

National Institute of Standards and Technology

National Institute for Standards and Technology (NIST), er en institution i USA, der svarer til Teknologisk Institut i Danmark. Efter terrorangrebet den 11. september 2001 fik NIST til opgave at undersøge de bygninger i World Trade Center, der blev ødelagte som følge af angrebet. Formålet med undersøgelserne var at komme med forebyggende forslag og standarder til bygge- og anlægsbranchen, så ulykker kunne undgås i fremtiden og brandbekæmpelse kunne forbedres.

Konklusion

I forbindelse med undersøgelserne, der skulle fastslå årsagerne til at de syv bygninger i World Trade Center komplekset blev ødelagte, afdækkede NIST systematisk alt tilgængeligt materiale, herunder de mange videoer, der optog WTC 1s kollaps. NIST kunne i 2004 konkludere, at WTC 1 kollapsede progressivt, uden brug af sprængstof eller missiler.

Det følgende er taget fra NISTs rapport, og besvarer centrale spørgsmål om bygningens kollaps.

Hvilke skader fik WTC 1, da Flight 11 ramte bygningen?

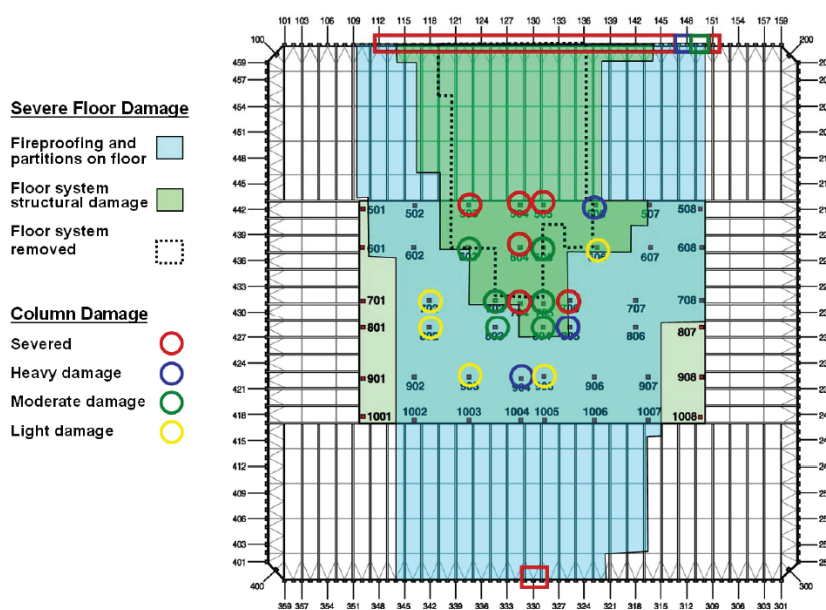


Figure 2-4. Simulation of cumulative aircraft impact damage to floors 93 through 98 in WTC 1.

Hvad skete der i WTC 1, efter Flight 11 havde ramt bygningen?

6.14.4 Events Following Collapse Initiation

Failure of the south wall in WTC 1 and east wall in WTC 2 cause the portion of the building above to tilt in the direction of the failed wall. The tilting was accompanied by a downward movement. The story immediately below the stories in which the columns failed was not able to arrest this initial movement as evidenced by videos from several vantage points.

The structure below the level of collapse initiation offered minimal resistance to the falling building mass at and above the impact zone. The potential energy released by the downward movement of the large building mass far exceeded the capacity of the intact structure below to absorb that through energy of deformation.

Since the stories below the level of collapse initiation provided little resistance to the tremendous energy released by the falling building mass, the building section above came down essentially in free fall, as seen in videos. As the stories below sequentially failed, the falling mass increased, further increasing the demand on the floors below, which were unable to arrest the moving mass.

The falling mass of the building compressed the air ahead of it, much like the action of a piston, forcing material, such as smoke and debris, out the windows as seen in several videos.

NIST found no corroborating evidence for alternative hypotheses suggesting that the WTC towers were brought down by controlled demolition using explosives planted prior to September 11, 2001. NIST also did not find any evidence that missiles were fired at or hit the towers. Instead, photographs and videos from several angles clearly show that the collapse initiated at the fire and impact floors and that the collapse progressed from the initiating floors downward, until the dust clouds obscured the view.

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Hvilke faktorer bidrog til WTC 1s kollaps?

2.10 The outcome

Seven major factors led to the collapse of WTC 1:

- Structural damage from the aircraft impact;
- Large amounts of jet fuel sprayed into the building interior, that ignited widespread fires over several floors;
- Dislodging of SFRM from structural members due to the aircraft impact, that enabled rapid heating of the unprotected structural steel;
- Open paths for fire spread resulting from the open plan of the impact floors and the breaking of partition walls by the impact debris;
- Weakened core columns that increased the load on the perimeter walls;
- Sagging of the south floors, that led to pull-in forces on the perimeter columns; and
- Bowed south perimeter columns that had reduced capacity to carry loads.

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Hvad var den formodentlige kollapssekvens for WTC 1?

6.14.6 Probable WTC 1 Collapse Sequence

Aircraft Impact Damage

- The aircraft impact severed a number of exterior columns on the north wall from the 93rd to the 98th floors, and the wall section above the impact zone moved downward.
- After breaching the building's perimeter, the aircraft continued to penetrate the building, severing floor framing and core columns at the north side of the core. Core columns were also damaged toward the center of the core. Insulation was damaged from the impact area to the south perimeter wall, primarily through the middle one-third to one-half of the core width. Finally, the aircraft debris removed a single exterior panel at the center of the south wall between the 94th and 96th floors.
- The impact damage to the exterior walls and to the core resulted in redistribution of severed column loads, mostly to the columns adjacent to the impact zones. The hat truss resisted the downward movement of the north wall.
- Loads on the damaged core columns were redistributed mostly to adjacent intact core columns and to a lesser extent to the north perimeter columns through the core floor systems and the hat truss.
- As a result of the aircraft impact damage, the north and south walls each carried about 7 percent less gravity load after impact, and the east and west walls each carried about 7 percent more load. The core carried about 1 percent more gravity load after impact.

Thermal Weakening of the Structure

- Under the high temperatures and stresses in the core area, the remaining core columns with damaged insulation were thermally weakened and shortened, causing the columns on the floors above to move downward. The hat truss resisted the core column shortening and redistributed loads to the perimeter walls. The north and south walls' loads increased by about 10 percent, and the east and west walls' loads increased by about 25 percent, while the core's loads decreased by about 20 percent.
- The long-span sections of the 95th to 99th floors on the south side weakened with increasing temperatures and began to sag. Early on, the floors on the north side had sagged and then contracted as the fires moved to the south and the floors cooled. As the fires intensified on the south side, the floors there sagged, and the floor connections weakened. About 20 percent of the connections on the south side of the 97th and 98th floors failed.
- The sagging floors with intact floor connections pulled inward on the south perimeter columns, causing them to bow inward.

Collapse Initiation

- The bowed south wall columns buckled and were unable to carry the gravity loads. Those loads shifted to the adjacent columns via the spandrels, but those columns quickly became overloaded as well. In rapid sequence, this instability spread all the way to the east and west walls.
- The section of the building above the impact zone (near the 98th floor), acting as a rigid block, tilted at least 8 degrees to the south.
- The downward movement of this structural block was more than the damaged structure could resist, and global collapse began.

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SFRM = Sprayed fire-resistive material