Sun Effect Through Windows

Windows present a problem somewhat different from that of opaque walls, because they permit a large percentage of the solar energy to pass through undiminished; only a small percentage (approximately 10 per cent) is reflected. This fact permits the solar heat gain through windows to be expressed by the simple formula:

$$H_G = A_G I_G \tag{3}$$

where

H_G = Solar radiation transmitted through a window, Btu per hour.

A_G = Area of glass, square feet.

I_G = Amount of solar radiation transmitted directly through the glass, Btu per hour per square foot (Tables 2, 3, 4 and 5).

Values for solar heat transmission through glass as determined by Formula 3 apply only to unshaded windows. Tests at the A.S.H.V.E. Research Laboratory[5] have determined the percentages of heat from solar radiation actually delivered to a room with bare windows and with various types of outdoor and indoor shading. The data in Table 8 are taken from these tests.

TABLE 8. SOLAR RADIATION TRANSMITTED THROUGH BARE AND SHADED WINDOWS

Type of Appurtenance	Finish Facing Sun	Per Cent Delivered to Room
Bare window glass		97
Canvas awning	Plain	28
Canvas awning	Aluminum	22
Inside shade, fully drawn	Aluminum	45
Inside shade, one-half drawn	Buff	68
Inside Venetian blind, fully covering window, slats at 45 deg	Aluminum	58
Outside Venetian blind, fully covering window, slats at 45 deg	Aluminum	22

The percentage values in this table were obtained by dividing the total amount of heat actually entering through the shaded window by the total amount of heat calculated to enter through a bare window (solar radiation plus glass transmission based on observed outside glass temperature). For bare windows on which the sun shines, the transmission of heat from outside air to glass is small or negative because the glass temperature is raised by the solar radiation absorbed. Therefore, in calculating the total heat gain through windows on the sunny sides of buildings, it is sufficiently accurate to determine the total cooling load due to the window, as the solar radiation times the proper factor from Table 8 and to neglect the heat transmission through the glass caused by the difference between the temperatures of the inside and outside air.

Although Table 8 shows that 97 per cent of the heat from solar radiation is delivered to a room through bare window glass, more recent tests[6] have indicated that in the case of a building having floors of high heat capacity such as concrete floors on which the solar radiation falls, approximately one-half of the heat entering a bare window is absorbed by the floor and does not immediately become a part of the cooling load but is delivered back to the air in the building at a slow rate over a period of 24 hours or longer.

[5]Radiation of Energy Through Glass, by J. L. Blackshaw and F. C. Houghten (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 93). Studies of Solar Radiation Through Bare and Shaded Windows, by F. C. Houghten, Carl Gutberlet, and J. L. Blackshaw (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 101).

[6]Cooling Requirements of Single Rooms in a Modern Office Building, by F. C. Houghten, Carl Gutberlet, and Albert J. Wahl (A.S.H.V.E. TRANSACTIONS, Vol. 41, 1935, p. 53).

The maximum solar intensity on any surface is of limited duration as shown in Fig. 1. In the case of windows the total energy impinging on the glass before and after the time of maximum intensity is further reduced by increased shading of the glass from the frame, or wall. The cooling load due to solar radiation therefore does not have to be calculated as a steady load. Another point which should be noted is that the maximum solar radiation load on the east wall occurs early in the morning when the outside temperature is low.

In a paper[7] by the A.S.H.V.E. Research Laboratory it was shown that ordinary double strength window glass transmits no measurable amount of energy radiated from a source at 500 F or lower; that it transmits only 6.0 and 12.3 per cent of the total radiation from surfaces at 700 F and 1000 F, respectively; and that it transmits 65.7 per cent of the radiation from an arc lamp, 76.3 per cent of the radiation from an incandescent tungsten lamp, and 89.9 per cent of the radiation from the sun. Thus, glass windows in a room constitute heat traps, which allow rather free transmission of radiant energy into the room from the sun to warm objects in it, but do not allow the transmission of re-radiated heat from these same objects.

Tests have been made which indicated that sunshine through window glass is the most important factor to contend with in the cooling of an office building. At times it was shown to account for as much as 75 per cent of the total cooling necessary. Because of the importance of the sunshine load, cooling systems should be zoned so that the side of the building on which the sun is shining can be controlled separately from the other sides of the building. If buildings are provided with awnings so that the window glass is shielded from sunshine, the amount of cooling required will be reduced and there will also be less difference in the cooling requirements of different sides of the building. The total cooling load for a building exposed to the sun on more than one side is of course less than the sum of the maximum cooling loads in the individual rooms since the maximum solar radiation load on the different sides occurs at different times. In determining the total cooling load for a building if the time when the maximum load occurs is not obvious, the load should be calculated for various times of day to determine the times at which the sum of the loads on the different sides of the building is a maximum.

Heat Emission of Occupants

The heat and moisture given off by human beings under various states of activity are shown in Figs. 8 to 11 and Table 4 of Chapter 3. It will be observed that the rate of sensible and latent heat emission by human beings varies greatly depending upon state of activity. In many applications this component becomes a large percentage of total load.

[7]Loc. Cit. Note 5.