Type of Aggregate	Fire Resistance Rating (hours)														
	½	¾	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4
Pumice or expanded slag	1.5	1.9	2.1	2.5	2.7	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.5	4.7
Expanded shale, clay, or slate	1.8	2.2	2.6	2.9	3.3	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	4.9	5.1
Limestone, cinders, or unexpanded slag	1.9	2.3	2.7	3.1	3.4	3.7	4.0	4.3	4.5	4.8	5.0	5.2	5.5	5.7	5.9
Calcareous or siliceous gravel	2.0	2.4	2.8	3.2	3.6	3.9	4.2	4.5	4.8	5.0	5.3	5.5	5.8	6.0	6.2

Notes:

- Values between those shown in the table may be determined by direct interpolation.
- Where combustible members are framed into the wall, the thickness of solid material between the ends of each member and the opposite face of the wall, or between members set in from opposite sides, shall not be less than 93% of the thickness shown.
- Minimum required equivalent thickness corresponding to the hourly fire resistance rating for units with a combination of aggregates shall be determined by linear interpolation based on the percent by volume of each aggregate used in manufacture.

Figure 8-14 Fire resistance of loadbearing and non-loadbearing concrete masonry walls. (*From* International Building Code 2003.)

	Fire Resistance Rating			
	1-hr.	2-hr.	3-hr.	4-hr.
Minimum column dimension (inches)	8	10	12	14

Figure 8-15 Fire resistance of concrete masonry columns. (*From* International Building Code 2003.)

on the equivalent solid thickness E_T of the units and the known fire resistance characteristics of the materials. Code requirements such as those in the IBC are based on a minimum required equivalent thickness for each rating. Equivalent solid thickness is the average thickness of solid material in the wall or unit, and is calculated from the actual thickness and the percentage of solid material in the unit. E_T is found by taking the total volume of a wall unit, subtracting the volume of core or cell spaces, and dividing by the area of the exposed face of the unit, using the equation

$$E_T = \frac{V}{l \times h} \tag{8.1}$$

where E_T = equivalent thickness, in.
V = net volume (gross volume less void area), in^3
l = length of unit, in.
h = height of unit, in.^{2}

For example, a nominal 8 × 8 modular face size structural clay tile unit that is 6 in. thick has a gross volume of 7⅝ × 7⅝ × 5⅝ = 327 in³. A void area of 40% leaves a net volume $V = 327 - 131 = 196$ in³. Using equation (8.1), the equivalent thickness can be calculated:

$$E_T = \frac{196}{7.625 \times 7.625} = 3.37 \text{ in.}$$

Volume characteristics and equivalent thickness for some typical concrete masonry units are shown in *Fig. 8-16.* The fire resistance of concrete masonry is a function of both aggregate type and equivalent thickness. Aggregates have a significant effect on fire resistance. Lightweight aggregates such as pumice, expanded slag, clay, or shale offer greater resistance to the transfer of heat in a fire because of their increased air content. Units made with these materials require less thickness to achieve the same fire rating as a heavyweight aggregate unit. The table in *Fig. 8-14* lists aggregate types and equivalent thicknesses which will satisfy specific fire rating requirements.

The fire resistance of units or wall assemblies which have not been tested can be calculated using the equation

$$R = (R_1^{0.59} + R_2^{0.59} + \ldots + R_n^{0.59} + A_1 + A_2 + A_n + pl)^{1.7} \qquad (8.2)$$

where R = calculated fire resistance of the assembly, hr
R_1, R_2, R_n = fire rating of the individual wythes, hr
A_1, A_2, A_n = 0.30 coefficient for each continuous air space of at least ½ in. between wythes
pl = coefficient for thickness of plaster (*see Fig. 8-17*)

This equation can be used to calculate the resistance of masonry cavity walls, composite walls which combine clay and concrete masonry, and grouted walls. For single-wythe or multi-wythe grouted walls, the grout is considered as one layer of a multi-layered assembly, and is rated based on the equivalent thickness of siliceous aggregate from the table in *Fig. 8-14.* The ratings of the unit or units and the rating of the grout are the values used for R_1, R_2, and R_3 in the equation, and the air space, if any, is *as.* For example, a 10-in. cavity wall with 4-in. brick, 2-in. open cavity, and 4-in. brick would be calculated as

$$R = (1.25^{0.59} + 1.25^{0.59} + 0.30)^{1.7} = 5.01 \text{ hr}$$

A limestone aggregate concrete block with an E_T of 4.2 in. is rated at 2 hours (from *Fig. 8-14*). If the cores of the block are grouted with a sand and gravel aggregate portland cement grout, the E_T of the grout is 7.625 in. − 4.2 in. = 3.4 in. The fire rating for the grout thickness is 1 hour (from *Fig. 8-14*). Therefore,

$$R = (2.0^{0.59} + 1.0^{0.59})^{1.7} = 4.78 \text{ hr}$$

In both instances, the whole is greater than the simple sum of the parts because of the increase in mass per unit of surface area.

The application of plaster to one or both sides of a clay or concrete masonry wall increases the fire rating of the assembly. For portland cement plaster, the plaster thickness may be added to the actual thickness of solid units or to the equivalent thickness of hollow units in determining the rating. For gypsum plaster, a coefficient is added to equation (8.2), $R = (R_1^{0.59} + R_2^{0.59} + \ldots + R_n^{0.59} + as + pl)^{1.7}$, where pl is the thickness coefficient of sanded gypsum plaster from *Fig. 8-17.* The methods used for calculating fire resistance are fully described in *Standard Method for Determining Fire Resistance of Concrete and Masonry Assemblies* (ANSI/ACI 216.1/TMS 0216.1).