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CONCRETE MASONRY FIREPLACES

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Construction (2003)

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INTRODUCTION

The fireplace is an American tradition and remains today a central feature of the home. Concrete masonry, due to its inherent fire resistance and beauty, is a popular and versatile building material for constructing part or all of a fireplace.

Noncombustible concrete masonry effectively isolates the fireplace fire from nearby combustible materials such as wood, plastic and insulation. In addition, because of concrete masonry's thermal mass, heat is stored in the concrete masonry itself. Thus, heat is not only radiated to the room from the fire, but also from the concrete masonry hours after the fire dies.

Concrete masonry fireplaces are a safe and efficient source of auxiliary heat when properly designed and constructed. All fireplaces contain essentially the same elements: a base, combustion chamber, smoke chamber and chimney, as shown in Figure 1 for a single opening fireplace. Requirements herein are based on the *2003 International Residential Code* (IRC) (ref. 1).

BASE

The fireplace base consists of the foundation and hearth extension support. The foundation consists of a concrete footing and concrete masonry foundation walls or a thickened slab for slab-on-grade construction (see Figure 1). Local building codes should be reviewed for design soil pressures for foundations. Void areas are often provided in the base to form an air passage for external combustion air, an ash pit or both. Nonessential void areas should be solidly filled with masonry.

Immediately above the foundation walls, support for the combustion chamber and the hearth extension are necessary. The hearth extension may be supported by corbelling the masonry foundation wall, but is usually provided by a poured concrete slab that also supports the combustion chamber. Forming the concrete

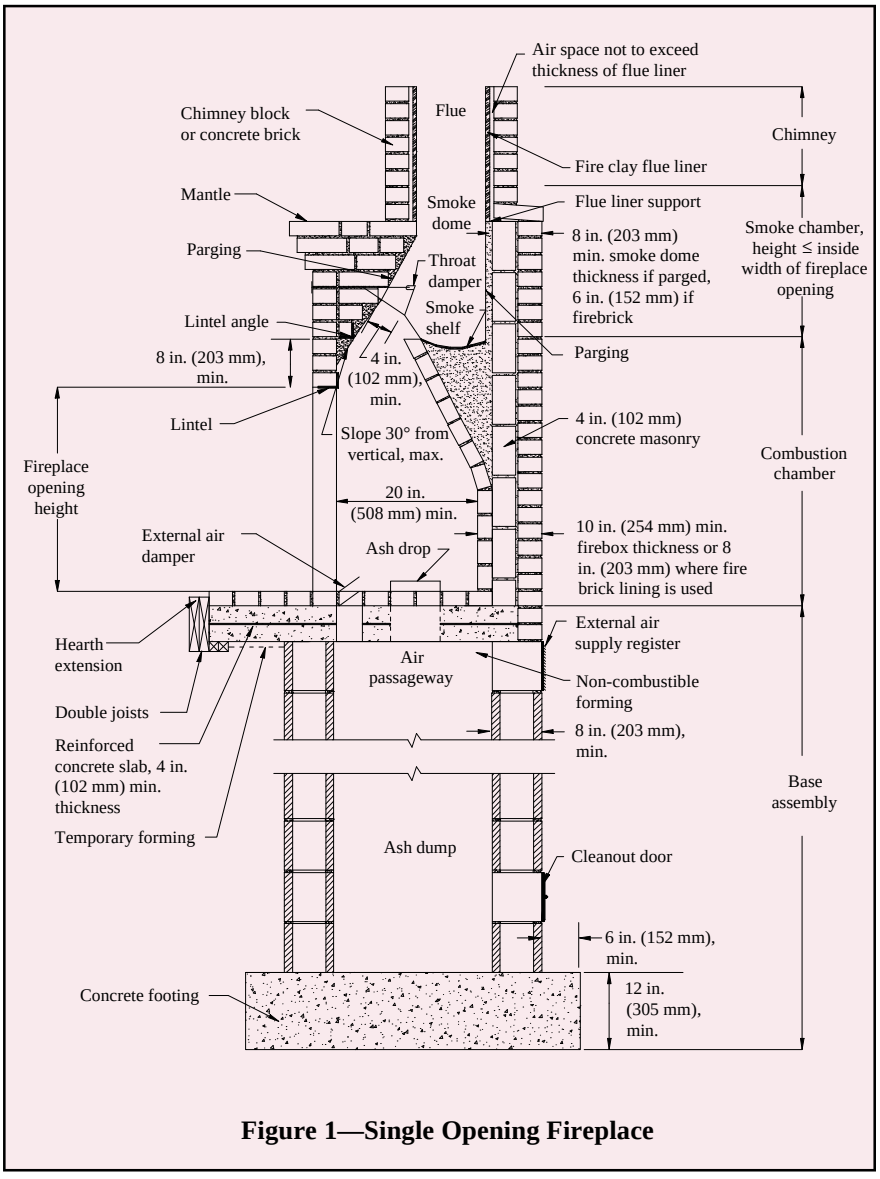

Figure 1—Single Opening Fireplace

slab requires "block outs" for external combustion air dampers and ash drops if there are air passageways or ash pits incorporated into the base of the fireplace. If permanent forming is required at the top of the foundation walls, it must be a noncombustible material. Temporary wood forming is typically used to pour the hearth extension support. The forming should be placed so that the projected slab will meet a doubled wood floor joist, and be such that it can be easily removed. The concrete slab must be at least 4 in. (102 mm) thick, reinforced and capable of resisting thermal stresses resulting from high temperatures.

The hearth extension must extend at least 16 in. (406 mm) in front of the fireplace face and at least 8 in. (203 mm) beyond each side of the fireplace opening for fireplaces with openings that are less than 6 ft^2 (0.56 m^2). If the area of the fireplace opening is 6 ft^2 (0.56 m^2) or larger, the hearth extension must be 20 in. (508 mm) in front of the fireplace face and at least 12 in. (305 mm) beyond each side of the opening. Because the hearth extension must be constructed of noncombustible materials, concrete brick or decorative concrete masonry units are often used to construct the hearth extension.

COMBUSTION CHAMBER

The combustion chamber consists of the hearth extension, the firebox and surrounding masonry and the throat. Fire brick, if used, must conform to *Standard Classification of Fireclay and High-Alumina Refractory Brick*, ASTM C 27 or *Standard Specification for Firebox Brick for Residential Fireplaces*, C 1261 (refs. 2, 3), laid to form a firebox wall thickness of at least 2 in. (51 mm). Fire brick is laid using medium-duty refractory mortar conforming to *Standard Test Method for Pier Test for Refractory Mortars*, ASTM C 199 (ref. 4), with 1/4 in. (6.35 mm) mortar joints maximum. The total minimum thickness of the back and side walls must be 8 in. (203 mm) of solid masonry including the lining. When no lining is used, this minimum thickness is 10 in. (254 mm).

The fireplace opening should be based on the room size for aesthetics and to prevent overheating the room. Suggested fireplace opening widths are provided in Table 1. Once the opening width is selected, the dimensions of the masonry combustion chamber may be determined using Table 2.

The steel angle lintel used above the fireplace opening should not be solidly embedded in mortar. With the ends free to move, lintel expansion due to high temperatures will not crack the masonry. The use of noncombustible fibrous insulation at the ends of the lintel angle will usually compensate for this expansion and eliminate cracking problems.

The size and position of the throat is critical for proper burning and draft. The fireplace throat should be as wide as the firebox and should be not less than 8 in. (203 mm) above the fireplace opening.

SMOKE CHAMBER

The smoke chamber consists of the damper, smoke shelf, smoke dome and surrounding concrete masonry. The damper, which is critical for proper performance, is placed directly over the throat. The metal damper, like the lintel over the fireplace opening, should not be solidly embedded in mortar. When the fireplace is not in use, the damper should be closed to prevent heat loss. When a fire is started, the damper should be wide open. Once the

Table 1—Suggested Width of Fireplace Openings Appropriate to Size of Room (ref. 5)

Size of room, ft x ft (m x m)	Width of fireplace opening, in. (mm) in short wall		in long wall	
10 x 14 (3.05 x 4.27)	24	(610)	24 to 32	(610-813)
12 x 16 (3.66 x 4.88)	28 to 36	(711-914)	32 to 36	(813-914)
12 x 20 (3.66 x 6.10)	32 to 36	(813-914)	36 to 40	(914-1,016)
12 x 24 (3.66 x 7.32)	32 to 36	(813-914)	36 to 48	(914-1,219)
14 x 28 (4.27 x 8.53)	32 to 40	(813-1,016)	40 to 48	(1,016-1,219)
16 x 30 (4.88 x 9.14)	36 to 40	(914-1,016)	48 to 60	(1,219-1,524)
20 x 36 (6.10 x 10.97)	40 to 48	(1,016-1,219)	48 to 72	(1,219-1,829)

Table 2—Single-Opening Fireplace Dimensions, Inches (ref. 5)[a]

Opening		Firebox				Throat depth	Smoke chamber			Steel angles	
			Rear wall								
Width	Height	Depth	Width	Vertical height	Splayed height		Width	Height	Shelf depth	Length	Size
24	24	16	11	14	18	$8^3/_4$	32	19	12	36	3 x 3 x $^1/_4$
26	24	16	13	14	18	$8^3/_4$	34	21	12	36	3 x 3 x $^1/_4$
28	24	16	15	14	18	$8^3/_4$	36	21	12	36	3 x 3 x $^1/_4$
30	29	16	17	14	23	$8^3/_4$	38	24	12	42	3 x 3 x $^1/_4$
32	29	16	19	14	23	$8^3/_4$	40	24	12	42	3 x 3 x $^1/_4$
36	29	16	23	14	23	$8^3/_4$	44	27	12	48	3 x 3 x $^1/_4$
40	29	16	27	14	23	$8^3/_4$	48	29	12	48	3 x 3 x $^1/_4$
42	32	16	29	16	24	$8^3/_4$	50	32	12	54	$3^1/_2$ x 3 x $^1/_4$
48	32	18	33	16	24	$8^3/_4$	56	37	14	60	$3^1/_2$ x 3 x $^1/_4$
54	37	20	37	16	29	13	68	45	12	66	$3^1/_2$ x 3 x $^1/_4$
60	37	22	42	16	29	13	72	45	14	72	$3^1/_2$ x 3 x $^1/_4$
60	40	22	42	18	30	13	72	45	14	72	$3^1/_2$ x 3 x $^1/_4$
72	40	22	54	18	30	13	84	56	14	84	5 x $3^1/_2$ x $^5/_{16}$

[a] For millimeters, multiply inches by 25.4.

fire is burning readily, the damper should be adjusted to produce more efficient combustion. Keeping the damper wide open reduces the fireplace efficiency. For convenience and safety, a rotary controlled damper that is adjusted with a control on the face of the fireplace is preferred, since adjusting a poker controlled damper usually requires reaching into the firebox.

The masonry above the damper should be supported on a second lintel angle (if required) and not on the damper. This lintel must be allowed to expand independently and thus should not be solidly embedded in the masonry.

Immediately behind the damper is the smoke shelf, which checks down drafts. Any down drafts strike the smoke shelf and are diverted upward by the damper assembly. The smoke shelf may be curved to assist in checking down drafts, but flat smoke shelves perform adequately.

The smoke dome should be constructed so that the side walls and front wall taper inward to form the chimney support. The walls of the smoke dome should be solid masonry or hollow unit masonry grouted solid and should provide a minimum of 8 in. (203 mm) of solid masonry between the smoke dome and exterior surfaces when no lining is used. When the smoke dome is lined using fire brick at least 2 in. (51 mm) thick or vitrified clay at least $^5/_8$ in. (16 mm) thick, this minimum thickness is reduced to 6 in. (152 mm). The inside of the smoke dome should be parged to reduce friction and help prevent gas and smoke leakage (when the inside is formed by corbelling the masonry, this parging is required).

For ease of construction, a high form damper may be used. High form dampers are constructed such that the damper, smoke shelf and smoke dome are contained in one metal unit. Additionally, fireplace inserts may be used. Inserts include the elements of the high form damper as well as the firebox. The inserts are placed directly on the firebrick hearth.

FLUE AND CHIMNEY

The chimney should be positioned so that it is centered on the width of the fireplace and the back of the flue liner aligns with the vertical rear surface of the smoke dome. This configuration funnels the smoke and gases from the fire into the chimney. The chimney is constructed directly over the smoke shelf and consists of a flue liner and a chimney wall. For residential fireplaces, the flue lining may be a clay flue lining complying with *Standard Specification for Clay Flue Linings,* ASTM C 315 (ref. 6), a listed chimney lining system complying with *Standard for Safety for Chimney Liners,* UL 1777 (ref. 7) or other approved system or material. Fireclay flue liners are laid in medium-duty refractory mortar conforming to *Standard Test Method for Pier Test for Refractory Mortars,* ASTM C 199 (ref. 4), with flush mortar joints on the inside. Care should be taken to use only enough mortar to make the joint. Flue lining installation should conform to *Standard Practice for Installing Clay Flue Lining,* ASTM C 1283 (ref. 8).

The chimney wall must be constructed of solid masonry units or hollow units grouted solid, and be at least 4 in. (102 mm) in nominal thickness. The chimney wall should be separated from the flue lining by an airspace or insulation not thicker than the thickness of the flue lining to permit the flue lining, when hot, to expand freely without cracking the chimney wall. Note that in Seismic Design Categories D and E, additional reinforcement and anchorage requirements apply to masonry chimneys in accordance with applicable building codes.

To ensure the fireplace draws adequately, flue size is determined by the shape of the flue and the size of the fireplace opening (see Table 3). The *International Residential Code* (ref. 1) has an Option 2 where the flue size is based on chimney height as well as the fireplace opening area.

The chimney must extend at least 3 ft (914 mm) above the point where the chimney passes through the roof and at least 2 ft (610 mm) above any part of the building within 10 ft (3,048 mm) of the chimney (see Figure 2). Higher chimneys may be required for adequate draft. Good draft is normally achieved with 15 ft (4,572 mm) high chimneys (measured from the top of the fireplace opening to the top of the chimney).

The chimney must be capped to resist water penetration. A mortar wash that is feathered to the edge of the chimney wall is not an adequate cap. The cap should be either cast-in-place or precast concrete, as shown in Figure 2. Metal pan flashing over the top of the chimney will also perform adequately.

CLEARANCES AND FIREBLOCKING

A minimum 2 in. (51 mm) airspace must be maintained between combustible framing and masonry fireplaces, or 4 in. (102 mm) from the back face, and any combustibles, excluding trim and the edges of sheathing materials. The IRC (ref. 1) contains minimum clearances between masonry fireplaces or chimneys and exposed combustible trim and the edges of sheathing materials such as wood siding, flooring and drywall as well as mantles. These air spaces should be firestopped using noncombustible materials as precribed by the building code.

A 2 in. (51 mm) clearance is required around the perimeter of the chimney wall. This clear space should be firestopped in the same manner as described for fireplaces. If the entire perimeter of the chimney wall is outside the building, including soffits or cornices, the clearance between the chimney wall and combustibles may be reduced to 1 in. (25 mm).

ENERGY EFFICIENCY

Proper fireplace design and operation helps maximize the efficiency. Maintaining efficient fuel consumption by properly adjusting the damper is critical. There are several other ways to significantly improve the performance of the concrete masonry fireplace. For example, positioning the fireplace on interior rather than exterior walls reduces heat loss when the fireplace is not in operation, and increases the amount of usable radiant heat from the concrete masonry.

Fireplace efficiency can also be improved by introducing external air into the firebox for draft and combustion (not within

Table 3—Minimum Flue Net Cross-Sectional Area for Masonry Fireplaces

Flue shape	Net cross-sectional area of flue, fraction of fireplace opening size
Round	$^1/_{12}$
Square	$^1/_{10}$
Rectangular:	
aspect ratio < 2 to 1	$^1/_{10}$
aspect ratio ≥ 2 to 1	$^1/_8$

the garage or basement. An external combustion air system requires a damper in the firebox, adequate ducting or air passageways and a grill or louver at the exterior opening. The external air damper should permit the control of both the direction and volume of the airflow for temperature control. The damper should be capable of directing air flow towards the back of the firebox so that when down drafts or negative pressures occur, hot ashes or embers are not forced into the room.

REFERENCES

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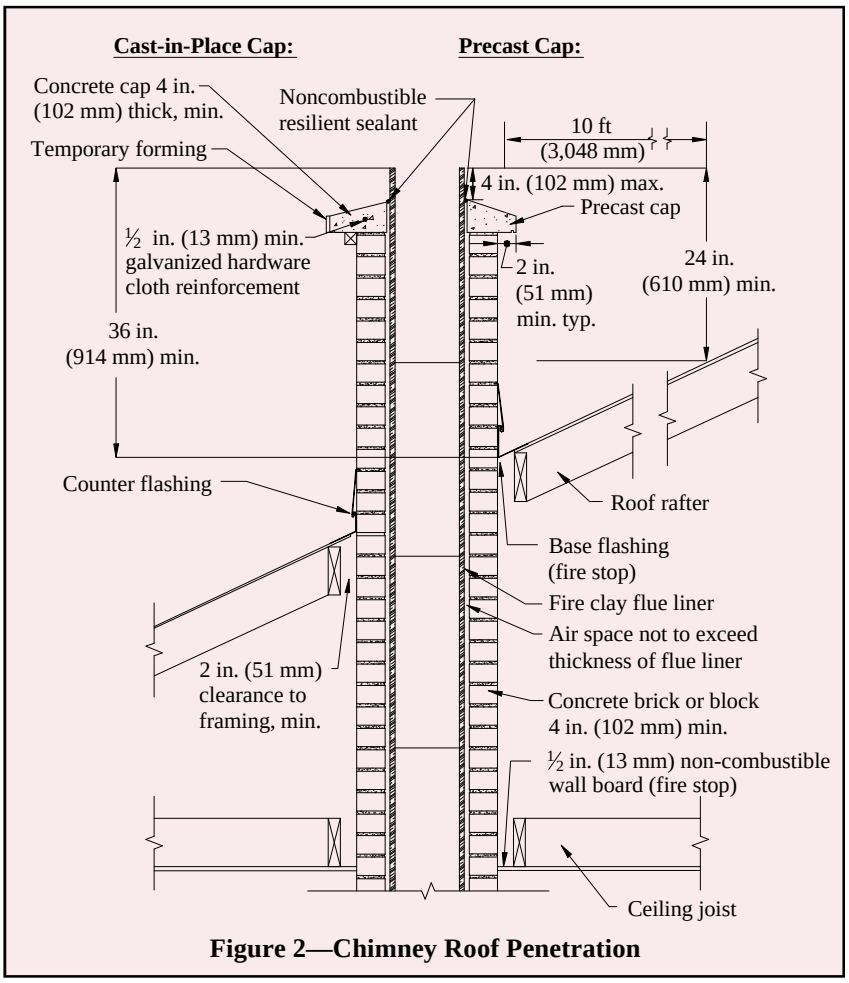

Figure 2—Chimney Roof Penetration