

## 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 2s kollaps. NIST kunne i 2004 konkludere, at WTC 2 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 2, da Flight 175 ramte bygningen?*

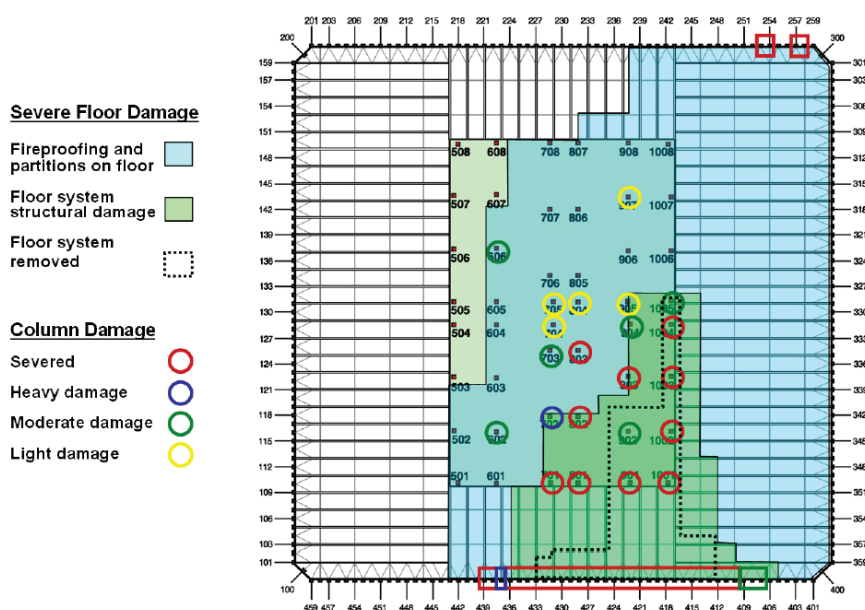


Figure 3-3. Simulation of aircraft impact damage to the 78<sup>th</sup> through 83<sup>rd</sup> floors in WTC 2.

*Hvad skete der i WTC 2, efter Flight 175 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.

*NIST NCSTAR 1 – Final Report on the Collapse of the World Trade Center Towers, side 146*

## Hvilke faktorer bidrog til WTC 2s kollaps?

### 3.7 The outcome

Seven factors led to the collapse of WTC 2:

- Direct structural damage from the aircraft impact, which included more severe damage to the core columns than in WTC 1;
- 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 and aircraft and building debris, which enabled rapid heating of the unprotected structural steel;
- Sustained fires on the east side of the tower and an ample air supply;
- Weakened core columns that increased the loads on the perimeter walls;
- Sagging of the east floors, that led to pull-in forces on the east perimeter columns; and
- Bowed east perimeter columns that had a reduced capacity to carry loads.

*NIST NCSTAR 1 – Final Report on the Collapse of the World Trade Center Towers, side 45-46*

## Hvad var den formodentlige kollapssekvens for WTC 2?

### 6.14.7 Probable WTC 2 Collapse Sequence

#### Aircraft Impact Damage

- The aircraft impact severed a number of exterior columns on the south wall from the 78th floor to the 84th floor, and the wall section above the impact zone moved downward.
- After breaching the building's perimeter, the aircraft continued to penetrate into the building, severing floor framing and core columns at the southeast corner of the core. Insulation was damaged from the impact area through the east half of the core to the north and east perimeter walls. The floor truss seat connections over about one-fourth to one-half of the east side of the core were severed on the 80th and 81st floors and over about one-third of the east perimeter wall on the 83rd floor. The debris severed four columns near the east corner of the north wall between the 80th and 82nd floors.
- The impact damage to the perimeter walls and to the core resulted in redistribution of severed column loads, mostly to the columns adjacent to the impact zones. The impact damage to the core columns resulted in redistribution of severed column loads, mainly to other intact core columns and the east exterior wall. The hat truss resisted the downward movement of the south wall.
- As a result of the aircraft impact damage, the core carried about 6 percent less gravity load. The north wall carried about 10 percent less, the east face carried about 24 percent more, and the west and south faces carried about 3 percent and two percent more, respectively.
- The core was then leaning slightly toward the south and east perimeter walls. The perimeter walls restrained the tendency of the core to lean via the hat truss and the intact floors.

#### 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.
- At this point, the east wall carried about 5 percent more of the gravity loads, and the core carried about 2 percent less. The other three walls carried between 0 percent and 3 percent less.
- The long-span floors on the east side of the 79th to 83rd floors weakened with increasing temperatures and began to sag. About one-third of the remaining floor connections to the east perimeter wall on the 83rd floor failed.
- Those sagging floors whose seats were still intact pulled inward on the east perimeter columns, causing them to bow inward. The inward bowing increased with time.

#### Collapse Initiation

- As in WTC 1, the bowed columns buckled and became unable to carry the gravity loads. Those loads shifted to the adjacent columns via the spandrels, but those columns quickly became overloaded. In rapid sequence, this instability spread all across the east wall.
- Loads were transferred from the failing east wall to the weakened core through the hat truss and to the north and south walls through the spandrels. The instability of the east face spread rapidly along the north and south walls.
- The building section above the impact zone (near the 82nd floor) tilted 7 degrees to 8 degrees to the east and 3 degrees to 4 degrees to the south prior to significant downward movement of the upper building section. The tilt to the south did not increase any further as the upper building section began to fall, but the tilt to the east was seen to increase to 20 degrees until dust clouds obscured the view.
- The downward movement of this structural block was more than the damaged structure could resist, and the global collapse began.

*NIST NCSTAR 1 – Final Report on the Collapse of the World Trade Center Towers, side 151-152*

*SFRM = Sprayed fire-resistive material*