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Study of Various Glass Window and Building Wall Materials in Different Climatic Zones of India for Energy Efficient Building Construction

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Abstract

The commercial and residential buildings consume about 33% of energy for cooling and day lighting in India. This paper aims to present thermal performance of buildings constructed with various building and window glass materials in five different climatic zones of India. The climates considered include: hot and dry (Ahmedabad), moderate (Bangalore), cold (Guwahati), warm and humid (Madras), and composite (New Delhi). In this study, four building materials such as laterite stone, dense concrete, burnt brick, and mud brick were selected and four glasses such as clear, bronze, green, and bronze-reflective glasses were used for windows. Spectral characteristics of four glasses were measured experimentally by using Perkin-Elmer lambda 950spectrophotometer in the wavelength range of 300 -2500 nm as per ASTM standards. A mat lab code was developed to compute the solar optical properties such as transmittance and reflectance of glasses as per European standards in entire solar spectrum region. The building models were designed in Design builder 4.3.0.039 and thermal analysis was carried out in Energy plus 8.1.0.009. The solar heat gain in buildings was investigated. The results revealed that the mud brick wall building with south bronze-reflective glass window as energy saving from the least heat gain point of view among eighty building models studied. The results also showed that the mud brick wall building with bronze, green and bronze reflective window glasses reduces heat gain through wall by 2.52%, 3.83%, and 6.46% as compared to the mud brick wall building with clear glass window. The results helps in selecting energy saving combination of wall envelope and window glass materials for reducing air-conditioning loads in residential and commercial buildings of five different climatic zones of India.

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1. Introduction

The commercial and residential buildings are responsible for 8% and 25% energy consumption in India, respectively [1]. The building enclosures such as walls, floors, roofs and windows are the most important elements of the buildings to control heat gain. Heat gain in buildings can be attenuated with the help of building enclosures. Glass is the main building element in the construction of residential and commercial buildings and it also accounts for a higher conductance coefficient than other building enclosures. Hence, it is mandatory to study the thermal behavior of the walls and window glasses to reduce heat gain in buildings.

The numerical computations of solar radiation in buildings using clear and brown glasses as window glazing were studied [2]. Solar optical properties of clear and bronze glasses were reported and thermal performance of glass combinations were studied [3]. The heat gain through window glasses of various window to wall ratios was reported [4] and the simulations were carried out on peak summer day of the cities [5-7]. The heat transfer modeling on clear glass window was carried out [8]. The insulation position inside the roof was optimized for reducing cooling loads [9]. The optical properties of low emissivity glasses were also studied and reported [10]. Thirteen various high performances glazing glasses of an office building with different window to wall ratios were studied and compared with conventional glasses in European continent (London, Helsinki, Rome) [11]. A novel methodology has been suggested to compute solar radiation through window glasses of various windows to wall ratios [12]. The present work presents the suitable combination of wall and window glasses for building enclosures to reduce heat gain in buildings of five different climatic zones of India.

2. Experimental procedure to measure the spectral data of window glasses

Solar radiation reaches the earth's surface in the form of electromagnetic waves. Solar radiation is divided in to three regions one is Ultra-violet wavelength region (300- 380 nm), second is visible wavelength region (380nm-780nm), and third is Infra-red wavelength region (780- 2500 nm). The ultra-violet rays are harmful to degradation of materials and skin of human beings and these ultra violet rays are responsible only for 5% of solar radiation. The visible rays produce about 45% of the solar radiation in the wavelength range (380- 780 nm). The infra-red region is responsible for 50% of solar radiation and this is lies in between (780- 2500 nm). For analytical computation of the solar radiation passing through window glasses, the spectral characteristics of glasses such as transmission and reflection are essential to measure in the entire solar spectrum wavelength region from 300 - 2500 nm wavelength region. The spectral data of four glasses (clear, bronze, green, and bronze-reflective glasses) were measured with Perkin Elmer Lambda 950 Spectrophotometer at INUP research center IIT Bombay, as per the standard procedure given in ASTM E:424 1971 standards [13]. The size of the glass used to explore spectral characteristics is 30 X 30 mm with 6mm thickness. Fig.1. (a) shows the spectral transmission characteristics of glass windows. Fig.1. (b) shows the spectral reflection of glass windows.

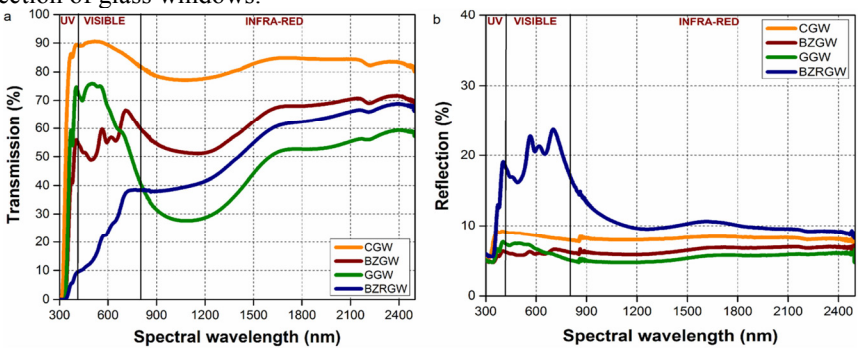

Fig. 1. (a) Spectral transmission of glass windows; (b) Spectral reflection of glass windows.