6.3 ARCHITECTURAL COMPONENTS

6.3.1 EXTERIOR WALL COMPONENTS

6.3.1.3 PREFABRICATED PANELS

This category covers any type of prefabricated exterior panel that is attached to the perimeter structural framing. These may be lightweight metal panels or precast concrete panels that may have adhered or anchored veneer.

TYPICAL CAUSES OF DAMAGE

- Both lightweight and heavier panels may be damaged by deformations of the building frame; heavier panels may also be damaged by direct acceleration.
- Unless the panel connections are specially detailed to allow the panel to move independently of the building, both the connections and the panel may be damaged. Panels may be racked, damage adjacent panels, connections may fracture, and panels may become dislodged or displaced.
- Deterioration or corrosion of the mechanical connections is a significant concern; corroded connections may fail prematurely. Maintaining watertight joints is important for the longevity of the anchors.

Damage Examples

Figure 6.3.1.3-1 Failure of precast panel at parking garage that resulted in fatality in the 1987 magnitude-5.9 Whittier, California earthquake (Photo courtesy of Degenkolb Engineers).

Figure 6.3.1.3-2 Precast panel failure at the top floor of a hospital in the1994 magnitude-6.7 Northridge Earthquake (Photo courtesy of OSHPD).

Figure 6.3.1.3-3 Precast panel damage at a building corner in the 1994 Northridge Earthquake (Photo courtesy of OSHPD).

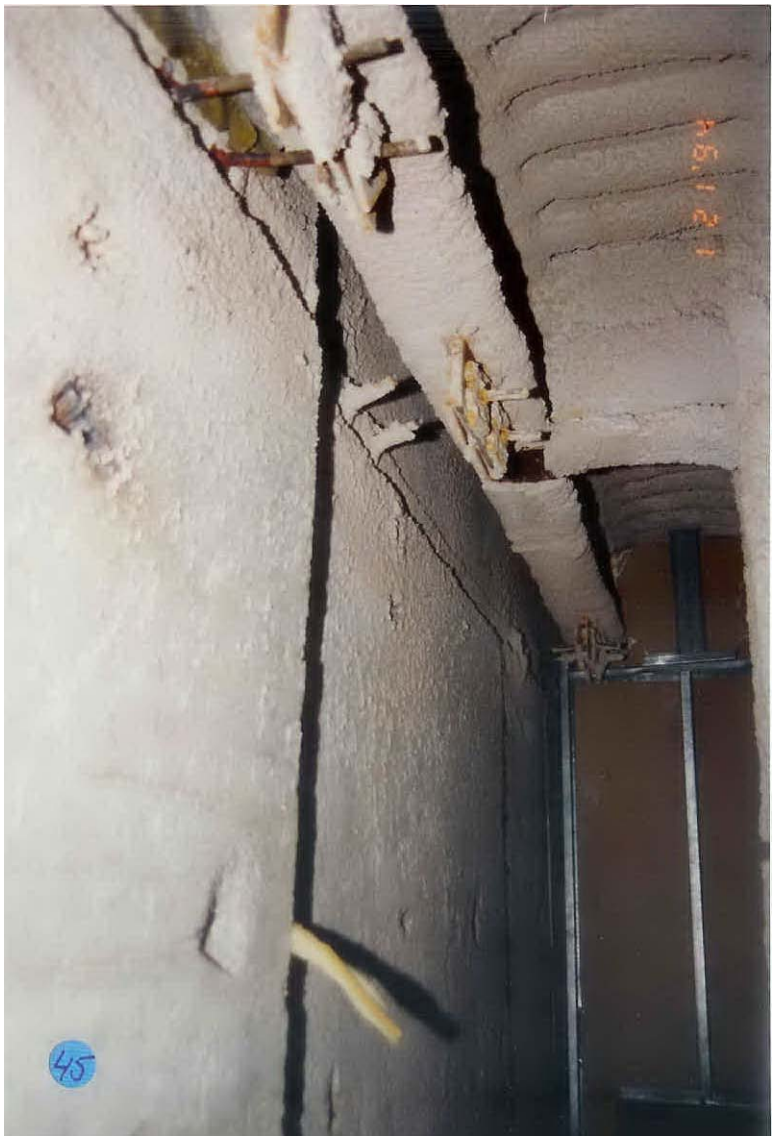

Figure 6.3.1.3-4 Interior view of precast panel showing response of three sets of push-pull connections in the 1994 Northridge Earthquake (Photo courtesy of OSHPD).

Figure 6.3.1.3-5 Close-up photo of two fractured connection bolts in a prefabricated panel in the 1994 Northridge Earthquake; corrosion of the rods may have contributed to the failure. (Photo courtesy of OSHPD).

Figure 6.3.1.3-6 Residential building with precast concrete corridor and balcony railing panels. Some panels were damaged and subsequently many were removed to prevent falling. Location in Rancaqua, Chile 154 miles northeast of the epicenter; estimated PGA of 0.3g during the 2010 magnitude-8.8 Chile Earthquake (Photo courtesy of Antonio Iruretagoyena, Rubén Boroschek & Associates).

Figure 6.3.1.3-7 Numerous precast panels removed to prevent falling; detail from residential building in Rancagua, Chile above. These panels had a bearing seat at the center and supported on steel dowels at either end (Photo courtesy of Eduardo Fierro, BFP Engineers).

SEISMIC MITIGATION CONSIDERATIONS

- Precast panel connections and panel joints require specialized design based on the expected inter-story drift of the structural system supporting them or 0.5 inch, whichever is greater. The connections must be detailed with sufficient ductility and rotation capacity to prevent failure. Typically, the panels are seated on two bearing connections at either the top or bottom floor and then have "push-pull" connections at the adjacent floor which resist out-of-plane loading but move laterally in the plane of the panel. In this way, the panels move with the floor where the bearing connections are located and the drift is accommodated by the rod at the "push-pull" connection.
- Architectural Design for Earthquake, A Guide to Nonstructural Elements, (Charleson, 2007) has a detailed discussion of issues related to exterior cladding. Sliding connections with slotted or oversized holes are commonly used in New Zealand as an alternative to push-pull connections.

MITIGATION DETAILS

Figure 6.3.1.3-8 Precast spandrel panel in San Francisco parking garage supported by bearing connections near top of panel (left) and slotted connections at bottom of panel (right); panels have four connections each. The remnants of a previous nonductile connection detail are visible in the photo at left (Photo courtesy of Cynthia Perry, BFP Engineers).

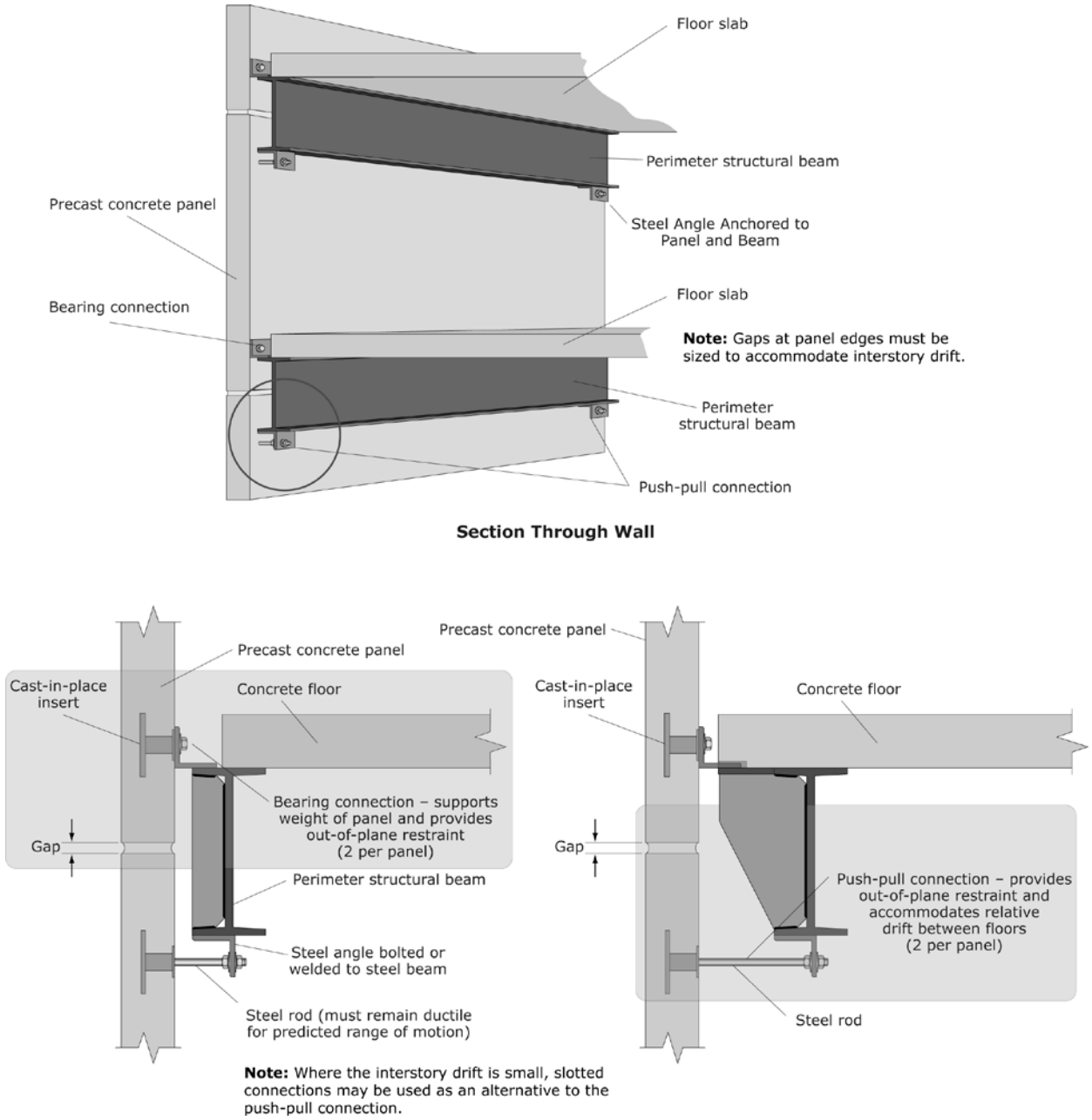

Figure 6.3.1.3-9 Prefabricated panels (ER).