

- Collapse then ensued.

Seven major factors led to the collapse of WTC 1 and WTC 2:

- Structural damage from the aircraft impact;
- Large amount of jet fuel sprayed into the building interior, that ignited widespread fires over several floors;
- Dislodging of SFRM from structural members due to the aircraft impact, that enabled rapid heating of the unprotected structural steel;
- Open plan of the impact floors and the breaking of the partition walls by the impact debris that resulted in increased ventilation;
- Weakened core columns that increased the load on the perimeter walls;
- Sagging of the floors, that led to pull-in forces on the perimeter columns; and
- Bowed perimeter columns that had a reduced capacity to carry loads.

8.3.2 Structural Steels

- Fourteen different strengths of steel were specified in the structural engineering plans, but only 12 steels of different strength were actually used in construction due to an upgrade of two steels. Ten different steel companies fabricated structural elements for the towers, using steel supplied from at least eight different suppliers. Four fabricators supplied the major structural elements of the 9th to the 107th floors. Material substitutions of higher strength steels were not uncommon in the perimeter columns and floor trusses.
- About 87 percent of the tested steel specimens (columns, trusses and bolts) met or exceeded the required yield strengths specified in design documents. About 13 percent had NIST-measured strengths that were slightly lower than the design values, but this may have arisen from mechanical damage during the collapse, the natural variability of structural steel, and slight differences between the NIST and original mill test report testing protocols.
- The safety of the WTC towers on September 11, 2001, was most likely not affected by the fraction of steel that, according to NIST testing, was modestly below the required minimum yield strength. The typical factors of safety in allowable stress design were capable of accommodating the measured property variations below the minimum.
- The pre-collapse photographic analysis showed that 16 recovered exterior panels were exposed to fire prior to collapse of WTC 1. None of the nine recovered panels from within the fire floors of WTC 2 were observed to have been directly exposed to fire.
- None of the recovered steel samples showed evidence of exposure to temperatures above 600 °C for as long as 15 min. This was based on NIST annealing studies that established the