6.4 Mechanical, Electrical, and Plumbing Components

6.4.1 Mechanical Equipment

6.4.1.5 HVAC Equipment Suspended In-Line with Ductwork

This in-line HVAC equipment typically includes suspended items of sheet metal construction such as fans, coils, VAV boxes, and blowers. The connection details for suspended equipment may also include vibration isolators.

Provisions

BUILDING CODE PROVISIONS

Seismic loads for suspended HVAC equipment in-line with ductwork are determined using ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010), Chapter 13. Depending on the nature of the equipment, the supports may include vibration isolators. The principal objective is to prevent the component from falling.

- ASCE/SEI 7-10 requires anchorage for all suspended equipment in Seismic Design Categories D, E, and F weighing over 20 pounds. Lighter items may be exempt if the component Importance Factor $I_p = 1.0$.
- Suspended HVAC equipment on vibration isolators should be designed using the appropriate design coefficients for isolated components, which will result in higher design forces. See Section 6.4.1.3.
- Equipment that is installed in-line with a duct system that has an operating weight greater than 75 pounds must be supported and laterally braced independent of the duct system. Equipment 75 pounds or less may be supported and braced integrally with the duct system, provided that the equipment is positively attached to the duct with mechanical fasteners.
- Unbraced piping attached to in-line equipment must be provided with flexibility adequate to accommodate seismic relative displacements.
- Items that are exempt from the anchorage requirements noted above are still required to be positively anchored to the structure. The anchorage need not be designed or detailed on the construction documents. Flexible connections must be provided between the equipment and associated pipes, ducts, or conduits, or alternate measures should be employed to protect the connections from damage.

RETROFIT STANDARD PROVISIONS

Suspended HVAC equipment in-line with ductwork is classified as force-controlled by, ASCE 41-06, *Seismic Rehabilitation of Existing Buildings* (ASCE, 2007). ASCE 41-06 requires compliance with the anchorage provisions of the standard when:

- The performance level is Immediate Occupancy
- The performance level is Life Safety in high seismicity areas, if
  - The item is gas-fired,
  - The item is part of an emergency power system, or
  - The item weighs over 20 pounds and is mounted over 4 feet above the floor.
- The recommended evaluation procedure is to use a prescriptive approach, such as provisions in ASCE 7-10 Section 13.6.7.

Typical Causes of Damage

- Poorly supported items can fall.
- Items can swing and impact structural, architectural or other mechanical items. Internal components may be damaged by shaking or impact.
- Connections of fuel lines, water piping, electrical conduit or ductwork may be damaged. Equipment may cease to function due to misalignment or internal damage.

DAMAGE EXAMPLES

Figure 6.4.1.5-1 Damage to suspended HVAC, signs, and louvers was caused when suspended fans in the mechanical penthouse swung and impacted the louver panels. Holy Cross Medical Center in Sylmar, as a result of the 1994 magnitude-6.7 Northridge Earthquake (Photo courtesy of Robert Reitherman).

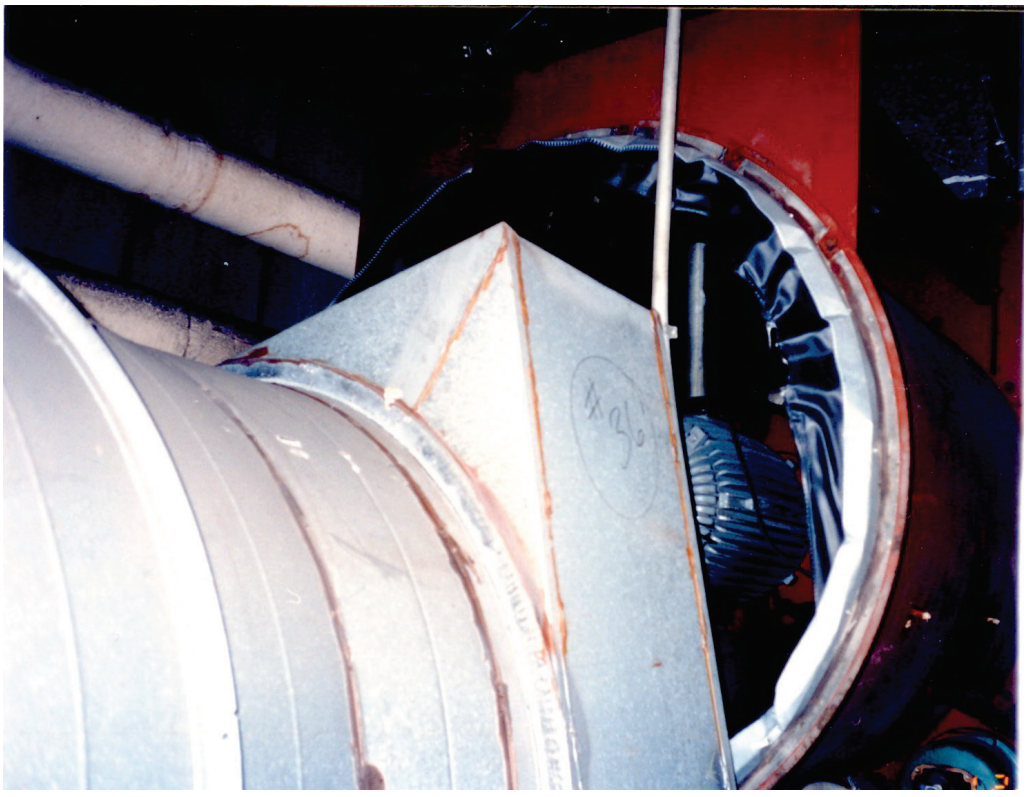


Figure 6.4.1.5-2 Sheet metal duct separated from suspended fan unit (Photo courtesy of Wiss, Jenney, Elstner Associates).

Figure 6.4.1.5-3 Suspended HVAC equipment came down at the Santiago airport terminal in the 2010 magnitude-8.8 Chile Earthquake (Photo courtesy of Gokhan Pekcan).

Seismic Mitigation Considerations

- Items should be braced to structural elements with sufficient capacity to resist the imposed loads. Do not brace to other equipment, ducts, or piping, unless specifically permitted by the reference standards. If installed on pipes, ducts, or conduit that are exempt from seismic bracing, in-line equipment must be supported and laterally braced independently, regardless of weight.
- Flexible connections should be provided for fuel lines and piping.
- Equipment may be suspended either with or without vibration isolation. The vibration isolators may allow more vertical motion in the hangers than in a non-isolated condition, resulting in larger lateral displacements. This should be considered when examining potential interaction with adjacent components and systems. Where vibration isolators are present, a bracing scheme that utilizes aircraft cable for lateral bracing rather than rigid element will prevent accidental transmission of vibration to the structure.
- Refer to FEMA 412 *Installing Seismic Restraints for Mechanical Equipment* (2002) and FEMA 414 *Installing Seismic Restraints for Duct and Pipe* (2004) for additional information and details.
- Several engineered seismic bracing systems are available for suspended equipment and can be customized for most applications. Other options may be found on the internet.

MITIGATION EXAMPLES

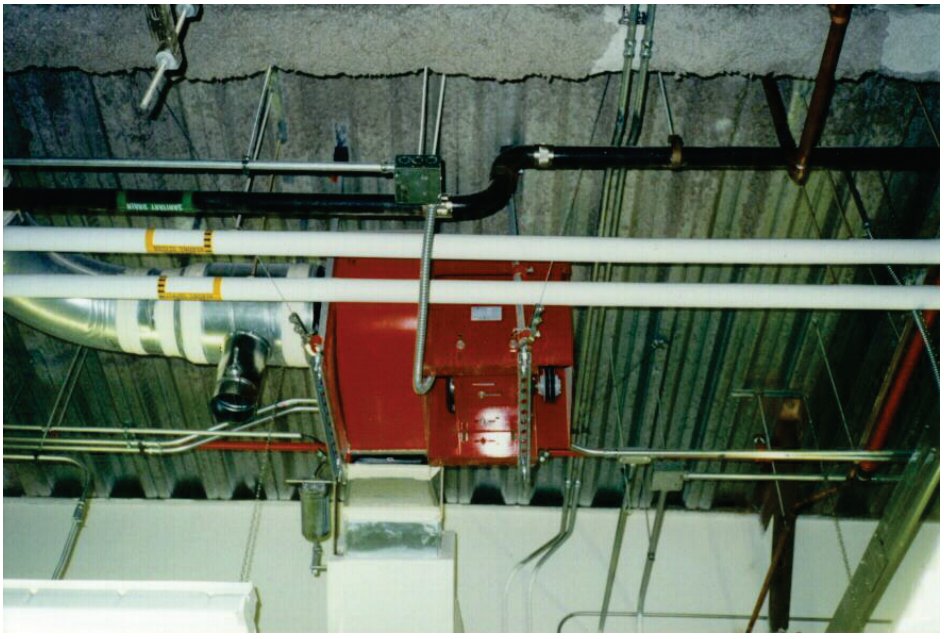


Figure 6.4.1.5-4 Suspended equipment with cable braces (Photo courtesy of Mason Industries).

MITIGATION DETAILS

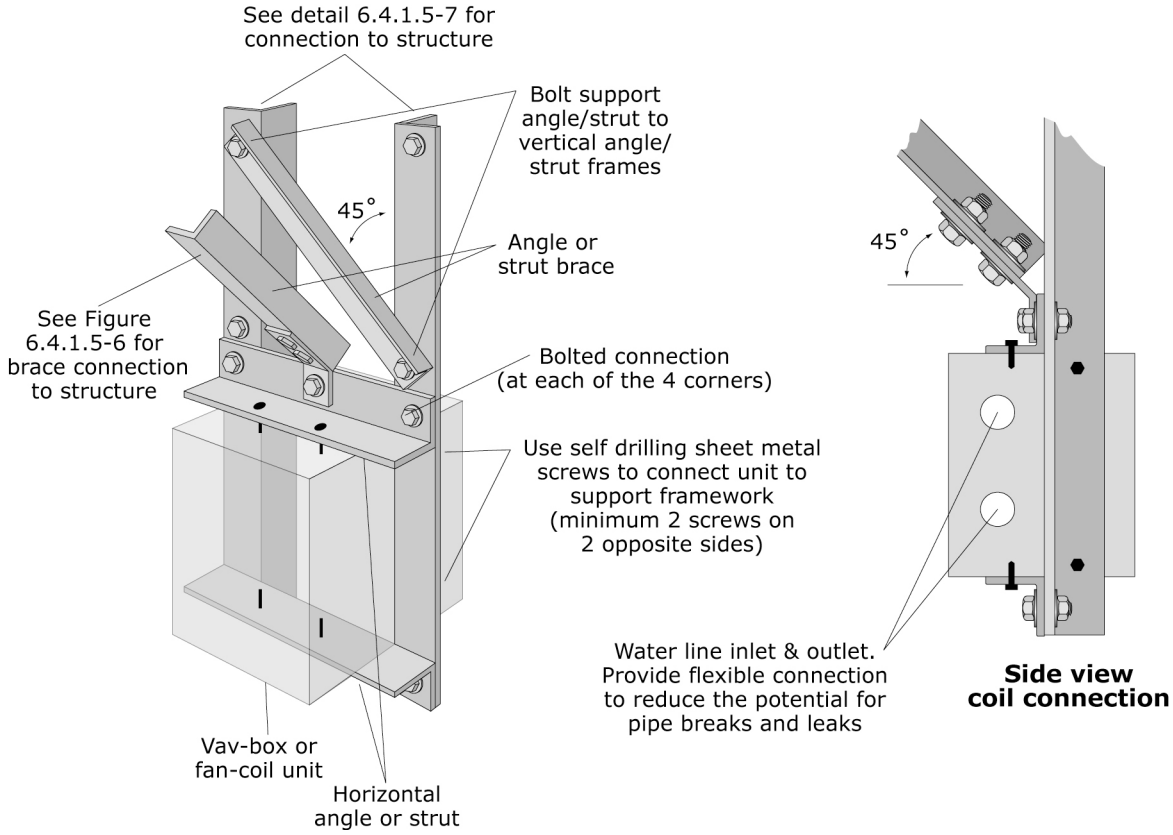
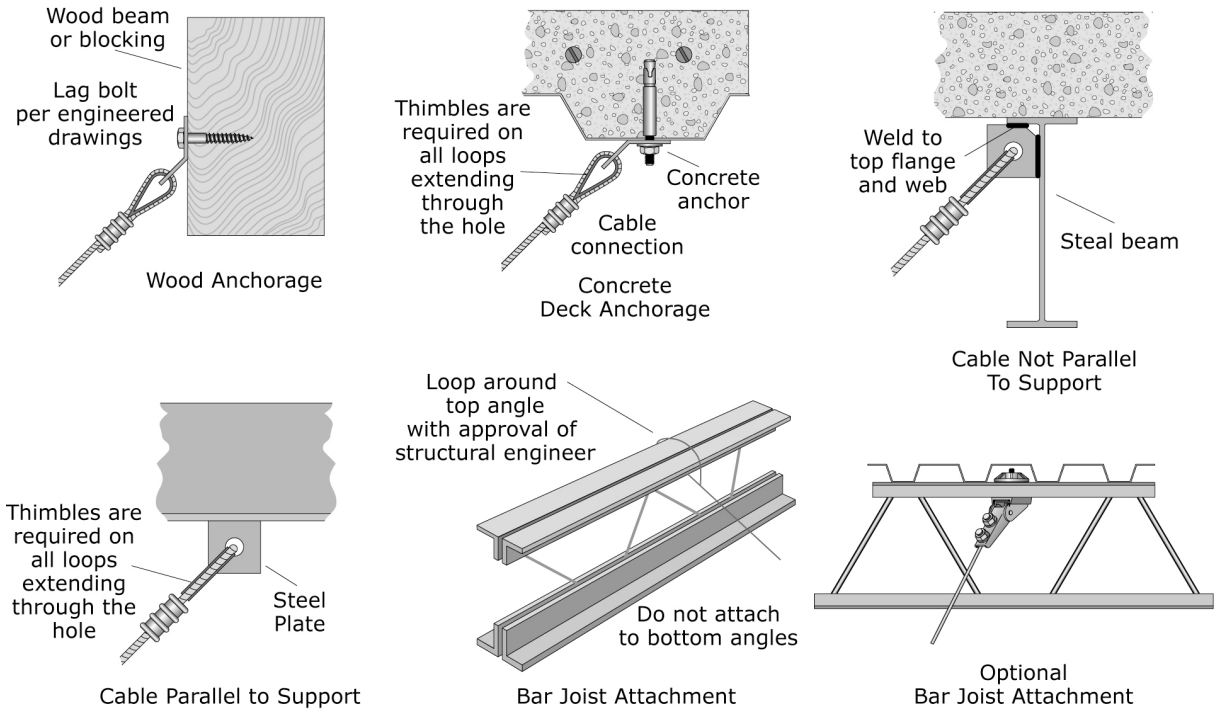
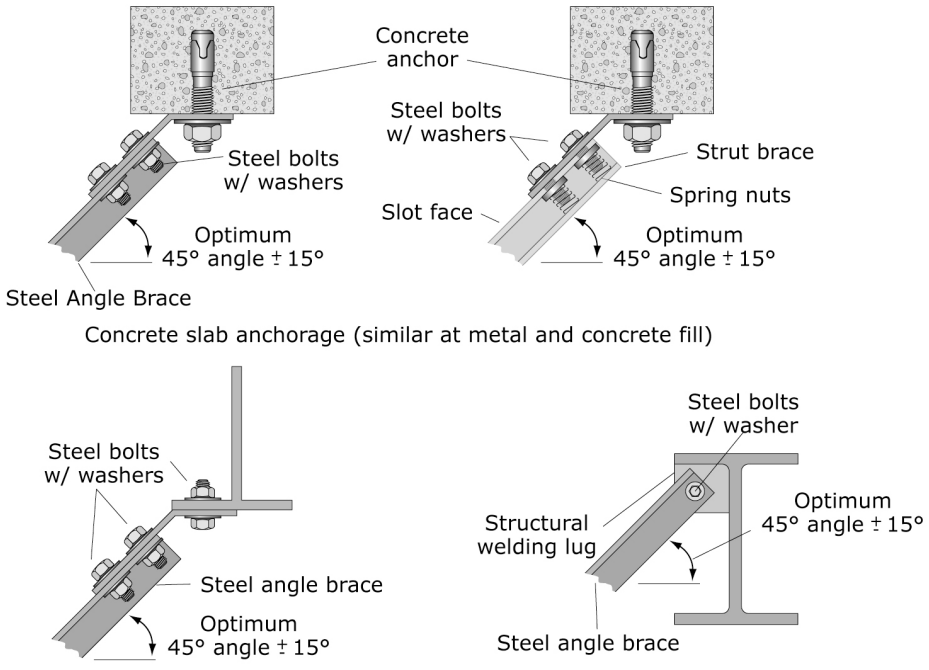


Figure 6.4.1.5-5 HVAC equipment suspended in-line with ductwork (ER).



Cable Brace Attachment to Structure



Rigid Brace Attachment to Structure

Figure 6.4.1.5-6 Cable and rigid brace attachments to structure (ER).

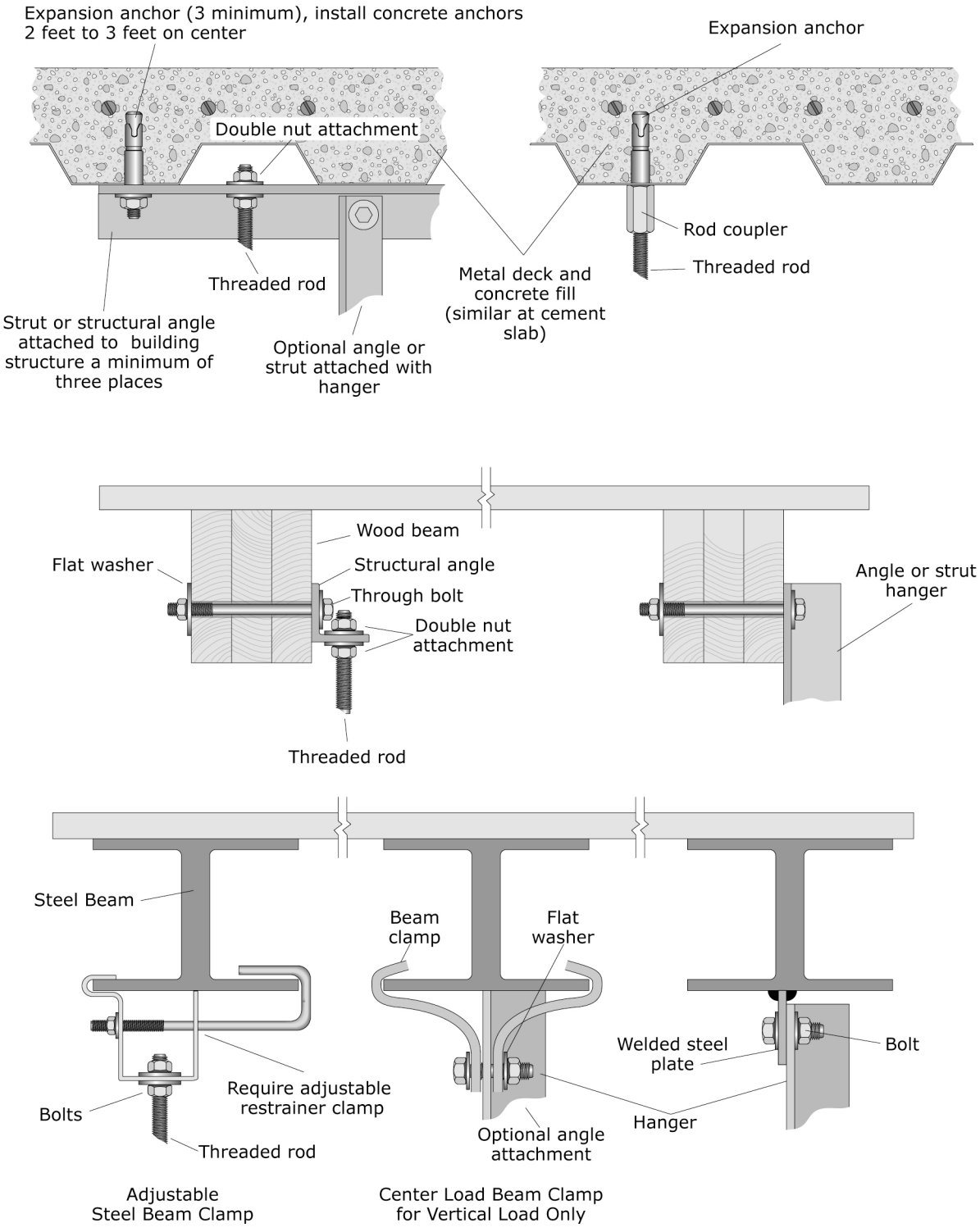


Figure 6.4.1.5-7 Hanger attachment details (ER).