

As before, beams and girders failed by loss of vertical support at connections or by buckling of beams or girders. The girder between Columns 70 and 73 and Columns 73 and 76 buckled, as shown in Figure 11–30. The floor beams that were supported by the girder between Columns 78 and 81 and Columns 71 and 74 also failed when the girder lost vertical support at an end connection, due to the effects of thermal expansion. Seven fin connections in the east tenant floor between Columns 44 and 80 had a 0.75 to 0.99 damage level.

Floors 10, 11, and 12. On Floors 10, 11, and 12 (Figure 11–32, Figure 11–33, and Figure 11–34), the girder between Columns 76 and 79 failed due to a tensile weld failure in the knife connection on the west side of Column 79. Temperatures in this region were less than 100 °C on these floors. The tensile force in the connection was due to an eastward lateral displacement of Column 79, which was primarily caused by thermal expansion of the girder between Column 76 and Column 79 at Floor 13.

There was connection damage and beam buckling around the southeast corner of Floor 11, but there were no fires on Floor 10 to heat the steel framing from below. The fires on Floor 11 caused heating and thermal expansion of the Floor 11 slab in this area. The concrete slab thermally expanded until it exceeded the compressive strain criteria, so that the floor system no longer acted as a composite system. As a result, the floor beams began to act independently, and connection damage and beam buckling occurred.

Floors 12, 13, and 14. Elevated temperatures in the southeast and east floor framing on Floors 12, 13, and 14 ranged from 150 °C to 550 °C in Floor 12, 300 °C to 700 °C in Floor 13, and 150 °C to 700 °C in Floor 14. However, the thermal analysis did not account for thermally induced damage to floor framing or slabs as the structure was heated. Figure 11–34, Figure 11–35, and Figure 11–36 show that the floor beams had failed by connection failures or buckling of beams or girders in areas where the steel temperatures were greater than 400 °C to 500 °C. The following beam and girder failures occurred:

- On Floors 12 and 14, most of the floor beams on the south and east floor areas near Columns 78, 81, and 80 (Figure 11–34 and Figure 11–36) had failed. The floor beams had either buckled or lost vertical support when all the fin connection bolts were sheared off due to thermal expansion. Both Floors 12 and 14 had a 0.75 to 0.99 damage level in several east floor beam connections near Column 79.
- On Floor 12, the girder between Column 26 and Column 81 had failed due to buckling, followed by walk off of the bearing seat, at Column 81.
- On Floor 13 (Figure 11–35), all four of the north-south girders attached to Columns 79, 80, and 81 had failed, due to either buckling or girder walk off of the bearing seat at Columns 79 and 81.
- On Floor 14, all four of the erection bolts in the seated connection at Column 79 on Floor 14 had failed due to the effects of thermal expansion.
- On Floor 14, the header connection for the girder west of Column 80 had failed at the weld to the girder web.