Thinner and tougher: A new kind of blast-resistant glass

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An engineer from the University of Missouri studies the glass pane after a test explosion. Credit: DHS S&T

Whether in a hurricane, tornado, or bomb attack, a leading cause of injury and death is often fast-flying shards of glass. Explosions and high winds can cause windows in buildings to shatter-spewing jagged pieces of glass in every direction.

A Pentagon report on the 1996 Khobar Towers bombing in Saudi Arabia, for example, noted:

Two of the 19 deceased had injuries know to be caused by glass fragments that were severe enough to cause death even without other contributing forces. Of the remaining 17 deceased, 10 had glass injuries that were *significant and which may have caused death even without blunt force trauma. Thus, for 12 of 19 deaths, glass fragmentation was a significant factor. More than 90% of the people injured suffered laceration injuries, many of which were significant.*

With an international research grant from the Department of Homeland Security's Science and Technology Directorate (S&T), a team of engineers from the University of Missouri and the University of Sydney in Australia is working to develop a blast-resistant glass that is lighter, thinner, and colorless, yet tough enough to withstand the force of an explosion, earthquake, or hurricanes winds.

Installing blast-resistant glass in buildings that are potential targets of attacks or in regions prone to severe weather can save lives. But current blast-resistant glass technology-the kind that protects the windows of key federal buildings, the president's limo, and the Popemobile -is thicker than a 300-page novel-so thick it cannot be placed in a regular window frame. This makes it very difficult–and expensive–to replace standard glass windows in present structures.

Unlike today's blast-resistant windows which are made of pure polymer layers, this new design is a plastic composite that has an interlayer of polymer reinforced with glass fibers-and it's only a quarter-inch thick.

The project team recently subjected their new glass pane to a small explosion. "The results were fantastic," exclaimed Sanjeev Khanna, the project's principal investigator and an associate professor of mechanical engineering at Missouri. "While the discharge left the pane cracked, the front surface remained completely intact."

The secret to the design's success is long glass fibers in the form of a woven cloth soaked with liquid plastic and bonded with adhesive. The pane is a layer of glass-reinforced clear plastic between two slim sheets of glass. Even the glue that holds it all together is clear. Think of it as a sandwich: the slim sheets of glass are the two slices of break; the liquid plastic and long glass fibers make up the crunchy peanut butter in the middle.

The glass fibers are typically 15 to 25 micrometers in diameter, about half the thickness of a typical human hair. The small size results in fewer defects and a decreased chance of cracking. The strong glass fibers also provide a significant reinforcing effect to the polymer matrix used to bind the fibers together. The more fibers used, the stronger the glass reinforcement. And while traditional blast-proof glass usually has a greenish ting, special engineering renders the polymer resin transparent to visible light.

Engineers expect the new design will be comparable in cost to current blast-proof glass panes, but lighter in weight. At only a quarter-inch thick, this newly engineered composite would slip into standard commercial window frames, making it much more practical and cost-efficient to install.

"Designing an affordable, easy-to-install blast-resistant window could encourage widespread use in civilian structures, thereby protecting the lives of occupants against multiple threats and hazards," notes John Fortune, manager of the project for the Infrastructure and Geophysical Division at S&T.

To date, the glass has been tested with small-scale prototypes. "In future tests, the size of the glass panels will be increased by two to four times to determine the effect of size on blast resistance," said Khanna.

The goal is to create blast-resistant panes as large as 48 by 66 inches-the standard General Services Administration window size for qualification blast testing-that can still be cost-effective. While dependent on results from upcoming tests, Khanna hopes this glass could become commercially available in three to four years.

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