

What caused the World Trade Center towers to collapse on 9/11?

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The south tower of the World Trade Center collapses on Sept. 11, 2001. ~

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What caused the World Trade Center towers to collapse on 9/11?

Ask any American and they'll tell you where they were when al-Qaeda terrorists attacked New York City's World Trade Center towers on Sept. 11, 2001. Millions of people across the nation stood slack-jawed in front of televisions as they watched airplanes slam into lower Manhattan's two tallest skyscrapers with fiery force. When it seemed that the country's worst fears had already been realized, the 110-story buildings collapsed, engulfing those fleeing the scene in a dusty cloud of debris. As people struggled to come to terms with the horrific

events of that day, they wondered, how could such massive structures be reduced to a pile of rubble?

This wasn't the first time the World Trade Center had been targeted by Islamic extremists. On Feb. 26, 1993, seven men collaborated to detonate a truck bomb in the underground parking garage, killing six people. While this earlier attack blew a crater 100 feet (30.5 meters) wide and several stories high into the base of the north tower, it failed to bring the building down [source: FBI]. To many Americans, the towering skyscrapers seemed indestructible. Less than a decade later, this perception would be contradicted in dramatic fashion.

Sept. 11, 2001, began as a typical Tuesday in New York City. Skies were clear as residents flooded the city's streets and subways to make their morning commute. Then, at 8:46 a.m., a Boeing 767-200ER aircraft crashed into the north face of the north tower between floors 94 and 98. Startled New Yorkers turned their eyes to the top of the city's skyline and wondered whether this was an accident, or perhaps something more sinister. Such questions were laid to rest at 9:03 a.m., when a second Boeing 767-200ER struck the south face of the south tower between the 78th and 84th floors. The airplanes, loaded with jet fuel, sparked fires in both buildings that burned intensely on several floors. At 9:59 a.m., just 56 minutes after the south tower was hit, it collapsed, sending up a choking cloud of dust that spread across the New York skyline. The north tower soon followed suit, crumpling to the ground at 10:29 a.m., 1 hour and 43 minutes after it was struck. The attacks killed 2,830 people, including 2,270 building occupants, 157 airline crew and passengers, and 403 emergency responders [source: FEMA].

The collapse of the World Trade Center towers shocked the world and changed the United States in significant ways. Why did they fall? Or perhaps the first question should be, how were they built?

DEEP IMPACT

The World Trade Center towers were actually built to withstand the initial impact from a common jetliner at the time of their construction - the Boeing 707. However, this aircraft was smaller than the Boeing

767s that struck the buildings in 2001, and the precautionary design didn't take into account any weakening of the steel superstructure caused by fire [source: NOVA].

World Trade Center Construction

To understand why the World Trade Center towers collapsed on Sept. 11, 2001, you need to first understand how they were constructed. The design was conceived in the early 1960s by architects from Minoru, Yamasaki & Associates and Emery Roth & Sons, along with structural engineers from Worthington, Skilling, Helle & Jackson. At that time most skyscrapers (like the Empire State Building) were supported by a dense grid of steel beams that was sturdy, but limited the open floor space on each level. The World Trade Center's architects and engineers employed revolutionary construction methods to maximize their buildings' floor space and build higher than anyone had before.

The most significant advancement in the World Trade Center's design had to do with the towers' steel framework. Instead of spacing the vertical support beams evenly across the floors, the designers moved all of them to the exterior walls and the central core of the structure. These columns supported all of the buildings' weight, but without lateral, or side-to-side, support from the floors, these columns would have buckled. The floors were built upon trusses, which bridged the distance between the exterior and core columns. Connected with two bolts on each end, these spans of rigid steel framework prevented the columns from bowing inward or outward. They also supported a 4-inch-thick (10 centimeters) floor made of reinforced concrete (reinforced concrete is embedded with steel for increased strength). Spray-on fireproofing, made from material similar to the rolled insulation in your home, further protected the integrity of the steel floor trusses, while the central columns were shielded by fire-resistant drywall. This economical design required less concrete and created nearly an acre of rentable office space on each of the buildings' 110 floors.

On Aug. 5, 1966, crews broke ground for the construction of the new World Trade Center towers. The north tower welcomed its first tenant in December 1970, while the south tower was first occupied in January

1972. The ribbon cutting for the entire complex occurred on April 4, 1973. Despite their innovative design, the buildings would be reduced to rubble just 28 years later. Read on to discover how the impact of the airplanes and the resulting fires ultimately brought down these massive skyscrapers.

LOW VISIBILITY

On a foggy July day in 1945, a B-25 bomber flown by Capt. William F. Smith accidentally crashed into the 79th floor of the Empire State Building, killing Smith and two others onboard, as well as 11 office workers. Despite fires sparked by the collision, the famous landmark survived. This event isn't directly comparable to the September 11 attacks, however, because the Boeing 767-200ER aircraft that hit the World Trade Center towers were significantly larger and heavier than the B-25, and were traveling much faster upon impact [source:NPR].

World Trade Center Collapse

We will never know for sure exactly what structural stresses and failures caused the World Trade Center towers to collapse. However, two government reports provide slightly different explanations of the possible processes that ultimately brought the buildings to the ground. The first of these reports was authored by the Federal Emergency Management Agency and completed in September 2002, while the second was done by the National Institute of Standards and Technology and finished in September 2005.

Both studies blame two general events for the collapse of the World Trade Center towers. The first was the initial impact of the airplanes. This occurrence caused significant damage to the buildings' external and core columns and increased the strain on those that remained intact. The impact also dislodged the spray-on fireproofing that protected the floor trusses and the fire-resistant drywall that encased the core columns. This left the buildings' steel components vulnerable to the second critical event: the fires sparked by the airplane collisions. Each of the aircraft carried about 10,000 gallons of fuel, which probably burned off quickly, but not before igniting the contents of several floors in both buildings. These fires burned at temperatures between 400 and 1,100 degrees Fahrenheit (800 and 2,000 degrees

Celsius), hot enough to weaken -- but not melt -- the towers' steel superstructure [source: FEMA]. It was a combination of the initial damage and these fires that ultimately led to the buildings' demise.

While the two government reports came to the same general conclusions, they disagreed on some of the specifics. The FEMA report blamed the failure of the bolts connecting the floor trusses to the external columns for the collapse of the buildings. According to this theory, the floor trusses began to sag when weakened by the fire, pulling at these bolts and causing them to shear off. The force of the collapsed floor then caused the next floor to fail, and the next, and so on in a phenomenon known as pancaking. With no lateral support, the vertical columns soon buckled, and the buildings collapsed. The NIST report also blames sagging floor trusses for the collapse, but suggests that the floors actually pulled the exterior columns inward, causing them to buckle. This brought the top section of the buildings down through the impact zone with a force too great to be stopped.

While no one will ever know exactly how the World Trade Center towers collapsed, we do know that the event changed the world forever.

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