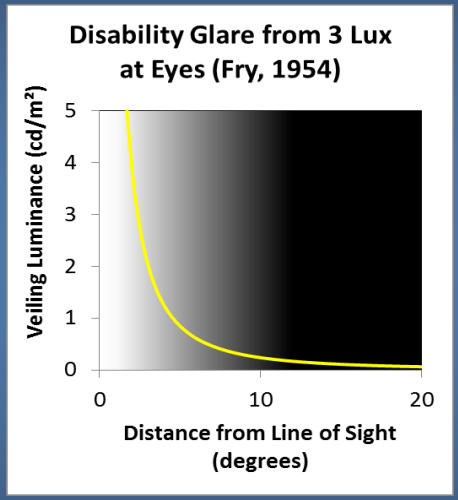


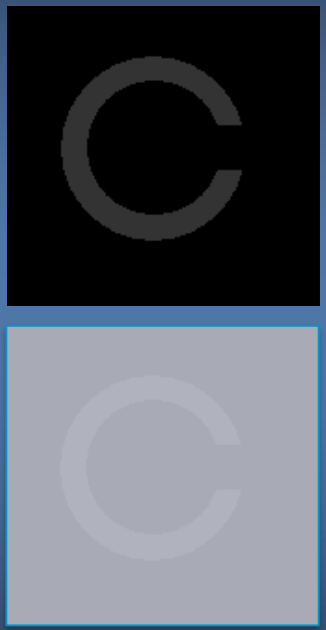
20 year old

60 year old

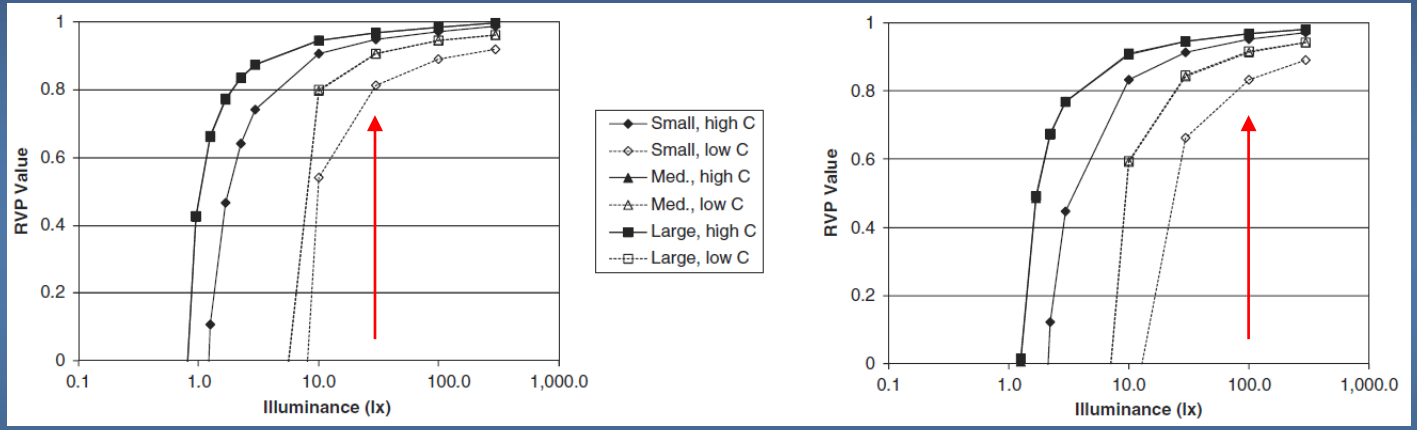
Glare and Veiling Luminance

- Disability glare: Veiling luminance caused by scatter within the eye
- Effect is largest when the offending source is closest to your line of sight





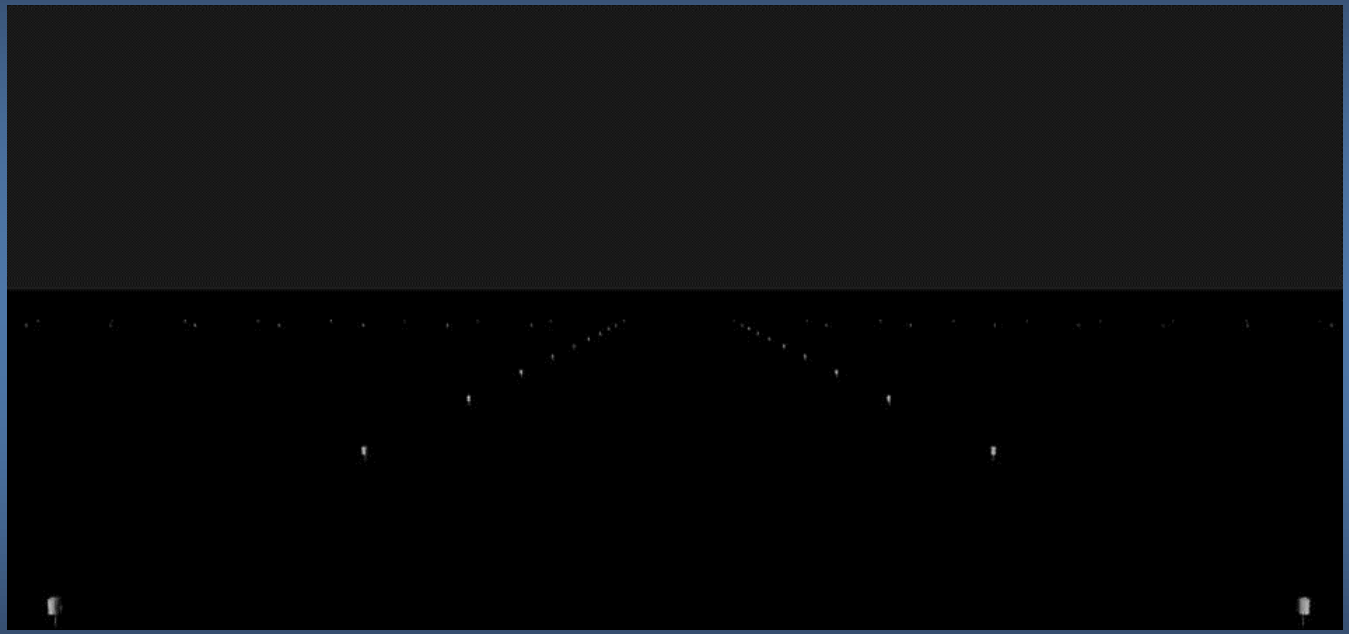
Impact of Lighting/Task/Age Parameters on Visual Performance with Glare Present



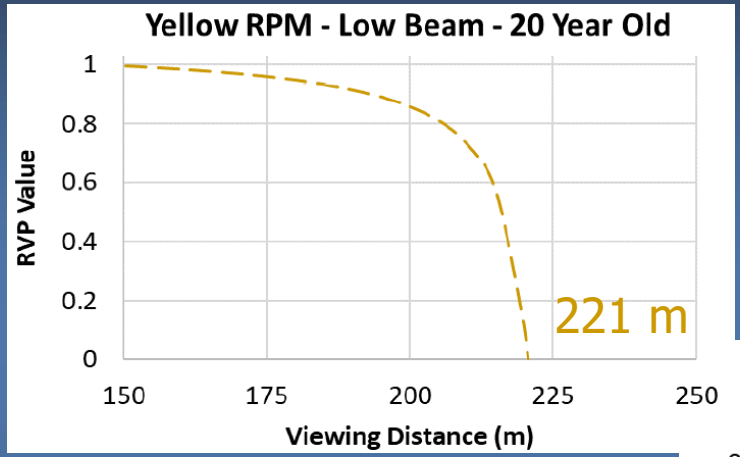
20 year old

60 year old

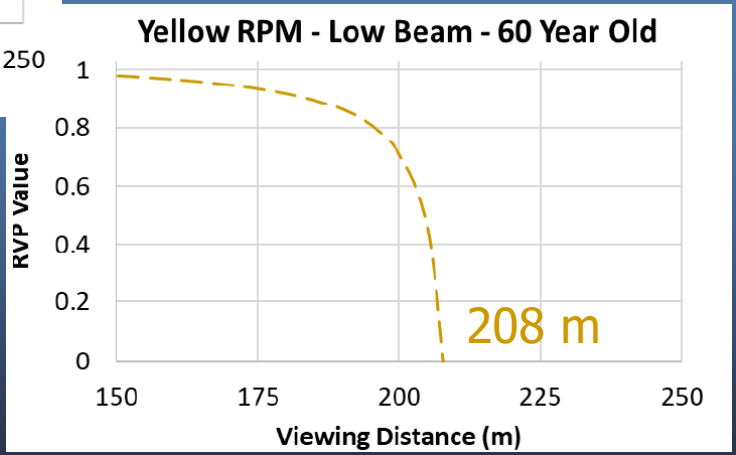
Visual Delineation, Signage and Age



Visibility of Raised Pavement Markings



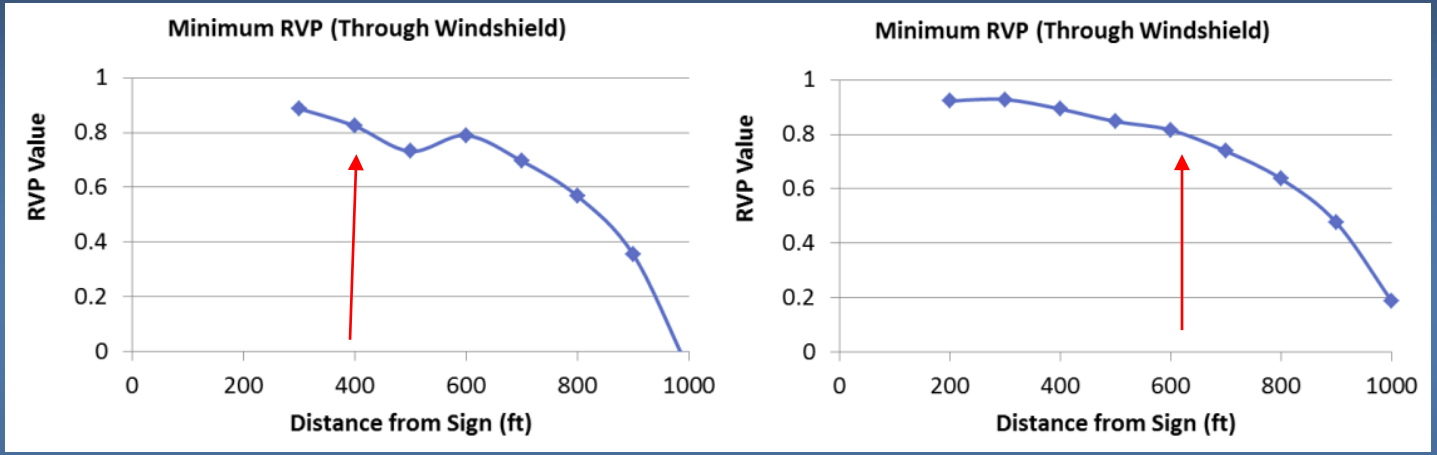
13 meter difference corresponds to a perception-response time difference of more than 0.8 seconds at 35 mph



Sign Legibility and Reflective Sheeting Materials

- ASTM Type III retroreflective materials (high intensity sheeting) are commonly used for work zone signage
- What is the impact of ASTM Type XI (full cube prismatic sheeting) on legibility for older drivers?

Type III vs. Type XI – 60 Year Old Drivers

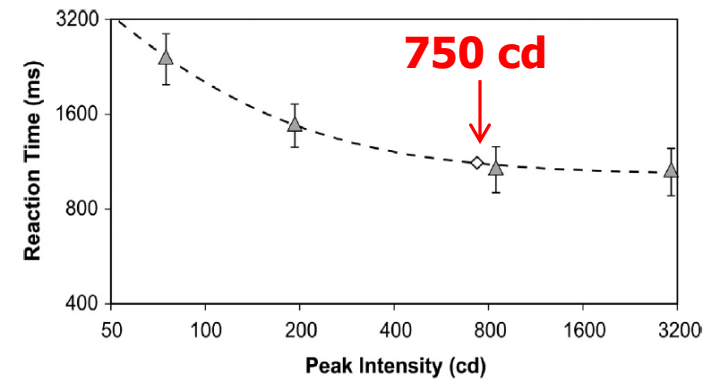


Type XI maintains
RVP > 0.8 for
200 additional ft

Controlling Intensity of Flashing Lights

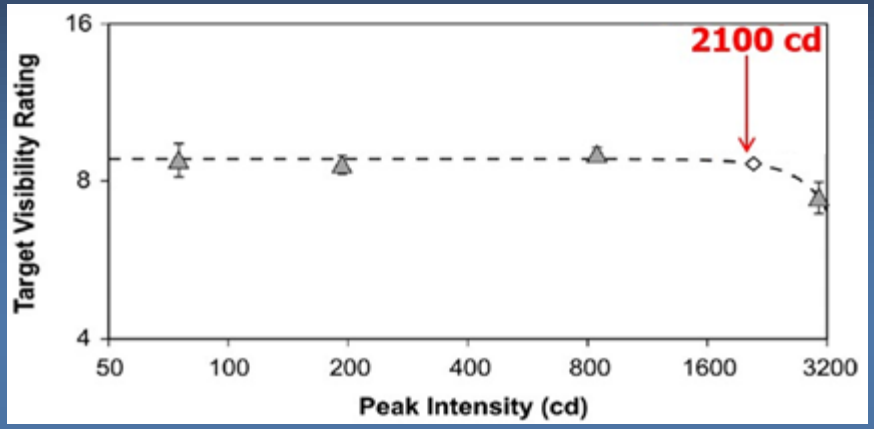

CAUTION

How Bright does the Flashing Light Need to Be in the Daytime?



- "Worst-case scenario:" older drivers (> 50 years), daytime urban/cluttered viewing conditions, location far from line of sight
- As intensity increases, reaction times are faster, up to 750 cd
- Minimum peak intensity of 750 cd needed for rapid detection under the most difficult daytime viewing conditions
  - Only 250 cd needed for younger drivers (< 30 years)

How Bright is Glaring or Distracting at Night?



- "Worst-case scenario:" older participants, nighttime urban/cluttered viewing conditions, location close to line of sight
- As intensity increases, visibility is not affected, until the intensity of a single light reaches 2100 cd
- Above 2100 cd, objects along the road start to become less visible
  - Younger drivers (< 30 years old) can tolerate glare up to 3100 cd

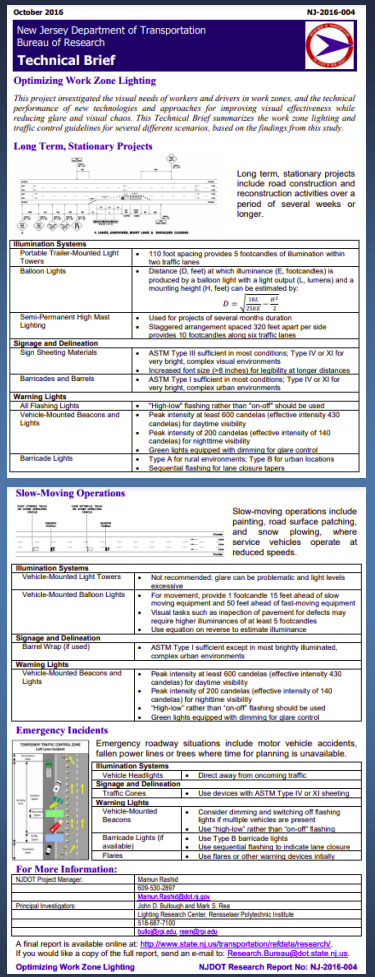
Summary

- Older adults may need 2-3 times higher light levels for visually challenging tasks to maintain similar levels of visual performance
  - Glare in work zone lighting conditions can further double or triple lighting needs, resulting in more glare, resulting in need for more light, etc.!
- Higher retroreflectivity in sign sheeting can extend legibility distances several hundred feet, which may be critical for older drivers
- Intensity specifications for flashing warning lights should be based on a wide range of ages to ensure visibility and minimize glare

Thank You!

- Lighting Research Center studies in work zone lighting were sponsored by:
  - New Jersey Department of Transportation http://hdl.handle.net/10929/40813
  - New York State Department of Transportation
  - National Institute for Occupational Safety and Health
- Rutgers Center for Advanced Infrastructure and Transportation, New Jersey Local Technical Assistance Program for invitation to participate

Contact: John D. Bullough (bulloj@rpi.edu)



October 2016 NJ-2016-004

New Jersey Department of Transportation
Bureau of Research

Technical Brief

Optimizing Work Zone Lighting

This project investigated the visual needs of workers and drivers in work zones, and the technical performance of new technologies and approaches for improving visual effectiveness while reducing glare and visual chaos. This Technical Brief summarizes the work zone lighting and traffic control guidelines for several different scenarios, based on the findings from this study.

Long Term, Stationary Projects

Long term, stationary projects include road construction and reconstruction activities over a period of several weeks or longer.

Illumination Systems	
Portable Trailer-Mounted Light Towers	• 110 foot spacing provides 5 footcandles of illumination within two traffic lanes
Balloon Lights	• Distance (D, feet) at which illuminance (E, footcandles) is produced by a balloon light with a light output (L, lumens) and a mounting height (H, feet) can be estimated by: $D = \sqrt{\frac{181}{250E} - \frac{H^2}{2}}$
Semi-Permanent High Mast Lighting	• Used for projects of several months duration • Staggered arrangement spaced 320 feet apart per side provides 10 footcandles along six traffic lanes
Signage and Delineation	
Sign Sheeting Materials	• ASTM Type III sufficient in most conditions; Type IV or XI for very bright, complex visual environments • Increased font size (>8 inches) for legibility at longer distances
Barricades and Barrels	• ASTM Type I sufficient in most conditions; Type IV or XI for very bright, complex urban environments
Warning Lights	
All Flashing Lights	• "High-low" flashing rather than "on-off" should be used
Vehicle-Mounted Beacons and Lights	• Peak intensity at least 600 candelas (effective intensity 430 candelas) for daytime visibility • Peak intensity of 200 candelas (effective intensity of 140 candelas) for nighttime visibility • Green lights equipped with dimming for glare control
Barricade Lights	• Type A for rural environments; Type B for urban locations • Sequential flashing for lane closure tapers

Slow-Moving Operations

Slow-moving operations include painting, road surface patching, and snow plowing, where service vehicles operate at reduced speeds.

Illumination Systems	
Vehicle-Mounted Light Towers	• Not recommended; glare can be problematic and light levels excessive
Vehicle-Mounted Balloon Lights	• For movement, provide 1 footcandle 15 feet ahead of slow moving equipment and 50 feet ahead of fast-moving equipment • Visual tasks such as inspection of pavement for defects may require higher illuminances of at least 5 footcandles • Use equation on reverse to estimate illuminance
Signage and Delineation	
Barrel Wrap (if used)	• ASTM Type I sufficient except in most brightly illuminated, complex urban environments
Warning Lights	
Vehicle-Mounted Beacons and Lights	• Peak intensity at least 600 candelas (effective intensity 430 candelas) for daytime visibility • Peak intensity of 200 candelas (effective intensity of 140 candelas) for nighttime visibility • "High-low" rather than "on-off" flashing should be used • Green lights equipped with dimming for glare control

Emergency Incidents

Emergency roadway situations include motor vehicle accidents, fallen power lines or trees where time for planning is unavailable.

Illumination Systems	
Vehicle Headlights	• Direct away from oncoming traffic
Signage and Delineation	
Traffic Cones	• Use devices with ASTM Type IV or XI sheeting
Warning Lights	
Vehicle-Mounted Beacons	• Consider dimming and switching off flashing lights if multiple vehicles are present • Use "high-low" rather than "on-off" flashing
Barricade Lights (if available)	• Use Type B barricade lights • Use sequential flashing to indicate lane closure
Flares	• Use flares or other warning devices initially

For More Information:

NJDOT Project Manager:	Mamun Rashid 609-530-2897 Mamun.Rashid@dot.nj.gov
Principal Investigators:	John D. Bullough and Mark S. Rea Lighting Research Center, Rensselaer Polytechnic Institute 518-687-7100 bulloj@rpi.edu, reamark@rpi.edu

A final report is available online at: http://www.state.nj.us/transportation/refdata/research/.
If you would like a copy of the full report, send an e-mail to: Research.Bureau@dot.state.nj.us.

Optimizing Work Zone Lighting NJDOT Research Report No: NJ-2016-004