Sustainable Cities and Society 28 (2017) 233–241

Contents lists available at ScienceDirect

Sustainable Cities and Society

journal homepage: www.elsevier.com/locate/scs

Improving community street lighting using CPTED: A case study of three communities in Korea

Donghyun Kim (Research Fellow)*, Songmi Park (Researcher)

Korea Environment Institute, 370 Sicheong-daero, Sejong 30147, Republic of Korea

ARTICLE INFO

Article history:
Received 6 June 2016
Received in revised form
24 September 2016
Accepted 27 September 2016
Available online 29 September 2016

Keywords:
Street lighting
CPTED
Visibility
Community safety
Illuminance

ABSTRACT

This study proposes design alternatives for community street lighting by applying "Crime Prevention Through Environmental Design" (CPTED) concepts to enhance natural surveillance and feelings of safety. We conducted simulations to analyze how these designs would improve three communities. To find ways to enhance community safety at night, we considered lighting standards and CPTED guidelines, using Relux Pro for a simulation analysis. We came up with design alternatives considering visibility and the facial recognition for street lighting; based on this, we proposed that more security lights be installed or existing lights be modified or oriented in a different direction. When we applied the proposed changes to the study areas, we found that our simulations would improve the "average horizontal illuminance" and the basic conditions for perceiving people. The study contributes alternatives for community street lighting based on CPTED, compares the alternatives to existing lighting using simulation software, and discusses the effects of these alternatives.

1. Introduction

In urban planning, lighting has become a topic of active debate with regard to safety, the vitality of social relations, and energy consumption. Urban lighting is defined as "the totality of all lighting in a city's public realm," and this includes street lighting as well as light from advertising, building interiors, or other artificial sources (ARUP, 2015). From the perspective of social development, the role and function of urban lighting is to make human interaction possible in the "public realm." Sociologist Lyn H. Lofland defined "public realm" as the social entity within a city's physical setting, and it can consist of interaction between strangers (Lofland, 1998). A successful public realm allows interaction between people, enhances economic vitality, and stimulates investment.

The function and role of urban lighting is based on the feelings of safety that a space provides at nighttime. Among the various types of urban lighting, street lighting is seen as one of the most important with regard to feelings of safety (Boomsma & Steg, 2014), and it is an important element in CPTED (Crime Prevention through Environmental Design), which relates urban design to crime and safety (Cozens & Love, 2015; Kyttä, Kuoppa, Hirvonen, Ahmadi, & Tzoulas, 2014). CPTED is based on the elements of a "safe city street," as proposed by Jacobs (1961). Its departure point is the environment-focused approach to crime described by Jeffery (1971). CPTED was further developed by the concept of "defensible space," as posited by Newman (1973). The key design elements that ensure security include territoriality, surveillance, image and milieu, and geographical juxtaposition (Cozens & Love, 2015).

The literature regarding CPTED is divided between "natural" and "technical" approaches to security surveillance (Ekblom, 2011). In urban planning and design, CPTED emphasizes natural surveillance (Crowe, 2000; Cozens & Love, 2015; Minnery & Lim, 2005), and street lighting is seen as an important element at night (Armitage, Monchuk, & Rogerson, 2011; Clancey, 2011; Kyttä et al., 2014). Street lighting is a basic facility within a community because it enhances residents' feelings of safety at night and allows for natural surveillance (Kyttä et al., 2014).

In conducting this study, we proposed ways to improve street lighting to enhance natural surveillance and feelings of safety in communities, as discussed in CPTED; and, to compare levels of improvement, we performed space simulations. The subjects of the study were three communities in the Daejeon metropolitan area that are typical old-fashioned Korean villages. In making our improvements, we used standards proposed in previous studies regarding CPTED street lighting factors and lighting planning. We used the Relux Professional 2016 version of software for spatial simulation. The main contribution of this study is its proposal of alternatives for community street lighting based on CPTED to enhance natural surveillance and feelings of safety, and its use of simulations to compare the alternatives.

This study is organized as follows. First, we include a theoretical discussion that links crime, safety, and street lighting to design

* Corresponding author.
E-mail addresses: donghyunkim@kei.re.kr (D. Kim), smpark@kei.re.kr (S. Park).

http://dx.doi.org/10.1016/j.scs.2016.09.016
2210-6707/

Table 1
CPTED Guideline Lighting Standards.

Location	Visibility	Distance of Perception of Risk	Other Factors
City of Virginia Beach (2000)	Brightness that allows two people to see each other at night		Height, installation area, etc.
Durham City and County Private Sector Taskforce (2004)	Enough to allow potential threats to be seen		
Ministry of Justice, New Zealand (2005)	Enough to allow messages to be sent to the public	Distance to improve perception of safety	Considered in overall design
Queensland Government (2007)	Pools of light and darkness	Identifying a face at a distance of 15 m	Vegetation is considered Maintenance, bushes, and trees that interfere with street lighting
Victoria State Government (Crime Prevention Victoria, 2005)	Avoid extreme contrast between light and dark surfaces	People are able to recognize an approaching person's face 10 to 15 m away.	
European Commission Directorate-General Justice Freedom and Security (2007)	Enough lighting to reduce fear of crime	Faces can be seen from a distance of 15 m	
Korea Agency for Technology and Standards (2012)		Characteristics of potential criminal can be seen from at least 4 m away	

Table 2
Lighting Standards for Pedestrian Streets (unit: lux).

(a) Lighting Standards for Pedestrian Streets in CIE 115 (Commission Internationale de L'Eclairage (CIE), 2010)

Lighting class	Average horizontal illuminance	Minimum horizontal illuminance	Additional requirement if facial recognition is necessary	
	(ground level)	(ground level)	Minimum vertical illuminance	Minimum semi-cylindrical illuminance
P1	15	3.0	5.0	3.0
P2	10	2.0	3.0	2.0
P3	7.5	1.5	2.5	1.5
P4	5.0	1.0	1.5	1.0
P5	3.0	0.6	1.0	0.6
P6	2.0	0.4	0.6	0.4

(b) KSA 3701 Pedestrian Street Lighting Standards (Korea Agency for Technology and Standards, 2014)

Traffic volume of pedestrians	Area	Average horizontal illuminance(ground level)	Minimum vertical illuminance (1.5 m from ground level)
High	Residential area	5	1
	Commercial area	20	4
Low	Residential area	3	0.5
	Commercial area	10	2

standards for street lighting. Next, we describe the study areas and the simulation method. In the "Results" section, we outline our proposals to improve street lighting in the three communities and the results of applying the simulation. Finally, we discuss the urban planning and design implications of using street lighting to enhance a community's natural surveillance and feelings of safety.

2. Theoretical discussion

2.1. CPTED and street lighting for community safety

Street lighting increases pedestrian and traffic safety, and reduces opportunities for crime (Boomsma & Steg, 2014). Thus, it plays an important role in increasing people's feelings of safety (Loewen, Steel, & Suedfeld, 1993), and enhances street visibility to improve natural surveillance and the community's safety (Armitage et al., 2011; Clancey, 2011; Kyttä et al., 2014; Welsh & Farrington, 2009). "Feelings of safety" are defined as a general cognitive response in which one feels protected from dangers arising from human action in the public sphere (Loewen et al., 1993). Blöbaum and Hunecke (2005) published results showing that low lighting conditions may reduce feelings of safety. Farrington and Welsh (2004) also stated that improved street lighting could reduce crime by up to 20% and argued that it is an important factor in safety.

The discussion of street lighting with regard to community safety from crime is related to CPTED. Street lighting is one of numerous methods proposed by CPTED, and it is discussed especially as a means to enhance natural surveillance and feelings of safety at night (Armitage et al., 2011; Marzbali, Abdullah, Razak, & Tilaki, 2012a). Natural surveillance is the ability of residents to observe their street in a natural way (Cozens & Love, 2015); thus, street lighting is included as a technical method for nighttime hours along with security cameras and security patrols (Clancey, 2011). The degree and quality of brightness is important in street lighting (Ekblom, 2011). Especially in communities, the format of lighting affects visibility (Blöbaum & Hunecke, 2005) and is even related to levels of fear (Nasar & Fisher, 1993); as a result, improvements in lighting are seen as an important factor in CPTED (Kyttä et al., 2014).

The CPTED guidelines suggest various design elements to increase feelings of safety and visibility with regard to crime. The guidelines for street lighting usually propose that lighting be adequate. Criteria for adequacy include visibility, distance of perception risk, and other factors, as shown in Table 1.