TABLE 6. VALUES OF THE WALL SOLAR AZIMUTH, γ, FOR VARIOUSLY ORIENTED WALLS AND SOLAR ALTITUDE

Computed for 18 Deg Declination, North (August 1)

Latitude	Sun Time AM→ ↓	Sun Time	Solar Altitude β Degrees	Azimuth Angle γ, Degrees N	NE	E	SE	S	SW
30 Deg North	6 a.m.	6 p.m.	9.0	74	29	16	61		
	7	5	21.5	81	36	9	54		
	8	4	34.5	88	43	2	47	shade	
	9	3	47.5	shade	51	6	39	84	
	10	2	60.0		62	17	28	73	
	11	1	72.0		83	38	7	52	shade
	12		78.0		shade	90	45	0	45
40 Deg North	5 a.m.	7 p.m.	0.5	66	21	24	69		
	6	6	11.5	76	31	14	59		
	7	5	23.0	85	40	5	50	shade	
	8	4	34.5	shade	50	5	40	85	
	9	3	45.5		61	16	29	74	
	10	2	56.0		76	31	14	59	shade
	11	1	64.5		shade	55	10	35	80
	12		68.0			90	45	0	45
50 Deg North	5 a.m.	7 p.m.	4.5	67	22	23	68		
	6	6	13.5	78	33	12	57		
	7	5	23.5	90	45	0	45	90	
	8	4	33.0	shade	57	12	33	78	
	9	3	42.0		70	25	20	65	
	10	2	50.0		87	42	3	48	shade
	11	1	56.0		shade	64	19	26	71
	12		58.0			90	45	0	45
		↑ PM →		N	NW	W	SW	S	SE

Values of K for other seasons and latitudes may be found in the literature,[7] or may be computed from data given in *Hydrographic Office Bulletin* No. 214, Tables of Computed Altitude and Azimuth[8] and the Ephemeris of the Sun.[9] Table 7 shows the variation of solar declination during the months ordinarily requiring cooling.

Example 1: Find the solar azimuth ϕ at 6:30 p.m. at 40 deg north latitude on August 1st.

Solution: From Table 6 in the column of γ for a wall facing west ϕ for 6:00 p.m. is $90 + 24 = 114$ deg. By interpolation, ϕ is $90 + 14 = 104$ deg, and at 7:00 p.m. is 90 + 24 = 114 deg. By interpolation, ϕ for 6:30 p.m. is 109 deg west of south (at 5:30 a.m. ϕ would be 109 deg east of south.)

Example 2: Find K for a wall facing 18 deg east of south at 10:00 a.m. on August 1 at 50 deg north latitude.

Solution: The wall azimuth is 18 deg. The solar azimuth is 48 deg east (Table 6). The wall solar azimuth is 48 − 18 or 30 deg. From Table 6, β is 50 deg. Then

$$K = \cos\beta \cos\gamma = \cos 50 \times \cos 30 = 0.643 \times 0.866 = 0.557.$$

TABLE 7. APPROXIMATE SOLAR DECLINATIONS IN DEGREES

Date	Declination	Date	Declination	Date	Declination
April 1	4.5	June 1	22.0	Aug. 1	18.0
April 15	10.0	June 15	23.5	Aug. 15	14.0
May 1	15.0	July 1	23.0	Sept. 1	8.5
May 15	19.0	July 15	21.5	Sept. 15	3.0

Example 3: Find K for the wall in *Example 2* at 3:00 p.m.

Solution: The solar azimuth is 65 deg west. The wall solar azimuth is therefore $65 + 18 = 83$ deg. The angle β is 42 deg.

$$K = \cos 42 \times \cos 83 = 0.743 \times 0.122 = 0.091.$$

Example 4: Find the total solar irradiation for the wall for the conditions of *Example 2*.

Solution: Use clear atmosphere solar intensities. At 50 deg altitude, the direct normal radiation is 273 Btu per (hr) (sq ft). Then,

$$I_D = K \times I_{Dn} = 0.557 \times 273 = 152.0 \text{ Btu per (hr) (sq ft)}.$$

By linear interpolation, the diffuse irradiation is

$$I_d = 25 + \tfrac{18}{60}(33 - 25) = 26.6 \text{ Btu per (hr) (sq ft)}.$$

The total solar irradiation is

$$I_t = 152.0 + 26.6 = 178.6 \text{ Btu per (hr)(sq ft)}.$$

PERIODIC HEAT FLOW THROUGH WALLS AND ROOFS

The calculation of heat flow, through a structural section of a building exposed to the weather, requires consideration of the diurnal cycles of solar irradiation and air temperature. These cycles and other factors lead to a periodic variation in the instantaneous rate of heat flow into the weather surface, and a related periodic variation in the rate of heat flow into the air conditioned space. Because of heat capacity and other factors, these heat flow cycles are, in general, out of time phase and unequal in amplitude.

In order to calculate the rate of heat entry into the weather surface of a building, it is necessary to know:

1. The intensity of direct solar radiation striking the surface.
2. The absorptivity (or reflectivity) of the surface for direct solar radiation.
3. The intensity of diffuse or sky solar radiation striking the surface.
4. The absorptivity (or reflectivity) of the surface for diffuse or sky solar radiation.
5. The rate at which the surface emits radiation to the sky and other surroundings.
6. The rate at which the surface absorbs the low temperature radiation emitted by the sky and other surroundings by virtue of their temperatures and radiating characteristics.
7. The temperature of the surrounding air.
8. The temperature of the outer building surface.
9. The unit convective conductance for heat transfer between the air and the building surface.

The Sol-Air Temperature

The complex interrelationship of the above factors can be considerably simplified through the use of the sol-air temperature concept. The sol-air temperature t_e is the temperature of the outdoor air, which, in the absence of all radiation exchanges, would give the same rate of heat entry into the surface as would exist with the actual combination of incident solar radiation, radiant energy exchange with the sky and other outdoor surroundings, and convective heat exchange with the outdoor air.

The sol-air temperature data[5, 6, 10] as developed by Mackey and Wright for an industrial atmosphere were used as a basis for preparing Table 8 showing summer design sol-air temperatures. Sol-air temperatures may also be estimated from experimental observation of surface temperatures