The science of how buildings fall down

By Colin Nickerson
GLOBE STAFF

A chunk of metal suspended from a string served for the bomb.

Mehrdad Sasani, an assistant professor of structural engineering at Northeastern University, aimed for the center support column on the base of a faux “three-story” building and loosed the makeshift projectile.

The column, made of glass for ease of destruction, exploded with a sharp pop.

Sasani, with his 1/8th-scale construction of reinforced concrete that was built to the exact structural specifications of a real building, was simulating the sudden loss of a key pillar — as if to an explosion — in an effort to learn how the rest of the structure would respond.

The rare experiment Thursday was also a contest. Teams from 33 universities and firms across North America had submitted laborious calculations to predict what would occur when a main column shattered. The best predictors in undergraduate and graduate/professional categories will win monetary prizes to be awarded at the 2008 Structures Congress in April, the top convention for US and Canadian structural engineers.

In a dangerous era that has seen major public edifices from the US embassy in Kenya to New York’s World Trade Center reduced to smoking rubble by terrorists, structural engineers believe they need a deeper understanding of how damage inflicted on one part of a building can ripple through the rest of the structure in a devastating and often mystifying phenomenon known as “progressive collapse.”

Northeastern University’s Mehrdad Sasani lets fly with a metal weight to break a support column of a model of a “three-story” building, loaded with weights to simulate walls and floors. The column was made of glass so it would shatter easily.
Colleagues watched Mehrdad Sasani perform the experiment last week at Northeastern University.

The science of how buildings collapse

PROGRESSIVE COLLAPSE

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The aim of the contest is to encourage young engineers to start thinking hard about how to protect against risks once considered unthinkable.

Specialists say 80 percent of casualties in such attacks occur as the buildings undergo chain-reaction structural breakdown, not as the direct result of the blast.

"It's a complicated problem, but if engineers could get a better handle on how buildings collapse during extreme events, we could make them better resistant to calamity," said Eric Williamson, professor of structural engineering at the University of Texas.

"Work like this could yield important data to help make structures able to stand for a few extra hours or even precious minutes, to allow escape," he said from Austin. "It's not about saving buildings, it's about saving lives."

As the column shattered at the base of the scale model structure in the basement lab, the downward force of the 5,000-pound load - metal weights simulating a real-life building's burden of walls, floors, and contents - shifted instantly, invisibly, to other beams and columns.

Beams bent on the 5.2-by-9.5-foot structure; cracks crazed the concrete; there was a groan of strained materials. "We've got point-46 deformity," called out graduate student Marlon Bazan, monitoring an array of 50 sensors. That meant the main beams had sagged by not quite a half-inch.

But the mock building held.

Applause rose from a small but rapt audience. Every twitch and quiver in the stressed structure had been captured by instruments. The data should yield a bonanza for engineering students.

"This is exciting stuff, for us, and very applicable for real-life work," said Omer O. Erbay, a senior engineer with Simpson Gumpertz & Heger, which has offices in Waltham and other cities. "Engineers are focusing more on structures that might face extreme events."

Surprisingly, little hard experimentation has been done on what happens to concrete-and-steel structures subjected to fast, devastating damage. Engineers rely mostly on computer simulations and pencilwork for such forecasts. That's because no one can afford to erect entire buildings just to record what happens when you try to knock them down.

Finding creative structural safeguards against progressive collapse looms as a priority for the profession, said Donald Grierson, a professor of engineering at Ontario's University of Waterloo. "Especially for the next generation of structural engineers," he said from Canada.

The topic is controversial in engineering circles. Clearly, for example, the toppling of the World Trade towers was "progressive," in that time passed before the damage inflicted by exploding passenger jets took its final toll. But labeling the horror "progressive collapse" implies that engineering flaws were somehow to blame.

Similar disagreement surrounds the 1995 bombing of the Alfred P. Murrah Federal Building in Oklahoma City. "A majority of fatalities were caused not by the force of the bomb blast itself, but by the progressive collapse of the building's floors," stated an official report.

"What makes progressive collapse tricky is that it involves a string of failures, not just one," Williamson said.

Sasani's research is supported by the National Science Foundation and the US General Services Administration, which oversees most nonmilitary federal buildings.

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ERIC WILLIAMSON, a professor of structural engineering at the University of Texas