

Table A.2 Fire Duration in Previous Fire Incidents in Steel-frame Buildings

Building	Date	Fire Duration (hours)
1st Interstate Bank Building	May 4-5, 1988	3.5
Broadgate Phase 8	1990	4.5
One Meridian Plaza	February 23-24, 1991	19 (11 uncontrolled)

One important aspect of these previous incidents is that the columns remained intact and sustained their load carrying ability throughout the fire incidents (though there was no structural damage caused by impacts). Throughout the fire in One Meridian Plaza, horizontal forces were exerted on the columns by the girders and despite the 24- to 36-inch deflections of the girders, floor beams, and concrete and steel deck floor slabs, the columns continued to stabilize the building throughout the fire and for several years after the fire.

Questions have been raised about the comparison of the structural performance of the WTC 1 and WTC 2 and the Empire State Building. In the case of the Empire State Building:

1. The impacting aircraft was a U. S. Army Air Force B-25 bomber weighing 12 tons with a fuel capacity of 975 gallons, which, at the time of the crash, was traveling at a speed estimated to be 250 mph;
2. Crash damage to structural steel was confined to three steel beams. One exterior wall column withstood the direct impact without visible effect;
3. Exterior walls are ornamental cast aluminum panels under windows with steel trim backed by 8 inches of brick. The walls at columns are 8 inches of limestone backed by 8 inches of brick supported on steel framing; and
4. The floors above the Saturday morning plane crash were largely vacant and unoccupied, so the fire load was minimal and perhaps close to zero. Fire was confined to a portion of two floors. Because the building had few occupants at the time of the crash, the fire department could concentrate on controlling and extinguishing the fire.

A.3.1.4 Properties of Steel

The principal thermal properties that influence the temperature rise and distribution in a member are its thermal conductivity, specific heat, and density. The temperature-dependence of the thermal conductivity and specific heat for steel are depicted in Figure A-4.

The mechanical properties that affect the fire performance of structural members are strength, modulus of elasticity, coefficient of thermal expansion, and creep of the component materials at elevated temperatures. Information on the thermal and mechanical properties at elevated temperatures for various types of steel is available in the literature (Lie 1992, Milke 1995, Kodur and Harmathy 2002).

References to the tensile or compressive strength of steel relate either to the yield strength or ultimate strength. Figure A-5 shows the stress-strain curves for a structural steel (ASTM A36) at room temperature and elevated temperatures. As indicated in the figure, the yield and ultimate strength decrease with temperature as does the modulus of elasticity. Figure A-6 shows the variation of strength with temperature (ratio of strength at elevated temperature to that at room temperature) for hot rolled steel such as A36. As indicated in the figure, if the steel attains a temperature of 550 °C (1,022 °F), the remaining strength is approximately half of the value at ambient temperature.