time lag to the time of maximum sol-air temperature (from Table 9) for the particular wall or roof.

The magnitude of the second term in Equation 5 relative to the first term indicates the relative portion of the structural heat in-flow assignable to periodic heat flow. The periodic term is continually passing through a *cyclic variation* from zero to a positive maximum, to zero, to a negative maximum, to zero again and so on over each 24-hour cycle. Surfaces with different exposures pass through these cycles with maximum points at different times of day.

TABLE 10. PERIODIC HEAT FLOW DATA FOR HOMOGENEOUS WALLS OR ROOFS

Material	Thickness, In.	Over-all Coefficient, Btu per (hr) (sq ft) (°F) U^a	Thermal Resistance of Solid Material (hr) (sq ft) (°F)/Btu $\frac{L}{k}$	Time Lag, Hr.	Factor, λ, in Equation 5: Horizontal and North	East	South	West
Stone	8	0.67	0.64	5.5	0.51	0.36	0.48	0.42
	12	0.55	0.96	8.0	0.28	0.19	0.26	0.22
	16	0.47	1.28	10.5	0.17	0.10	0.15	0.13
	24	0.36	1.92	15.5	0.06	0.03	0.05	0.04
Solid Concrete	2	0.98	0.17	1.1	0.93	0.87	0.92	0.89
	4	0.84	0.33	2.5	0.79	0.68	0.76	0.72
	6	0.74	0.50	3.8	0.61	0.46	0.58	0.51
	8	0.66	0.67	5.1	0.49	0.33	0.46	0.39
	12	0.54	1.00	7.8	0.29	0.17	0.26	0.22
	16	0.46	1.33	10.2	0.17	0.09	0.15	0.12
Common Brick	4	0.60	0.80	2.3	0.83	0.75	0.81	0.78
	8	0.41	1.60	5.5	0.51	0.39	0.49	0.44
	12	0.31	2.40	8.5	0.26	0.17	0.25	0.21
	16	0.25	3.20	12.0	0.13	0.08	0.12	0.10
Face Brick	4	0.77	0.44	2.4	0.81	0.70	0.78	0.74
Wood	½	0.68	0.62	0.17	1.0	1.0	1.0	1.0
	1	0.48	1.25	0.45	1.0	0.99	0.99	0.99
	2	0.30	2.50	1.3	0.98	0.91	0.96	0.94
Insulating Board	½	0.42	1.51	0.08	1.0	1.0	1.0	1.0
	1	0.26	3.03	0.23	1.0	1.0	1.0	1.0
	2	0.14	6.05	0.77	1.0	1.0	1.0	1.0
	4	0.08	12.1	2.7	0.83	0.74	0.81	0.76
	6	0.05	18.2	5.0	0.64	0.49	0.61	0.55

[a] Based upon an outdoor surface conductance of 4.0 and an indoor surface conductance of 1.65 Btu per (hour) (square foot) (Fahrenheit degree).

An example in the use of Tables 9 and 10 follows:

Example 7. Find the instantaneous rate of heat gain through an 8 in. west wall of common brick ($\alpha_t = 0.7$, $f_{o} = 4.0$) located at 40 deg north latitude at 9:30 p.m. sun time. The indoor air temperature is constant at 80 F. Use sol-air data for an industrial atmosphere.

Solution. From Table 10, $U = 0.41$, the time lag is 5.5 hr, and $\lambda = 0.44$. By linear interpolation on the basis of α_t/f_{o} in Table 9,

$$t_m = 83.1 + \frac{0.175}{0.25}\,(92.9 - 83.1) = 90.0\text{ F.}$$

The design sol-air temperature at a time earlier than 9:30 p.m. by the time lag (at 4:00 p.m.) is, by interpolation, from Table 9,

$$t_e' = 94 + \frac{0.175}{0.25}\,(137 - 94) = 124.1\text{ F.}$$

From Equation 5, the instantaneous design rate of heat gain is

$$\frac{q}{A} = 0.41[(90.0 - 80) + 0.44(124.1 - 90.0)] = 10.3\text{ Btu per (hr) (sq ft).}$$

From Table 10, the time lag is 5.5 hr. From Table 9, the time of maximum rate of heat entry for a west wall is 4:00 p.m. plus 5.5 hr or 9:30 p.m. (*this is sun time*). The computed rate is therefore the maximum rate.

Composite Walls or Roofs, Constant Indoor Temperature

A composite wall or roof is made up of two or more layers of different materials. Since the analytical solution for this type of construction has not been reduced to simple and practical terms, it is necessary at present

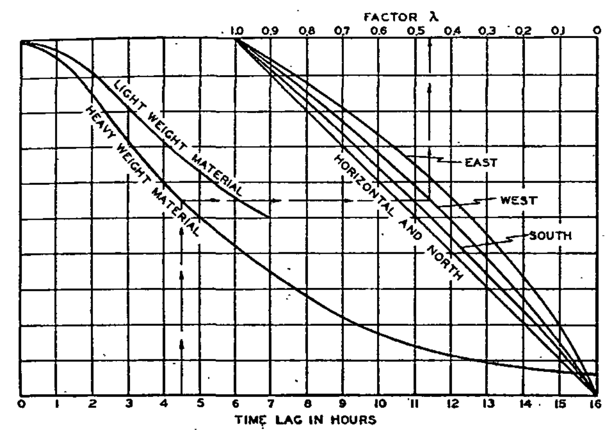

FIG. 2. APPROXIMATE VALUE OF THE AMPLITUDE DECREMENT FACTOR λ FOR USE IN EQUATION 5

to utilize approximate procedures. In accord with the results of comparative calculations, the following procedures are suggested.[11]

To find the time lag for a composite construction:

a. Find the time lag for each layer from Table 10.

b. Add the individual time lags, recognizing that this sum will always be *less* than the true time lag for the actual composite wall.

c. To the sum from (b), *add* an *arbitrary* additional lag of ½ to 1 hr to obtain the estimated lag for the actual construction. For two-layer and light construction walls, the ½-hr value will be suitable while, for walls of three or more layers, or very heavy construction, the 1-hr value is preferred. For intermediate conditions, individual judgment is the only guide. (Computed time lags should not be considered to be accurate closer than to about the nearest hour by this method.)

To find the amplitude decrement factor, λ, for composite construction:

Having determined the time lag and the orientation, use Fig. 2. (Note also that the factor λ for a composite construction should never exceed the *product* of the factors for the individual layers.)

One valuable result of the analytical studies made to date on composite walls has been the demonstration of the effect of the *order* of the materials. Other factors remaining the same, the use of the material of lower density