

set of time and temperature conditions necessary to alter the steel microstructure. These results provide some confirmation of the thermal modeling of the structures, since none of the samples were from zones where such heating was predicted.

- Only three of the recovered samples of exterior panels reached temperatures in excess of 250 °C during the fires or after the collapse. This was based on a method developed by NIST to characterize maximum temperatures experienced by steel members through observations of paint cracking.
- Perimeter columns exposed to fire had a great tendency for local buckling of the inner web; a similar correlation did not exist for weld failure.
- Observations of the recovered steel provided significant guidance for modeling the damage from the aircraft impact with the towers.
- For the perimeter columns struck by the aircraft, fractures of the plates in areas away from a welded joint exhibited ductile behavior (necking and thinning away from the fracture) under very high strain rates. Conversely, fractures occurring next to a welded joint exhibited little or no ductile characteristics.
- There was no evidence to indicate that the type of joining method, materials, or welding procedures were improper. The welds appeared to perform as intended.
- The failure mode of spandrel connections on perimeter panels differed above and below the impact zone. Spandrel connections on exterior panels at or above the impact zone were more likely to fail by bolt tear out. For those exterior panels below the impact zone, there was a higher propensity for the spandrels to be ripped off from the panels. This may be due to shear failures as the weight of the building came down on these lower panels. There was no difference in failure mode for the spandrel connections whether the exterior panels were exposed to fire or not.
- With the exception of the mechanical floors, the perimeter panel column splices failed by fracture of the bolts. At mechanical floors, where splices were welded in addition to being bolted, the majority of the splices did not fail.
- Core columns failed at both splice connection and by fracture of the columns themselves.
- The damage to truss seats on perimeter panels differed above and below the impact zone in both towers. The majority of recovered perimeter panel floor truss connectors (perimeter seats) below the impact floors were either missing or bent downward. Above this level, the failure modes were more randomly distributed.
- In the floor trusses, a large majority of the electric resistance welds at the web-to-chord connections failed. The floor truss and the perimeter panel floor truss connectors typically failed at welds and bolts.