

The perimeter columns, floors, and core columns were immersed in these hot gases and began to weaken. Where the insulation was dislodged, the temperature of the steel rose rapidly, in contrast to steel members where insulation was intact (Figure 2–8). The heaviest core columns with damaged insulation heated slowly, as the absorbed heat was dissipated through their massive cross sections. The temperatures of the lighter columns and the floor slabs rose more quickly, and those of the stripped trusses even more so.

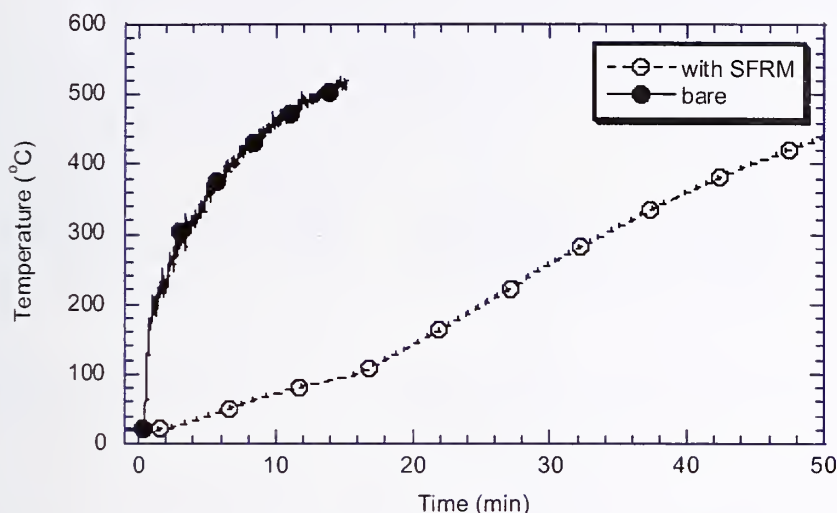


Figure 2–8. Steel surface temperatures on the bottom chords of fire-exposed trusses, uninsulated and insulated with ¾ in. of BLAZE-SHIELD DC/F.

As a steel column is heated, its ability to support gravity loads and resist lateral loads decreases. At temperatures of about 300 °C, steel loses about 20 percent of its yield strength (Figure 2–9). Under modest loads, steel is *elastic*, that is, it can compress, or shorten, but will recover when loads are removed. As the load increases, the steel becomes *plastic*, and the shortening is unrecoverable. At still higher loads, the column buckles. At temperatures above 500 °C, the steel further weakens, the loss of strength and stiffness become significant, and the column’s ability to carry its share of the building loads decreases. It shortens due to a combination of plastic deformation and an additional, time-dependent deformation called *creep* that can increase column shortening and hasten buckling. Figure 2–10 indicates the rates at which structural steel could have been heated by the WTC fires and the effect of the thermal insulation in slowing the heating process.⁶

Structural steels do not need to melt to lose strength. Their melting points are about 1,600 °C, well above the 1,100 °C typical peak value reached by fires of common building combustibles.

At this point, the core of WTC 1 could be imagined to be in three sections. There was a bottom section below the impact floors that could be thought of as a strong, rigid box, structurally undamaged and at almost normal temperature. There was a top section above the impact and fire floors that was also a heavy, rigid box. In the middle was the third section, partially damaged by the aircraft and weakened by heat from the fires. The core of the top section tried to move downward, but was held up by the hat truss. The hat truss, in turn redistributed the load to the perimeter columns.

⁶ Chapter 6 contains an explanation of how these temperature profiles were developed.