6.3 Architectural Components

6.3.7 Chimneys and Stacks

6.3.7.1 Unreinforced Masonry Chimney

Unreinforced masonry (URM) chimneys are extremely vulnerable to earthquake damage; their behavior has long been used as an indicator of seismic intensity as in the Modified Mercalli Intensity (MMI) scale.

Provisions

BUILDING CODE PROVISIONS

Masonry chimneys are subject to the force requirements of ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010), Chapter 13, Nonstructural Components. In addition, masonry fireplaces are subject to the prescriptive requirements of 2012 IBC, *International Building Code*, (ICC 2012), Chapter 21. The 2012 IBC provisions focus on seismic reinforcing and anchorage of masonry fireplaces. In general, unreinforced masonry chimney construction is not permitted in areas of moderate and high seismicity (Seismic Design Categories C and higher).

RETROFIT STANDARD PROVISIONS

ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings* (ASCE, 2007) classifies unreinforced masonry chimneys as force-controlled. Compliance with the requirements of the standard is required for all performance levels in areas of high and moderate seismicity. If the performance level is Hazards Reduced and the unreinforced masonry chimney is located in areas of public occupancy or egress, it must meet the Life Safety performance level. Residential unreinforced masonry chimneys may be retrofitted using prescriptive design concepts.

Typical Causes of Damage

- Unreinforced masonry chimneys may crack, spall, separate from the structure, or collapse. They may fall through the roof structure and injure occupants or fall to the ground.
- Chimneys may suffer damage even at relatively low levels of ground shaking.

DAMAGE EXAMPLES

Figure 6.3.7.1-1 Chimney collapsed and fell through the roof; approximately 2,600 chimneys were destroyed in the 1992 Big Bear City, California earthquake (NGDC, 2009).

Figure 6.3.7.1-2 Residential metal flue in wood frame chimney that failed in the 2003 magnitude-6.5 San Simeon earthquake. The house fell off its cripple wall, pushing over the chimney (Photo courtesy of Michael Mahoney).

Figure 6.3.7.1-3 Chimney collapse (Photo courtesy of Earthquake Engineering Research Institute).

Seismic Mitigation Considerations

- The most reliable mitigation measure is to remove a URM chimney and replace it with a metal flue inside a framed enclosure or to remove the chimney and firebox entirely.
- If the chimney is not being used, reducing its height to not more than 1 to 2 feet above the roofline will limit the potential for damage.
- Chimney and roof configurations vary widely. If a URM chimney is to be braced in place, an engineered design is needed to account for specific as-built construction details.
- To protect against a chimney falling in toward the roof and posing a safety hazard below, the roof can be locally strengthened with plywood.
- Large historically important chimneys need special consideration; these could be reinforced using a "center core" technology to improve their performance; this method involves core drilling the masonry and filling the cores with reinforcing and grout.
- Fire code requirements and local ordinances must be considered when considering strategies for reducing the risk of unreinforced masonry chimneys.
- The City of Seattle developed guidelines for *Alteration and Repair of Unreinforced Masonry Chimneys* following the 2001 Nisqually Earthquake; these can be found at http://www.seattle.gov/dclu/codes/dr/DR2004-5.pdf and include details for straps at the roof and floor lines, bracing above the roofline, and partial replacement above the roofline. Similarly, the Los Angeles Department of Building and Safety developed prescriptive measures for *Reconstruction and Replacement of Earthquake Damaged Masonry Chimneys*, available at http://ladbs.org/LADBSWeb/LADBS_Forms/InformationBulletins/IB-P-BC2008-070EQDamagedChimney.pdf.

MITIGATION EXAMPLES

Figure 6.3.7.1-4 Braced chimney (FEMA, 2004).

MITIGATION DETAILS

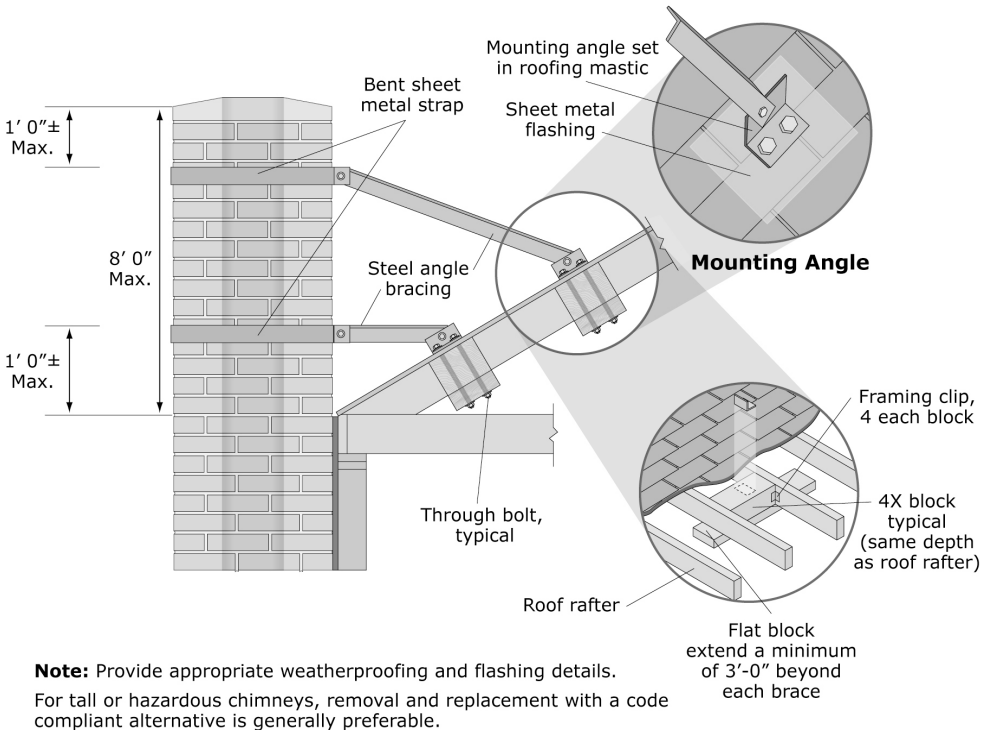

Figure 6.3.7.1-5 Unreinforced masonry chimney bracing (ER).