

supply the lower zone following the collapse of WTC 1. Also, FDNY decided not to fight the fires due to the lack of water and safety considerations.

- The fires on Floors 7, 8, and 9 spread in a clockwise direction (southwest to north to east) while the fires on Floors 11, 12, and 13 spread in a counterclockwise direction (southwest to east to north).
- Fires on the upper floors (Floor 19 and higher) were not observed after approximately 1 p.m. It is possible that some fires could have been extinguished by the gravity-fed sprinkler system that supplied Floors 21 and higher.

11. Initial Local Failure for Collapse Initiation. The simple shear connection between Column 79 and the girder that spanned the distance to the north face (to Column 44) failed on Floor 13. The connection failed due to shearing of erection bolts, caused by lateral thermal expansion of floor beams supporting the northeast floor system and, to a lesser extent, by the thermal expansion of the girder connecting Columns 79 and 44. Further thermal expansion of the floor beams pushed the girder off its seat, which led to the failure of the floor system surrounding Column 79 on Floor 13. The collapse of Floor 13 onto the floors below—some of which were already weakened by fires—triggered a cascade of floor failures in the northeast region. This, in turn, led to loss of lateral support to Column 79 in the east-west direction over nine stories (between Floors 5 and 14). The increase in unsupported length led to the buckling failure of Column 79, which was the collapse initiation event.

- The failure of the girder-to-column connections was caused primarily by the thermal expansion of the large span-length northeast floor beams. Additional factors that contributed to the failure were the absence of girder shear studs that would have provided lateral restraint and the one-sided lateral support to the girder provided by the northeast corner floor beams.
- In addition to the failure of the connection to Column 79 for the girder spanning to Column 44 on Floor 13, which had the most severe fire condition, the same connection on Floors 8 to 12 were partially damaged due to the failure of some or all of the four bolts. Complete failure of the connection required girder walk-off in addition to the failure of all four bolts.
- The temperatures in the columns in WTC 7 did not exceed 300 °C and, therefore, the columns did not buckle due to direct fire-induced thermal expansion or weakening. The interior columns were not thermally restrained and, therefore, did not develop increased loads due to thermal expansion which could have led to buckling.

12. Vertical Progression of Failure. The buckling of Column 79 (the collapse initiation event) triggered a vertical progression of floor system failures to the east penthouse and subsequent cascading failure of the adjacent interior columns on the east side of the building (i.e., Columns 80 and 81). The vertical progression of floor system failures spread to include the entire east region all the way to the top of the building since all three columns in this region had buckled.

- The buckling of Column 79 at the lower floors led to downward movement of the upper section of Column 79. The adjacent floor framing was pulled downward, leading to the observed kink in the east penthouse roof framing.