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Study of Various Glass Materials to Provide Adequate Day Lighting in Office Buildings of Warm and Humid Climatic Zone in India

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Abstract

A huge amount of energy is attributed to cooling, heating and day lighting in buildings. In the air conditioned space the windows have been closed and the sun control is used to reduce the radiation load. This results in low lumens of light in air conditioned space and demands the artificial lighting and increases the energy consumption for lighting and also the air conditioning load. The objective of this work is to allow the natural sun light through the glass window of same area, and thus less lighting load in the air conditioned space for different climatic conditions. To achieve the objective of the work an investigation of spectral properties of different glass materials such as bronze, green, grey, bronze-reflective, green-reflective and grey-reflective glasses is carried out experimentally using Perkin Elmer lambda 950 Spectrophotometer in the visible solar spectrum region of wavelength range from 380nm-780nm, to provide optimum daylight factor as per SP: 41 1987 Indian standards to office buildings. The measured spectral properties were used to compute the visible solar properties in the visible region by using British standard method with a MATLAB code. The computed properties transmittance, reflectance and absorbance are used in the simulation tool for daylight calculations. The laterite building models with various window glazing materials were designed in Design builder 4.3.0.039 version tool and day lighting simulation was carried out in Energy plus 8.1.0.009 simulation tool for warm and humid climatic region of India. In this work, total twenty four building models with six window glass materials were investigated in four orientations of window such as East, West, North and South. The simulations were carried out in both summer and winter climates of warm and humid climatic zone for an office building. As far as the daylight factor is concerned, the green-reflective glass placed in south orientation is the best due to its adequate daylight factor (2.05% to 2.06%) in summer season and bronze glass window placed in north orientation is observed to be the best due to its sufficient daylight factor (2.2% to 2.8%) in winter among six studied window glass materials to Mangalore location (Latitude 12.87 N). The results of the study help in designing natural daylight buildings which in turn reduce energy consumption.

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1. Introduction

Buildings are substantially responsible for 33% of energy consumption in India for air-conditioning and artificial day lighting [1]. The commercial and residential buildings account for about 8% and 25% of energy consumption, respectively in India. The use of sunlight to illuminate buildings is an effective way of designing energy efficient buildings. The window glazing is one of the significant enclosures to admit daylight into the building. Day lighting is a natural source of light, which meets all the requirements of good lighting while enhancing user efficiency and productivity. Daylight factor is defined as the ratio of indoor illumination to outdoor illumination available in outside the building. Units of day light factor is in (%) or in (Lux).

$$DF = \frac{Ei}{Eo} \times 100\% \quad (1)$$

The day lighting strategies not only reduce lighting energy use but they are also responsible for an increase in cooling/heating loads. Hence, proper attention should be focused on selection of window glazing material for buildings. In the literature, the daylight factor model was developed and it was validated experimentally for east oriented windows with clear glass in clear sky conditions [2]. Thermal comfort and day lighting studies in a hot climate (Dhahran, Saudi Arabia) for office buildings have been carried out using double clear, tinted and low emissivity glasses [3]. Effect of different window panes like double pane windows with various air gaps and to keep the window south direction to laboratory building assess day lighting performance algorithm by comparing radiosity and Split-Flux Methods and compared by using Energy plus 6.0 version and validated by experimental results were reported [4]. The RADIANCE simulation tool was used in the literature to determine vertical daylight illuminance of buildings in non-overcast sky conditions with a clear glass window [5]. The studies on illuminance distribution and light dimming for a room with double glazed window with highly reflective blinds were reported [6]. To study the day light coefficient method and different window complex fenestrations to apply an office room and result were compared to Radiance and Dayism simulation software day lighting illuminance reduce the energy consumption annually was reported [7]. Sky light systems were studied and applied like tropical climates in Malaysian country to allowable daylight illuminance levels and reduce the electricity consumption annually to single-story buildings were reported [8]. Effect of window position, geometry and various inside floor reflectance's to office buildings to reduce the electricity consumption results in all orientations and different climatic regions in Spain were simulated by Daysim 3.2 version tool. [9]. To measure and collect the global radiation data was taken every 10 minutes and evaluate the daylight illuminance levels on horizontal and vertical surfaces of specific area to Valladolid climatic region in the year 2007 on clear days of Spain Country was studied [10]. The main objective of this study is to find the average daylight factor levels in an office building from 0.75m from the floor of various window glass materials such as bronze, green, grey, bronze-reflective, green-reflective and grey-reflective in warm and humid climatic zone of India with split-flux algorithm method in Energy plus 8.1.0.009 simulation tool to both summer and winter seasons. The simulations were carried out in four different orientations (East, West, North and South) of window walls. The results of the study present exact orientation of window and appropriate selection of window glass material from adequate daylight factor perspective.

Nomenclature	**Greek letters**
DF Daylight factor	λ Wavelength
Ei Indoor illuminance	$\Delta\lambda$ Wavelength interval
Eo Outdoor illuminance	D_λ Relative spectral distribution of illuminant D65
BZGW Bronze glass window	τ_v Visible transmission
GGW Green glass window	ρ_v Visible reflection
GrGW Grey glass window	α_v Visible absorption
BZRGW Bronze reflective glass window	$\tau(\lambda)$ Spectral transmission
GRGW Green reflective glass window	$\rho(\lambda)$ Spectral reflection
GrRGW Grey reflective glass window	$\alpha(\lambda)$ Spectral absorption
k Thermal conductivity	$V(\lambda)$spectral luminous efficiency for photopic vision defining