

6.4 Mechanical, Electrical, and Plumbing Components

6.4.10 Elevators and Escalators

6.4.10.3 Escalators

Escalators typically span between two floors, and although most escalators run in a straight line, spiral escalators are found in some locations. The failure of any of the component parts of the escalator or escalator equipment could disable the functionality of the system. Relative horizontal displacements between supporting floors that are greater than the displacement capacity of the connection can result in the escalator coming of its supports and falling to the floor below resulting in severe damage to the escalator and a serious life safety threat.

Provisions

BUILDING CODE PROVISIONS

Seismic loads for Escalators are determined using ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010), Chapter 13. Escalators are classified as mechanical components, and are sensitive to both story drift and acceleration. Escalators designed in accordance with the seismic requirements of ASME A17.1 *Safety Code for Elevators and Escalators* (ASME, 2007a) are deemed to meet the requirements of ASCE/SEI 7-10, provided the forces and displacements used in the design meet the provisions of ASCE/SEI 7-10.

RETROFIT STANDARD PROVISIONS

ASCE 41-06, *Seismic Rehabilitation of Existing Buildings* (ASCE, 2007) does not provide seismic retrofit criteria for escalators. In lieu of specific guidance, retrofit criteria may be inferred from the requirements for stairways, as follows

- Stairs are subject to the requirements of ASCE/SEI 41-06 when the performance level is Immediate Occupancy, or in regions of high and moderate seismicity when the performance level is Life Safety. Similar criteria may be used for escalators.
- The evaluation must consider the escalator and the connection of the escalator to the supports, and adjacent supporting beams or slabs.
- Acceptance criteria should focus on verifying that the escalator has sufficient strength to resist out-of-plane forces, and the ability to accommodate the expected relative displacements.

Typical Causes of Damage

- The primary components of an escalator system are the steps, chain, inner rail, chain guide, drive gear, handrail, handrail drive, electric motor, and electrical control panel. These components are often supported by a truss that spans between the floors. Any of these components could be damaged if not properly detailed or restrained; failure of any of the component parts could disable the system.
- Escalators, like stairs, may form a strut or brace between adjacent floors unless they are detailed so the system will accommodate inter-story drift. Damage could occur to the skirt, landing plate or other components not detailed to accommodate either an extension or shortening of the distance between the two landings. An example of the results of a failure and collapse of an escalator that occurred during the 2011 Great Tokohu Japan Earthquake is provided in Figure 6.4.10.3-1. A total of 4 escalators fell in this earthquake at 3 separate locations in the Sendai and Fukushima areas.
- According to survey responses collected by the Division of Occupational Safety and Health Elevator, Tramway, and Ride unit, 65 escalators were damaged in the 1994 Northridge earthquake. It was reported that escalators came off upper supports, and several truss support angles had their bolts sheared off where one truss actually dropped. Glass came out of its supports and shattered, handrails collapsed. In addition, numerous deckboards, skirts and newels were damaged.

DAMAGE EXAMPLES

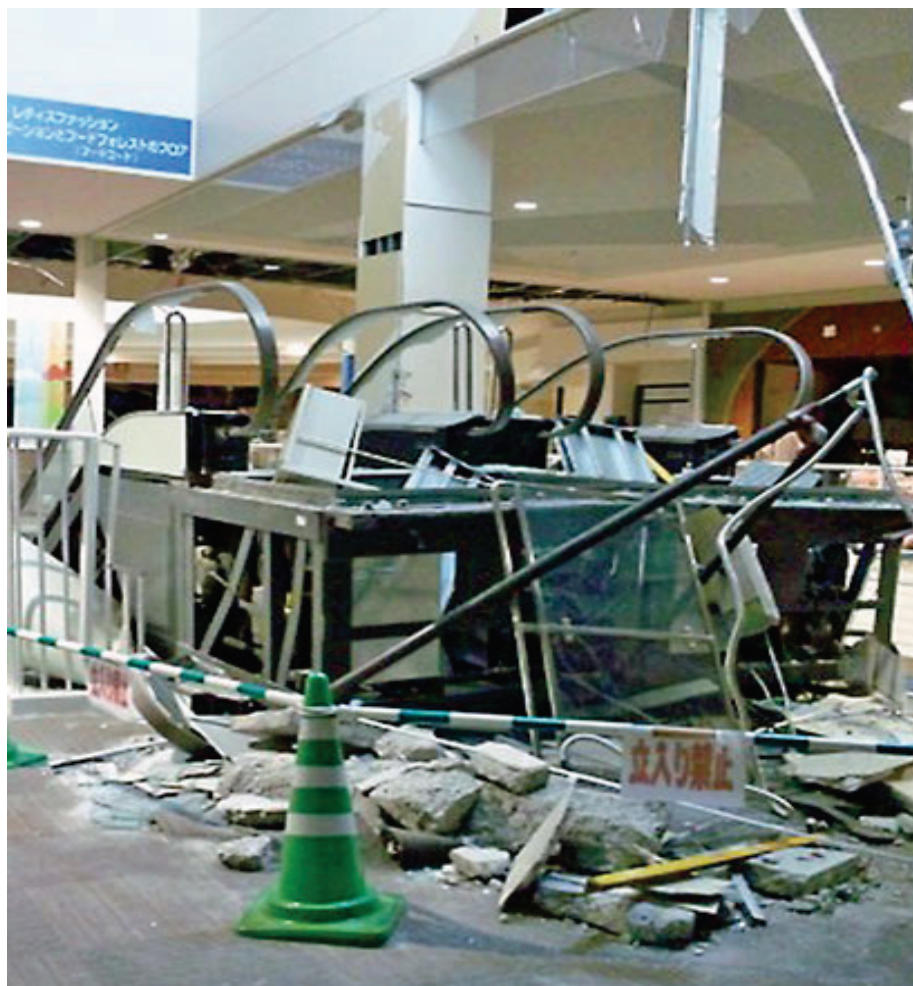


Figure 6.4.10.3-1 Photo of escalator, located in the Sendai area of Japan, which fell from the floor above onto the escalator on the floor below during the magnitude-9.0 Great Tohoku Earthquake of March 11, 2011. The probable cause of this collapse was that the relative displacements between floors exceeded the connection bearing width capacity of the escalator. This type of failure creates a serious life safety hazard (Photo source: Nekkei Architecture).

Seismic Mitigation Considerations

- Each of the components of an escalator system need to be detailed to accommodate movement, or restrained and anchored to prevent damage in an earthquake. The system must be designed to accommodate the anticipated inter-story drift between the two connected floors. Where a truss is used to span between the two floors, the bearing seats should allow movement at one or both ends. Components such as the rail supports, handrails, landing plates, and skirts must be detailed to accommodate lateral deformations. All of the mechanical and electrical equipment needs to be properly anchored or restrained.
- Escalators have traditionally been designed to run continuously, whether they are in use or not. Some more energy efficient escalators operate on an intermittent basis and are triggered by the presence of passengers but otherwise are in a standby idle mode.
- All escalators should be inspected by qualified personnel following an earthquake. Unlike elevators, escalators typically function as a usable stair when they are not operating and could be used to facilitate evacuation following an earthquake.
- Elevator and escalator safety is governed by the prescriptive requirements in ASME A17.1, *Safety Code for Elevators and Escalators* (ASME, 2007a), a document that is continually evolving to reflect new elevator and escalator technologies. Seismic requirements for escalators were first introduced into A17.1 in the 2000 edition include the design of connections for relative displacements effects between floors. Escalators installed prior to the adoption of A17.1–2000 may be particularly vulnerable. Local or state jurisdictions may have other elevator and escalator requirements. In California, Escalator Seismic Requirements are provided in Title 8 in the California Code of Regulations.
- The internet provides information regarding escalators. Websites such as <http://science.howstuffworks.com/transport/engines-equipment/escalator.htm> describe the workings of escalators and provide links to other resources
- Some escalator models are offered with a seismic option; check for appropriate equipment before purchasing a new escalator. The escalators should comply with the seismic requirements of Section 8.5 of ASTM A17.1 especially the drift requirements between floors.

MITIGATION DETAILS

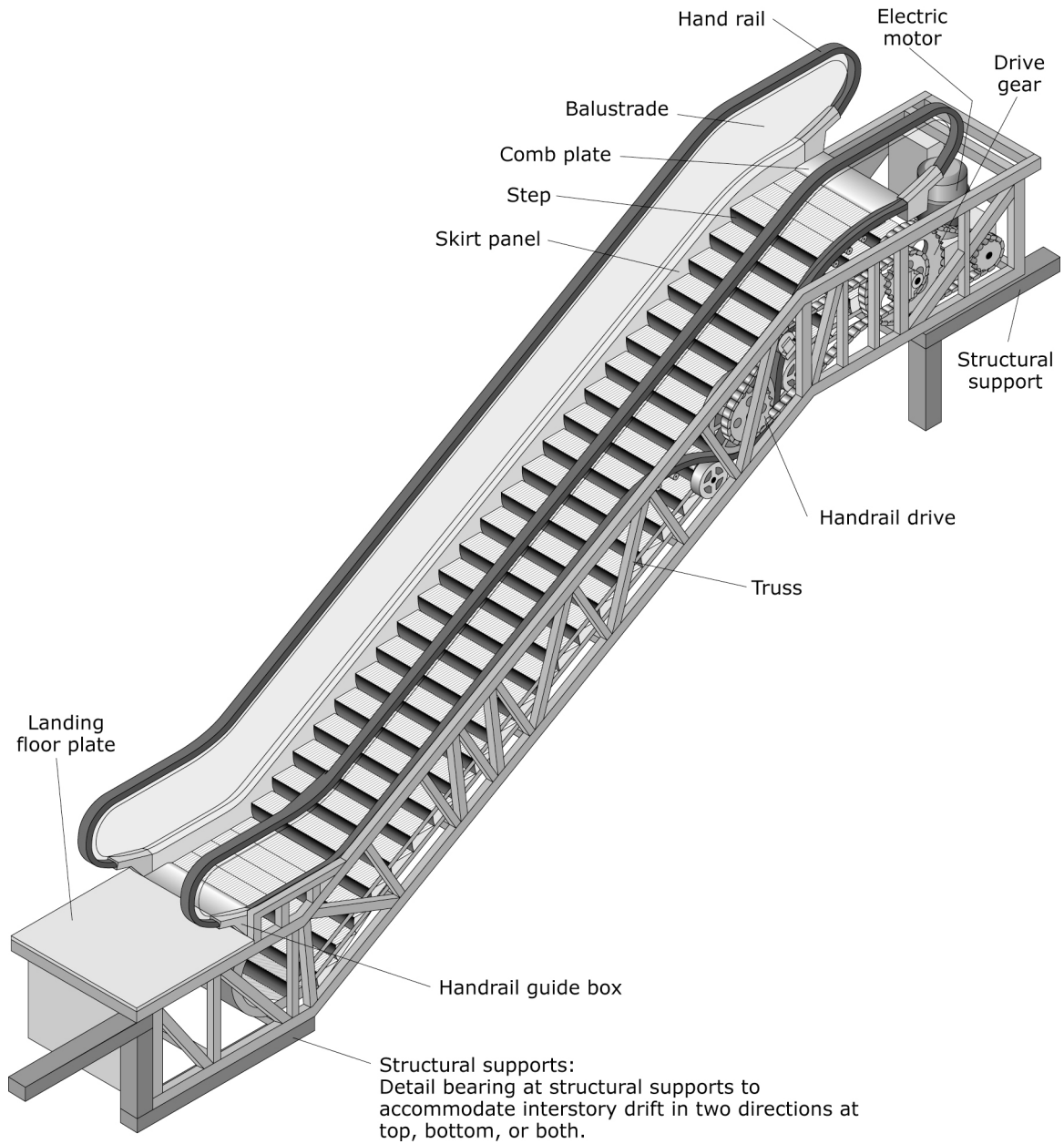


Figure 6.4.10.3-2 Schematic view of escalator (ER).