

Engineers search for answers in rubble of collapsed World Trade Towers

by Sara Peters

Shock paralyzed the world as we watched the World Trade Center (WTC) Towers disappear in a cloud of smoke like some sick magic trick. Perhaps no eyewitnesses were more shocked than the engineers who understood the structural details that made the buildings nigh invincible.

Engineer **CHARLES THORNTON** painted a very grim picture for a packed audience Oct. 4, when he presented current information on the collapse of the WTC.

Dr. Thornton explained that the towers were constructed to withstand the impact of a 707, and that the fireproofing systems were built to endure a three-hour-long fire. Nonetheless, 1 WTC collapsed after only 1 hour and 43 minutes; 2 WTC came down in a mere 47 minutes.

Dr. Thornton's engineering firm has been charged to find an explanation for this surprising catastrophe. He is a practicing engineer and managing principal of Thornton-Tomasetti Engineers, the company that designed the Petronas Towers in Kuala Lumpur. He is also a visiting lecturer in the civil and environmental engineering (CEE) department, where he teaches *CEE462: Design of Large-Scale Structures*, a required senior-level course for CEE undergraduates.

Dr. Thornton was in downtown Manhattan when the terrorist attack happened.

"My first reaction was, it isn't so bad. It's only the top 12 floors," he said of that

morning. He went uptown to see things closer, and watched 1 WTC collapse.

"I couldn't believe it," he said.

Although the firm's reports are not yet complete, Dr. Thornton and his team have ascertained some information explaining why the towers collapsed so completely and so rapidly.

The leading assumption is that the damage to the building came in two major ways. Though the delicate airplane fuselages were probably shredded by the buildings' steel girders, the heavy engines could have crashed through the steel, wrecking entire floors at impact.

It is speculated that tons of jet fuel inside the plane may have poured down into the central core of the building, where the elevator shafts and stairwells are located. Though the building is fireproofed to prevent damage, and sprinkler systems are located throughout the building, the conflagration of so much jet fuel could not be extinguished. The amount of water pressure necessary far exceeded the capacity of the sprinkler system.

Once the engine and flames destroyed the floors at the impact point, the building probably underwent progressive collapse. Once the structure supporting the top floors was destroyed, those top floors collapsed. The weight of those floors falling caused the lower floors to fail.

Dr. Thornton admitted, however, that there are very few things of which engineers

can be certain. He expects that even the terrorists had no way of knowing that the buildings would collapse.

"I believe they absolutely lucked out," he said.

Also speaking at the lecture was **BRIAN TOKARCZIK**, a young engineer at Thornton-Tomasetti. Mr. Tokarczik had been working on cleanup at ground zero for 11 days when he spoke about the progress. Mr. Tokarczik, a Navy veteran of the Gulf War, said he was reminded of Kuwait, stating that there was "an ominous smell of burning iron," and that the jet fuel sticking to everything reminded him of napalm.

"As we walked, it was like a transition from reality into what seemed surreal," Mr. Tokarczik said. "We went from New York City to a demolition zone."

Mr. Tokarczik described the on-site work as "engineering on the fly." The situation is very treacherous. It is difficult to estimate the stability of the ground, so engineers are timid when driving cranes over the rubble to remove debris. Mr. Tokarczik said the engineers planned to bring in a crane with a 700-ft. long boom, in order to keep workers away from dangerous grounds.

However, a larger problem, for which no one yet seems to have any solution, is "the bathtub."

What engineers refer to as "the bathtub" is the six-story-deep underground slurry wall that surrounds the perimeter of the WTC. The basement floors normally brace the sides of the wall, and keep it

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A word of remembrance

More than 4,000 people lost their lives on Sept. 11, 2001, when the towers were rammed by hijacked airliners. Among the missing and confirmed dead are 13 Princetonians.

JEFFREY WIENER '90, who majored in mechanical and aerospace engineering, is among those who perished in the WTC attack. He graduated Princeton University with high honors and went on to receive his master's in engineering from Penn State. Mr. Wiener worked at Marsh Inc. in the WTC.

A list of Princetonians who died Sept. 11, 2001, is available online at: <http://tigernet.princeton.edu> Select In Memoriam under Princeton links.

The staff of *EQuad News* sends our greatest sympathy to the families and friends of all the victims.

A city's skyline changed

Construction on the World Trade Towers began in 1966 at an estimated cost of \$1.5 billion. One World Trade Center was ready for its first tenants in late 1970, though the upper stories were not completed until 1972; Two World Trade Center was finished in 1973.

Architect Minoru Yamasaki designed the project. The New York architectural firm of Emery Roth and Sons handled production work, and at the request of Mr. Yamasaki, the firm of Worthington, Skilling, Helle and Jackson served as engineers.

The towers were two of seven office buildings in the complex. A massive shopping concourse existed underground. The 110-story towers were wrapped in stainless steel bodies lined with tall, narrow windows. 1 WTC was home to Windows on the World restaurant, while 2 WTC contained the indoor and outdoor observation decks.



Photo by Denise Applewhite

Princeton faculty members and students are helping to assess structural damage in buildings in Lower Manhattan following the terrorist attacks of Sept. 11. Looking at an aerial photo of ground zero are (seated from left), Guy Nordenson, associate professor of architecture, and Michael Tantalà, a graduate student in civil and environmental engineering. George Deodatis (standing left), associate professor of civil and environmental engineering, looks over building plans with Brett Schneider, who recently received a master's in civil engineering and is pursuing a master's in architecture.

Searching for answers

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from collapsing.

One WTC collapsed almost entirely in on itself, breaking the basement floors. The debris filling the bathtub is now the only thing preventing its walls from collapsing completely. If these walls fall, the tubes of the PATH trains will flood all the way to the sources in New Jersey, making the situation more diffi-

cult and more dangerous.

Nevertheless, the debris needs to be removed. How to remove it without catastrophe is a question yet to be answered.

Dr. Thornton and Mr. Tokarczik agreed that the only thing they know for certain is that the process will be a long and arduous one, and that they doubt they will ever

have all the answers.

"When the buildings collapsed, it became very important to me and other structural engineers," Dr. Thornton said. He assured the audience that changes would be occurring in the industry of constructing and regulating tall buildings. "Obviously, we're going to be reevaluating." ♥