Building a better chimney

Use proper detailing and the best materials to avoid moisture-penetration problems

By Christine A. Subasic

Designers and builders of residential chimneys sometimes fail to realize the severity of the conditions to which a chimney is exposed. As a result, efflorescence, staining, water penetration, and deterioration of masonry chimneys may occur, unless precautions are taken.

Most problems associated with masonry chimneys, whether aesthetic or more substantial, are related to water. Chimneys can be exposed to significant amounts of water under a variety of climatic conditions. Both the warm rains of the South and the cold wind-driven rains and snow of the Northeast can be damaging to a masonry chimney, particularly if the chimney is improperly constructed or poorly maintained. In addition, the thermal cycling that occurs due to varying outdoor temperatures and normal chimney usage can create a potentially damaging environment.

To withstand the rigors of such an environment, a chimney must be properly designed and constructed of the best materials.

Chimney exterior

The materials used to construct exterior chimney walls are subject to the most severe exposure. If brick is used, it should conform to the requirements of ASTM C 216 *Specification for Facing Brick* for Grade SW (severe weathering). Because they have a higher compressive strength and are less absorptive than Grade MW (moderate weathering), Grade SW brick meeting this standard are durable even if frozen while saturated with water (Ref. 1).

ASTM C 216 requirements limit the boiling-water absorption for Grade SW to 17% and the cold-water absorption to 13.3% for an average of five brick. The boiling-water absorption reflects the moisture absorbed under pressure, such as from driving rain or freezing effects. The cold-water absorption is a measure of the moisture absorbed by a unit under normal conditions.

However, in areas with large amounts of rain or numerous freeze-thaw cycles, consider using even less absorptive masonry units—Class SX paving brick conforming to ASTM C 902 *Specification for Pedestrian and Light Traffic Paving Brick*. Because they are laid horizontally, pavers typically

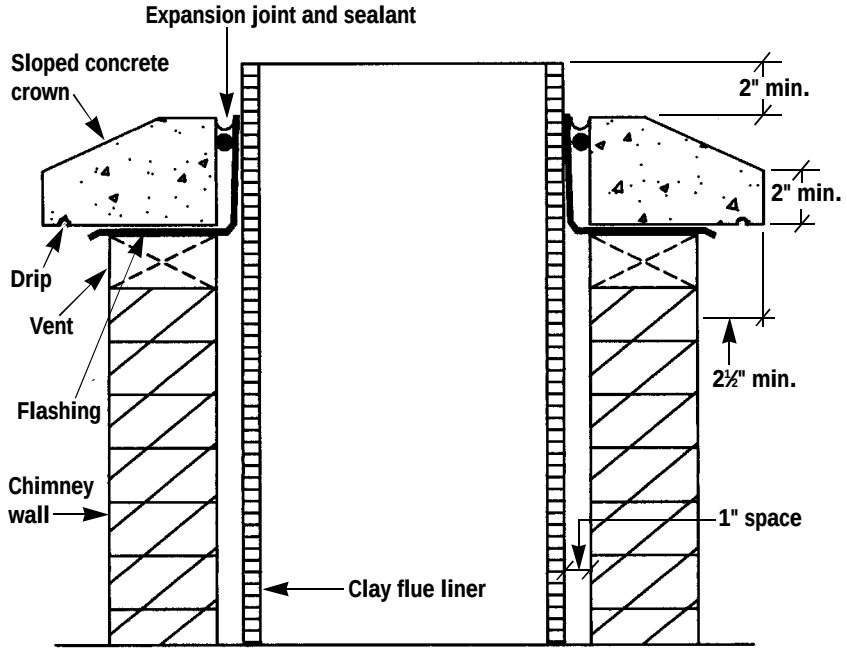


Figure 1 Chimney crown

are subject to more severe weather exposure than brick in vertical applications. Consequently, the absorption limits found in C 902 are considerably lower than those in C 216 (Ref. 2).

ASTM C 902 limits cold water absorption to 8.0% and boiling water absorption to 10.3% for an average of five units. As a result, chimneys built with C 902 brick absorb less water and should provide better durability than those built from C 216 brick.

Mortar used on the exterior of a chimney can be Type N or S mortar made from portland cement and lime or from masonry cement. In areas with wind pressures over 25 psf, the Brick Institute of America (BIA) recommends Type S portland cement-lime mortar for its high tensile strength. Under these conditions, chimneys made with other mortars are more prone to cracks at the brick/mortar interface.

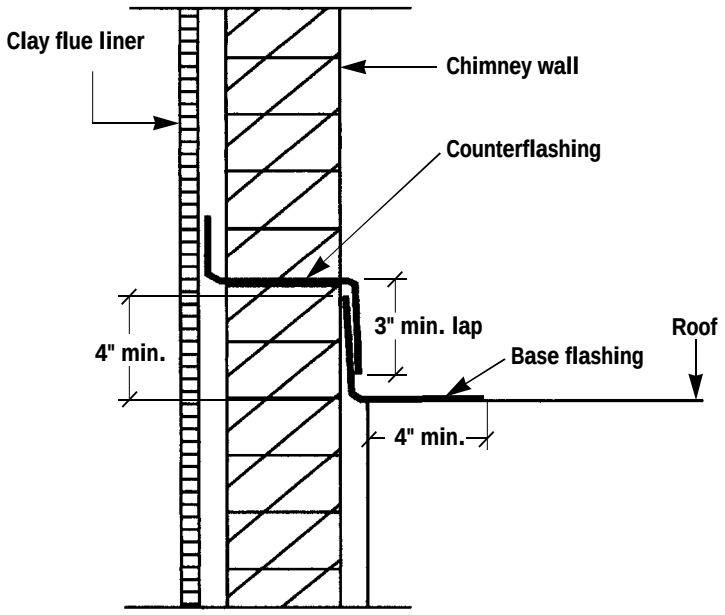


Figure 3 **Through-wall counterflashing**

Chimney interior

The interior of a masonry chimney typically is constructed with clay flue liners conforming to the requirements of ASTM C 315 *Specification for Clay Flue Linings*. Because of their exposure to moisture from condensing flue gases and the exterior elements, only non-water-soluble refractory mortars should be used for laying the flue, as specified by the National Fire Protection Association standard NFPA 211 (Ref. 3). These mortars should meet the requirements of ASTM C 105 *Specification for Ground Fire Clay as a Refractory Mortar for Laying Up Fireclay Brick* or ASTM C 199 *Test Method for Pier Test for Refractory Mortars,* medium-duty.

Chimneys used to vent high-efficiency gas appliances are subject to highly acidic condensate. Use clay flue liners and an acid-resistant or chemical-resistant mortar in these chimneys for best performance. Do not use portland cement or calcium aluminate cement because of their low acid resistance.

To accommodate the wide temperature changes experienced by the flue, include a 1-inch air space between the exterior chimney walls and the flue. In high seismic areas, this space is filled with grout for structural reasons, but reinforcement placed within this space helps to accommodate the thermal stresses that occur.

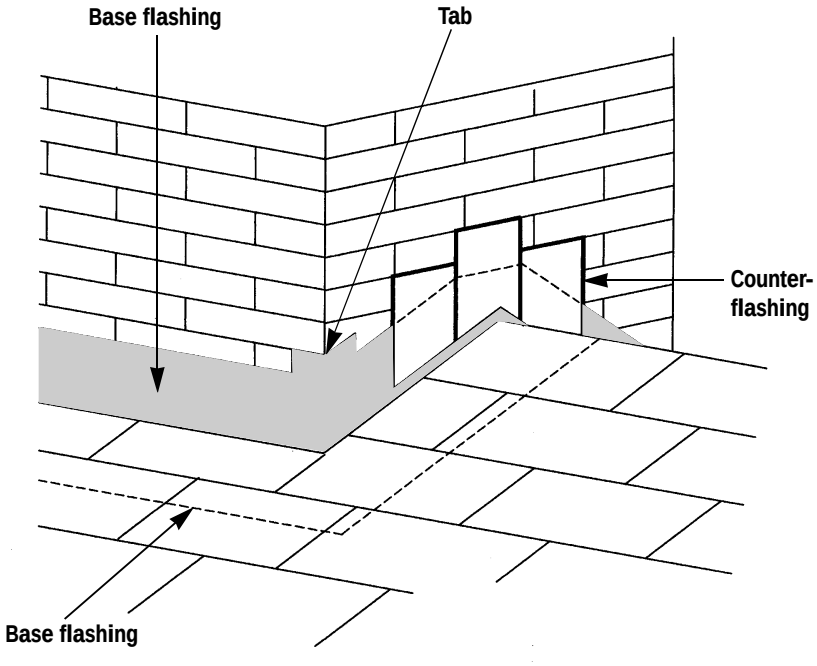


Figure 2 **Intersection with the roof**

Crown

Better chimney design always includes a crown to protect the chimney walls and interior from rain and snow. A portland cement concrete crown is recommended. Whether prefabricated or cast-in-place, a concrete crown should be at least 2 inches thick with a slope of 3 inches or more to promote drainage, as shown in Figure 1. The chimney crown should project at least 2½ inches past the face of the chimney wall below and in-

corporate a drip. This reduces water run down on the chimney walls.

Leave a ⅜-inch gap between the chimney crown and the flue to allow for thermal expansion of the flue. The gap should be filled with a backer rod and an elastomeric sealant, such as a silicone or a polysulfide sealant. Extend the flue at least 2 inches or the minimum code-required distance above the top of the crown.

To promote drying of the chimney interior, BIA recommends placing vents in the mortar joints directly below the crown flashing, spaced at 24 inches on center (Ref. 4). Brick vents placed in mortar head joints, combined with weep holes at flashed locations, encourage air circulation in the cavity between the chimney and the flue.

Don't use a mortar wash in lieu of a chimney crown. A mortar wash does not withstand the moisture and temperature changes as well as a concrete crown, nor does it provide an overhang to protect the chimney walls.

Flashing

Flashing should be placed at three locations in a masonry chimney—directly beneath the crown, at the intersection of the chimney and the roof, and at the base of the chimney.

Beneath the crown. Flashing placed beneath the chimney crown protects the chimney walls from any moisture that might penetrate the crown and prevents water from entering the space between the crown and the flue. The flashing should extend beyond the chimney walls to form a drip edge. It should pass through the chimney walls into the space between the walls and the flue. The flashing should be turned upward against the flue and extend up to the top of the crown (see Figure 1). A backer rod and sealant placed between the flashing and the crown provides a tight barrier to water penetration.

Chimney-roof intersection. Proper flashing is critical at the chimney-roof intersection because it prevents water from penetrating into the interior of the structure. Typically, roof or base flashing is installed first. Extend the base flashing at least 4 inches horizontally along the roof and at least 4 inches up the face of the chimney.

Then the counterflashing is installed. It should lap the base flashing a minimum of 3 inches (see Figure 2). BIA recommends extending the counterflashing through the chimney wall, up into the space between the chimney and the flue (see Figure 3). This provides maximum protection from water that penetrates the chimney walls and can be particularly important on tall chimneys that have large areas of exposed wall (Ref. 5).

However, in dry regions with little rainfall, the counterflashing may be terminated in the mortar joints. In this case, the mason should rake out the joint to receive the flashing ¾ to 1 inch. Then the flashing is inserted into the joint and mortared or caulked in place. But use this detail cautiously because it does not provide drainage for water entering the chimney space.

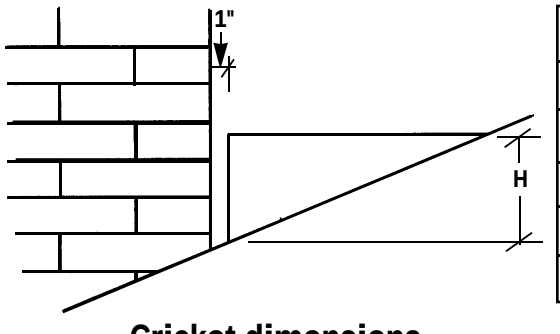
In the northeastern United States, where driving rains are severe, tray or pan flashing may be used. A solid sheet of flashing, often made of lead, is cut to match the chimney cross-section. Holes are then cut for the flue(s).

The tray flashing is laid in place, generally two to four courses above the highest point where the chimney intersects the roof. The flashing is turned up into the cavity around each flue and down to form a drip on the exterior. This provides a continuous barrier to any moisture that penetrates the chimney walls above. To provide drainage, locate weep holes directly above the flashing at 24 inches on center.

Chimney base. If the chimney is built on an outside wall of the residence, the base of the chimney must also be flashed. Place through-wall flashing between the bottom course of brick and the foundation. If the top of the foundation is below grade, provide flashing at a level above the grade line. Weep holes should be placed above grade at the flashing.

Cricket

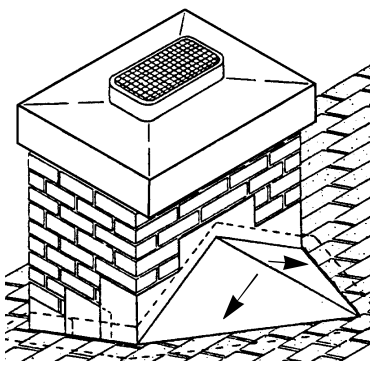
A cricket should be used when the chimney penetrates the roof below the ridge line and the face of the intersecting chimney wall parallel to the roof line is over 30 inches long. Framed of wood and covered with roofing material,



Cricket dimensions

Roof pitch	H
1:1	½W
2:3	⅓W
1:2	¼W
1:3	⅙W
1:4	⅛W

W = Cricket width
H = Cricket height



Chimney cricket

Figure 4

Source: Masonry Institute of America (Ref.6)

crickets are used to divert water from the roof around the chimney. But they do not eliminate the need for flashing and counter flashing around the chimney walls. Crickets should be flashed and counter-flashed like a typical roof intersection (see Figure 4).

Water-repellent coatings

The use of water-repellent coatings when constructing a masonry chimney is not widespread. More often, water repellents are considered when existing chimneys have problems. In the case of newly constructed masonry chimneys, such coatings are appropriate in a limited number of circumstances.

In regions with large amounts of rainfall, the chimney exterior may benefit from treatment with a water-repellent coating, regardless of the type of masonry unit used. When relatively absorptive masonry units are used, water-repellent coatings often can reduce the amount of efflorescence and staining and the likelihood of other water-related problems. More absorptive units include some molded brick, concrete brick, and concrete masonry made from lightweight aggregates.

The type of water-repellent coating to use depends on the type of masonry and the desired chimney appearance. Use a clear water repellent for most brick chimneys; recommended types include siloxanes, silanes, and blends.

For concrete brick and lightweight concrete masonry, an opaque water-repellent coating is used more often. Choose specific brands based on past successful performance in a similar application.

Structural requirements

Constructing a structurally sound chimney depends on anticipating structural loads from wind or seismic forces, as well as the shape and path of the flue. Building codes provide information on minimum wall thicknesses, materials, and other structural requirements. In some cases, high lateral loads may necessitate bracing at the floors and roof and reinforcing of the chimney. Offset or sloped flues must not exceed the limits of structural stability.

When sloping a flue, the maximum angle should be 30 degrees from the vertical. In addition, when corbeling is used, an imaginary line drawn down through the center of the upper, offset portion of the chimney must fall within the lower chimney walls.

Additional limits are placed on corbeling when it is used as a decorative accent at the chimney top. The maximum projection of the decorative corbeling should not exceed the nominal thickness of the chimney wall. For a typical brick chimney, this limits total corbeling to 4 inches. Corbeling of individual units should not exceed one-half the nominal unit height or one-third the nominal unit bed depth.

Maintenance

Yearly inspection of both the interior and exterior of a masonry chimney is recommended for best performance. The interior of the chimney flue should be checked for accumulated creosote and other debris and cleaned as necessary. A visual inspection of the exterior chimney walls and crown will help prevent many water-related problems. Inspection should include:

- Examining the chimney crown for cracks or other deterioration
- Examining the sealant between the top of the crown and flue
- Examining the chimney walls for signs of water penetration, such as efflorescence, staining, cracking, or spalling
- Examining the mortar joints for deterioration
- Ensuring weep holes are clear of any blockage

Making needed repairs will prevent major problems in the future.

Building a better chimney means choosing the best materials for the job, including a concrete chimney crown, flashing at the proper locations, and designing for structural stability in accordance with code requirements. Properly designed, constructed, and maintained, a residential chimney should last a lifetime.

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References

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PUBLICATION #M960244