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Safe glass facades

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Researchers use this apparatus to identify the stresses at which windows and glass facades crack and shatter. Credit: © Fraunhofer EMI

Metropolises like San Francisco are in a state of constant flux. Excavators and wrecking balls tear down dilapidated old factories and houses that are beyond renovation, freeing up space for new structures. Entirely in this spirit of dynamism, a huge building complex will soon go up on a site where until recently a train station stood: the Transbay Transit Center, a five-story structure with glass facades, over 20,000 square meters of floor area, and a glass-covered park on the roof. A second phase will see the construction of an additional high-rise building. The budget is 4 billion US dollars.

The glass facades and glass roof add greatly to the building's esthetic appeal. But what about the safety of the huge areas of glass? What happens if a bomb detonates in the vicinity of the complex? This is precisely what a New York engineering office has commissioned researchers at the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach Institute, EMI in Efringen-Kirchen in southwest Germany to investigate. "We are using the 'Blast-STAR' shock tube to test different glazing structures of glass facades for their resistance to the pressures produced by explosions at various distances," says the EMI researcher Oliver Millon.

Testing safety glazing, windows, and doors

The principle behind it is this: the shock tube consists of a driver (high-pressure) section and a driven (low-pressure) section, which are separated by a steel diaphragm. Researchers can compress the air in the driver section to a pressure of up to 30 bar, i.e. to approximately 30 times atmospheric pressure on Earth at sea level. This permits the component to be subjected to a load pressure of 2.3 bar. When researchers set the appropriate amount of pressure, the steel diaphragm is ruptured: the air rushes out into and through the driven section and hits the glass section being tested, which is attached to the end of the shock tube, as a planar shock front. First the glass is forcefully pushed backward, before the pressure relents and the glass is sucked forward. Depending on the pressure the researchers set in the driver section, they can simulate detonations of different amounts of explosive at different distances from the building – from 100 to 2,500 kilograms of TNT at distances from 35 to 50 meters from the building. Does the glass come through the procedure undamaged? Or does it crack or even shatter into tiny pieces? There are various DIN and ISO standards specifying the different pressures that windows and glass facades must withstand without cracking, and EMI researchers are testing different manufacturers' safety glazing, windows, and doors against the specifications laid down in these standards.

"Although shock tube technology is well known in principle, there are only a handful of shock tubes in existence worldwide," explains Millon. "The fact that extremely high stresses arise in the tubes makes them very complex to manufacture and operate." For example, the apparatus must be able to withstand abrupt changes in pressure across a large area; the glass sections being tested can be up to nine square meters in size. "In addition, we must ensure that we achieve a planar shock front at the glass section being tested, in other words that the shock wave reaches each part of the glass section at the same time," says Millon. To this end, the researchers carried out computer simulations prior to construction of the shock tube and subsequently confirmed the results by taking measurements in the finished apparatus.

The preliminary investigations into selecting suitable glass structures for the Transbay Transit Center have already been completed. Further investigations are planned for certified demonstration of the blast resistance of the pane types selected during the construction phase.

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