6.4 Mechanical, Electrical, and Plumbing Components

6.4.3 Pressure piping

6.4.3.1 Suspended Pressure Piping

There are many types of piping systems which convey a wide variety of fluids and gases in and around buildings. In this section, pressure piping refers to "all piping (except fire suppression piping) that carries fluids which, in their vapor stage, exhibit a pressure of 15 psi, gauge, or higher." See Sections 6.4.4 and 6.4.5 for other piping categories. This example addresses seismic restraint details for suspended piping; see Sections 6.4.3.2 through 6.4.3.8 for other types of piping system restraints as shown in Figure 6.4.3.1-10.

Provisions

BUILDING CODE PROVISIONS

Seismic loads for suspended pressure piping are determined using ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures*, (ASCE, 2010), Chapter 13. The principal objective is to prevent the system from falling. Depending on the configuration of the piping, it may also be sensitive to building displacements if it is connected to multiple levels in the same structure, or is supported by adjacent structures.

- ASCE/SEI 7-10 exempts suspended pressure 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 in Seismic Design Categories D, E, and F that weighs more than 5 pounds per linear foot.
- Unbraced piping attached to in-line equipment must be provided with flexibility adequate to accommodate seismic relative displacements.
- Pressure piping systems, including their supports, may be designed either using the provisions of ASME B31 *Process Piping* (ASME, 2008) or ASCE/SEI 7-10. If ASME B31 is used, the forces and displacements of ASCE/SEI 7-10 must be used for design. See Section 6.4.4 for issues related to fire protection piping systems.
- ASCE/SEI 7-10 contains a number of bracing exemptions for suspended piping:
    - Trapeze assemblies are used to support piping whereby no single pipe exceeds certain size limits and the total weight of the piping supported by the trapeze assemblies is less than 10 lb/ft

  - Suspended piping where the hangers are less than 12 inches long. Rod hangers must be detailed to prevent bending of the rod.
  - 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
- Allowable stresses are provided in ASCE/SEI 7-10 for suspended pressure piping that is not design to ASME B31 or other approved material standards or design bases.

RETROFIT STANDARDS PROVISIONS

ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings*, (ASCE, 2007) classifies suspended pressure piping as force controlled, meaning that the principal objective is to prevent the piping from falling. Where piping runs between floors or crosses seismic joints it as also deformation controlled. Suspended pressure piping must meet the force and deformation requirements of the standard.

- For suspended pressure piping, ASCE/SEI 41-06 requires compliance with the anchorage provisions of the standard when the performance level is Life Safety or higher.
- Rehabilitation may utilize prescriptive standard.

Typical Causes of Damage

- Improperly supported pipes can become dislodged and fall.
- Pipes are particularly vulnerable to damage at joints, bends, penetrations through walls or structural members, and connections to equipment.
- Unbraced piping can sway and impact adjacent items.
- Piping may be damaged as a result of differential movement between points of attachment.
- Fluids may leak from damaged joints or broken pipe; property losses and business outages are often attributed to fluid leaks from piping.

DAMAGE EXAMPLES

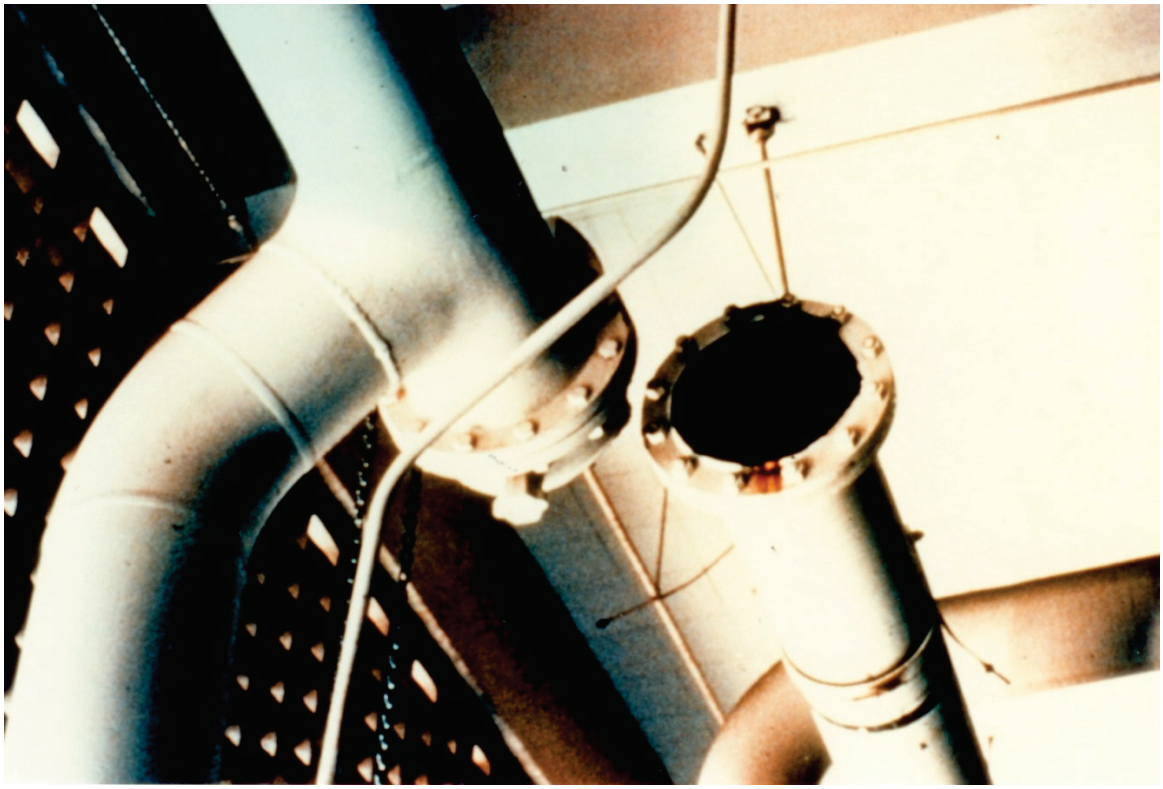

Figure 6.4.3.1-1 Pipe joint failure in the 1971 magnitude-6.6 San Fernando Earthquake (Photo courtesy of John F. Meehan).

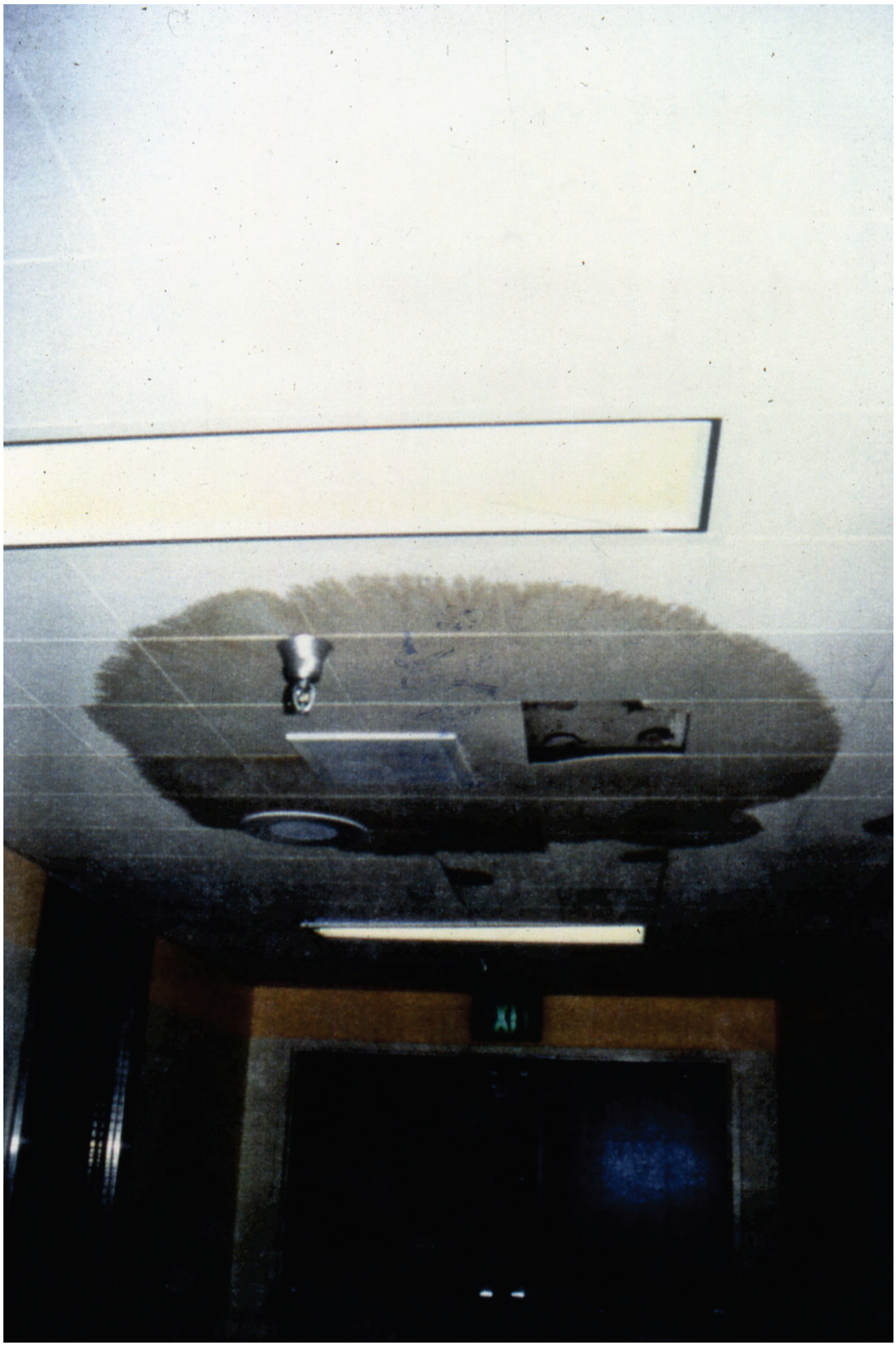

Figure 6.4.3.1-2 Leakage caused by pipe damage at joint in the 1994 magnitude-6.7 Northridge Earthquake (Photo courtesy of Degenkolb Engineers).

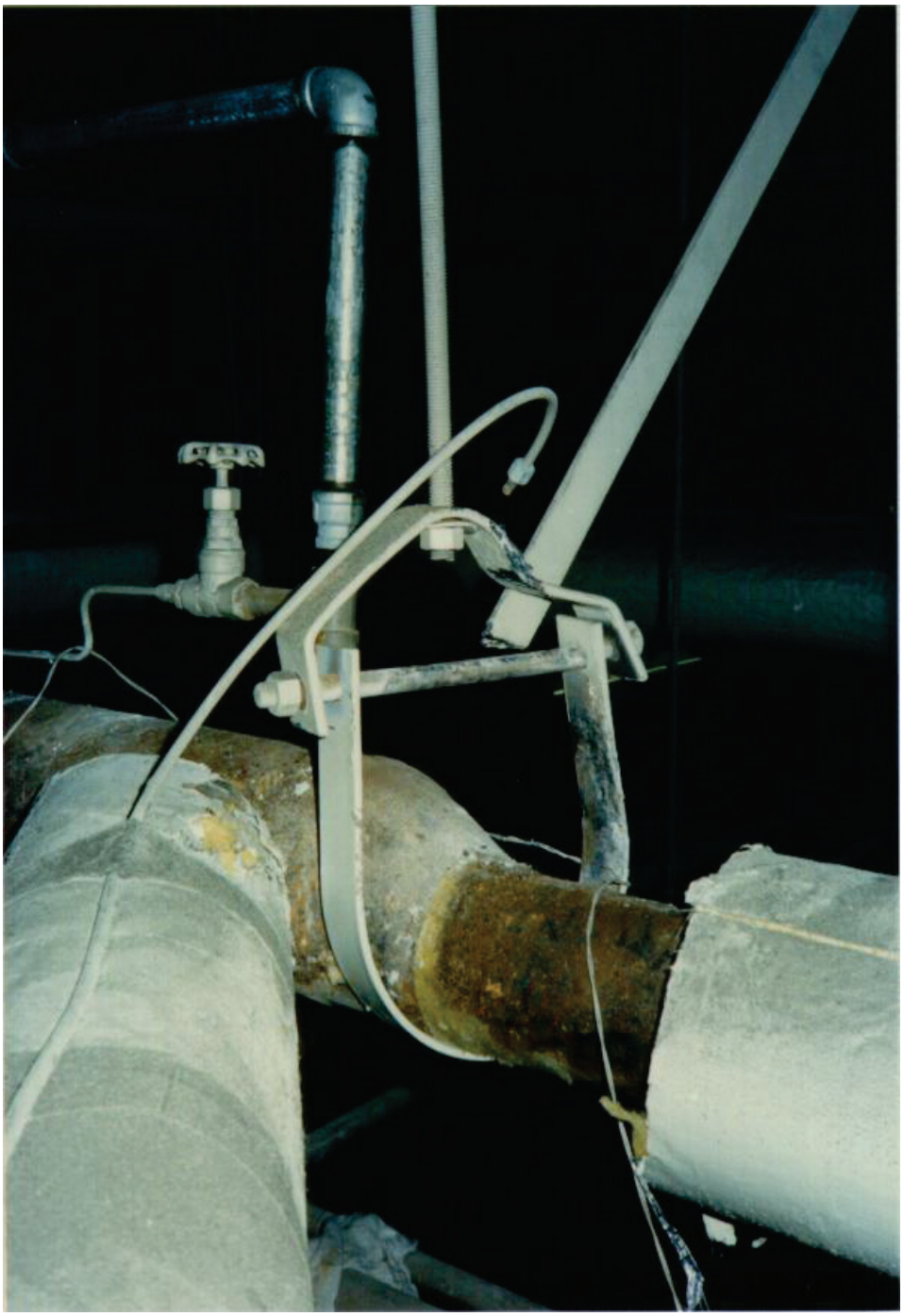

Figure 6.4.3.1-3 Pipe brace failed at connection in 1994 Northridge Earthquake; insulation removed prior to photo (Photo courtesy of Mason Industries).

Seismic Mitigation Considerations

- Details shown are for overhead attachments for suspended piping. Seismic detailing for pipes requires both transverse and longitudinal braces; while these are shown here as separate details, both types of bracing are required. The spacing of pipe bracing is dependent on the level of seismicity, location in a building, size of the pipe, type of pipe, and strength of connections to the structure.
- Many vendors supply specialized hardware used for the seismic anchorage or sway bracing of piping systems. These vendors offer a wide variety of products and services including design, installation and inspection manuals, load tables, load rated hardware, spring loaded hangers, couplers and fittings, pipe dampers, preassembled seismic bracing kits, AUTOCAD details, calculation packages, and technical support.
- Longitudinal pipe bracing requires the use of a pipe clamp, riser clamp, welded lug or device that provides positive attachment to the pipe and will not slip along the length of the pipe. Longitudinal pipe supports should not rely on friction connections such as U-bolts as these do not provide reliable longitudinal restraint during an earthquake and are likely to slip. Some vendors have items with names such as “seismic pipe clamp” or “longitudinal restraint device” that are intended for use with longitudinal restraints.
- Virtual Design and Construction (VDC) and Building Information Models (BIM) involve the development of 3D computer models depicting all the structural and many nonstructural components of buildings. Increasing use of these 3D models that incorporate all the MEP systems will facilitate the design and coordination of these components with the structural system and other nonstructural components. An example of a BIM model with piping and pipe supports is shown in Figure 6.4.3.1-9.
- Piping systems are typically combinations of horizontal and vertical runs of pipe; vertical runs are often called risers. Pipes may be suspended overhead as shown in this example or floor-mounted, roof-mounted, or wall-mounted. Flexible connections are often required at fixed equipment or where piping crosses an expansion joint or seismic separation. Pipe runs also typically include penetrations through floor slabs, roof slabs, and walls or structural framing. Details for many restraint conditions can be found in FEMA 414 *Installing Seismic Restraints for Duct and Pipe (2004).* Some of these conditions are shown in Sections 6.4.3.2 through 6.4.3.8 (See Figure 6.4.3.1-11).

MITIGATION EXAMPLES

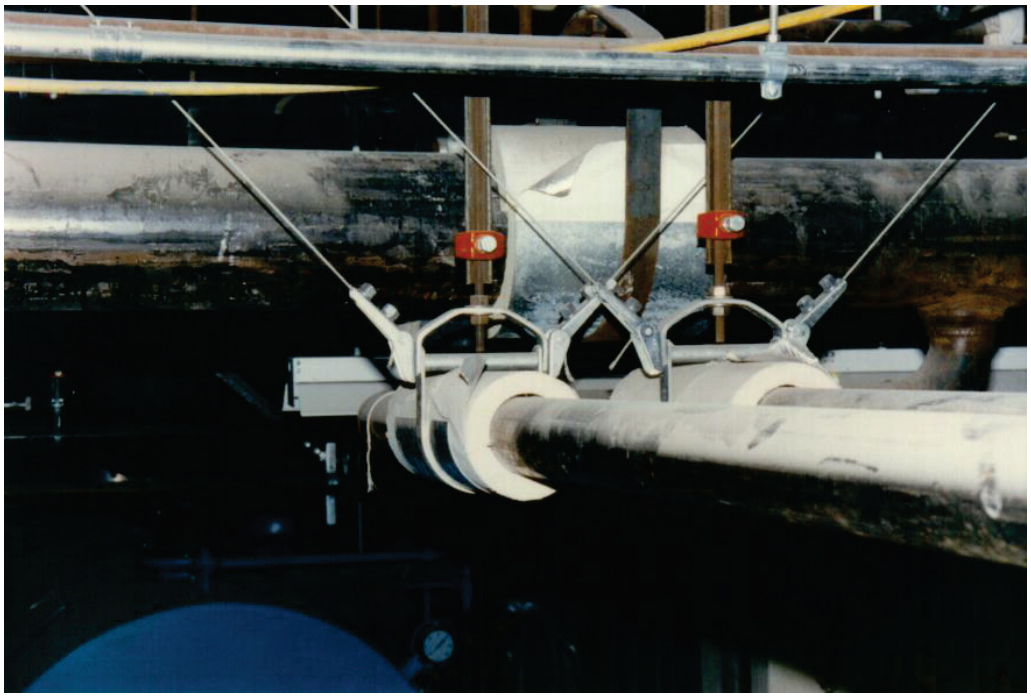

Figure 6.4.3.1-4 Single clevis hanger support with transverse cable bracing at the restraining bolt (Photo courtesy of Mason Industries).

Figure 6.4.3.1-5 Pipe clamp supports with transverse and longitudinal angle braces; note pipe clamp for longitudinal brace in direct contact with pipe (Photo courtesy of Mason Industries).

Figure 6.4.3.1-6 All-directional cable bracing of suspended piping (Photo courtesy of ISAT).

Figure 6.4.3.1-7 Transverse bracing with J-hanger and strut at the restraining bolt. Note that longitudinal brace shown is ineffective because the J-hanger can slip along the length of the pipe; a pipe clamp or equivalent is required for a longitudinal brace (Photo courtesy of Cynthia Perry, BFP Engineers).

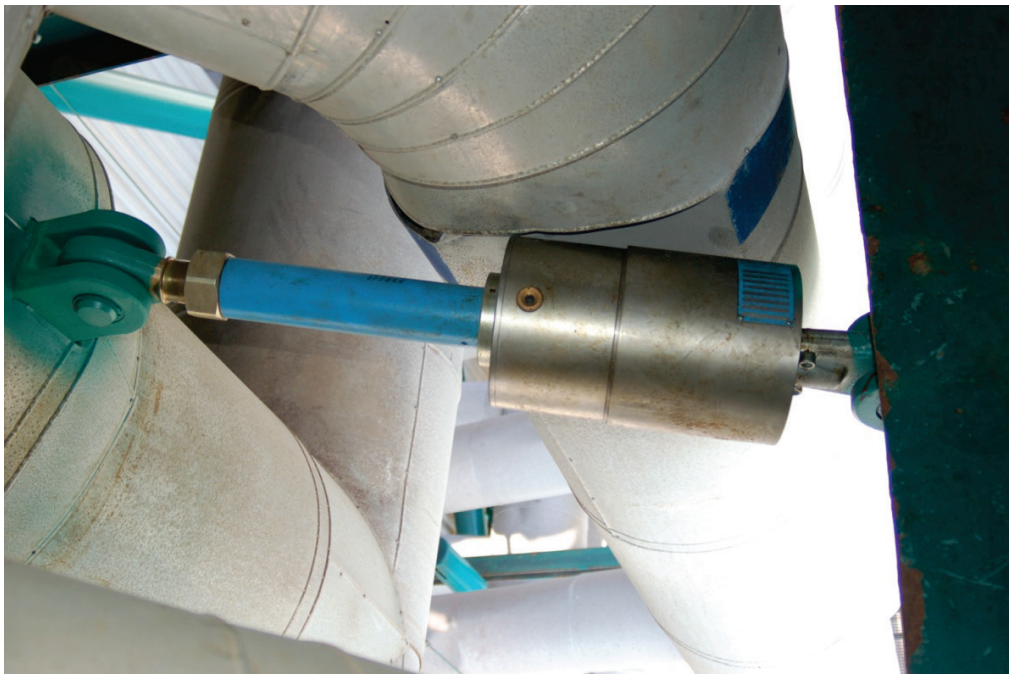

Figure 6.4.3.1-8 Viscous damper used as restraint on large insulated pipe (Photo courtesy of Eduardo Fierro, BFP Engineers).

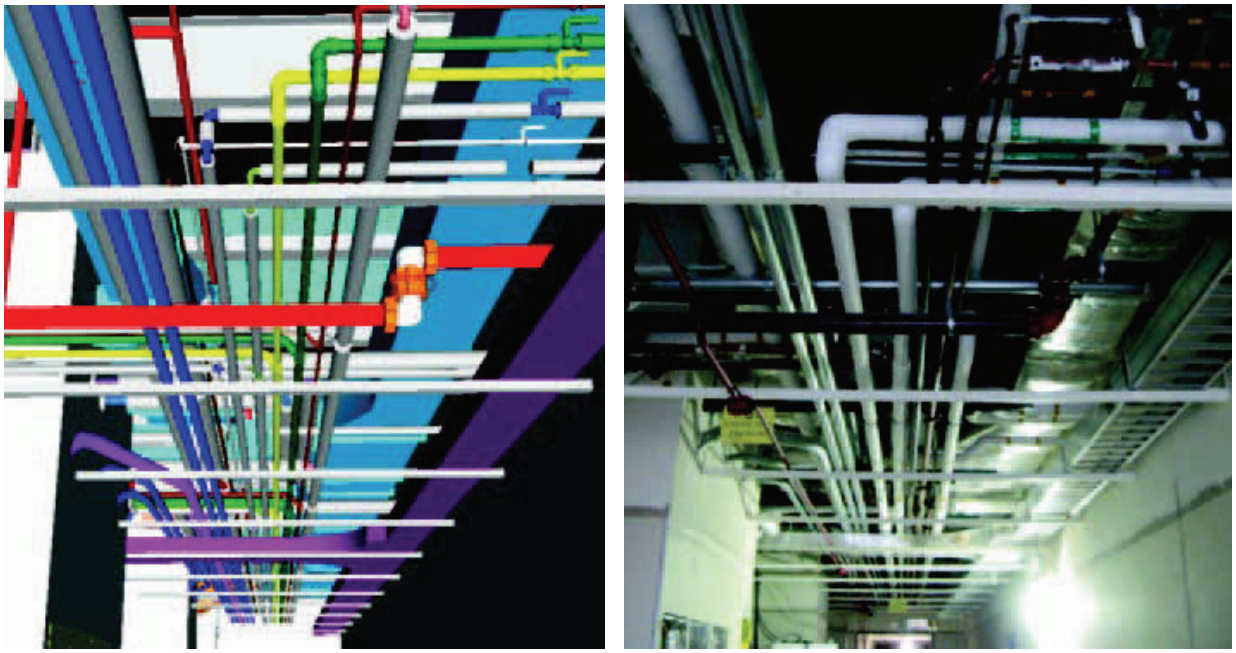

Figure 6.4.3.1-9 Example of BIM Model (left) compared to installed piping (right) (Photo and image courtesy of ISAT).

MITIGATION DETAILS

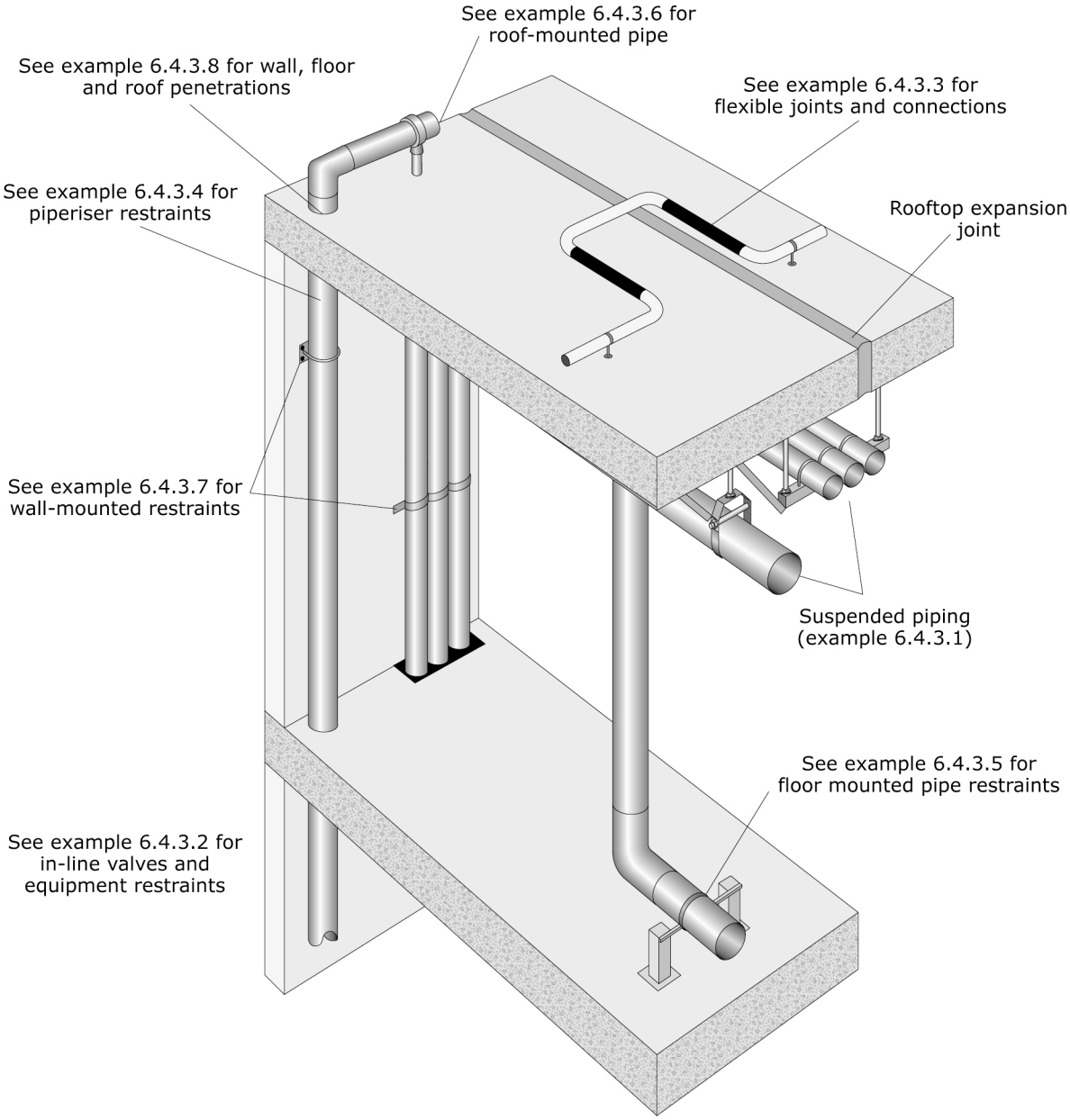

Figure 6.4.3.1-10 Schematic of seismic restraint conditions for piping (ER)

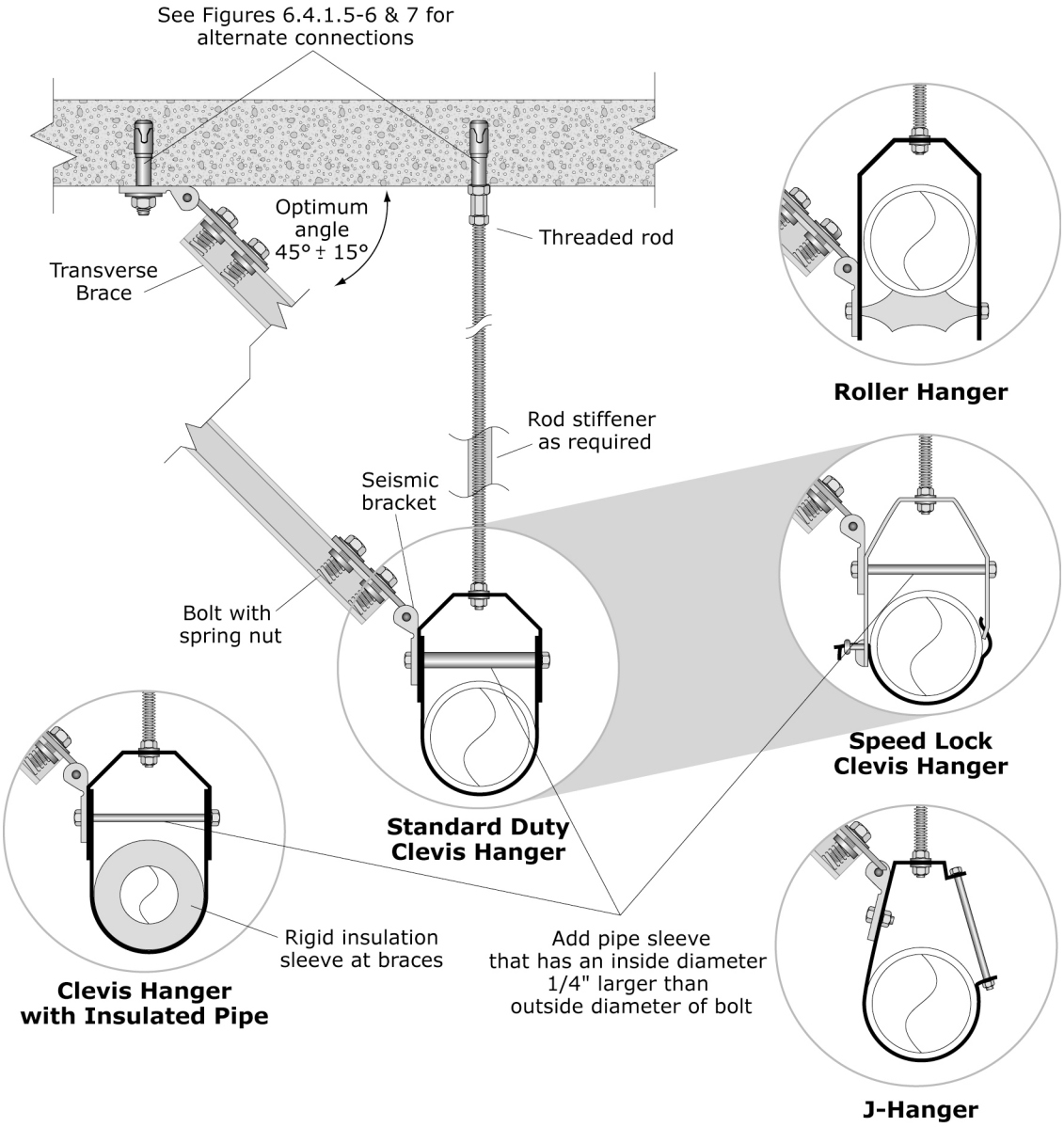

Figure 6.4.3.1-11 Rigid bracing - single pipe transverse (ER). Note that insulated pipes need special rigid insulation sleeves at hangers and braces to prevent compression of the insulation.

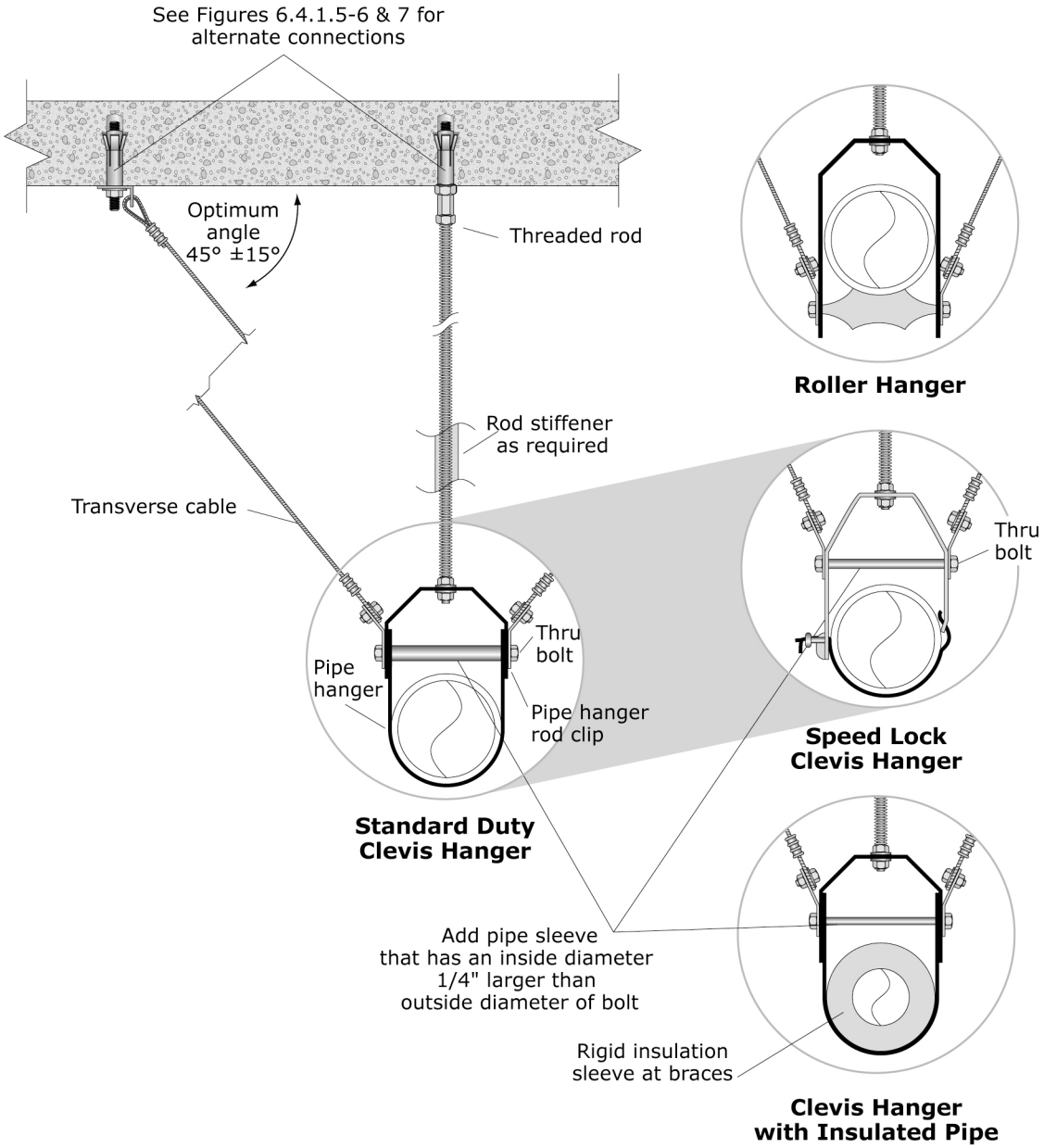

Figure 6.4.3.1-12 Cable bracing - single pipe transverse (ER). Note that insulated pipes need special rigid insulation sleeves at hangers and braces to prevent compression of the insulation.

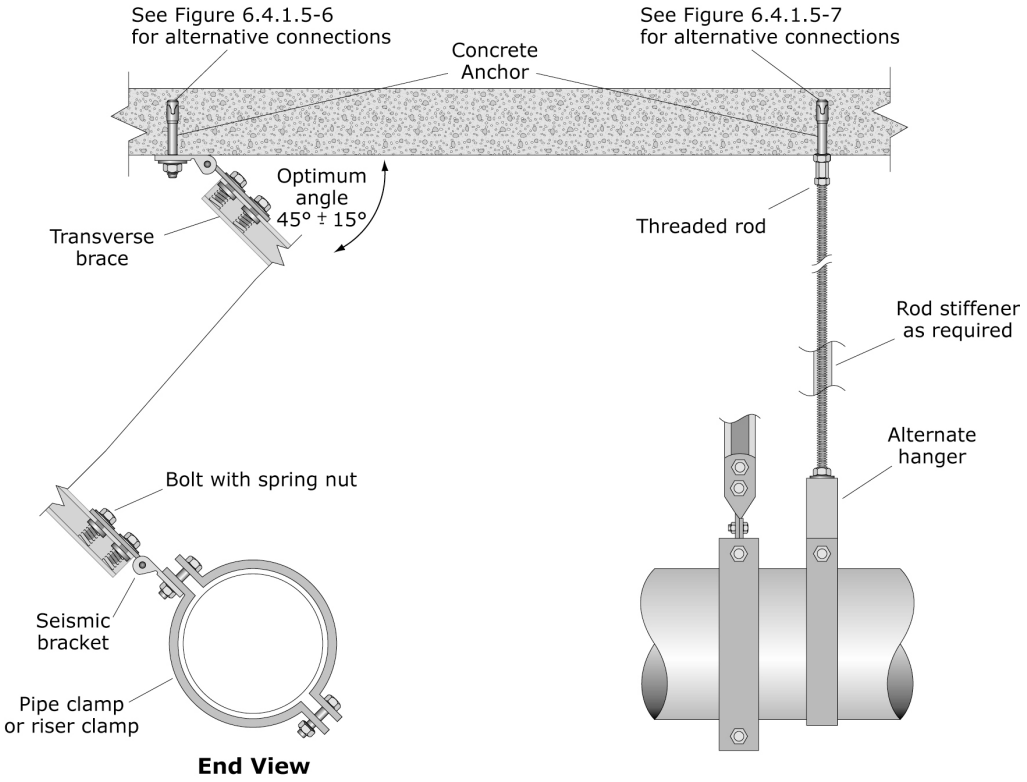

Figure 6.4.3.1-13 Rigid bracing - single pipe alternate transverse (ER).

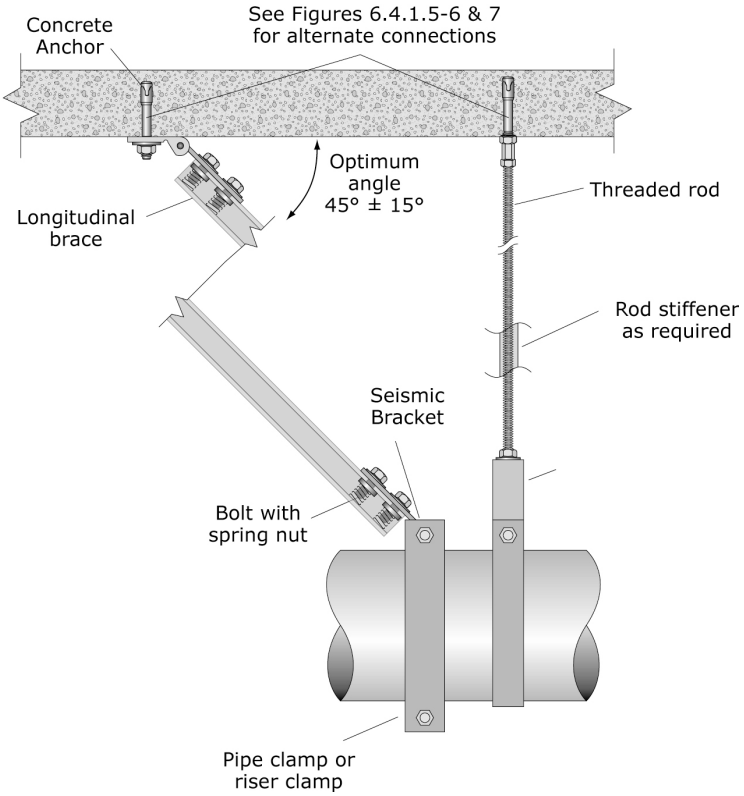

Figure 6.4.3.1-14 Rigid bracing - single pipe longitudinal (ER).

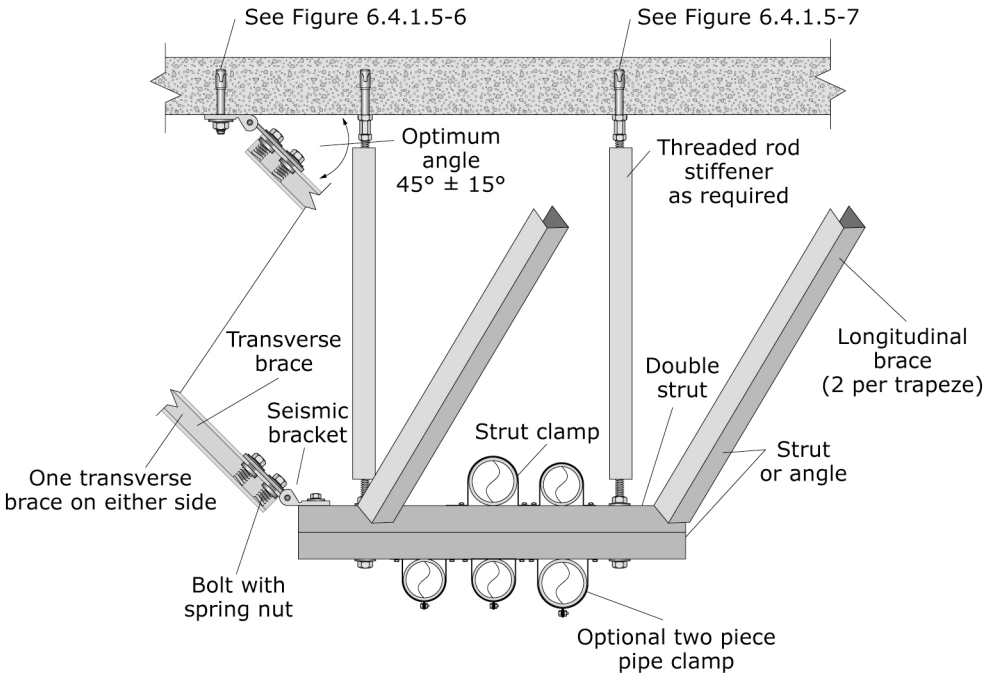

Figure 6.4.3.1-15 Rigid bracing - Trapeze supported piping (ER).

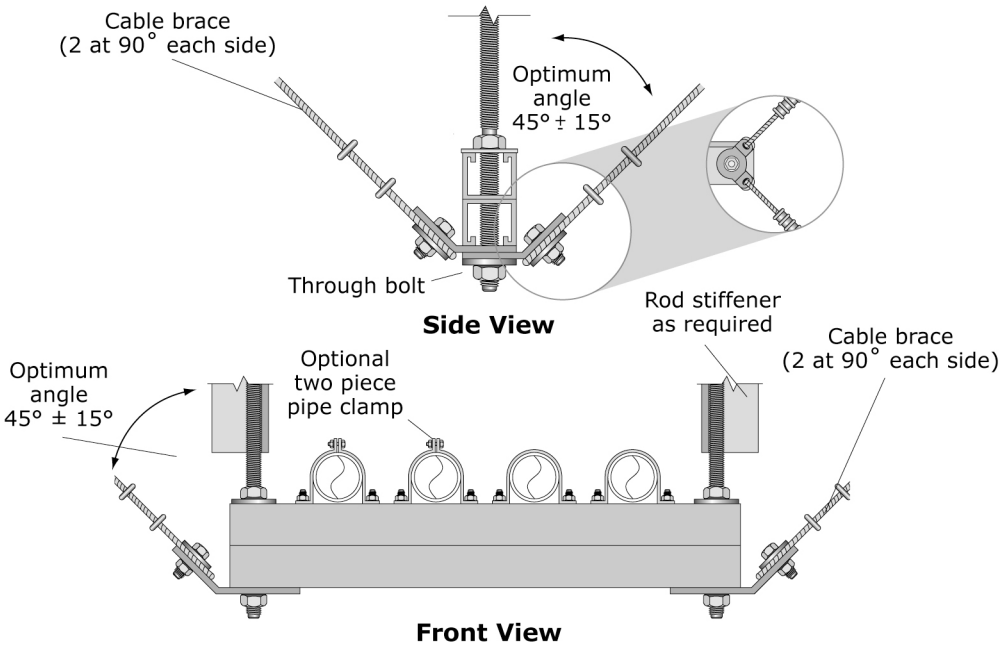

Figure 6.4.3.1-16 Cable bracing - Trapeze supported piping (ER).