Reinforcing new and old masonry chimneys

Adding internal reinforcement and external supports can keep chimneys from toppling during earthquakes or high winds

By John A. Koski

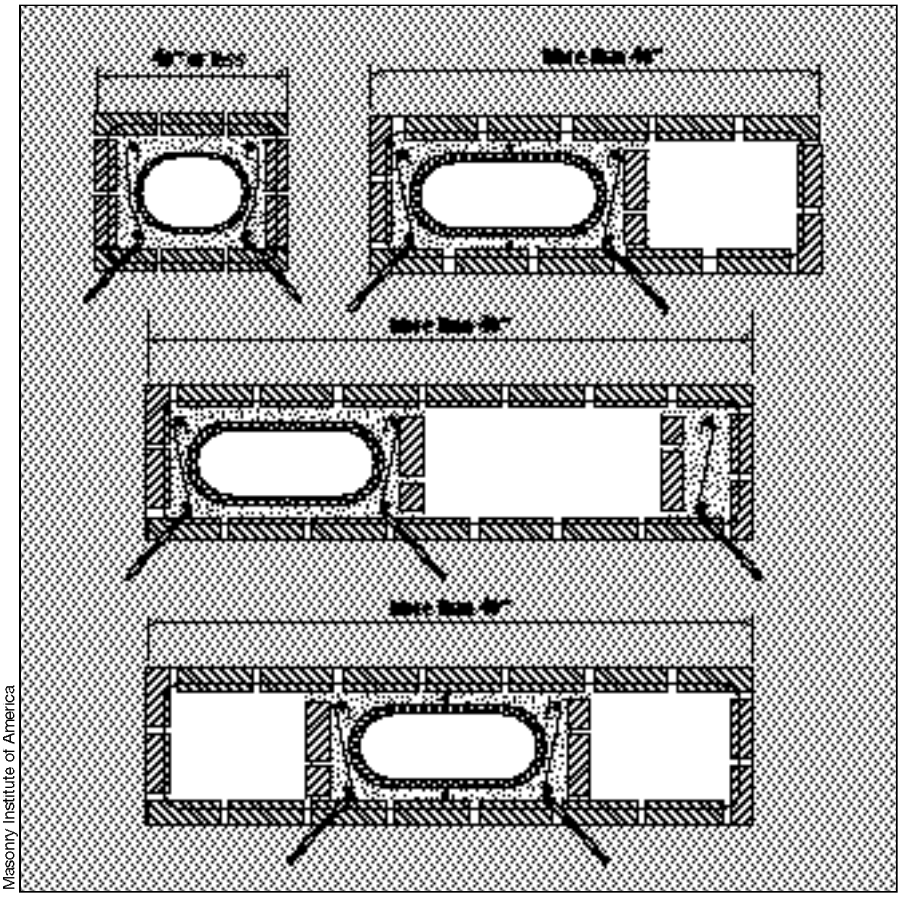
The Richter and Modified Mercalli scales are the most common means of measuring earthquake intensity. Counting toppled chimneys is another method. Because masonry chimneys are one of the most visibly damaged features of a building, scientists sometimes calculate the percentage of chimneys that have fallen in a given area to help determine the severity of an earthquake. During the 1906 San Francisco earthquake, for example, more than 90% of the area's chimneys were destroyed. Those chimneys were unreinforced.

During the 1971 San Fernando earthquake—where most homes were less than 15 years old and had reinforced chimneys—less than one-third of the chimneys in the area of highest seismicity were destroyed. San Fernando's reinforced chimneys helped prevent physical injury to building occupants and greatly reduced the structural damage that occurs when chimneys topple into walls or onto roofs and decks.

Reinforcing chimneys not only is sound practice in areas of seismic risk, but also in areas subject to high winds. To prevent property damage and injury, building codes used in such areas often require reinforced chimneys on new construction and provide details on how to reinforce existing and damaged chimneys.

Perhaps the easiest method to safeguard chimneys against toppling is to build them completely within the exterior walls of a building. However, because this often can't be done for practical or aesthetic reasons, reinforcing the chimney may be necessary.

Figure 1. Vertical and horizontal reinforcement and anchor strap placement on four types of single-flue chimneys.



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Reinforcing new chimneys

Three methods of reinforcement can be used to help ensure the structural stability of new chimneys: vertical reinforcement grouted inside the chimney, horizontal reinforcement placed in the mortar bed, and anchor straps securing the chimney to the building's frame. On some chimneys, anchoring the chimney to the building's frame, at a point above the roof line, will provide sufficient stability against toppling. On other chimneys, all three methods should be used. To ensure adequate reinforcement, always check the building codes in force in your area for specific guidance. The following guidelines incorporate information found in the 1991 Uniform Building Code and other sources.

Vertical reinforcement. On chimneys 40 inches wide or less, use four #4 vertical reinforcing bars. Place one bar in each of the chimney's inside corners. Install the bars to allow a minimum ½ inch of grout cover on all sides. The reinforcement should extend the full height of the chimney.

For chimneys wider than 40 inches, use two additional vertical reinforcing bars for each additional flue in the chimney or for each additional 40 inches in width or fraction thereof. For example, a chimney with three flues or one 90 inches wide each require eight vertical reinforcing bars. Figures 1 and 2 illustrate vertical reinforcing bar locations for six typical chimneys.

Because chimney liners, such as clay flue tiles, need room to expand vertically in response to high flue temperatures, wrap the liner with fiberglass or refractory paper before pouring the grout. Doing so creates a slip plane between the grout and chimney liner, allowing room for the liner to expand vertically.

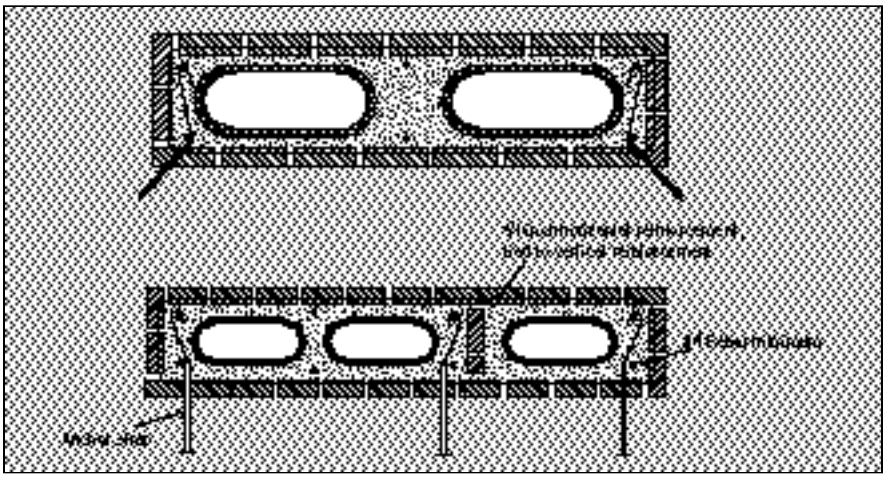

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Figure 2. Vertical and horizontal reinforcement and anchor strap placement on double- and triple-flue chimneys.

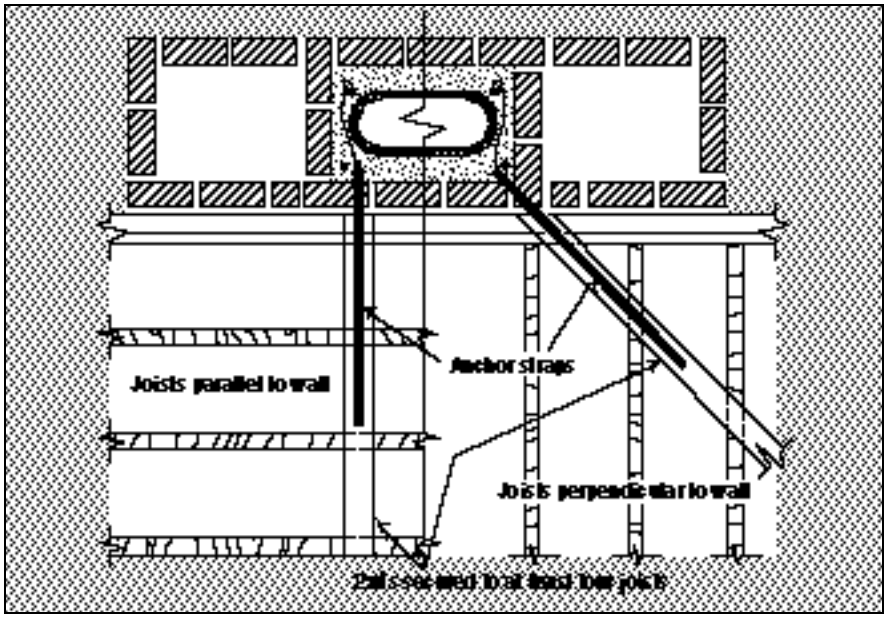
Using hollow core chimney block is another method. Place the vertical reinforcing bars in the corner cores of the chimney block and then grout the cores solid. Make sure, however, that the size of the cores provides adequate grout cover on all sides of the reinforcing bar.

Use a lap splice at least 40 bar diameters long or an approved rebar connector where the ends of vertical reinforcement meet inside the chimney. Tie vertical reinforcement to the chimney at 18-inch intervals vertically, using ¼-inch-diameter steel ties.

Angled offsets in vertical reinforcement should not exceed 1 inch horizontal in 2 inches vertical. Use two ties at any bend in the bar, one tie on each side of the bend.

These reinforcement guidelines are adequate for chimneys that extend no more than 12 feet above the topmost anchor tie or strap. Chimneys that extend more than 12 feet above the topmost anchor tie or strap, those of unusual height, weight, width, and those with other special or unusual features, should be engineered by a competent professional to make sure they are structurally sound.

Figure 3. Two methods for securing chimney anchor straps to wooden joists.



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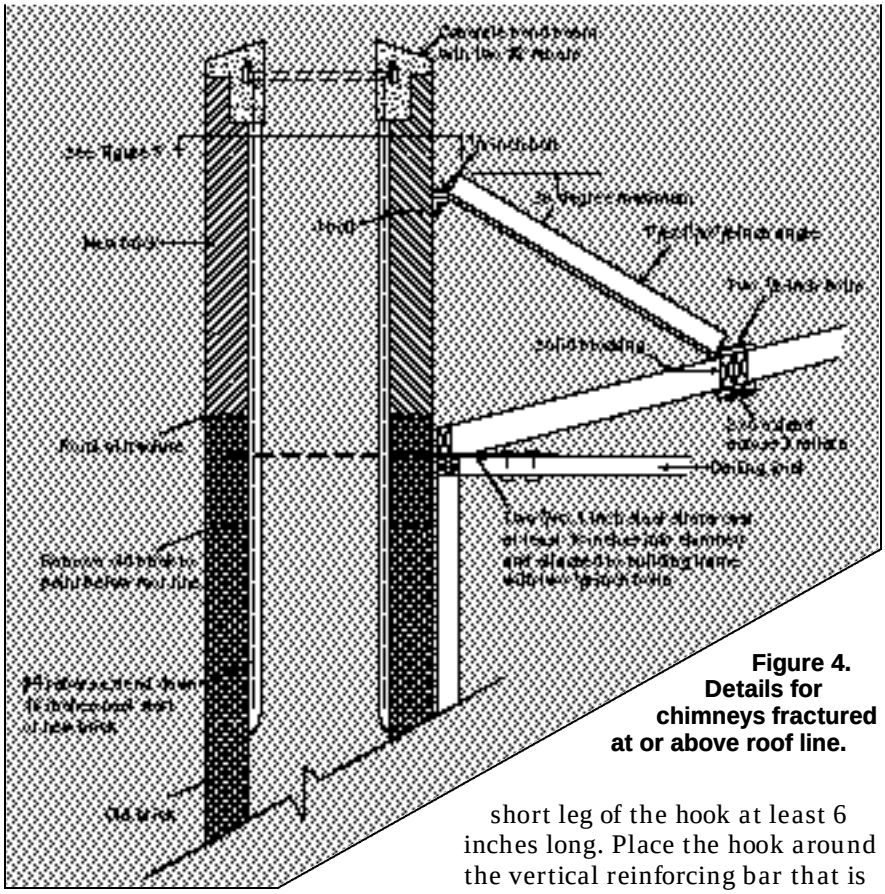

Figure 4. Details for chimneys fractured at or above roof line.

Once vertical reinforcement is in place, grout it with a minimum cover of ½ inch on all sides. Use masonry grout or mortar that has been tempered to a pouring consistency. Before grouting the vertical reinforcement, make sure that any anchor straps needed to secure the chimney to the building's frame are in place.

Horizontal reinforcement. Place horizontal reinforcement in mortar beds at 18-inch intervals vertically and tie it to vertical reinforcement using steel ties at least ¼ inch in diameter.

Chimney anchor straps. Anchor chimneys to the building's frame at each floor or ceiling level that is more than 6 feet above grade. Note, however, that this guideline does not apply when a chimney is constructed completely within the exterior walls of a building. Anchors should consist of two 3/16x1-inch steel straps embedded at least 12 inches into the chimney. Bend the chimney end of the strap into a J-hook with the short leg of the hook at least 6 inches long. Place the hook around the vertical reinforcing bar that is furthest from the building. Then grout the J-hook and vertical reinforcement in place.

Fasten the other end of the anchor strap to the building's frame using two ½-inch-diameter bolts or lag screws. Where joists do not head into the chimney or where they head into the chimney but do not line up with the anchor straps, nail a 2x4 across at least four joists using 16d nails (see Figure 3). Attach the anchor strap to the 2x4 with two ½-inch-diameter bolts or lag screws.

Reinforcing existing chimneys

The Department of Building and Safety for the City of Los Angeles details several methods for repairing and reinforcing damaged chimneys. These techniques also can be used to retrofit existing, undamaged chimneys.

Before repairing a damaged chimney, always inspect the firebox and thoroughly look for cracks or voids that might allow flames or hot gases to contact wood or other flammable materials on the exterior of the firebox or chimney. Repair these cracks or voids before using the fireplace or chimney. Also inspect existing anchorage straps to make sure they are not loose. Securely bolt all loose straps to joists or rafters.

On damaged chimneys, existing reinforcement can be reused if it is sound and can be straightened. Otherwise, cut off damaged rebar and extend the reinforcement by welding new reinforcement to the remaining stub section. Existing reinforcement that has been spliced with C-clamps that have slipped also should be welded.

Figure 4 details how to attach a 1½x1½x⅛-inch angle-iron brace from the chimney to the roof and shows how to use 1x3/16-inch steel straps to secure a chimney to the building's frame just below the roof line. Figure 4 also shows details for a reinforced chimney cap and for placing vertical reinforcement inside the chimney.

The four details in Figure 5 detail three methods for attaching angle-iron braces to chimneys of different construction and four methods for securing vertical and horizontal reinforcing within the same chimneys. Note that two angle-iron braces should be used if a chimney extends more than 5 feet above the roof line.

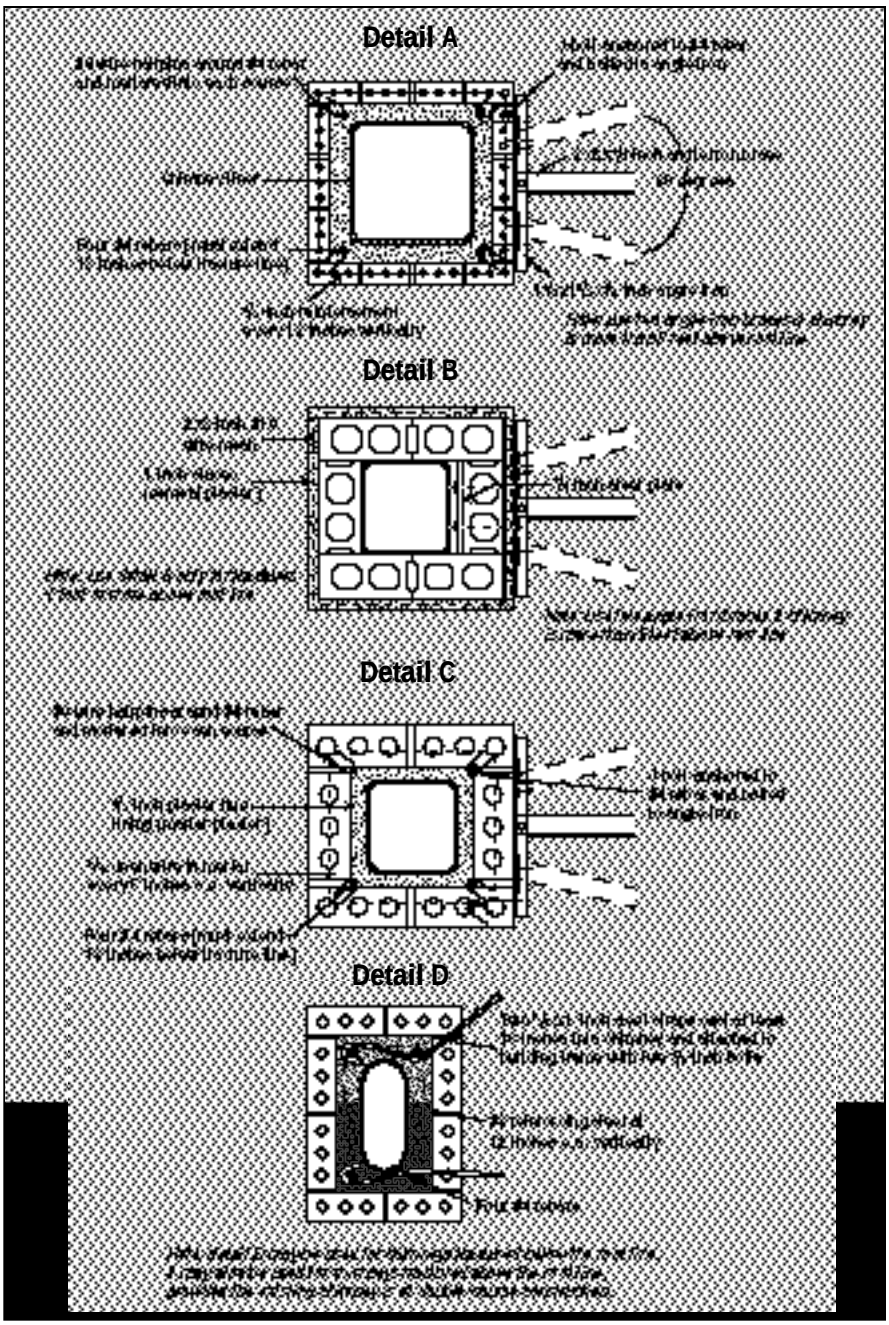

Figure 5. Rebuilding damaged chimneys using external anchor straps and internal vertical and horizontal reinforcement.

References

James E. Amrhein, “Residential Masonry Fireplace and Chimney Handbook,” 1989, Masonry Institute of America, 2550 Beverly Blvd., Los Angeles, CA 90057.

“Repair of Earthquake Damaged Chimneys,” City of Los Angeles, Department of Building and Safety, 200 N. Spring St., 4th floor, Los Angeles, CA 90012.

“Residential Masonry Fireplace and Chimney Construction Details and Specifications,” Masonry Institute of America.

Peter I. Yanev, “Peace of Mind in Earthquake Country,” 1991, Chronicle Books, 275 Fifth St., San Francisco, CA 94103.

“Uniform Building Code,” 1991 edition, International Conference of Building Officials, 5360 S. Workman Mill Rd., Whittier, CA 90601.