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Applicability of Shading Devices in Building Design for Reducing Heat

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ABSTRACT: There are several ways the heat reduction in a building can be achieved but making a provision of shading device and its incorporation in the building design does play a major role as they don't need any extra energy requirement or consume any to control the heat flow. By controlling the heat gain from solar radiation, the building energy requirement is also reduced as the major contributor in energy consumption is played by cooling and heating loads. The efficiency of the shading device in controlling such heat gain is looked upon and the possibility of improving or incorporating new technologies to make its use more efficient and sustainable is mentioned. This paper focuses on the effects of shading device for reducing heat in a building with the aim towards the incorporation and applicability of shading devices in a building design.

KEYWORDS: Shading Device, Heat Reduction, Efficiency, Heat Flow.

INTRODUCTION

In a building, the energy consumption is mainly dependent on lighting load, heating, and cooling loads which vary on the type of occupancy inhabiting. From the aforementioned loads, the major contributor is the heating and cooling load after consideration of the lighting load. In most of the buildings, artificial sources for lighting and air conditioning provisions are made instead of considering passive methods in their design section. With the variation in temperature due to global warming these loads are found to increase with the passage of time. And to overcome them more air conditioning systems are put into use to reduce the heating effect which in turn lead to the increase of the energy consumption. (Rastogi & Paul, 2020) have highlighted various issues related to the design methods in context with the overall ambient temperature changes in in India. These energy requirements are met by the consumption of natural resources which in turn leads to global warming. This endless cycle of demand and consumption can only be controlled by incorporating various passive methods in the designing of building to overcome such demands. The selection of the passive method, its design, its incorporation with the building design, sustainability considerations, and ways to incorporate technologies with the passive method to reduce the impact on the environment is to be considered when any particular method is to be adopted. Besides, (Seshadhri & Paul, 2017) have highlighted facts about the requirements and importance of performance of the shading devices in the building construction projects in terms of its functionality and design.

Further (Mittal *et al*., 2020) have revealed the lack of awareness of relevant technologies pertaining to the shading devices technology with respect to the aspects of heat reduction. Considering such conditions and criteria a study on shading devices is done in this paper which discourse about the different types of shading devices, the optimal design that could be incorporated in building design for reducing heat, and incorporation of technology in shading devices for increasing the energy efficiency of the shading devices.

TYPES OF SHADING DEVICES AND THE OPTIMAL DESIGN

The uses of shading devices are to reduce the heat generated due to solar radiation; control the lighting inside the building to achieve the proper visual and thermal comfort to the occupants. There are 13 different types of shading devices that can be incorporated into a building design (Baiche & Walliman, 2002). Refer Fig. 1 for the various types of fixed shading devices used in the building design. The external fixed shading devices are more preferable to the internal ones as they prevent the heat from the solar radiation to enter the internal space and minimize the heat dissipation from the inside than outside. Furthermore, it is essential to standardize the implementation processes and design of the devices which can help in enhancing the functionality of the building in terms of prevention from solar radiation and heat prevention. (Paul *et al*., 2020). It is imperative to note that such issues are significant during the construction phase as well which provides opportunities to innovate new shading devices with the appropriate details and suitable methodologies (Paul & Seth, 2017). The external shading device will absorb most of the heat gains and dissipate them into the outer environment before they even affect the ambient temperature and provide thermal comfort.

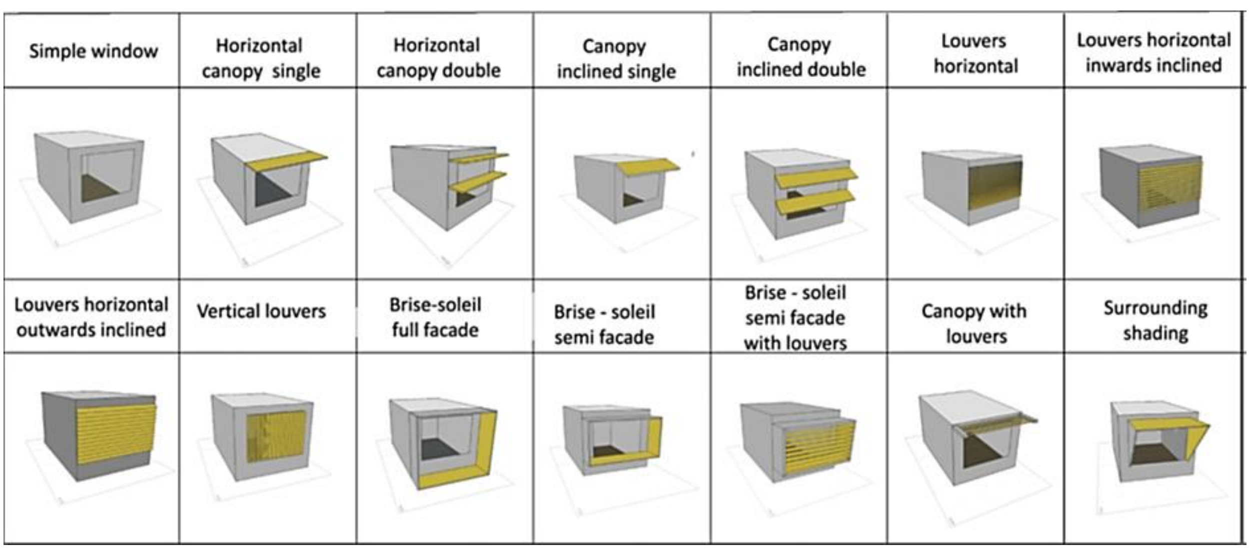

Figure 1: Types of fixed shading devices

For the determination of an optimal design any particular type of shading device is to be considered. As each of them fulfils the same functionality the selection could be done on the basis of the building design incorporation (Seshadhri & Paul, 2018). The selection of fixed shading device is to be done with the consideration of the building design and the design of the shading devices are done keeping various factors like the orientation of the building, the daylight factor, solar radiation, building typology, and thermal comfort. In this context, (Mittal, et al., 2019) related the same with the value-adding aspects are considered with respect to the thermal comfort of the building occupants, through diligent consideration of the above-mentioned factors pertaining to selection shading devices. The type of shading device focused on in this paper are external fixed horizontal louvers as shown in Fig. 2 with three types of s/l ratio where l is the length of the slat and s is the vertical distance of the slat, furthermore different inclination angles 30°, 45°, 60° and 90° with respect to horizontal are also considered (Datta, 2001).

The three different types of shading devices are:

- Type h1 where s/l is 1
- Type h2 where s/l is 2
- Type h92 where s/l is 0.92

With the use of TRNSYS software, a simulation was done for a building of floor area of 50 m2 with the provision of opening at the south face of area 5 m2 and 2.5 m2 at both east and west face of the building. Other details as the windows were doubly glazed having a U-value of 2.8 W/m2 K, walls thickness was considered as 0.34m, and its U value as 1.691 W/m2 K. Along with these data few other parameters were also considered in the software. In the TRNSYS simulation a set of individual components were defined and by proper logical connections they were connected to form an assembly with a flowchart of information from one component to the other. The result given by one could be the data for the other (Datta, 2001).

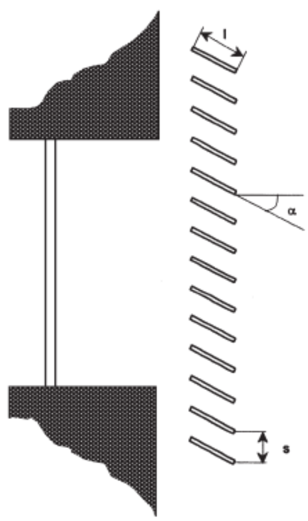

Figure 2: Fixed horizontal louver shading devices

The components of the flowchart are:

- Weather Data Generator:
  - ➢ Input: Monthly average values of solar radiation, DBT, humidity ratio, and wind speed
  - ➢ Output: Hourly weather data

- Solar Radiation Processor:
  - Input: Hourly solar radiation data, Position of the sun
  - Output: Hourly radiation data on the horizontal surface, insolation up to four surfaces depending on their orientation
- Shade:
  - Input: Shade design
  - Output: Three transmittances- primary, secondary, and diffuse for the shading devices
- Equation 1 Algebraic Operations:
  - Input: Transmittance value from the shade
  - Output: Shading factor, i.e., the average value of the transmittances
- Building:
  - Input: Radiation values, Area of different zones
  - Output: Thermal behaviour of the building having different thermal zones
- Equation 2 Algebraic Operations:
  - Input: Sensible energy demands
  - Output: Heating and cooling loads

FINDINGS AND ANALYSIS

After carrying out the simulation the first thing that was put into consideration was the amount of heat gains from the solar radiation through the openings and the effect of the shading device on the same. As the horizontal louvers are fixed on the south face then the variation of total solar gains including the effect of the shading device is presented. From the graph figure 3, it is observed that when there is no shading then the gains are at a peak compared to when the slats are completely closed. Even when they are completely closed the value is not zero as there are still chances of admittance of heat from the east and west face of the building.

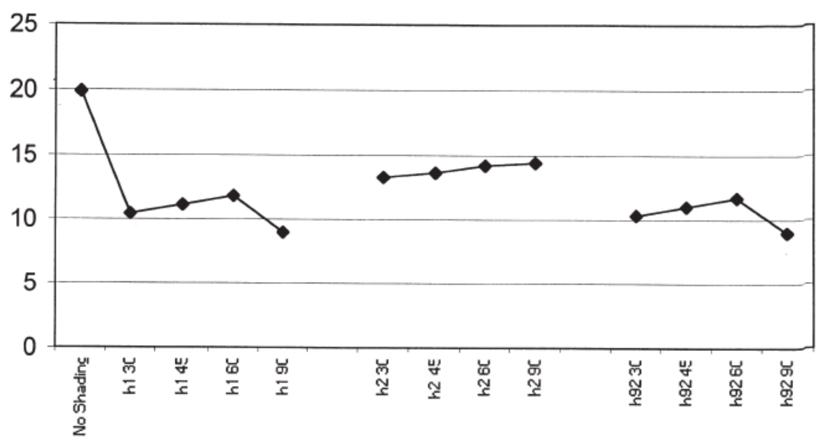

Figure 3: Solar gains through openings

While considering slats completely closed in type h1 and h92 there is a huge decrease in the value as the south opening is completely shaded whereas in the case of h2 the value increases when the slats are closed. The reason for the increase in the heat gain in the case of h2 is because when the value of s/l is 2 the complete opening is not shaded, only half of the area is shaded. The other half permits the entrance of sunlight in the building which leads to the increase in the gain value. In the case of other tilts in h2 the shaded area is more compared to the completely closed. It is observed that the shading device h2 gives the lowest load. The graph gives the variation in the loads for a different tilt of the louvers at specific angles which in turn gives the information about which sort of the shading device can be incorporated in the building design and at which angle it should be fixed to give the minimum load. The graph in figure 4 shows the optimization of the shading device with respect to primary energy. It also shows the effect of the shading device. The selection of primary energy is done as an optimization index because for different areas the efficiencies of heating and cooling are different.

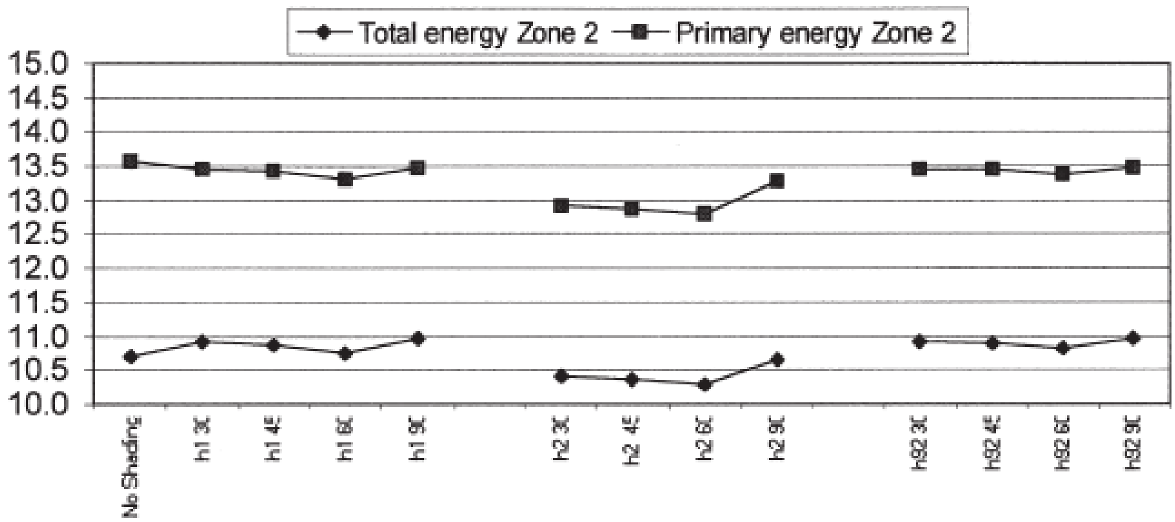

Figure 4: Shading device optimization

CONCLUSION

It can be concluded that the incorporation of fixed shading device in building design for the south openings are efficient in reducing the overall load of the building not only limited to heating or cooling loads. Still, the selection of the shading system should be done by considering the weather and location it has to be used in and the optimum shading system should be incorporated. The use of photovoltaic panels can be integrated with the shading devices so that the maximum solar radiating surface can be used to generate energy and reduce the loads further by contributing to energy production. The use of photovoltaic panels and incorporation with the shading device will reduce the loads and contribute to the use of the passive method of reducing the loads than the dependency on the types of equipment for obtaining thermal comfort.

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