6.5 Furniture, Fixtures, Equipment and Contents

6.5.1 Storage Racks

6.5.1.2 Industrial Storage Racks

This subcategory includes heavy duty steel pallet storage racks such as those found in public warehouse stores. These racks are typically 42 to 44 inches deep, 8 feet wide and up to 14 to 18 feet tall, often configured with two rows back-to-back. They are composed of specially designed steel elements that permit easy installation and reconfiguration consistent with merchandising needs.

Provisions

BUILDING CODE PROVISIONS

Industrial storage racks are considered nonbuilding structures. The seismic design provisions for industrial storage racks in ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures*, (ASCE, 2010) Chapter 15 include two approaches to the design of steel storage racks that are intended to produce comparable results. Racks can be designed in accordance with ANSI/RMI MH 16.1, *Specification for the Design, Testing, and Utilization of Industrial Steel Storage Racks*, (ANSI/RMI, 2008), as amended by ASCE/SEI 7-10. As an alternative, racks may be designed to comply with the requirements of ASCE/SEI 7-10 Section 15.5.3.4.

- Industrial storage racks in areas open to the public are designed with an importance factor of $I_p = 1.5$.
- While beyond the scope ASCE/SEI 7-10, contents on the storage racks may pose a potentially serious threat to life should they fall during an earthquake. It is recommended that restraints be provided.

RETROFIT STANDARD PROVISIONS

ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings*, (ASCE, 2007) may require compliance with the anchorage provisions of the standard when the performance level is Hazards Reduced, Life Safety, or Immediate Occupancy. Storage racks over 4 feet in height should be evaluated. Storage racks in unoccupied spaces where the performance level is Life Safety are exempt. When the performance level is Hazards Reduced, storage racks in areas of public assembly must comply with the provisions of the standard.

Typical Causes of Damage

- Industrial storage racks may slide or overturn, or failure of individual components can cause collapse or partial collapse.
- Stored contents may become dislodged and fall. Items falling from the upper shelves can cause serious bodily harm. Damage to merchandise or inventory may be costly to replace and reshelf and may result in significant business interruption.
- In cases with heavy stored products and light structural framing, collapsed racks and falling goods have caused damage to structural framing members and/or architectural cladding.
- Industrial storage racks can be weakened if damaged from collisions with forklifts. Bent or damaged legs or anchor bolts reduce the lateral capacity of the rack system.

DAMAGE EXAMPLES

Figure 6.5.1.2-1 Damage to overloaded racks during the 1994 magnitude-6.7 Northridge Earthquake (FEMA 460, 2005).

Figure 6.5.1.2-2 Spilled contents during the 1994 Northridge Earthquake (FEMA 460, 2005).

Figure 6.5.1.2-3 Rack collapse during the 1994 Northridge Earthquake. Note the minimal damage to shrink wrapped merchandise (FEMA 460, 2005).

Figure 6.5.1.2-4 Failure of anchored racks in the 2010 magnitude-8.8 Chile Earthquake. The racks are leaning precariously due to inadequate bracing in the longitudinal direction and weak connections between the components. The welded fitting at the end of the beam failed at the weld in many places. Note that most items were shrink wrapped so merchandise did not scatter (Photos courtesy of Rodrigo Retamales, Rubén Boroschek & Associates).

Seismic Mitigation Considerations

- Storage racks in warehouse-type retail stores may pose a greater seismic risk to the general public than exists in low-occupancy warehouses or more conventional retail environments, due to their higher occupant load. The use of an Importance Factor of 1.5 provides an appropriate level of additional safety in areas open to the public.
- Project specific design of industrial storage racks is required. Each design must account for proprietary members and connectors that are used. Anchorage of the rack to the floor must be engineered and verification of the adequacy of the slab to accommodate forces generated by the rack is required. Storage racks are classified as nonbuilding structures.
- Industrial storage rack systems may experience high lateral displacements during strong shaking. For the purposes of providing adequate clearances between the rack and adjacent structural and nonstructural elements, ASCE/SEI 7-10 specifies relative displacements of not less than 5 percent of the height of the rack.
- Pallet racks should be installed by trained and experienced personnel working from installation drawings provided by the rack designer. Reconfiguration from the as-designed condition should be evaluated by the designer.
- To prevent or minimize the falling hazard posed by stored overhead merchandise, a dual approach is recommended: prevent merchandise from falling down from one shelf to the next; and prevent pallets and individual merchandise from falling from the shelves into the aisles. The use of wire decking or spaced framing on each shelf will reduce the potential for fall-through of merchandise. Stretch-wrapping, shrink-wrapping, banding or use of integral pallet box units can reduce the potential falling hazard posed by pallets. Restraining bars, chains or cables, netting and/or slip-resistant containers can reduce the potential for loss of individual merchandise.
- FEMA 460 *Seismic Considerations for Steel Storage Racks Located in Areas Accessible to the Public* (2005) provides a comprehensive treatment of seismic resistant design considerations for steel storage racks.
- The Rack Manufacturers Institute (RMI) publishes industry-wide standards for engineering design of steel storage racks.
- Purchase storage racks designed for seismic resistance. Some industrial storage racks are now available with proprietary schemes for improved seismic performance such as base isolation, added damping, or shelves sloped toward the back of the rack.

MITIGATION EXAMPLES

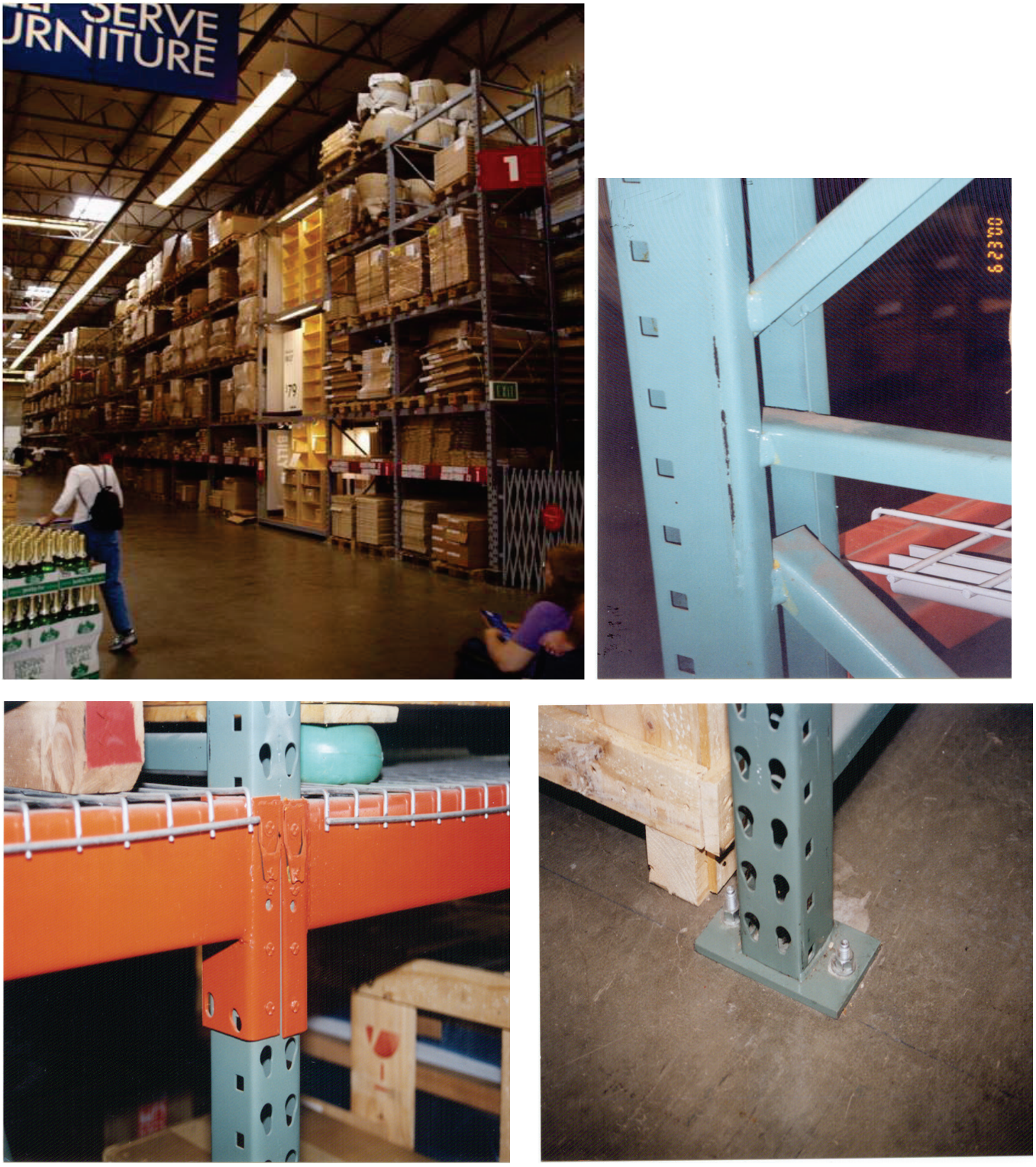
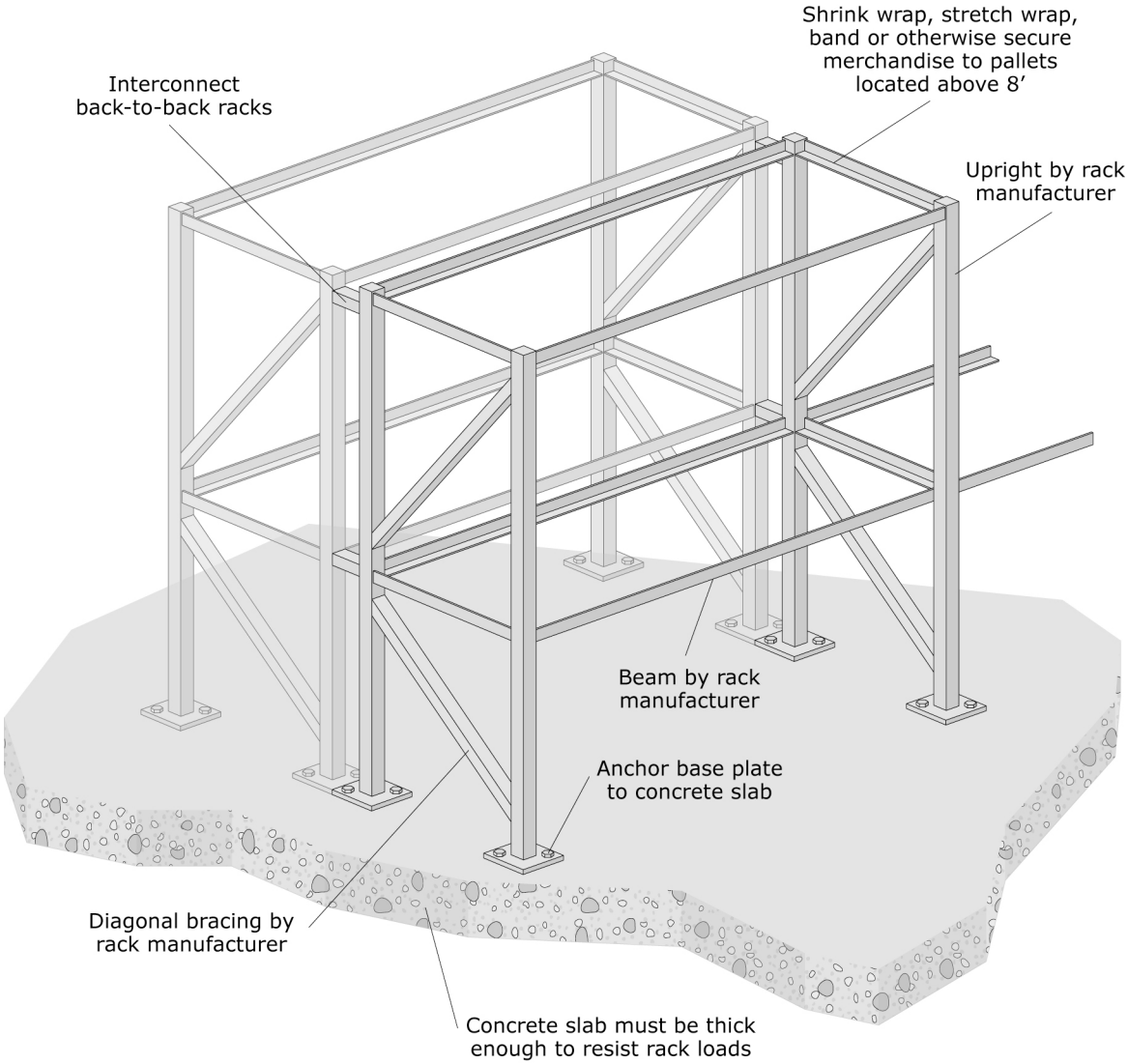


Figure 6.5.1.2-5 Typical pallet storage rack configuration and details (Photos courtesy of Maryann Phipps, Estructure).

Figure 6.5.1.2-6 Photo showing netting used to keep storage on upper portions of steel storage racks in a big box hardware store (Photo courtesy of Mike Mahoney, FEMA).

MITIGATION DETAILS



Note: Purchase storage racks designed for seismic resistance. Storage racks may be classified as either nonstructural elements or nonbuilding structures depending upon their size and support conditions. Check the applicable code to see which provisions apply.

Figure 6.5.1.2-7 Industrial storage rack (ER).