Unit IX
Building Design Guidance

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Unit Objectives

Explain architectural considerations to mitigate impacts from blast effects and transmission of chemical, biological, and radiological agents from exterior and interior incidents.

Identify key elements of building structural and non-structural systems for mitigation of blast effects.

Compare and contrast the benefit of building envelope, mechanical system, electrical system, fire protection system, and communication system mitigation measures, including synergies and conflicts.

Apply these concepts to an existing building or building conceptual design and identify mitigation measures needed to reduce vulnerabilities.

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Overview

Architectural

Building Structural and Nonstructural Considerations

Building Envelope Considerations

Other Building Systems

Building Mitigation Measures

Activity

References

FEMA Building Vulnerability Assessment Checklist, Chapter 1, page 1-46, FEMA 426

Building Design Guidance, Chapter 3, FEMA 426

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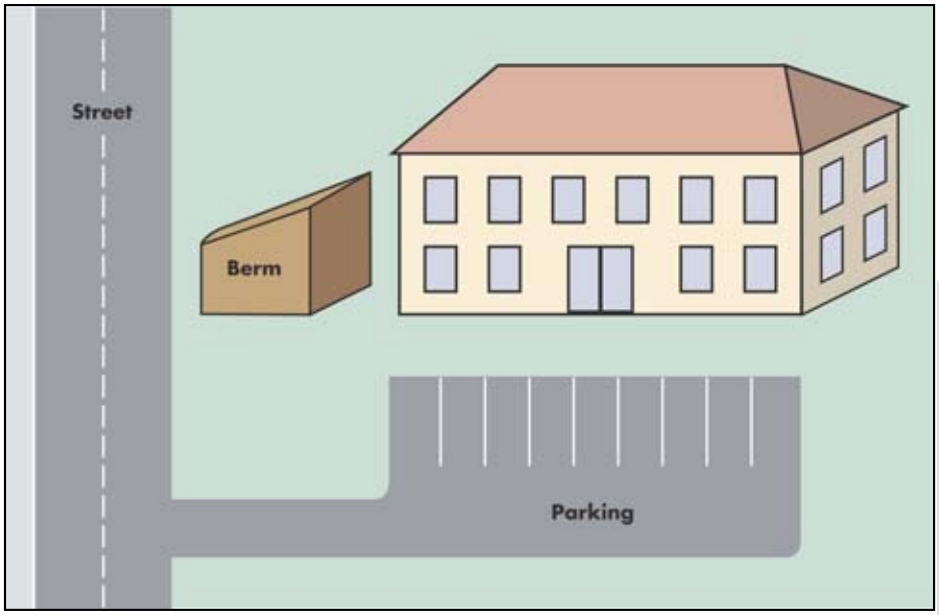
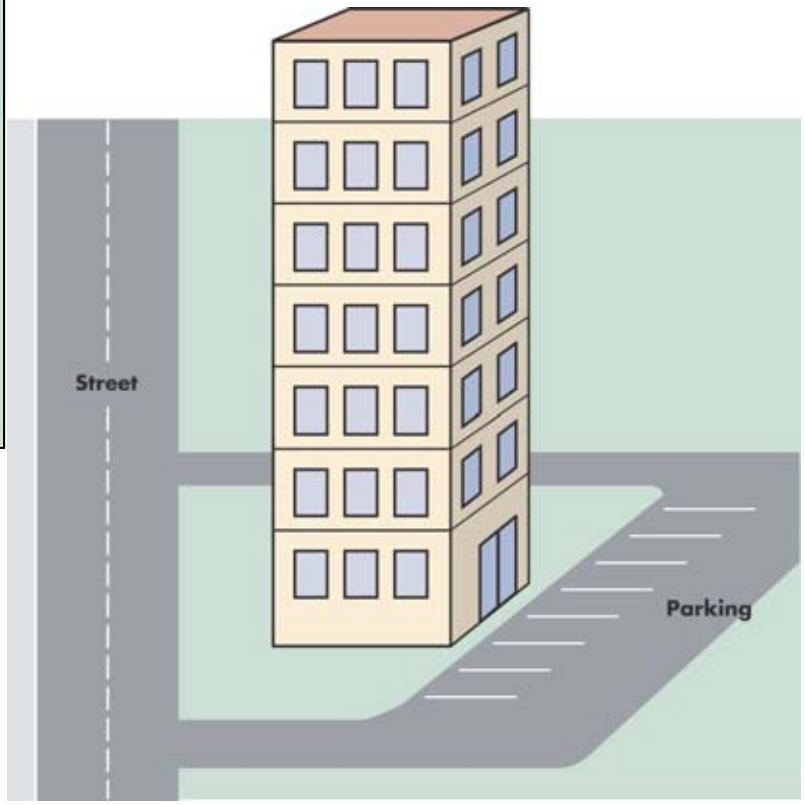
Architectural Building Configuration



Low, Large Footprint

Tall, Small Footprint



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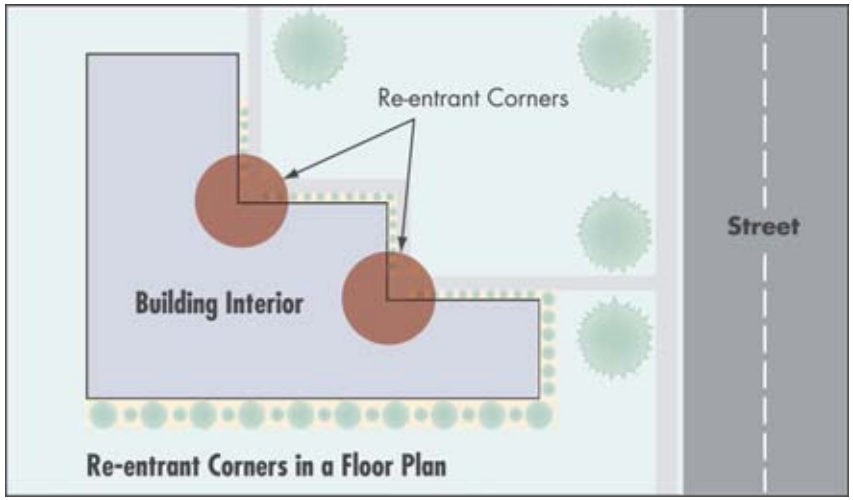
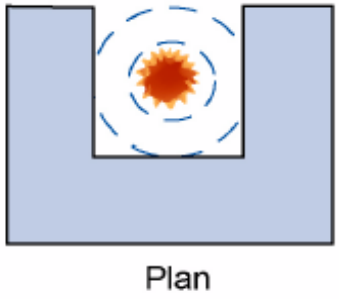
Architectural Building Configuration

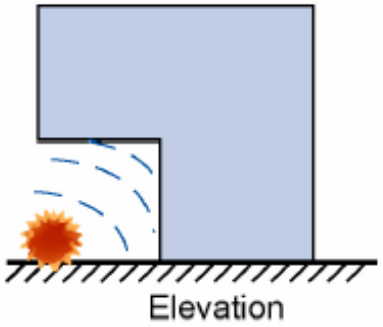
Rectangular versus "U", "L" or "E"

Avoid re-entrant corners

Flush face versus eaves and overhangs







Shapes That Accentuate Blast

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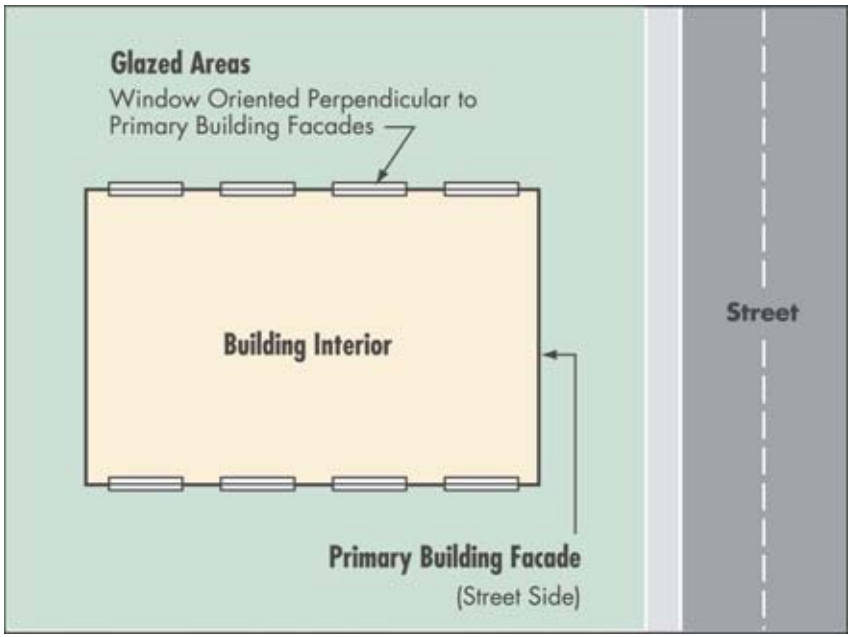
Architectural Building Configuration

Ground floor elevation 4 feet above grade

Orient glazing perpendicular

Avoid exposed structural elements

Pitched roofs and pitched window sills



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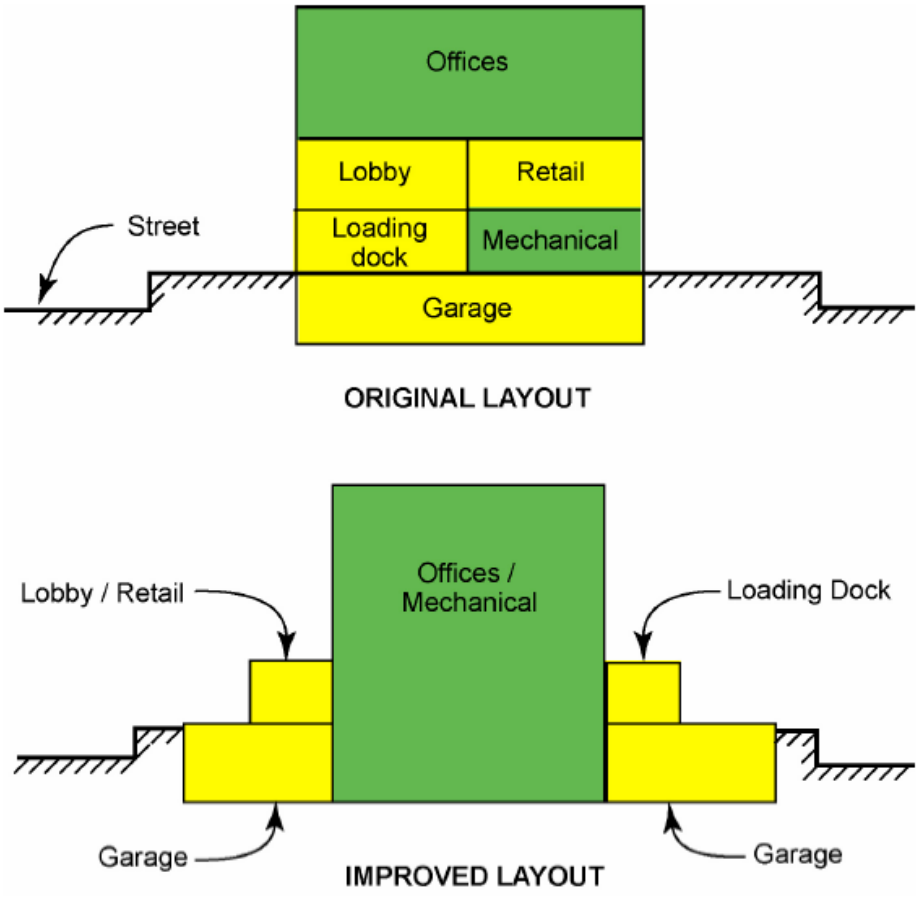
Architectural – Space Design (1)

Place unsecured or high risk areas outside building footprint

Do not mix high risk and low risk tenants in same building

Locate critical assets into interior of building

Separate areas of high visitc activity (unsecured) from critical assets



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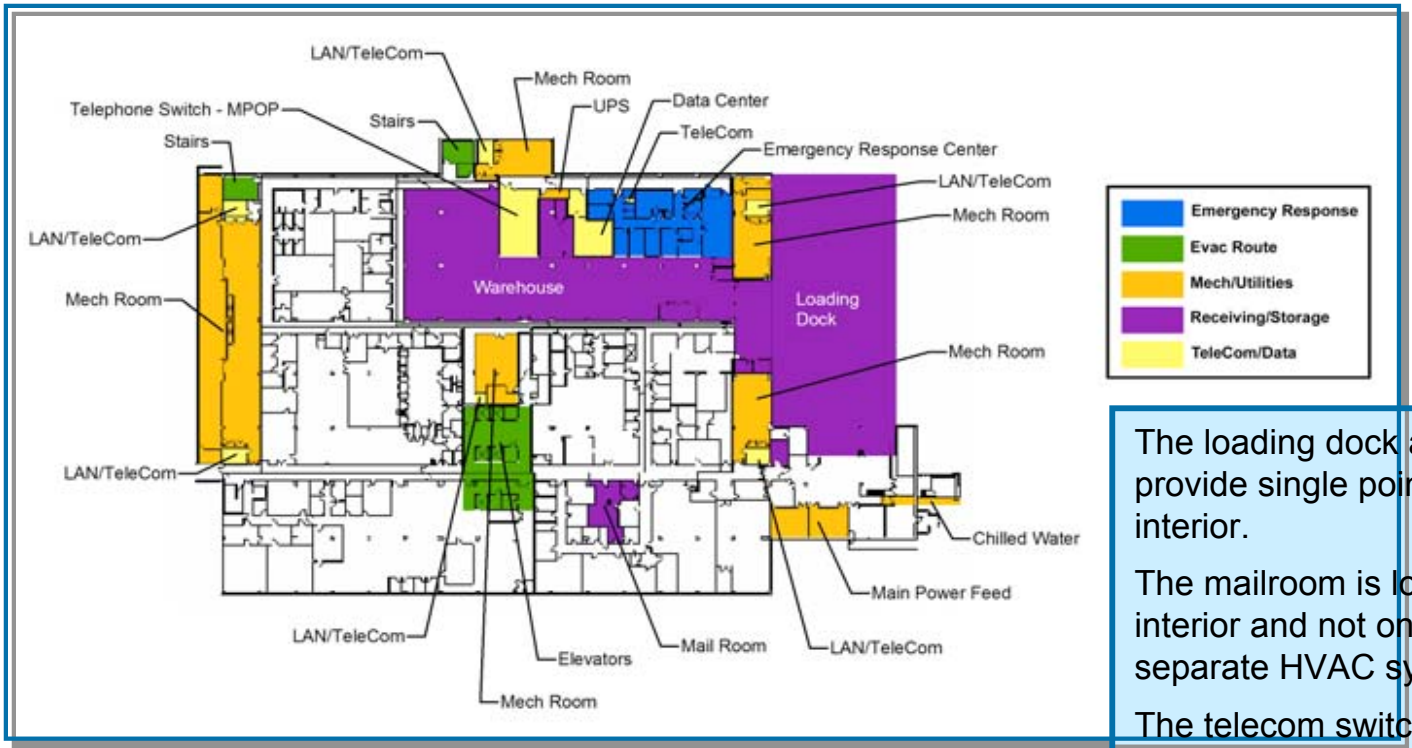
Architectural – Space Design (2)



The loading dock and warehouse provide single point of entry to the interior.

The mailroom is located within the interior and not on exterior wall or separate HVAC system.

The telecom switch and computer data center are adjacent to the warehouse.

The trash dumpster and emergency generator are located adjacent to the loading dock.

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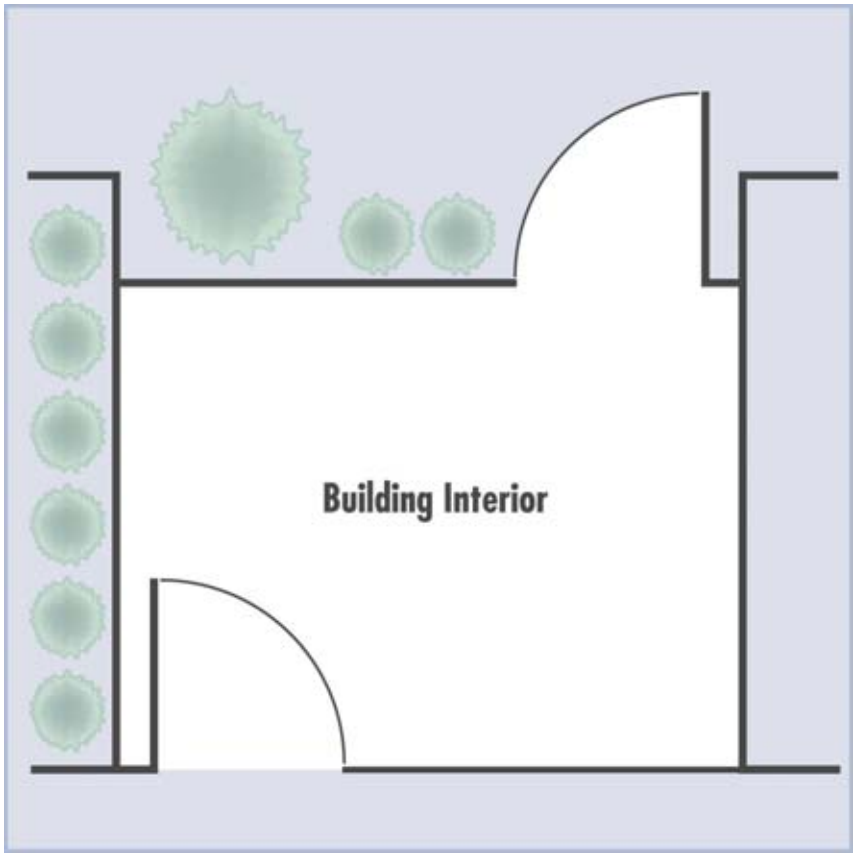
Architectural – Space Design (3)

Eliminate hiding places

Interior barriers

Offset doorways

Minimize glazing, particularly interior glazing near high-risk areas



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Architectural – Other Design Elements

Safe havens

Office locations

Mixed occupancies

Public toilets and service areas

Retail uses in the lobby

Stairwells

Mailroom

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Progressive Collapse Design

GSA Progressive Collapse Analysis and Design Guidance for New Federal Office Buildings and Major Modernization Projects

DoD Unified Facilities Criteria - Minimum Antiterrorism Standards for Buildings

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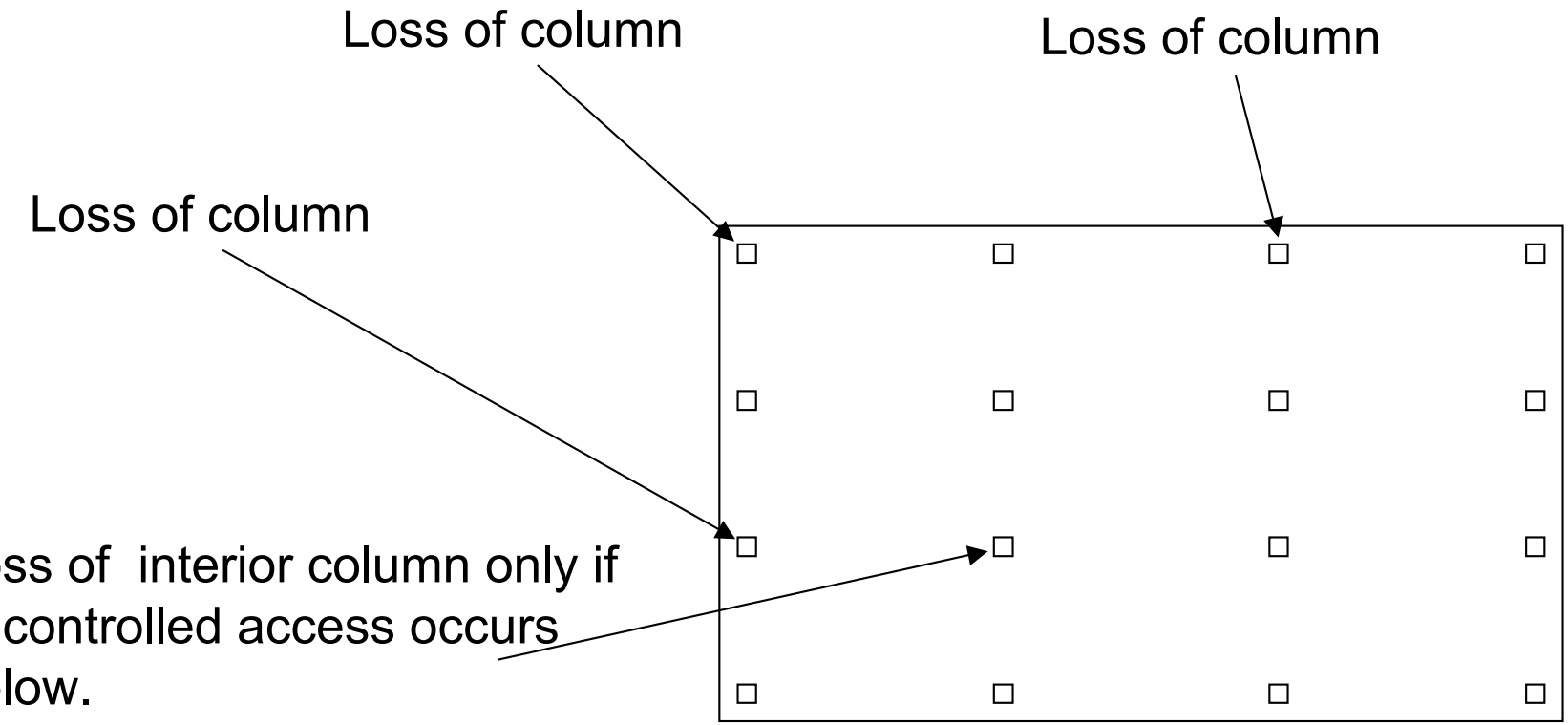
Progressive Collapse Concept



BUILDING PLAN

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Structural Systems - Collapse

GSA and DoD criteria do not provide specific guidance for an engineering structural response model.

Owner and design team should decide how much progressive collapse analysis and mitigation to incorporate into design.

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Nonstructural Elements

Overhead architectural features, utilities, and other fixtures > 14 kilograms (31 pounds)

- Mount to resist forces 0.5 x W in any direction and 1.5 x W in downward direction (DoD Unified Facilities Criteria)
- Plus any seismic requirements

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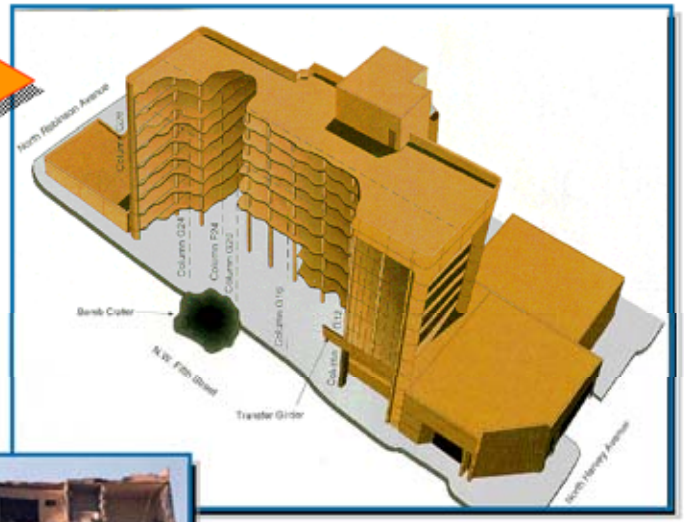
Loads and Stresses - Collapse

Ronan Point, London

Murrah Federal Building, Oklahoma City



Khobar Towers, Dhahran

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Good Engineering Guidelines (1)

Consider incorporating internal damping into the structural system.

Use of symmetric reinforcement.

Use wire mesh in plaster.

Use multiple barrier materials and construction techniques.

Recognize that components might act in opposite directions than designed.

Lap splices and other discontinuities should be staggered and should fully develop the reinforcement capacity.

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Good Engineering Guidelines (2)

Column spacing should be minimized.

Floor to floor heights should be minimized, less than or equal to 16 feet.

Use fully grouted and reinforced construction when CMU is selected.

Use one-way wall elements spanning from floor-to-floor.

Use ductile detailing requirements for seismic design when possible.

Use architectural features that provide a minimum of 6 inches from primary vertical load carrying members.

Deflections around certain members, such as windows, should be controlled to prevent premature failure.

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Building Materials: General Guidance

Generally speaking:

All building materials and types acceptable under model building codes are allowed.

Special consideration should be given to materials that have inherent flexibility and that are better able to respond to load reversals.

Careful detailing is required for material such as pre-stressed concrete, pre-cast concrete, and masonry to adequately respond to the design loads.

The construction type selected must meet all performance criteria of the specified level of protection.

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Building Envelope

During an actual blast or CBR event, the building envelope becomes the first layer of defense to protect the people inside:

- Walls
- Windows
- Doors
- Roofs

Soil can be highly effective in reducing damage during an explosive event

Minimize “ornamentation” that may become flying debris in an explosion.

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Building Envelope-Walls (1)

Exterior walls should resist the actual pressures and impulses acting on the exterior wall surfaces from the threats defined for the facility.

Exterior walls should be capable of withstanding the dynamic reactions from the windows.

Beyond ensuring a flexible failure mode, design the exterior wall to resist the pressure levels of the design threat.

As desired Level of Protection increases, additional mass and reinforcement may be required.

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Building Envelope – Windows (1)

Balanced Window Design

Glass strength

Glass connection to window frame (bite)

Frame strength

Frame anchoring to building

Frame and building interaction

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Building Envelope – Windows (2)

Glass (weakest to strongest)

- Annealed (shards)
- Heat Strengthened (shards)
- Fully Tempered (pellets)
- Laminated (large pieces)
- Polycarbonate (bullet-resistant)

"Balanced Design"

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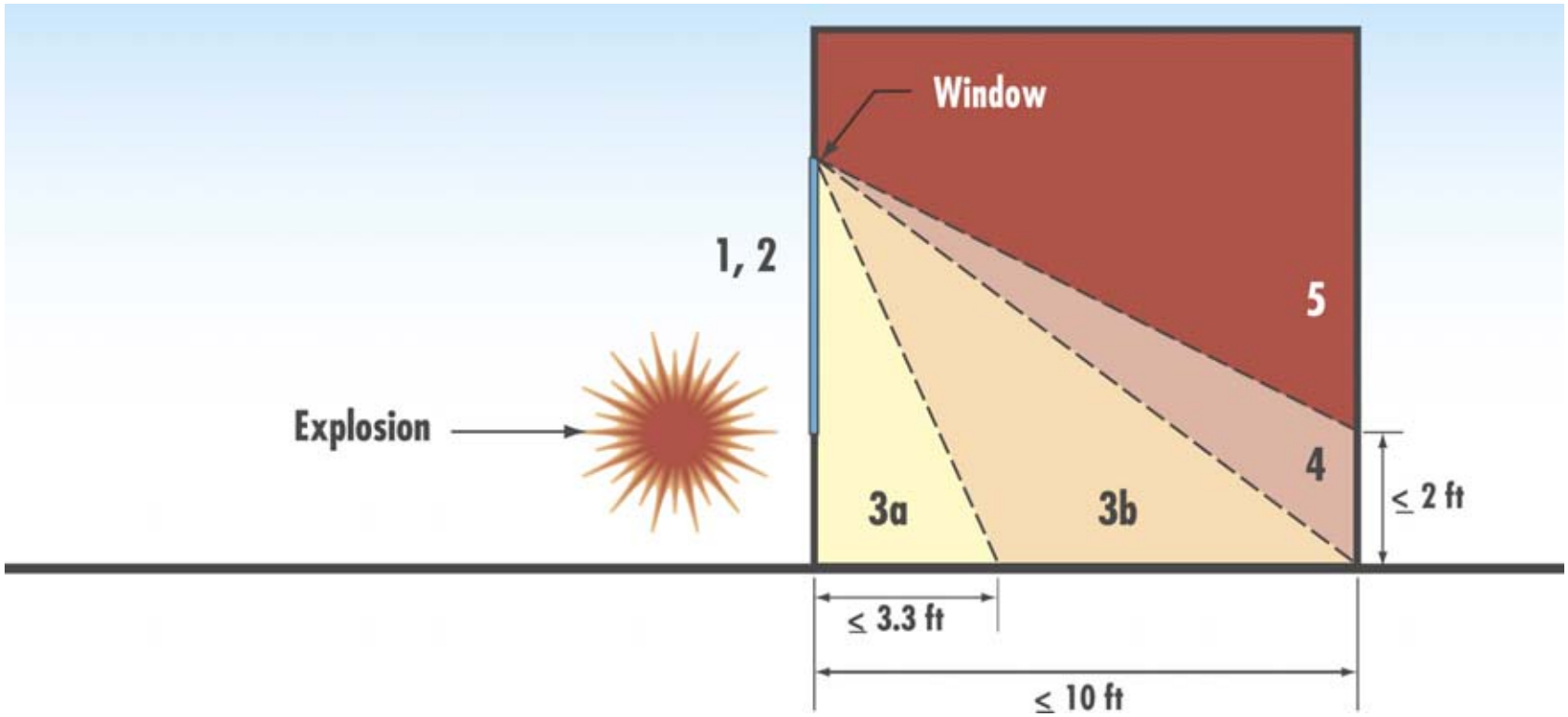
GSA Glazing Performance Conditions



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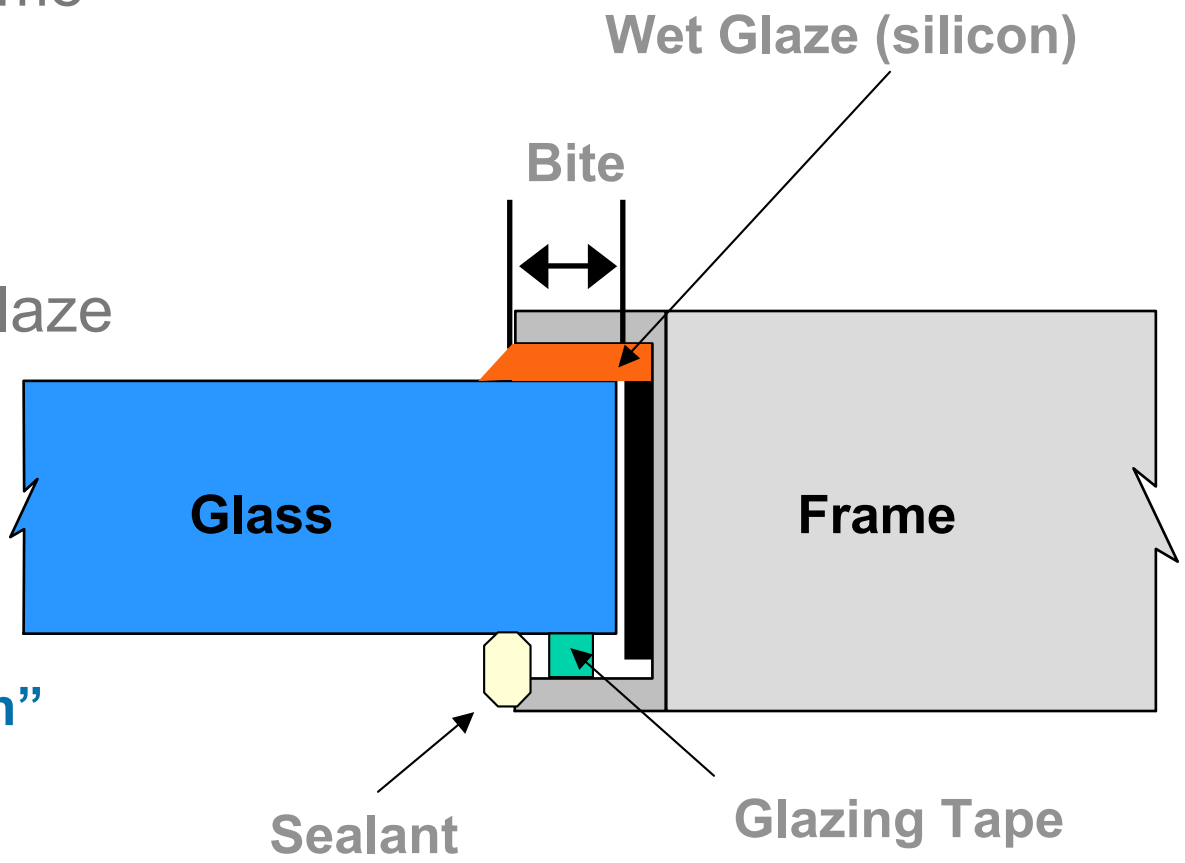
Window Frames (1)

Goal: transfer the load from the glass to the frame and retain glass in the frame

Bite: _ inch minimum

Structural sealant:
_ inch bead or wet glaze



"Balanced Design"

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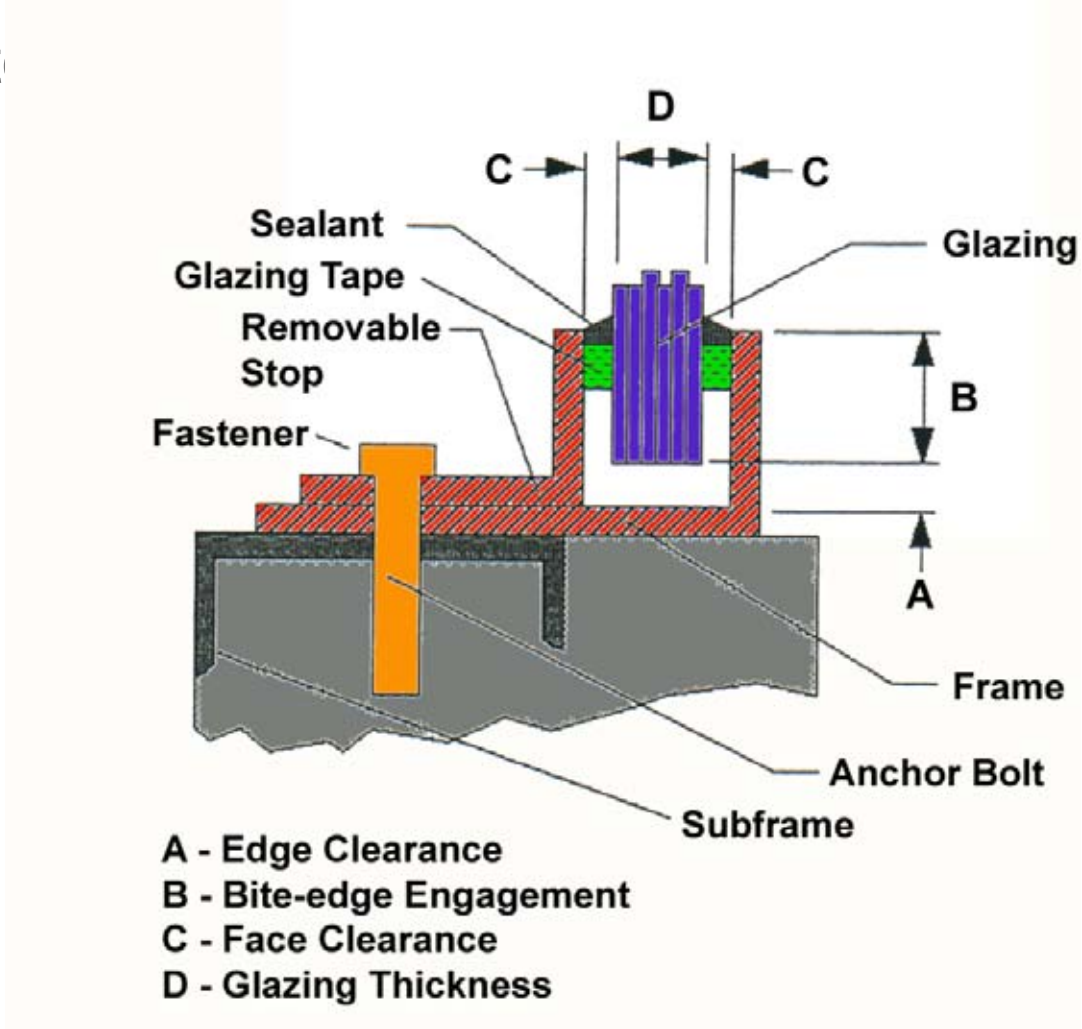
Window Frames (2)

Goal: transfer the load t

Balanced strength:
glass, frame,
and connection
of frame to the wall

"Balanced Design"



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Fragment Retention Film (1)

Clear tough polyester film attached to the inside of a glass surface with strong pressure-sensitive adhesive.

Also known as shatter-resistant film, safety film, or protective film.

Relatively low installation costs.

Level of protection varies with thickness of film and method of installation.

Limited life.

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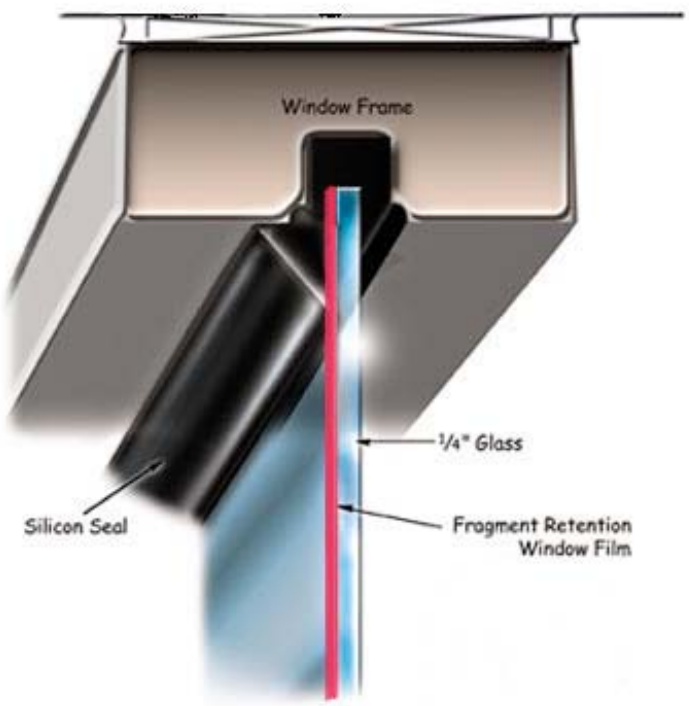
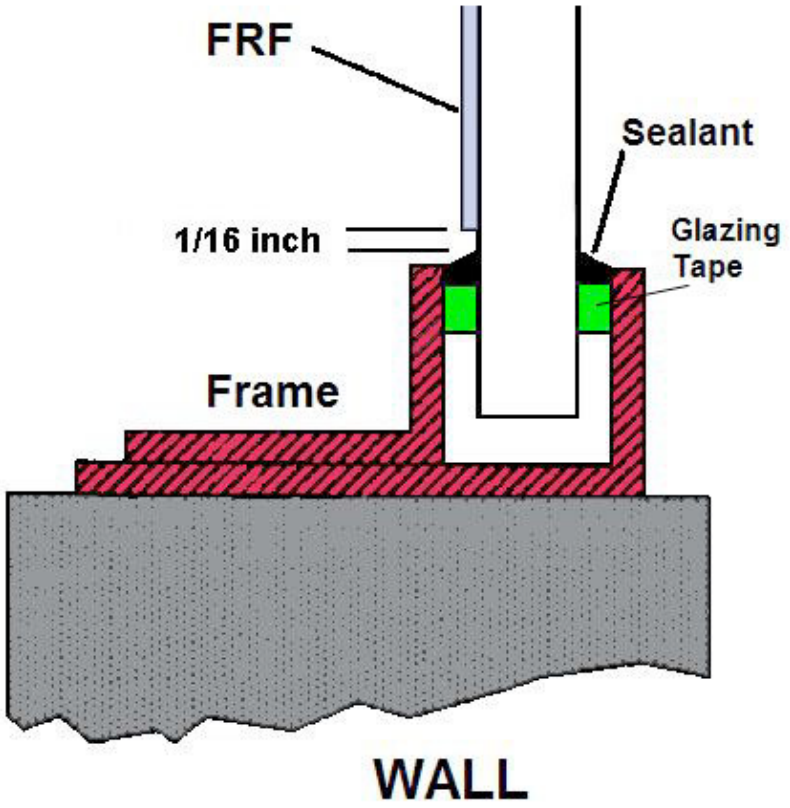
FRF (2)



"Wet Glazing" (edge to edge)



"Daylight Application"

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Blast Curtains

Invented by the British during WW II

Kevlar curtains

Allow venting of the blast wave while “catching” fragments

May be augmented with FRF

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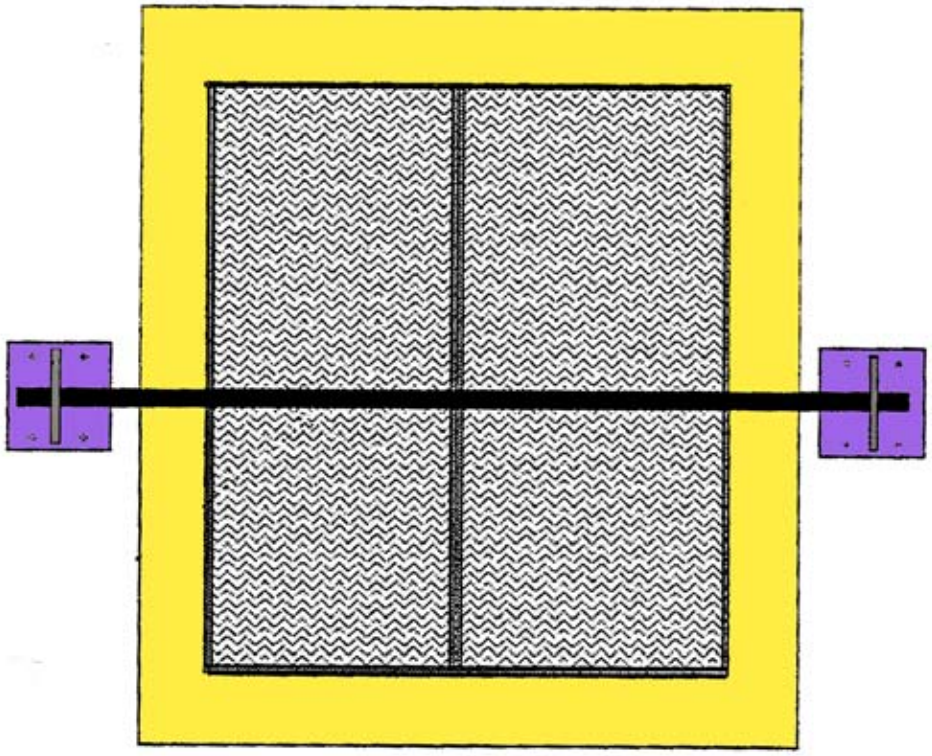
Catch Bar

Must be centered on window.

FRF must be thick enough to hold the fragments (≥ 7 mil).

Plan View



Building Envelope – Good Window Practice

No windows adjacent to doors.

Minimize number and size of windows.

DoD requires laminated glass for high-occupancy buildings.

Stationary, non-operating windows, but operable window may be needed by code.

Steel versus aluminum window framing.

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Building Envelope – Doors

Balanced strength

- Door
- Frame
- Anchorage to building

Hollow steel doors or steel-clad doors

Steel door frames

Blast-resistant doors available

- Generally heavy
- Generally expensive

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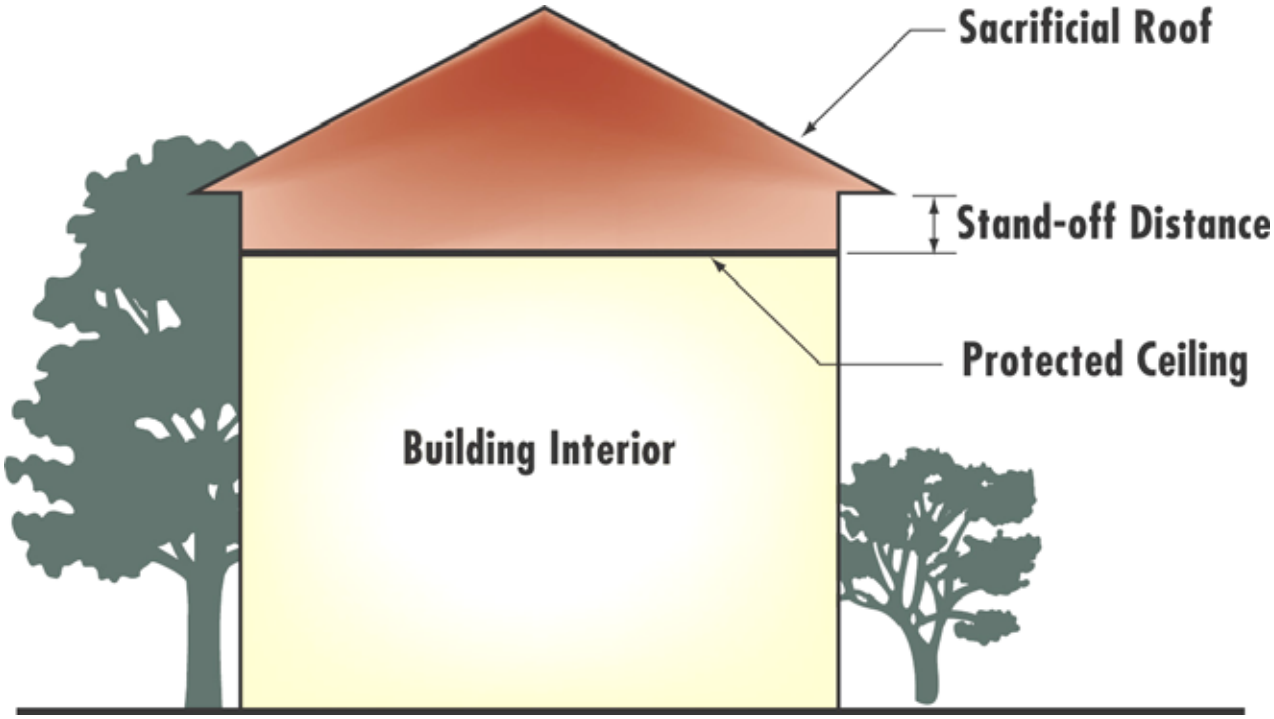
Building Envelope – Roofs

Preferred – poured in place reinforced concrete

Lower protection – steel framing with concrete and metal deck slab

Sloped sacrificial roof over protective roof/ceiling

Restrict access to roof



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Mechanical Systems (1)

Functional layout – physical separation or hardening

Structural layout – systems installation

Do not mount utility equipment or fixtures on exterior walls or mailrooms

Avoid hanging utility equipment and fixtures from roof slab or ceiling

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Mechanical Systems (2)

Restrict Access

- Rooms
- Closets
- Roofs
- Building information
- Also consider for other systems

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Ventilation and Filtration

Evaluate HVAC Control Options (Building Specific)

- System shutdown
- Zone pressurization
- Air purge (e.g., 100 percent OA if internal release)
- Specialized exhaust for some areas
- Pressurized egress routes (may already exist)
- Procedures and training incorporated into building's emergency response plan

Emergency Plans

Site lighting

Emergency lighting

Duress alarms

Internal mass notification system

Secure dedicated telephone lines between critical security functions

Redundant communications

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Maintenance, Administration, and Training (1)

HVAC Maintenance Staff Training

- System upgrades will require new training.

Preventive Maintenance and Procedures

- Maintenance is critical to keep protective systems operational.
- Regularly test strategic equipment.

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Maintenance, Administration, and Training (2)

Emergency response plans, policies, procedures

- All buildings should have current emergency plans.
- Incorporate CBR scenarios into plans.
- Coordinate with local emergency response personnel.
- Train and rehearse.
- Detail communication capabilities.
  - Upgrade as necessary.
  - Will likely need specific instructions for CBR event.

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Building Electrical Systems

Normal power location

Emergency power location

Site lighting and CCTV compatibility

Backups

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Fire Protection Systems

Single-point failure

Dual pumps

Dual pumps at different locations

Security locks comply with NFPA code

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Communications Systems

Redundant communications

Radio telemetry

Alarm and information systems

Empty conduits

Mass notification

Electronic Security Systems

The purpose of electronic security is to improve the reliability and effectiveness of life safety systems, security systems, and building functions.

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Entry Control Stations

Holding area for unauthorized vehicles or those needing further inspection.

Control measures such as displaying a decal.

Proper lighting for entry-control stations that are manned 24 hours each day.

Signs should be erected to assist in controlling authorized entry.

Entry control stations should be hardened against attacks.

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Practical Applications

What can be done with a reasonable level of effort?

End of Chapter 3, FEMA 426 listing of

- Less protection, less cost, and less effort
- Greater protection, greater cost, at greater effort

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Desired Building Protection Level

Component design based on:

Design Basis Threat

Threat Independent approach

Level of Protection sought

Leverage natural hazards design/retrofit

Incorporate security design as part of normal capital or O&M program

Use existing tools/techniques, but augment with new standards/guidelines/codes

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Summary

Building Design Guidance and Mitigation Options

Using the FEMA 426 Checklist will help identify vulnerabilities and provide recommended mitigation options.

There are many methods to mitigate each vulnerability.

Relatively low cost mitigations significantly reduce risk.

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Unit IX Case Study Activity

Building Design Guidance and Mitigation Measures

Background

Emphasis:

- Providing a balanced building envelope that is a defensive layer against the terrorist tactic of interest
- Avoiding situations where one incident affects more than one building system

FEMA 426, Building Vulnerability Assessment Checklist

Requirements

Assign sections of the checklist to qualified group members

Refer to HIC case study, and answer worksheet questions

Review results to identify vulnerabilities and possible mitigation measures

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