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Years to Build and Moments to Destroy: How the Twin Towers Fell

By WARREN E. LEARY

Little is left but rubble and dust. The degree of destruction at the World Trade Center after the Sept. 11 terrorist attacks seems almost beyond comprehension.

But understanding the natural forces that contributed to the disaster can help explain the destruction of the twin towers, why they came crashing down the way they did and why enormous clouds of dust erupted from the site, experts say.

The buildings contained more than 200,000 tons of steel, 425,000 cubic yards of concrete and 600,000 square feet of glass in 43,000 windows. Each floor, a reinforced concrete pad on a metal deck supported by steel cross beams, was about one acre and weighed about 4.8 million pounds.

The general outline of the towers' collapse was well known soon after the terrorist attack: engineers believe that the crash of the 767's and the intense heat generated from thousands of gallons of burning jet fuel weakened and buckled the buildings' steel framework, causing the upper floors to collapse and beginning an unstoppable chain reaction borne along by the force of gravity.
Since the crash, engineers have continued to analyze the
catastrophe. The buildings came down, engineers said, much
as they would have in a controlled demolition — although a
controlled collapse would have started with the strategic
placement of small explosives.

The size and weight of the concrete floor pads, and the way
they collapsed onto one another, helps explain why so much of
the mass of each building was smashed into small pieces,
demolition engineers said. As each concrete floor pancaked
into the one below, their combined weight grew so large that
they and everything in their path broke into smaller and
smaller pieces, until mostly dust and small pieces of rubble
remained.

Dr. Frank A. Moscatelli, a professor of physics at Swarthmore
College in Pennsylvania, calculated that the total energy
released in the disaster was equivalent to the explosion of 600
tons of TNT. This energy discharge, which takes into account
the weight of the airplanes that struck the buildings, their
speed at impact, the jet fuel and the mass of the buildings, is
about one-twentieth of that released by the 10-kiloton atom
bomb dropped on Hiroshima, he said.

"And most of this energy was supplied by gravitational
collapse," Dr. Moscatelli said. "People don't think of an item
sitting still as having energy, but it does. The energy from
gravitational collapse is what the controlled demolition people
use to take down structures, and it is very powerful."

Once the mass of the upper part of a building begins to fall,
Dr. Moscatelli said, it gains momentum that adds to the force
the structure below has to resist. "If the rest of the building
can't do it, everything begins to fall straight down," he said.

Jon D. Magnusson, chairman and chief executive of Skilling
Ward Magnusson Barkshire in Seattle, a structural engineering
company that worked out the original World Trade Center
design, said the enormous energy released in the collapse was
enough to pulverize the 110-story towers and their contents.

As the buildings fell, large plumes of dust billowed from the
structures in what appeared to be high-speed jets. Engineers
said compression of the buildings' air propelled the dust.

"People don't think about it, but there is a large amount of air
in a structure," said James Redyke, president of Dykon
Blasting, a demolition company in Tulsa, Okla. "A building is like an accordion, and when it collapses the air has to exit someplace. It exits at a pretty good volume, carrying all the dust from concrete, sheetrock and other things inside."

An initial analysis of the World Trade Center disaster released last week by Risk Management Solutions of Newark, Calif., a company that analyzes catastrophes for the insurance industry and others, estimated that the pancake collapse of the tower floors produced a major airborne "debris surge." This cloud, which it said initially spread at more than 50 miles per hour, dumped significant deposits of dust more than a half mile from the site and small amounts up to two miles away.

Larry Gilmore, president of Controlled Blasting, a demolition company in Norcross, Ga., said the large cloud of dust coming from the fall of a tall structure was from more than the displacement of air inside. Watching tapes of the New York disaster, he said he noticed another phenomenon seen during controlled demolitions.

"As a building falls, it pulls the atmosphere down with it, creating a vacuum behind it," Mr. Gilmore said. "Air rushes into the space that has been evacuated above and creates a downdraft that hits the debris below, pushing even more dust out with great force."

Impact of the collapse coupled with this powerful downdraft provided the force to propel the giant dust cloud down nearby streets and around buildings, he said.

Mr. Magnusson and others said they were initially surprised that the buildings went straight down without sliding to the side or toppling.

Pictures of the collapse indicate that the buildings' outer support structures may have helped guide the falling floors, Mr. Magnusson said.

The buildings had a so-called metal tube structure design, which consisted of hundreds of steel columns spaced around the outer face of each tower to give the structures stiffness and to support much of their weight, including the floor pads. This outer ring was connected by steel trusses to a cluster of metal columns in the center that supported core components such as elevators and stairs, as well as part of each concrete floor.
Mr. Magnusson said the outer tubes of the buildings, consisting of 61 steel columns on each of a tower's four sides, seemed to keep the concrete floors aligned as they fell.

"As you look at the videotape, it seems that as the building frame peels back, it stays long enough for the floors to pass," Mr. Magnusson said. "The reason the buildings stood and the reason they went straight down was that strong exterior tube."