Illuminance Level as a Security and Comfort-Based Design Criteria for Pedestrian Facilities in SJMA

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Abstract

One of the key aspects of Transit Oriented Development (TOD) and Smart Growth (SG) urban development is to provide walkable environments. In that sense, pedestrian and recreational facilities should be designed to provide an adequate level of comfort that stimulates and promotes its usage. These aspects are considered crucial for the successful development of these facilities but are usually disregarded during the design. Currently, a major infrastructure and economic inversion such as Puerto Rico's urban (metro) train is considerably limited to daylight time usage; minimizing the intended potential of lowering private car use and the consequent reduction in carbon emissions. This motivated the research project to focus on the evaluation of the level of illumination as design criteria for pedestrian and recreational facilities by assessing the current conditions in key places within the San Juan Metropolitan Area (SJMA) in Puerto Rico. The evaluation considered the recommended standards for illumination, safety and comfort suggested by Illuminating Engineering Society (IES) and other well recognized organizations. A photometry study was conducted around three main train station areas, where data sets were mapped and represented using ArcGIS. Critical scenarios that were also identified were represented using Google SketchUP, Artlantis and Adobe Illustrator. Using linear regression an existing correlation between the illumination levels and ridership after 7:00 PM was evidenced. Although pedestrian lighting levels meet the recommended values for security and comfort in the immediate surroundings of the train stations, adjacent locations under the radio of influence fail to meet these values. Finally, best management practices (BMPs) were developed to provide applicable solutions to help the city comply with these recommended standards and promote the success and further encourage the nighttime use of the mass transportation system in (SJMA).

Objectives

General Objectives

- To study the level of illumination as a design criterion for pedestrian facilities within the San Juan Metropolitan Area (SJMA) in Puerto Rico.
- To assess current conditions within the SJMA.
- To recommend environmental and economically efficiency-based solutions to comply with the necessary levels of illumination according to recommended values associated with comfort and security.

Specific Objectives

- Provide with a scientific-based source regarding existent lighting conditions in representative train stations of SJMA public transportation system.
- Provide viable solutions and recommendations for effective lighting designs.

Introduction

The "Tren Urbano" is Puerto Rico's first and only rapid transit system. It consists of 16 stations along its 10.7 mile route and travels at a speed of about 21 mph. It was opened in late 2004 with a price tag of $2.5 billion; and since then, a problem with the quantity of ridership has troubled the rail transit system. Significant low ridership numbers has brought economic problems and planned future phases are being delayed (Graterole, 2009).

Figure 1: "Tren Urbano"

Selected Train Stations:

- Hato Rey
- Roosevelt
- Domenech

Figure 2: Train Stations Arrangement within SJMA

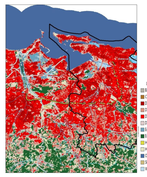

Figure 4: Land Use Characterization

Figure 3: Aerial view of Hato Rey Station

Figure 5: Aerial picture of Hato Rey Station

Methodology

A site-specific methodology was created in order to quantify current conditions.

Theoretical Basis

- **Applicable local regulations**
- **Design criteria documents**
- **Lighting manuals**

Direct Data

- **Photometry Study**
- **Units: footcandles (fc)**
- **Additional scenarios**
- **9:00 pm – 12:00 m**
- **May 2011/Field Data**

Indirect Data

- **Train Station Ridership**
- **'Cutoff hour' was identified**
- **Alternative Concepts, Inc.**

Table 1: Recommended Illumination Levels Compilation

Source	Publication	Class.	E_h min (lux)	E_h max (lux)
IESNA	Lighting Handbook 2000	Intermediate area	6	11 (max)
CIE	CIE 136-2000 CIE-115-1995	Moderate use area (P3)	1.5 - 2	7.5-8 (median)
"Instituto para Diversificación y Ahorro de la Energía"	Compilation of IESNA & CIE Documents	S3	1.9	7.5 (median)
"Tren Urbano"	Electrical Design Guide	Pedestrian walkways	30 lux at pavement	

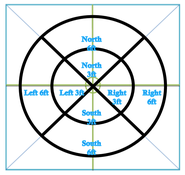

Figure 6: Template used for Field data Collection

Figure 7: Extech HD400 Digital Light Meter

Table 2: Example of Photometry Collected Data

IDNUM	North 3'			North 6'			East 3'			East 6'			South 3'			South 6'			West 3'			West 6'		
	Max (fc)	Min (fc)	AVG (fc)	Max (fc)	Min (fc)	AVG (fc)	Max (fc)	Min (fc)	AVG (fc)	Max (fc)	Min (fc)	AVG (fc)	Max (fc)	Min (fc)	AVG (fc)	Max (fc)	Min (fc)	AVG (fc)	Max (fc)	Min (fc)	AVG (fc)	Max (fc)	Min (fc)	AVG (fc)
Hato Rey North																								
H1	1.30	0.90	1.10	1.10	1.00	1.05	3.50	3.40	3.45	2.70	2.60	2.65	1.60	1.50	1.55	1.40	1.30	1.35	1.00	0.80	0.90	0.00	0.00	0.00
H2	end of sidewalk		n/a	end of sidewalk		n/a	1.30	1.20	1.25	3.40	2.90	3.15	4.40	4.20	4.30	3.30	3.20	3.25	1.40	1.30	1.35	0.04	0.02	0.03
H3	end of sidewalk		n/a	end of sidewalk		n/a	13.20	13.10	13.15	9.00	9.00	9.00	11.80	11.70	11.75	8.87	8.60	8.74	12.40	12.20	12.30	10.80	10.60	10.70
H4	end of sidewalk		n/a	end of sidewalk		n/a	8.80	8.70	8.75	9.00	8.90	8.95	6.10	5.90	6.00	5.00	2.80	3.90	5.60	5.40	5.50	6.40	6.30	6.35
H5	3.70	3.60	3.65	5.00	4.80	4.90	5.50	5.40	5.45	4.80	4.60	4.70	4.30	4.20	4.25	3.90	3.10	3.50	3.40	3.20	3.30	3.20	3.14	3.17

Results

Illumination Levels mapped using ArcGIS and corresponding Ridership Data Graphs

Figure 8: Photometry Results for Hato Rey Station

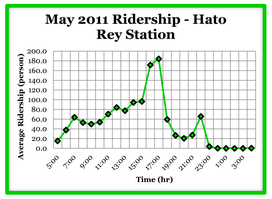

Figure 11: Ridership Data for Hato Rey Station

Figure 9: Photometry Results for Roosevelt Station

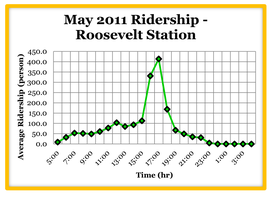

Figure 12: Ridership Data for Roosevelt Station

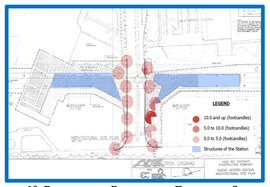

Figure 10: Photometry Results for Domenech Station

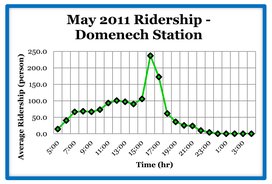

Figure 13: Ridership Data for Domenech Station

Data Synthesis

Table 2: Field Data Summary for Illuminance levels. Source: Field Data, May 2011

Station	E_h average (fc)	E_h average (lux)
HR	4.13	44.5
RO	7.43	80.0
DO	6.11	65.8
Average	5.89	63.4

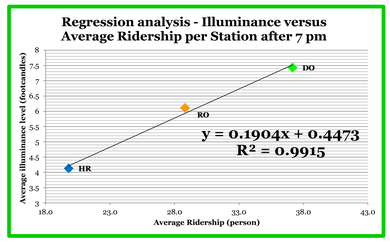

Figure 13: Regression Analysis

Data Representation

Critical scenarios were represented using Google SketchUP, Artlantis and Adobe Illustrator

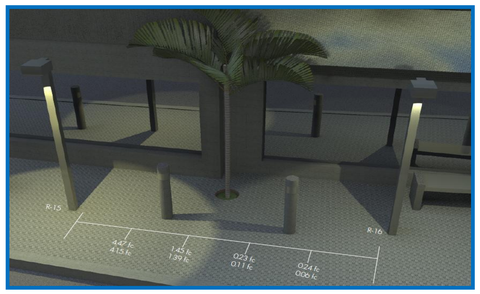

Figure 14 : Scenario #1, Out of service fixture. Source: Field Data, May 2011

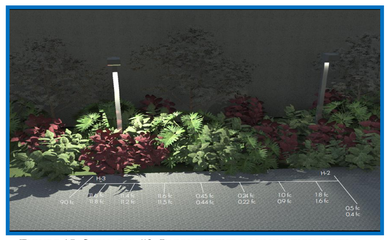

Figure 15: Scenario #2, Inconsistent illumination levels. Source: Field Data, May 2011.

Figure 17: tree Obstruction example

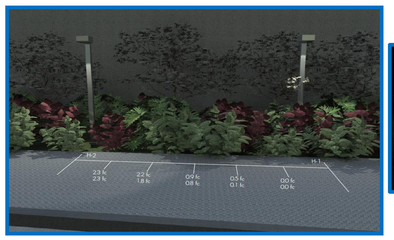

Figure 16: Scenario #3, Low illumination levels. Source: Field Data, May 2011

Figure 18: Tree Obstruction & Inconsistency example

Best Management Practices

- Consider illumination levels as a design criteria
- Enforce connectivity for new projects
- Advanced Occupancy Sensing
- Intelligent, bi-level luminaires

Figure 19: Carmanah EverGEN 1710 Solar Outdoor Light

Figure 20: The Edge™ LED Area luminaire with two-level option

Figure 21: Solar Outdoor Light

Conclusions

- Photometry study showed that pedestrian lighting levels in the immediate surroundings of the train were acceptable under the recommended values of IESNA, CIE and others.
- The identified real problem was the lack of local authorities' interest to provide lighting in sidewalks under the adjacent radius of influence. The gap analysis revealed that since illumination level for pedestrians is disregarded from every applicable regulation, there is not any type of lighting plan in the area.
- **There is evidence of a linear correlation between illumination levels and ridership for train stations in SJMA**. (Figure 13). Improving this first while being consistent with IESNA/CIE illumination levels recommendations for comfort and security can provide a more inviting and walkable area for pedestrians.
- The study confirmed and further revealed that there is a real need for developing rules for increasing connectivity between train stations and its surroundings.
- **Facing one of the most unnoticed local transportation issues, this study serves as quantified supporting evidence while providing local and feasible recommendations to succeed in creating a TOD-oriented and environmentally conscious SJMA pedestrian culture.**

References

Graterole, Agustín B., 2009. Transportation Systems and Planning Department of Geography and Planning. The University of Akron. Pedestrian Accessibility and Residential Density around the Tren Urbano Rail Transit System, San Juan Metropolitan Region.

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