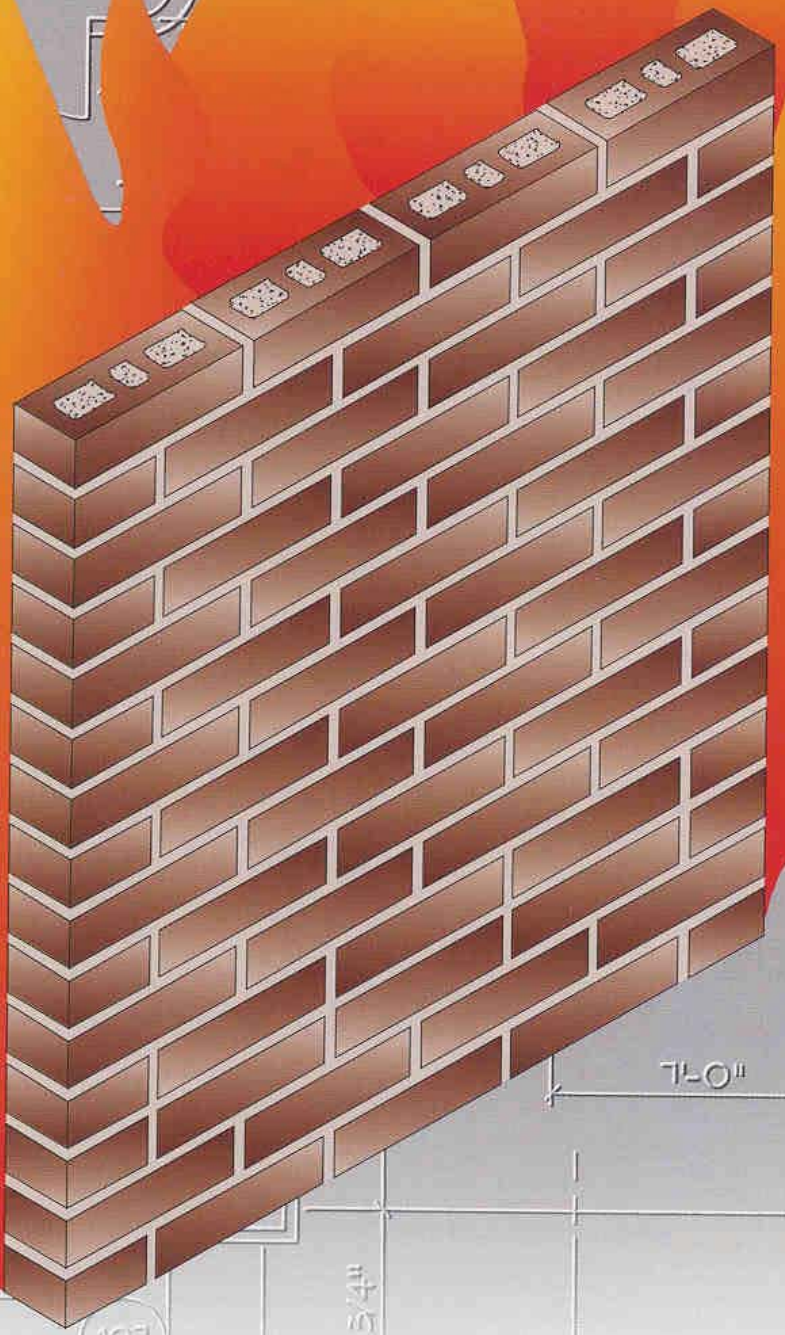
FIRE ENDURANCE RATINGS OF CLAY BRICK MASONRY



WESTERN STATES CLAY PRODUCTS ASSOCIATION

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FIRE ENDURANCE RATINGS

OF

CLAY BRICK MASONRY

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Western States Clay Products Association

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1.0 INTRODUCTION

One of the most frequently asked questions of the designer is “How do I achieve a 1, 2, 3, or 4-hour fire rating using various clay brick masonry assemblies?”

Intuitively, we are comfortable with clay bricks as a fire resistant material because of their use as a liner in fireplaces and kilns where temperatures exceed those expected in most construction fires. In addition, we have observed the effect of fires on buildings where the only thing to remain standing is the brick. Most designers do not question that brick is non-cobustible, or resistant to fire, what they question is the fire resistant of each of the brick wall configurations in hours.

For many wall assemblies, the information was available from BIA technical Notes 16, 16A, and 16B, and the Uniform Building Code Table 7B. For some assemblies, the designer was allowed to use methods of calculating fire resistance. recently, additional tests provided 1 and 2-hour fire ratings for adhered and anchored veneers according to ICBO Evaluating report #5058.

See Appendix A for a copy of ICBO ER 5058

2.0 Fire Resistance Basics

Fire resistance refers to the ability of a structure to act as a barrier to the spread of fire and to confine it to the area of origin. Therefore, in addition to withstanding the fire, the intent of the code is to prevent other materials adjacent to the brick from combusting after prolonged increased temperatures from fire, flame, or hot gases. Consequently, the assemblies are given a fire rating which is the time it takes for a prescribed fire on one side of the assembly to reach an average temperature on the other side that would ignite cotton waste (250°F). Refer to ASTM E119.

Fire ratings are required for load bearing and non-load bearing wall assemblies. Load bearing assemblies must be capable of withstanding the same conditions as the non-load bearing assemblies. In addition, they must be capable of supporting their prescribed design load for the duration of the fire.

Fire endurance tests alone cannot supply all data needed for intelligent appraisal of fire ratings of building elements. There are simply too many different types of assemblies and combinations of materials to classify them all through actual tests. Fortunately, the theory of fire endurance ratings is sufficiently advanced to offer guidance in estimating fire endurance ratings.

The ultimate goal of this guide is to bring together in one location all of the approved fire ratings for adhered veneer, anchored veneer, structural brick veneer and load bearing brick. Our hope is that in the future this material will find a home in Table 719.1(2) of the International Building Code. Until that time arrives, we wish to provide a ready reference table listing the fire resistance ratings for all of the basic wall assembly configurations for brick. See Table 1.

3.0 Masonry Assemblies

Masonry fire resistant assemblies are broken down into adhered brick veneer, anchored brick veneer, structural brick veneer, and load bearing brick.

3.1 Adhered Brick Veneer is defined as brick veneer secured and supported through adhesion to an approved bonding material applied over an approved backing. The most common wall assembly is defined by a facing of thin brick between ½” to 1-1/2” in thickness applied over a plaster backing to create a 1-3/4” masonry layer for a 1-hr rating to 2”masonry layer for a 2-hr rating. The plaster is applied

to metal lath, which in turn is applied to wood or steel framing.

The wood or steel framing members must be sized for all design loads. Steel studs are to be a minimum of 2-1/2". Wood framing is to be 2 x 4 minimum. Wider framing members can be used without degrading the fire resistance rating.

Fire Resistance Tests. Approved fire resistance ratings for adhered veneer have not yet found acceptance into the body of the code. However, a series of test panels constructed and tested in accordance with ASTM E119 have been submitted to ICBO E.R. and have received acceptance number 5058.

3.1.1 Panel Construction.

The panels were constructed similar to those for the earlier large program of gypsum board fire evaluation tests. Type X gypsum board was applied to one face of standard steel stud construction. Typical backing and adhered brick veneer was installed on the opposite face by masons experienced in such work.

The panel was designed for symmetrical resistance as required by the International and Uniform Building Codes; however, if one designs for a situation in which fire exposure is limited to 1-face only, the resisting thickness can all be on one side.

3.1.2 Fire Testing. The veneered panels were exposed according to the procedures of ASTM E119, ie. Standard furnace temperature rise; thermocouples on the unexposed face to show temperature rise; verification that there were no cracks that would allow passage of flame or hot spots; and resistance to hose stream exposure without penetration. Additional thermocouples were installed during construction to provide information on the thermal gradient through the section during the fire test. This information helped revise design alternates with greater accuracy.

3.1.3 Results. All panels passed the three basic ASTM requirements with considerable margin. Although the results were somewhat conservative, indicating that thinner veneer might be used, no further refinements or reduction in design thickness was attempted. Precise refinements are not justified in variable hand placed materials, especially if no great cost benefits would result.

The maximum temperature rise on the unexposed face is permitted to be a maximum of 325°F for a single thermocouple and 250°F for the average of all thermocouples, at the specified time period. The test panels showed the following maximum and average rise of temperature. All withstood more hose stream exposure than required by code.

	Maximum	Average
Panel 1A:	162°F pt.	158°F
Panel 1B:	145°F pt.	135°F
Panel 2A:	129°F pt.	110°F
Panel 2B:	107°F pt.	104°F

3.1.4 Conclusion. Adhered brick veneer 1-3/4" in combined masonry thickness provides 1-hour of fire resistance. Adhered brick veneer 2" in combined masonry thickness provides 2-hours of fire resistance.

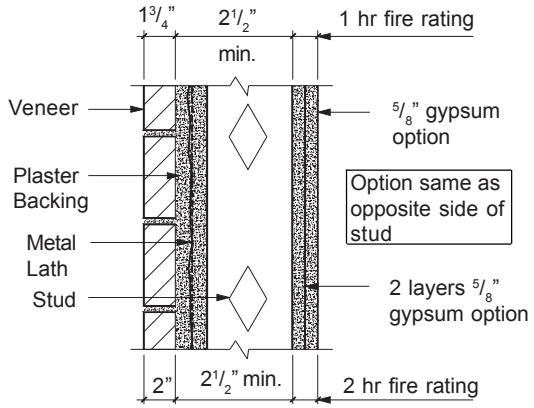


Figure 1 Adhered brick veneer.

3.2 Anchored Brick Veneer is defined as brick veneer secured to an approved backing by mechanical fasteners. The most common wall assembly is defined by a facing of brick between 2" and 5" in width anchored through mechanical connectors to wood or steel framing.

3.2.1 Fire Resistance. From the fire endurance test data for ICBO E.R. 5058, additional information was provided which reduced the thickness of the veneer to 2" with a 1/2" air space for a 1-hour fire rating and a 2" veneer with a 1" air space for a 2-hour fire rating.

Table 719.1(2) of the International Building Code item numbers 1-1.1 through 1-2.1 can also be used to determine the minimum equivalent thickness for brick to achieve a fire rating from 1 to 4 hours. This section of the table is used for veneer brick and structural brick in load bearing and non-load bearing construction.

Excerpts From Table 719.1(2)

Item #	construction	4hr	3hr	2hr	1hr
1-1.1	solid brick	6.0"	4.9"	3.8"	2.7"
1-1.2	hollow brick	5.0"	4.3"	3.4"	2.3"
1-1.3	hollow w/ insulation	6.6"	5.5"	4.4"	3.0"
1-2.1	4" brick w/ furring	-	-	5.0"	-

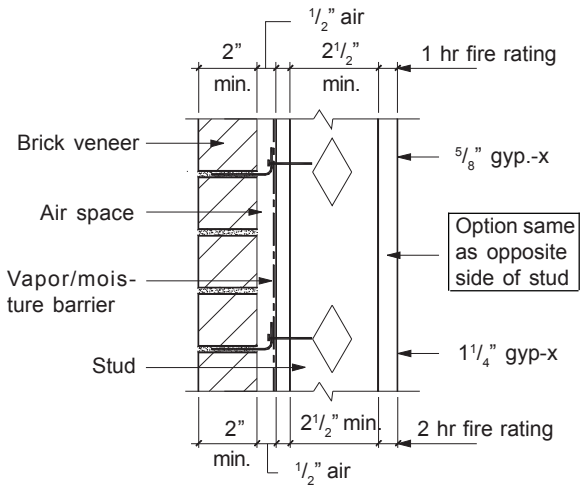


Figure 2 Anchored brick veneer.

3.3 Structural Brick Veneer is similar to anchored brick veneer as it carries no gravity loads other than its own weight, the weight of windows, and possibly other miscellaneous loads. In addition, it is not part of the lateral load resisting system. The difference is that the structural brick veneer is reinforced and grouted to allow the brick to span much further between wall ties. Structural brick veneer does not generally require a backup system to carry lateral loads within the panel. In the Structural brick veneer, the lateral loads are transferred through tensile stresses in the masonry.

3.3.1 Fire Resistance. Table 719.1(2) of the International Building Code item numbers 1-1.1 through 1-2.1 can also be used to determine the minimum brick thickness to achieve a fire rating from 1 to 4 hours. This section of the table is used for structural brick veneer.

Two of the sections shown on the Research Evaluation 5058 are for reinforced hollow brick veneer.

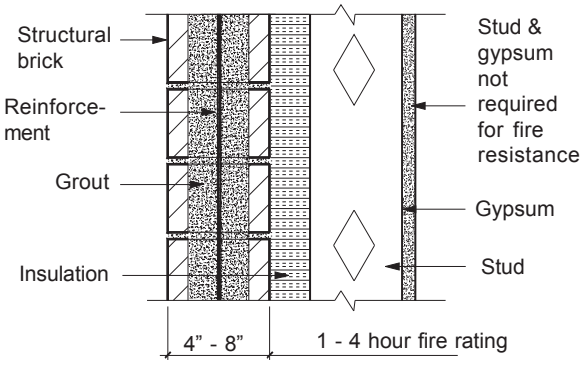


Figure 3 Structural brick veneer.

3.4 Structural Load Bearing Brick is defined as a masonry assembly of brick, mortar, grout and reinforcing that is designed to support all gravity and lateral loads. These masonry elements are generally part of the lateral load resisting system. Greater fire endurance performance and economics can be

Table 1
Fire Resistance (R) in Hours

Masonry Assembly		Actual Wall Thickness (inches)	3.1 Fire Resistance (hours)
Adhered veneer	**ASTM C 1088**	1.75" *	1
		2" *	2
Anchored Veneer	**ASTM C 216**	2" to 5"	1
Structural Veneer and Load Bearing Brick			
Solid 75%	**ASTM C 216**	3.5"	1.25
		5.5"	2.55
		7.5"	4
8" Cavity wall with 2" air space		8"	3
10" Cavity wall with 2" air space		10"	4
Hollow - cells not filled	**ASTM C 652**	3.5"	1
		5.5"	1
		7.5"	4
Hollow - all cells filled [1]	**ASTM C 652**	3.5"	1
		5.5"	3
		7.5"	4
Air (A)		1/2" to 3-1/2"	0.30
Plaster (Pl)		1/2"	0.30
		5/8"	0.37
		3/4"	0.45

Notes:
* Thickness includes plaster bedding
[1] Cells may be filled with perlite, vermiculite, expanded shale aggregate or grout

achieved through the use of reinforced masonry. Fire ratings of 3 and 4 hours can be achieved through the use of up to 8" hollow clay brick.

3.4.1 Fire Resistance. Table 719.1(2) of the International Building Code item numbers 1-1.1 through 1-2.1 can also be used to determine the minimum brick thickness to achieve a fire rating from 1 to 4 hours. This section of the table is used for structural brick in load bearing and non-load bearing construction.

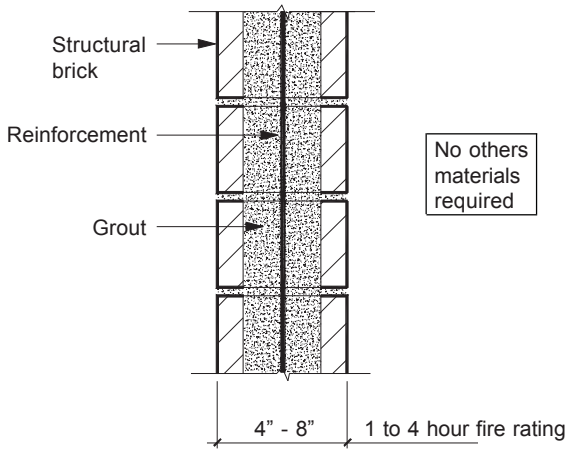


Figure 4 Structural load bearing brick.

See Appendix A for a copy of ICBO ER 5058.

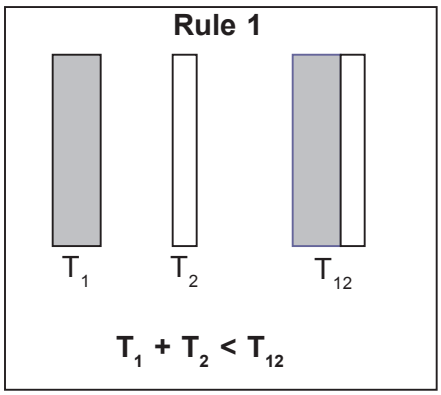
4.0 Estimating Fire Endurance Ratings

As it is impossible to define all of the possible configurations that might be conceived in a wall design, a new standard has been added to the code, Standard 7-7. This standard lists more precise rating values for thicknesses of brick, mortar, air space, cement, gypsum plaster, wall board, insulation, studs, siding, etc. The standard refers to more precise acceptable calculations or combinations and provides the exponential equation $R = (R_1^{0.59} + R_2^{0.59} + R_n^{0.59} + A_1 + A_2 + \ldots PI)^{1.7}$ where R is the fire resistance of each material layer, A is the resistance of each air layer and PI is the resistance of gypsum plaster. Table 1 identifies a list of R, A, and PI values for use in determining the Fire endurance of miscellaneous clay masonry assemblies.

Standard 7-7 lists 8 rules that are helpful in making a quick assessment of the fire endurance of building elements when fire test data on the elements are not available.

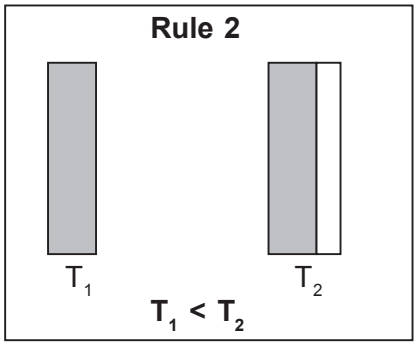
4.1 Rule 1

The "thermal" fire endurance of a construction assembly consisting of a number of parallel layers is greater than the sum of the "thermal" fire endurance characteristic of the individual layers when exposed separately to fire.



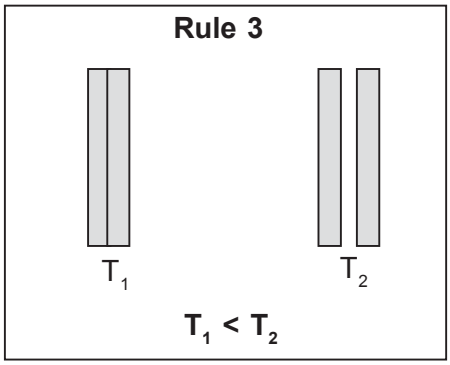
4.2 Rule 2

The fire endurance of a construction assembly does not decrease with the addition of further layers.



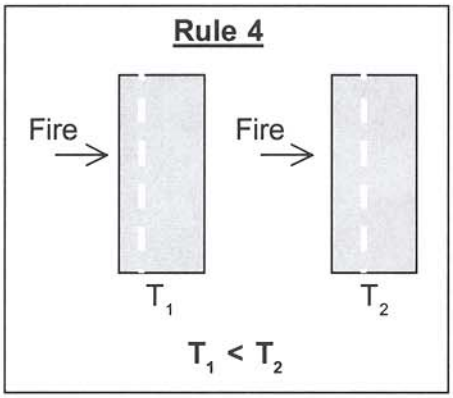
4.3 Rule 3

The fire endurance of a construction assembly containing continuous air gaps or cavities is greater than the fire endurance of similar constructions of the same weight, but containing no air gaps or cavities.



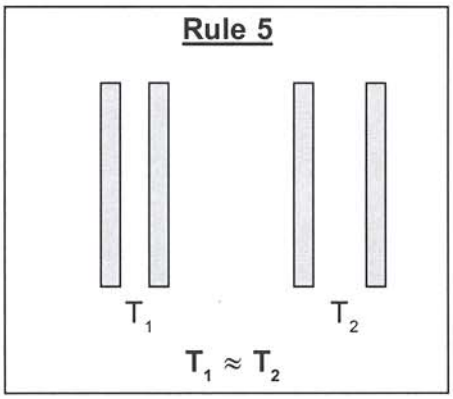
4.4 Rule 4

The farther an air gap or cavity is located from the exposed surface, the more beneficial is its effect on the fire endurance.



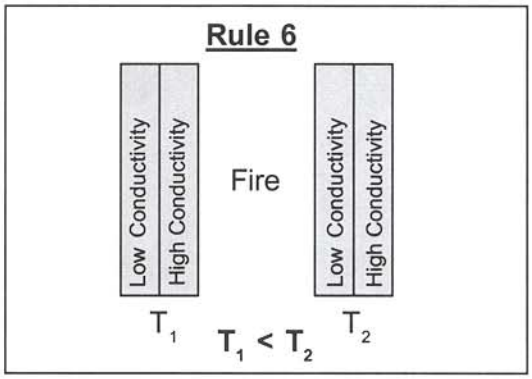
4.5 Rule 5

The fire endurance of a construction assembly can not be increased by increasing the thickness of a completely enclosed air layer.



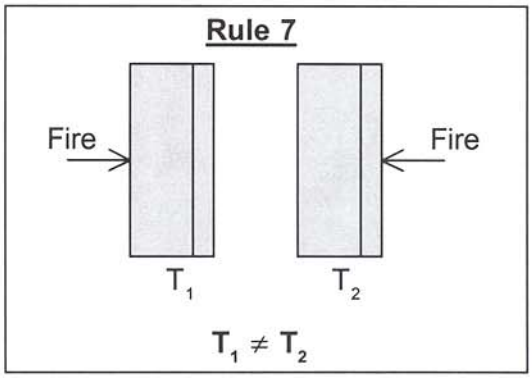
4.6 Rule 6

Layers of materials of low thermal conductivity are better utilized on that side of the construction on which fire is more likely to happen.



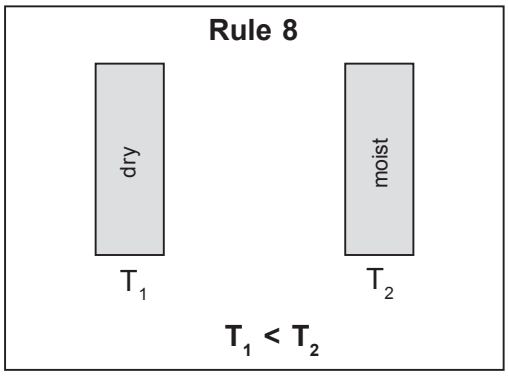
4.7 Rule 7

The fire endurance of asymmetrical construction assemblies depends on the direction of heat flow.



4.8 Rule 8

The presence of moisture, if it does not result in explosive spalling, increases the fire endurance.



5.0 Considerations

When backing materials are used to provide support for the fire resistive materials, the backing material shall be protected with the same fire resistance rating on both sides.

Although life safety is the primary reason for incorporating fire resistance in construction, when considering tradeoffs such as gypsum, or sprinklers, other issues should also be considered such as, fire separation, property protection, water damage, replacement costs and reuse of structure.

ES REPORT™

ER-5058

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Filing Category: FIRE-RESISTIVE CONSTRUCTION—Other Fire-resistive Construction

BRICK VENEER FIRE ENDURANCE RATINGS OF WALL ASSEMBLIES

WESTERN STATES CLAY PRODUCTS ASSOCIATION (WSCPA)
386 BEECH AVENUE, UNIT #4
TORRANCE, CALIFORNIA 90501-6202

1.0 SUBJECT

Brick Veneer Fire Endurance Ratings of Wall Assemblies.

2.0 DESCRIPTION

2.1 General:

The brick veneer may be adhered or anchored in compliance with Chapter 14 of the 1997 *Uniform Building Code*™ (UBC), and applied to one or two faces of nonbearing wall assemblies for one- or two-hour fire-resistive assembly ratings.

2.2 Materials:

2.2.1 Thin Veneer Brick Units: Units are produced from clay or shale in thicknesses from $^1/_2$ to $1^1/_2$ inches (12.7 to 38 mm) and comply with ASTM C 1088, Grade TBS or better.

2.2.2 Brick Units: Units are made from clay or shale in thicknesses exceeding $1^1/_2$ inches (38 mm) and comply with UBC Standard 21-1 in the appropriate grade for exposure as described in Section 21.101.3 or 21.106.2 of the standard.

2.2.3 Mortar: Type S as set forth in Table 21-A of the UBC.

2.2.4 Plaster Backing: Portland cement plaster complying with Section 2508.1 of the UBC.

2.2.5 Lath: Minimum 3.4 pounds per square yard (1.8 kg/m^3) metal lath complying with Section 2506 of the UBC.

2.3 Installation:

Details of one- and two-hour nonbearing walls are noted in Figures 1a and 1b. For symmetrical one-hour fire resistance, each face shall have not less than one layer of $^5/_8$-inch-thick (15.9 mm) Type X gypsum wallboard, or equivalent gypsum plaster, or $1^3/_4$-inch (45 mm) thickness of masonry veneer. For two-hour fire resistance, each face shall have not less than two layers of $^5/_8$-inch-thick (15.9 mm) Type X gypsum wallboard, or equivalent gypsum plaster, or 2-inch (51 mm) thickness of masonry veneer.

2.3.1 Steel Framing: Framing with either gypsum plaster of gypsum wallboard must comply with Items 14-1.1, 14-1.2, 14-1.3, 14-1.4, 16-1.1, 16-1.2, or 16-1.3, Table 7-B of the UBC.

2.3.2 Wood Framing: Framing with either gypsum wallboard or gypsum plaster must comply with Items 15-1.1, 15-1.2, 15-1.3, 15-1.4, 17-1.1, , 17-1.2, 17-1.3, 17-1.4, 17-1.5 or 17-1.6, Table 7-B of the UBC.

2.3.3 Adhered Veneer: Metal lath is installed in compliance with Section 2506.1 of the UBC. Where lath is attached to steel framing, minimum 1-inch-long (25.4 mm), No. 6 drywall screws are used. For exterior walls, a weather-resistive barrier described in Section 2506.4 of the UBC is required. As an alternative, paperbacked metal lath recognized in a current evaluation report, with paper complying with Section 1402.1 of the UBC may be used. The portland cement plaster is applied in compliance with Section 2508 of the UBC to a minimum $^3/_4$-inch (19.1 mm) thickness. The thin veneer units are applied in compliance with Section 1403.5.4.1 of the UBC in running bond. For one-hour fire resistance, the total thickness of plaster, mortar and brick veneer shall be at least $1^3/_4$ inches (45 mm). For two-hour fire resistance, the total thickness of plaster, mortar and thin brick shall be at least 2 inches (51 mm).

2.3.4 Anchored Veneer: Anchored veneer is installed in compliance with Section 1403.6.4.2 of the UBC for 2-to-5-inch-thick (51 to 127 mm) units and Section 1403.6.4.3 of the UBC for units up to 10 inches (254 mm) thick. Stud spacing is limited to 16 inches (406 mm) on center, and a weather-resistive barrier complying with Section 1402 of the UBC is required on the exterior side of exterior walls. Anchored units may be used for one- or two-hour fire-resistive assemblies.

2.4 Identification:

The materials are identified as specified in the UBC or a current evaluation report. Thin veneer units are identified with the manufacturer's name and address, size, type and grade in evidence of compliance with ASTM C 1088.

3.0 EVIDENCE SUBMITTED

Reports of fire-resistive tests conducted in accordance with UBC Standard 7-1, and descriptive details.

4.0 FINDINGS

That the Brick Veneer Fire Endurance Ratings of Wall Assemblies comply with the 1997 *Uniform Building Code*™ (UBC), subject to the following conditions:

4.1 Materials and installation comply with this report and the UBC.

4.2 Wall systems are limited to nonbearing assemblies.

This report is subject to re-examination in two years.

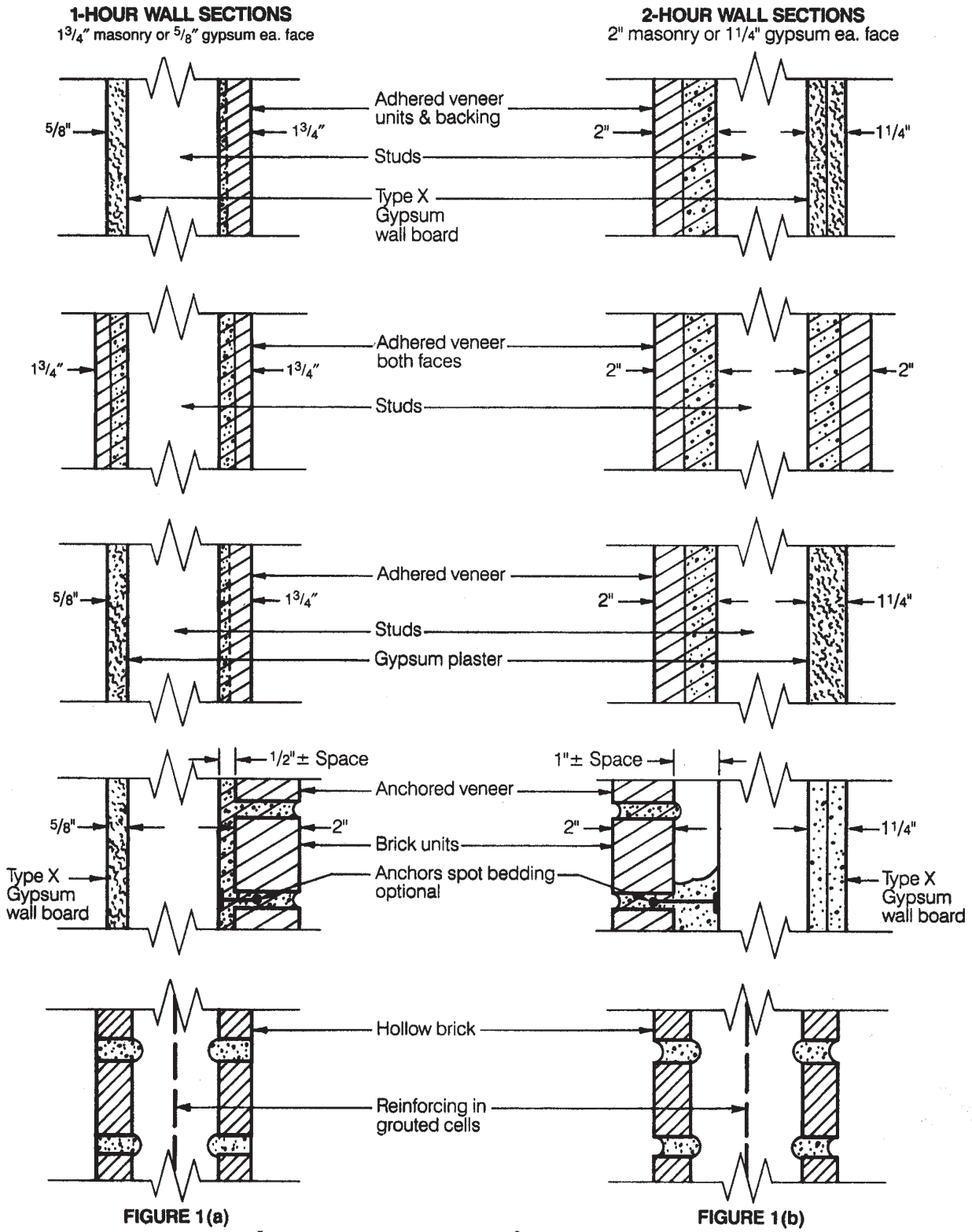

FIGURE 1(a) **FIGURE 1(b)**

The one-hour walls require not less than $5/8$-inch gypsum board or plaster, or $1\,3/4$ inches of adhered veneer and backing on each face. The two-hour walls require not less than $1\,1/4$ inches (two $5/8$-inch boards) wallboard or gypsum plaster, or not less than 2 inches of brick veneer and backing on each face.

The thickness of brick veneer includes the unit, the cement bond coat and cement backing surface. Walls of hollow brick construction, in compliance with Chapter 21 serving as reinforced veneer may be rated for fire endurance as in Items 1-2.4 or 1-2.5 of Table 7-B.

FIGURE 1—FIRE RATINGS OF BRICK VENEER WALLS