ums) are constructed to essentially the same fire safety standards as single-family dwellings, despite the significantly increased risk posed by the proximity of adjacent units and the vulnerability of occupants to the actions of their neighbors. Code requirements are much less stringent for two- and three-story residential occupancies than for high-rise buildings, and fires can quickly consume several adjacent units of combustible construction. Multifamily dwellings are all too frequently built of wood frame and gypsum board to achieve only a "1-hour" rating. This can be provided by simple 2 × 4 studs, 16 in. on center, with one layer of ⅝-in. Type X gypsum board on each side of the wall. A "2-hour" rating is achieved with a double layer of Type X gypsum board on each side. Townhouse and zero-lot-line developments, however, are often required to have 2-hour *non-combustible masonry* fire walls separating units, and as a result, statistics show that fire losses are greatly reduced.

8.4.6 Fire Insurance Rates

There is one source to which we can look for a realistic comparison of combustible and non-combustible construction, and that is fire insurance rates. The insurance industry must literally guarantee the fire safety of buildings, and they do so for a price that is based on actual fire loss experience and the corresponding degree of risk presented by various types of construction. Studies show that, throughout the United States, insurance premiums for wood frame apartments may be five to ten times higher than for the same apartments built of 2-hour non-combustible masonry walls with concrete floor and roof slabs.

The superior performance of concrete and masonry is recognized by the insurance industry, and putting discrepancies in test results and ratings aside, this is perhaps the best indicator of just how unequal drywall and masonry construction are.

8.5 THERMAL PROPERTIES

The thermal efficiency of a building material is normally judged by its resistance to heat flow. A material's *R value* is a measure of this resistance taken under laboratory conditions with a constant temperature differential from one side to the other. This is called a *steady-state* or *static condition*.

Thermal resistance depends on the density of the material. By this measure, masonry is a poor insulator. Urethane insulation, on the other hand, has a very high resistance because it incorporates closed cells or air pockets to inhibit heat transfer. The reciprocal of the R value is the U value, or the overall coefficient of heat transmission. Both values are derived from the inherent thermal *conductance* of the material, and its *conductivity* per inch of thickness.

Materials in which heat flow is identical in all directions are considered thermally homogeneous. Materials that are not isotropic with respect to heat transmission (such as hollow masonry units) are considered thermally heterogeneous. Thermal conductance and thermal resistance of homogeneous materials of any thickness can be calculated from the equations

$$C_x = \frac{k}{x} \tag{8.3}$$

and

$$R_x = \frac{x}{k} \tag{8.4}$$

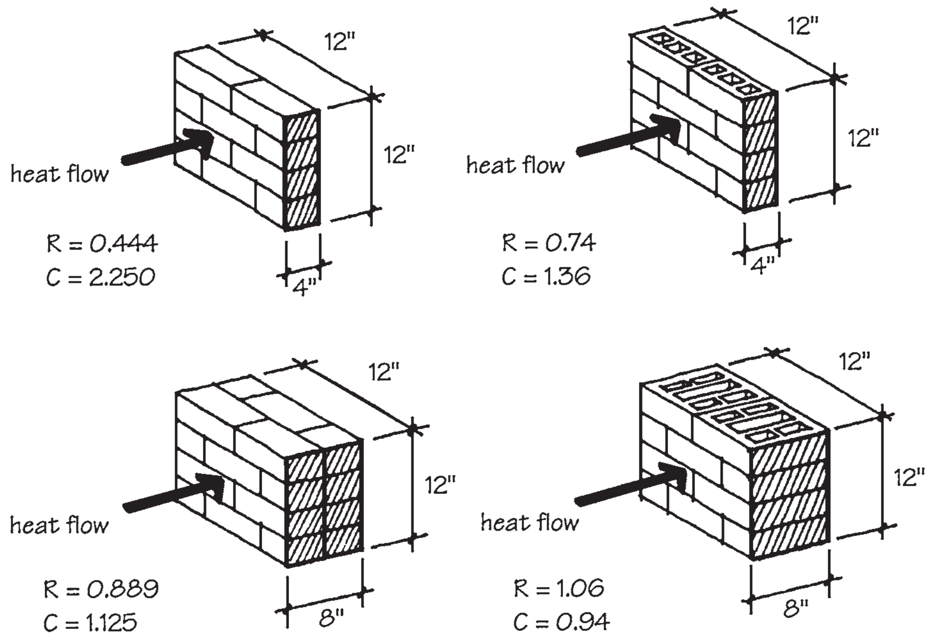

Figure 8-20 Thermal transmittance through masonry walls. (*From* BIA Technical Note 4 Rev.)

where C = thermal conductance, Btu/ (hr × °F × ft²)
R = thermal resistance, (hr × °F × ft²) / (Btu × in.)
k = thermal conductivity, (Btu × in.) / (hr × °F × ft²)
x = thickness of material, in.

Figure 8-20 shows the difference between thermal resistance (R) and thermal conductance (C) for thermally homogeneous and thermally heterogeneous masonry walls.

Whenever an opaque wall assembly is analyzed, it should include both the inside and outside air surfaces, which affect both convection and conduction of heat. The inclusion of these air surfaces makes all opaque wall assemblies "layered" construction. In computing the heat transmission coefficients of layered construction, the paths of heat flow must first be determined. If the heat flow paths are in series, the thermal resistances (R) of the layers are additive, but if the paths are in parallel, then the thermal transmittances (U) are averaged. For layered construction with paths of heat flow in series, the total thermal resistance (R) of the wall is obtained by adding the thermal resistances of each layer ($R = R_1 + R_2 + \ldots + R_n$), and the overall coefficient of heat transmission is $U = 1/R$. Average transmittances for parallel paths of heat flow are obtained using the equation

$$U_{\text{avg}} = \frac{A_A\,(U_A) + A_B\,(U_B) + \ldots + A_n\,(U_n)}{A_t} \tag{8.5}$$

or

$$U_{\text{avg}} = \frac{[1/\,(R_A/A_A) + 1/\,(R_B/A_B) + \ldots + 1/\,(R_n/A_n)\,]}{A_t} \tag{8.6}$$