NCMA TEK

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# INCREASING THE FIRE RESISTANCE OF CONCRETE MASONRY

**TEK 7-4**
Fire Resistance (2001)

**Keywords:** fire resistance ratings, fire walls, plaster

## INTRODUCTION

It has been accepted practice to determine the fire resistance rating of concrete masonry walls based on the aggregate type used to manufacture the units and the equivalent thickness of solid material in the wall. Each of the model building codes have established minimum thickness requirements (Table 1) for given hourly ratings developed and refined over the years through the results of actual fire tests.

Equivalent thickness of concrete masonry is determined by calculating the product of the net volume (expressed in the form of percent solid) and the actual width of the unit. The net volume is found by the test procedures described in ASTM C 140, *Standard Methods of Sampling and Testing Concrete Masonry Units*. (ref. 5)

In most instances, concrete masonry units which meet the equivalent thickness requirements for a given hourly fire rating are readily available. However, when such units are not available, it may be necessary to increase the fire resistance rating by adding supplemental materials either into the cores of the block or attached to the surface of the wall.

Fire ratings may also need to be increased when the endurance periods of existing walls must be improved to accommodate changes in building usage, classification, or to bring older structures into compliance with current building code requirements.

This TEK describes procedures to increase the fire resistance of concrete masonry construction by adding specific materials or combinations of materials to the wall.

## FILLED CORES

Filling the hollow core spaces, or the air space in a cavity wall, with an approved material will reduce the rate of heat flow through the wall and result in an increased fire endurance.

Under the provisions of each of the national model codes (refs. 1, 3, 10, 11), when the cells of the units are solidly filled with grout the equivalent thickness is considered to be the actual thickness of the unit.

Research conducted by the Portland Cement Association (Figure 1) (ref. 2) indicates that a fairly wide range of granular materials may increase the fire endurance if employed in the hollow cells. Of course, use of an approved insulating material in the hollow cells to increase the fire endurance has the added benefit of increasing resistance to heat flow.

*Standard Method for Determining Fire Endurance of Concrete and Masonry Construction Assemblies*, ACI 216.1 (ref. 4) allows the equivalent thickness of the unit to be taken as the actual thickness when all cores are filled with: sand, pea gravel, crushed stone, or slag that meet ASTM C 33 (ref. 6) requirements; pumice, scoria, expanded shale, expanded clay, expanded slate, expanded slag, expanded fly ash, or cinders that comply with ASTM C 331 (ref. 7); or perlite or vermiculite meeting the requirements of ASTM C 549 and C 516 (refs. 8, 9), respectively.

## SURFACE FINISHES

The fire resistance values shown in Table 1 are for concrete masonry walls without plaster or wallboard fin-

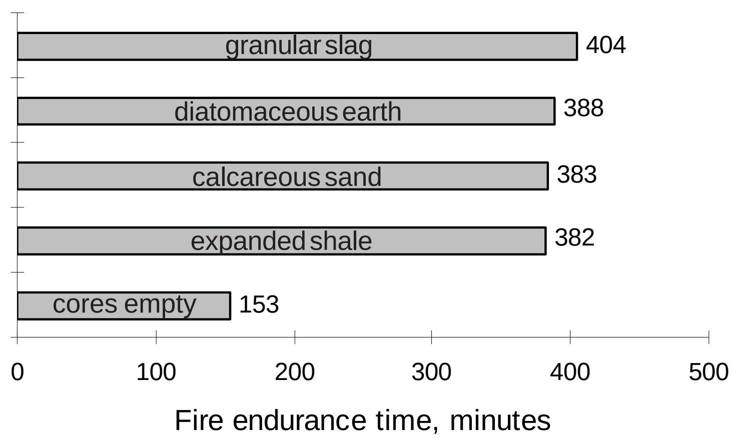


**Figure 1—Test Results of Core Fills to Increase Fire Resistance Rating (ref. 2)**

**Table 1—Fire Resistance Rating Period of Concrete Masonry Assemblies (ref. 4)**

| Aggregate type in the concrete masonry unit[b] | Minimum required equivalent thickness, in. (mm), of the concrete masonry assembly,[a] to achieve a fire resistance rating period of | | | | |
|---|---|---|---|---|---|
| | 4 hr. | 3 hr. | 2 hr. | 1.5 hr. | 1 hr. |
| Calcareous or siliceous gravel (other than limestone) | 6.2 (157) | 5.3 (135) | 4.2 (107) | 3.6(91) | 2.8 (71) |
| Limestone, cinders or air-cooled slag | 5.9 (150) | 5.0 (127) | 4.0 (102) | 3.4(86) | 2.7 (69) |
| Expanded clay, expanded shale or expanded slate | 5.1 (130) | 4.4 (112) | 3.6 (91) | 3.3(84) | 2.6 (66) |
| Expanded slag or pumice | 4.7 (119) | 4.0 (102) | 3.2 (81) | 2.7(69) | 2.1 (53) |

[a] Fire resistance rating between the hourly fire resistance rating periods listed shall be determined by linear interpolation based on the equivalent thickness value of the concrete masonry assembly.

[b] Minimum required equivalent thickness corresponding to the fire resistance rating for units made with a combination of aggregatesshall be determined by linear interpolation based on the percent by volume of each aggregate used in the manufacture.

**Table 2—Multiplying Factor for Finishes on Non-Fire-Exposed Side of Wall (ref. 4)**

| Type of finish applied to wall: | Siliceous or carbonate aggregate | Semi-lightweight concrete | Expanded shale, expanded clay, expanded slag, or pumice less than 20% sand |
|---|---|---|---|
| Portland cement-sand plaster[a] or terrazzo | 1.00 | 0.75 | 0.75 |
| Gypsum-sand plaster | 1.25 | 1.00 | 1.00 |
| Gypsum-vermiculite or perlite plaster | 1.75 | 1.50 | 1.25 |
| Gypsum wallboard | 3.00 | 2.25 | 2.25 |

[a] For portland cement-sand plaster 5/8 in. (16 mm) or less in thickness, and applied directly to concrete or masonry on the non-fire exposed side of the wall, the multiplying factor is 1.0.

ishes. Plaster or wallboard finishes increase the fire resistance of the concrete masonry wall, with the increase in fire endurance depending on the type of finish, the type of block, and whether the finish is on the fire exposed or non-exposed side of the wall. When gypsum wallboard or plaster finishes are applied to a concrete masonry wall, the calculated fire resistance rating for the masonry alone should not be less than one-half the required fire resistance rating.

Since the contribution of the finish to the fire resistance of the wall is largely a matter of its ability to stay in place, consideration must be given to methods of attachment. Plaster and stucco should be applied directly to the concrete masonry in accordance with building code provisions. Gypsum wallboard may be attached using wood or steel furring, or attached directly to the walls by adhesives. Requirements for fastening wallboard to masonry walls are listed below.

1. Self-tapping drywall screws spaced at a maximum of 12 in. (305 mm) on center and penetrating 3/8 in. (10 mm) into resilient steel furring channels running horizontally and spaced at a maximum of 24 in. (610 mm).
2. Lath nails spaced at a maximum of 12 in. (305 mm) on center penetrating 3/4 in. (19 mm) into nominal 1 x 2 wood furring strips that are secured to the masonry by 2 in. (51 mm) concrete nails and spaced a maximum of 16 in. on center (406 mm).
3. Application of a 3/8 in. (10 mm) bead of panel adhesive around the perimeter of the wallboard and across the diagonals. After the wallboard is laminated to the concrete masonry surface, secure it with one masonry nail for each 2 ft$^2$ (0.19 m$^2$) of panel.
4. Gypsum wallboard must be installed with the long dimension parallel to furring members and with all horizontal and vertical joints supported and finished. 5/8 in. (16 mm) Type X gypsum wallboard is permitted to be installed horizontally on walls with the horizontal joints unsupported.

## NON-FIRE EXPOSED SURFACES

An increase in equivalent thickness can be calculated for wallboard and plaster applied to the unexposed side of the masonry wall. Multiplying factors (Table 2) are employed to calculate the added equivalent thickness. The increase or decrease in added thickness (i.e., the value of the multiplying factor) depends on the relative heat resistance of the concrete masonry and the finish material. The corrected thickness is then added to the equivalent thickness of the concrete masonry to determine the fire resistance.

**Example 1: Use of Table 2**

Assume that a wall finish will be applied to the non-fire-exposed side of the wall. The actual thickness of the finish is 3/4 in. (19 mm). The added equivalent thickness is calculated as follows:

(a) If the masonry unit is manufactured of siliceous or calcareous gravel and gypsum wallboard is the finish material, the added equivalent thickness will be:
0.75 in. x 3.00 = 2.25 in. (57 mm)

(b) If the unit is manufactured of expanded slag and the finish material is portland cement-sand plaster, the added equivalent thickness will be:

0.75 in. x 0.75 = 0.56 in. (14 mm)

Similar calculations may be made for units manufactured of other aggregate types or covered with different finish materials.

## FIRE EXPOSED SURFACES

Wallboards and plasters applied to lath on the fire exposed side of a concrete masonry wall are treated differently since their contribution to additional fire endurance is limited to the period of time they stay on the wall during a fire. Wallboard exposed to a fire test generally will burst into flame within the first 30 seconds; and will have lost its outer paper cover in about five minutes. The material between the paper covers will then begin to deflect and crack, however still offering some protection to the masonry until it has fallen off. The total length of time it protects the wall varies with the total thickness of the cover, and with its ability to stay in place when exposed to fire.

**Table 3—Time Assigned to Finish Materials on Fire Exposed Side of Wall (ref. 4)**

| Finish description: | Time, min. |
|---|---|
| Gypsum wallboard | |
| 3/8 in. (10 mm) | 10 |
| 1/2 in. (13 mm) | 15 |
| 5/8 in. (16 mm) | 20 |
| 2 layers of 3/8 in. (10 mm) | 25 |
| 1 layer 3/8 in. (10 mm) and 1 layer 1/2 in. (13 mm) | 35 |
| 2 layers 1/2 in. (13 mm) | 40 |
| Type X gypsum wallboard | |
| 1/2 in. (13 mm) | 25 |
| 5/8 in. (16 mm) | 40 |
| Direct-applied cement-sand plaster | see note a |
| Portland cement-sand plaster on metal lath | |
| 3/4 in. (19 mm) | 20 |
| 7/8 in. (22 mm) | 25 |
| 1 in. (25 mm) | 30 |
| Gypsum-sand plaster on 5/8 in. (19.9 mm) gypsum lath | |
| 1/2 in. (13 mm) | 35 |
| 5/8 in. (16 mm) | 40 |
| 3/4 in. (19 mm) | 50 |
| Gypsum-sand plaster on metal lath | |
| 3/4 in. (11 mm) | 50 |
| 7/8 in. (22 mm) | 60 |
| 1 in. (25 mm) | 80 |

[a] For purposes of determining the contribution of portland cement-sand plaster to the equivalent thickness of concrete masonry for use in Table 1, it is permitted to use the actual thickness of plaster, or 5/8 in. (16 mm), whichever is smaller.

The "falloff time" for wallboard or plaster on lath is added directly to the fire resistance of the unfinished concrete masonry wall. Table 3 shows fire endurance times of some selected common wallboard finishes and plaster on lath systems. To calculate the total resistance rating of these finishes on a concrete masonry wall, the times listed are added directly to the fire resistance rating of the unfinished masonry as long as the finish is on the fire exposed side of the wall.

For example, 5/8 in. (16 mm) gypsum wallboard will contribute an additional 20 minutes to the fire resistance rating of the wall.

With the exception of exterior walls required to be rated by only one side, walls must be rated for exposure to fire from both sides. Therefore, two calculations must be performed assuming each side to be the fire exposed side. The calculated fire resistance rating must not exceed the lower of the two ratings determined by assuming each side to be the fire-exposed side. Two calculations are not necessary for walls having the same type and thickness of finish on each side.

**Example 2: Finishes on Both Sides of Wall**

A fire wall required to have a 4 hour fire resistance rating will be constructed of 8 in. (203 mm) hollow concrete masonry units (55% solid) manufactured from expanded slag aggregate. What type and thickness of additional finish material is required?

1. The required equivalent thickness is 4.7 in. (119 mm) (from Table 1).
2. The calculated equivalent thickness is:
   0.55 x 7.625 in. = 4.19 in. (106 mm)
3. The calculated fire resistance period is 3.27 hours (by interpolation from Table 1). The requirement that the masonry alone provide at least one-half of the total required rating is satisfied (3.27 > 2.0).
4. Sufficient finish material is required to provide an additional fire resistance period of:
   4 - 3.27 = 0.73 hours
5. One layer of 5/8 in. (16 mm) gypsum wallboard on the fire-exposed side has a "time assigned" of 20 minutes (Table 3).
6. On the non-fire exposed side sufficient equivalent thickness is required for 0.73 - (20/60) = 0.4 hours.
7. By interpolation from Table 1, an additional 1.38 in. (35 mm) of equivalent thickness are required. From Table 2, one layer of 5/8 in. (16 mm) gypsum wallboard is equivalent to:
   0.625 in. x 2.25 = 1.4 in. (36 mm) of equivalent thickness > 1.38

In this example, the fire resistance requirement is met by using the same type and thickness of finish material on each side of the masonry wall, therefore a second calculation is not necessary.

**Example 3: Finishes on Both Sides of Wall**

A fire wall required to have a 4 hour fire resistance rating will be constructed with 8 in. (203 mm), 53% solid, concrete masonry units of expanded shale aggregate. The wall will be finished on each side with a layer of $^1/_2$ in. (13 mm) gypsum wallboard. What is the minimum equivalent thickness of concrete masonry required?

Since the wall has the same type and thickness of finish on each side, only one calculation is required.

1. The $^1/_2$ in. (13 mm) gypsum wallboard on the fire-exposed side has a "time assigned" of 15 minutes per Table 3.
2. Therefore, the fire resistance required to be provided by the masonry and gypsum wallboard on the non-fire-exposed side is 3 hours and 45 minutes (4 hours minus 15 minutes).
3. From Table 2, the corrected thickness of gypsum wallboard on the non-fire-exposed side is 1.1 in. (28 mm) (2.25 x $^1/_2$ in.).
4. From Table 1, the minimum equivalent thickness of masonry, including the corrected thickness of gypsum wallboard, required for a rating of 3 hours and 45 minutes is 4.9 in. (124 mm).
5. Therefore, the equivalent thickness of masonry required is 3.8 in. (4.9 minus 1.1) (97 mm).
6. The equivalent thickness of the masonry is:
   7.625 in. x 0.53 = 4.0 in. (102 mm)

The unit has sufficient equivalent thickness to meet the four hour rating in conjunction with the finish. From Table 1, 4.0 in. (102 mm) of expanded shale aggregate concrete masonry will provide a fire resistance of over two hours. Therefore, the requirement that the masonry alone provide at least one-half of the total required rating is satisfied.

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