6.3 ARCHITECTURAL COMPONENTS

6.3.8 STAIRWAYS

6.3.8.1 STAIRWAYS

This includes stairs between floors, which may be independent of the structure, or integral with it. Stairs are needed for exiting following an earthquake and hence protecting them from damage and keeping them clear should be a high priority. Protecting a stair from damage is a structural concern that requires engineering expertise to address.

TYPICAL CAUSES OF DAMAGE

- Stairs are primarily damaged by interstory drift, i.e., differential movement of the adjacent floors, which forces a stairway to try to act like a diagonal brace. Stair damage is more likely to occur in flexible buildings with larger inter-story drift and less likely to occur in stiffer buildings.
- The walls surrounding a stairway may be damaged during an earthquake causing debris to fall into the stairwell and rendering the stairs unusable. Brittle materials such as brick, hollow clay tile, or glass are particularly vulnerable and may create falling and debris hazards in stair enclosures.

Damage Examples

Figure 6.3.8.1-1 Damaged stairway in the 1994 magnitude-6.7 Northridge, California earthquake (Photo courtesy of Wiss, Jenney, Elstner Associates).

Figure 6.3.8.1-2 Stair damaged beyond repair in the 2001 magnitude-8.4 Peru Earthquake; concrete demolished prior to photo (Photo courtesy of Eduardo Fierro, BFP Engineers).

Figure 6.3.8.1-3 View of stairway in the Banco Central Building, Managua, Nicaragua after the 1972 magnitude-6.2 Managua Earthquake. Most of the stairs were covered with debris that resulted from the failure of the hollow tile partitions surrounding the stairs. This photograph highlights the need to not only prevent direct damage to stairway framing and connections, but also to protect against damage to surrounding walls (Photo courtesy of PEER Godden Collection, No. J94).

Figure 6.3.8.1-4 Concrete stair dangling from landing above in the 2010 magnitude-7 Haiti Earthquake (Photo courtesy of Eduardo Fierro, BFP Engineers).

Figure 6.3.8.1-5 Stairs damaged up the full height of this apartment building in Viña del Mar in the 2010 magnitude-8.8 Chile Earthquake (Photo courtesy of Santiago Pujol, Purdue University). The stairs were rigidly attached at adjacent floors and behaved like diagonal braces although they were neither designed nor detailed to function as structural braces.

SEISMIC MITIGATION CONSIDERATIONS

- ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010), Section 13.1.3.1 now requires that egress stairways required to function for life-safety purposes after an earthquake be assigned a component importance factor, I_p, of 1.5 and be treated as designed seismic systems. This may include egress stairways that are not part of the building structure. Structural calculations, special details and additional inspection may be required.
- In order to prevent stairs from behaving like diagonal struts between adjacent floors, the stairs should be detailed with a fixed connection at one floor and a sliding connection at the other that allows movement parallel to the direction of the stair.
- Sliding "gang plank" connections or connections with slotted holes can be used to isolate the stair from one of the attached floors and prevent damage due to inter-story drift. The connection must be designed to accommodate the anticipated drift.
- If stair enclosures are built using brittle materials such as unreinforced masonry, hollow clay tile, glass block, or skylights, it is recommended that they be encapsulated or replaced to prevent falling hazards and debris in the stairwell. Provide bracing and anchorage for pipes, lighting, emergency lighting or ducts to prevent falling hazards and debris in the stairwell. Maintaining safe exits is a critical element of earthquake safety.

Mitigation Details

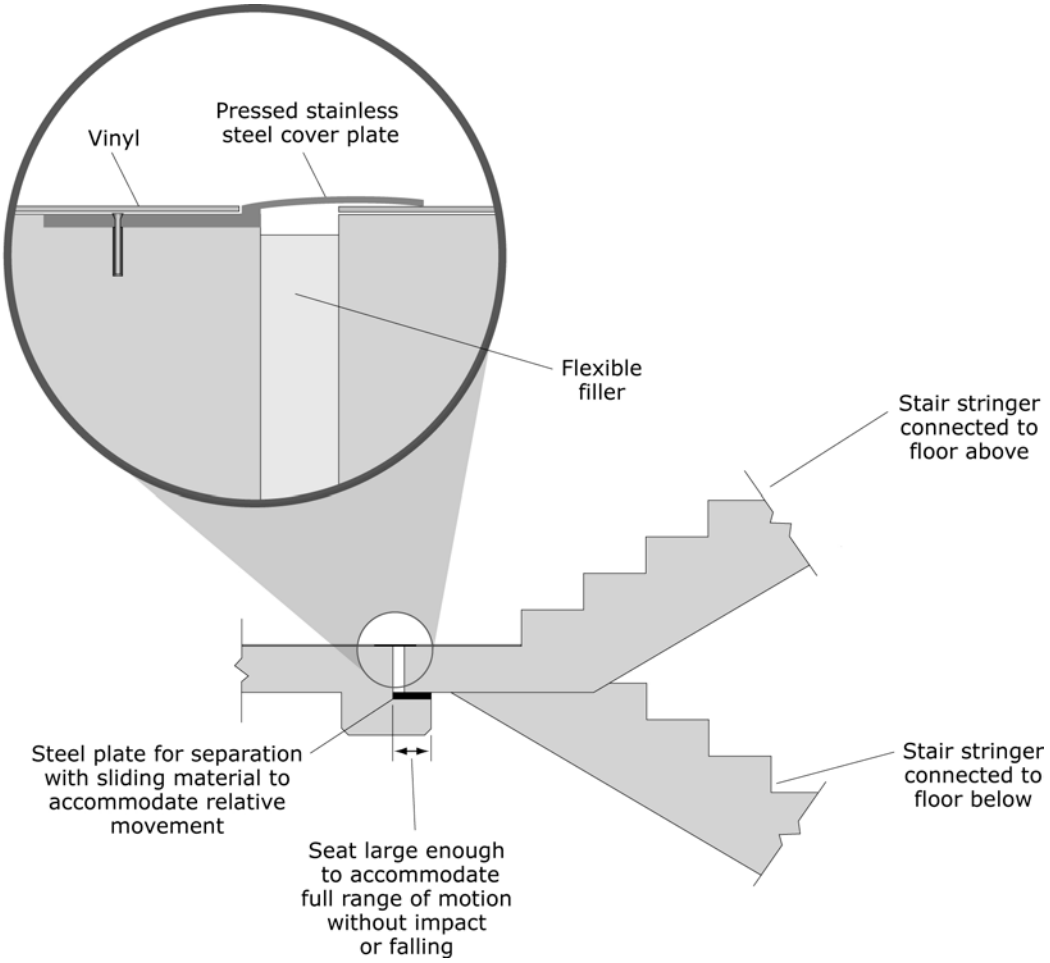

Figure 6.3.8.1-6 Stairway with landing (ER).

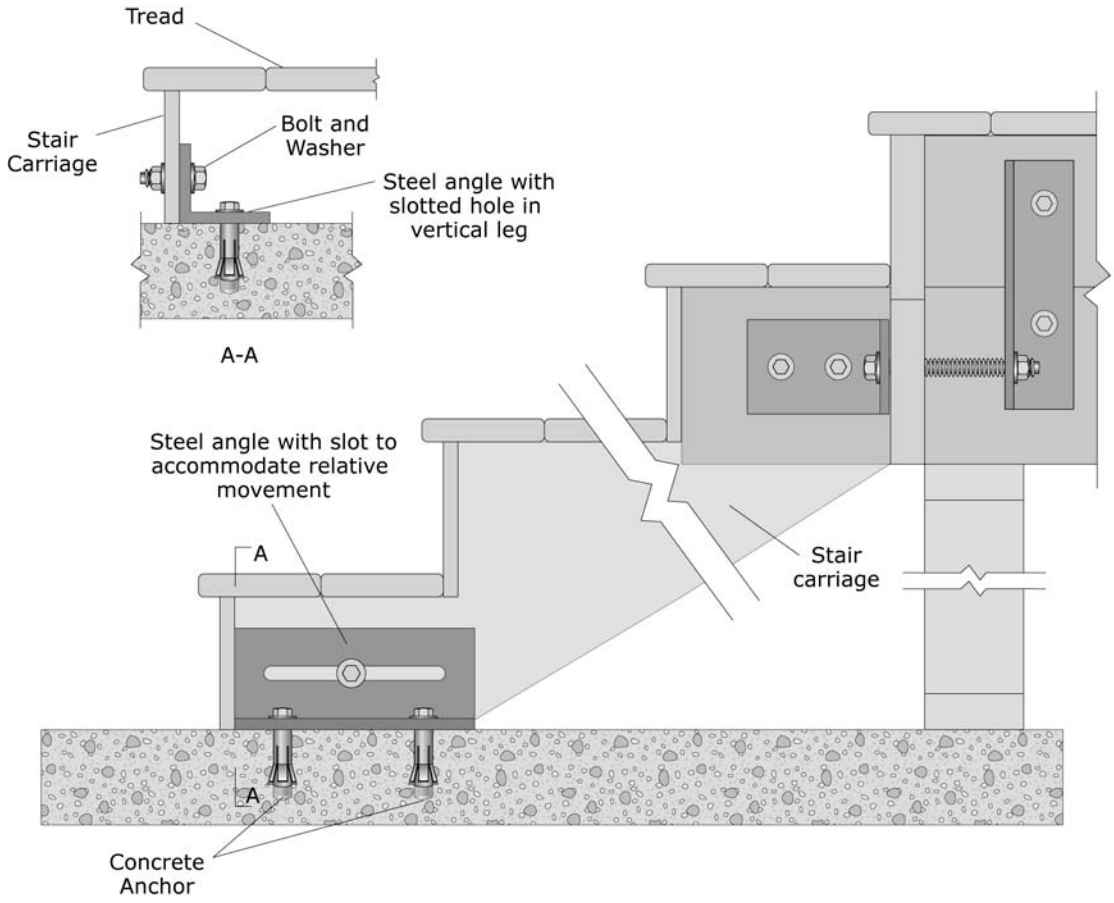

Figure 6.3.8.1-7 Stairway with landing with single run between floors (ER).