Structural Engineers Receive $7.5 Million Contract To Test Bomb Blast Mitigation Technologies

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UCSD structural engineers together with a team of industry and university partners will develop and evaluate blast mitigation technologies to harden buildings and bridges against terrorist bomb attacks through a new $7.5 million federal contract. More than 40 tests will be performed over the next two years in the new blast simulator laboratory at the UCSD Jacobs School of Engineering's Englekirk Structural Research Center. Testing is expected to begin in June, after the simulator has been commissioned.

The blast mitigation program at UCSD is supported by the Technical Support Working Group (TSWG), the federal interagency organization for combating terrorism. In 2003 and 2004, TSWG awarded UCSD contracts totaling $8.6 million to construct the blast simulator. The newest contract brings cumulative support for the blast mitigation program to $16.1 million.

Partners in the UCSD blast mitigation testing program include Karagozian and Case (K&C) and Science Applications International Corporation (SAIC), who will aid in computational analysis required to design the tests. K&C and SAIC will also develop predictive computer tools based on testing results. MTS Systems Corporation, the company which originally built the UCSD blast simulator, will continue to enhance the equipment in preparation for the blast load simulations. The Energetic Materials Research and Testing Center at the New Mexico Institute of Mining and Technology will oversee a series of explosive field tests which will help validate UCSD's laboratory results. Structural Group is providing blast mitigation technologies for the test specimens.

The UCSD blast simulator is the world's first laboratory to simulate the effects of bombs without the use of explosive materials. The project is led by UCSD structural engineering professors Gil Hegemier and Frieder Seible.

"Today, hardening buildings and bridges against terrorist bomb attacks is more of an art than a science," said Seible, dean of the UCSD Jacobs School of Engineering. "Now for the first time, we will be able to create fully controlled and repeatable blast simulations. We will use these results, together with explosive field tests, to create computer tools to design and assess blast mitigation strategies for important facilities such as federal buildings and embassies, as well as critical long-span bridges."

"Most people think the fireball is the dangerous part of a bomb blast, but in reality it is the blast impulse that is most dangerous to the structure," says Hegemier. "Blasts are like earthquakes in the sense that they put a horizontal load on structures. Blast impulses create shock waves that literally push and pull structures to the point that key load bearing elements can fail, and lead to the kind of progressive collapse we saw in the Oklahoma City federal building bombing ten years ago."

The UCSD blast simulator generates the speed and force of explosive blasts through a servo-controlled hydraulic system that punches test specimens at speeds of up to 26 meters per second during a 1-2 millisecond pulse. In the accumulator bank, nitrogen charges hydraulic fluid and builds up pressure. This pressure is released

through velocity generators which propel steel plates carrying elastomeric pads precisely shaped to impart specific pressure distributions on the test specimen.

UCSD structural engineers will test a variety of building components, such as structural columns, which are most vulnerable to blast loads, as well as load-bearing and infill walls, and bridge elements such as towers. They will simulate a range of blast scenarios including the equivalent of 50 pounds of TNT detonated within a few feet of a structure to 5,000 pounds of TNT detonated from more than 100 feet away.

Throughout the program, the team will evaluate how the structural components perform before and after retrofitting with blast mitigation technologies. One candidate technology is fiber reinforced polymer (FRP) composite overlays originally designed to protect structures from earthquakes. Such material is as thin as a cotton shirt, stronger than steel, and consists of carbon threads woven in a polymer matrix which is bonded with resin. Composite overlays performed successfully in full-scale explosive field tests in which unretrofitted building columns suffered catastrophic damage, while columns wrapped with the composite overlay were virtually undamaged. Such overlays have been deployed on several federal buildings in the U.S. and abroad.

"Technologies such as overlays and steel jackets can mitigate damage to buildings by confining and containing concrete in load-bearing elements such as columns. We're actually strengthening concrete columns so that they behave more like metal," says Gil Hegemier. "In addition, concrete is brittle and can fragment in an explosion, but when we wrap it with these materials we can contain the concrete for the short duration of the shock wave."

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