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Evaluation of Energy in Residential Building by Using Energy Efficient Solar Glazing Window in Different Climatic Zone

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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. To properly calculate dynamic solar gain in buildings, one must know the optical properties of the window in detail. In this paper, we develop a complete set of calculation procedures for determining the solar transmittance, reflectance, and absorptance of a window composed of an arbitrary number of partially transparent layers. Any layer may have a thin-film multilayer coating, such as an anti-reflection coating for increasing solar transmittance, a solar control film for reducing solar heat gain, or a transparent heat-reflecting mirror for improving thermal resistance. The results of sample calculations of 1 month electricity bill will be compared by using solar passive window that, how much energy will be consumed and further it will be applied.**

It is experimentally obtained spectral optical property data from spectrophotometer for the computation of transmission and reflection of window glasses.. 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 residence buildings for reduced cooling loads.

I. 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 . The studies have also been carried out for reducing cooling loads inside the building by providing air spaces with in the wall . The studies on cooling load reduction by various insulation locations in the roof were reported . The heat transfer through buildings with different glass and wall materials in warm and humid climates of India was presented in the literature . The effect of moisture, relative humidity and temperature on heat transfer characteristics of laterite building walls was reported . 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.[2]

The three major types of energy flow that occur through windows: (1) non solar heat losses and gains in the form of conduction, convection, and radiation; (2)solar heat gains in the form of radiation; and (3) airflow, both intentional (ventilation) and unintentional (infiltration).[3]

II. 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).

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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:

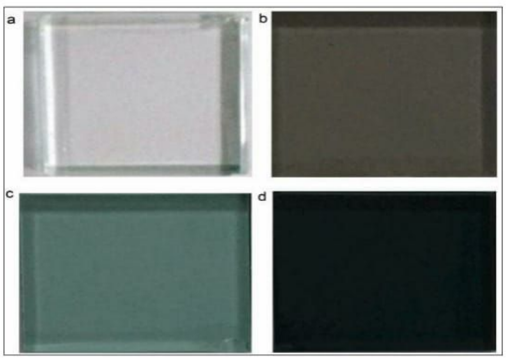

Fig. 1. Images of glass materials (a) Clear glass; (b) Bronze glass (c) Green glass; (d) Grey glass [3]

These properties are useful in computing solar heat gain coefficient of glass materials. The solar heat gain coefficient is used to compute total solar radiation passing through glass. The solar heat gain coefficient of the glass should be in between 0 and 1. The solar heat gain coefficient of the glass is directly proportional to the heat gain. Fig1 (a) shows the spectral transmission of glass materials and Fig 1 (b) shows the spectral reflection of glass materials. From the figures, it is observed that the clear glazing has the highest transmission values and the grey glazing has the least transmission values among four studied window glazing materials. Fig 2 shows the images of clear, bronze, green and grey glass materials [4].

III. Computational Method

Solar radiation from the Sun reaches the earth's surface in the form of direct and diffused radiation. The solar radiation enters into the building space through building enclosures such as walls, roofs and windows. The solar radiation passing into the building through window glazing is higher than that of any other enclosure of the building. A Mathematical calculation has been developed to compute direct, diffused and reflected radiation through window glass. The mathematical correlations of declination angle, solar altitude, solar azimuth angle, surface solar azimuth angle and angle of incidence to compute the intensity of direct, diffuse and ground reflected radiation.

The solar declination is the angle between the earth and sun vector and the equatorial plane. The various weather conditions across the globe are due to the tilt of the earth's equator by 23.45^{o} with respect to the earth's orbit plane around the sun [5].

IV. Energy Rating Systems Of Windows

Many aspects need to be taken into account when choosing windows for a building. Some of them are shown below in Fig.1 such as day light transmittance, visual aspects, sound, fire resistance, etc, but in this thesis we are going to focus on the energy efficiency of the windows. Windows, skylights, and glazed doors can account for over25% of the heating and cooling energy bills in a typical home. Designers, builders, and homeowners have never had a tool for determining or comparing the energy performances off fenestration products to assist them in their purchase decisions. Many manufacturers offer a variety of energy-efficient products, but have not been able to demonstrate their superiority through comparable performance ratings Advanced computer tools are developed in United States and Canada, and used to determine the energy ratings. Fenestration is a term used to describe an opening in a building envelope which includes windows, skylights and doors. An organization called the National Fenestration Rating Council (NFRC) began since 1993 to make window energy efficiency labels for new buildings. (NFRC) has developed a window energy rating system based on the whole product performance. The main aim of this company is to make accurate standardized information which enables consumers to make comparison between the energy performance of different types of windows, doors and skylights. The label of (NFRC) describes the type of window, and rates it for these factors such as: U-Factor, solar heat-gain coefficient (SHGC), and visible light transmittance. The rating of windows could be divided in two levels:

Level 1 is to label the physical properties of the window such as the U-value, the g-value and the visual transmittance (Tvis). The NFRC in the USA has developed such a rating.

Level 2 is to develop the energy rating as discussed above. This system yields one single figure that is labeled on the window, independent of zone and type of building. This rating favors a choice of window with a high gvalue, low U-value and low infiltration, which is preferable in many cases in heating dominated (cold) climates [6].

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V. WINDOW ASPECTS

The tools that have been used in the present research study can be summarized as shown in Fig. 2 as follows:

1) General resources of information with links to the subject of the study such as books, journals, proceedings, dissertations, institution publications and internet.
2) Survey to determine the most common windows that used in apartment buildings and study their influence on the energy balance of buildings.
3) Scientific and mathematical equations to calculate heat gain and loss

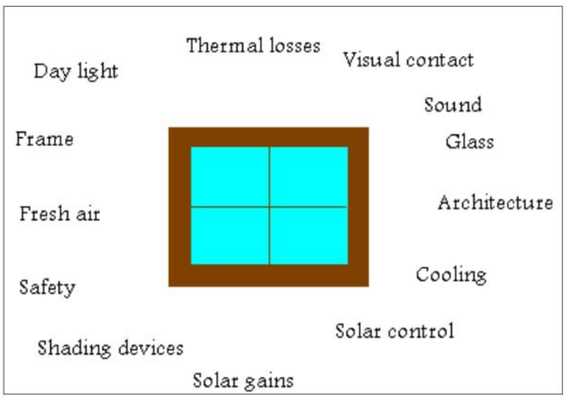

Fig: 3 Different aspects of window [2]

VI. CASE STUDY

The influence of windows on the energy balance of 4X4 m2room in the residential buildings in jabalpur has been studied. The schematic diagram of the room can be shown in Fig. 3.The room composed of one exterior wall of U value = 0.8W/m2.K, and three interior walls with U value = 1.9 W/m2.K,one window is located in the exterior wall. Calculations are made for Jabalpur city, Latitude 31 ºN. Windows are supposed to be located in the main directions (N, S, E, W). The energy saving is calculated for winter season (January, February, March, April, November, December). The study has been carried out by making variations on the type of glazing, area of glazing, and orientation. Self Developed software is used to calculate solar heat gain due to fenestration and to define the influence of the glazing area on the amount of energy saving in the building.

VII. RESULTS

The results for the influence of the glazed area on the energy balance of a building are discussed in this section. Also, the influences of the other factors such as orientation, type of glazing, climate and comfort on the choice of window area are investigated and the results are discussed and presented. It is found that some types of glazing can save more energy than other types, and some types of glazing are more efficient in a specific direction than others. Also the effect of the ratio of the glazing area with respect to the wall area on the energy saving of different types of glazing has been investigated and the results are shown in the coming parts of the thesis. As it was mentioned previously, the energy saving has been calculated as a ratio between the net energy gain (heat gain from solar energy through glazing area – heat loss from the glazing area) divided by the total energy losses from the wall and glass. The total area of the wall was selected to be 12 m2 and the glazed area was changed from 0 m2 (no window) till 12m2 (full glazed area). By using energy calculation, it has been found that the clear glass is very effective in the south, The selection of the optimum window size for each direction depends not only on the amount of energy saving provided by the window but also on the cost of glazing and the amount of money saved. Therefore, the best type of window from the energy point of view can be described as follows as those who saves energy, reduces heat loss; saves money and has low cost.

VIII.CONCLUSION

The results show that some types of glazing are more efficient in a specific direction than others. The best type of window from the energy point of view is that the windows that can save energy, save money, reduce heat loss, and its cost is low. The using of glass type C in the north direction causes losses inenergy reaches 20% when the wall is totally glazed but it is more effective in the south direction and the energy saving increases with the increased area of glass. The amount of energy saving in the case of glass type D is better than clear glass in all directions. Glass type D can be considered in the second choice after glass type B for north direction. By using energy calculations, it has been found that the clear glass have more efficient than other glass.

Some types of glasses are more efficient than others and the most types of glazing losses energy in the north direction except type B which can save a reasonable amount of energy in the north direction. It has been found also that, increasing the glazing area for each type of glazing in the east and west directions can provide a good opportunity to save energy.

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