

Explosive Threat:

How to Reduce your Vulnerability

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About Stone Security Engineering

- Consulting and engineering firm dedicated to protect people and operations from terrorist attacks.
- Engineers at Stone have over 20 years of experience in the field.
- Bridging the gap between security requirements and engineering design.

Do I Need a Blast Assessment?

- Am I at risk of a terror attack associated with explosive devices?
- Do I understand operational vulnerabilities associated with and explosive attack?
- Do I understand structural/architectural vulnerabilities associated to how my building perform under a explosive attack?
- Does the cost (in casualties/injuries, operations, etc.) justify knowing my vulnerabilities?



WHAT IS AN EXPLOSION?



INJURIES AND DAMAGE



BLAST ASSESSMENT

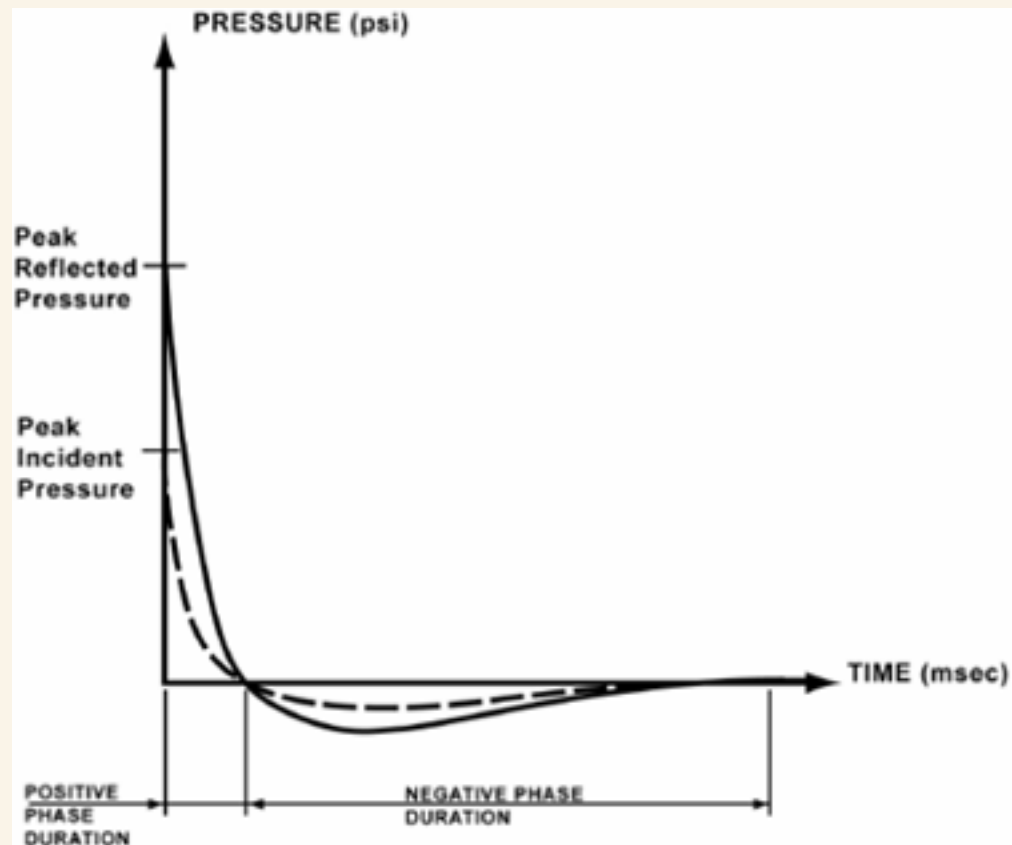
What is an Explosion?

- An explosion is a exothermic reaction, such as an oxidation, with a very fast the release of energy to the soundings.
- The energy gets released in the form of light, heat, sound and overpressure.
- Harmful effects are associated to heat and overpressure.
- Heat is localized to the volume where the reactive products exist.
- Overpressures travels much larger distances in the form of a shock-wave.

General Types of Explosions

- Boiling Liquid Expanding Vapor Explosion (BLEVE)
- Vapor Cloud Explosion (Fuel Gas Explosion or Dust Explosion)
- Explosives (TNT, ANFO, etc.)

Air-Blast Load



Parameters Influencing Air-Blast Load

- **Threat Size.** Mass/weight of explosive (Expressed in lbs, kg, etc.)
- **Standoff Distance.** Separation between the threat and the target (Expressed in feet, meters, etc.)
- **Threat-Target Orientation.** Angle between normal to the target surface and the line-of-sight between the target and the threat (Expressed in degrees)

Order of Magnitude



- The pressure at the bottom of Hoover Dam (Arizona) can reach 45,000-psf (312-psi)
- A 250-kg TNT at 6-meters gives a peak pressure of 1,300-psi.
- At 12-meter the peak pressure results 200-psi

Order of Magnitude



- A hummingbird flap takes between 5 to 20 millisecond.
- The duration of blast load goes between 2 to 200 milliseconds

Other Parameters

- Confinement Effects
- Tunneling Effects
- Shadowing Effects
- (Breach/Spalling Effects)

Effect of Confinement

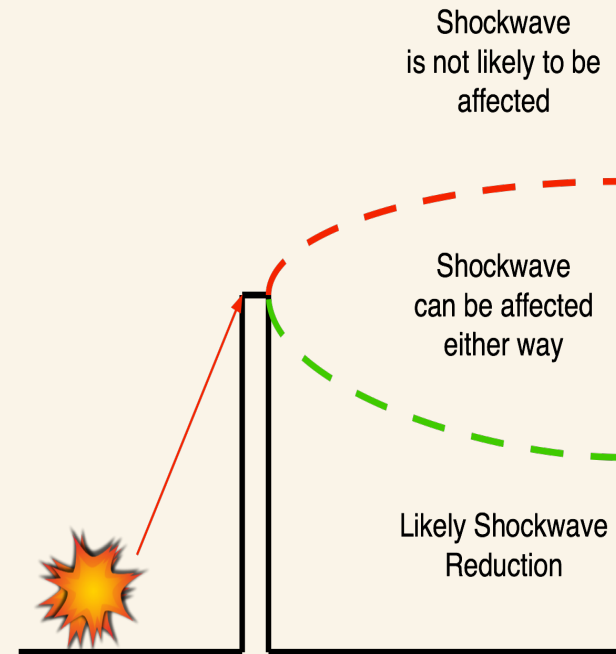
- Associated with interior threats (within building, parking, etc.)
- Shock-wave gets amplified by multiple reflections on surrounding walls.
- Larger load duration caused by build-up gas pressure (controlled by venting areas)

Tunneling Effects

- Associated with exterior threats in high-dense urban environments.
- Shock-wave gets amplified by multiple reflections caused by surrounding buildings.

Shadowing Effects

- Associated with exterior threats with exterior blast wall.
- If design properly reduces shock-wave on the high-load areas of a target.
- Complex calculations using CFD or Empirical Tables



Breach/Spall Effects

- Cause by near-contact or contact threats.
- Critical in the design of magazines.
- Critical in the design of exposed load-bearing columns/wall as can initiate progressive collapse

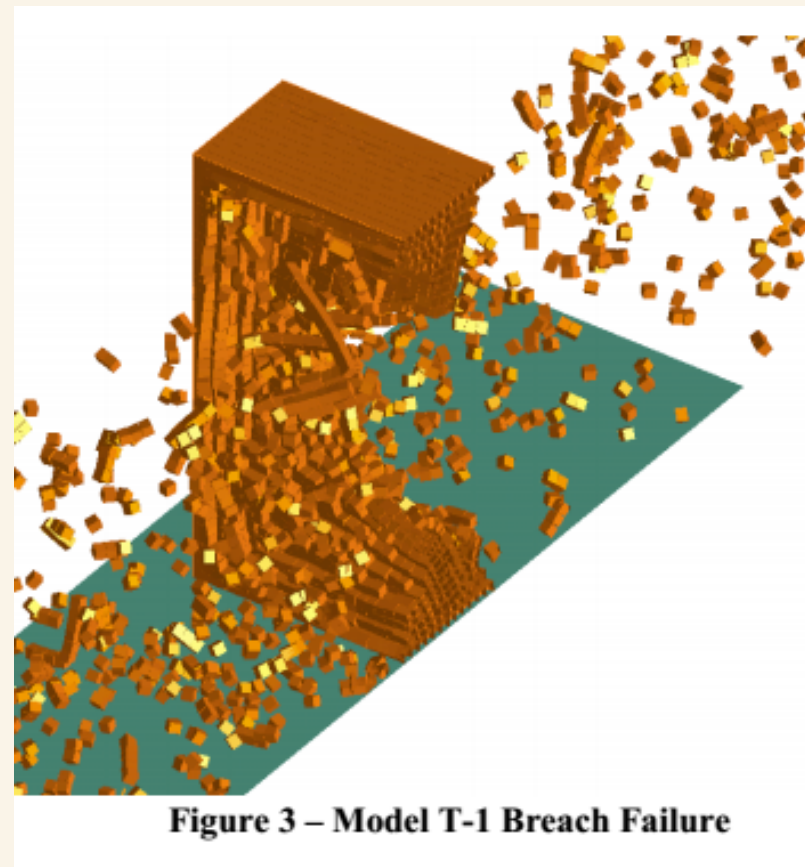


Figure 3 – Model T-1 Breach Failure



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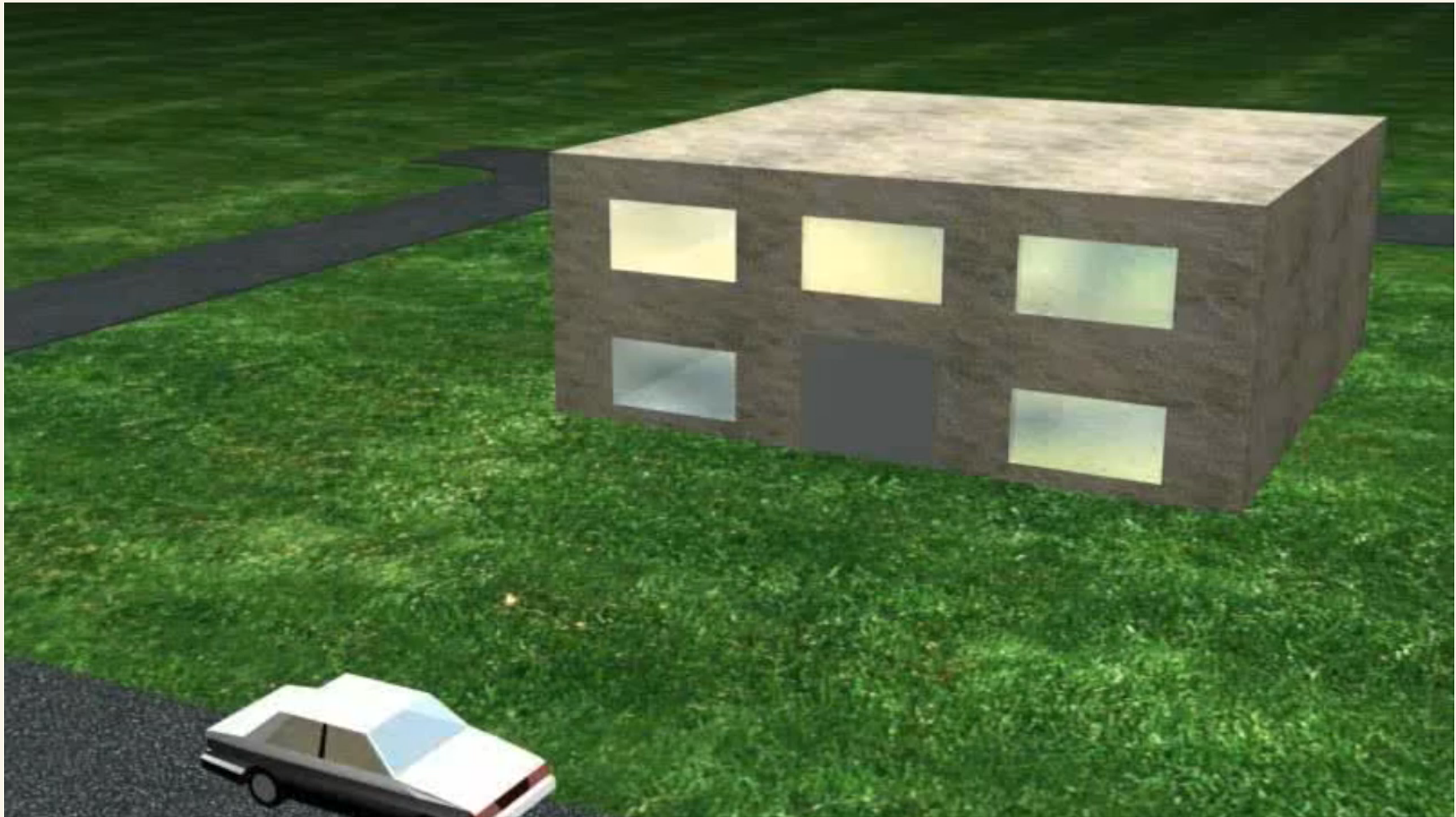
Effects in Humans

Critical Organ or Event	Maximum Effective Pressure (psi)*
Eardrum Rupture	
Threshold	5
50 percent	15
Lung Damage	
Threshold	30-40
50 percent	80 and above
Lethality	
Threshold	100-120
50 percent	130-180
Near 100 percent	200-250

For a 250-kg of TNT

- Lethality at 15-meters.
- Lung Damage at 23-meters.
- Eardrum Rupture at 60-meters.

Other associated effects caused by debris or shrapnel



Effects in Buildings



- Failure of exterior glazed systems.
- Hazard to floor occupants.

Effects in Buildings



- Failure of architectural partition.
- Hazard to floor occupants.

Effects in Buildings



- Failure of structural secondary elements.
- Hazard to building occupants.

Effects in Buildings



- Failure of primary structural elements.
- Hazard to building occupants.



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Results from a Blast Assessment

- Is it likely that my building will collapse under the explosive threat?
- What level of structural damage is expected after an explosive threat?
- Can architectural elements (windows/walls) be hazardous to building occupants?
- Is it possible/reasonable to harden/retrofit the building to mitigate hazard (reduced vulnerability)?

Identify a Credible Threat

- Have I been targeted before?
- Have my neighbors been targeted before?
- What type of explosive threat is more likely to happen?
- Am I willing or are there operational measures in place to detect threats in transit?

Types of Improvised Explosive Devices (IED)

Threat Description Improvised Explosive Device (IED)		Explosives Capacity ¹ (TNT Equivalent)	Building Evacuation Distance ²	Outdoor Evacuation Distance ³
	Pipe Bomb	5 LBS	70 FT	1200 FT
	Suicide Bomber	20 LBS	110 FT	1700 FT
	Briefcase/Suitcase	50 LBS	150 FT	1850 FT
	Car	500 LBS	320 FT	1500 FT
	SUV/Van	1,000 LBS	400 FT	2400 FT
	Small Moving Van/ Delivery Truck	4,000 LBS	640 FT	3800 FT
	Moving Van/ Water Truck	10,000 LBS	860 FT	5100 FT
	Semi-Trailer	60,000 LBS	1570 FT	9300 FT

1. These capacities are based on the maximum weight of explosive material that could reasonably fit in a container of similar size.

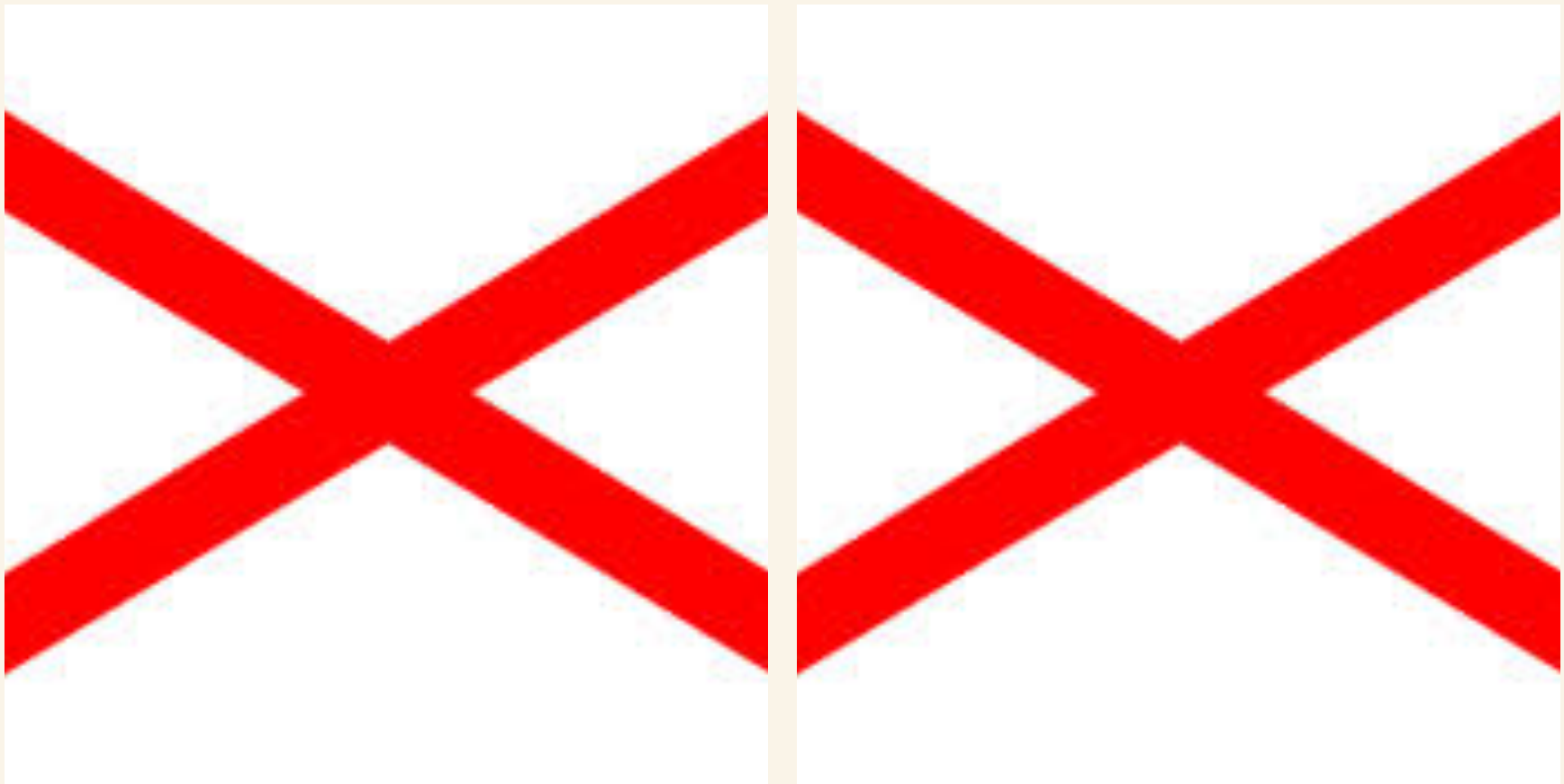
2. Personnel in buildings are provided a high degree of protection from death or serious injury; however, glass breakage and building debris may still cause some injuries. Unstrengthened buildings can be expected to sustain damage that approximates five percent of their replacement cost.

3. If personnel cannot enter a building to seek shelter they must evacuate to the minimum distance recommended by Outdoor Evacuation Distance. These distance is governed by the greater hazard of fragmentation distance, glass breakage or threshold for ear drum rupture.

Identify Level of Protection

- What damage is acceptable?
- Does my facility host critical areas/VIP?
- Does my facility require continuity of operations? Are my critical utilities redundant?
- Are the egress paths for my personnel susceptible of damage?

Identify Threat Effects and Vulnerabilities



Increase Operational Measures



- Control parking.
- Provide anti-ram barriers
- Enhance/Provide screening

Because YOU WANT TO
KEEP THE THREAT AWAY

Windows Hardening



- At least install (but not just) security film.
- If required provide catchment system to minimize glass hazard; or
- Replace/reinforce window with blast resistant window

Architectural Partitions Hardening



- Avoid unreinforced CMU.
- Harden partition with catchment system, or
- Reinforcement System
- Control Connection Design
- Install Secondary Hardened Wall

Structural Hardening



- Install retrofit system to enhance structural resistance/ductility.
- Fiber wrap Systems
- Steel Jackets
- Concrete Covers



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