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A Holistic Approach for Improving Visual Environment in Private Offices

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Abstract

Visual comfort is one of the main priorities in designing working and living environments. An efficient design of an office space however should also take into account its energy performance, and the connection to the outdoors. The latter is a poorly studied but critical factor connected to the overall visual satisfaction in the interior. While new designs offer freedom to the architects in terms of orientations, window-to-wall ratios and high performance glazing systems, existing spaces require more targeted and effective retrofit solutions, mostly connected to shading devices and automatic control systems or even the potential adjustment of the positional layout in the interior. Glare from daylight is a common issue in building perimeter zones with large facades that highly affects productivity and occupant comfort, therefore its mitigation should be considered as a priority. Then, maximizing the lighting energy performance or the degree of connection to the outdoors should be secondary decisions connected to the use of the space. Several indicators have been developed to quantify the degree of visual discomfort, and Daylight Glare Probability (DGP) is widely accepted as an appropriate index. However, in this study, due to limitations of the applicability of DGP in cases with the sun visible through roller shades, an alternative criterion is being used, based on thresholds for the direct and total vertical illuminance on the eye. In compliance with IES Standard LM-83-12, the continuous daylight autonomy is used to assess the lighting energy performance of the space, while for the connection to the outdoors, the newly developed Effective Outside View index is extended in order to quantify the case of dynamic shading systems. The triple visual environment criterion allows a holistic evaluation of the visual environment in private offices with roller shades.

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Keywords: Daylight glare; visual comfort; lighting energy use; connection to the outdoors; roller shades; office layout

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1. Introduction

Visual comfort in office spaces has been the main focus of building science research regulations attempts and control and façade configuration designs over the past few years. Maintaining comfortable and desirable conditions within office spaces leads for the occupants to be more productive, desire to spend more time in their workstations, and even leads to improve health. Although open plan offices are gaining popularity nowadays, private offices, a common practice of the past still remain the main trend in older buildings, compensating poor space utilization and isolation of employees with benefits as the complete freedom of positioning and the potential for personalized comfort for the occupants. A successful design of an office should provide comfortable conditions, taking also into account the lighting energy performance and the connection to the outdoors[1].

Visual comfort has been studied mostly associated with discomfort glare. Daylight Glare Probability or DGP[2] is the most recent index used to evaluate glare from daylight, and it is extracted by experimental data in private office spaces involving human test subjects focusing their view to a specific task area. Chan et al.[3] suggested an alternative criterion based on the direct and total parts of vertical illuminance on the eye to assess discomfort glare for the cases of direct sunlight penetrating the room through shading fabrics. The positional aspects of discomfort glare (distance from the window and view direction) have been discussed in several studies; Konis[4] investigated the occupants' preferences in side-lit open plan offices, while Jakubiec and Reinhart[5] stated that rotated views can reduce or eliminate discomfort glare. In a simulation study, Chan et al.[6] stated that wall-facing directions lead to less uncomfortable conditions over the year, while Konstantzos and Tzempelikos[1] investigated open plan offices with fully applied shading devices to state that side wall facing could allow fabrics of high visual clarity to be used to improve outside view without creating issues of discomfort.

Energy efficiency in terms of lighting energy use is studied through daylighting design metrics. The most widely used is Daylight Autonomy, defined as the percentage of annual office hours when the interior the illuminance is higher than a pre-defined level. In order to obtain a more realistic daylighting amount due to the values below the set point, continuous Daylight Autonomy or cDA[7] has been suggested, accounting for the values lower than the desired threshold. IES Standard LM-83-12[8] suggests a desirable set point of 300 lux.

The connection to the outdoors, in terms of amount and clarity of view is not adequately studied; Konis[4] found that occupants in perimeter zones left a portion of the window unshaded for most of the time to maintain adequate outdoor view, despite the occurrence of visual discomfort. Other studies [9,10] pointed the qualitative relationship between sensation of glare and outside view, while Hellinga and Hester[11] presented a computational method to assess outdoor view quality. Konstantzos and Tzempelikos[1] proposed the Effective Outside View, a geometrical metric to quantify the connection to outdoors for the case of windows with fully applied shading fabrics.

This study applies a triple criterion to select the most effective design visual environment approach for a private office space with respect to visual comfort, lighting energy performance and connection to the outdoors. A strategy of maximizing lighting energy performance and connection to the outdoors while keeping visual comfort as a constrain constitutes a straightforward decision making process, which can be used either in existing buildings, in terms of retrofitting and positional layouts or also optimize the design of new spaces, in terms of orientations, façade configurations, control methods or even spatial layouts according to the specific needs and functions of the space.

2. A suite of metrics for the holistic evaluation of the visual environment

2.1 Visual Comfort Autonomy (VCA)

The Visual Comfort Autonomy or VCA[1] is defined as the portion of working hours when a person in a specific position and under a selected viewing direction is under comfortable conditions. There is some controversy regarding the use of DGP[2] in the cases of direct sunlight penetrating the room through roller shade fabrics, stated by Konstantzos et al.[12] and the common experience that roller shade fabrics of low openness lead to comfortable conditions for most of the time; as the solar corona's luminance reaches extreme values, even when observed through low-openness fabrics, the calculations of the contrast term of DGP inflate the predicted glare level compared to everyday practice, especially for the cases of tight fabrics. To account for these inconsistencies, given that the objective of this study is to retrofit existing spaces with the application of shading fabrics, an alternative