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Seasonal optimization of a fixed exterior complex fenestration system considering visual comfort and energy performance criteria

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Abstract

In a certain climate, the lighting and thermal performance of a building can be improved if the position of a fixed solar protection system of a complex fenestration system (CFS) is changed according to the period of year. The main objective of this paper is to optimize the lighting and energy performance of a fixed exterior horizontal and curved perforated louver used on a fully glazed façade of an office space located in Santiago (Chile) and Oslo (Norway), considering different slats angles of the CFS, depending of the season of the year. Bi-monthly, quarterly and bi-annual position of the CFS has been evaluated. The highest reduction of the total energy consumption corresponds to the bi-annual and quarterly cases in Santiago with 11.6% with respect to the annual case, and the quarterly case in Oslo with 8.3% with respect of annual case.

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Keywords: Complex fenestration systems, seasonal optimization, office buildings, louvers, thermal and lighting simulations;

1. Introduction

Highly glazed façades are commonly used in modern architecture, especially in office buildings [1]. They are highly affected by daylight and solar heat gains (SHGs) through fenestrations [2]. Therefore, daylight control through the

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transparent façade of the building may be considered for reducing energy consumption in buildings. Moreover, daylight within certain standards has a significant impact on occupants' comfort, health and productivity in built environments [3].

Shading devices, such as louvers, venetian blinds and perforated screens control daylight and solar heat transmission through fenestration systems. These shading devices typically involve a non-specularly transmitting fenestration layer [4, 5] that redirects both light and solar radiation in complex ways; thus, they are considered complex fenestration systems (CFSs). These CFSs can be fixed or movable. Many studies have been published lately about the impact of CFSs on building energy performance [1, 2, 6-8].

In order to determine the best option of CFSs to be defined during early stages of design, different optimization processes have been developed. The parameters and objective functions of these processes vary depending on the case. For example, [9] applied GAs and Radiance to design a slat-type shading. [10] designed a shading device using ESP-r and DAYSIM. In this case, a multi-objective optimization to minimize the energy consumption was used. On the other hand, [11] designed a lightshelf using multi-objective optimization to maximize daylight transmission and minimize energy consumption. Also, [5] proposed a methodology to optimize a CFSs minimizing the energy consumption, and considering the visual comfort parameters as a restriction.

Literature shows an important number of studies on the influence of fixed and movable CFSs. In this paper, the evaluation of the building performance using fixed CFSs that can seasonally change their position is proposed. This can result in a more effective performance than using a fixed CFS, and less expensive than a movable CFS by saving on engine operation and maintenance costs.

The main objective of this paper is to optimize the performance of a CFS, which corresponds to a fixed exterior horizontal and curved perforated louvers of a fully glazed façade, subject to different position angles depending on the season of the year. This CFS is incorporated in an office space in two cities: Santiago (Chile) and Oslo (Norway). Particularly, non-shading, annual, bi-monthly, quarterly and bi-annual position changes of the CFSs is being evaluated. The methodology used by [4] was applied in this problem.

Nomenclature

SHGs	Solar heat gains
CFSs	Complex fenestration systems
GAs	Genetic algorithms
PSO	Particle swarm optimization algorithm
HJ	Hooke-Jeeves algorithm
COP	Coefficient of performance
BSDF	Bidirectional scattering distribution function
IES	Illuminating Engineering Society
sDA	Spatial daylight autonomy
ASE	Annual sunlight exposure
sDA_M	Spatial daylight modified
ASE_M	Annual sunlight exposure modified
E_T	Total energy consumption (sum of lighting, cooling and heating)
OF	Objective function

2. Methodology

2.1. Overview

In this study, the optimization methodology of Ref. [4] has been applied. The only parameter to be optimized is the tilt angle of the slats, which can change the position according to different seasons. GenOpt was used as the optimization engine, using PSO-HJ algorithm. This engine is particularly suited to this task because it allows the cost function to be minimized by using external simulation software. *mkSchedule* [5] is used for lighting and energy