Lighting Design: Basics and Considerations

City of Dallas
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Like a lot of engineering design, a good lighting design is never noticed but everyone will notice when it’s bad.
How light works
How light is measured

THE BASICS OF LIGHT
What is Light

• Light is linear
• Light loss
  • Over distance \((1/d^2)\)
  • Reflection (absorbed)
• The human eye adapts to ambient light levels. We perceive light relative to surroundings.
• High contrast is glare
Measuring Light

- How to quantify light:
  - Intensity
  - Color
  - Uniformity
  - Contrast
  - Glare (extreme contrast)

- Quality of light is subjective. Many variables play into the perception of light quality; age, height, location, emotional state, etc.
Measuring Light

• Light exiting a source is measured in Lumens.
• Light on an object is measured as lumens per area.
  • Foot-Candle is lumens per square foot
  • Lux is Lumens per square meter.
• Light output of lamps/fixtures should not be compared with power input (Watts).
Lighting Efficiency/Efficacy
Energy – Heat – Light
Measuring Light

- The color of light is measured as °Kelvin (°K)
  - Lower °K, say 2600°K, is “warm” yellow/red light
  - Higher °K, say 5000°K, is “cooler” white/blue light
Measuring Light

• Color rendering
  • If a color is not present from a light source an object cannot reflect it.
  • A green car will appear black or gray in a warm light.

• Color Rendering Index (CRI)
  • Higher CRI means more accurate color

Extreme example: The light source above produces little to no light in the green/blue frequency spectrum. Is the car green, blue, other?
Spectral Power Density

- Sunlight
- LED
- Incandescent
- CFL

WAVELENGTH (nanometers)
GENERAL BACKGROUND - DESIGNING WITH LIGHT

Lamps
Fixtures
Fixtures (Luminaires)

• Distribution! Same fixture can have many distributions:
  • Roadway (Type I, II, III, IV, V, VS)
  • Flood – Forward throw, general, spot, etc.
  • Direct – Indirect – Direct/Indirect combo
  • Wall Wash
  • AND MORE
Fixtures (Luminaires)

• Distribution: How light is “thrown” from a source or fixture.
• Distribution is independent of mounting height, lamp lumen rating, wattage, lamp orientation, fixture aiming.
LIGHTING ROADWAYS

Road types and light levels
Conflicts and Concerns
Electrical systems for roadway lighting
Roadway Lighting

- The goal is uniform light levels with minimum number of fixtures and minimum power.
- IES (Illuminating Engineering Society) for recommendations.
- IES RP-8 is specifically for Roadway Lighting

Table 2. Average and Ave/Min Ratio Recommendations from IES RP-8. RP-8 has similar tables for intersections, bike lanes, pedestrian sidewalks, etc.
Conflicts require more light

- Conflicts are where traffic of various kinds meet;
  - Vehicle intersections
  - Pedestrian crosswalks
  - Bicycle lanes
  - Conflict of any kind

- Conflict areas often require more light but designs should avoid immediate light increases. (night blind)
Additional Consideration to Determine Light Levels

- Surrounding area levels
- Light levels for safety
- Mounting location
- Adjusting/Commissioning
Lighting Concerns

• Glare – Avoid direct view of light source! (acorn / tear drop / sag lens)

• Light trespass on adjacent properties

• Glare – Avoid perceived light trespass (also consider light color)

• Don’t mix light sources
Electrically design is a balancing act:

- Taller poles with higher wattage means further spacing but higher voltage drop
- Shorter poles with lower wattage means more fixtures
Oncor Lights

• Flat rate monthly charge from Oncor per fixture and includes:
  • Electric demand
  • Maintenance
  • Replacement
• Limited selection of styles (economy of scale)
EXAMPLE PROJECT
Background

• Downtown square for a city near the metroplex
• The City has plans for future community gathering and event areas in the square center
• The City is particular about a classic feel fixture in the high profile area. Proposed tear drop or globe fixtures.
• Construction cost is a big constraint
Practice

• The engineer has worked closely with the City and agreed on the provided fixture with a flat glass lens.
• Given the provided fixture and roadway layout how would you layout the lights? What light distribution(s) would you specify?
• Now given a budget that limits the design to no more than 14 fixtures how would you change your design?
MORE ON LIGHT EMITTING DIODES
Lamps

• Omnidirectional Sources:
  • HID
    • High Pressure Sodium
    • Metal Halide
  • Fluorescent
  • Incandescent
• Directional Sources:
  • LED
LED Benefits

• Directional light output means more control
• Better light control can means more energy efficient design*
• Better efficacy (Lumens/Watt), lower energy bills**
• Most LEDs are easily dimmed allowing advanced control options. Motion sensors and timers
• More color options; warm, neutral and cool color ranges.
• Significantly longer lamp life means lower maintenance costs.
• Technology is advancing FAST

*efficient design depends on the materials and the effort by the designer.
**Higher efficacy lights are wasted if the local Utility bills the Owner per fixture per month instead of by demand
LED Deterrents

- Technology is advancing FAST
- Priced at 2x to 3x HID fixtures
- Young manufacturers everywhere. “I know a guy who makes amazing fixtures out of his mom’s garage. They’re 14% more efficient than everything else out there. Yeah, he offers a warranty.”
- LEDs don’t burn out. The LED end of life defined as “70% of initial light output.” Minor concern for most designers but it should be a big deal for Owners.
- When it is time to change the “bulb” the entire fixture must be replaced.
- Efficacy is good, but not great. Yet.
Solar Powered Lights

Solar Powered Lights (Off Grid)
- Lights determined by lighting design
- Additional Costs
  - Solar Panels
  - Inverter
  - Battery Bank
  - New Maintenance
- Savings
  - Conduit and Conductor
  - Utility bills

Green and Friendly (Offset Demand)
- Lights determined by lighting design
- Additional Costs
  - Solar Panels
  - Inverter (Grid Tied)
- Savings
  - Lighting demand offset by energy provided to the grid
QUESTIONS AND DISCUSSION
Thank you