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FAST energy and daylight optimization of an office with fixed and movable shading devices

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ABSTRACT

This paper describes the Energy and Daylighting optimization of a fixed inclined panel which shades an office room with a south exposed window. The window features also user deployable internal Venetian blinds. Energy analysis takes into account the primary energy required for heating, cooling and artificial lights. Different numerical codes have been employed in order to perform the simulations required by the optimization process: Daysim estimates the artificial light consumption based on daylighting distribution, ESP-r computes heating and cooling loads and modeFRONTIER integrates the simulation codes in an automatic optimization loop. The performance of an algorithm specifically designed to deal with problems involving long simulation times (combining response surfaces and genetic algorithms) has been successfully evaluated; the algorithm has then been applied in the optimization loop. The optimized solutions are analysed in this paper, in particular three solutions have been selected: minimum primary energy consumption, minimum hours of blind deployed and an intermediate solution. The analysis compares the primary energy consumption and daylighting performance on the basis of the Useful Daylight Illuminance indicator and the time history of illuminance on predefined locations.

1. Introduction

Healthy conditions in occupied spaces is a common goal for designers and this involve a series of interlocked problems since different aspects of the problem must be taken into account simultaneously. In the process physical and psychological points of view should also be taken into account. Internal condition are usually maintained using air conditioning plants responsible for the constant increase of energy consumption, therefore, passive approaches are drawing great interest from researchers and designers with the aim of reducing the overall energy requirement. The key component of an energy aware building is the façade since it separates the internal comfortable environment from the external ambient. Nowadays office buildings present extensive glazed areas for enhancing daylighting availability but, especially in Mediterranean area, this leads to high cooling loads and increasing problems related to glare. The installation of external shading devices or glazing systems with low solar gain is becoming a natural solution for reducing the aforementioned problems. External shading devices can be fixed or moveable and each solution has its drawbacks and advantages. Fixed shading devices has low maintenance cost, but can be optimized for a single season, on the other hand a moveable device such as an external Venetian blind, can be efficient in reducing cooling loads and glare problems but with the drawback of obstructing the view towards the external environment.

In this paper the coupling between a fixed external shading device and an internal moveable blind system for avoiding excessive direct sunlight is considered. The external device geometry is optimized taking into account the overall energy consumption for building air conditioning and illumination.

The impact of shading devices on building energy consumption has been widely dealt with in scientific literature. Franzetti, Fraisse and Achard [1] analysed the connexion between daylight and thermal loads emphasizing the effect of light control devices on luminaries, heating and cooling energy consumption. Shen, H. and Tzempelikos [2] considered the effect of internal roller shades on daylighting and energy consumption for offices with different orientation showing that automated roller shades are energy efficient with windows covering 30–50% of the façade. Some authors used different numerical codes for solving daylight and energy problems. A common tool for daylighting analysis is DAYSIM, used

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