6.4 MECHANICAL, ELECTRICAL, AND PLUMBING COMPONENTS

6.4.2 STORAGE TANKS AND WATER HEATERS

6.4.2.1 STRUCTURALLY SUPPORTED TANKS AND VESSELS

This category covers any type of tank or vessel supported on legs or a structural frame and may be either vertical or horizontal. Tanks may be made of steel, stainless steel, polyethylene, polypropylene, fiberglass reinforced plastic (FRP), or concrete.

TYPICAL CAUSES OF DAMAGE

- If the tank is not anchored to the structural supports or the structural supports are not properly braced and anchored, the tanks may slide or fall. Poorly anchored tanks may damage the supports or damage the tank wall.
- Connections of supply lines or fuel lines may be damaged; contents may slosh or spill.

Damage Examples

Figure 6.4.2.1-1 Tank shifted off support curb, Granada Hills Hospital in the 1994 magnitude-6.7 Northridge Earthquake (Photo courtesy of OSHPD).

Figure 6.4.2.1-2 A vertical tank at hospital overturned due to inadequate anchorage in the 1994 Northridge Earthquake (Photo courtesy of OSHPD).

Figure 6.4.2.1-3 Horizontal tank strapped to structural support frame on hospital roof; one strap failed and tank slid six inches in the 1994 Northridge Earthquake (Photo courtesy of OSHPD).

Figure 6.4.2.1-4 Wineries suffered extensive damage in the 2010 magnitude-8.8 Chile Earthquake with many barrels of wine spilled. This winery had damage to anchored tanks; tank anchorage failed, legs buckled, welds tore, anchor bolts pulled up, etc. The tank legs all have leveling bolts at the bottom, creating a weak zone between the bottom of the leg and the anchor plate. Similar unanchored tanks in this facility shifted position but were undamaged (Photos courtesy of Eduardo Fierro, BFP Engineers).

SEISMIC MITIGATION CONSIDERATIONS

- Tanks must have adequate vertical and horizontal support. Provide anchorage and bracing for tank legs or support structure; provide positive attachment from tank to support structure. Provide concrete pad large enough to prevent tank from overturning.
- Provide flexible connections for fuel lines and piping.
- The details shown are for rigid connections; see also FEMA 412 *Installing Seismic Restraints for Mechanical Equipment* (2002) for attachment details.
- For some installations where tanks have a low aspect ratio (i.e., the tank is relatively wide compared to the height) and are unlikely to overturn, it may be preferable to allow the tank to slide rather than providing rigid anchorage. As shown in the photos in Figure 6.4.2.1-4 taken at a winery, many stainless steel tanks on legs with base anchorage were damaged while nearby unanchored tanks shifted slightly but were undamaged. Flexible connections designed to accommodate sliding would be required for tanks left free at the base.

Mitigation Examples

Figure 6.4.2.1-5 Braces added to four sides of tank support structure (Photo courtesy of Eduardo Fierro, BFP Engineers).

Figure 6.4.2.1-6 Gusset plates and cross bracing added at base of vertical tank on four legs following the 2001 magnitude-8.4 Peru Earthquake (Photo courtesy of Eduardo Fierro, BFP Engineers).

Mitigation Details

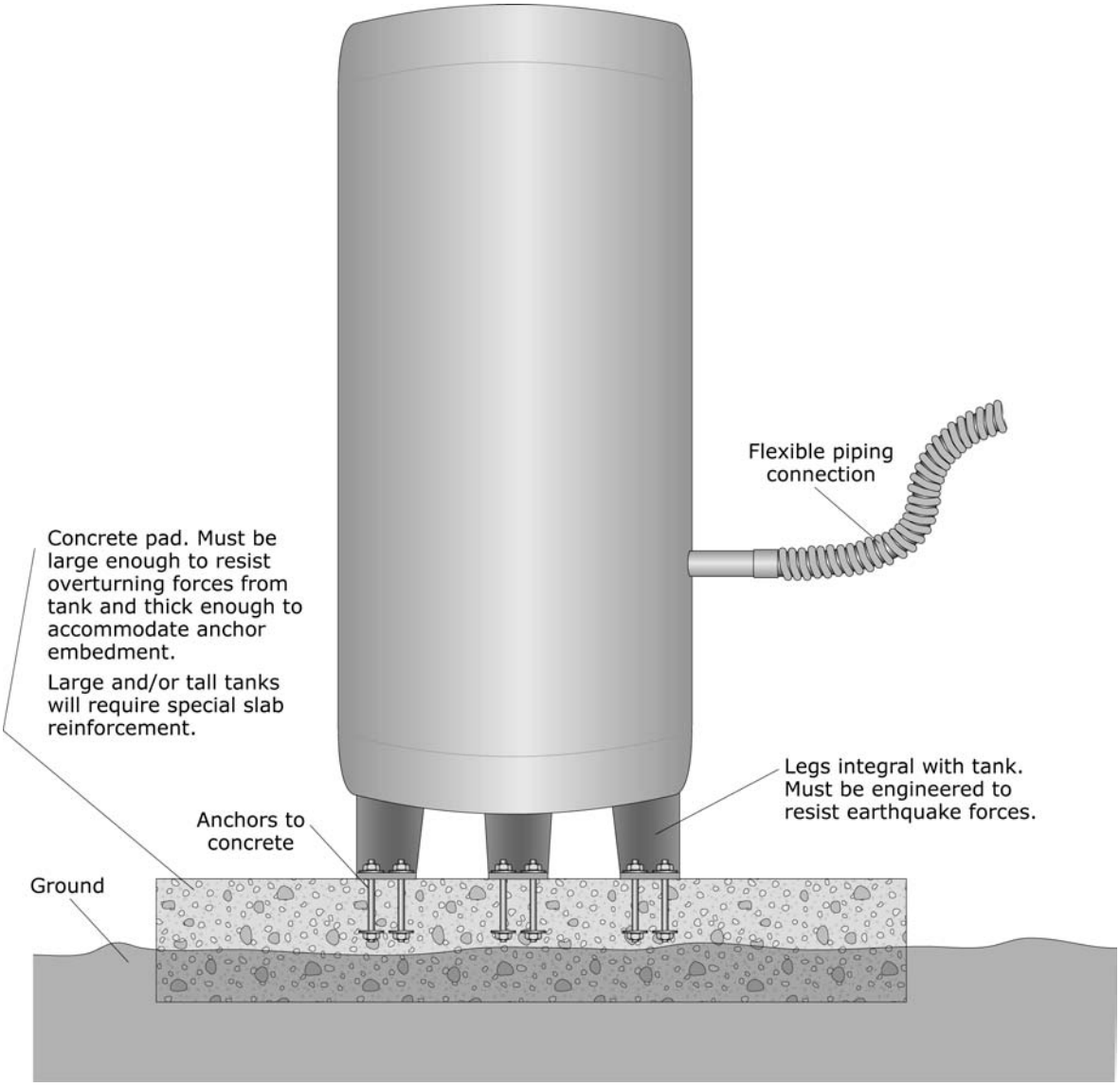

Figure 6.4.2.1-7 Vertical tank on legs (ER).