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

Baseline Structural Performance and Aircraft Impact Damage Analysis

Response to Public Comments

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NIST

Statistics on Comments Received

- Total Number of submissions: 60

  - ❑ 2 from code organizations (editorial)
  - ❑ 57 from two engineers from industry (technical clarifications)
  - ❑ 1 from an individual (questions and clarifications)

Nature of Comments

Most of the comments dealt with the following issues:

- Clarifications (or justifications) on the use of materials constitutive models in LS-DYNA for steel and concrete, including strain rate models.
- Adequacy of the plow-type impactor for the floor component analysis.
- Accuracy and sources of the aircraft model.
- Reasonableness of the bounds used for the variables in the sensitivity analyses.
- Adequacy of using 32-bit precision versus 64-bit precision.
- The influence of the P-delta effects due to building sway after impact.
- Accuracy and level of confidence in the SPH approach used in modeling fuel dispersion.

Changes to Project Report

The adequacy of using 32-bit precision versus 64-bit precision:

- To confirm the adequacy of the single precision analysis, subassembly impact analyses were performed on the same model in both single and double precision. The comparison of the two analyses showed no substantial difference in the impact response and damage.

The influence of the P-delta effects due to building sway after impact :

- P-Δ effects generated due to the sway of the towers after impact, as observed in video evidence, were not expected to affect or impose additional damage to the core columns. The core columns were designed as axially loaded members without continuity of framing, and thus would not develop significant P-Δ moments (see NIST NCSTAR 1-2A).

Changes to Project Report

The accuracy and the level of confidence in the SPH approach used in modeling fuel dispersion:

- Both the SPH and ALE analysis techniques available for the analysis of the fuel impact and dispersion had limitations. Details of the fuel behavior such as the wetting of the fuel against tower structures and interior contents or the physics of the fuel breakup into droplets are not accurately reproduced in either analysis technique. However, the momentum transfer from the fuel to the tower structures and subsequent impact damage produced by the fuel can be modeled by both analysis techniques.

  The detailed predictions of the fuel dispersion and distribution using SPH in the global impact analyses had significant uncertainties in the absence of improved validation testing. However, some aspects of the distribution had a higher confidence. The floors confined the vertical motion of the fuel, and the floor-by-floor distribution of fuel was controlled more by the geometry of the tower and impact conditions. As a result, this distribution by floor has a higher level of confidence. Similarly, the interior contents and partition walls, and the damage to these structures, controlled the spread of fuel.