

greatly increased the model size and affected the rate of solution convergence. Since the collapse of WTC 7 clearly initiated on the east side of the structure (Chapters 5 and 8), the break elements were only used in the east side of the model.

Debris impact damage from the collapse of WTC 1 was included in the LS-DYNA model, but not in the ANSYS model. The structural damage that was observed following the collapse of WTC 1 was between Floors 7 and 17 in the southwest quadrant of the building (Chapter 5). The WTC 7 structure redistributed loads around this damage through the Vierendeel truss action¹ provided by the exterior moment frame. The ANSYS model, which modeled the structure from ground level to Floor 16, did not include a sufficient number of floors to capture the load redistribution following the debris impact damage. Inclusion of debris damage was unnecessary for analyzing the initiating event which occurred in the northeast region of the building.

The ANSYS analysis included the effects of gravity and temperature loads. Gravity loads included: the dead load of the structure; superimposed dead loads consisting of the weight of ceilings, mechanical and electrical equipment, thermal insulation, and floor finishes; and service live load, which was taken as 25 percent of the design live load specified in the original design documents. The gravity loads from the floors above Floor 16 were applied to the top of the columns in the model. Wind loads were not considered in the analyses, as the wind speeds on September 11, 2001, were not structurally significant.

Temperature data were input at 30 min intervals for the fires observed on Floors 7 to 9, and 11 to 13. The temperature data were obtained from the FSI analysis (Chapter 10), which was based on the FDS analysis of the fires (Chapter 9). Three different thermal cases were developed and used in the ANSYS analysis. These cases were within the range of realistic and reasonable fires in WTC 7 on September 11, 2001. Case A used the temperature data as obtained from the FDS simulations. Cases B and C increased and decreased, respectively, the Case A gas temperature by 10 percent, which was judged to be within the range of uncertainty for these fires.

11.2 ANSYS MODEL

11.2.1 Model Description

A finite element model, referred to hereafter as the 16 story model, was developed and is illustrated in Figure 11–1. As fires were observed on Floors 7 to 9 and 11 to 13, the floors and columns in these areas were subject to heating and possible thermally induced failures, while floors and columns above Floor 14 and below Floor 7 were not. Floor framing between Floors 8 and 14 and columns between Floors 7 and 14 were explicitly modeled, while Floor 7 and below and Floors 15 and 16 were modeled using superelements. Superelements reduce the degrees of freedom, and hence, computational time, while appropriately representing the stiffness at the top and bottom of the model.

The gravity load was applied in stages to represent the effects of construction sequence. The thermal loading was applied in the form of temperature-time histories. Examination of temporal changes in structural elements temperatures with time during the FSI analysis found that the temperature state of

¹ Most trusses have a triangular shape and pinned joints that can transfer forces but not bending moments. A Vierendeel truss has a rectangular shape and fixed joints that can transfer and resist forces and bending moments.