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Model of solar diffuse radiation transmission through circular perforated louvers and program realization

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Abstract

The main problem of previous methods for diffuse radiation transmission calculation of shading louvers is that they can only deal with flat slats. Taking the radian and perforation rate of louvers into consideration, a new model of solar diffuse radiation transmitted through circular perforated louvers was established and experimentally verified in this paper. Firstly, taking two adjacent circular perforated louvers as the research object, the new calculation model was established, and based on the model, a computer program was developed with MATLAB, which can be used to study the impact of shape, size, rotation angle, and surface optical properties of circular perforated louvers on diffuse radiation transmission. Secondly, the correctness of the calculating program was verified , and sensitivity analysis was carried out on the partition number of circular translucent louvers, and then find that the relative error rate decreases with the partition number , results no longer change when partition number over 7; Finally, the error of the conventional calculation methods was analyzed, and the results showed that, the “flat slat model” led to overestimation of the transmittance of diffuse radiation, and the relative error increased from 2.9% to 13.1% when the rotation angle increasing from 0 to 85°.

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Keywords: Circular translucent louvers; Solar diffuse radiation transporting; Calculating model;Programming verification;Sensitivity analysis

Nomenclature

β	the rotation angle of louvers
d	the arc height of louvers

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E	the solar radiance
F	the view factor from surface to surface
L	the louvers length
P	the reflectivity of louvers
S	the spacing between two adjacent louvers
τ	the perforation rate of louvers
J	the diffuse radiance from the environment

1. Introduction

Solar radiation is an important factor affecting the indoor environment, and it also has a significant impact on energy consumption of air conditioning and lighting. Shading is a rational way of dealing with solar radiation when it is more than needed: on the one hand, solar radiation and heat gain can be partly blocked by shading in summer, resulting in lower indoor temperature and improved indoor thermal environment; on the other hand, the amount of sunlight entering the rooms can be adjusted by shading, thus promoted the human visual effect [1]. There are various kinds of building shades that are commonly used, especially circular perforated louvers. Circular perforated louvers are made of circular aluminum plate with perforation. Louvers can be rotated along the axial within 0-90° to achieve the goal of reasonable shading and day-lighting. Compared with flat and shuttle louvers, the obvious advantages of perforated louvers include light weight and excellent ventilation [2].

Solar radiation irradiating on building envelope includes beam radiation, sky diffuse radiation, ground reflection radiation, diffuse radiation reflected from surrounding buildings, and long-wave radiation [3-4]. Because shade louvers can block most of the direct radiation, almost entering the interior environment is diffuse radiation, making it necessary to develop diffuse radiation calculation model to reflect and evaluate the shading effect of louvers.

Parmelee and Aubele [5] developed a mathematical model of solar radiation transmission based on analytical method, which can be used to calculate the effective optical properties (transmission, reflection and absorption) of slat. Pfrommer et al. [6-7] also developed a solar radiation transmission model of slat, with the calculation method for diffuse radiation transmission similar with that in [5]. Simmler et al. [8] developed a “Simmler model”, which can be used to analyze the relationship between effective optical properties and surface reflectivity of slat, assuming that “slat was flat”. Van Dijk et al. [9-10] developed an “Advanced Windows Information System”, where one of the important components was the shading model with the assumption that “slat was flat”. This method was adopted by ISO 15099-2003 [11]. Zhang et al. [12] analyzed a calculation model of solar diffuse radiation transport through flat blinds. In general, the main problem of previous methods of diffuse radiation transmission calculations is that they can only deal with flat slats.

In this paper, the diffuse radiation transmission mechanism of circular perforated louvers is discussed, and then a calculation model is set up to describe the effect of shape, size, rotation angle, and surface optical properties on diffuse transmission of circular perforated louvers.

2. Calculation model of diffuse radiation transmission

Two adjacent perforated louvers are taken as the object of study, and each louver is subdivided into n equal segments, as shown in Fig.1, where d is the arc height, S is the spacing between two adjacent louvers which is determined by the location of rotation axis of louvers, L is the louvers length, and β is the rotation angle.