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Assessment of the thermal and visual efficiency of solar shades

M. David [a,*], M. Donn [b], F. Garde [a], A. Lenoir [a]

[a] PIMENT, University of La Reunion, 117 avenue du Général Ailleret, 97430 Tampon, Reunion Island, France
[b] Centre for Building Performance Research (CBPR), School of Architecture, Victoria University, Wellington 6001, New Zealand

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ABSTRACT

Solar shades are efficient architectural elements in order to reduce the thermal loads inside buildings. In one way, they can reduce significantly the energy needs of cooling systems. But in other way, they can decrease the visual comfort and increase the energy consumption of artificial lighting. Actually, the sizing of shading devices is mainly a thermal optimization process. The efficacy of solar shades must be assess taking into account both thermal and visual point of view.

In this paper simple indices were proposed to compare the thermal and visual efficacy of different types of solar shadings in non-residential buildings. These indices can be derived from the results of numerical simulations that include thermal and daylighting analysis such as the EnergyPlus software. A typical office is studied in order to assess the efficacy of different types of solar protections. The use of the proposed indices made obvious the choice and the sizing of the most efficient solar shade for the case study.

1. Introduction

The design of low energy buildings in tropical climates and in warm climates normally focuses first on the quality of solar shading. Solar shading is the over-riding design feature needed to avoid overheating inside the building and thus decrease the cooling capacity of air conditioning. The capital cost of installation and the operating time of air conditioning systems can be reduced or avoided if solar shading is combined with architectural design features such as cross natural ventilation.

As reduction of the energy consumption of the building sector constitutes now a priority objective, consideration of natural lighting also is essential. This because lighting is a significant proportion of total energy use in many buildings, so replacing it with “free” light from a renewable source such as the sun brings about significant reduction in purchased energy loads. However, with natural light there is a second bonus. In spite of all technological advances in electric light in the past decade, the sun is still the coolest source of light available in buildings.[1] The problem is one of intensity: a 1.2 m long fluorescent lamp on the ceiling of a room will produce approximately 4500 lm [1]; whilst a one square meter skylight will have approximately 100,000 lm impacting it in bright sun, and 20–30,000 lm on a cloudy day. When one is aiming for 200–500 lm per square meter (lux) on the working surfaces in a room, the problem of daylight is how to control the amount of this cooler source of light to the degree that is required.

Few building projects in tropic make the design of natural lighting a primary focus. The impact of solar protections on natural lighting has apparently not been widely studied. Only a few relevant references exist [2,3]. In certain buildings were care has been taken in design of solar protection, it is even possible that artificial lighting is required almost every day because the solar protection is too efficient. This results in increased energy use even though it had been thought during design that the optimum energy design had already been created with the solar protections to reduce cooling load of the air conditioning system. Good solar shade typically excludes all direct sun and much of the indirect light from the sky as well. An optimum design will be a compromise between effective solar protection and a suitable level of natural lighting. The ideal combination of both objectives in terms of reducing the overall building consumption is not obvious.

This paper presents a preliminary study of the simultaneous taking into account of solar shading and natural lighting in a typical room. The goal is to explore whether simple design guidance can be provided to designers that will assist them to balance solar protection and natural light. The room studied is an air conditioned office with a floor area of 12 m^2 and a single window.

After a brief review of typical indices used to evaluate the quality of natural light such as Daylight Factor, a simplified index

* Corresponding author. Tel.: +262 262961647; fax: +262 262962899.
E-mail address: mathieu.david@univ-reunion.fr (M. David).

[1] The efficacy of the sun has been reported as 100–130 lm W^{-1} [EERE 2009]; while the current best efficacy of a fluorescent lamp is 70–90 lm W^{-1}.

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