Building Security Design Considerations: The Effects of Bomb Blasts

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SUMMARY

An understanding of bomb threats, bomb blasts, and blast wave effects will help an architect design buildings that protect against the effects of bomb blasts.

BOMBS: THREATS IN MANY FORMS

Bombs are popular weapons among terrorists and extremists and can be delivered in many forms: hurled Molotov cocktails or hand grenades; small explosives placed in strategic locations or sent through the mail; or larger explosives carried in parked or moving vehicles. Even small bombs can damage buildings and cause severe injury or death.

By understanding the capabilities and physical effects of conventional explosives as well as the size of the containers needed to deliver them, architects and engineers may design facilities to minimize the likelihood of exposure to explosives and mitigate the effects of a bomb blast.

THE PHYSICS OF BOMB BLASTS

Most people understand that bomb blasts result in high-speed projectiles that cause injury and death. Of particular concern are the glass shards formed when glass explodes. Safety glass, which breaks into noninjurious glass pellets when subjected to normal breaking force, breaks into thousands of sharp-edged shards flying at near-supersonic speed when subjected to the force of a bomb blast.

Overpressure—a nearly instantaneous increase in atmospheric pressure that radiates outward from the bomb—is less understood but equally deadly. When a bomb detonates, a chemical reaction converts the bomb matter to heat and energy. The bomb releases both a heat wave and an overpressure blast wave (caused by the supersonic expansion of atmospheric gases), resulting in a seismic event—the transmission of the blast wave into the ground and the atmosphere.

Compared to the blast wave, the heat wave is transmitted a fairly short distance, though it can ignite combustible materials in its path. The blast wave, however, forms a wall of highly compressed air that can travel as fast as 1,150 feet per second, or 784 miles per hour. Blast waves dissipate as they radiate outward, so distance is a major factor in protecting against bomb blasts.

The initial period of extreme overpressure following a bomb blast is immediately followed by a reverse blast wave of nearly equal intensity as air rushes to fill the vacuum created by the initial blast. Both the initial and reverse blast waves are highly destructive.

THE EFFECTS OF BLAST WAVES

Adult humans can withstand only 30 to 40 pounds per square inch (psi) of overpressure before their lungs collapse. Death is certain at 100 to 120 psi. For children and the elderly, death can occur at overpressures as low as 10 psi.

When a blast wave meets a structure, it wraps around all surfaces of the structure for less than a second. The forces on the structure are great, and the larger the structure, the greater the effect. Smokestacks often survive bomb blasts because blast waves wrap around them so quickly, while adjacent buildings might be completely destroyed because blast waves exert pressure on buildings for a far longer time.

A person on the opposite side of a building from a blast is not protected from the blast wave. There is no shadow for the blast wave, as there is for the heat wave, because the blast wave wraps entirely around the building. Protection is afforded only to the extent that the building mass absorbs the energy of the blast by disintegrating and dissipating the force of the blast wave.

Total disintegration of a human can occur at pressures above 2,000 psi. Above 5,000 psi, sometimes not even a trace of the person remains. Obviously, it is best to be as far away from a blast as possible. That is why *standoff distance* is among the most important design considerations for protecting against blasts.

The following is a list of vehicles, their general delivery capabilities (in pounds of TNT), and the amount of atmospheric overpressure such charges would create 30 feet and 100 feet from the blast's point of origin:

Vehicle type	Charge, in lbs.	psi at 30 feet	psi at 100 feet
Compact car trunk	250	182	9.5
Large car trunk	500	367	15
Panel van	1,500	1,063	33
Box truck	5,000	2,900	100
Single tractor-trailer	30,000	9,290	593
Double tractor-trailer	60,000	13,760	1,150

ABOUT THE CONTRIBUTOR

Thomas L. Norman is director of security and antiterrorism for TRC Security Consulting in New York City. He has expertise in integrated security master planning, counterterrorism, threat assessment, security cost-benefit analysis, and threat-countermeasure balancing. Norman has worked on projects for the U.S. Department of Homeland Security, the Central Bank of Lebanon, and the State of Algeria. He is a member of the United Nations Security Consultative Committee.

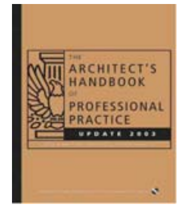
RESOURCES

More Best Practices

The following AIA Best Practices provide additional information related to this topic:

11.10.04	Building Security: Basic Design Elements
03.01.02	Becoming a Certified Protection Professional
11.10.06	Vulnerability Analysis and Security Assessment

For More Information on This Topic



See also "Security Evaluation and Planning," by Marco A. Monsalve and James R. Sutton, The Architect's Handbook of Professional Practice Update 2003.

See also the 14th edition of the *Handbook*, which can be ordered from the AIA Bookstore by calling 800-242-3837 (option 4) or by email at bookstore@aia.org.

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Key Terms

- Building performance
- Use
- Security
- Crime
- Terrorism