An Examination and Recommendation for Current Practices in Roundabout Lighting

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Abstract

In 2000, the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO) sponsored an international scan on the topic of roadway lighting. One of the topics covered in the international scan was roundabout lighting design practices. At the same time, the FHWA was actively promoting the use of roundabout intersections in the United States based on their safety and operational benefits. On return from the international scan, it was observed that there were a wide variety of practices with regard to roundabout lighting and that there was not a uniform understanding about what the recommended design practice should be.

In response to this the Illuminating Engineering Society of North America (IESNA) Roadway Lighting Committee created a subcommittee to examine this issue and develop design guidelines for roundabout lighting. The authors of this paper are both members of the subcommittee.

The current study was initiated in support of the IESNA effort in order gather information on the specific practices for lighting roundabouts in the United States and to obtain a better quantitative understanding of what constitutes a well lit roundabout in order to assist the IESNA in developing practical guidelines. The study evaluates the lighting at four roundabout sites with different levels of lighting and different lighting configurations. In addition to assessing general visibility criteria, the project examined overall roadway and pedestrian visibility. Various methods for collecting data are described and computer modeling results are presented.

Introduction/Background

In 2000, the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO) sponsored an international scan on the topic of roadway lighting. One of the topics covered in the international scan was roundabout lighting design practices. At the same time, the FHWA was actively promoting the use of roundabout intersections in the United States based on their safety and operational benefits. On return from the international scan, it was observed that there were a wide variety of practices with regard to roundabout lighting and that there was not a uniform understanding about what the recommended design practice should be. For example, one can find French (1), Australian (2), British (3) and other roundabout lighting design guidelines being used as well as the application of general intersection lighting principles from AASHTO or the Illumination Engineering Society of North America (IESNA). The result is a tremendous lack of uniformity in lighting roundabouts across the U.S.

In response to this knowledge, the IESNA Roadway Lighting Committee created a subcommittee to examine this issue and develop design guidelines for roundabout lighting. The authors of this paper are both members of the subcommittee.

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Existing Standards

There currently are existing lighting standards in many countries as well as recommendations included in the Federal Highway Administration Publication No. FHWA-RD-00-067 Roundabouts: An Informational Guide. A brief review of the major lighting components of these standards shows the following:

For FHWA-RD-00-067 Roundabouts: An Informational Guide:

- Illumination recommended for all roundabouts but not mandatory (rural with no other lighting)
- 80m transition lighting
- Recommends perimeter lighting and approach lighting

Table 1 is included in this document with the guidance that a roundabout should be illuminated to a level that equals the sum of the intersecting roads. For example if a commercial arterial intersected with an intermediate collector the level in the roundabout should be 17 lux + 9 lux = 26 lux. Using this method the lighting level for roundabouts will range from 8 lux to 34 lux. This method of summing intersecting roads has been used for intersection lighting for many years.

Table 1 – Exhibit 7-23 from the FHWA-RD-00-067 Roundabouts: An Informational Guide showing recommended street lighting levels

Street Classification	Area Classification	Average Maintained Illuminance Values	Illuminance Uniformity Ratio (Average to Minimum)
Arterial	Commercial Intermediate Residential	17 lx (1.7 fc) 13 lx (1.3 fc) 9 lx (0.9 fc)	3 to 1
Collector	Commercial Intermediate Residential	12 lx (1.2 fc) 9 lx (0.9 fc) 6 lx (0.6 fc)	4 to 1
Local	Commercial Intermediate Residential	9 lx (0.9 fc) 7 lx (0.7 fc) 4 lx (0.4 fc)	6 to 1

For Centre d'Etudes des Transports Urbains – Illumination of Roundabouts

- Either approach or center lighting acceptable
- Includes examples of roundabout lighting ranging from 23 to 35 lux

For Australian/New Zealand Standard AS/NZS 1158.1.1:1997

- Recommends approach lighting
- Ranges from 5 to 20 lux minimum illuminance
- Includes other criteria for glare, uplight, and surround brightness

We can see from these examples of lighting recommendations that they are quite varied on both the upper and lower limits of their criteria. Research data comparing accident frequency with lighting levels also does not appear to be available so it appears that the lighting levels recommended are done so by the experience of each country.

Study Methodology

Site Selection

In order to have a closer look at what the US experience is we considered various locations around the United States with a large number roundabouts such that a cross section of lighting approaches could be examined. Within this context, the States of Maryland, Colorado, Washington and Kansas were all considered. Because of the number of roundabouts in Maryland and the relative ease with which one can physically visit a high number of these roundabouts, Maryland was chosen for the review.

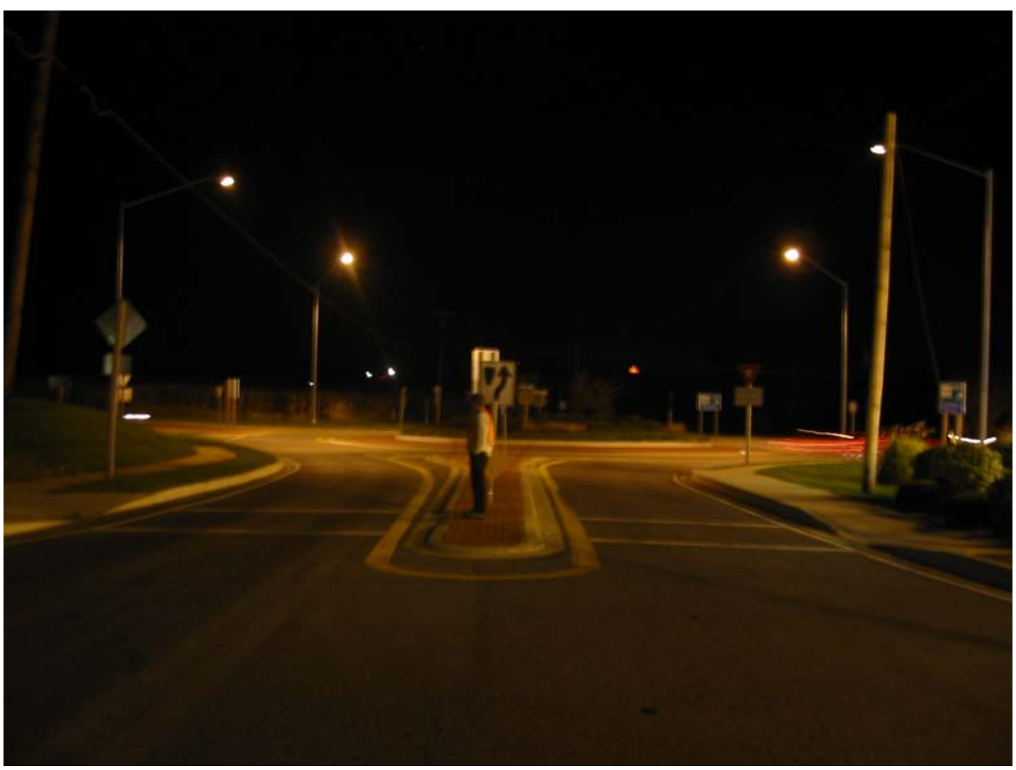
More than 20 single-lane roundabouts were reviewed Maryland. The roundabouts reviewed were chosen after consultation with the MD State Highway Administration (SHA) and the Howard and Harford County Governments. A list of the roundabouts that were visited and pertinent information is provided in Appendix A.

After reviewing the roundabouts in both day and night conditions, 4 roundabouts were chosen for more in-depth study. The following list identifies the roundabouts and provides information on why they were chosen.

- Intersection of Shepherd and Folly Quarter Roads in Howard County, Maryland. This roundabout was chosen because it is a rural single lane roundabout that was newly constructed. On visiting the roundabout it was found that the lighting had not been activated and the site proved useful for gathering information on roundabouts in an unlit condition.

- Intersection of Woodbine Road and Route 40 in Lisbon, Maryland. This rural single lane roundabout is in close proximity to Interstate 70. It was chosen because it has only two light fixtures located diagonally across from each other as shown in the Figure 1. It provides a good example of a roundabout with minimal lighting.

- Intersection of MD 180 and MD 17 in Brunswick, Maryland. This single lane rural roundabout was chosen because it has four light fixtures placed



symmetrically around the roundabout as shown in Figure 2. It provides a good illustration of uniform lighting of the circulatory roadway.

- Intersection of Cradlerock Way and Homespun Drive in Howard County, Maryland. This single lane, 3-leg, suburban roundabout was chosen because it has light fixtures placed in close approximation to the French Roundabout Lighting Guide as shown in Figure 3. It provides a good illustration of lighting the roundabout approaches, crosswalks and circulatory roadway.

Data Collection Methods
At each site a variety of data were collected. Information on traffic and crashes for day and night were received from the MD SHA. The team also collected spot horizontal and vertical illuminance readings at locations approaching and within the roundabouts. In particular, when pedestrian crosswalks were present, readings were taken within the crosswalk. The team also shot video driving through the roundabouts in daylight and darkness to document what drivers actually see in both conditions. Still images using 35 mm film and digital cameras were taken to document what people see at the entrances

and exits to the roundabouts. Representative photos of individuals in the crosswalks were also taken to illustrate the visibility of pedestrians to drivers.

Finally, full scene images were collected using a CCD Meter that allowed for comparative luminance readings among the various lighting configurations. The CCD Meter captures a digital image of a full scene and allows point by point analysis of luminance measures or a full scene representation through color representation. The CCD Meter was placed at locations considered critical to a driver's performance – i.e. approximately 225 feet in advance of the pedestrian crosswalk to represent stopping sight distance and at the yield line to represent what a driver sees when negotiating the entrance to the roundabout.

Data Analysis
All photos and videos were used to provide subjective analysis of the overall quality of visibility of the roadway, pedestrians and other users in the roundabouts. In addition, color spectrometry from the CCD meter provided a good basis for uniform comparative analysis of lighting quality across roundabouts. Finally, all of the lighting data was used in the development of computer-based models that provide detailed review of lighting balance, uniformity and visibility of roundabout features and users.

Findings
Examination of the day and night crash data before and after installation of the roundabouts did not provide any valuable or reliable information and so is not recorded here. Essentially, there were too few crashes to provide and reliable estimates of the day and night crash problem or to assign any benefits to the lighting. Other findings based on the other data collected are reported below by location.

Shepherd and Folly Quarter Roads
The roundabout at this location was newly constructed and the lighting had not yet been turned on. As such, it provided a perfect scenario for examining the "no lighting" option. Through video and other data collection, the following are the observations of the review:

- When negotiating a roundabout at night, the driver's eyes are directed to the left through the driver door window. However, the headlights of the vehicle are directed tangentially off of the roundabout and therefore provide no visual support to the driver. As a result, the driver has little or no visual cues either upon entering or circulating in the roundabout. The experience indicates the importance and necessity of lighting of roundabouts, especially in the absence of any other light sources.

- On approaching and entering the roundabout, it was impossible to see the roadway features or to see the center island or other parts of the roundabout. In this roundabout, great care was taken to properly install advance warning and other signs as well as pavement markings. The support that well-designed, high quality signs and markings provided to the driver in this extreme example indicated their significant importance and safety value. Even with well-lit roundabouts, good signs and markings are essential to support safe driving behavior.

Woodbine Road and Route 40

This roundabout in Lisbon, MD is lit with two 250 watt high pressure sodium cobra head fixtures and illustrates a step up from no lighting to what could be considered "minimal lighting". The lighting levels at this location averaged between 8 lux and 12 lux. This level of lighting does overcome the worst aspects of no lighting – i.e. providing some preview distance to the driver circulating in the roundabout. Other observations include:

- Lack of uniformity in the lighting does not provide a comfortable or reliable driving environment.
- In locations where crosswalks would be available, this lighting does not provide adequate lighting to make the pedestrian visible in at least half of the crosswalks. As such, driver and pedestrian expectancies are not matched in all situations.
- Considering typical maintenance cycles, if one light goes out, the negative effects are far greater than they would be with other, more extensive lighting configurations.

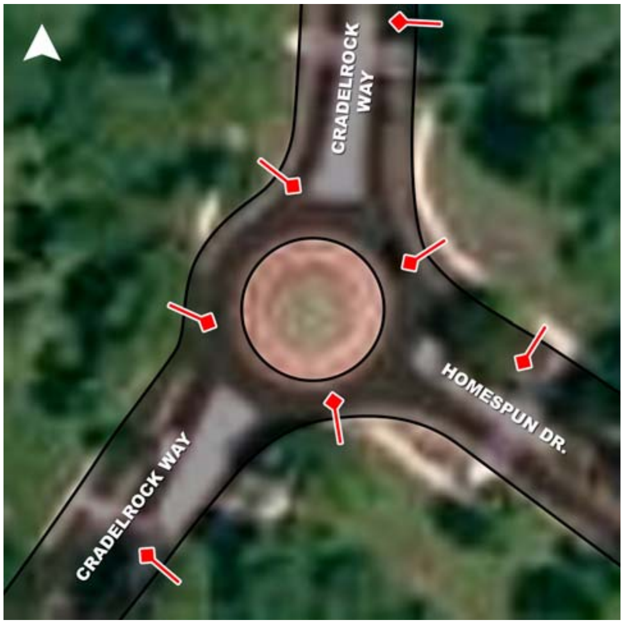
Taking the above into consideration, this lighting arrangement is not practical for most applications. However, in a rural environment with no pedestrians and where funding for installation and maintenance of lighting equipment is limited, this would be a useful approach. However, higher levels of lighting would be far better if at all possible and should be installed whenever possible.

MD 180 and MD 17

This roundabout is near an Interstate interchange and, as such, serves both local users as well as long distance travelers that are stopping for food or fuel. On the periphery of the roundabout is a gas station and just off the roundabout on one leg is a fast food restaurant and one or two businesses. There is a crosswalk between the fast food restaurant and the gas station.

Four 250 watt high pressure sodium cobra head lighting fixtures were placed symmetrically around the roundabout. Lighting levels measured between 18lux to 60 lux because of some spill light but in general averaged between 30lux and 40 lux. The vertical illuminance at some of the approached ranged from 5 to 10 lux However, a gas station with a high level of flood lighting caused significant glare that affected the entire area around the roundabout. After close evaluation of photos, videos and CCD meter output, it was determined that the site was not suitable for drawing meaningful conclusions with regard to the roadway lighting and environment.

Cradlerock Way and Homespun Drive

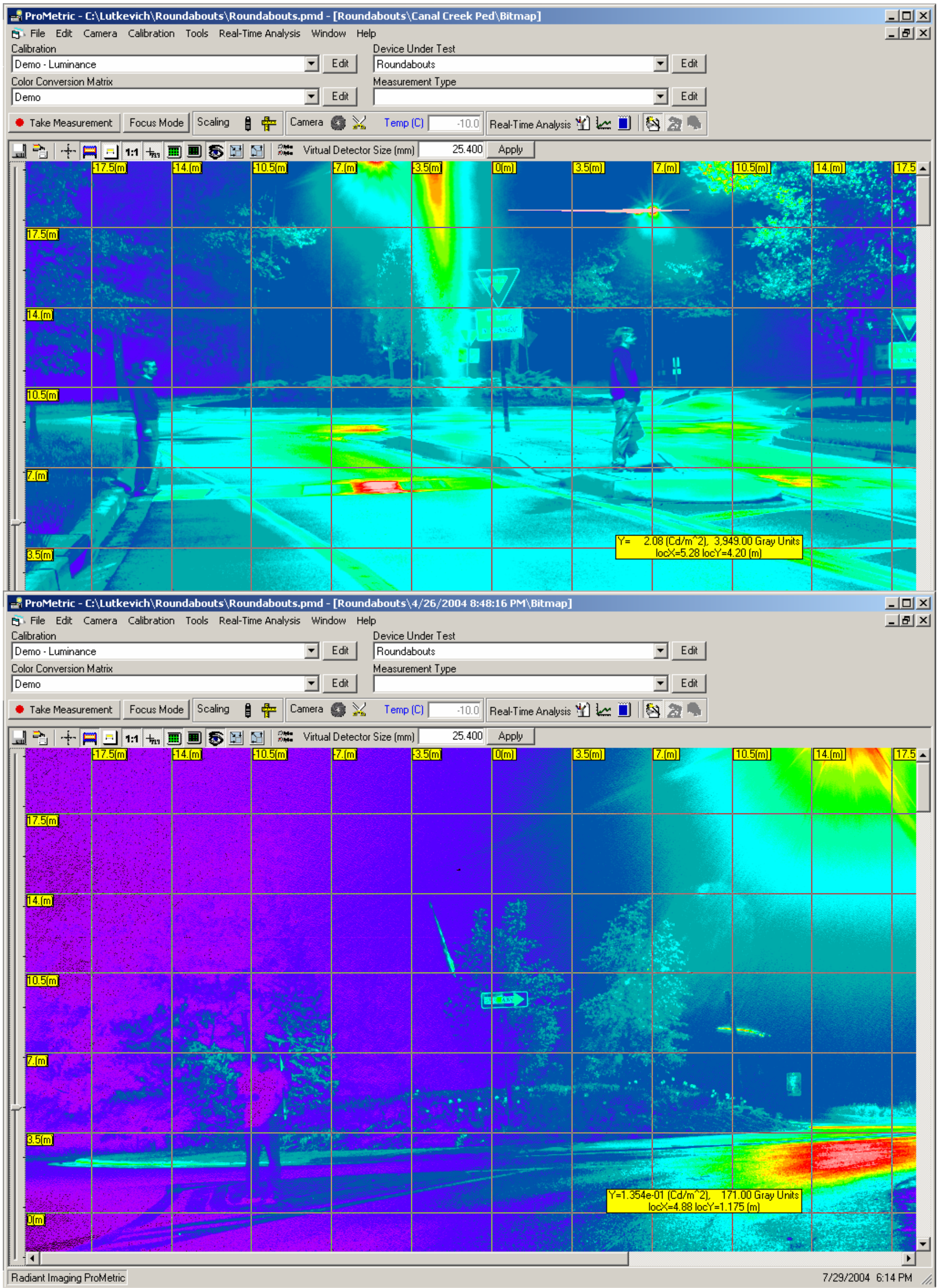


This suburban roundabout has three approaches with pedestrian crosswalks on all legs. Lighting is symmetric around the circular roadway and includes approach lighting in advance of all crosswalks. Four 250 watt high pressure sodium cobra head luminaries are placed around the roundabout with one unit on each of the approach roads. Lighting levels averaged 30 lux to 40 lux in the roundabout and vertical illuminnances at the crosswalks ranged from 20 lux to 40 lux. Observations from analysis of this roundabout include:

- For vehicles approaching the roundabout, the roundabout features are clear and conspicuous. Drivers have the ability to see and react to other vehicles approaching or circulating in the roundabout.

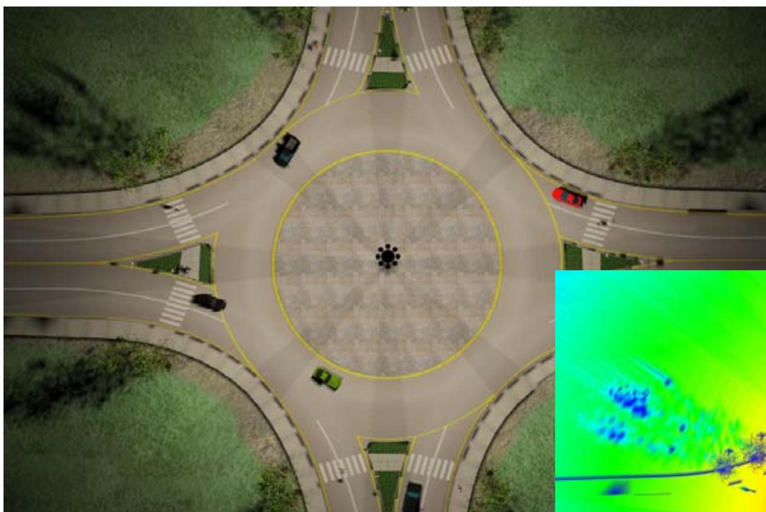
- All pedestrian crosswalks are clearly identifiable and pedestrians in the crosswalk are visible from 250 feet in advance.
- Vehicles operating on the circular roadway can clearly see around the roadway and anticipate entering or exiting vehicles as well as pedestrians.

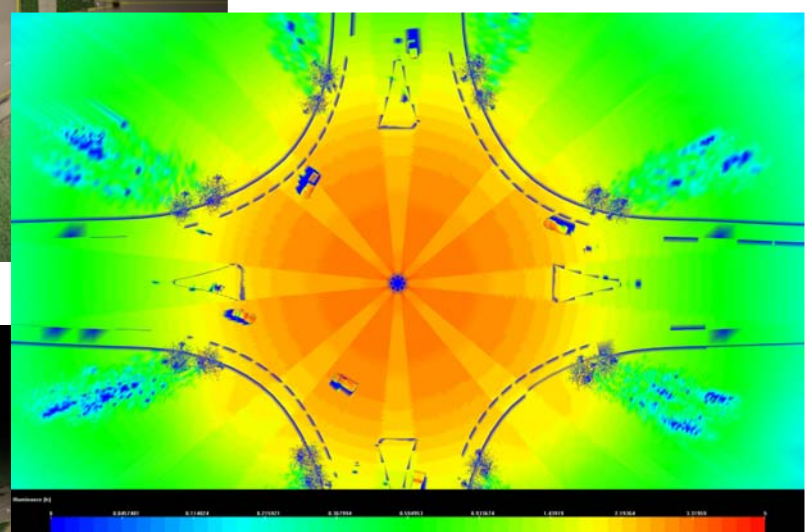
The meter readings taken with the CCD meter showed distinct differences in the visibility of pedestrians comparing the lighting systems for the roundabout only and lighting systems that also included approach lighting.

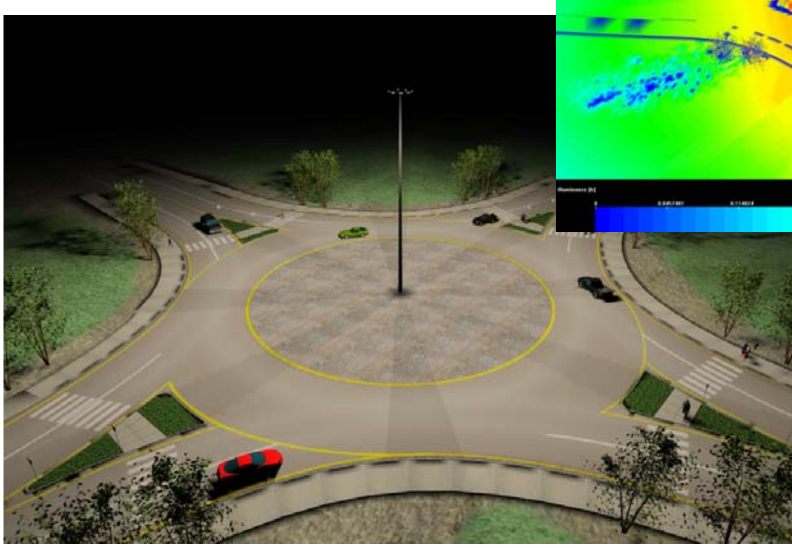


The contrast values for the pedestrians were considerably higher for the roundabout with approach lighting. It should be noted however that contrast values consist of the brightness of the pedestrian against the contrast of the background. This varies considerably between locations, viewing direction, type of clothing, type of roadway surfaces and plantings, etc.

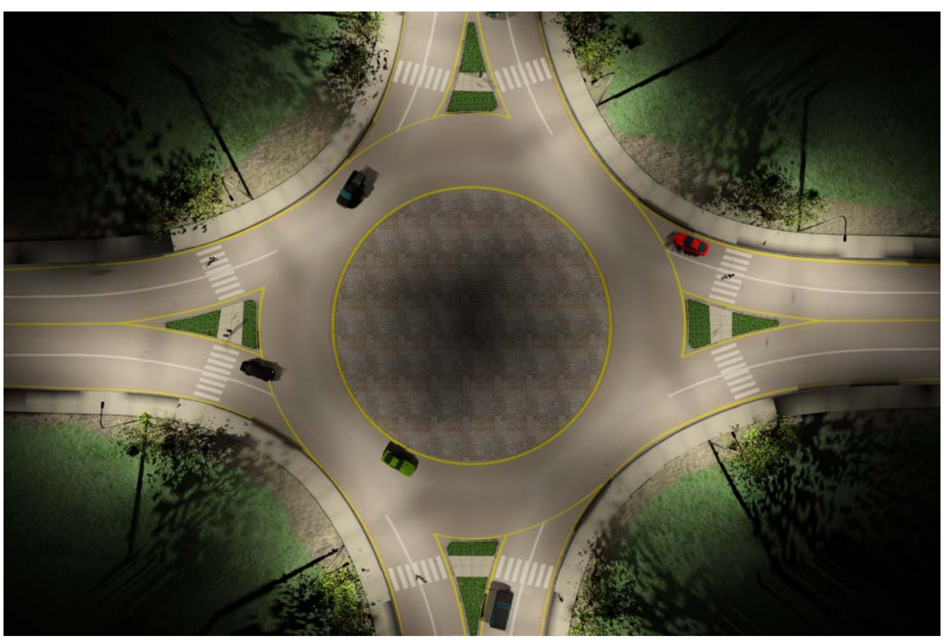
To simplify some of the visibility complexities we also prepared computer models to compare roundabout only lighting and a roundabout that also had approach lighting. For the roundabout only system we used a 24 meter pole with 8-400 watt high pressure sodium luminaries.

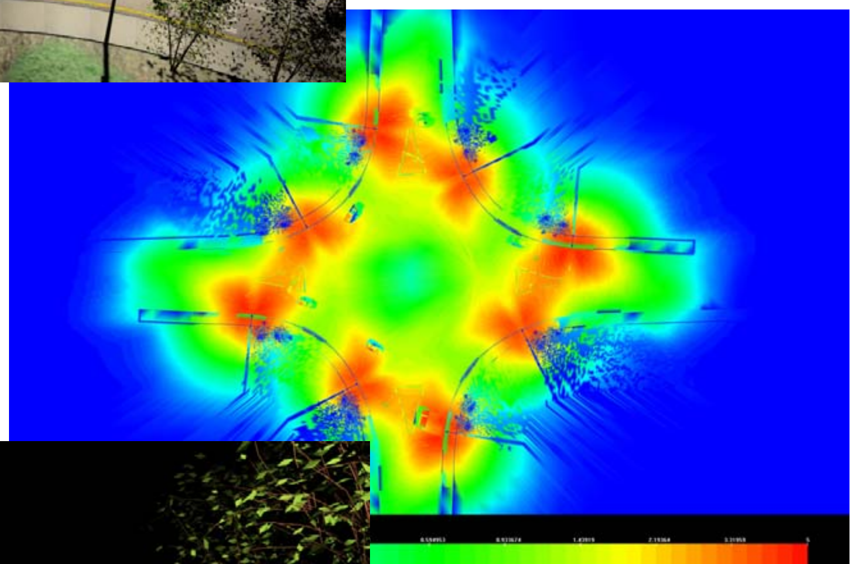


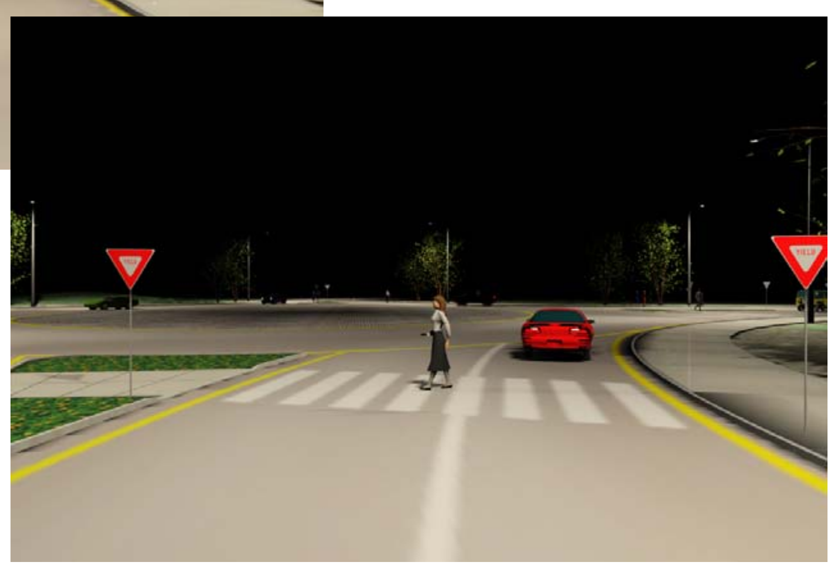




For the roundabout with approach lighting we used 8-10 meter poles with 250 watt high pressure sodium full cutoff cobra head luminaries.







The images generated by the computer models as well as the calculated values of all of the surfaces seemed to show preferable pedestrian visibility with an approach lighting system.

Conclusions

Based on the review and analysis of the roundabouts in this study, the authors believe that lighting should be provided for all roundabouts. Approach lighting for a roundabout appears to be critical in creating good visibility throughout the roundabout particularly with the presence of a pedestrian crosswalk, high traffic volumes or the potential for other significant roadway features in advance of the roundabout. The lighting levels are very subjective at this point in time. In locations where the minimum levels are 10 lux or above there appears to be sufficient illumination. Using a 10 lux minimum values with good uniformity will most likely result in an average of 20 lux or above as a design value. Vertical illuminance also seems to be a strong consideration and the 20 lux to 40 lux values also subjectively appear to provide adequate visibility.

The authors are aware of other ongoing studies that are refining lighting values that can be used at pedestrian crosswalks. The values defined in these other studies will be suitable for application at roundabouts.

Finally, the work carried out in this study also reinforced the essential importance of good signing and pavement markings to support of lighting. Whether lighting systems are operational or not signs and markings can provide vital information to drivers as they approach and negotiate a roundabout.

The information provided in this paper will be taken forward by the authors to the Illumination Engineering Society of North America (IESNA), Subcommittee on Roundabout Lighting. It will provide a basis for further discussion and consideration by the IESNA as they develop U.S. national standards for roundabout lighting.

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