Light Levels Related to Uniformity Ratio

by Michael Whittingham

LED lighting has changed the way we experience light. LED was first introduced in 1962, much earlier than most would imagine. Nearly 30 years elapsed before it became commercially available as a light source, and even then it remained in its infancy—too expensive and not very effective. Today, LED lighting is broadly accepted as the norm and is rapidly replacing technologies such as metal-halide, high-pressure sodium, fluorescent and mercury-vapor lighting.

Shrinking acquisition costs and massive improvements in efficacy (quantified as lumens created per watt of energy used) lead this charge. Between improved efficacy, which can shrink power consumption by 70% or more, and nearly maintenance-free life spans of high quality LED luminaires reaching 15–20 years, replacing antiquated technologies with high efficacy LED lighting seems like a simple choice. Like anything else though, LED lighting is not created equally. Some products are significantly better than others, so people must do their homework to help make the right choice.

One lesser known but significant improvement resulting from high quality LED lighting is the ability to distribute light evenly. Antiquated technologies mentioned above use lamps and reflectors to direct and distribute light. While it works to some degree, inconsistencies are so common they are compensated for by requiring high average light levels (brightness), and poor uniformity is tolerated.

For a quick dive into what uniformity is, look at the photo in Figure 1 below. The left side shows a parking lot using metal-halide lighting with poor uniformity while the right side shows another section of the property with an LED retrofit. The section lit by LEDs exhibits much higher uniformity. Due to careful engineering, the dark and shadowy areas have been all but eliminated by installing new LED luminaires.

Figure 1. Parking lots on the left side of the property are lit using traditional metal-halide lighting and parking lots on the right side are lit using LEDs. Notice the difference in uniformity levels.

Uniformity is measured by taking the highest light-level measurement and the lowest light-level measurement in an area and expressing them as a ratio. According to Illuminating Engineering Society of North America (IESNA) standards, a 15:1 maximum to minimum light-level ratio is the limit of an allowable uniformity ratio. This means if the highest light level measured is 5.6 foot candles, then to maintain the ratio, 0.37 foot candles is the minimum allowable measured light level. The result is a patchwork quilt of very inconsistent light levels, or poor uniformity. To make up for poorly distrib-

uted light using standard pole and fixture placement, light levels are increased. Light levels have been required to average 3.5 foot candles or more with older lighting technology. Using high quality LEDs to create the light and precision optics to distribute it, lighting uniformity can be improved to 3:1, enabling patrons to have an equivalent very safe perception of an outdoor area at much lower light levels. Light levels can be reduced by up to 70%, with the added benefit of operators enjoying significant cost savings due to lower energy consumption.

To demonstrate this point, a field test was conducted by the Lighting Research Center at Rensselaer Polytechnic Institute (RPI) in Troy, NY[1] to determine just how low light levels could be reduced before 15 patrons familiar with a particular site felt their visual experience was diminished. Testers wanted to quantify the perception of safety and security, light quality and energy efficiency by surveying these patrons about the parking lot under different lighting conditions.

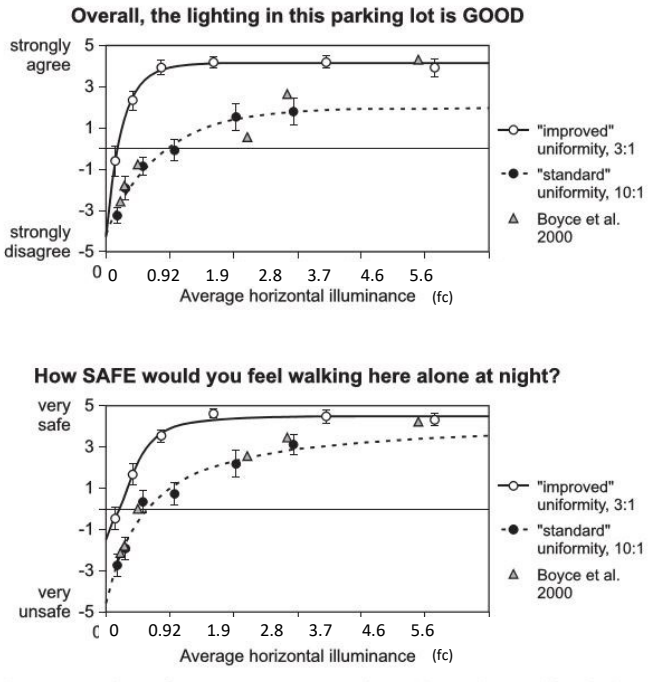

Figure 3. Average ratings for two survey questions about the parking lot's lighting as a function of average ground illuminance.

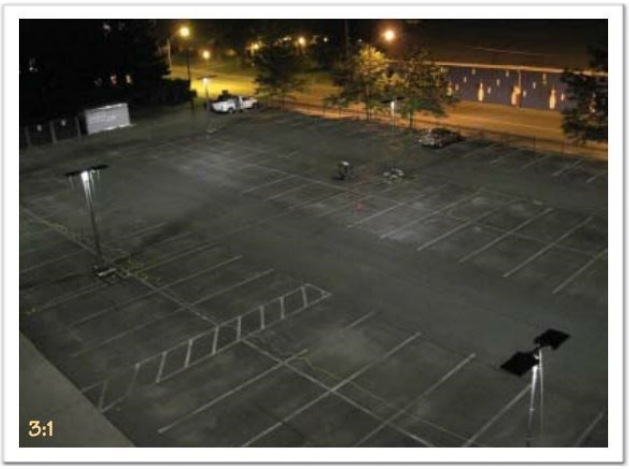

Figure 2a. Parking lot with LED lighting shows improved uniformity of 3:1.

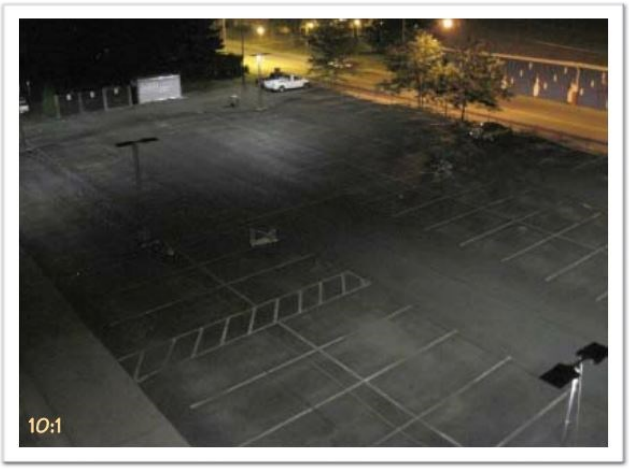

Figure 2b. Parking lot with older lighting technology and uniformity ratio of 10:1.

Using standard pole spacing with dimming LED fixtures, the testers created a parking lot (see Figure 2a) with a maximum-minimum uniformity ratio of 3:1 (5x better than standard). Testers then adjusted to 6 light levels between 0–5.6 foot candles and the 15 participants were surveyed. Testers then created a nearly identical parking lot (see Figure 2b) with a maximum-minimum uniformity ratio of only 10:1 using the same fixtures and pole spacing. They repeated the 6 light levels and surveyed the same participants once again.

As can be seen in the two graphs in Figure 3, participants said that no matter what the light level was, with the improved 3:1 maximum-minimum uniformity ratio provided by LED lighting that they felt the light quality was **"good"** and they felt **"very safe"** on the site. Testers concluded that patron perceptions were greatly improved if the uniformity ratio was improved, even while reducing light output from 5.6 foot candles to only 0.92 foot candles. Upgrading old technology to LED often results in a 50% energy savings, but when designing the light distribution to provide excellent uniformity, a 75% or greater savings is possible.

These findings reinforce that beyond simply upgrading lighting to LED there are substantial benefits to properly engineering a lighting upgrade to

not only provide a safer environment but to also maximize energy savings.