

**Federal Building and Fire Safety Investigation
of the World Trade Center Disaster**

**Reconstruction of the Fires in the WTC
Towers: Findings and Issues**

October 19, 2004

Richard G. Gann, Ph.D.
Senior Research Scientist

**Building and Fire Research Laboratory
National Institute of Standards and Technology
U.S. Department of Commerce**

rggann@nist.gov

Project Objective

Reconstruct, with assessed uncertainty limits, the time-evolving temperature, thermal radiation, and smoke fields in World Trade Center 1, 2, and 7 for use in evaluating the behavior and fate of occupants and responders and the structural performance of the buildings

Findings to Date - I

- Loading of building combustibles was on the light side of typical
- Mass of aircraft solid combustibles was significant relative to the mass of the building combustibles in the impact zone
- Ceiling tiles were likely to have been dislodged throughout the impact floors
- The movement of the fires was complex and varied from floor to floor in each building
- View of fires through many windows was hindered by interior walls, as well as by steep viewing angles and smoke clouds
- It was possible to discern instances where an internal wall stopped the fire spread for an appreciable time
- FDS and FSI can be used with confidence to recreate the thermal effect of a given WTC fire event

Findings to Date - II

- The results of FDS modeling were relatively insensitive to small variations in damage estimates and combustible load in WTC 1
- Both FDS and the photographic evidence indicate that the “dwell time” of the fires was ca. 20 min
- The gross uncertainty in the damage to the core walls on multiple floors makes it impossible to obtain information from computer simulations of the tenability of the building interiors that is surer than the (qualitative) information deduced from the activity of the occupants
- FSI simulations of both towers show high (dominant) sensitivity of structural element temperatures to the presence or absence of SFRM
- The predictions of maximum temperatures reached by certain core columns in FDS/FSI simulations are consistent with those determined from the analyses of the actual columns

Findings to Date - III

- WTC 1:
 - The oxygen-limited fires spread both counterclockwise and clockwise from the initial locations on the north side, taking most of an hour to become established along the south face.
 - By the end of an hour, there were many severely heated structural members on the south end of the core, complementing the previously heated or impact-damaged core elements to the north
- WTC 2:
 - There was steady burning in the northeast quadrant of the building
 - Within an hour, there had been severe heating of nearly all the perimeter and core columns and floors on the east side of the impact floors
 - There was little heating of the structural elements on the west side of the building, where damage to the SFRM was not expected

Issues - I

- Predictive tools for design-based fire scenarios that include:
 - Computational code for determining the fire contribution of real combustibles to fire scenarios
 - An accurate model for predicting the performance of openings in fires, including open doors and window breakage
 - Mechanisms of and models for floor-to-floor fire spread

Issues - II

- Availability of standards and codes, methodology, analytical design tools, and practical design guidance to permit considering fire as a design condition for the structure as a whole system
 - Broad training opportunities for rigorous use of computational fire dynamics and thermostructural analysis tools
 - Method for rating the fire resistance of structural systems and barriers for realistic design-basis fire scenarios (as contrasted with furnace conditions)
 - Structural principles education for fire protection engineers

**Federal Building and Fire Safety Investigation
of the World Trade Center Disaster**

**Reconstruction of the Fires in the WTC
Towers: Findings and Issues**

Thank you

Richard G. Gann, Ph.D.
Senior Research Scientist
rggann@nist.gov