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ScienceDirect

Energy Procedia 109 (2017) 306 – 313

Energy Procedia

International Conference on Recent Advancement in Air Conditioning and Refrigeration, RAAR 2016, 10-12 November 2016, Bhubaneswar, India

Experimental and Theoretical Studies of Window Glazing Materials of Green Energy Building in Indian Climatic Zones

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Abstract

Buildings consume plenty of power for providing thermal and visual comfort inside the buildings. This paper aims at presenting the experimental results of spectral optical properties of the most widely used window glazing materials. The window glazing materials studied include clear glazing, bronze glazing, green glazing and grey coloured glazing materials. A Matlab code employing the British standard method was developed to compute transmittance and reflectance of window glasses at normal incidence angle. This code uses experimentally obtained spectral optical property data from Perkin Elmer lambda 950 spectrophotometer for the computation of transmission and reflection of window glasses. A computer program was developed for computing the total solar radiation passing through glass materials. The heat gain through different glass windows of eight coordinal orientations such as east, west, north, south, northeast, northwest, southeast and southwest in four climatic zones of India was investigated. The solar radiation through south oriented glass was found to be the least among all other orientations studied in four Indian climatic zones. The cooling load through south oriented bronze, glass, green glass and grey glass window were reduced by 23%, 31% and 37%, respectively, as compared to the south oriented clear glass window in four climatic zones of India. The grey glass window is observed to be the most energy efficient as it reduces maximum cooling loads within the building as compared to the other considered glazing materials. The results of this paper are helpful in designing energy efficient commercial buildings for reduced cooling loads.

Peer-review under responsibility of the organizing committee of RAAR 2016.

Keywords: Spectrophotometer; Spectral optical properties; Solar thermal properties; Window glass orientation; Energy efficient glass

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Peer-review under responsibility of the organizing committee of RAAR 2016.
doi:10.1016/j.egypro.2017.03.072

1. Introduction

Buildings consume lots of energy for artificial lighting and forced ventilation to provide visual and thermal comfort, respectively to the occupants inside the buildings. Glass is one of the most widely used building enclosures in commercial buildings. Extensive use of glass enclosures in commercial buildings causes more heat gain and uncomfortable conditions inside the building. Hence, attention has to be focused on the selection of alternative window glass materials for reducing cooling loads in buildings. With the appropriate selection of window glasses for windows, both visual and thermal comfort can be maintained inside the buildings. In the literature, TRANSYS was used to study heat transfer through the float and tinted glasses of single and double glazing with air gap filled by air, xenon, krypton gases in Indian climates [1]. The studies on the window glass inward tilt to reduce solar beam radiation through various glass materials in Baghdad city and various Indian climatic zones were carried out [2,3]. The studies have also been carried out for reducing cooling loads inside the building by providing air spaces with in the wall [4]. The studies on cooling load reduction by various insulation locations in the roof were reported [5]. The heat transfer through buildings with different glass and wall materials in warm and humid climates of India was presented in the literature [6]. The effect of moisture, relative humidity and temperature on heat transfer characteristics of laterite building walls was reported [7]. The objective of this work is to investigate heat gain through different window glass materials on peak summer day in a clear atmosphere for four climatic regions of India as per ASHRAE clear sky model.

Nomenclature

A_g Area of the glass
A Solar radiation in absence of atmosphere
B Atmospheric extinction coefficient
C Dimensionless coefficient for sky radiation
d declination angle
f Inward flowing fraction of energy
h hour angle
k angle of window glass from vertical
l latitude
n number of days
I_{DN} Solar radiation at normal incidence
I_D Direct solar radiation from the sun
I_d Diffuse radiation from the sky
I_r Ground reflected sun radiation
I_T Total solar radiation
h_o Outside surface heat transfer coefficient

Greek letters

λ Wavelength
$\Delta\lambda$ Wavelength interval
β Solar altitude angle
θ Solar incidence angle
ϕ Solar azimuth angle
γ Surface solar azimuth angle
ρ_g Ground reflectance factor
τ_s Solar transmittance
ρ_s Solar reflectance
α_s Solar absorbance
τ_λ Spectral transmittance
ρ_λ Spectral reflectance
α_λ Spectral absorbance

2. Experimental methodology

Computation of solar radiation through window glasses requires the solar thermal properties of window glazing materials. The solar thermal properties of window glazing materials can be obtained from experimentally measured spectral optical properties in total solar spectrum region of 300nm to 2500nm as per ASTM Standards for normal angle of incidence (When the glass is placed vertically) [8]. The window glazing materials studied in this paper include clear glazing, bronze glazing, green glazing and grey glazing materials. The solar optical properties of glazing materials are transmission and reflection and they are obtained experimentally in spectrophotometer (Model: Perkin Elmer lambda 950). These solar spectral optical properties were utilized to compute solar thermal properties as per British standard method using Eqs (1)-(3) [9].

$$\tau_s = \frac{\sum_{\lambda=300}^{\lambda=2500} S_\lambda\, \tau(\lambda) \Delta\lambda}{\sum_{\lambda=300}^{\lambda=2500} S_\lambda\, \Delta\lambda} \quad (1)$$