32ND MAJ GEN HARKIRAT SINGH MEMORIAL LECTURE [INSTITUTION OF ENGINEERS(INDIA)]

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Planning and Design of Public Buildings to Combat Terrorism

Combating Terrorism

- Anti-terrorism (defensive measures taken to reduce vulnerability to terrorist acts)
- Counter-terrorism (offensive measures taken to prevent, deter, and respond to terrorism)
- Terrorism consequence management (preparation for and response to the consequences of a terrorist incident/event)
- Intelligence support (collection and dissemination of terrorism-related information), taken to oppose terrorism throughout the entire threat spectrum.

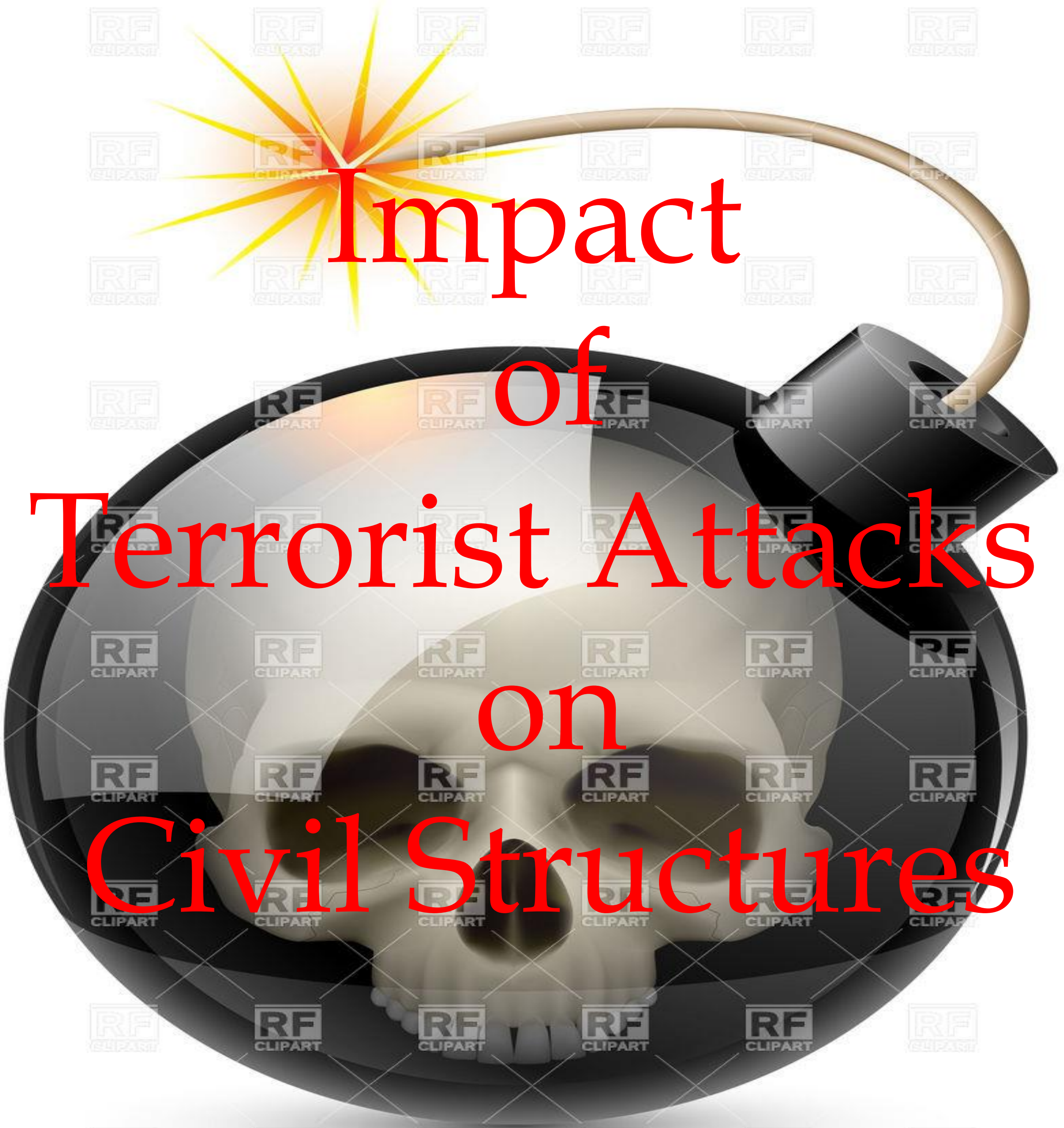
Planning for the Threat.

- Steps taken to oppose terrorism throughout the entire threat spectrum, including terrorist use of chemical, biological, radiological, or nuclear materials or high-yield explosive devices.

Anti Terrorism

- Where counter-terrorism is offensive, antiterrorism is defensive.
- Anti-terrorism focuses on defensive measures taken to reduce the vulnerability of individuals and property to terrorist acts.
- Role of an Engineer mainly pertain to Anti terrorism and terrorism consequence management

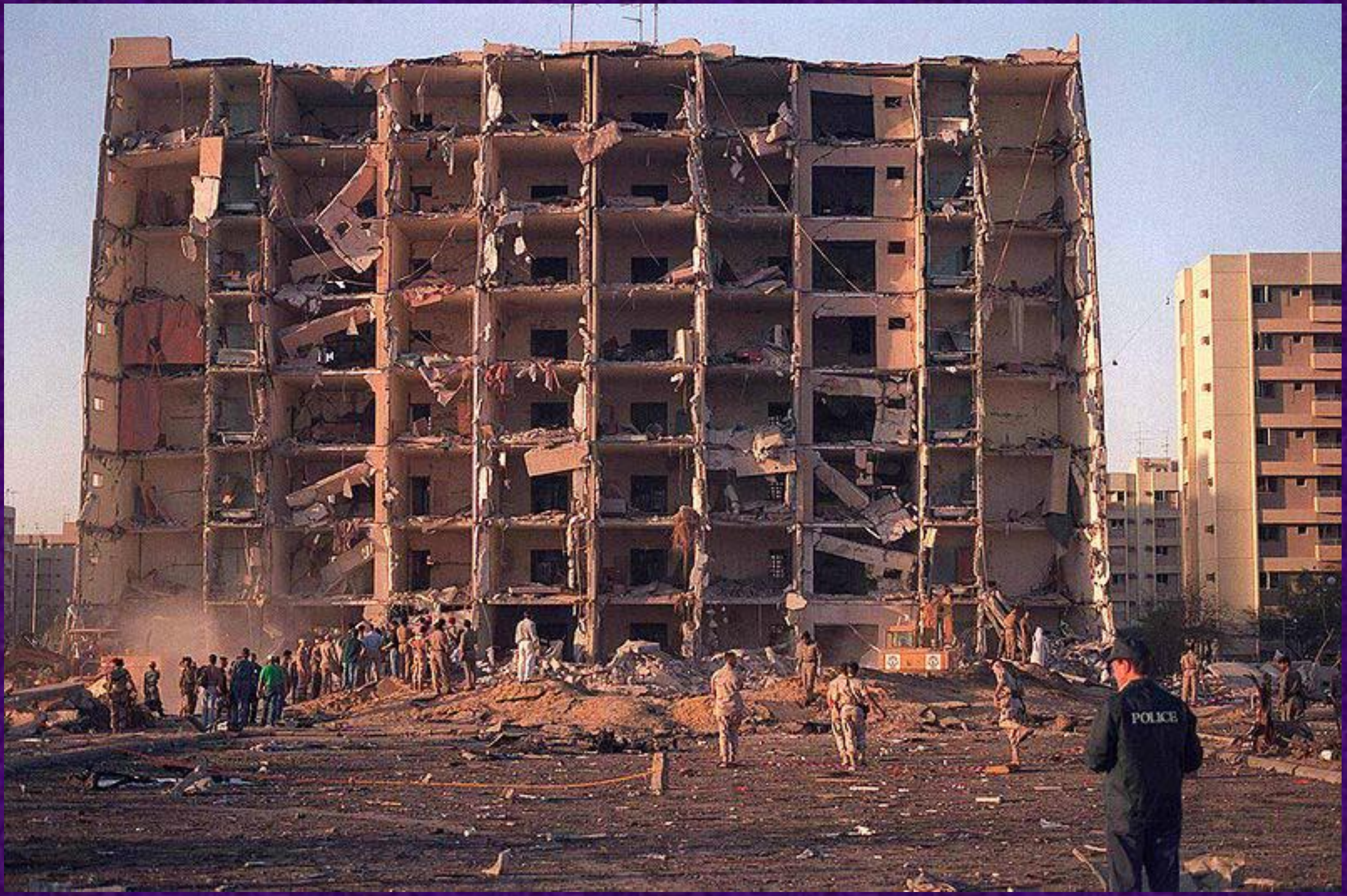
Impact of Terrorist Attacks on Civil Structures



1920 Wall Street Bombing

Turkey Attack

Khobar Tower- Façade Collapse



Marriot Hotel Peshawar

Oklohama Bombing

Oklohama Bombing

Damascus bombing

IRA: Manchester

IBIZA: Spain bombing

Nigeria US Embassy

Riyadh: Soudi Arabia

WTC Tower 9/11

Question??

- Whether technology, properly deployed, could have played a role in saving lives, reducing the number and severity of injuries, and protecting property from damage

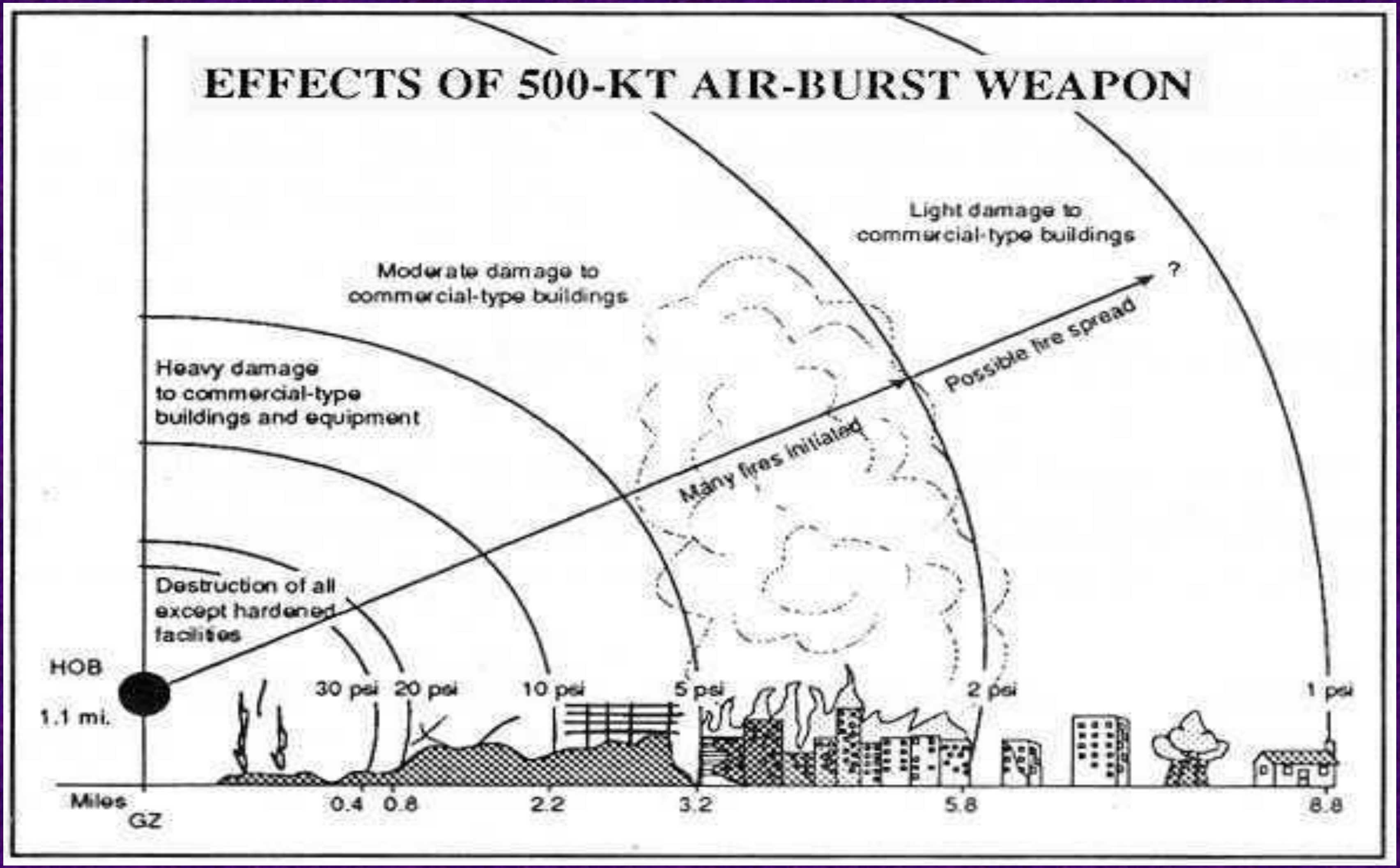
Awareness

- After Bombings of Buildings world over as well as a heightened awareness in both government and industry of the need to protect the nation's critical infrastructure against a wide range of potential terrorist threats, the engineering community is finally coming to recognize both the scope of the problem and the domain of the solution.

Types of blasts

- Moving vehicle attack
- Stationary vehicle bomb
- Exterior attack
- Arsons
- Others
- Ballistic attacks

Hiroshima Bombing (Engineers Helpless)



Caveat

- Not all Anti terrorist design procedures are clearly defined.
- Client unwilling or unable to state specifically what level of risk they will accept.
- Anti terrorist design does not follow a "cookbook" design as for service loads.
- There is no single authoritative reference.
- Many references are restricted to government agencies.
- Available references often conflict.

Effects of Explosion or Blast on a Building

- Produce, in a very short time, an overload much greater than the design load of a building.
- can cut or deform structural members with Chemical Energy or Kinetic Energy.
- buildings can and do survive such effects without collapse, if correctly designed
- non blast resistant structures can suffer rapid cumulative collapse, such as we have seen at Oklahoma City the World Trade Centre, the Marine Base in Lebanon etc.
- Shock waves cause cladding and glass to become detached and fly around, forming lethal weapons. the biggest cause of injury and death.

How blast waves cause damage

- combination of significant compression of air in front of wave (forming a shock front) and subsequent wind that follows.[1
- The original explosion send out fragments that travel very fast. Debris and sometimes even people can get swept up into a blast wave, causing more injuries such as penetrating wounds, impalement, broken bones, or even death.
- blast wind is area of low pressure that causes debris and fragments to actually rush back towards original explosions.
- blast wave can also cause fires or even secondary explosions by a combination of the high temperatures due to physical destruction of fuel-containing objects.

Effect of Blast Wave

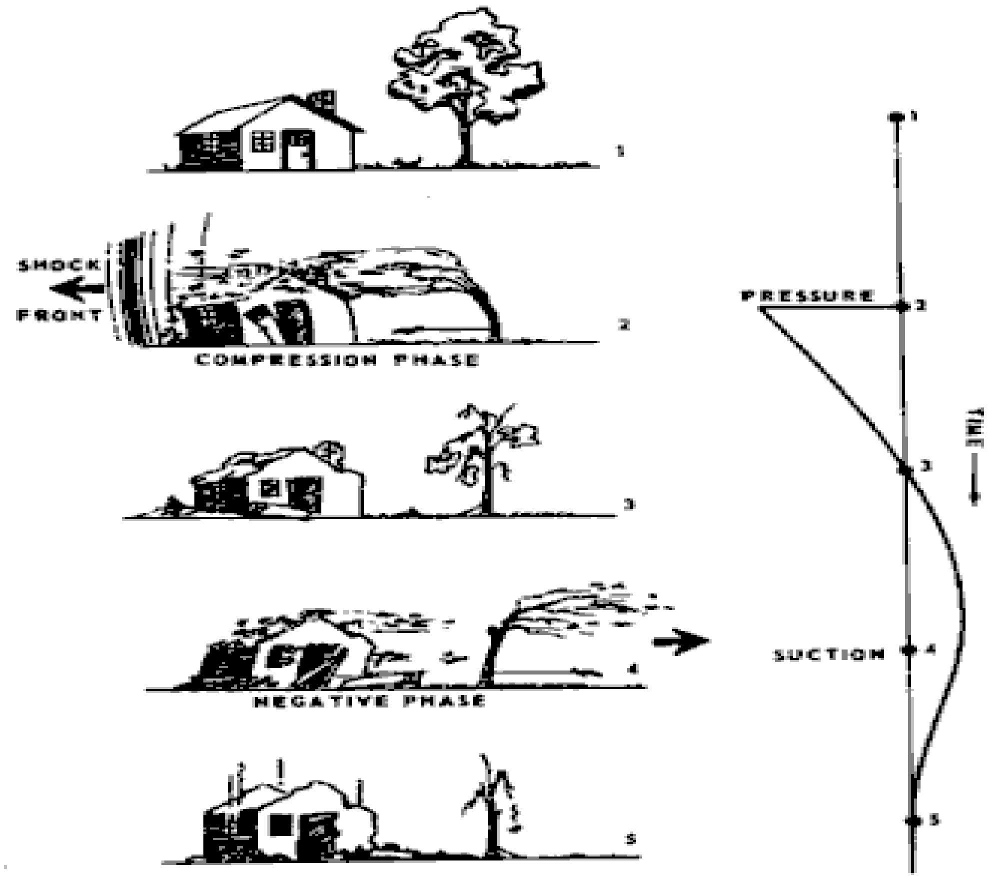
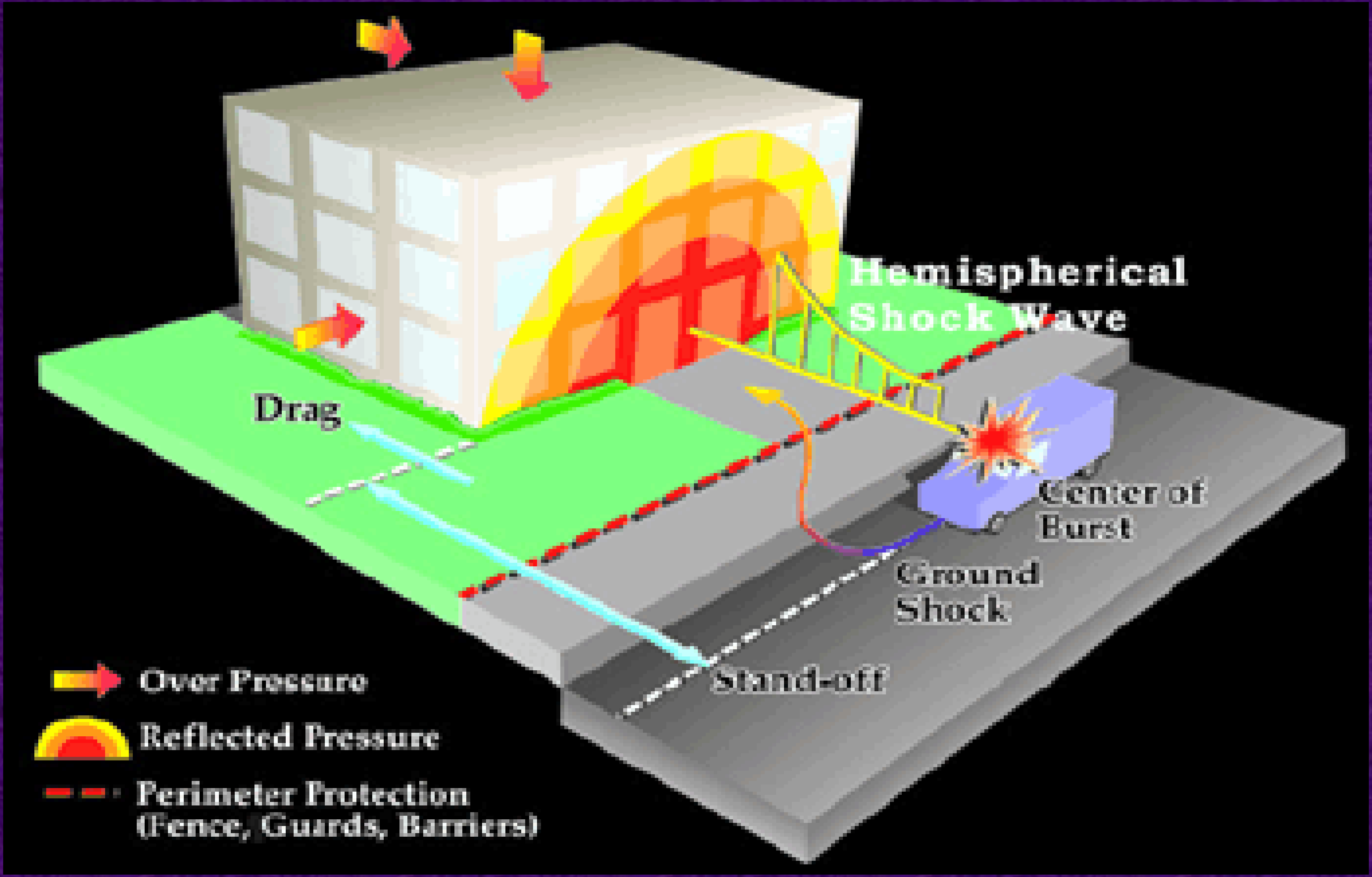


Figure 3-III. Variations of Blast Effects Associated with Positive and Negative Phase Pressures with Time

Stand off



Hemispherical
Shock Wave
Drag
Center of
Burst
Ground
Shock
Stand-off
Over Pressure
Reflected Pressure
Perimeter Protection
(Fence, Guards, Barriers)

Fundamental Planning & design objectives

- Denying the means of attack;
- Maintaining safe separation of attackers and targets through good planning and architectural practice;
- Providing strong, resilient construction to protect personnel and other key building assets;
- Facilitating rescue and recovery operations in the event an attack occurs.
- Retrofitting of existing buildings
- Restoration of Buildings after attack

ISC Security Criteria of USA

- The Interagency Security Committee (ISC) developed the ISC Security Design Criteria to ensure that security becomes an integral part of the planning, design, and construction of new office buildings and major modernization projects. The criteria consider security in all building systems and elements.

Sources of Blast Waves

- High-order explosives (HE) are more powerful than low-order explosives (LE).
- HE produce a defining supersonic over-pressurization shock wave.
- LE create a subsonic explosion and lack HE's over-pressurization wave.
- HE and LE induce different injury patterns. Only HE produce true blast waves.

Primary Concerns of Design Safety

- to minimize the number and severity of casualties sustained in the initial blast;
- limit the subsequent response of the building;
- and improve the chances of successful rescue and recovery of the survivors.

Preliminary Aspects

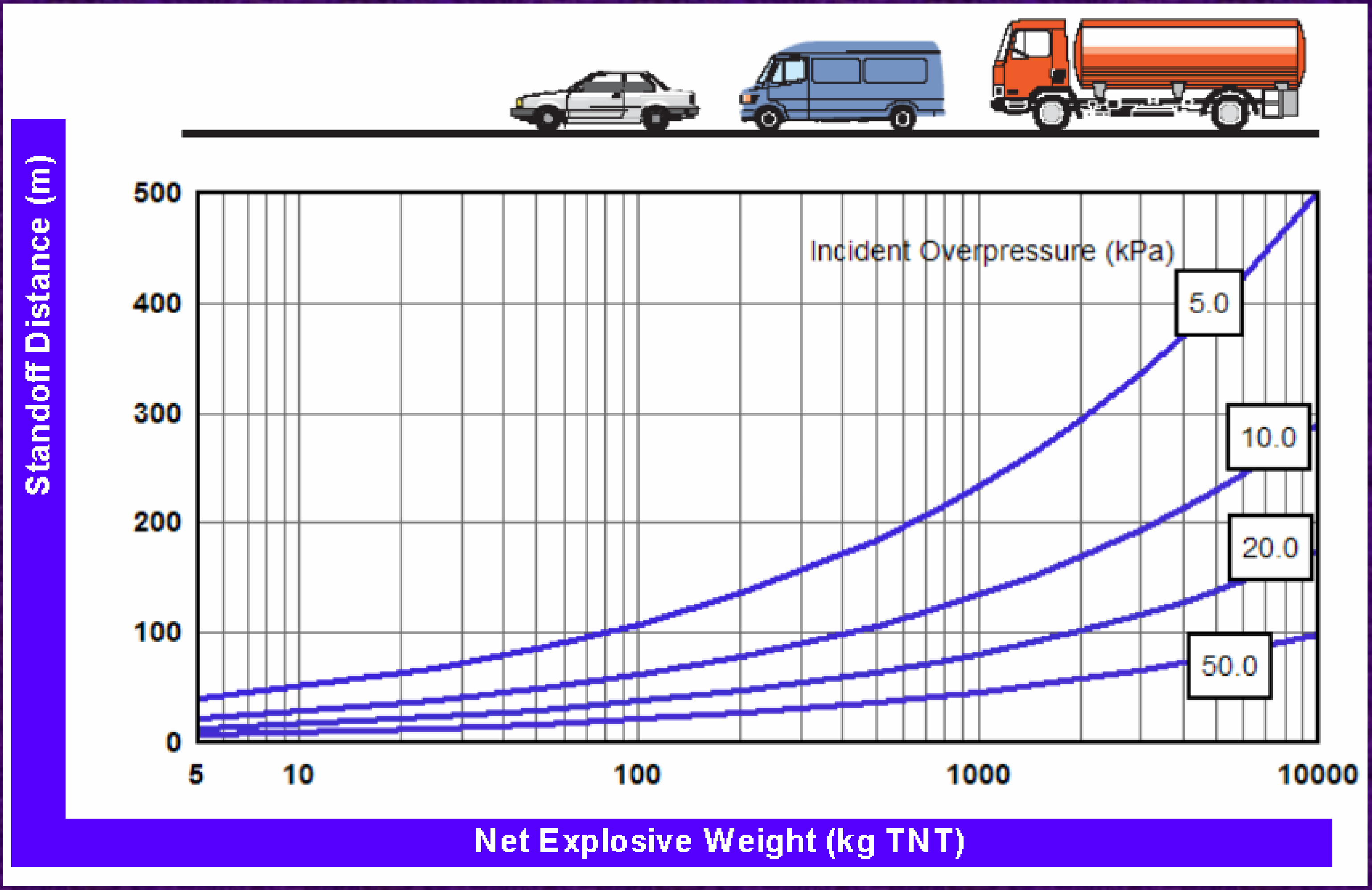
- Site planning – Physical layout and physical security
- access controls and physical barriers.
- restricted parking near the building
- Deep buried structures are safer. Walls with soil cover on the side perform well under blast loading; soil is highly effective in reducing the impact of explosions

KEY ANTI-TERROR MEASURES FOR PUBLIC BUILDINGS

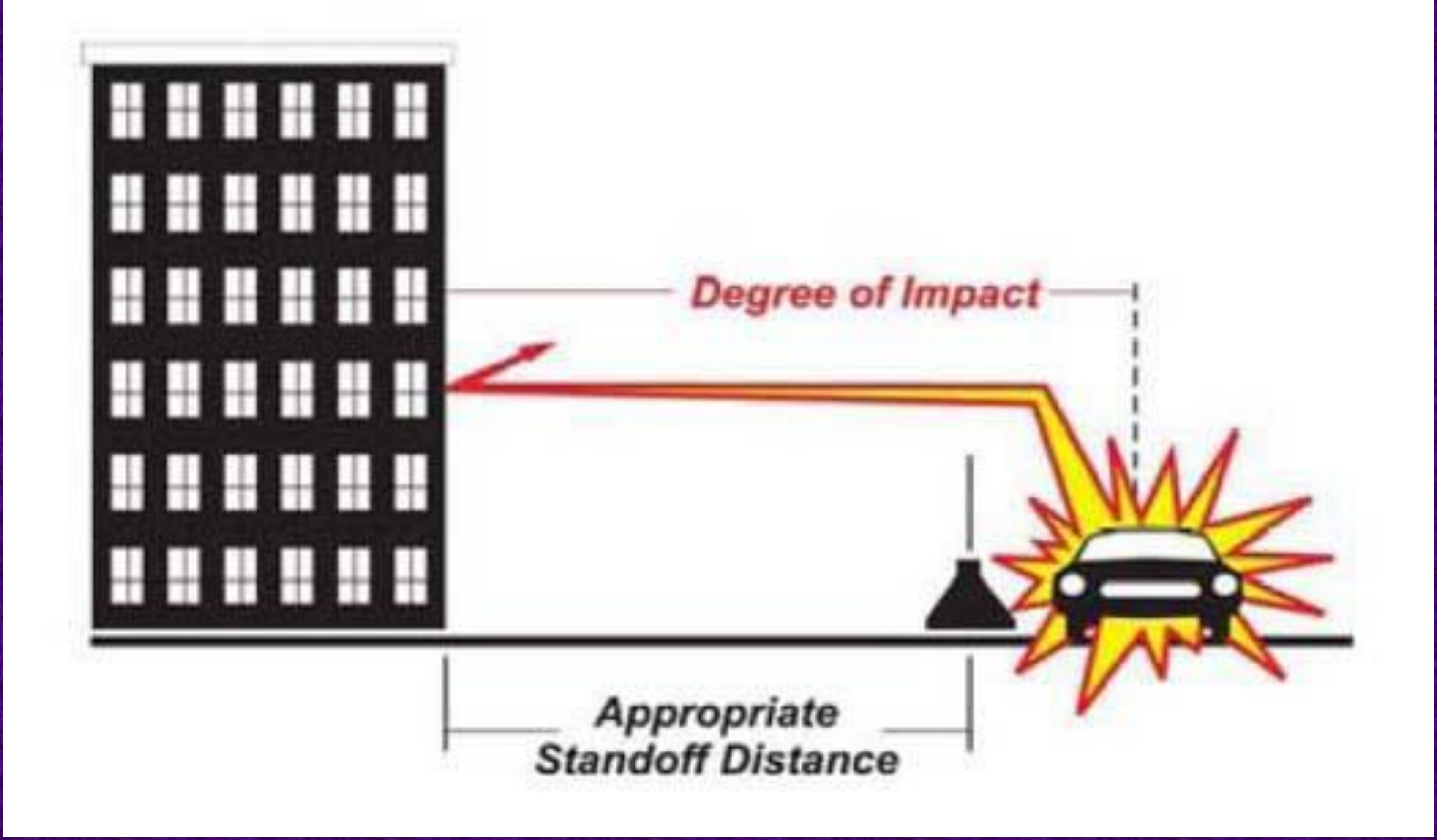
First Line Defence

- The first line of defense is denying access to explosives and detecting and apprehending potential perpetrators before they can act.

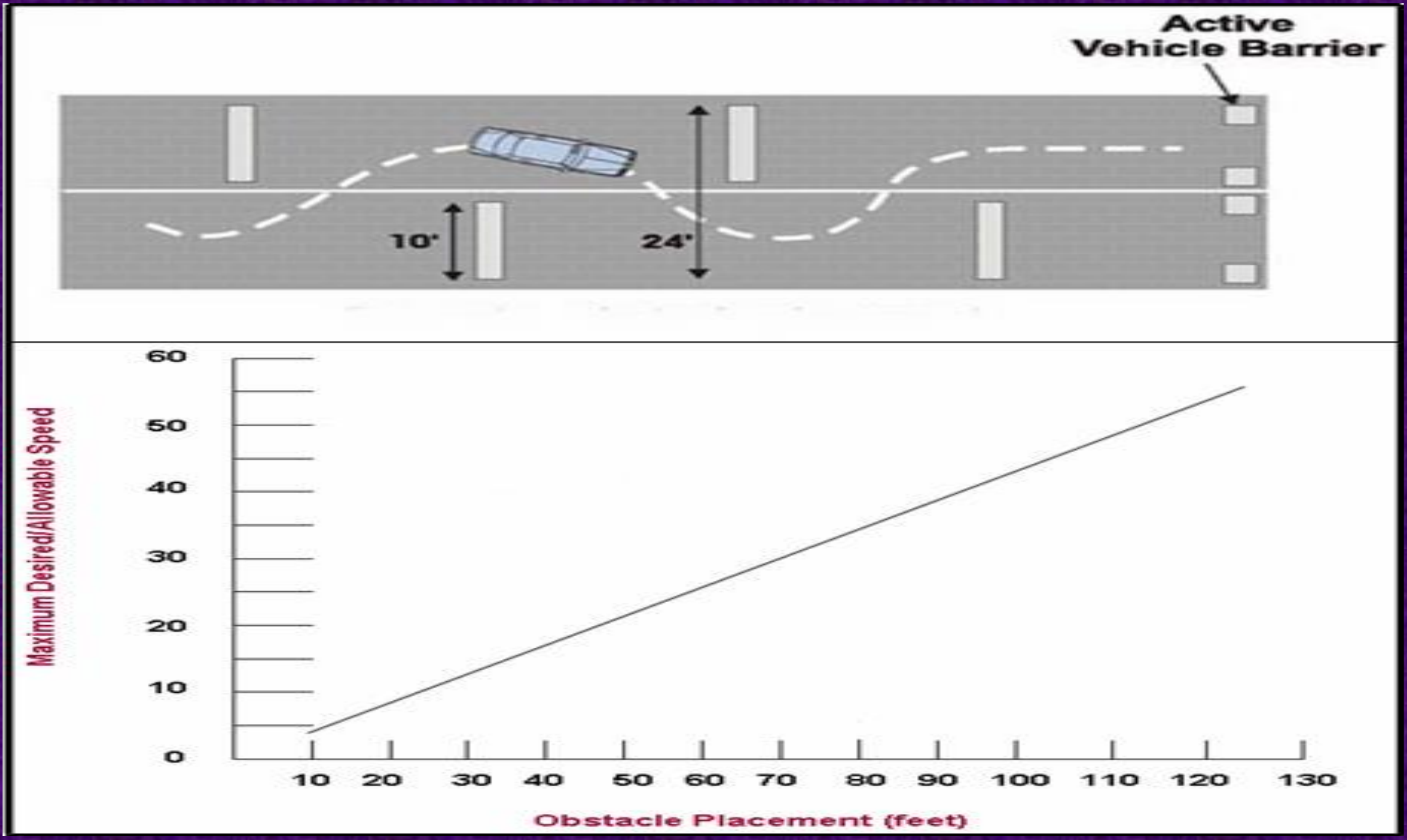
Incident pressure as a function of distance and explosive weight



Appropriate Stand Off



Barrier Design



Second Line Defence

- Needs engineer to work closely with other professionals such as architects, landscape architects, and security specialists to ensure attractive integration of site and structure in a manner that minimizes the opportunity for attackers to approach or enter a building.
- This approach uses such features as landscaped berms that function as blast barriers and traffic controls and bollards disguised as planter boxes that prevent vehicular access.

Typical Planter Designs

Typical Planter Designs

Typical Planter Designs

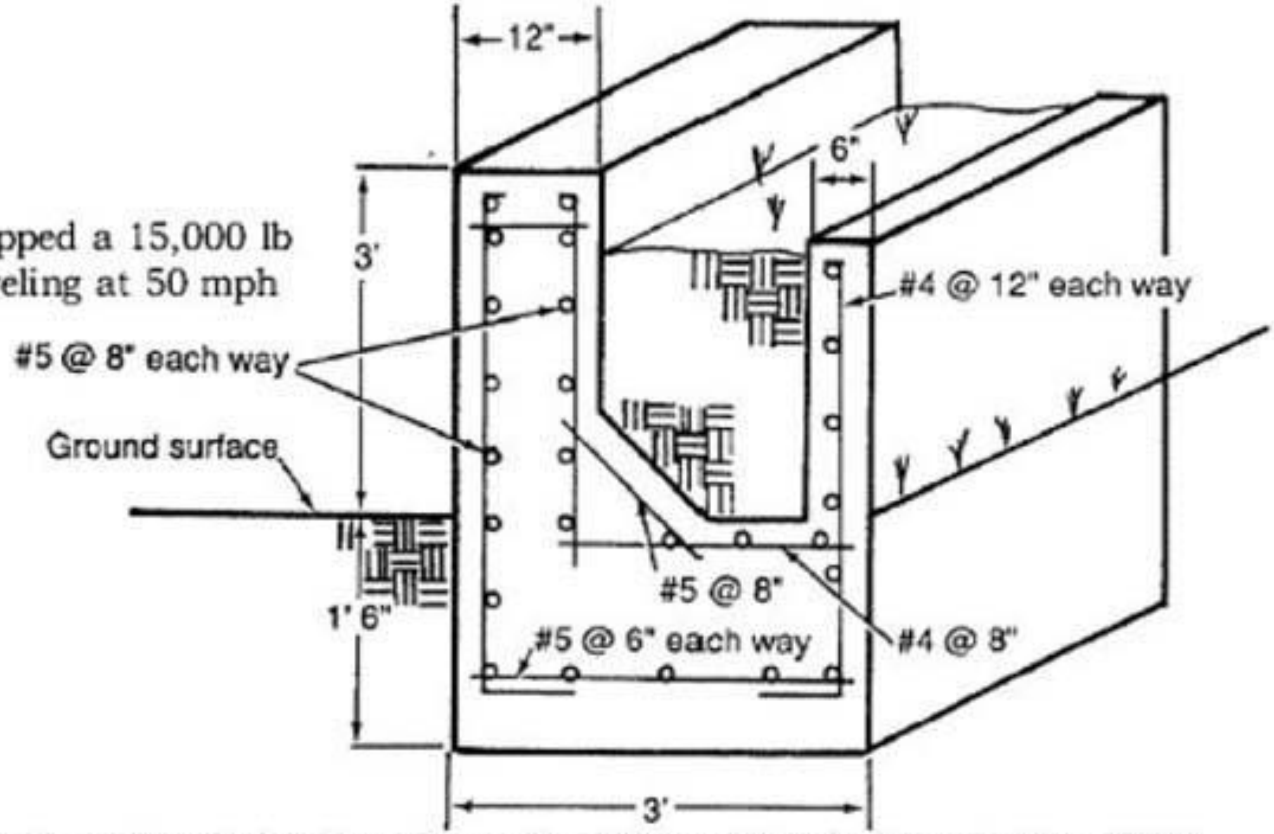
Typical Planter Designs

Planter outside white house

Typical Boulder Barrier

Typical Cross Section

Tested: Stopped a 15,000 lb vehicle traveling at 50 mph



Note: Each wall must be calculated based on soil conditions at that site. Concrete: f'c = 3,000 psi. Reinforcement steel bars: fy = 60 ksi. 1 ½-inch concrete cover all around, except as noted.
Source: Military FM 5-114

Typical truck stopper

Barriers and Bollards

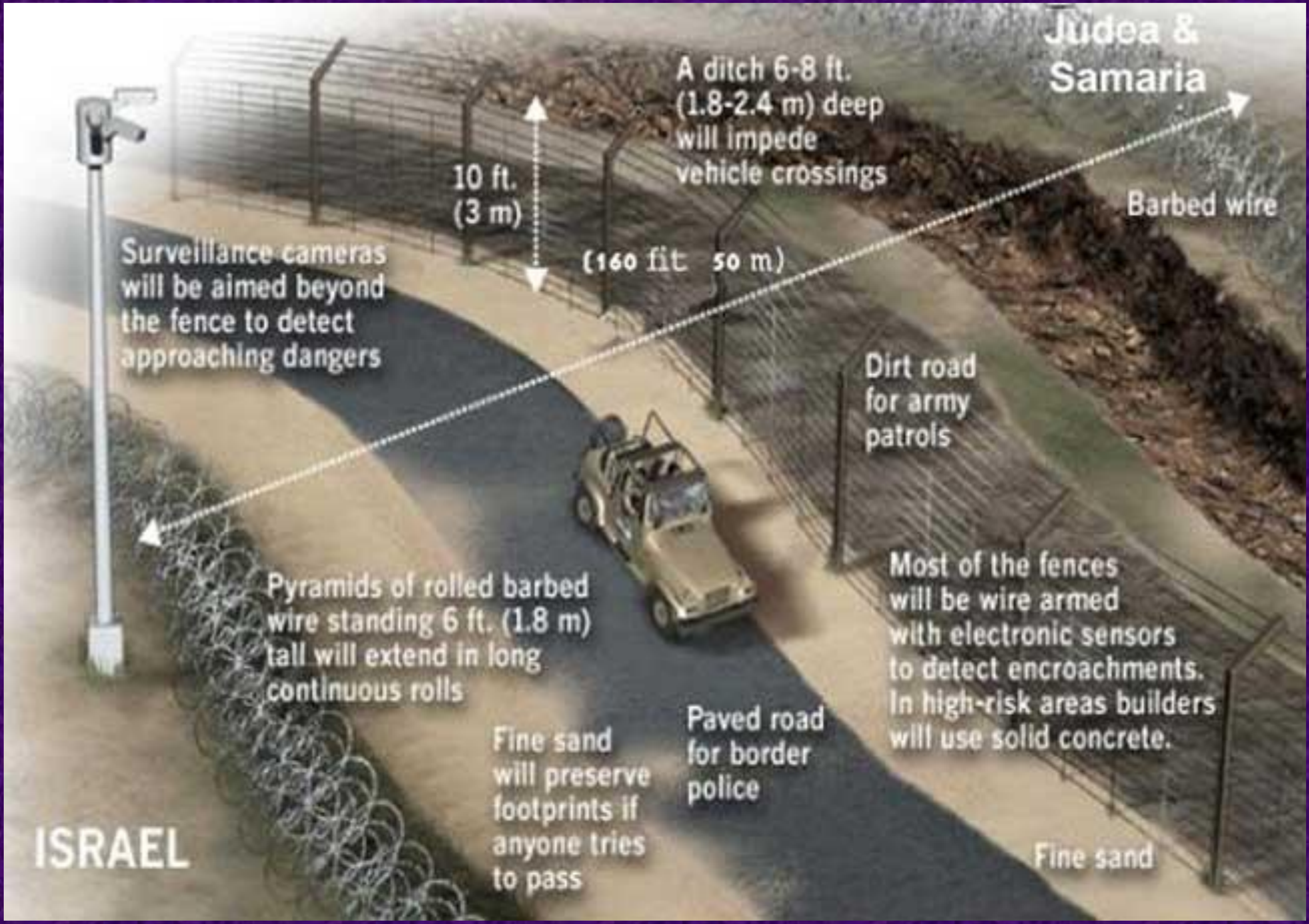
Earthen Berms

Floating Security Barriers

High Security Barriers

Internal turnstiles

Other features

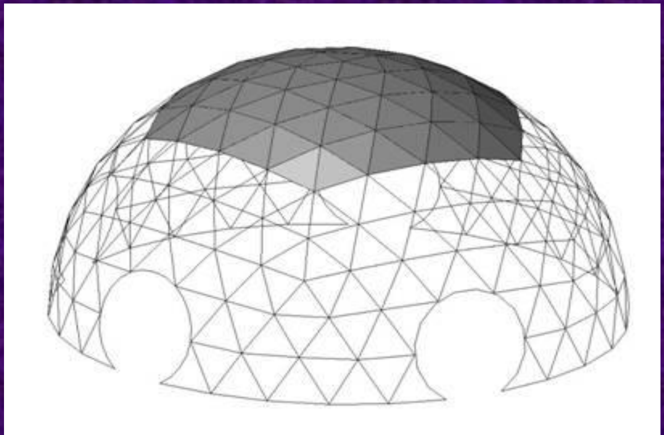


Structural form and internal layout

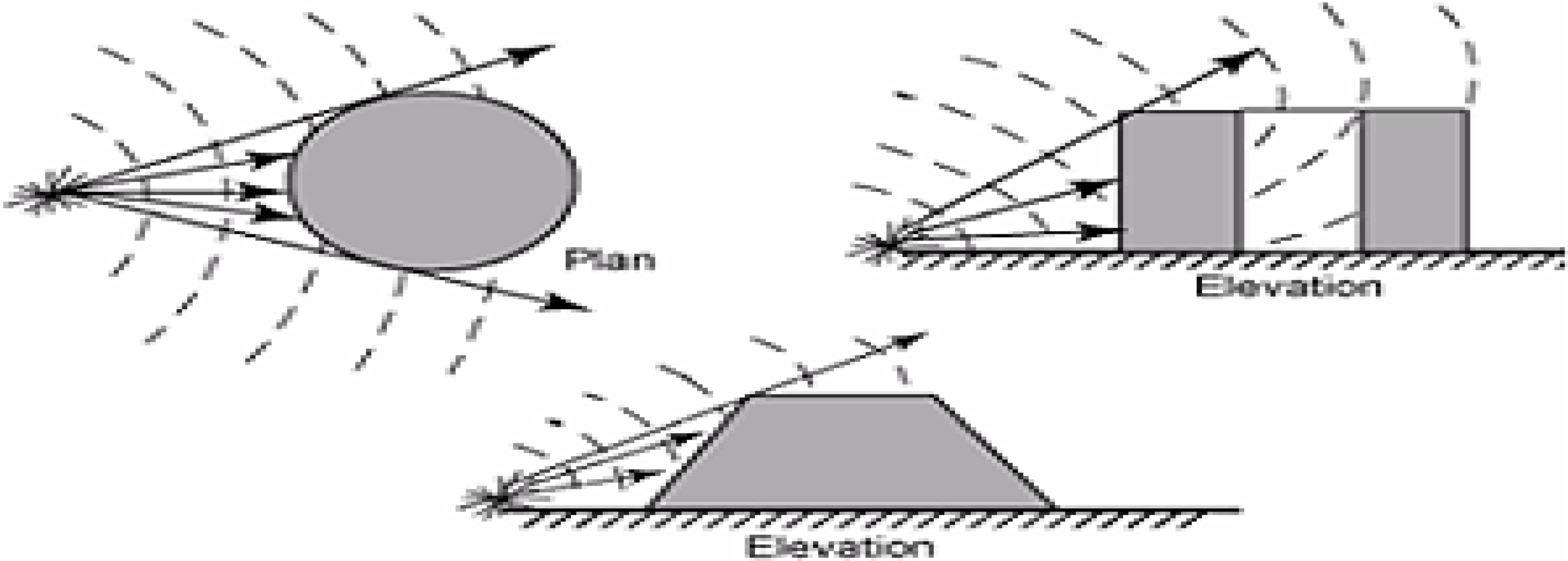
- This greatly affects the blast loads.
- Arches / domes reduce the blast effects compared with a cubicle form.
- plan-shape also has a significant influence of the blast load.
- Complex shapes cause multiple reflections of blast wave- should be discouraged.
- Projecting roofs or floors, and buildings U-shaped on plan are undesirable.
- single story buildings are more blast resistant compared with multi-story.

Structural Solutions for Blast Resistant Buildings:

Roof: Arches and domes are the types of structural forms that reduce the blast effects on the building compared with a cubicle form.



Flooring: They must be prevented from 'falling off' their supports. Pre-cast flooring is to be avoided in case of blast resistant structures



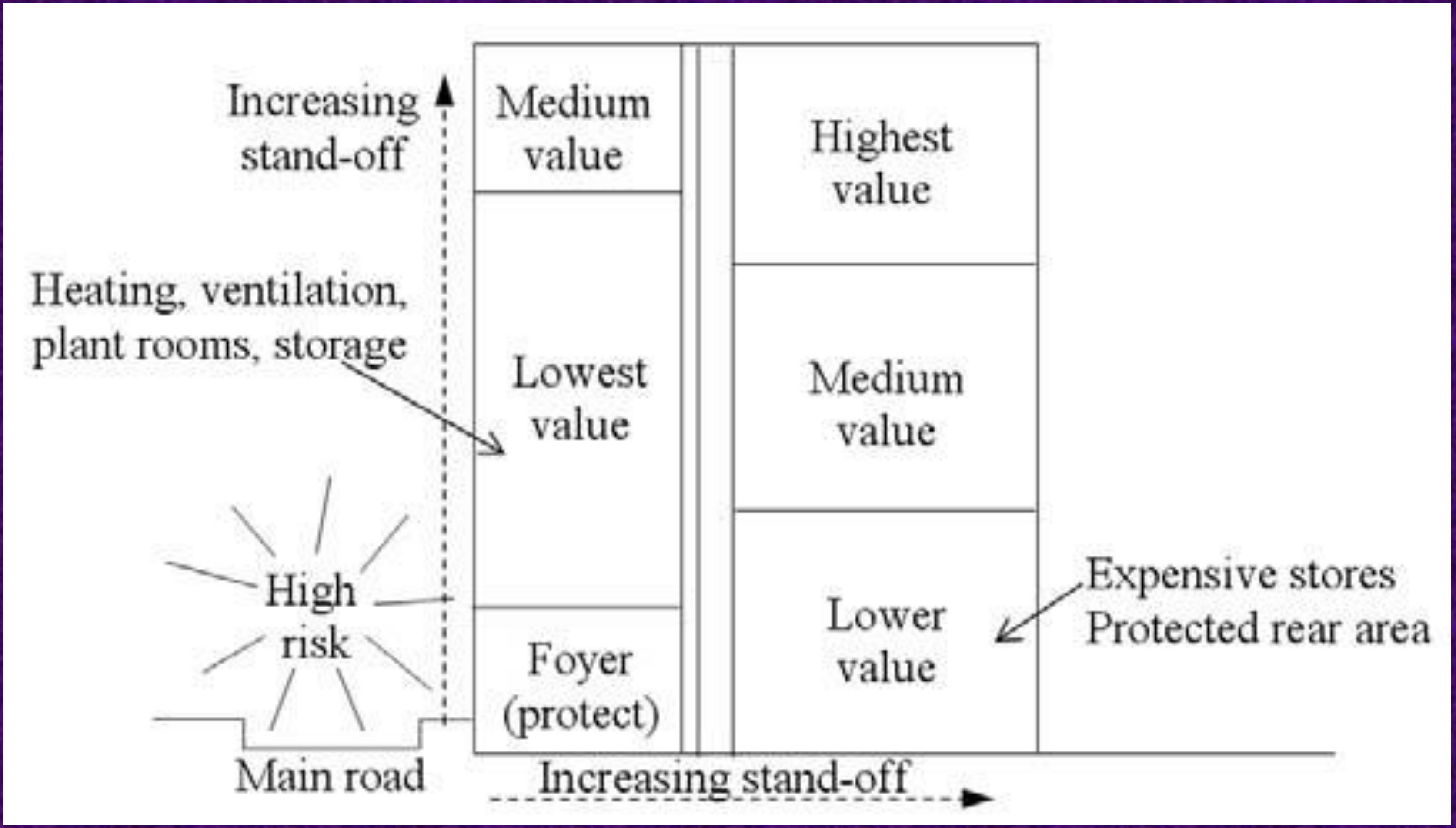
SHAPES THAT DISSIPATE AIR BLAST

SHAPES THAT ACCENTUATE AIR BLAST

The internal layout

- be planned with aim of isolating the value from the threat - highest exterior threat separated by greatest distance from highest value asset.
- Foyer areas be protected with RCC walls; double-dooring be used and the doors should be arranged eccentrically within a corridor to prevent the blast pressure entering the internals of the building.
- Entrance to building be separated from other parts of the building by robust construction for greater physical protection.
- An underpass beneath or car parking below or within the building should be avoided unless access can be effectively controlled.

Internal planning



open yet secure, safe, and sustainable buildings

California's Office of Emergency Services Headquarters —Sacramento, California.
Break out rooms surround the command and logistics room, shielding it from exposure to the outside, although clear windows allow a generous amount of daylight to enter the space.

Third Line Defence

- building to have a range of blast-resistant features such as additional steel reinforcement, composite fiber wraps, and high-performance glazing materials.
- The structure's electrical and utility systems be placed in protected raceways and Intakes protected.
- critical facilities or operations housed in specially hardened areas or underground
- Primary and backup systems located in different parts of the building.

Typical safety features

Effect on Glazing Materials

- Modern buildings typically contain several tons of glass.
  - windows, curtain walls, and skylights.
  - Potential hazardous projectiles.
- obvious solution-
  - greatly reducing the size and number of windows
  - found to be aesthetically wanting.
- proactive approach
  - to develop glazing materials that meet aesthetic and functional design objectives but do not contribute to the explosion-induced projectile hazard

Anti blast Criteria

Table 1 – ISC Security Criteria Glazing Performance Conditions

Performance Condition	Protection Level	Hazard Level	Description of Glazing Response
1	Safe	None	Glazing does not break. No visible damage to glazing or frame.
2	Very High	None	Glazing cracks but is retained by the frame. Dusting or very small fragments near sill or on floor acceptable.
3a	High	Very Low	Glazing cracks. Fragments enter space and land on floor no further than 3.3 ft. from the window.
3b	High	Low	Glazing cracks. Fragments enter space and land on floor no further than 10 ft. from the window.
4	Medium	Medium	Glazing cracks. Fragments enter space, land on floor and impact a vertical witness panel at a distance of no more than 10 ft. from the window at a height no greater than 2 ft. above the floor.
5	Low	High	Glazing cracks and window system fails catastrophically. Fragments enter space impacting a vertical witness panel at a distance of no more than 10 ft. from the window at a height greater than 2 ft above the floor.

Bullet proof Glazing

Underwriters Laboratory UL 752 Ballistic Standards			
UL Level	Weapon	Ammunition	Shots
1	Baretta 9mm Parabellum	9mm, 124 grain FMJ	3
2	.Smith & Wesson .357 Magnum	.357 Magnum, 158 grain JSP	3
3	Colt .44 Magnum	.44 Magnum, 240 grain SWC	3
4	M-1 Garand 30-06, .30 Caliber	.30 cal, 30-06, 180 grain JSP	1
5	Heckler & Koch Model G3 7.62 X 51 NATO	.30 cal, 7.62 NATO, 150 grain FMJ	1
6	Baretta 9mm Parabellum	9mm, 124 grain FMJ	5
7	Colt M16 (AR15 Semi), 5.56 X 45 NATO	.223 cal, 5.56 NATO, 55 grain FMJ	5
8	Heckler & Koch Model G3 7.62 X 51 NATO	.30 cal, 7.62 NATO, 150 grain FMJ	5
Shotgun Supplement			
SG 1-8	Benelli 12GA Shotgun	12GA, 2.75" 437 grain Slug 12GA, 2.75" 650 grain #00 Buck	

Product	Threat	Thickness	Lbs/Sq.Ft.
1	Forced Entry	.375"	4.00
2	.38 Special, Forced Entry	.450"	4.40
3	.38 Special, Forced Entry	.530"	4.79
4	.38 Special, Forced Entry	.600"	5.18
5	9 mm, Forced Entry	.625"	5.28
6	9 mm, Forced Entry	.725"	5.96
7	9 mm, .357 MAG, Forced Entry, 30 Minute Physical Attack	.750"	6.06
8	.357 MAG, Forced Entry, 60 Minute Physical Attack	.875"	7.14
9	.357 MAG, Forced Entry, 60 Minute Physical Attack	.960"	7.30
10	.357 MAG, Forced Entry, 60 Minute Physical Attack	1.000"	9.33
11	.44. MAG, Forced Entry, 60 Minute Physical Attack	1.250"	10.50

Different thickness bulletproof glass for different bulletproof Level

Ballistic Level	Thickness	Composition (mm)	Weapon Striking	Velocity (m/sec)	Penetration	Fire Distance	Splintering
NIJ IIA	18 mm	8 +1+5+1+3	9mm Parabellum	330+/-15	No	3 meters	Yes
	27 mm	8 +1+8+1+5+1+3	9mm Parabellum	330+/-15	No	3 meters	No
NIJ II	26 mm	8 +1+12+1+4	.357 Magnum	425+/-15	No	3 meters	Yes
	38 mm	10+1+10+1.5+10+1.5+4	.357 Magnum	425+/-15	No	3 meters	No
NIJ IIIA	29 mm	10+1.5+12+1.5+4	.44 Magnum	426+/-15	No	3 meters	Yes
	40 mm	12+1.5+12+1.5+8+1+4	.44 Magnum	426+/-15	No	3 meters	No
NIJ III	48 mm	10+1.5+12+1.5+10+1+6 +2+4	7.62x51mm NATO	838+/-15	No	10 meters	Yes
	57 mm	10+1.5+12+1.5+10+1+6 +2.5+6+2.5+4	7.62x51mm NATO	838+/-15	No	10 meters	No
NIJ IV	67 mm	12+1.5+12+1.5+12+1.5 +10+1+4+1+4+2.5+4	30-06 AP	868+/-15	No	25 meters	Yes
	78 mm	12+1.5+12+1.5+12+1.5 +10+1+10+1+4+1+4+2.5+4	30-06 AP	868+/-15	No	25 meters	No

the red words is the thickness of glas

the black words is the thickness of resin layer

Analysis of Injuries

- primary cause of death relates to building collapse
- nonfatal injuries caused by blast-generated debris, mainly glass fragments.
- In milliseconds following an explosion, much of the glass in a building is transformed into fragments and propelled into building at high velocity or sucked out of the structure during the subsequent vacuum phase.
- Many blast-related deaths and injuries are attributable to the body of the victim being penetrated by these missiles.

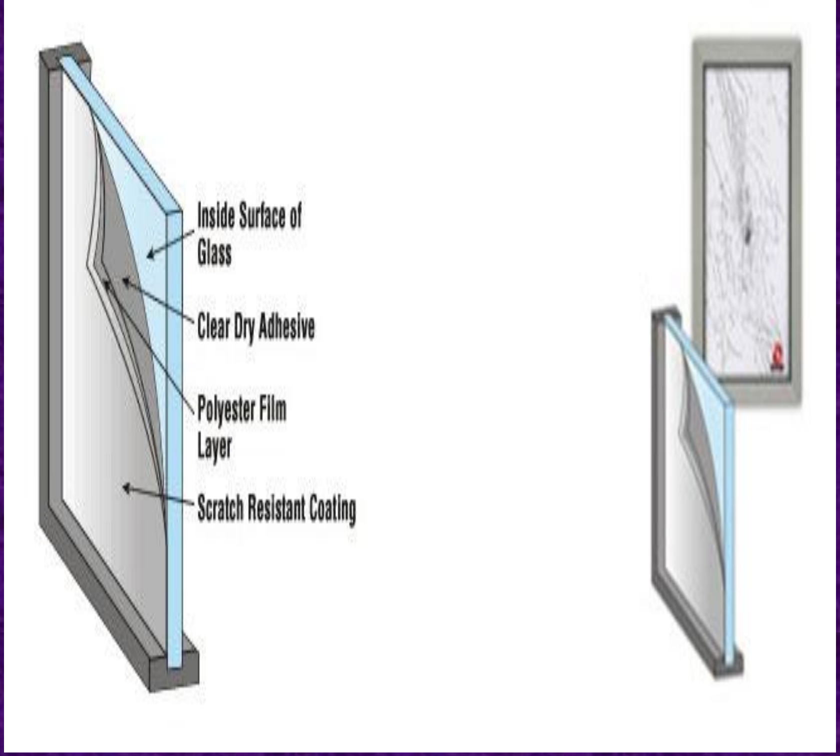
Selection of Glazing Materials

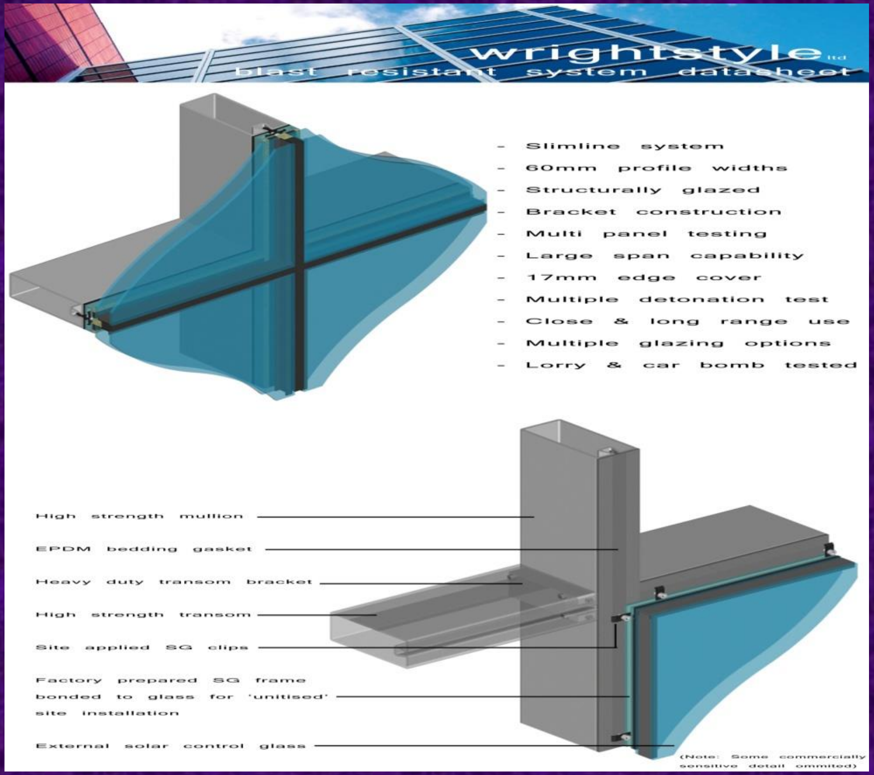
- glazing materials should meet aesthetic and functional objectives without explosion-induced projectile hazard, either by controlling the nature of the projectile patterns or limiting their range and dispersion patterns.
- Glazing materials can be tempered, annealed, laminated, protective window films, and glass substitutes such as polycarbonates.
- Fiber composite
- When window replacement not feasible, materials such as Kevlar can be woven into blast curtains and drapes to limit the dispersion of blast-generated debris.

Kevelar curtain and blankets

Typical blast resistant doors

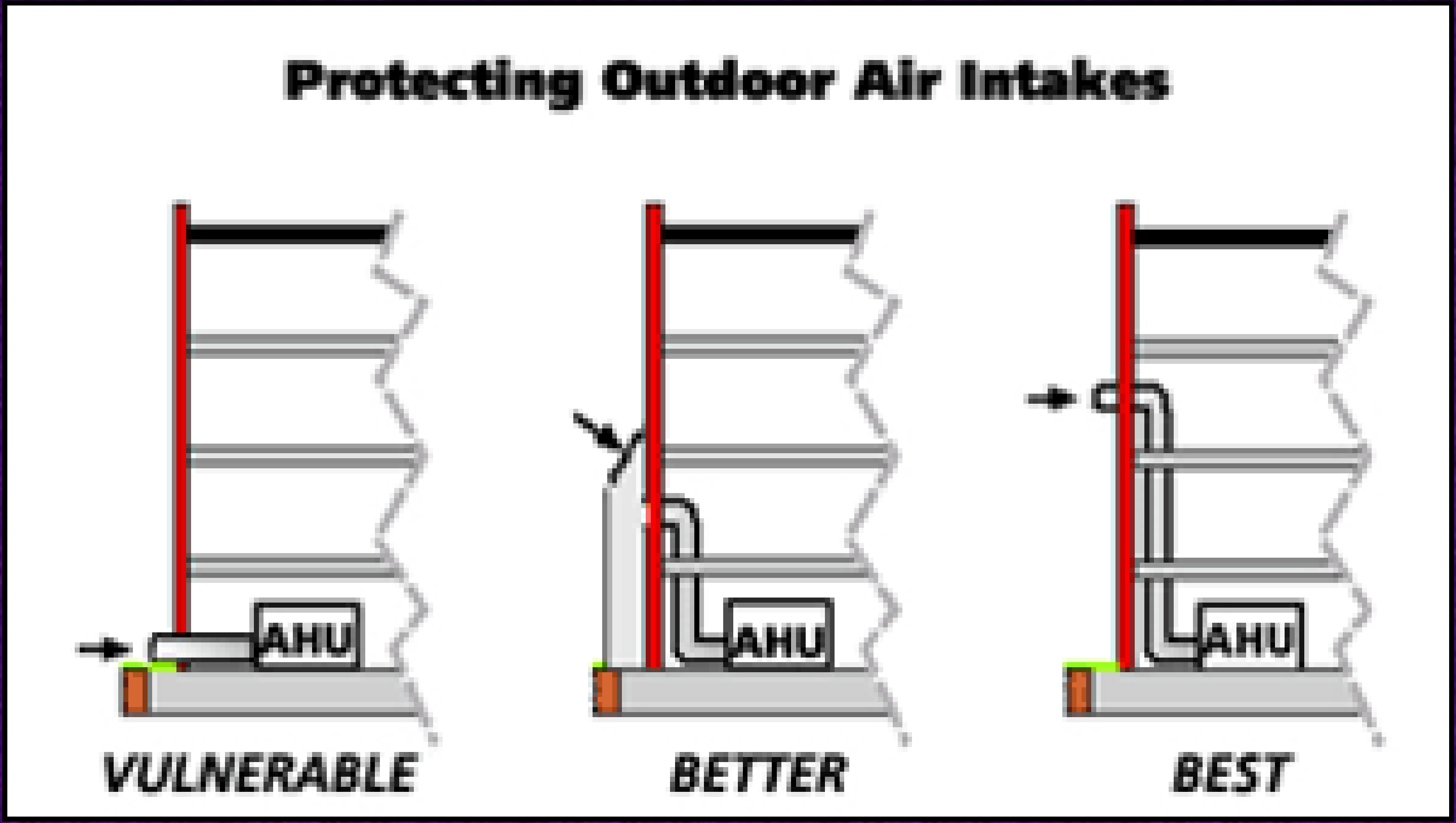
Typical blast resistant Windows





Blast Resistant openings

Environmental Quality protection



Protection of water

- Attacks on water supply can come mainly in two forms.
- Contamination from chemical , biological or radiological agents or
- Disruption to the processing, filtration and distribution
- Focus is on access control and intelligence, with minimal attention given to enhanced sensors to detect chemicals or biological agents.

Stage 4-challenges for Structural Engineer

- **two critical challenges for the structural engineer:**
  - **ensure against the progressive collapse of structure**
  - **Minimize quantity and hazards of broken glass and other blast-induced debris.**

Key planning assumptions

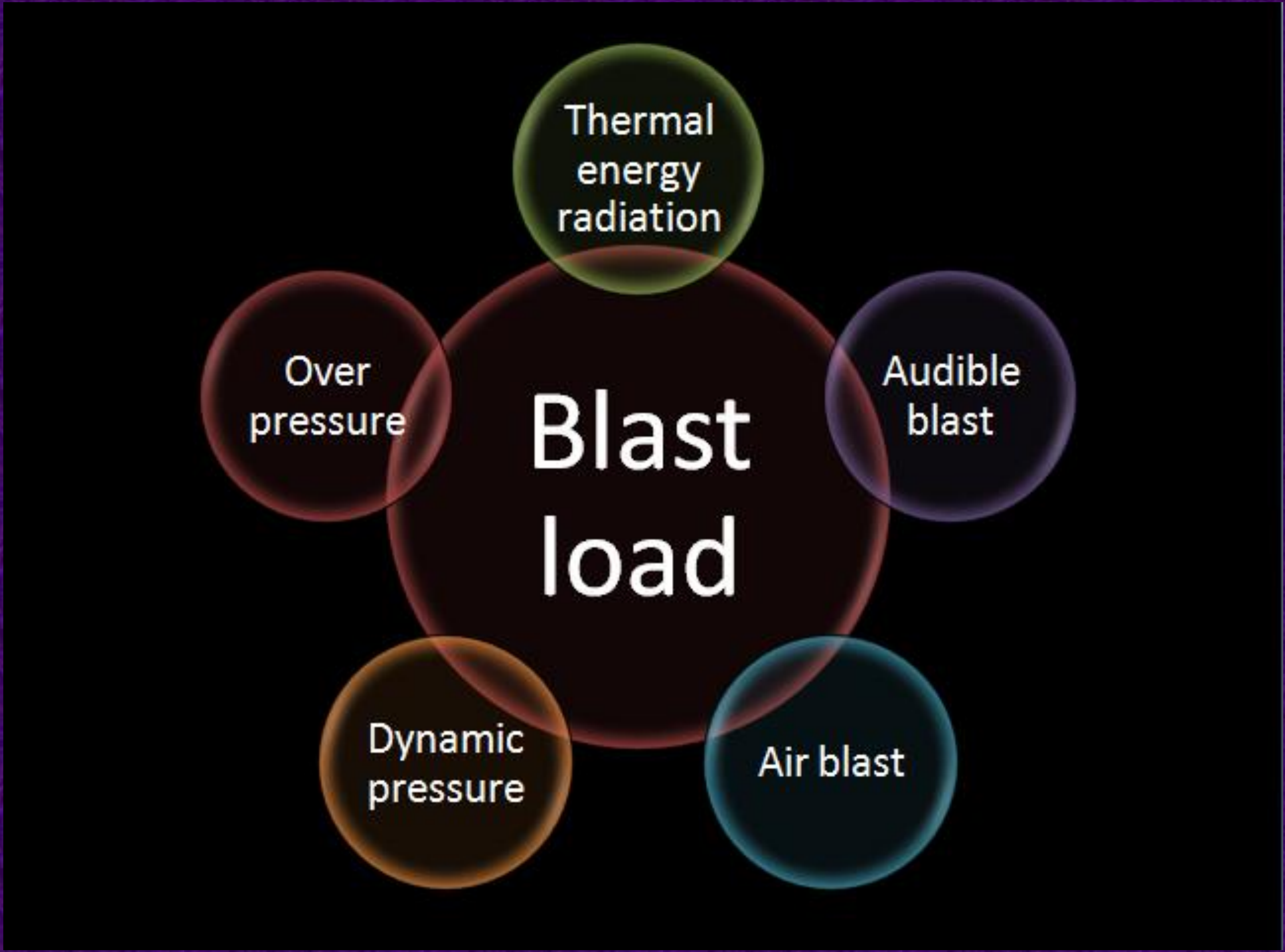
- *Terrorists want something big.*
- *Potential consequences should be beyond the experience of typical accidents.*

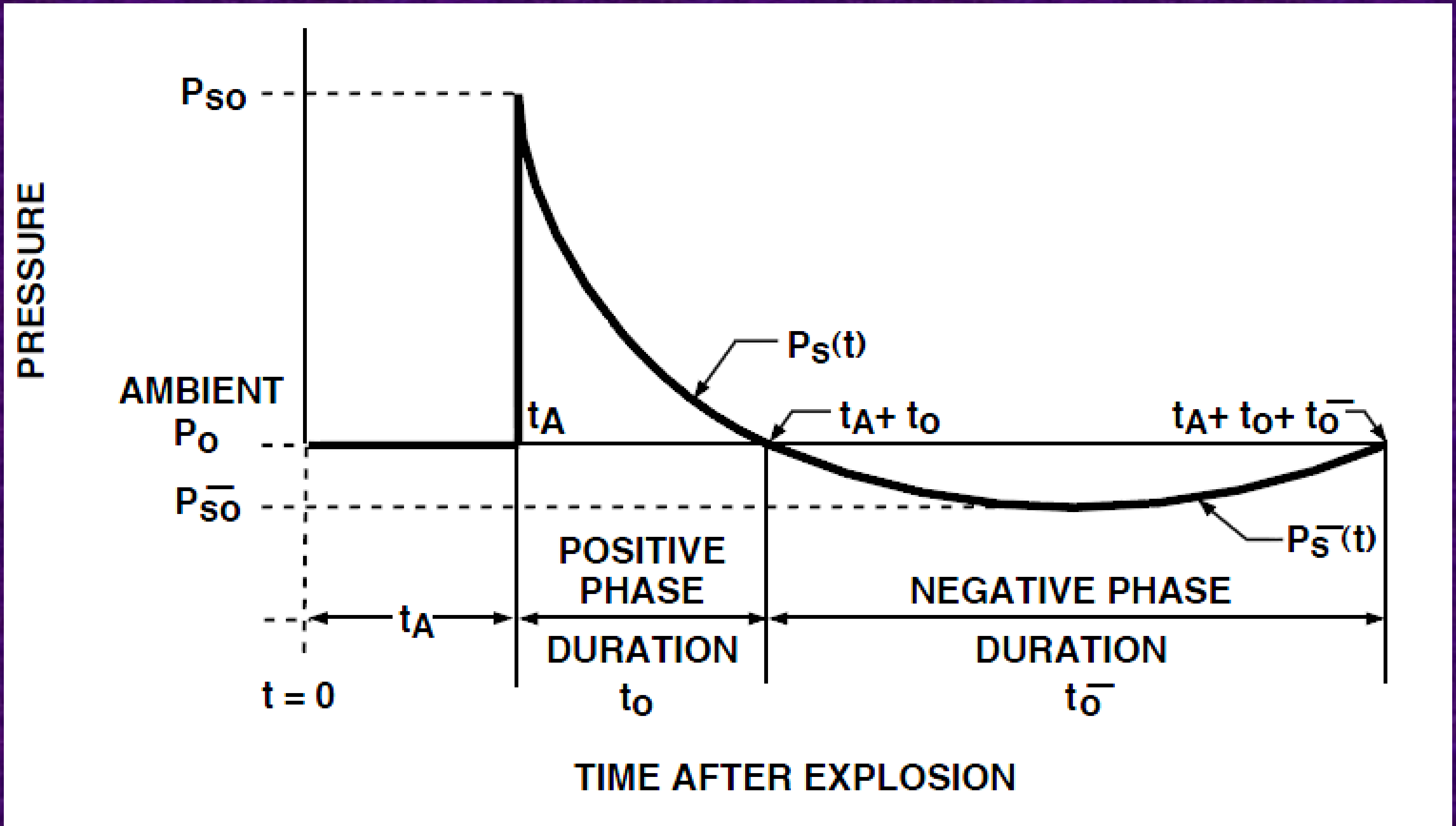
Design Criteria- Damage Level

- **Two types of damage levels**
  - *Component*
  - *Building*
- **Allowable damage level depends on criticality of asset being protected**
  - *Low damage: high-priority buildings with critical function(e.g., central control room)*
  - *Medium damage: low-priority buildings with non-critical function, but significant populations*
  - *High damage: sparsely populated or unoccupied buildings*

Tolerable Damage Level

- As long as the roof and floor slabs stay up:
  - *Wall debris poses greatest risk close to the wall (i.e., close to falling brick wall)*
  - *Structural framing and columns should be redundant (no progressive collapse)*
  - *Primary causes of fatalities are building collapse*
- Tolerable damage can be tied to occupancy and function
  - *Unoccupied, non-critical area – tolerate collapse*
  - *Highly occupied or important area – limited damage with ability to restore services*
- *Critical areas – minimal damage*


Thermal energy radiation
Over pressure
Blast load
Audible blast
Dynamic pressure
Air blast



As a rough approximation, 1kg of explosive produces about $1m^3$ of gas. As this gas expands, its act on the air surrounding the source of the explosion causes it to move and increase in pressure.

Collapse analysis

- Two design requirements determined by the type of weapon are
  - direct effects of blast causing extensive damage to the façade and
  - localized damage due to attack on individual elements leading to *progressive collapse*
- Of these two design requirements, the design for the latter is the most difficult.

Structural aspects of design for terrorism

- **Objective is to offers large stiffness and significant lateral & vertical strength.**
- **Five basic features of the building's structural system are known to enhance hardness of the building. These features are:**
  - ***Large Mass & Stiffness***
  - ***Large redundancy***
  - ***Member Strengths Proportioned as per Capacity Design Concept***
  - ***Resistance to Reversed Loading***
  - ***Strong Connections***

Large Mass & Stiffness

- Buildings with large mass perform well under blast loading; lightweight constructions are unsuitable. buildings having large inertia take a while before they respond to the severe blast overpressure. This is beneficial because before the building sets into oscillations, the blast overpressure duration is passed. Also, large mass structures often have high stiffness, which also means smaller deformations in them.

Large redundancy

- High redundancy in vertical & lateral load resisting systems with ductile members connecting them is one major factor for the survival of buildings under blast loading. This ensures that when localized damage occurs in any of the structural elements, re-distribution of load is possible and collapse of the structure can be prevented.

Member Strengths Proportioned as per Capacity Design Concept

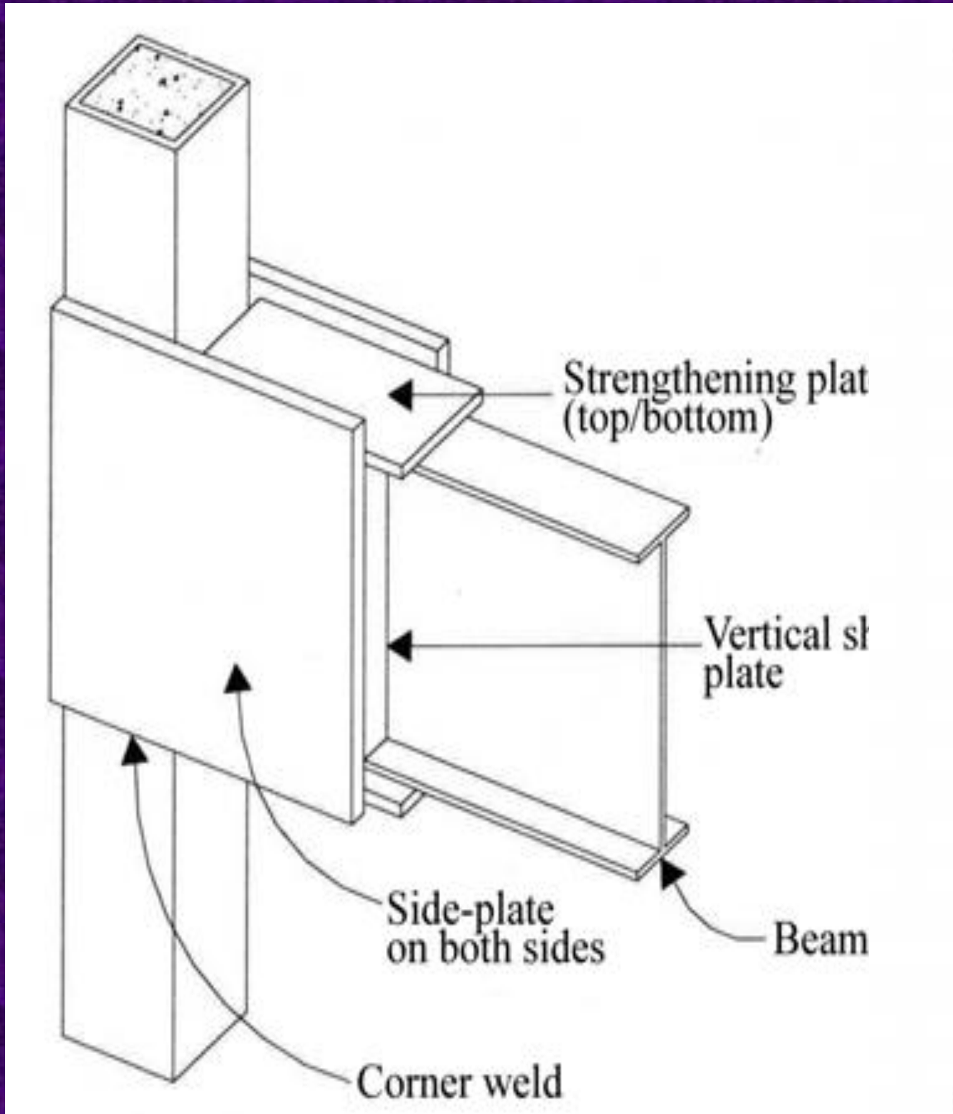
- **Blast loading is a force applied on the building. Thus, buildings are designed to possess more vertical/lateral strength than the vertical/horizontal force imposed on them due to the blast.**
- **buildings are designed as per *capacity design concept*. This ensures that members are prevented from undergoing brittle shear failure before they sustain ductile flexural failure.**
- **it is imperative that the connections should allow this without themselves being damaged. Such an approach enhances the energy absorption capacity of the structure.**

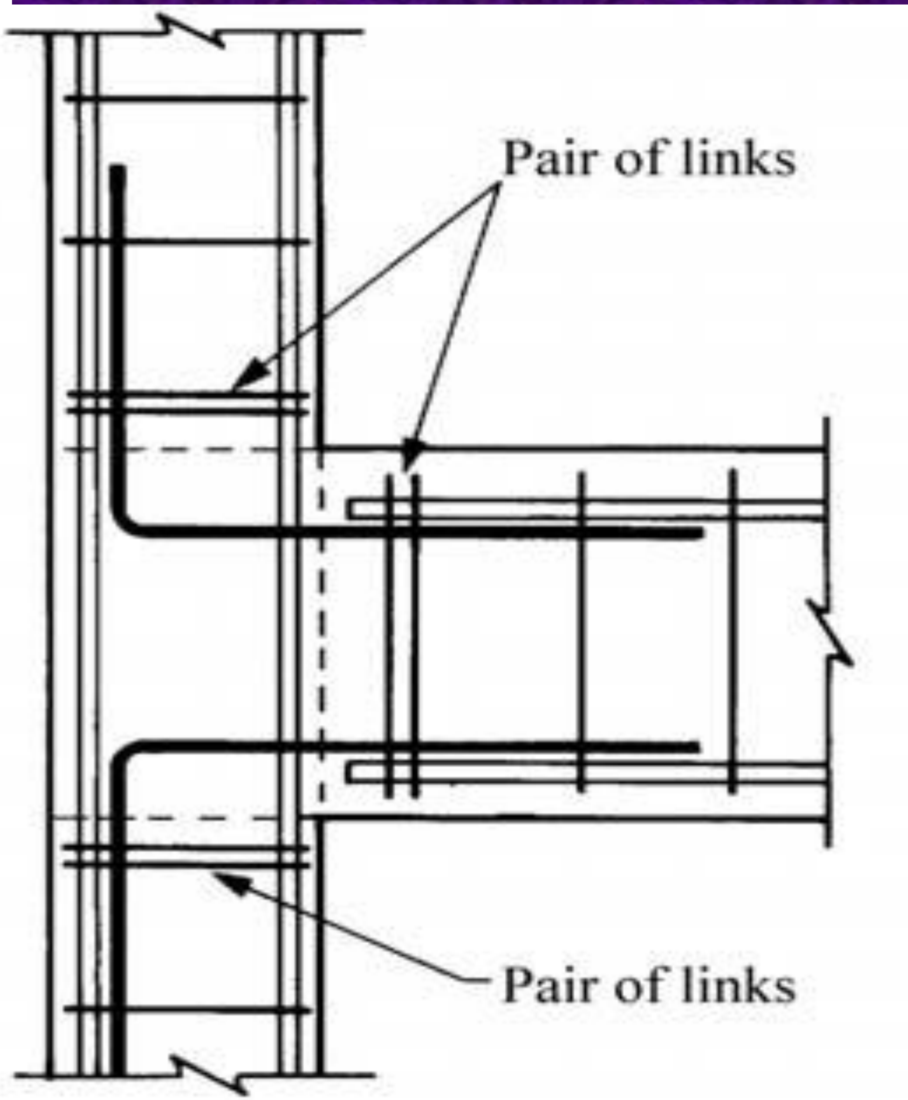
Resistance to Reversed Loading:

- The structural design of primary structural members (resisting vertical and lateral loads) accounts for reversal of blast overpressures loads, namely the positive pressure phase followed by negative pressure phase.
- Thus, structural systems with gravity load-based prestressing and with seated connections should not be used. In particular, roofing systems should be bolted or anchored down to prevent lift-off under upward pressure in buildings.

Strong Connections

- Connections between structural elements must be strong to allow large deformations without dropping strength, and thereby facilitate redistribution of loads from one vertical & lateral load resisting system to another in a ductile manner.
- Over the years, cast-in-situ RC constructions have performed well in many military applications, *as* it is possible to
  - (a) detail RC beams to perform in a ductile manner, and (b) design columns with large cross-sectional area so that they do no buckle when large overpressures cause a sudden increase of axial loads in them.

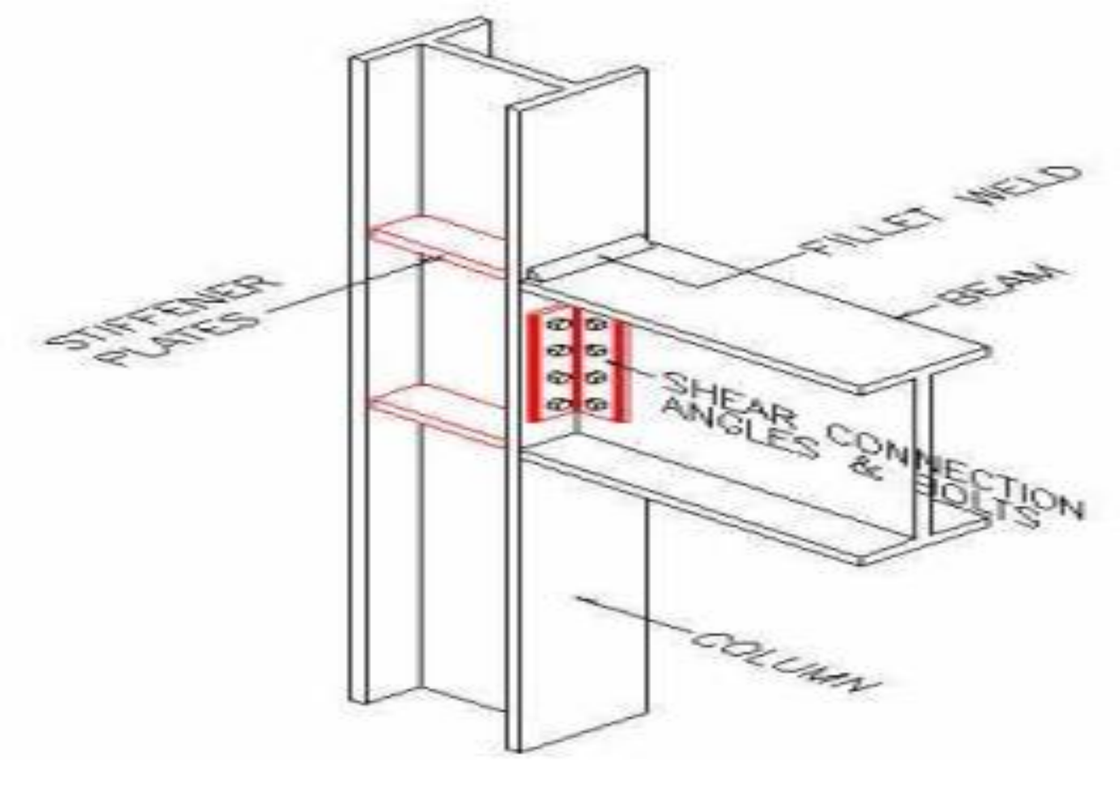


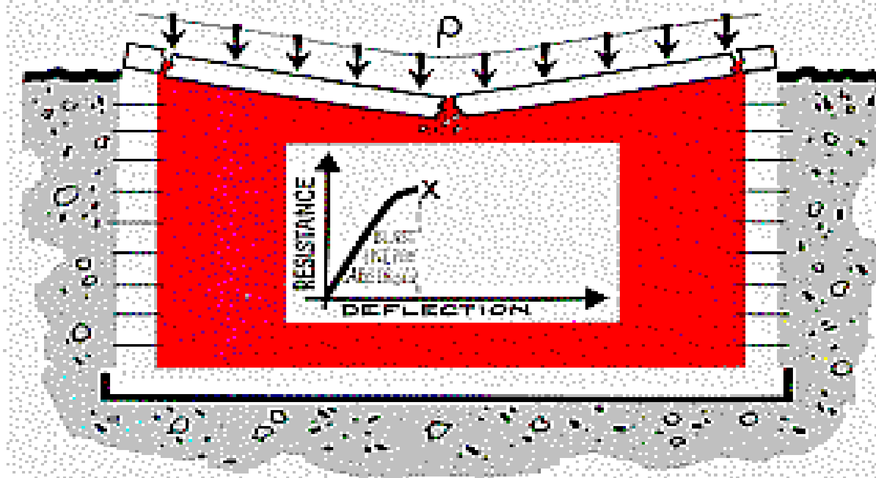


Side plate connection for a steel structure

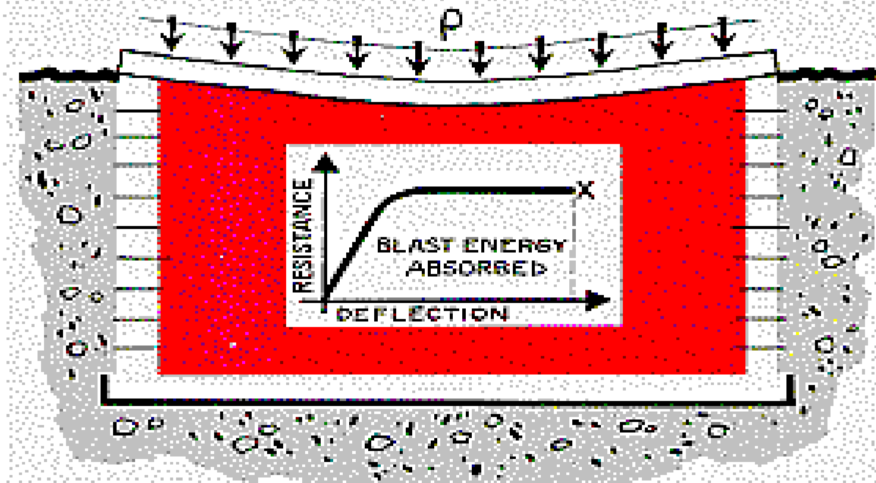
Beam to column connection in Reinforced concrete structure

- use of extra links and location of starter bars in the connection reduce collapse and damages.
- In critical areas full moment-resisting connections are made in order to ensure the load carrying capacity of structural members after an explosion is nor decreased.

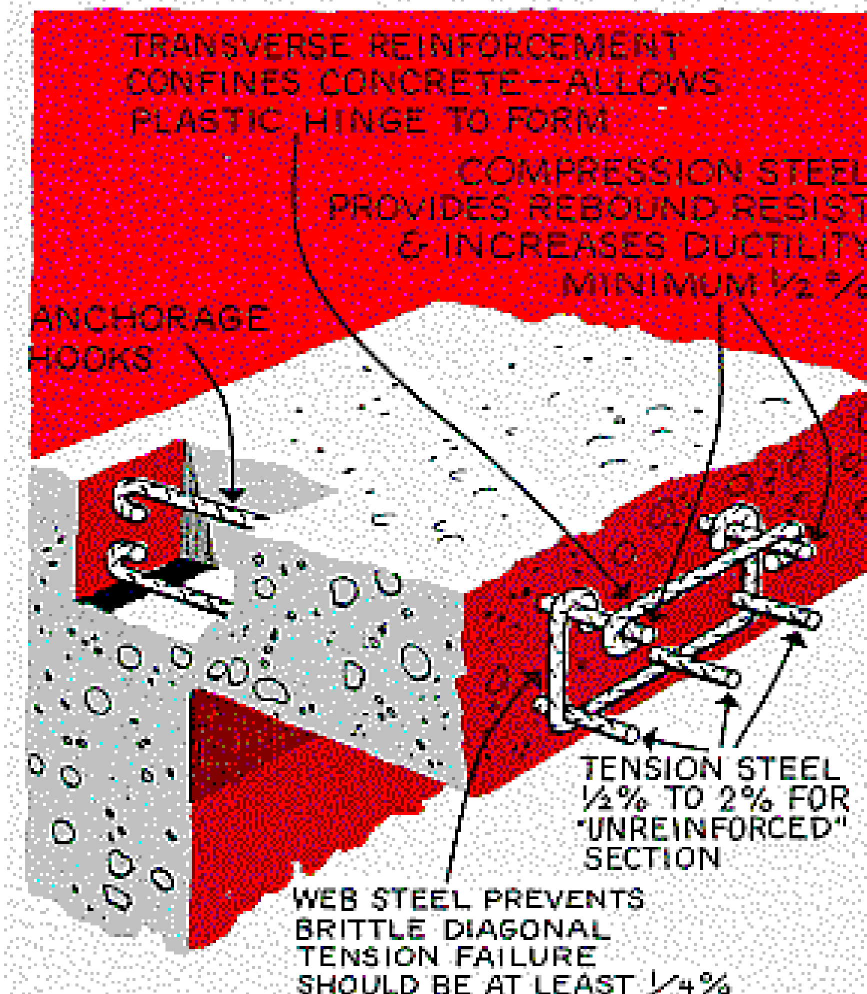




BRITTLE FAILURE



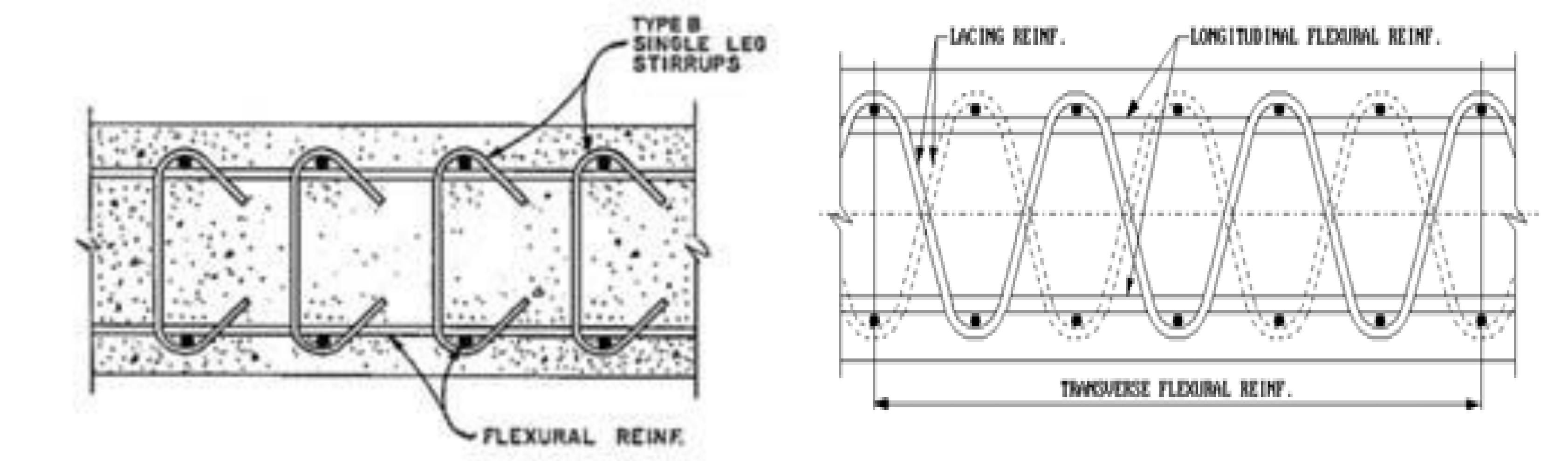
DUCTILE RESPONSE



DUCTILE REINFORCED CONCRETE

Type of reinforcement
(Unified Facilities Criteria)

CONVENTIONAL **LACED**



Lacing has not been widely accepted in the community

- *Extremely difficult to construct*
- *Dubious benefits for dynamic response*
- *For lacing detail requirements, refer to UFC 3-340-02*

What is Progressive collapse

- In progressive collapse, the failure of a member in the primary load resisting system leads to redistribution of force to the adjoining members.
- If the adjoining member cannot resist the additional load, then even that member fails. This process continues in the structure and eventually the building collapses.
- Thus, the failure of a member at the *local level* results in the collapse of the structure at the *global level*, in a progressive manner, one member at a time.

Progressive collapse analysis

- Irrespective of building function, structural system used in it, and level of security employed in it, every building should be designed to prevent progressive collapse.
- Redundancy is the first measure to ensure that there are many alternate load paths and increased number of locations where plastic hinges must occur before the structure collapses.
- Members where plastic hinges are likely to form should have ductile detailing incorporated in them to perform in a ductile manner, and
- other non-ductile members must be designed as per capacity design concept, thus minimizing the possibility of progressive collapse

Methodology

- Perform structural analysis of building by removing one important element in the load path, *e.g.*, column, load-bearing wall or beam, to simulate local damage from an explosion. This method of analysis can be both linear and nonlinear, and within that both static as well as dynamic.
- Check if available load path in remaining structure is able to resist the loading. If it can, the exercise is repeated by removing another critical element in the load path. Otherwise, the structure is rendered vulnerable.
- If in all possible cases of removal of an important member in load path, one at a time, the structure is able to resist the loading, the structure is said to meet the progressive collapse requirement.

IS : 4991 - 1968
(Reaffirmed 2003)

Indian Standard

CRITERIA FOR BLAST RESISTANT DESIGN OF STRUCTURES FOR EXPLOSIONS ABOVE GROUND

(Fourth Reprint APRIL 2006)

UDC 699.85 : 624.04

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG

UFC 4-010-01 9 February 2012 Amended in October 2013

- DoD MINIMUM ANTITERRORISM STANDARDS FOR BUILDINGS
- UNIFIED FACILITIES CRITERIA (UFC)
- APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

Standard References

- United Facilities Criteria (UFC) 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings*
- UFC 4-023-03, *Design of Buildings to Resist Progressive Collapse*
- U.S. General Services Administration (GSA) Progressive Collapse Design Guidelines
- GSA Blast and Window Design Requirements U.S. Department of Homeland Security (DHS)
- Chemical Facility Anti-Terrorism Standards (CFATS)
- *Facilities Standards for the Public Buildings Service,* PBS-P100, Chapter 4 – Structural Engineering Design Requirements

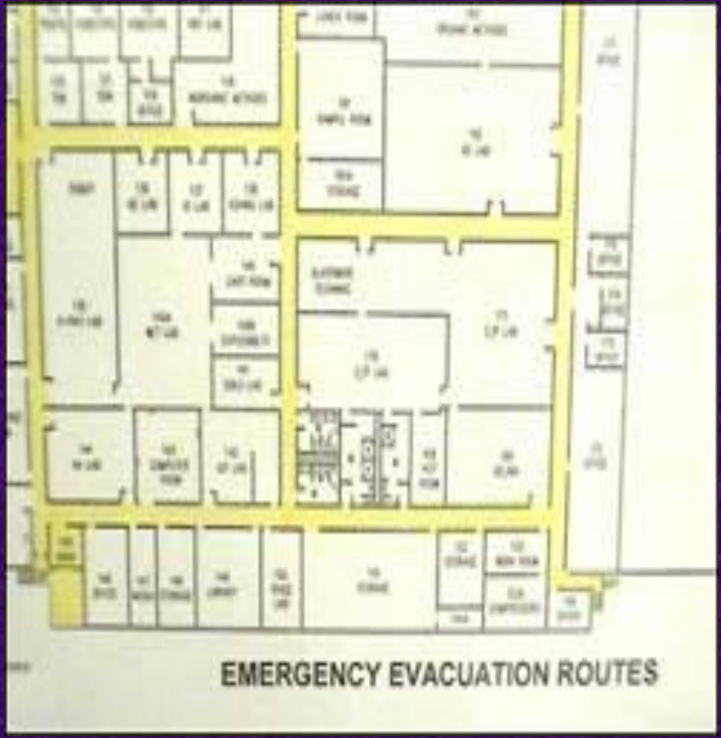
Software tools

- Blast loads from external detonations – ConWep
- Blast loads from internal detonations –BlastX
- Complex detonations using Computational Fluid Dynamics (CFD) such as BWTI™ and FLACS
- Fragment, projectile, and penetration – ConWep
- Window glazing analysis response and design –WinGARD
- Single- or 2-degree of freedom analysis of individual components –SBEDS
- Multi-component analysis of building systems - RISA3D
- Complex dynamic structural response using Finite Element Analysis (FEA) - LS-DYNA
- Injury modeling - BICADS

Fifth line Defence

- Planning the routes and facilities for Relief and Rescue
- Retrofitting of existing buildings

Markings and unobstructed routes



Exit routes should be strong enough to ensure a safe passage without collapse and Free from obstructions

Adequate number of Respirators

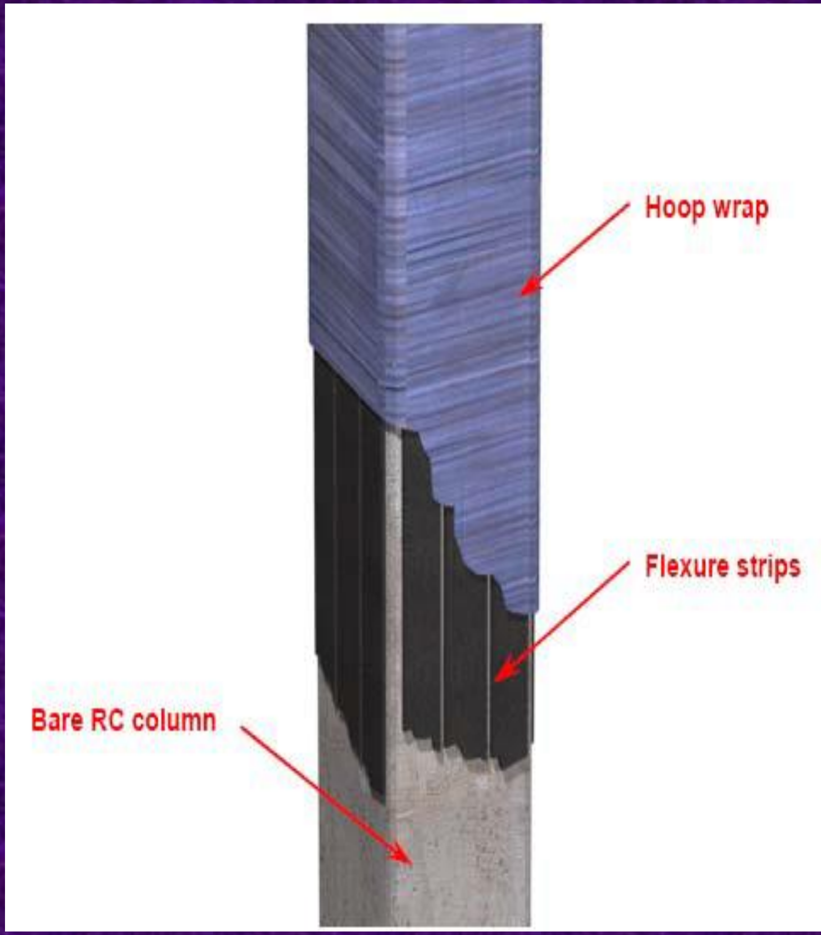
Respiratory protection may be necessary if people have to pass through toxic atmospheres (such as dust, mists, gases, or vapors) or through oxygen-deficient areas while evacuating. These should be available in evacuation passage in sufficient quantity.

Wrapping of columns:

Wrapping is done to done for external protection of columns and also to protect the column from shock waves. Two types of wrapping can be applied. Wrapping with steel belts or wrapping with carbon fiber-reinforced polymers (CFRP).

Column Confinement

- Fibers oriented transverse to longitudinal axis of member
- *Contribution of longitudinal fibers to axial strength is negligible*
- Results in increase in apparent strength of concrete and in max usable compressive strain
- *Increase in axial compressive strength*
- Enhance the ductility of members subjectedto combined axial and bending forces
- Contact between FRP and member is critical
- Apply to circular and square columns



Response of Columns to explosion

NORMAL RCC COLUMN

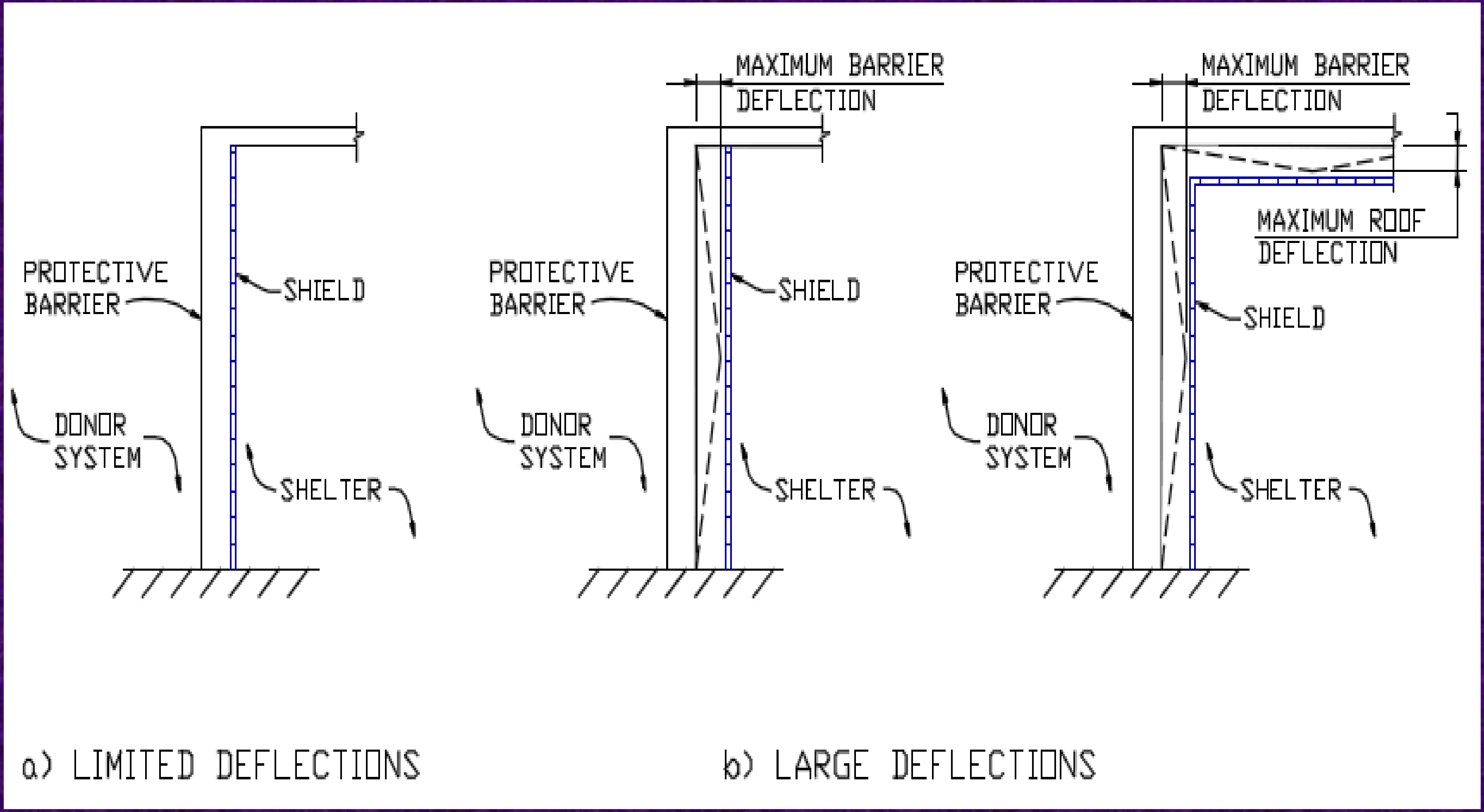
COLUMN WITH FIBRE WRAP

Progressive Collapse Resistance.

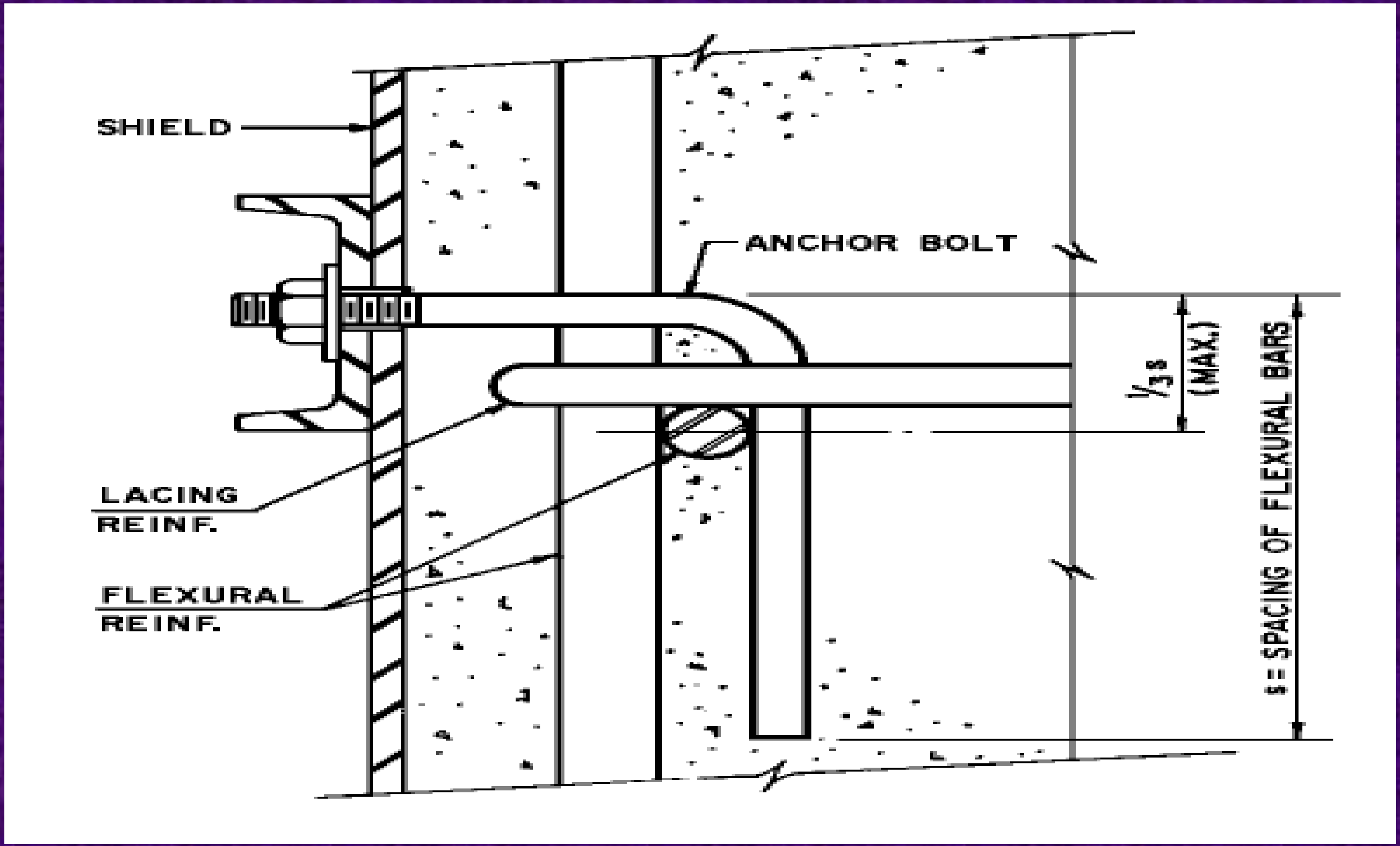
Shear Walls

- Use a well distributed lateral load resisting mechanism in the horizontal floor plan.
- Shear walls around the plan will improve the overall seismic as well as blast behaviour of the building.

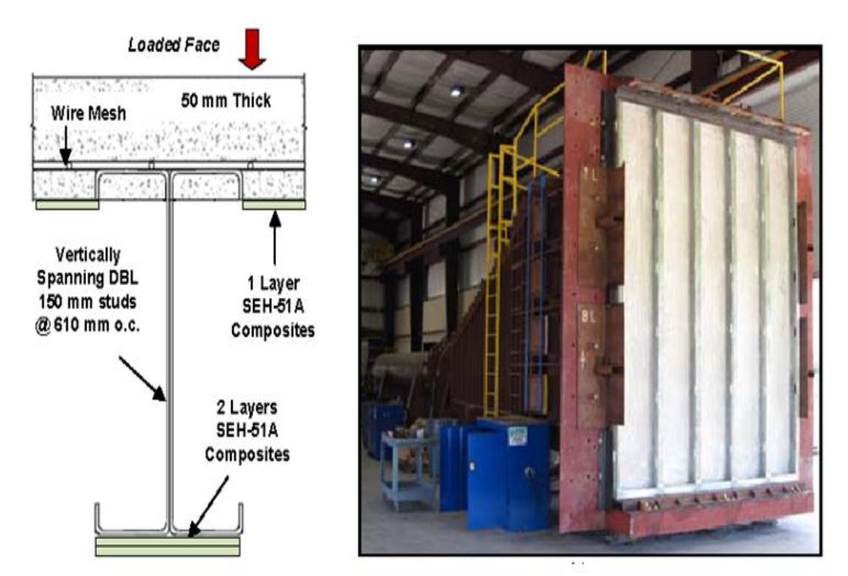
Shielding System for protection against concrete fragmentation



Attachment of fragment shield to Barrier



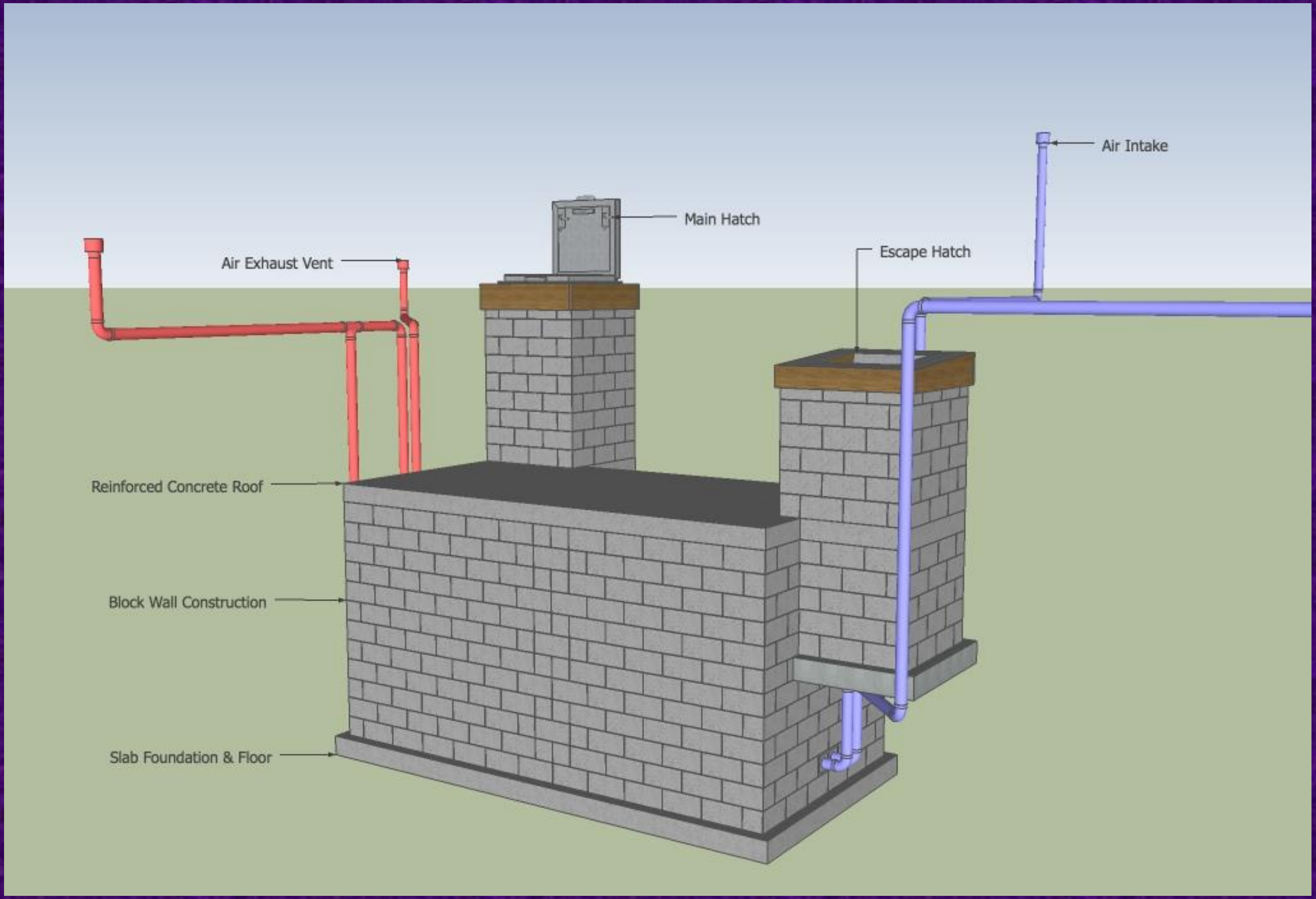
Composite Steel Stud Panels



Blast resistant façade to resist specific blast loads

- Concrete
- Cold-formed steel studs
- FRP

Typical shelter



Limitations

- It is **not practical** to design buildings to withstand any conceivable terrorist attack.
- It is **possible to improve the performance** of structures should one occur in the form of an external explosion.
- continuous process to ensure that appropriate threat conditions and levels of protection are being incorporated

Role of Blast Consultant

- Need to be involved in the early stages of the project
  - *Incorporate blast resistance in the structural system*
  - *Since blastloads typically controls, best to allow blast design to proceed first, then check for service loads*
  - *Far more efficient than upgrading a building after it is built*
- Assist in developing the system, not just the structure
  - *Value of trade-offs*
    - E.g., longer distance from operator shelter to process unit
    - Lower blast loads
    - More time spent walking to/from shelter
- *Assist client in prioritizing objectives*
- *Assist in selecting design threat, acceptable damage level*

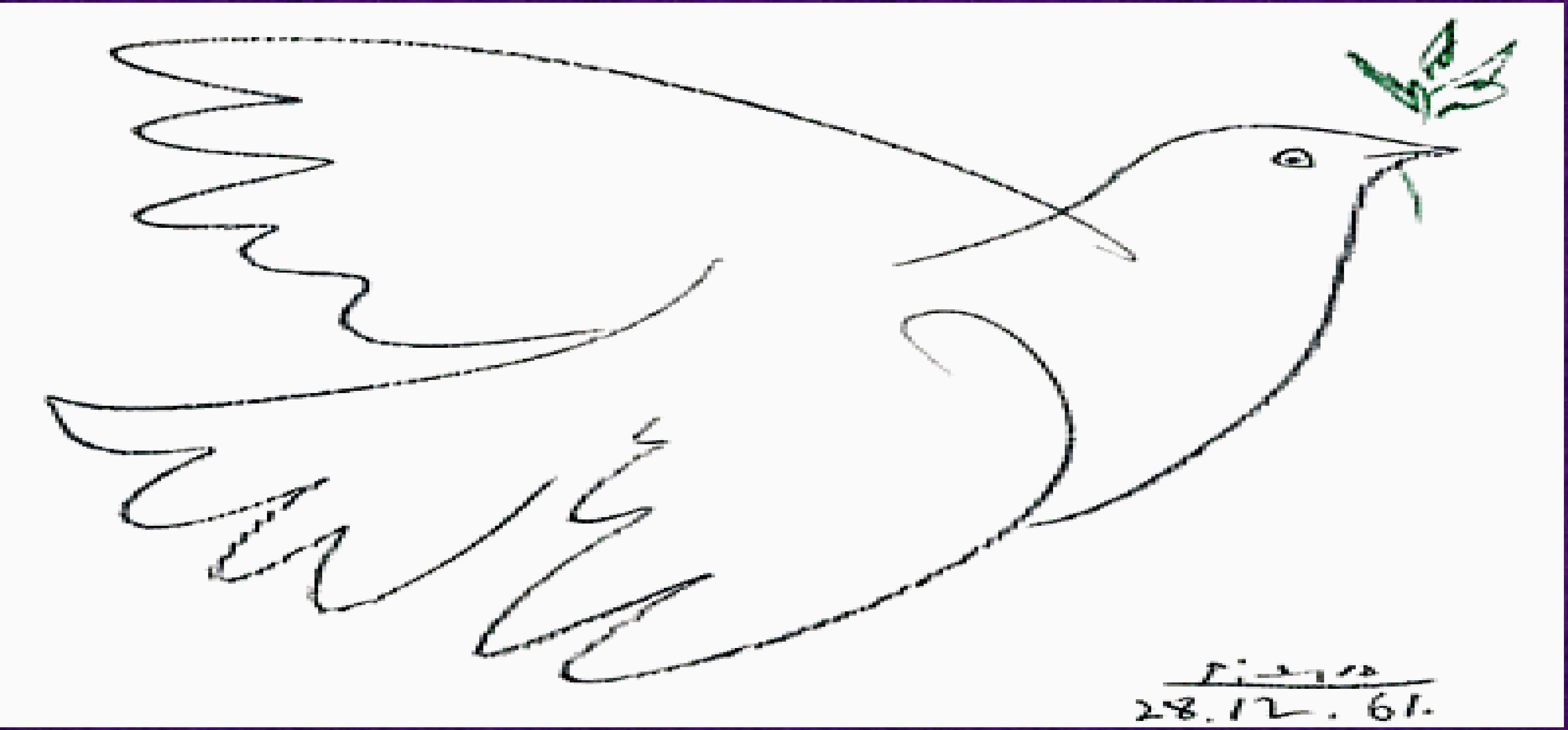
Addressing Risk through awareness

- Because people are notoriously unwilling or unable to state specifically what level of risk they will accept, the engineering community does this by default in the design process.
- But this is not an issue for the engineer alone to solve. It needs to be elevated to a high level of public discourse.
- This is particularly true for the private sector. Protecting Buildings From Bomb Damage found that financial considerations were a serious barrier to the deployment of blast-resistant practices in commercial structures.

Security Vs Personal Freedom

- In an open, democratic society, there is inevitable friction between security needs and personal freedom.
- In the built environment, these conflicts often manifest themselves in the design and accessibility of our public buildings.
- Unfortunately, the state of the world requires that a prudent balance be struck between free and open access on the one hand, and security-driven fortresses on the other.
- Finding technical solutions to combat terrorism is a constant process of one up man ship between terrorists and Security Agencies including Engineers.

Lets defeat the Terrorist without resorting to violence



THANK YOU

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