

The project staff computerized drawings of each floor, including the layout of the partitions, stairwells and other features that might affect fire spread. These became input to the fire modeling described in Chapter 4. These drawings are included in NIST NCSTAR 1-5F.

As the Investigation proceeded, NIST determined that a smaller number of floors (a) experienced fires that were of sufficient intensity, expanse, and duration to compromise significant numbers of structural elements, and (b) were in the vicinity of the observed collapse initiations. These floors were 92 through 99 in WTC 1 and 78 through 85 in WTC 2. These are hereafter referred to as the focus floors.

### 3.1.3 Ceilings

The condition of the ceiling tile system following the aircraft impact would have had a significant effect on the spread of the fires and their impact on the structural elements, especially the floor joists. The hot gases from a fire rise and form a hot layer across the top of a room. The temperatures in this layer could have exceeded 1,000 °C, well above the threshold temperature at which the strength of structural steels diminishes. However, as long as the ceiling tile system were intact, this layer would have formed *below* the floor joists, and the temperature in the upper “box” would have remained relatively cool for some time interval. This delay time is most often characterized by a fire resistance rating, obtained from a standard furnace test such as ASTM E 119 (ASTM 2000). Were a significant fraction of the tiles displaced from the framework, the hot flames from fires underneath would have bathed the floor system immediately. Further away, the hot upper layer formed from the fire effluent would have enveloped the floor trusses, rather than building from the drop ceiling down. It was thus deemed valuable to determine the condition of the ceiling tile systems in the regions where the fires existed and where their heat might have had structural implications. This determination consisted of measuring the response of the systems to shocks of different magnitudes, and then putting those results in the context of the shocks resulting from the aircraft impacts into the towers.

There were two different ceiling tile systems originally installed in the towers. The framing for each was hung from the bottom of the floor trusses, resulting in an apparent room height of about 2.6 m (8.6 ft) and an above-ceiling height of about 1.0 m (3.4 ft). Both sets of tiles were manufactured by Armstrong World Industries, Inc, specifically for the WTC (Fritz and Hough 2002).

- Tenant spaces: The PANYNJ originally specified Armstrong BF 803 tiles for the towers. These were 20 in. square,  $\frac{3}{4}$  in. thick, lay-in tiles on an exposed tee bar grid system. Figure 3–1 is a photograph of a similar system. This was sold as a non-fire resistance rated system. The combustible content of the original tiles was estimated to be 13 percent to 15 percent by mass. Using ASTM E 84 (Test Method for Surface Burning Characteristics of Building Materials ASTM 2003), Armstrong determined the flame spread index as under 25 and the smoke developed index as under 50. The density of the tiles was approximately 1 lb/ft<sup>3</sup> (16 kg/m<sup>3</sup>) (Fritz and Hough 2002). The ceilings were the responsibility of the tenants, and over the years many (if not all) tiles were replaced. Some of the replacement was with similar products by Armstrong and other manufacturers; some were replaced with alternative products such as gypsum board. The 20 in. tiles were manufactured only for the WTC towers and thus were no longer available.