A. Forensic Study of Steel in the World Trade Center

T.A. Siewert, F. Gayle, R. Fields, D. McColskey, and C. McCowan, National Institute of Standards and Technology, Boulder, CO

Summary

In 2002, NIST became the lead agency in a planned investigation of the World Trade Center collapse. The investigation addresses many aspects of the catastrophe, from occupant egress to factors affecting how long the Twin Towers stood after being hit by the airplanes, with a goal of gaining valuable information for the future. A critical aspect of the investigation is the metallurgical and mechanical analyses of structural steels from the Twin Towers and WTC 7. The analyses include characterization of properties, failure modes, and temperature excursions seen by the steel.

Background

The collapse of the twin World Trade Center Towers on September 11, 2001, was the worst building disaster in human history. Engineers, emergency responders, and the nation were largely unprepared for such a catastrophe. The disaster highlights the following national needs:

- To establish the probable technical causes of the collapses and derive the lessons to be learned;
- To develop and disseminate immediate guidance and tools to assess and reduce future vulnerabilities; and
- To produce the technical basis upon which cost-effective changes to national practices and standards can be developed.

Program

NIST is implementing its technical plan to address these issues (see http://wtc.nist.gov/). A primary objective of the investigation is to determine why and how the towers collapsed after the initial impact of the aircraft. As part of this investigation, the Materials Reliability and Metallurgy Divisions in MSEL are studying more than 200 structural steel pieces from the WTC site. Progress in this study is outlined here.

Task 1: Collect and catalog physical evidence. More than 200 pieces of the World Trade Center towers have been collected and brought to NIST. The locations of 41 exterior column panels within the WTC towers have been positively identified, of which 15 were located in or near the impact zones of the aircraft. Specified strengths of structural components have been identified through engineering drawings for the buildings.

Task 2: Failure mechanisms based on visual evidence. Recovered steel is being examined and documented as to failure mechanisms.

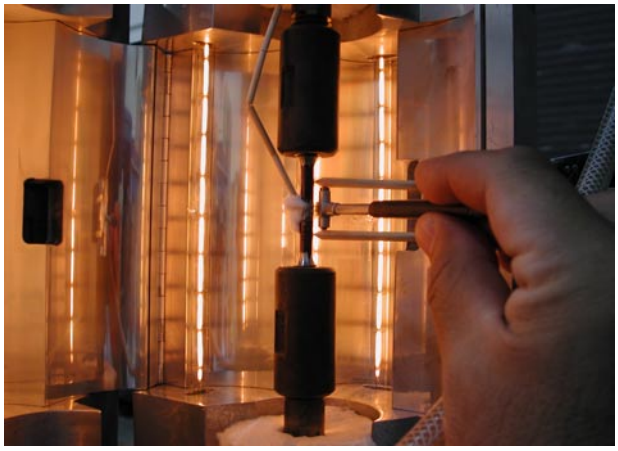

Figure 1. Instrumentation adjustment on high temperature specimen.

Task 3: Property data to support studies of structure performance and airplane impact modeling. Fourteen grades of steel were specified in the design of the WTC towers. All grades have been characterized for room-temperature mechanical properties, and initial high-temperature test results are complete. Testing at high strain rate is underway to determine the effects of strain rate on the mechanical properties of the outer columns, the inner columns and the spandrels. Chemical composition and metallographic examinations have been completed on the majority of the steels. Creep, or time-temperature-dependent behavior of some steels will be studied after the high temperature properties are developed.

Task 4: Correlate determined steel properties with specified properties. As data are generated during the testing phase of the investigation, measured values of strength are compared to those specified in the engineering drawings.

Task 5: Metallographic analysis of steel to estimate temperature extremes. Microscopic, macroscopic and metallographic analyses are under way to determine the maximum temperature excursions seen by the steel.

Interim reports containing data generated to date is being released to aid in the modeling of the aircraft impact and building response to subsequent fires. A final report will be complete by the Fall of 2004.