Appendix IV

Estimation of Solar Data and Weather Information

The meteorological records from the Royal Observatory Hong Kong (ROHK) do not have all the weather parameters necessary for compiling the weather files for building energy simulation. To generate the weather files, values of the following parameters are estimated from empirical models: (a) extraterrestial solar radiation, (b) true solar time and (c) direct and diffuse components of solar radiation.

Extraterrestrial solar radiation

The (daily) extraterrestrial solar radiation outside the earth's atmosphere is calculated by (Stine and Harrigan, 1985; Iqbal, 1983):

$$ETSR = I_{SC}\left[1 + 0.034\cos\left(\frac{360 \times N}{365.25}\right)\right] \qquad \text{(A4.1)}$$

where $ETSR$ = (daily) extraterrestrial solar radiation (W/m^2)

I_{SC} = solar constant (taken as 1370 W/m^2 in our case)

N = day number (such as 1 January = day no. 1)

(The value in the small bracket of the cosine term is in degrees, not in radians.)

The hourly value of extraterrestrial solar radiation falling on a horizontal surface is determined by multiplying $ETSR$ by the sine value of the solar altitude as follows:

$$ET_{hr} = ETSR \cdot \sin\alpha \qquad \text{(A4.2)}$$

where ET_{hr} = hourly extraterrestrial solar radiation (W/m^2)

α = solar altitude (in radian or degrees)

True solar time

The true solar time is related to the local clock time (or local standard time) as follows:

$$TST = LST - \frac{LongCor - EOT}{60} \qquad \text{(A4.3)}$$

where *TST* = true solar time (in hours, 1 to 24)

LST = local standard time (in hours, 1 to 24)

LongCor = longitude correction (in min.) = 23 minutes for HK

EOT = equation of time (in min.)

The equation of time (EOT) is calculated by (Iqbal, 1983):

$$EOT = k_1 + k_2 \cos A + k_3 \sin A + k_4 \cos(2A) + k_5 \sin(2A) \qquad \text{(A4.4)}$$

where *A* = a function of the day number (in degree) = $\frac{360 \times (N-1)}{365}$

N = day number (such as 1 January = day no. 1)

k_1 = 0.000075 k_2 = 0.001868 k_3 = -0.032077

k_4 = -0.014615 k_5 = -0.04089

Direct and diffuse solar radiation

Direct and diffuse components of solar radiation in Hong Kong are estimated from the global solar radiation (GSR) data using a simple method developed by Lam and Li (1994). First, the clearness index, defined as the ratio of the global solar radiation on a horizontal surface to the global extraterrestrial solar radiation on a horizontal surface, is determined:

$$k_t = \frac{I_{th}}{ET_{hr}} \qquad \text{(A4.5)}$$

where k_t = clearness index defined on a hourly basis (dimensionless)

I_{th} = horizontal global solar radiation (W / m²) = GSR

ET_{hr} = hourly extraterrestrial solar radiation (W / m²)

Then, the direct and diffuse components, as well as the direct normal solar radiation, are calculated by the appropriate equations in the two regions defined based on the clearness index:

- Region I (k_t ≤ 0.3) — The diffuse component, horizontal direct component and the direct normal solar radiation are calculated by:

$$I_{dif} = 0.84 \times I_{th} \quad \text{(A4.6)}$$

$$I_{dir} = 0.16 \times I_{th} \quad \text{(A4.7)}$$

$$I_{DN} = I_{dir} \sin \alpha \quad \text{(A4.8)}$$

where I_{dif} = diffuse solar radiation (W / m²)

I_{dir} = horizontal direct solar radiation (W / m²)

I_{DN} = direct normal solar radiation (W / m²)

- Region II (k_t > 0.3) — Depending on which month it is working on, the horizontal direct component are estimated by:

$$I_{dir} = (1602 \cdot k_t - 441) \sin \alpha \quad \text{for March} \quad \text{(A4.9)}$$

$$I_{dir} = (1240 \cdot k_t - 365) \sin \alpha \quad \text{for months other than March} \quad \text{(A4.10)}$$

The direct normal solar radiation is calculated using Equation (A4.7) and the diffuse component is determined by the difference between GSR and the direct component as follows:

$$I_{dif} = I_{th} - I_{dir} \quad \text{(A4.11)}$$