

With either thickness of insulation applied, it would take at least 7 h (3,600 s = 1 h) for the steel to reach 600 °C, the temperature at which the steel would have lost approximately 50 percent of its strength. (See NIST NCSTAR 1-3D for a thorough description of the loss of strength as a function of temperature.) For the fires in the WTC towers and in WTC 7 (see Chapter 9 of this report), the compartment air temperatures typically were near 1100 °C for less than 2 h. Even if the room temperature from the fires reached 1400 °C, a temperature that might be realized in a wind-aided fire and an extreme upper limit to the air temperatures probable in the types of fires experienced in WTC 7, the steel temperature would remain low enough after 4 to 5 h of such intense fire exposures for the steel to preserve its strength. By contrast, with no thermal insulation, the column would lose much of its strength within the first half hour of exposure to 1100 °C.

Figure 4–5 shows the results of similar calculations for the lighter, W14 x 500, column. The green data represent temperatures at the outer surface of the thermal insulation; the red data represent temperatures at the interior of the center of the web plate. For the insulated column, shown in the left plot, the web temperature reaches 600 °C in about 4 h. With no insulation (right plot), this temperature is reached in a matter of minutes. As expected, the lighter columns heat somewhat more rapidly, but, if properly insulated, the steel temperature would remain low enough after 3 h of such intense fire exposures for the steel to preserve its strength.

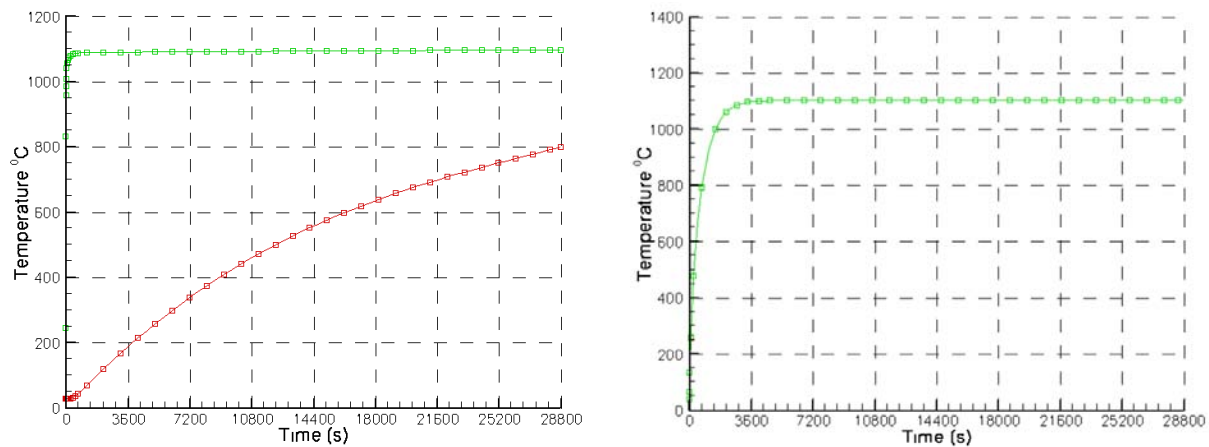


Figure 4–5. Calculated temperature rise in a typical core or exterior column exposed to 1100 °C air temperature.

Left: insulated with 7/8 in. Monokote MK-5; right: uninsulated.

Each composite floor, with one of three representative beam sections, was exposed to an 1100 °C air temperature from below. Figure 4–6 shows the result of heating the floor with the insulated lightest steel section. The lower flange of the steel reached compromising temperatures in about 15 min, the upper flange in about 1 h. Figure 4–7 and Figure 4–8 show the slower temperature rises in the insulated midweight and heaviest beams, respectively. The lower flange temperatures are virtually identical to the web plate temperatures. Figure 4–9 shows the temperatures reached at the top and bottom of a typical floor slab at the thinnest sections located at the top of the steel deck corrugation.