Building and Environment 46 (2011) 54–64

Contents lists available at ScienceDirect

Building and Environment

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

Effectiveness of daylighting design and occupant visual satisfaction in a LEED Gold laboratory building

Ying Hua [a,*], Anne Oswald [a], Xiaodi Yang [b]

[a] Department of Design and Environmental Analysis, Cornell University, Ithaca, NY 14853, USA
[b] School of Architecture, Carnegie Mellon University, Pittsburgh, PA 15213, USA

ARTICLE INFO

Article history:
Received 14 February 2010
Received in revised form
9 June 2010
Accepted 26 June 2010

Keywords:
Daylighting
Visual environment
Laboratory
Occupant visual satisfaction
User control
Post-occupancy study

ABSTRACT

Using daylight as primary light source has been widely recognized as an important strategy to reduce building energy demand and enhance indoor environment quality. However, to design and operate a building to make full use of daylight, which is a dynamic light source, to meet diverse occupant needs remains a challenge. This paper reports a post-occupancy study of the visual environment in a laboratory building on a university campus, and puts a spotlight on the building occupants as it examines the effectiveness of the daylighting design and systems integration in creating a visual environment to support occupant comfort and satisfaction while reducing artificial lighting demand. Results show generally high satisfaction with daylit work environment and positive effect of the horizontal shading strategy. Issues about the integration between daylighting and electric lighting systems and level of occupant control are identified and discussed for improving the effectiveness of daylighting and enhancing the quality of the visual environment in the building of study. A multiple-tool methodology is developed and tested, which included occupant surveys, interviews, illuminance measurements, continuous data loggers, fisheye-lens camera and glare-identifying software, and documentation of spatial settings, systems features, and user behavior.

1. Background

Energy consumption for artificial lighting in all buildings in the United States is about 18% of the total electricity generated in the country [1]. Lighting consumes more electricity than any other end uses in buildings. The huge amount of consumption and the low resource-to-site conversion efficiency of electricity supply make lighting the single energy end use in buildings that is associated with the largest quantity of carbon emissions (554 million metric tons of CO_2) as well as other environmental effects [2]. Furthermore, the conversion of electricity into useful light is one of the least efficient energy conversion processes in buildings today.

In order to change this situation, besides relying on improving lighting fixture efficiency and introducing sophisticated controls, using daylight as primary light source has been widely recognized as an important strategy to reduce lighting energy demand in buildings. Many green buildings adopted daylighting design strategies for the superior luminous efficacy of daylight [3] and the resulted energy and environmental benefits. In addition, the financial benefits do not stop at energy savings but carry over to even larger gains because of the effect of daylight on the health, comfort, satisfaction, well-being, and productivity of occupants [4–6].

However, introducing daylight into buildings is not as simple as having glazed areas or windows on the building façade. Architects and building owners could run the risk of failing the occupants if they do not understand the mechanism how daylighting works and how to incorporate daylighting in a wise manner to ensure the "right" amount, intensity, distribution, and penetration of daylight in the building interior, as well as avoid various types of glare, which is known to be a large impediment to visual comfort and work performance [7,8]. Particularly, glare on computer screen, or veiling reflection, was the most frequently voted among problems that caused environmental discomfort in several post-occupancy evaluation studies [9,10]. Proper daylighting design strategies, integration between daylighting and the design and operation of other building systems, and a careful consideration of occupant perception and behavior are all necessary in order to realize the potential energy savings from daylighting and to support the comfort, health, and performance of building occupants. How to design a building to make full use of daylight, which is a dynamic light source, to meet the diverse occupant needs is a constant

* Corresponding author. Tel.: +1 607 254 6415; fax: +1 607 255 0305.
E-mail address: yh294@cornell.edu (Y. Hua).

0360-1323/$ – see front matter
doi:10.1016/j.buildenv.2010.06.016