

The properties of the steel samples tested were consistent with the specifications called for in the steel contracts. In particular, the yield strengths of all samples of the floor trusses were higher than called for in the original specifications. This was in part because the truss steels were supplied as a higher grade than specified. Overall, approximately 87 percent of all perimeter and core column steel tested exceeded the required minimum yield strengths specified in design documents. Test data for the remaining samples were below specifications, but were within the expected variability and did not affect the safety of the towers on September 11, 2001. Furthermore, lower strength values measured by NIST could be expected due to (a) differences in test procedures from those used in the qualifying mill tests and (b) the damaged state of the samples. The values of other steel properties were similar to typical construction steels of the WTC construction era. The limited tests on bolts indicated that their strengths were greater than the specified minimum, and they were stronger than contemporaneous literature would suggest as typical. The tested welds performed as expected.

NIST measured the stress-strain behavior at room temperature (for modeling baseline performance), high temperature strength (for modeling structural response to fire), and at high strain rates (for modeling the aircraft impact). Based on data from published sources, NIST estimated the thermal properties of the steels (specific heat, thermal conductivity, and coefficient of thermal expansion) and creep behavior for use in the structural modeling of the towers' response to fire.

6.4.3 Damage Analysis

NIST performed extensive analyses of the recovered steel specimens to determine their damage characteristics, failure modes, and (for those near the fire zones) fire-related degradation. In some cases, assessment of enhanced photographic and video images of the towers enabled distinguishing between damage that occurred prior to the collapse and damage that occurred as a result of the collapse. Because the only visual evidence was from the outside of the buildings, this differentiation was only possible for the perimeter panel sections. The observations of fracture and failure behavior, confirmed by an Investigation contractor, were also used to guide the modeling of the towers' performance during impact and subsequent fires and to evaluate the model output.



Source: NIST.

Figure 6–5. WTC 1 exterior panel hit by the nose of the aircraft.