

Not all of the observables were closely matched by the simulations due to the uncertainties in exact impact conditions, the imperfect knowledge of the interior tower contents, the chaotic behavior of the aircraft breakup and subsequent debris motion, and the limitations of the models. In general, however, the results of the simulations matched these observables sufficiently well that the Investigation Team could rely on the predicted trends.

Simulations of the damage to the core columns had been performed previously by staff of Weidlinger Associates, Inc. (WAI) and the Massachusetts Institute of Technology (MIT). Each developed a range of numbers of failed and damaged columns, as did NIST. The range of the MIT results straddled the NIST results. WAI's analysis resulted in more failed and damaged columns, with WTC 2 being unstable immediately following impact.

6.9.3 Damage to Thermal Insulation

The dislodgement of thermal insulation from structural members could have occurred as a result of (a) direct impact by debris and (b) inertial forces due to vibration of structural members as a result of the aircraft impact. The debris from the aircraft impact included the fragments that were formed from both the aircraft (including the contents and fuel) and the building (structural members, walls, and furnishings). In interpreting the output of the aircraft impact simulations, NIST assumed that the debris impact dislodged insulation if the debris force was strong enough to break a gypsum board partition immediately in front of the structural component. Experiments at NIST confirmed that an array of 0.3 in. diameter pellets traveling at approximately 350 mph stripped the insulation from steel bars like those used in the WTC trusses.

Determining the adherence of SFRM outside the debris zones was more difficult. There was photographic evidence that some fraction of the SFRM was dislodged from perimeter columns not directly impacted by debris.

NIST developed a simple model to estimate the range of accelerations that might dislodge the SFRM from the structural steel components. As the SFRM in the towers was being upgraded with BLAZE-SHIELD II in the 1990s, The Port Authority had measured the insulation bond strength (force required to pull the insulation from the steel). The model used these data as input to some basic physics equations. The resulting ranges of accelerations depended on the geometry of the coated steel component and the SFRM thickness, density and bond strength. For a flat surface (as on the surface of a column), the range was from 20g to 530g, where g is the gravitational acceleration. For an encased bar (such as used in the WTC trusses), the range was from 40g to 730g. NIST estimated accelerations from the aircraft impacts of approximately 100g.

In determining the extent of insulation damage in each tower, NIST only assumed damage where dislodgement criteria could be established and supported through observations or analysis. Thus, NIST made the conservative assumption that insulation was removed only where direct debris impact occurred and did not include the possibility of insulation damage or dislodgement from structural vibration. This assumption produced a lower bound on the bared steel surface area, thereby making it more difficult to heat the steel to the point of failure.