

Table 6–2. Indications of major structural changes up to collapse initiation.

Tower	Time (a.m.)	Observation
WTC 1	10:18	Smoke suddenly expelled on the north face (floors 92, 94, 95 to 98) and west face (92, 94 to 98).
	10:23	Inward bowing of perimeter columns on the east side of the south face from floors 94 to 100; maximum extent: 55 in. $\pm$ 6 in. at floor 97.
	10:28:22	First exterior sign of collapse (downward movement of building exterior). Tilting of the building section above the impact and fire area to due south as the structural collapse initiated. First exterior sign of downward movement of building at floor 98.
WTC 2	9:02:59	Exterior fireball from the east face of floor 82 and from the north face from floors 79 to 82. The deflagration prior to the fireballs may have caused a significant pressure pulse to act on floors above and below.
	9:21	Inward bowing of exterior wall columns on most of the east face from floors 78 to 83; maximum extent: 7 in. to 9 in. at floor 80.
	9:58:59	First exterior sign of collapse (downward movement of building exterior). The northeast corner tilted counterclockwise around the base of floor 82. Column buckling was then seen progressing across the north face and nearly simultaneously on the east face. Tilting of the building section above the impact and fire area to the east and south prior to significant downward movement of the upper building section. The tilt to the south did not increase any further as the upper building section began to fall, but the tilt to the east did increase until dust clouds obscured the view.

Within weeks of the destruction of the WTC, contractors of New York City had begun cutting up and removing the debris from the site. Members of the FEMA-sponsored and ASCE-led Building Performance Assessment Team, members of the Structural Engineers Association of New York, and Professor A. Astaneh-Asl of the University of California, Berkeley, CA, with support from the National Science Foundation, had begun work to identify and collect WTC structural steel from various recycling yards where the steel was taken during the clean-up effort. The Port Authority of New York and New Jersey (Port Authority) also collected structural steel elements for future exhibits and memorials.

Over a period of about 18 months, 236 pieces of steel were shipped to the NIST campus, starting about six months before NIST launched its Investigation. These samples ranged in size and complexity from a nearly complete three-column, three-floor perimeter assembly to bolts and small fragments. Figures 6–3 through 6–5 show some of the recovered steel pieces. Seven of the pieces were from WTC 5. The remaining 229 samples represented roughly 0.25 percent to 0.5 percent of the 200,000 tons of structural steel used in the construction of the two towers.

The collection at NIST included samples of all the steel strength levels specified for the construction of the towers. The locations of all structural steel pieces in WTC 1 and WTC 2 were uniquely identified by stampings (recessed letters and numbers) and/or painted stencils. NIST was successful in finding and deciphering these identification markings on many of the perimeter panel sections and core columns, in many cases using metallurgical characterization to complete missing identifiers. In all, 42 exterior panels were positively identified: 26 from WTC 1 and 16 from WTC 2. Twelve core columns were positively identified: eight from WTC 1 and four from WTC 2. Twenty-three pieces were identified as being parts of trusses, although it was not possible to identify their locations within the buildings.