6.4 Mechanical, Electrical, and Plumbing Components

6.4.3 Pressure Piping

6.4.3.5 Floor-mounted supports

This category covers floor-mounted supports for pressure piping. Floor-mounted supports may be used to support either horizontal or vertical pipe runs with or without vibration isolation, either indoors or outdoors. Floor-mounted supports typically involve steel shapes anchored to structural framing or a structural concrete slab. These supports may have one cantilevered support member, one propped cantilever member, or be built up of multiple elements to form a trapeze or braced frame.

Provisions

BUILDING CODE PROVISIONS

ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures*, (ASCE, 2010), Chapter 13 classifies floor-mounted supports as "Component Supports". The design for component supports may be based on reference standards, proprietary systems, or calculated forces. When calculating seismic forces, the design coefficients for the supports are typically the same as those used for the piping. However, in no case should the value of R_p used for support design be greater than 6.0.

- ASCE/SEI 7-10 exempts piping from seismic bracing requirements in Seismic Design Category C if $I_p = 1.0$.
- ASCE/SEI 7-10 requires seismic design for all distribution systems including piping in Seismic Design Categories D, E, and F that weighs more than 5 pounds per linear foot.
- ASCE/SEI 7-10 exempts high-deformability or limited deformability piping (such as steel and copper pipe) where the pipe diameter is small (anywhere from 1- to 3-inch diameter depending on the Seismic Design Category and occupancy). Provisions must be made to accommodate anticipated movement (such as by providing flexible connections, as shown in Section 6.4.3.3) and to avoid impact with other structural or nonstructural components or to protect the piping in the event of such impact.

The stiffness of the support should be designed to be compatible with its' intended function. For example, a relatively slender, flexible cantilever pipe support may not provide effective restraint for a stiff, large diameter steel pipe.

RETROFIT STANDARD PROVISIONS

The requirements for component supports in ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings*, (ASCE, 2007) depend on the type of piping system. Refer to the discussions of different distribution systems for more specific application information. Floor-mounted supports are acceleration sensitive, and when retrofit is required, they must meet the force requirements of the standard.

Typical Causes of Damage

- Failure of pipe supports may result in damage to the support in question, damage to adjacent supports which are overloaded due to the initial failure, damage to the piping or pipe joints, damage to insulation, leakage of the contents, and outage of the system that the pipes support. Joints may fail if the layout of the seismic restraints is poor or where the restraints are inadequate for the anticipated forces and displacements. Piping damage may occur at building separations, seismic joints, or penetrations if the piping has not been detailed to account for the differential movement.
- Several failure mechanisms exist for floor-mounted supports: failure at base if anchorage is undersized, yielding of cantilever elements causing excessive deflection, and buckling of braced elements if braces are undersized.
- Unrestrained piping supported directly on the floor is vulnerable to damage due to excessive movement. Section 6.4.3.8 provides more information about potential damage at pipe penetrations.
- Low lying piping, regardless of the mounting details, is vulnerable to damage due to items falling from above. Pipes may be knocked loose or crushed if heavy items fall on them.

DAMAGE EXAMPLES

Figure 6.4.3.5-1 Pipe and support assembly seem intact but photo shows evidence of longitudinal movement of the pipe in the U-bolts (Photo courtesy of BFP Engineers). A rubber pad was installed between the U-bolt and pipe in order to increase the friction coefficient, but was not sufficient to provide longitudinal restraint.

Figure 6.4.3.5-2 Damage to piping, stud wall and finishes due to movement of poorly restrained floor-mounted piping in the 1994 magnitude-6.7 Northridge Earthquake (Photo courtesy of Mason Industries).

Seismic Mitigation Considerations

- Horizontal and vertical pipe runs need vertical, lateral, and longitudinal restraints. Floor-mounted supports can be used to provide restraint for any combination of these loads, can be designed for many different configurations, may be used with or without vibration isolation, and may be used either indoors or outdoors.
- If the pipe supports are vibration isolated, analysis is required to determine the appropriate seismic design force.
- Longitudinal restraints require positive support to the pipe with a pipe clamp or welded lug; U-bolts do not provide sufficient longitudinal restraint, as observed in Figure 6.4.3.5-1. For insulated piping, longitudinal restraint hardware may need to be located beneath the insulation in order to prevent longitudinal slip.
- In an existing concrete slab, care must be taken to locate rebar or post-tensioned tendons prior to drilling holes for anchor bolts. If the base plate for the pipe support is near the edge of a concrete curb or slab, care must be taken to provide sufficient edge distance and embedment for the anchor bolts. Some types of anchors are not

recommended for use with vibratory loads. FEMA 414, Installing Seismic Restraints for Duct and Pipe (2004) provides additional precautions regarding the installation of anchor bolts and general guidance on pipe restraints.

MITIGATION EXAMPLES

Figure 6.4.3.5-3 Floor-mounted supports for insulated pipe with vibration isolation (Photo courtesy of Mason Industries).

Figure 6.4.3.5-4 Floor/ground-mounted supports for industrial piping in Chile; piping undamaged in the 2010 magnitude-8.8 Chile Earthquake. Pipe supports include concrete pedestal, base plate, and built-up welded support stand. (Photos courtesy of Antonio Iruretagoyena, Rubén Boroschek & Associates).

Figure 6.4.3.5-5 Floor-mounted supports for industrial piping in Chile; piping undamaged in the 2010 Chile Earthquake. The Chilean Industrial Code (Norma Chilena 2369) requires that shear forces be resisted by shear keys as shown; lower photo is detail of piping at upper right (Photos courtesy of Antonio Iruretagoyena, Rubén Boroschek & Associates).

MITIGATION DETAILS

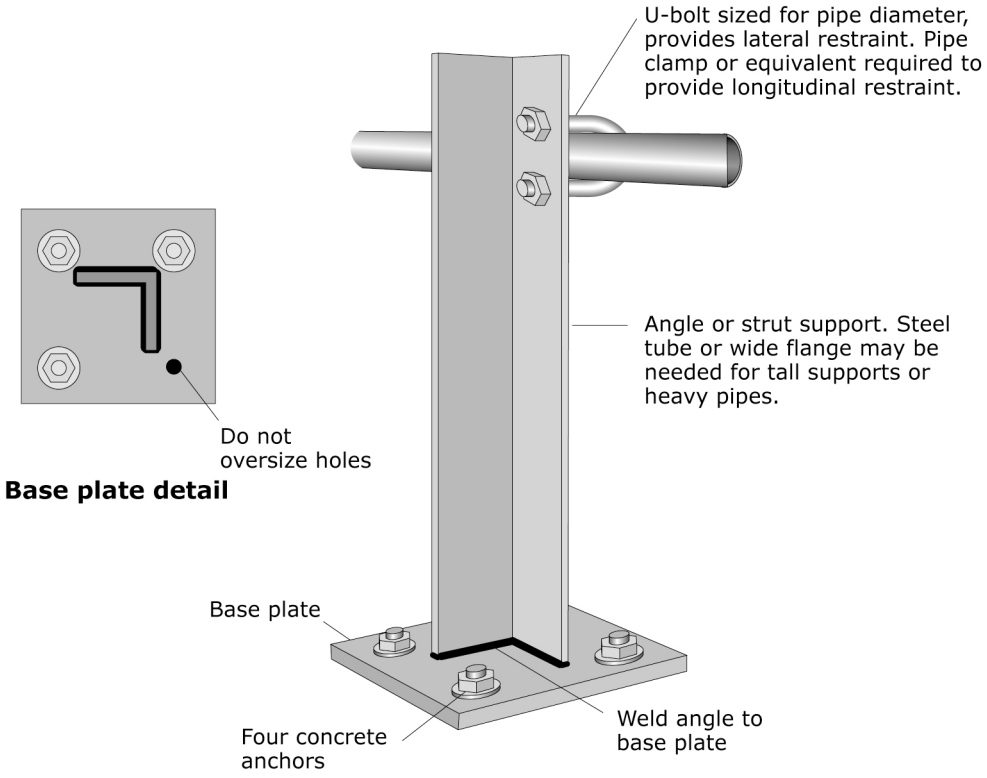

Figure 6.4.3.5-6 Floor-mounted single vertical pipe support (ER).

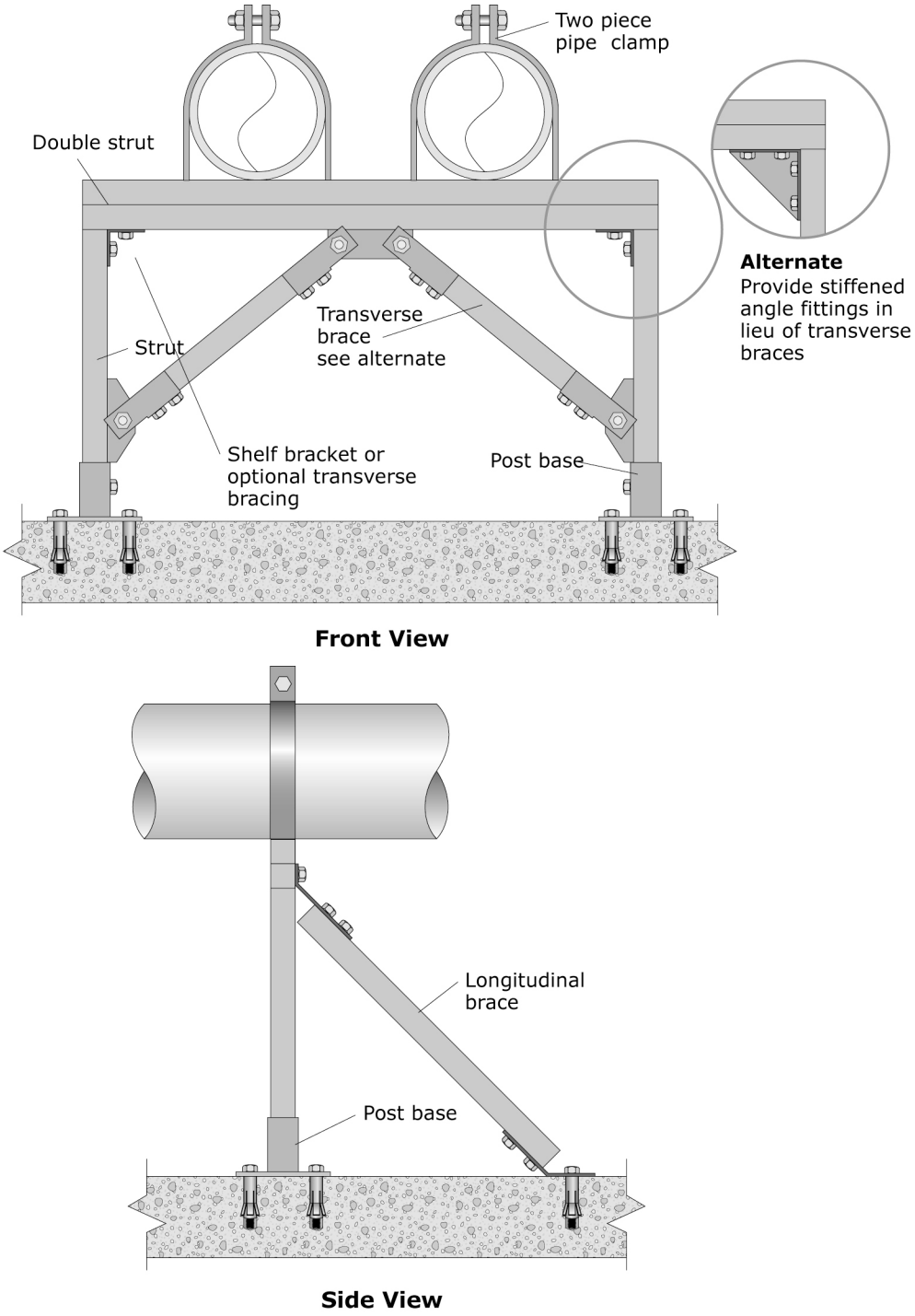

Figure 6.4.3.5-7 Floor-mounted pipe stand (strut frame) (ER).

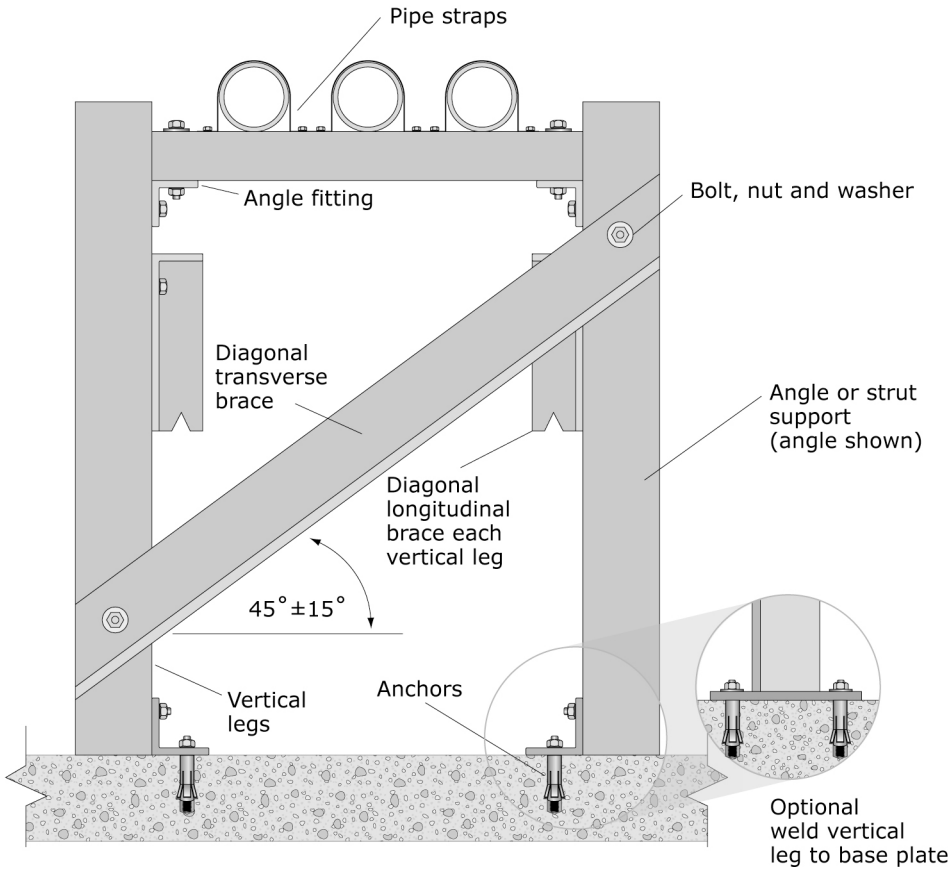

Figure 6.4.3.5-8 Floor-mounted pipe stand (steel shapes) (ER).