

The fact that the simulated fires encircled the building in roughly the same amount of time as the actual fires supported the estimate of the overall combustible load of 20 kg/m^2 (4 lb/ft^2). Simulations performed with higher loads required a proportionately longer amount of time to bring the fires around to the southeast because of the fact that the burn time was roughly proportional to the fuel mass in the oxygen-limited interior of the fire floors.

For WTC 2, relying mainly on Case D, there was less movement of the fires. The major burning occurred along the east side, with some spread to the north.

6.7.2 Fire Temperatures

It was clear from both the simulations and observations that the computation of some “average” gas temperature was not a satisfactory means of assessing the thermal environment on floors that were over $4,000 \text{ m}^2$ (1 acre) in area. Not only would the assumption of an average temperature have been inconsistent with the visual evidence, but it would also have led to large errors in the subsequent thermal and structural analyses.

The heat transferred to the structural components was largely by means of thermal radiation, which is roughly proportional to the fourth power of the gas temperature. The simulations and the visual evidence suggested that the duration of temperatures in the neighborhood of $1,000^\circ\text{C}$ at any given location on any given floor was about 15 min to 20 min. The rest of the time, temperatures were predicted to have been in the range of 400°C to 600°C on floors with active fires. To put this in perspective, the heat flux onto a truss surrounded by smoke-laden gases of $1,000^\circ\text{C}$ is approximately 150 kW/m^2 , whereas it is 20 kW/m^2 for gases of 500°C .

6.7.3 Global Heat Release Rates

Much of the information needed to simulate the fires as described above came from laboratory-scale tests. While some of these (NIST NCSTAR 1-5E) involved enclosures several meters in dimension and fires that reached heat release rates of 10 MW and 12 GJ in total heat output, they were still far smaller than the fires that burned on September 11, 2001, in the WTC towers. Figure 6-30 shows the heat release rates from the FDS simulations of the WTC fires. The peak plateau heat release rates were about 2 GW for WTC 1 and 1 GW for WTC 2. (These are quite similar to the preliminary estimates by Rehm et al. (2002), which were between 1 to 1.5 GW for each tower.) Integrating the area under these curves produced total heat outputs from the simulated fires of about 8,000 GJ from WTC 1 and 3,000 GJ from WTC 2. That adequate representations of disasters can be generated using data from experiments two orders of magnitude smaller is an indication of the capability within the fire research community.