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External perforated Solar Screens for daylighting in residential desert buildings: Identification of minimum perforation percentages

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Abstract

The desert climate is endowed by clear sky conditions, providing an excellent opportunity for optimum utilization of natural light in daylighting building indoor spaces. However, the sunny conditions of the desert skies, in countries like Egypt and Saudi Arabia, result in the admittance of direct solar radiation, which leads to thermal discomfort and the incidence of undesired glare. One type of shading systems that is used to permit daylight while controlling solar penetration is "Solar Screens". Very little research work addressed different design aspects of external Solar Screens and their influence on daylighting performance, especially in desert conditions, although these screens proved their effectiveness in controlling solar radiation in traditional buildings throughout history.

This paper reports on the outcomes of an investigation that studied the influence of perforation percentage of Solar Screens on daylighting performance in a typical residential living room of a building in a desert location. The objective was to identify minimum perforation percentage of screen openings that provides adequate illuminance levels in design-specific cases and all-year-round.

Research work was divided into three stages. Stage one focused on the analysis of daylighting illuminance levels in specific dates and times, while the second stage was built on the results of the first stage, and addressed year round performance using Dynamic Daylight Performance Metrics (DDPMs). The third stage addressed the possibility of incidence of glare in specific cases where illuminance levels where found very high in some specific points during the analysis of first stage. The research examined the daylighting performance in an indoor space with a number of assumed fixed experimentation parameters that were chosen to represent the principal features of a typical residential living room located in a desert environment setting.

Stage one experiments demonstrated that the screens fulfilled the requirements of the majority of tested cases. Illuminance levels in the examined residential space were satisfactory in 83% of the near zone cases and 53% in the mid-length zone, while the far zone suites 40% of the cases. Screen influence on daylighting was found to be very much dependent on the orientation of the window and time of the day.

In stage two, the percentage of annual "Daylight Availability" was very much related to screen perforation percentage. As perforation percentage decreased, the percentage of Daylit and Over lit spaces decreased. At the same time, Partially Daylit areas of the space increased with similar percentages irrespective of the orientation. As a result of the twofold research stages, it is recommended to utilize a minimum of 80% perforation percentages for spaces similar to the tested case in the South orientation.

In stage three, an initial investigation suggests that the use of screens can significantly reduce the occurrence of glare phenomena. Also, it is suggested to study the efficiency of designing Solar Screens that have non-uniform perforation ratios. These could prove useful in improving the illuminance levels in the mid-length and far zones of the unsatisfactory cases.

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In conclusion, minimum perforation percentages for Solar Screens were presented for specific design cases that encompassed different orientations, seasons and time of the day. In addition, a tool that could be used by architects for based on required annual "Daylit" areas for the design of Solar Screens that effectively achieve functional needs was provided.

Keywords: Desert; Clear sky; Dynamic Daylight Performance Metrics; Solar Screen; Daylight Glare Probability

1. Introduction

The desert climate is endowed by clear sky conditions, providing an excellent opportunity for optimum utilization of natural light in daylighting building indoor spaces. However, the sunny conditions of the desert skies, in countries like Egypt and Saudi Arabia, result in the admittance of direct solar radiation, which leads to thermal discomfort and the incidence of undesired glare. One type of shading systems that is used to permit daylight while controlling solar penetration is "Solar Screens". These are external perforated panels that are fixed in front of windows (Harris, 2006). They resemble a traditional solution named "Mashrabeya" or "Rawshan", which are made of wooden lattice of cylinders connected with spherical joints (Fig. 1a). These traditional screens were used as a shading device to protect unglazed openings of Middle Eastern buildings throughout history (Fig. 1b). An additional advantage of these screens lies in their provision of privacy, which is a socio-cultural need present in the culture of communities in the region (Belakehal et al., 2004 and Fathy, 1986).

A number of previous publications addressed the performance of Solar Screens, similar to the ones concerned in this study. These screens were either located in front of, or integrated with window glazing. The study most related to this work is a publication by Aljofi (2005), which examined the potentiality of reflected sunlight through "Rawshan" screens. These architectural devices made of a combination of wood strips and screens were commonly used for large external openings. They are exactly similar to the "Masharabia" screens but the name differs from one country to another due to historical reasons. It was concluded that for all shapes of Solar Screen cell configurations (Fig. 2), the highest value of reflected light contribution was experienced at the central zone of the tested space. The daylight factor was ranging between 10% and 23% in the center, while it was less than 12% on both sides. In addition, light was lower in the case of rounded shapes

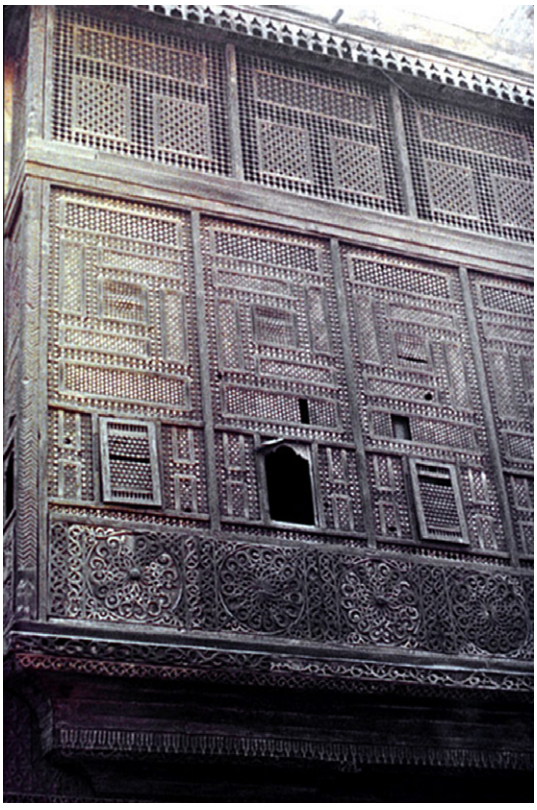

Fig. 1a. Exterior detail, Mashrabeya bay window (Alden and Williams, 1977).

Fig. 1b. Interior photo of a house in old Cairo, Egypt (Bugarin, 2005).