

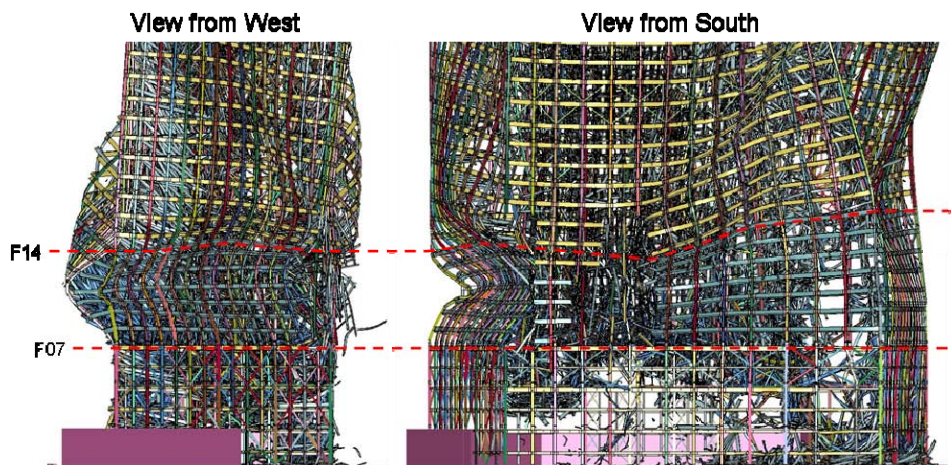


Figure 3-14. Buckling of the lower exterior columns within 1 s of Figure 3-13.

The second LS-DYNA analysis (lesser degree of fire-induced damage) did not lead to a collapse-initiating event, despite the extensive damage shown in Figure 3-9a.

The third LS-DYNA analysis demonstrated that the fire-induced damage led to the collapse of WTC 7, even without any structural damage from the debris impact. However, the mechanism of the collapse differed from the first analysis. This is discussed further in the next section.

The fourth LS-DYNA analysis showed that, following the removal of Column 79 between Floors 11 and 13, vertical and horizontal progression of failure occurred. This was followed by downward movement at the roofline due to buckling of exterior columns, which led to the collapse of the entire building. This analysis showed that WTC 7 was prone to classic progressive collapse associated with the local failure of Column 79.

3.5 ACCURACY OF THE PROBABLE COLLAPSE SEQUENCE

Independent assessment of the validity of the key steps in the collapse of WTC 7 was a challenging task. Some of the photographic information had been used to direct the simulations. For example, the timing of the appearance of broken windows was an input to the fire growth modeling. However, there were significant observables that were usable as corroborating evidence, as shown in Table 3-1. The "Observation Times" were determined from examinations of photographs and videos shot on September 11, 2001. The times in the second and third columns are from the two global analyses with and without debris impact damage for Case B temperatures at 4.0 h. Time "zero" was set as the start of the descent of the east penthouse.

3.5.1 Aspects prior to the Global Collapse

Analysis of a video shot prior to and during the collapse showed an east-west vibration of the building prior to its collapse (NIST NCSTAR 1-9, Chapter 5 and Appendix C). The horizontal motion (± 2 in.) began 6 s before the east penthouse began to move downward. The horizontal building motion started at nearly the same time as the cascading floor failures started in the LS-DYNA analysis (-6.5 s), which preceded the buckling failure of Column 79. A seismic signal approximately 10 s prior to the onset of