Coefficients for masonry units vary with the raw material or type of aggregate used. The stress developed in a restrained element due to temperature change is equal to the *modulus of elasticity* × *coefficient of thermal expansion* × *mean wall temperature change*. For instance, the tensile stress in a fully restrained block wall with a thermal expansion coefficient of 4.5×10^{-6} and modulus of elasticity of 1.8×10^{6} for a temperature change of 100°F is

$$0.0000045 \times 1{,}800{,}000 \times 100°\text{F} = 810 \text{ psi}$$

Wall surface temperatures must be used to calculate thermal movement because they represent greater extremes than ambient air temperatures, and therefore predict actual movement more accurately. Vertical wall surface temperatures in winter are usually within a few degrees of ambient (depending on the amount of insulation present in the wall), and may safely be assumed to equal the ASHRAE winter design dry-bulb temperature. Summer surface temperatures, however, are affected by solar radiation, thermal mass, and the temperature gradient through the thickness of the material. One equation used to calculate summer surface temperature taking these factors into consideration is

$$T_s = T_a + (H)(A) \qquad (9.1)$$

where T_s = extreme summer surface temperature of wall, °F
T_a = extreme summer air temperature, °F (dry bulb)
H = constant for heat capacity of material (*see Fig. 9-2*)
A = solar absorption coefficient of material (*see Fig. 9-3*)

The total wall surface temperature differential (ΔT) is found by subtracting winter surface temperature from summer surface temperature:

$$\Delta T = T_s - T_w \qquad (9.2)$$

where ΔT = total surface temperature differential, °F
T_s = extreme summer surface temperature of wall, °F [from equation (9.1)]
T_w = extreme winter surface temperature, °F (ASHRAE dry bulb)

The formula given in ASTM C1193, *Standard Guide for Use of Joint Sealants,* can then be used to calculate thermal movement:

$$\Delta L_t = (T_c)(\Delta T)(L) \qquad (9.3)$$

where ΔL = dimensional change, in.
T_c = thermal movement coefficient (*see Fig. 9-1*)
ΔT = total surface temperature differential, °F [from equation (9.2)]
L = panel length, in.

For example, thermal movement for a clay brick panel with a thermal expansion coefficient of 3.6×10^{-6} (from *Fig. 9-1*), an estimated surface temperature differential of 145°F, and a panel length or joint spacing of 20 ft is calculated as

$$\Delta L_t = (0.0000036)(145°\text{F})(240 \text{ in.}) = 0.12528 \text{ in.} \qquad (\text{or about } ⅛ \text{ in.})$$

9.1.2 Moisture Movement

Many building materials expand as moisture content increases and then contract when it decreases. In some instances this moisture movement is almost fully reversible, but in others the change in dimension is permanent

Constant for Heat Capacity (H)	
Type of Material	(H)
Low heat capacity materials[§]	100
	or
Solar radiation reflected on low heat capacity materials[±]	130
High heat capacity materials[§]	75
	or
Solar radiation reflected on high heat capacity materials[±]	100

§ Materials such as EIFS and well-insulated metal panel curtain walls have low thermal storage capacity. Materials such as concrete and masonry have high thermal storage capacity.

± If the wall surface receives reflected as well as direct solar radiation, use the larger coefficient. Reflected radiation may be from adjacent wall surfaces, roofs, and paving.

Figure 9-2 Constant for heat capacity of materials with low thermal storage capacity and high thermal storage capacity. (*From ASTM C1472,* Standard Guide for Calculating Movement and Other Effects When Establishing Sealant Joint Width. *Copyright ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428. Reprinted with permission.*)

Solar Absorption Coefficient (A)	
Material	A
Aluminum	0.40–0.65
Black, non-metallic (asphalt or slate)	0.85–0.98
Brick, light buff	0.50–0.70
Brick, red	0.65–0.85
Brick, white	0.25–0.50
Concrete, natural	0.65
Copper	0.65–0.80
Galvanized steel	0.40–0.65
Glass, clear, 1/4"	0.15
Glass, tinted, 1/4"	0.48–0.53
Glass, reflective, 1/4"	0.60–0.83
Marble, white	0.58
Paint	
dark red, brown or green	0.65–0.85
black	0.85–0.98
white	0.23–0.49
Surface color	
black	0.95
dark gray	0.80
light gray	0.65
white	0.45
Wood, smooth	0.78

Figure 9-3 Solar absorption coefficient for calculating thermal movement. (*From ASTM C1472,* Standard Guide for Calculating Movement and Other Effects When Establishing Sealant Joint Width. *Copyright ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428. Reprinted with permission.*)