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An improved design method for estimating the annual auxiliary energy requirement for solar heating building

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Abstract

Thermal design of a passive building is closely interrelated to the architectural design of the structure itself, there is a spectrum of methods for estimating long-term thermal performance of these buildings that ranges from practical experience using of charts and tables that are based on combinations of experience and calculations to correlation and useful methods that are the counterparts of the methods for active systems. The design method to be described in more details in the following, have common basic feature. It uses the correlations of result of simulations to determine long-term performance. The correlating variables, the definitions of terms, the ways in which the correlations are used are however very different from one to another. In this paper the unutilizability method design collector–storage wall will illustrate in details.

Keywords: Design; Energy requirement; Solar; Building

1. Introduction

1.1. A collector–storage wall

In passive heating systems, storage of thermal energy is provided in the walls and roofs of the buildings. A case of particular interest is the collector–storage wall, which is arranged so that solar radiation transmitted through glazing is absorbed on one side of the wall. The temperature of the wall increases as energy is absorbed and time-dependent temperature gradients are established in the wall. Energy is lost through the glazing and is transferred from the room side of the wall to the room by radiation i.e., convection. Some of these walls may vented, have openings in the top and bottom through which air can circulate from and to the room by natural convection, providing an additional mechanism

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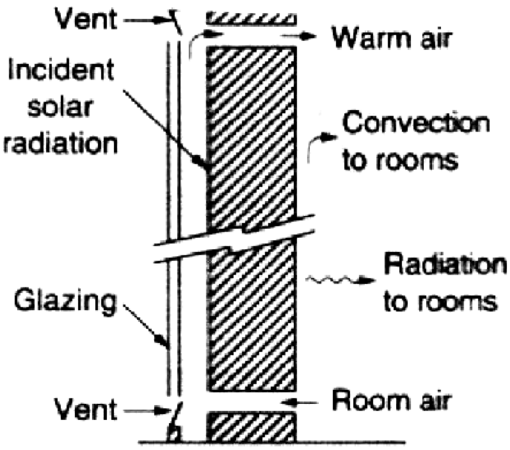

Fig. 1. Section of a storage wall with glazing and energy absorbing surface on one surface.

for transfer of energy of the room. Fig. 1 shows a section of the wall.

The monthly average absorbed radiation $\bar{S}$ can be calculated from:

$$\bar{S} = \overline{H_b}\,\overline{R_b}\,\overline{(\tau\alpha)}_b + \overline{H_d}\,\overline{R_d}\,\overline{(\tau\alpha)}_d\left(\frac{1+\cos\beta}{2}\right) + \overline{H_g}\rho_g\overline{(\tau\alpha)}_g\left(\frac{1-\cos\beta}{2}\right) \quad (1)$$

where $\overline{\tau_\alpha}$ is estimated from:

$$\overline{(\tau\alpha)} = \frac{\bar{S}}{\overline{H_T}} = \frac{\bar{S}}{\overline{H}\,\overline{R}} \quad (2)$$

An isotropic-diffuse assumption is used for the diffuse and ground reflected terms, $(\tau\alpha)_b$ and $(\tau\alpha)_d$ can be evaluated by using the effective incidence angle. As functions of properties of the cover and absorber and, the collector slope angle β, and so do not change with time. Mounted at fixed β the hourly and monthly values are thus following the same pattern and they all can be written with or without a mean value.

The long-term value of $\bar{R}$ can be calculated by integrating G_T and G from sunrise to sunset.

For all days over many years of data $\bar{R}$ can be written as:

$$\bar{R} = \frac{\sum_{\text{day}=1}^{N}\int_{\text{tsr}}^{\text{tss}} G_T \mathrm{d}t}{\sum_{\text{day}=1}^{N}\int_{\text{tsr}}^{\text{tss}} G \mathrm{d}t} \quad (3)$$

To evaluate the numerator, it is convenient to replace G_T by I_T, where I_T is the radiation at any time of the day. So for N days this radiation is defined as:

$$NI_{\mathrm{T}} = N\left\{(\bar{I} - \bar{I}_d)R_b + \bar{I}_d\left(\frac{1+\cos\beta}{2}\right) + \bar{I}_g\rho_g\left(\frac{1-\cos\beta}{2}\right)\right\} \quad (4)$$

where $\bar{I}$ and $\bar{I}_d$ are long-term average of the total and diffuse radiation, obtained by summing the values of I and I_d over N days. Then Eq. (3) becomes:

$$\bar{R} = \frac{\int_{\text{tsr}}^{\text{tss}}\left(\bar{I} - \bar{I}_d\right)R_b + \overline{I_d}\left(\frac{1+\cos\beta}{2}\right) + \overline{I_g}\rho_g\left(\frac{1-\cos\beta}{2}\right)}{\overline{H}} \quad (5)$$

The ratio of total hourly to total daily radiation, r_t, can be evaluated from:

$$r_t = \frac{\Pi}{24}\left(a + b\cos\omega\right)\frac{\cos\omega - \cos\omega_s}{\sin\omega - \frac{\Pi\omega_s}{180}\cos\omega_s} \quad (6)$$

where:

$$a = .409 + .5016 \sin(\omega_s - 60) \quad (7)$$

$$b = .6609 - .4767 \sin(\omega_s - 60) \quad (8)$$