

- In-plane strains of the floor slab
- Degree of damage in connections
- Lateral displacement and rotation of floor beams and girders

Damage to the floor framing depended primarily on the heating from fires on the floor below, whereas the slab was affected by fires on the top of the slab as well as from the floor below. The vertical displacements generally increased as the temperature of the structural framing increased.

In general, the steel framing heated more quickly than the concrete slab. Thus, even though steel and concrete have similar coefficients of thermal expansion, differential thermal expansion occurred between the steel floor beams and concrete slab when the composite floor was subjected to fire.

Axial stresses in the floor beams increased as the beam temperatures increased due to restrained thermal expansion, but the column axial stresses remained relatively constant during the response. Interior columns were not thermally restrained and were free to expand. Exterior columns had some thermal restraint due to the moment framing, but their temperatures remained low. Axial column stresses remained essentially constant because (1) interior column temperatures were less than 200 °C and exterior column temperatures were less than 150 °C, except for a few columns in the 12th and 13th floors which were less than 300 °C; and (2) the failure of girders in a floor did not noticeably decrease the column load. The change in column load following a girder failure at any given floor was small compared to the total column loads from the tenant floors above. Additionally, the only path for redistribution of gravity loads in WTC 7 between interior columns was through the floor framing. Any load redistribution would have occurred until the beam or girder connections failed at the column.

A damage index was computed for the horizontal and vertical direction (shear and axial loads) for each connection. Failure of fin, knife, and header connections resulted in a loss of support for both horizontal and vertical directions, whereas, loss of horizontal and vertical support in the seated connections (SWC, STC, and STP) occurred separately. For example, if all the bolts in a fin connection were sheared, the connection would be fully damaged (failed with a damage level of 1.0) in both the horizontal and vertical directions. However, if all the bolts of a seated connection were sheared, the connection would be fully damaged in the horizontal direction, but not in the vertical direction as the beam or girder would still be resting on the seat. Failure in the vertical direction would occur when either the member supported by the connection walked off the seat or the weld at the seat failed.

The damage state of connections, floor beams, and girders for each floor is illustrated in Sections 11.3.2 and 11.3.3. Connection damage is shown separately for the horizontal and vertical directions. For example, in Figure 11–22 (first graphic in Section 11.3.2), tan dots represent connections without any damage and black dots represent connections with full damage for a given direction. The other colors indicate the degree of damage to the connection at a given time in the analysis. For example, a blue dot, with the degree of damage labeled as “0.5 to 0.74,” represents a 6-bolt fin connection with 4 failed bolts, which gives a damage index of 0.66. Connection damage was typically gradual, with bolts and/or welds failing sequentially over time. In addition to showing connection damage, these graphics also present the floor beam and girder damage, where buckled beams are pink lines and failed end connections are red lines. Prior to end connection failure, many, if not all, of the shear stud connections had failed along the