TEK NOTE

February 2005

Concrete Masonry Fire Resistance

Concrete masonry is a noncombustible construction material possessing excellent fire-resistive properties. The resistance of concrete masonry to fire is well established by extensive testing to be a function of the type of aggregate used in the manufacture of the masonry units and their equivalent thickness. The rated fire-resistive periods for block walls can be determined by knowing this information and complying with Table 720.1(2), item number 3 of the International Building Code (IBC)(ref. 1).

The equivalent thickness of concrete masonry assemblies, T_{EA}, shall be computed as the sum of the equivalent thickness (average solid thickness as shown in Figure 1) of the concrete masonry unit, T_E, plus the equivalent thickness of finishes, T_{EF}, per Equation 1.

$$T_{EA} = T_E + T_{EF} \qquad \text{(Equation 1)}$$

$$T_E = V/LH$$

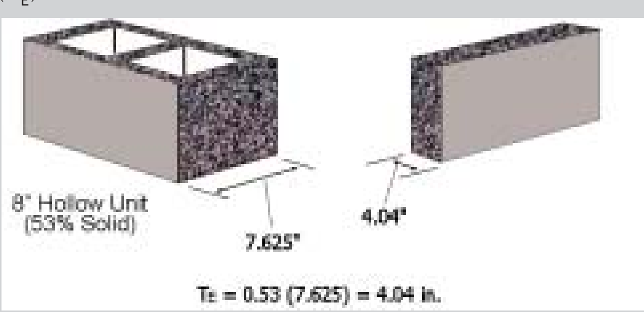
where:

- V = net volume of masonry unit, in.^{3} (per ASTM C-140)(ref. 2)
- L = specified length of masonry unit, in.
- H = specified height of masonry unit, in.

Equivalent thickness values for standard concrete block are shown in Table 1. Individual block manufacturers may have higher values based on a greater percentage of solids.

Figure 1. Concrete masonry unit equivalent thickness

If this hollow unit is 53% solid, the equivalent thickness (T_E) is 4.04 inches.



Concrete masonry units (CMU) are commonly manufactured with a combination or blend of aggregate types. The International Building Code covers this condition by reference to standard TMS 216 (ref. 5). The minimum equivalent thickness value required for a desired fire rating can be determined by interpolating between requirements for different aggregate types in proportion to the percentage by volume of each aggregate used in manufacture.

For example, for a standard block manufactured in the Northwest, which is approximately a 60/40 percentage blend of gravel and pumice aggregates, the required equivalent thickness values to achieve various fire ratings are shown in Table 2.

Table 1. Equivalent thickness (in.) for standard concrete block widths

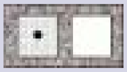
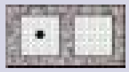
Nominal Block Width (in.)	Block Cell Treatment	
	 Partial Fill Cells	 Solid Fill Cells[1]
4	2.7	3.6
6	3.1	5.6
8	4.0	7.6
10	5.0	9.6
12	5.7	11.6

[1]Cells can be filled with grout, loose-fill insulation, or aggregate meeting ASTM C-33 (ref. 3) or C-331 (ref. 4) requirements.

Table 2. Minimum equivalent thickness required (in.) for standard northwest block

Fire Rating			
1 Hr.	2 Hr.	3 Hr.	4 Hr.
2.52	3.80	4.78	5.60

Table 3. Fire-resistance ratings of concrete masonry walls[1]

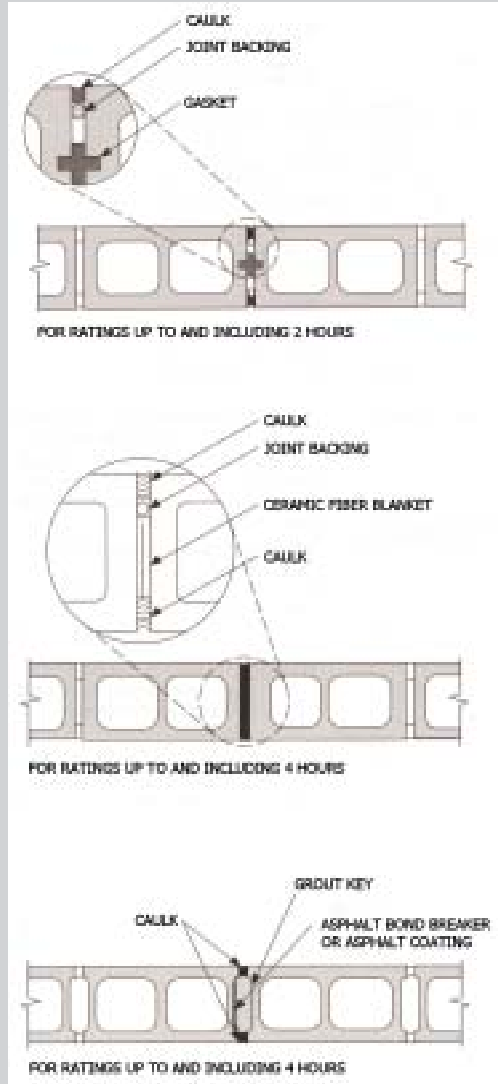
Nominal Block Width (in.)	Block Cell Treatment	
	 Partial Fill Cells	 Solid Fill Cells[2]
4	1 hour	1 hour
6	1 hour	4 hours[3]
8	2 hours	4 hours
10	3 hours	4 hours
12	4 hours[3]	4 hours

[1]Based upon a standard 60/40 blend of gravel and pumice aggregates in the concrete block mix.

[2]Cells can be filled with grout, loose-fill insulation, or aggregate meeting ASTM C-33 or C-331 requirements.

[3]If the aggregate blend is changed to 70/30 to produce a denser architectural unit, the fire rating is decreased to three hours.

Figure 2. Control joints for fire resistant concrete masonry assemblies (1/2 in. maximum control joint width)



Application of the information in Tables 1 and 2 results in the listing of concrete masonry wall fire ratings in Table 3.

Fire-Resistance Rating Increases/Decreases

Finishes on concrete masonry walls can increase the fire-resistance rating. If wall finishes are used see IBC Section 721.3.2. Contributions of plaster or gypsum wallboard shall be determined from IBC Tables 721.2.1.4(1) and 721.2.1.4(2).

Additional masonry wythes can also increase the fire-resistance rating of wall assemblies. Equation 7-7 of IBC section 721.3.3 addresses multi-wythe masonry walls.

If the specified CMU density is increased, the proportions of blended aggregates will vary from the 60/40 percentage example used in Tables 2 and 3. There will be more heavy weight aggregate and less lightweight aggregate in the concrete mix and some ratings may decrease (see footnote 3 in Table 3 above).

Fire Resistance Testing

It is important to remember that the term “fire-resistance rating” is a legal term utilized by building codes to regulate building construction. While the ratings are based upon a standard fire test exposure, assemblies having the same rating, but constructed with different materials, often perform quite differently.

Fire-resistance rated wall assemblies are commonly evaluated using ASTM Standard E-119 (ref. 6). The standard is used to determine the wall’s hourly fire rating and to indicate its expected durability during a fire. A wall tested according to E-119 undergoes both fire exposure and water hose-stream testing.

The hose-stream test provides a meaningful measure of durability during a fire. It provides an indication of how well the wall can endure fire exposure as well as falling debris, pressure waves due to explosions, actual fire hose-streams and other rough usage that often occurs during a real fire, which can never be truly replicated in a laboratory test.

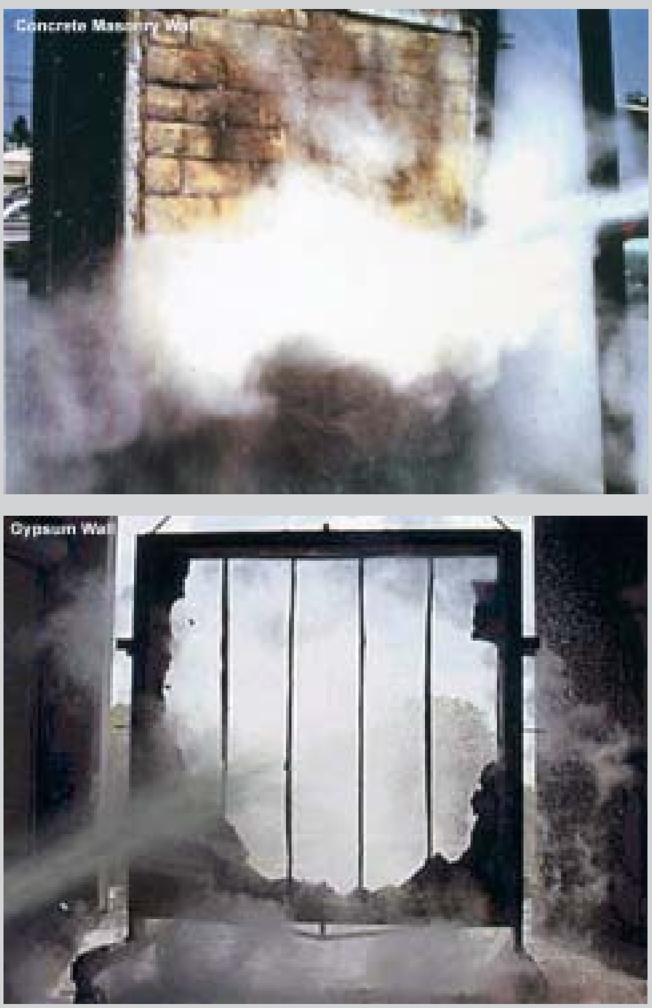
According to ASTM E-119, the hose-stream exposure test may be performed in one of two ways. The basic test, typically used for frame wall construction, permits the use of two identical assemblies. The first one is subjected to the fire exposure test to determine its hourly fire-resistance rating. The second specimen is subjected to the fire exposure test for only one half the recorded rating period (but not for more than one hour). The second assembly is then removed and hose-stream tested. The more rigorous optional E-119 test method is commonly used for concrete masonry assemblies. This second test method allows the hose-stream to be applied to the same specimen that has undergone the full fire exposure test.

By including both hose-stream test procedures, ASTM E-119 includes two distinct levels of durability performance. Clearly, application of the hose stream to a specimen that has undergone the full fire-exposure test is more rigorous and indicates a high level of durability. **In a real building fire, a wall assembly doesn't get a second chance to perform**. In typical code applications, however, no distinction is made between the two tests and, as a result, assemblies that pass the duplicate specimen test are assumed to have the same "durability rating" as those passing the more rigorous optional test method. This is an erroneous assumption (see Fig. 3).

Control Joints

Movement control joints in fire rated wall assemblies should also be rated. Figure 2 shows the types of control joints available in accordance with standard TMS 216 to maintain the fire-resistance rating of the wall in which they are constructed.

Figure 3. By virtue of duplicate test specimen provisions in ASTM E119 - these are both 2-hour rated walls.



Improving Fire Safety

Hourly fire ratings alone do not adequately address structural performance and durability under real world fire conditions. This means that some "rated" walls may not be able to provide the level of fire safety expected. However, concrete masonry's inherent non-combustibility coupled with excellent strength and durability combine to provide fire rated walls whose performance is exceptional. Masonry walls offer the following fire safety benefits:

- Protect building egress
- Prevent fire-spread within a building and to adjacent buildings
- Maintain the structural integrity of bearing walls
- Provide firefighter protection

Building owners and designers should consider the advantages offered by durable, noncombustible concrete masonry wall systems over other systems having equivalent fire-resistance ratings. **The added protection provided to both life and property should not be overlooked**.

To provide the best fire protection for occupants and the greatest opportunity to escape, the masonry industry recommends that building codes require a **balanced design** approach comprised of three key elements: fire detection, suppression, and containment by compartmentation. Fire detection includes the installation of smoke detectors and fire alarms; active fire suppression includes the use of sprinkler systems; and fire containment includes interior firewalls, and exterior walls built of noncombustible fire-resistant materials such as concrete masonry. Concrete masonry construction can contain the spread of fire while not emitting toxic gases or smoke, allowing precious additional time for building occupants to exit. Unfortunately, building and fire codes have strayed significantly from this balanced design approach to fire safety. Codes often except (trade-off) the requirements to use noncombustible construction when certain fire sprinkler requirements are met.

Today's building code officials should be encouraged to develop code provisions that provide an improved level of redundancy for life safety and property protection and to eliminate sprinkler trade-offs. Owners and designers should be aware of the benefits of **balanced design**. Consider the reliability of protection from only individual fire-safety components versus the redundancy provided by the complementary features of the balanced-design system. For example, in the event the sprinkler systems fails to properly operate during a fire, the built-in protection offered by concrete masonry fire-separation walls will help contain the fire until it can be controlled. Along with this built-in fire protection, concrete masonry provides property protection, and ensures building stability to allow occupants to safely exit. Without this level of protection, safety can be jeopardized.

References

1. *International Building Code*. International Code Council, Inc., 2003.
2. *Sampling and Testing Concrete Masonry Units*, ASTM C-140-03. American Society for Testing and Materials, 2003.
3. *Standard Specification for Concrete Aggregates*, ASTM C-33-03. American Society for Testing and Materials, 2003.
4. *Lightweight Aggregates for Concrete Masonry Units*, ASTM C-331-04. American Society for Testing and Materials, 2004.
5. *Standard Method for Determining Fire Resistance of Concrete and Masonry Construction Assemblies*, ANSI/ ACI 216.1-97, TMS 0216-97. American Concrete Institute/ The Masonry Society, 1997.
6. *Fire Tests of Building Construction and Materials*, ASTM E-119-00a. American Society for Testing and Materials, 2000.

Wildfire blackened the landscape surrounding this residence, but the concrete masonry walls were unharmed. (Photo courtesy of Concrete Masonry Association of California/Nevada)

For further information on how to put concrete masonry to work for you contact:

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