Unit X (C)

COURSE TITLE

Building Design for Homeland Security for Continuity of Operations (COOP) Train-the-Trainer

TIME 165 minutes

UNIT TITLE

Building Design Guidance

OBJECTIVES

1. Explain architectural considerations to mitigate impacts from blast effects and transmission of chemical, biological, and radiological agents from exterior and interior incidents.
2. Identify key elements of building structural and nonstructural systems for mitigation of blast effects.
3. Compare and contrast the benefit of building envelope, mechanical system, electrical system, fire protection system, and communications system mitigation measures, including synergies and conflicts.
4. Apply these concepts to an existing building or building conceptual design and identify mitigation measures needed to reduce vulnerabilities.

SCOPE

The following topics will be covered in this unit:

1. Architectural considerations, including building configuration, space design, and special situations.
2. Building structural and nonstructural considerations with emphasis on progressive collapse, loads and stresses, and good engineering practices.
3. Design issues for the building envelope, including wall design, window design, door design, and roof system design with approaches to define levels of protection.
4. Mechanical system design issues, including interfacing with operational procedures, emergency plans, and training.
5. Other building systems design consideration for electrical, fire protection, communications, electronic security, entry control, and physical security that mitigate the effects of a threat or hazard.
6. Activity: Select mitigation measures that reduce vulnerability and associated risk from the building perspective for the highest risk pairs (asset - threat/hazard) identified in Unit V.

REFERENCES

1. FEMA 426, *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings*, pages 3-1 to 3-46 and 3-48 to 3-52; Checklist at end of Chapter 1
2. FEMA 427, *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks*
3. FEMA 430, *Site and Urban Design for Security*
4. FEMA 452, *Risk Assessment: A How-To Guide to Mitigate Potential Terrorist Attacks Against Buildings*, pages 5-1 to 5-16
5. FEMA 453, *Design Guidance for Shelters and Safe Rooms*
6. Case Study – Appendix C: COOP, Cooperville Information / Business Center
7. Student Manual, Unit X (C) (info only – not listed in SM)
8. Unit X (C) visuals (info only – not listed in SM)

REQUIREMENTS

1. FEMA 426, Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings (one per student)
2. FEMA 452, Risk Assessment: A How-To Guide to Mitigate Potential Terrorist Attacks Against Buildings (one per student)
3. Instructor Guides, Unit X (C)
4. Student Manual, COOP Case Study (C) (one per student)
5. Overhead projector or computer display unit
6. Unit X (C) visuals
7. Risk Matrix poster and box of dry-erase markers (one per team)
8. Chart paper, easel, and markers (one per team)

UNIT X (C) OUTLINE

8. Fire Alarm Systems	1.5 minutes	IG-X-C-49
9. Communications – Information Technology Systems	3 minutes	IG-X-C-50
10. Equipment Operations and Maintenance	3 minutes	IG-X-C-52
11. Security Systems	4.5 minutes	IG-X-C-54
12. Practical Applications	1.5 minutes	IG-X-C-58
13. Building Materials: General Guidance	1.5 minutes	IG-X-C-58
14. Desired Building Protection Level	1.5 minutes	IG-X-C-59
15. Summary/Activity/Transition	3.0 minutes	IG-X-C-60
16. Student Activity: Building Design Guidance (Version **(C) COOP**) [45 minutes for students, 15 minutes for review]	60 minutes	IG X-C-62

PREPARING TO TEACH THIS UNIT

- **Tailoring Content to the Local Area:** This is a generic instruction unit, but it has great capability for linking to the Local Area. Local Area discussion may be generated as students have specific situations for which they would like to determine vulnerabilities or vulnerability rating prompted by points brought up in the presentation.
- **Optional Activity:** There are no optional activities in this unit. However if the Group Roundtable / Plenary / Discussion session is held after Unit IX, then the student activities for Units IX and X will be accomplished after the Unit X presentation.
- **Activity:** The students will continue familiarizing themselves with the Case Study materials. The Case Study is a risk assessment and analysis of mitigation options and strategies for an alternate facility to be assessed for potential Continuity of Operations (COOP). This alternate facility is a typical commercial office building located in a suburban business park. The assessment uses the DoD Antiterrorism Standards and the GSA Interagency Security Criteria to determine Levels of Protection and identify specific vulnerabilities. Mitigation options and strategies will use the concepts provided in **FEMA 426** and other reference materials.
- Refer students to their Student Manuals for worksheets and activities.
- Direct students to the appropriate page (Unit #) in the Student Manual.
- Instruct the students to read the activity instructions found in the Student Manual.

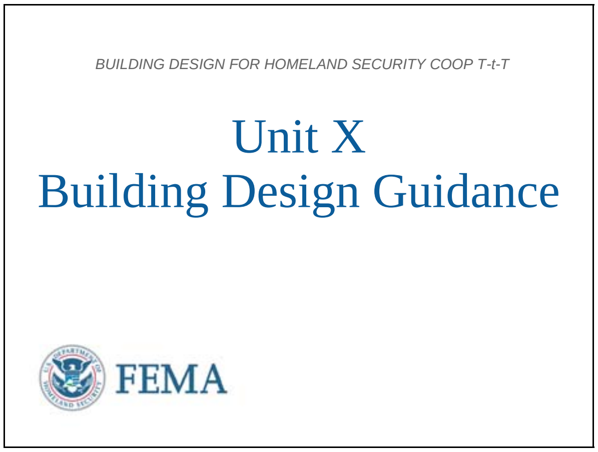
- "Walk through" the pages of the activity with the students, describing the steps followed to obtain the answers in the completed examples, and what is expected of the groups for this activity.
- For this activity, the assessment of the site and layout of the building in greater depth may result in the group adjusting the Risk Matrix scores for vulnerability rating, with resultant changes to risk rating. Transfer these changes to the Risk Matrix poster.
- Tell students how long they have to work on the requirements.
- While students are working, <u>all</u> instructors should closely observe the groups' process and progress. If any groups are struggling, immediately assist them by clarifying the assignment and providing as much help as is necessary for the groups to complete the requirement in the allotted time. Also, monitor each group for full participation of all members. For example, ask any student who is not fully engaged a question that requires his/her viewpoint to be presented to the group.
- At the end of the working period, reconvene the class.
- After the students have completed the assignment, "walk through" the activity with the students during the plenary session. Call on different teams to provide the answer(s) for each checklist section of questions, in summary fashion or select representative questions in each section as the starting points of discussion. Then simply ask if anyone disagrees. If the answer is correct and no one disagrees, state that the answer is correct and move on to the next requirement. If there is disagreement, allow some discussion of rationale, provide the "school solution" and move on.
- If time is short, simply provide the "school solution" and ask for questions. Do not end the activity without ensuring that students know if their answers are correct or at least on the right track. Note, there are no right or wrong answers, but all answers must be justified with rationale.
- Ask for and answer questions.

<u>Editor Note</u>: Two methods have been used in Instructor Guides to ensure the slide designation and slide thumbnail in the left column aligns with the Content/Activity in the right column.

(1) Highlight row by placing cursor in left column until arrow shifts to right, Tab <Insert>, <Break>, <select Page Break>, <OK>
(2) Highlight row as in (1), right click on highlighted row for menu, <Table Properties>, Tab <Row>, remove check in box <Allow row to break across pages>
(3) Alternate for (2), highlight row, click on <Table> at top of screen, <Table Properties> and continue like (2)

INSTRUCTOR NOTES

VISUAL X-C-1



CONTENT/ACTIVITY

Introduction and Unit Overview

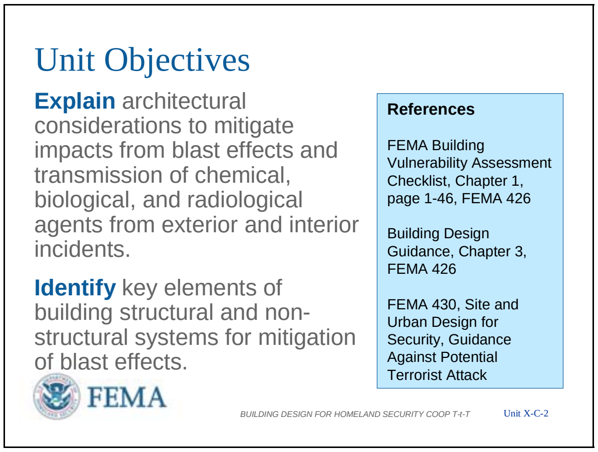
This is Unit X Building Design Guidance. Continuing with our understanding of vulnerability and mitigation measures, we have looked at site and layout concerns and now turn our attention to what considerations are needed in building design to mitigate tactics involving explosive blast or CBR agents.

We will examine design considerations that achieve a balanced building envelope that provides a defensive layer against the given terrorist tactic and avoids creating ripple effects where one incident may affect more than one building system.

Catastrophic collapse of any building is a primary concern. Historically, the majority of fatalities that occur in terrorist attacks directed against buildings are due to building collapse. This was true for the Oklahoma City bombing in 1995 when 87 percent of the building occupants who were killed were in the collapsed portion of the Murrah Federal Building. But glass causes over 80 percent of injuries during bomb blast and there are some low cost techniques to keep CBR agents outside of buildings or to limit their spread inside.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-2



Unit Objectives

At the end of this unit, the students should be able to:

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

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

In addition to FEMA 426, also consult FEMA 430 (future) for additional design concepts.

VISUAL X-C-3

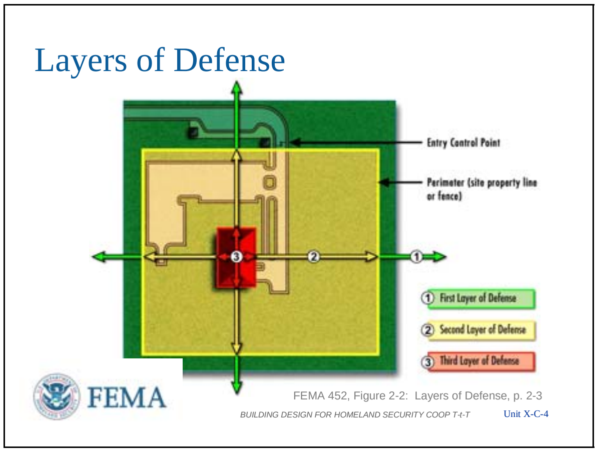
Unit Objectives (continued)

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.

INSTRUCTOR NOTES

VISUAL X-C-4



From FEMA 452

The layers of defense is a traditional approach in security engineering and use concentric circles extending out from an area or site to the building or asset that requires protection. They can be seen as demarcation points for different security strategies. Identifying the layers of defense early in the assessment process will help you to understand better the assets that require protection and determine your mitigation options. Figure 2-2 shows the layers of defense described above.

CONTENT/ACTIVITY

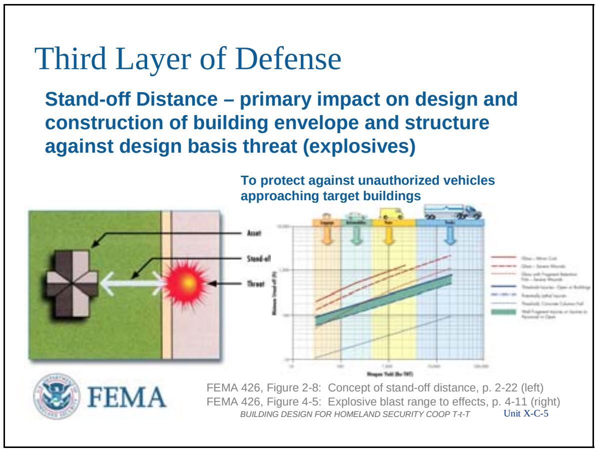
Layers of Defense

The first and second layers were discussed in the previous instruction unit. The Third Layer of Defense is applicable to Building Design – starting at the building drip line, taking into account the complete building envelope, and including any additional considerations found anywhere in the building.

FEMA 452 -- Third Layer of Defense. This deals with the protection of the asset itself. It proposes to harden the structures and systems, incorporate effective HVAC systems and surveillance equipment, and wisely design and locate utilities and mechanical systems. Note that, of all blast mitigation measures, distance is the most effective measure because other measures vary in effectiveness and can be more costly. However, often it is not possible to provide adequate stand-off distance. For example, sidewalks in many urban areas may be less than 10 meters (33 feet), while appropriate stand-off may require a minimum of 25 meters (82 feet). **The building owner has control of this layer and its main mitigation measures are hardening against blast and security sensors/CCTV as final access control.**

INSTRUCTOR NOTES	**CONTENT/ACTIVITY**

VISUAL X-C-5



Third Layer of Defense

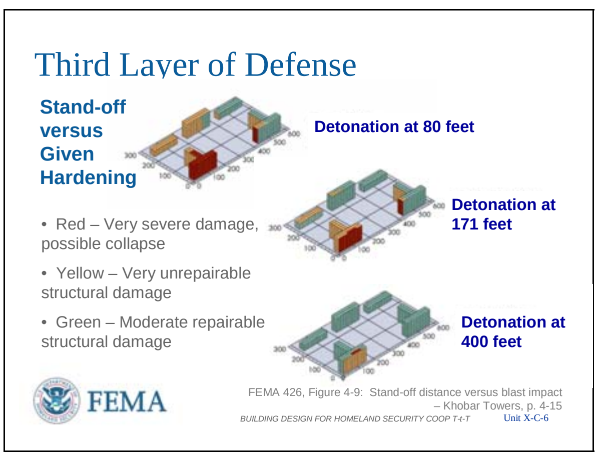
Stand-off Distance versus Hardening of Structures

Of all blast mitigation measures, distance is the most effective measure because other measures vary in effectiveness and can be more costly. However, many times it is not possible to provide adequate stand-off distance.

Desired minimum stand-off in the DoD Unified Facility Criteria (UFC) and used as the initial screening distance in FEMA 426 is 82 feet. However, this may only protect against column collapse for a 250 pound car bomb at 82 feet.

The design basis threat weapon yield and the level of protection desired drive the hardening required for the stand-off distance available.

VISUAL X-C-6



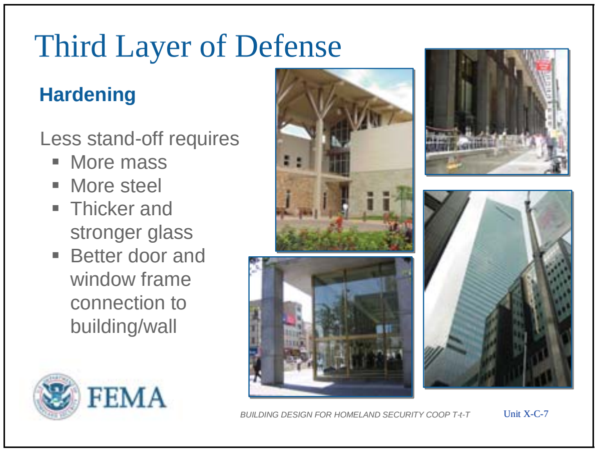
Third Layer of Defense

Stand-off versus Given Hardening

This representation of the estimated damage at Khobar Towers uses the blast modeling software available circa 1997. It shows the front façade of the target building receiving very severe damage when the estimated bomb is at 80 feet. Increasing the stand-off using the same building construction and bomb size shows that the stand-off required to limit damage is 400 feet.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-7



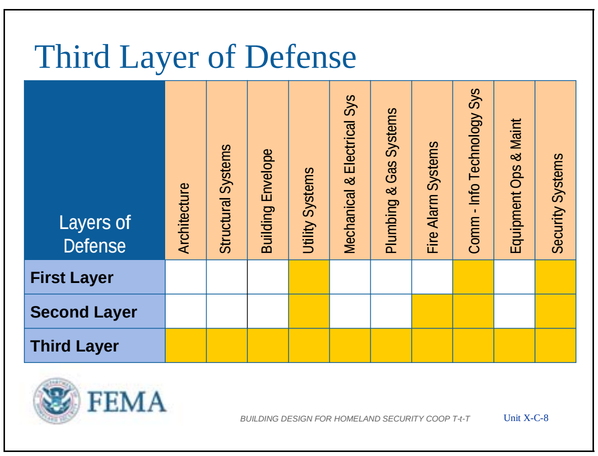
U.S. Embassy: Kampala, Uganda designed to resist explosive blast [upper left – DOS and Hinman]. Other three photos are from New York City indicating glass and overhang (poor) [lower left], similar glass and overhang (poor) but with wall (better) [upper right], and window curtain wall (usually poor) [lower right].

Third Layer of Defense
Hardening

Less stand-off requires more mass and more steel for hardening, thicker and stronger glass, and better window frame connection to the building/wall. However, this should be done in concert with good architecture design and aesthetics principles. As you can see, the other photos show architectural treatments that increase blast damage – overhangs and much glass.

Note that 82 feet of stand-off allows use of conventional construction with minimal upgrades when used in conjunction with a controlled perimeter that detects larger bombs prior to getting anywhere near the building.

VISUAL X-C-8



Third Layer of Defense

The third layer of defense deals with the protection of the asset itself. The column headings include key elements of protection and the row headings includes the three layers of defense. The matrix allows designers to consider different methods of protection and when they could be used. For the third layer of defense, designers should go through each system to take appropriate mitigation measures for an existing building or provide increased hardening when designing a building.

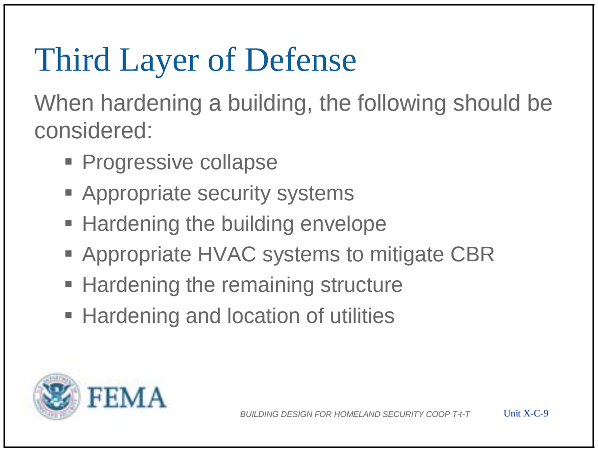
Note that one mitigation measure may reduce the risk of more than one asset-threat/hazard pair of interest as illustrated by **Table 2-1, page 2-54, of FEMA 426**, where a mitigation measure may apply to multiple tactics. On

The rest of this instruction unit will follow along the column headings in the order shown. This is the same order as found in the Building Vulnerability Checklist at the end of Chapter 1 of FEMA 426.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

the other hand, a mitigation measure against one tactic may increase the vulnerability to other tactics.

VISUAL X-C-9



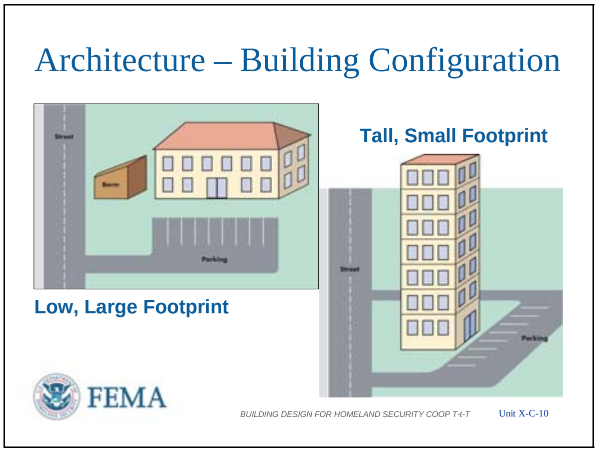
Third Layer of Defense

Hardening Considerations:

- Progressive collapse
  This should be the first consideration as most deaths result from building collapse and life safety seeks to ensure safe evacuation of a building during or after any incident. Structural framing and load-bearing components are the concern here.
- Appropriate security systems
  For an existing building the addition of security systems to deter, detect, and deny the building needs to be done whether or not building hardening can be done.
- Hardening the building envelope
  After progressive collapse, hardening the building envelope provides the most protection against injury during blast events and aligns with building tightness considerations for exterior CBR releases.
- Appropriate HVAC systems to mitigate against CBR
  Next the control of HVAC operation for exterior and interior CBR releases should be considered based upon the complexity of the existing or designed system.
- Hardening the structure
  After progressive collapse and hardening the building envelope, hardening the rest of the structural/nonstructural components to reduce injury should be considered.
- Hardening and location of utilities
  This might be the most expensive to do with an existing building, but should be fully implemented in a new building design. Accessible, aboveground utilities should receive first consideration for hardening.

INSTRUCTOR NOTES

VISUAL X-C-10



CONTENT/ACTIVITY

Architecture – Building Configuration

Designers should balance a number of relevant considerations to the extent that site, economic, and other factors allow.

Some of the relevant considerations include the following:

- The shape of the building
  - Low, large footprint buildings
  - Tall, small footprint buildings

General benefits of the two basic approaches:

Low, Large Footprint:

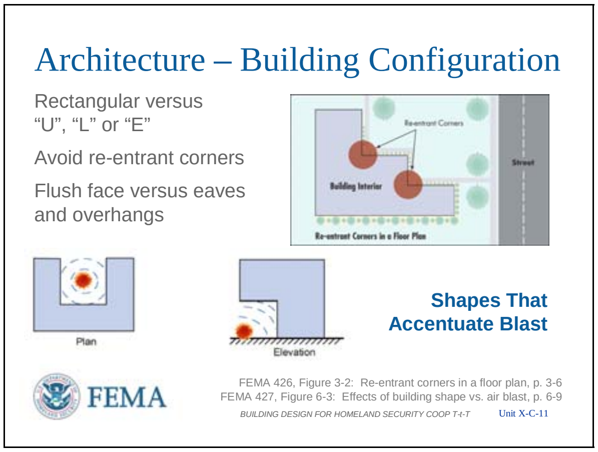
- Reduced effect of explosive blast (catches less of the blast wave) – Dispersed and blast wave rolls over the top.
- Reduced effect of progressive collapse (less of the building can fall) – Due to less structural members impacted.
- Reduced surveillance or easier mitigation (lower height allows terrain and landscaping options)
- Better energy conservation (green roof potential and earth-sheltered design – earth berm reduces energy loss and directs blast wave over the building if the berm is as high as the building)

Tall, Small Footprint:

- Reduced blast effects on upper floors
- Air intakes better protected against CBR events
- Site runoff reduced, reducing culvert size as a covert entry point
- More parking space that meets local planning commission/building code

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-11

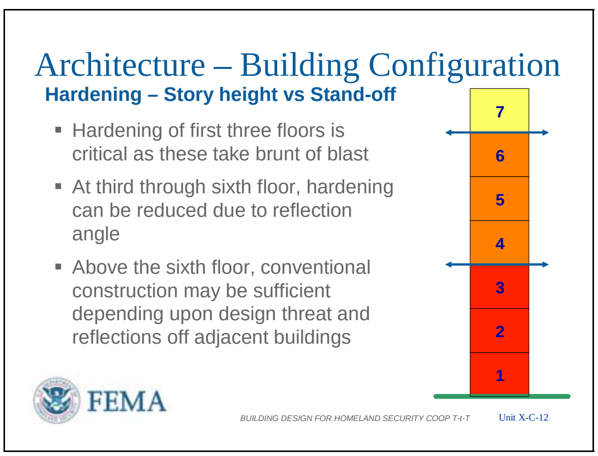


Architecture – Building Configuration

A lot can be done architecturally to mitigate the effects of a terrorist bombing on a facility. These measures often cost nothing or very little if implemented early in the design process. FEMA 430 (future) will contain an expanded discussion of incorporating security components in architectural design.

- Further looking at building shapes, certain configurations trap the blast wave, increasing overall damage to the structure. For example, “U” or “L” shaped buildings, overhangs, and re-entrant corners in general should be avoided. Either the reflected pressure increases as it cannot vent around the building or the building gets hit with reflected blast waves at points already hit by the initial blast wave.

VISUAL X-C-12



Architecture – Building Configuration

GSA has stated the hardening for the urban situation will be fully evaluated for the first three floors of the building because these floors are most vulnerable. At the third through sixth floor, the hardening can be reduced, but some hardening is still necessary. Above the sixth floor may need only conventional construction with minimal hardening -- because the reflection angle is going to result in a lower coefficient of reflection and the increased stand-off distance to these floors also results in less reflected pressure.

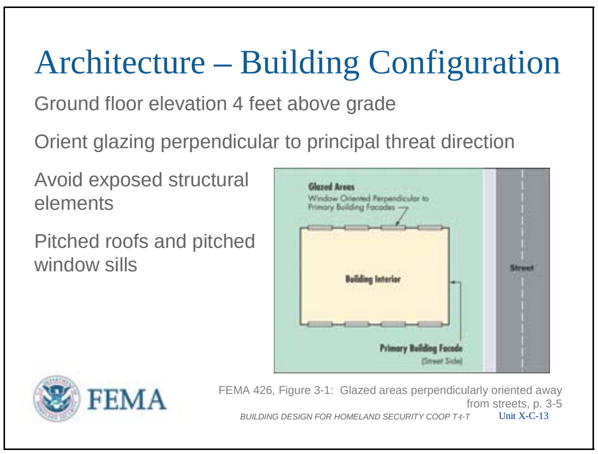
However, as the bomb gets bigger, the upper floors will see severe damage even with the increased reflection angles just due to the higher incident pressure generated by larger bombs.

The GSA approach would hold very well for a

INSTRUCTOR NOTES	CONTENT/ACTIVITY

high-rise building surrounded by low-rise buildings (3 floors and less), but is probably less applicable for the high-rise building surrounded by other high-rise buildings. Blast wave reflections off adjacent buildings, will affect all floors of the building of interest to varying degrees. The reflections will follow much longer paths resulting in larger effective stand-off distances and the various reflection angles will result in lower incident and reflected pressures compared to the initial blast wave. Unfortunately, the reflections my hit a very weak point in the response motion of the building or building component at any floor level resulting in more damage than would have been originally expected.

VISUAL X-C-13



Architecture – Building Configuration

- Elevating the ground floor makes moving vehicle attack more difficult
- If the glazing looks perpendicular to the direction of travel for the blast wave, the glass sees less reflected pressure.
- Do not have structural elements, like columns, easily exposed on the outside of the building. This goes for any architectural feature that can become damaged or disconnected by a blast wave.
- If armed attack includes Molotov cocktails or home-made grenades, pitched roofs and pitched window sills tend to cause the thrown item to roll off and away from the building. Air intakes have similar considerations.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-14
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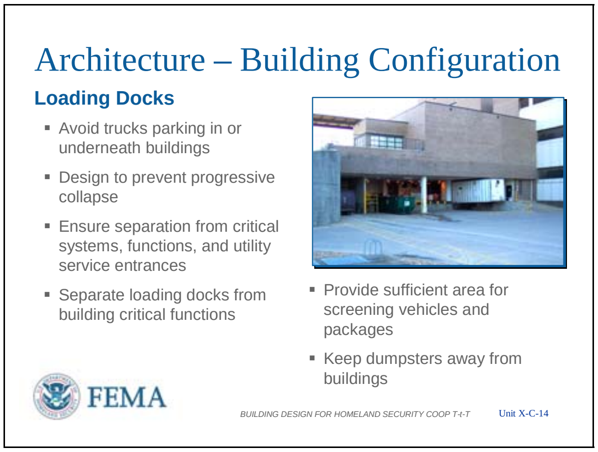

Architecture – Building Configuration

Loading Docks

- Loading docks are higher risk locations as larger vehicles with potentially larger bombs are allowed minimal stand-off from the building.
- Building design calls for the basics of preventing progressive collapse, and separating critical equipment, systems, components and functions away from the loading dock.
- Do not provide a hiding location by placing dumpsters adjacent to the building
- Screen packages and vehicles coming to the loading dock at other locations or in an area of sufficient size to allow searches and sufficient distance from the building to reduce the impact of any incident.

VISUAL X-C-15
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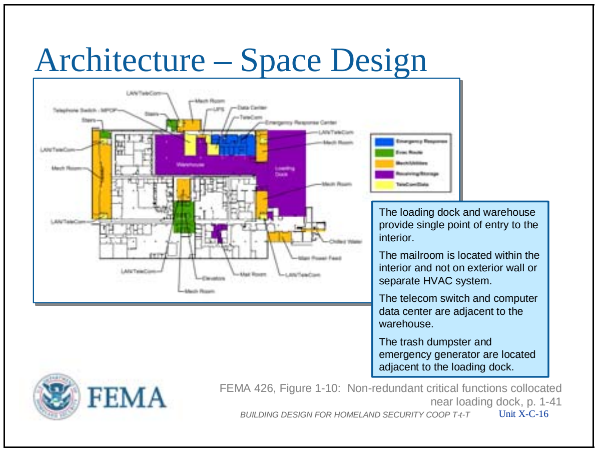
Architecture – Building Configuration

Parking Considerations

- As with loading docks, parking underneath a building is a higher risk situation as larger bombs than can be hand-carried approach the building with minimal stand-off.
- As with loading docks, progressive collapse is a primary concern
- Restrict parking to vetted vehicles, but also provide access control and security systems
- Access from underground parking (stairwells and elevators) to the building should be only to unsecured spaces where access control then occurs, such as outside the footprint of the building

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-16



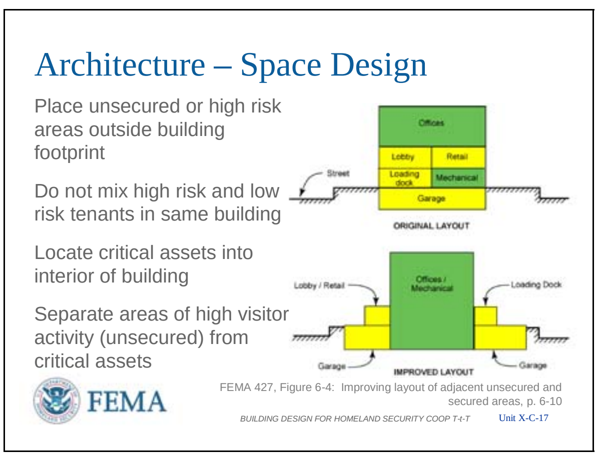
Architecture – Space Design

Functional Layout

Public areas such as the lobby, loading dock, mail room, garage, and retail areas need to be separated from the more secured areas of the facility. This can be done by creating internal "hard lines" or buffer zones, using secondary stairwells, elevator shafts, corridors, and storage areas between public and secured areas.

In lobby areas, the architect would be wise to consider the queuing requirements in front of the inspection stations so that visitors are not forced to stand outside during bad weather conditions or in a congested line inside a small lobby while waiting to enter the secured areas. Consider allowing enough lobby space for future inspection equipment.

VISUAL X-C-17



Architecture – Space Design

Structural Layout

Unsecured areas should be physically separated from the main building to the extent possible.

For example, a separate lobby pavilion or loading dock outside the main footprint provides enhanced protection against damage and potential building collapse in the event of an explosion. Similarly, placing parking areas outside the main footprint of the building can be highly effective in reducing the vulnerability to catastrophic collapse.

Mixed occupancies. High-risk tenants should not be housed with low-risk tenants. Terrorists may identify some targets based on their symbology, visibility, ideology, political views, potential for publicity, or simply the

INSTRUCTOR NOTES	CONTENT/ACTIVITY

consequences of their loss. Low-risk tenants are then placed at higher risk due to proximity.

- However, if there are very few high-risk tenants among many low-risk tenants, then dispersal and devalue can be mitigation techniques.
- After Oklahoma City, day care centers (low-risk) are separated from the main building functions (high-risk) to reduce the risk to the day care centers. This has been done at the Pentagon, with a relatively minor decrease in convenience.

VISUAL X-C-18
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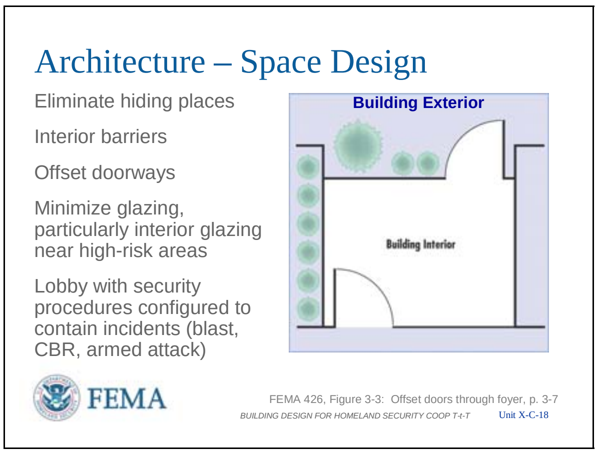

Architecture – Space Design

Design Measures

- Eliminate hiding places
  Generally a good security idea, especially in any areas where few people may frequent, like stairwells or underground parking
- Interior barriers
  Channel building staff and visitors to their respective areas and use interior barriers to provide separation between unsecure and secure areas
- Offset doorways
  If an explosive blast breaches the first door in a foyer, the offset will provide additional protection to the next door -- less incident pressure striking the interior door due to swirling of the blast wave.
- Minimize glazing
  Glass, unless hardened, adds to injuries during incidents. Reducing glazing is one approach, hardening is another, and proper placement is a third.
- Lobby design
  While it is a given that security and access control should be in the lobby, but design should accommodate the occurrence of an incident within lobby – reversal of standard design pressures, containment of the event

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

inside the lobby without affecting the rest of the building, control of agents and toxic gases, and hardening against armed attack.

VISUAL X-C-19
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For additional information on safe havens, see **FEMA 453** - *Design Guidance for Shelters and Safe Rooms: Protecting People Against Terrorist Attacks*

Architecture – Other Location Concerns

When designing high-risk buildings, engineers and architects should consider the following:

The innermost layer of protection within a physical security system is the **safe haven**. Safe havens are not intended to withstand a disciplined, paramilitary attack featuring explosives and heavy weapons. They are locations where sheltering-in-place for CBR, protection from natural hazards or bomb blast can occur.

Offices considered to be high risk (more likely to be targeted by terrorists) should be placed or glazed so that the occupants cannot be seen from an uncontrolled public area such as a street. Whenever possible, these spaces should face courtyards, internal sites, or controlled areas.

Public toilets and service areas, or access to vertical circulation systems (stairwells and elevators) should not be located in any non-secure areas, including the queuing area before visitor screening at the public entrance.

Retail and other mixed uses, which have been encouraged in public buildings by the Public Buildings Cooperative Use Act of 1976, create spaces that are open and inviting. Although important to the public nature of the buildings, the presence of retail and other mixed uses may present a risk to buildings and their occupants and should be carefully considered on a project-specific basis during project design. Consider allowing access to retail space only from the outside of the building and not between any interior spaces

INSTRUCTOR NOTES	CONTENT/ACTIVITY

or consider access configuration so that movement from retail spaces must go past security to get to the rest of the building.

Stairwells required for emergency egress should be located as remotely as possible from areas where blast events might occur and, wherever possible, should not discharge into lobbies, parking, or loading areas. When possible, emergency egress stairwells should be separate from the main building ingress stairwells, and secured to prevent individuals from accessing the secured floors of the building. Also do "What-If" as what would be done if a stairwell is lost as an egress during an incident.

Mailrooms should be located away from facility main entrances, areas containing critical services, utilities, distribution systems, and important assets. Avoid locating a mailroom in the same building as a child care center. In fact, the processing and inspection of mail and packages is best done in a separate building if possible. If an incident requires evacuation of the building, a separate building would limit the impact, vice a high-occupancy office building. Ditto, do "What-If" and plan alternatives.

VISUAL X-C-20

Structural Systems

Progressive Collapse Design

Progressive collapse is a situation where local failure of a primary structural component leads to the collapse of adjoining members, which, in turn, leads to additional collapse. Hence, the total damage is disproportionate to the original cause. Progressive collapse is a chain reaction of structural failures that follows from damage to a relatively small portion of a structure. More information on progressive collapse can also be found in

INSTRUCTOR NOTES

To minimize the potential for **progressive collapse**, designers should understand the following:

- The use of **redundant** lateral and vertical load paths is highly encouraged.
- Ductile materials are needed for both primary and secondary structural elements to be capable of deforming well beyond the elastic limit.
- Both the primary and secondary structural elements should be designed to resist load reversals.
- Primary structural elements should be able to resist shear failures by having flexural capacity greater than shear capacity.
- Fire protection should be applied to structural members to survive a worst-case fire duration allows fire fighters to control damage prior to initiation of structural collapse. Suggest reviewing the National Institute of Standards and Technology (NIST) report dealing with World Trade Center 7 (WTC 7) which collapsed due to fire.

CONTENT/ACTIVITY

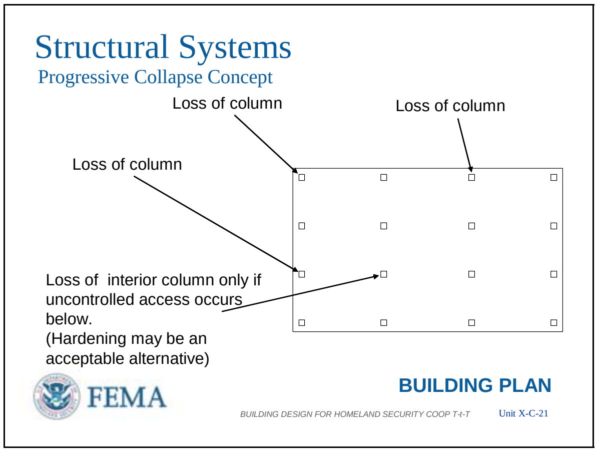
FEMA 427, *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks*.

Buildings should be designed with the intent of reducing the potential for progressive collapse as a result of an abnormal loading event, regardless of the required level of protection.

- Primary structural elements are columns girders and roof beams that are the first items for design to prevent progressive collapse.
- Secondary structural elements, such as floor beams and slabs, also may contribute to progressive collapse. Of particular weakness to progressive collapse is flat slab construction where the floor is thickened in areas to substitute for beams in the interest of cost savings. Floor connections to columns are the concern in this type of construction. This has been a standard office building design for many years, but should not be used if progressive collapse is a concern.
- Primary nonstructural elements, such as ceilings and heavy suspended mechanical equipment, contribute to casualties but not progressive collapse.
- Secondary nonstructural elements, such as partitions, furniture, and light fixtures, like primary nonstructural elements, also contribute to casualties, but not progressive collapse.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-21



Structural Systems

Progressive Collapse Concept

The GSA and DoD require that the structural response of a building be analyzed in a methodology that removes a key structural element (e.g., vertical load carrying column, section of bearing wall, beam, etc.) to simulate local damage from any incident. If effective alternative load paths are available for redistributing the loads that was originally supported by the removed structural element, the building has a low potential for progressive collapse.

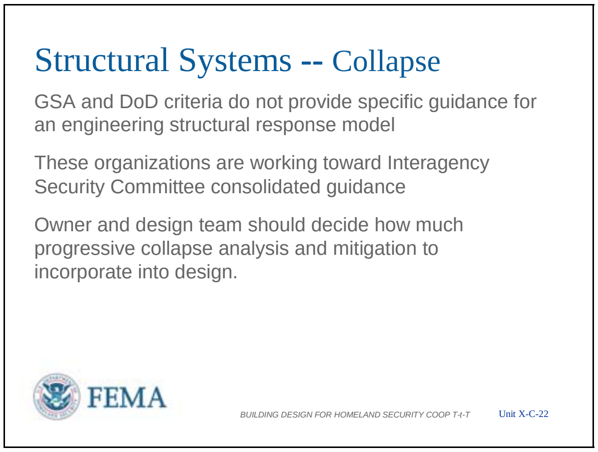
- If a column is lost, will the rest of the building still stand?
- If an exterior beam is lost, will the rest of the building still stand?
- If connections between column and floors are lost will the slenderized column still be able to carry the load or if the column fails, will the rest of the building still stand? DoD criteria states that columns of high-occupancy buildings will remain standing if all the floor connections on a given floor connecting to that column are lost.

If the threat can get to an interior column or beam, the same questions apply, such as underground parking or a mailroom.

Note that the more complex the structure layout (differing from square or rectangle) the more components (columns and beams) that must be analyzed.

INSTRUCTOR NOTES

VISUAL X-C-22
Hidden Slide



CONTENT/ACTIVITY

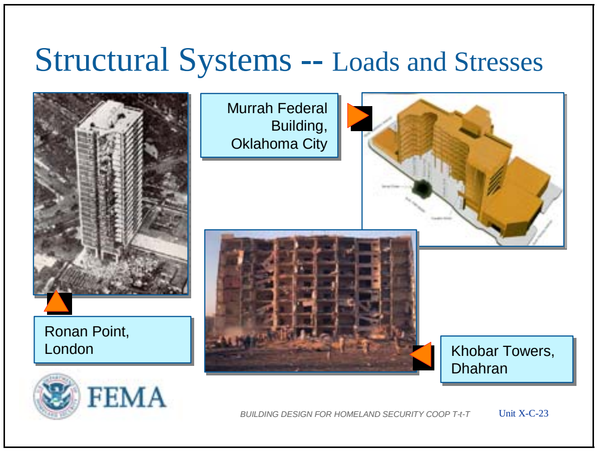
Structural Systems -- Collapse

- Although these criteria provide specific guidance on which structural elements must be analyzed for removal from the structural design configuration, they do not provide specific guidance for choosing an engineering structural response model for verifying the effectiveness of alternate load paths.
- Unless a building is being designed to meet the GSA or DOD criteria, it is up to the owner and the design team to decide how much progressive collapse analysis and mitigation to incorporate into their design.
- Priority should be given to the critical elements that are essential to mitigating the extent of collapse. Designs for secondary structural elements should minimize injury and damage.
- Consideration should be given to reducing damage and injury from primary as well as secondary nonstructural elements.

Both GSA and DoD take a threat-independent approach to progressive collapse – it does not matter how the column or beam is damaged or removed, the intent is that the building will remain standing. However, the concept is a single structural member being removed – if the Design Basis Threat is large enough to damage two components simultaneously, then additional analysis would be needed.

INSTRUCTOR NOTES

VISUAL X-C-23



Ronan Point: On the morning of 16 May 1968, Mrs. Ivy Hodge, a tenant on the 18th floor of the 22 (24 in other reports) -story Ronan Point apartment tower in Newham, east London, struck a match in her kitchen. The match set off a gas explosion that knocked out load-bearing precast concrete panels near the corner of the building. The loss of support at the 18th floor caused the floors above to collapse all the way to the roof.

The impact of these collapsing floors set off a chain reaction of collapses almost all the way to the ground. The ultimate result can be seen in Figure 1: the corner bay of the building has collapsed from top to bottom. Mrs. Hodge survived but four others died.

Construction of Ronan Point primarily consisted of precast concrete panels. While this type of construction can be designed to avoid progressive collapse from abnormal loading conditions, Ronan Point lacked the connection details necessary to effectively redistribute load. The essential missing detail was reinforcement continuity between panels. Because of this, there was no mechanism in place for achieving effective alternate load

CONTENT/ACTIVITY

Structural Systems -- Loads and Stresses

The DoD designates the level of blast protection a building must meet based on how many occupants it contains and its function. The demands on the structure will be equal to the combined effects of dead, live, and blast loads. Blast loads or dynamic rebound may occur in directions opposed to typical gravity loads.

Ronan Point had a whole section of the building collapse due to load-bearing precast concrete panels in one apartment being lost. That incident changed the British Code to prevent similar occurrences.

Khobar Towers was designed to the British Code, and only the façade was lost.

The Murrah Federal Building was not designed to the British Code and the loss of one column then affected a transfer girder. There were discontinuities in columns across the lobby causing multiple columns to fail when the transfer girder became unsupported, resulting in load transfers that the building could not handle.

The minimum goal is to have continuous columns from foundation to roof. When assessing a building any discontinuity of columns is a flag indicated the need for further analysis.

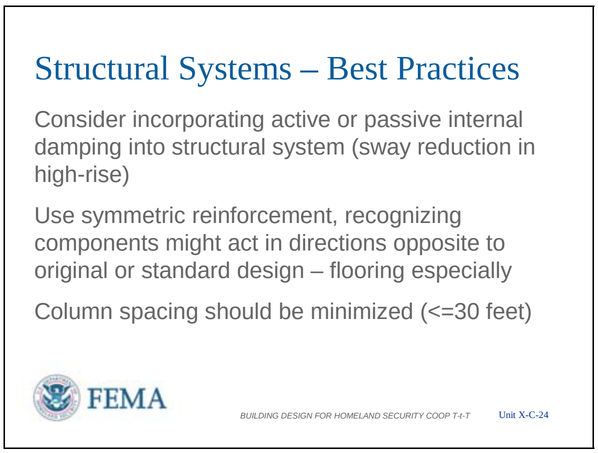
INSTRUCTOR NOTES	CONTENT/ACTIVITY

paths once failure began to propagate.

Khobar Towers was built to the British Standard that was a result of Ronan Point.

The Murrah Building owner wanted no columns in the lobby, thus designer used transfer beams to carry the load of the upper columns.

VISUAL X-C-24



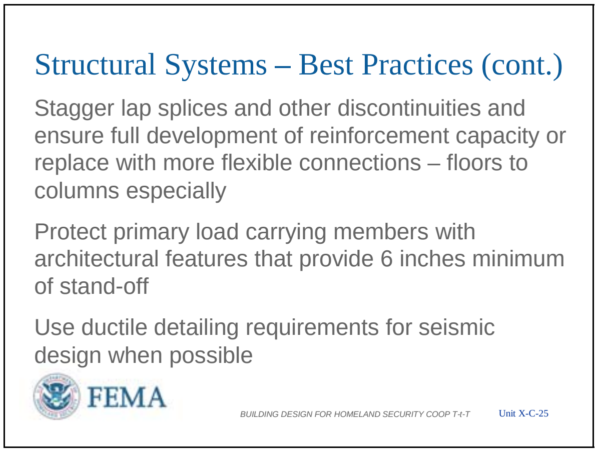
Structural Systems – Best Practices

The following guidelines are commonly used to mitigate the effects of blast on structures and to mitigate the potential for progressive collapse. These guidelines are not meant to be complete, but are provided to assist the designer in the initial evaluation and selection of design approaches. For example:

- Consider incorporating internal damping into the structural system to absorb the blast impact. Although mass has been the blast design approach in the past, using more ductile materials with damping is being investigated. Damping systems will most likely be found in high-rise buildings.
- The use of symmetric reinforcement can increase the ultimate load capacity of the structure. This is especially true for load reversals on floor slabs.
- A practical upper level for column spacing is 30 feet, but 20 feet is better. If the column is lost, the remaining beam must span 40 to 60 feet. Above 60 feet, the beam becomes unreasonably large and expensive. Note that the Murrah Building had 40-foot column spacing in the lobby.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

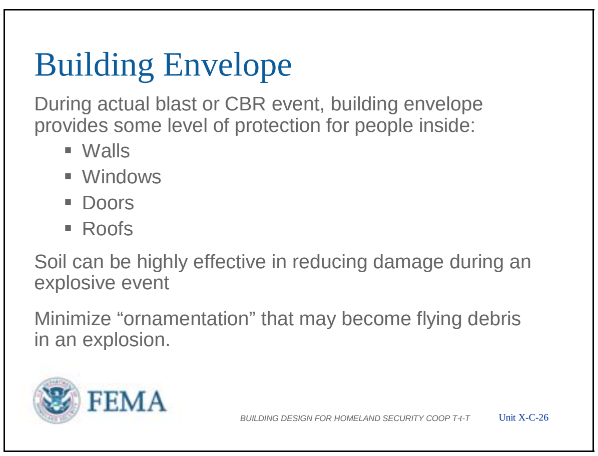
VISUAL X-C-25



Structural Systems – Best Practices (cont.)

- Lap splices must be upgraded from those found in conventional construction to handle the forces during a blast event. Consider interlocking "J" splices.
- By keeping a 6-inch stand-off from vertical load carrying members, a small weapons charge is less likely to shear the member.
- In many cases, the ductile detailing requirements for seismic design and the alternate load paths provided by progressive collapse design assist in the protection from blast.
- Ductility can be imbedded in the material, like steel reinforcing of concrete, or added to an existing component, like fragment-retention film on windows or spray-on truck bed liner on walls to strengthen weaker structures and catch fragmentation.

VISUAL X-C-26



Building Envelope

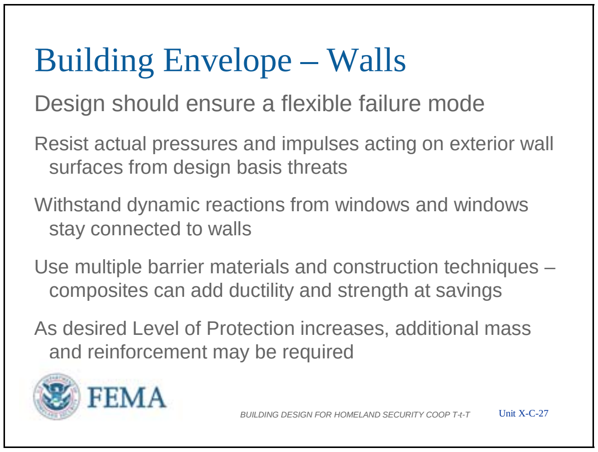
General principles:

- The exterior envelope of the building is the most vulnerable to an exterior explosive threat because it is closest to the blast.
- The exterior envelope also impacts the infiltration of CBR agents into the structure, but tight building construction must be done in conjunction with other actions to ensure some level of protection
- Soil can be highly effective in reducing the impact of a major explosion by reducing fragmentation off walls and street furniture or directing a blast wave over a building.
- Minimize "ornamentation" that may become flying debris in an explosion. This

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

includes street furniture, overhangs, sculptures, etc.

VISUAL X-C-27
Hidden Slide



Building Envelope – Walls

Ideally, the exterior walls need to be able to resist the loads transmitted by the windows and doors. It is not uncommon for bullet-resistant windows to have a higher ultimate capacity than the walls to which they are attached.

Beyond ensuring a flexible failure mode, design the exterior wall to resist the pressure levels of the design basis threat. Special reinforcing and anchors should be provided around blast-resistant window and door frames.

Deflections around certain members, such as windows, should be controlled to prevent premature failure. Additional reinforcement is generally required. Window frame deflection must not cause premature window glazing failure and window frame deflection must not differ greatly from the wall deflections. Seismic pinning of window frames may be required.

Poured-in-place reinforced concrete will provide the highest level of protection, but solutions like pre-cast concrete, reinforced CMU block, metal studs, and a combination of these may also be used to achieve lower levels of protection. Connections are the key, especially for pre-cast concrete curtain walls.

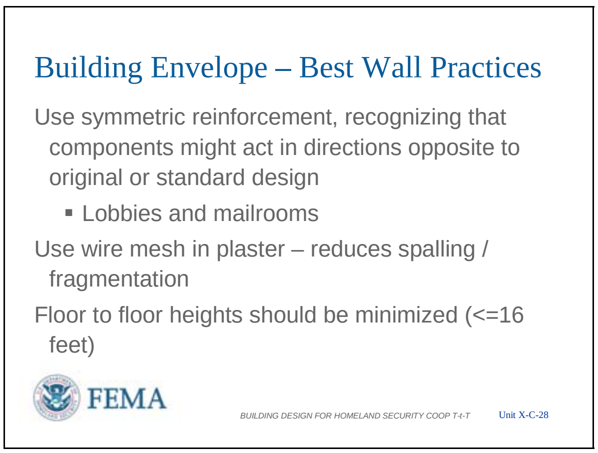
Retrofitting existing unreinforced masonry walls may consider steel plates, metal studs, reinforced concrete backing wall, high-strength fibers glued to the wall, or spray-on truck bed liner. If the wall is double-wythe (two wall system) – usually a brick exterior, air gap, and interior CMU block, consider

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

spraying vermiculite into the air gap to add mass and ductility.

When the design basis threat increases or the level of protection desired increases, the solution is more mass and more reinforcement to add ductility. Increasing the ductility of exterior walls along with mass are suitable ways to ensure blast pressure and fragmentation do not readily enter the building.

VISUAL X-C-28



Building Envelope – Best Wall Practices

The following best practices are commonly used to mitigate the effects of blast on structures and to mitigate the potential for progressive collapse. These guidelines are not meant to be complete, but are provided to assist the designer in the initial evaluation and selection of design approaches. For example:

Just as mentioned with structural framing, symmetrical reinforcement adds strength to masonry and concrete walls, especially on the side away from the bomb where the reinforcement increases the tensile strength of the concrete. Thus, for lobbies and mailrooms the bombs can be exterior (where standard design places wind loading, rain, snow, and flying debris) or interior, so the symmetric reinforcement adds strength to the wall in either direction.

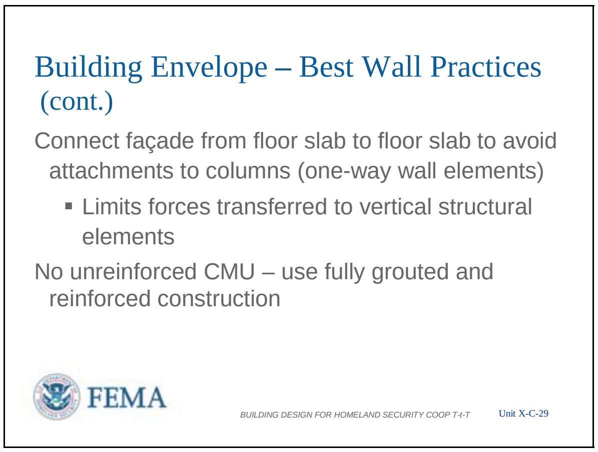
Wire mesh keeps plaster together, adds tensile strength, reduces spalling of the plaster, and assists in keeping fragmentation from entering the room (plaster or otherwise).

In general, floor to floor heights should be minimized. Unless there is an overriding architectural requirement, a practical limit is generally less than or equal to 16 feet. Consider bond beams (which connect

INSTRUCTOR NOTES	CONTENT/ACTIVITY

columns at about the mid-point between floor or run across the top of doors and windows), as used in seismic zones, to reduce the effective height of the wall. Since the walls are connected to the floor above and below, the shorter the wall height the stronger the wall all other things being equal.

VISUAL X-C-29



Building Envelope – Best Wall Practices (cont.)

Additional best practices include:

The reason why the walls are connected to the floor above and the floor below is to ensure there is no direct loading on the columns. Since the walls are only pinned at the top and the bottom this is called one-way. If they were also pinned to the columns on each side they would be two-way wall elements. Good blast design seeks to keep the structural framing as the absolute last component of the building to fail, thus the use of one-way wall elements.

Avoid the use of unreinforced masonry when blast is a threat. Masonry walls break up readily and become secondary fragments during blasts. Grout (mass) and reinforcement (ductility) are definitely required for blast resistance. The Ufundi building next to the Kenya embassy was all unreinforced brick and the bomb blast toppled the whole building.

INSTRUCTOR NOTES	**CONTENT/ACTIVITY**

VISUAL X-C-30

Building Envelope – Windows

Balanced Window Design

Glass strength

Glass connection to window frame (bite)

Frame strength

Frame anchoring to building

Frame and building interaction

FEMA BUILDING DESIGN FOR HOMELAND SECURITY COOP T-t-T Unit X-C-30

Building Envelope – Windows

Window systems on the exterior façade of a building should be designed to mitigate the hazardous effects of flying glass during an explosion event. Designs should integrate the features of the glass, connection of the glass to the frame (bite), and anchoring of the frame to the building structure to achieve a "balanced design." This means all the components should have compatible capacities and theoretically would all fail at the same pressure-pulse levels. In this way, the damage sequence and extent of damage are controlled.

Ultimately, in a "balanced" design, the order of failure should be:

- Glass
- Window frame and frame anchoring
- Wall
- Building structural framing

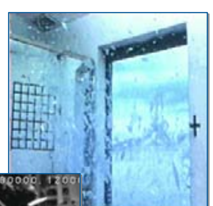
The pressure differences should not be large and the Level of Protection for the Design Basis Threat should be met.

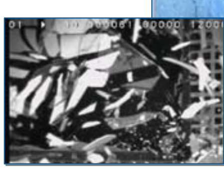
VISUAL X-C-31

Building Envelope – Windows

Glass (weakest to strongest)

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





"Balanced Design"

FEMA BUILDING DESIGN FOR HOMELAND SECURITY COOP T-t-T Unit X-C-31

Building Envelope – Windows

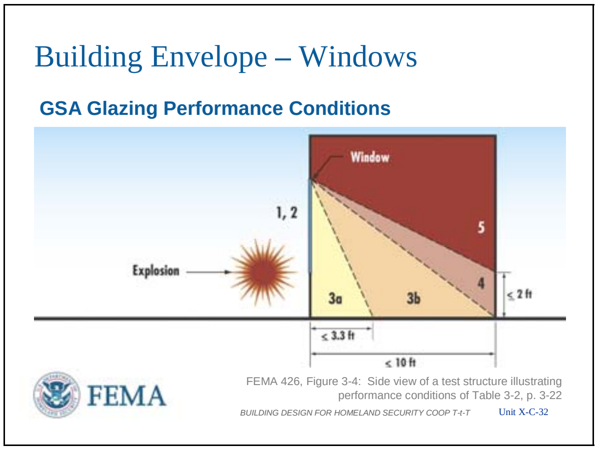
Five types of glass are commonly used in window glazing systems: annealed glass, heat strengthened glass, fully thermally tempered, laminated glass, and polycarbonate. Other types of glass materials exist, but are not commonly used in typical commercial window systems. Of the five common types, **annealed glass** and **fully thermally tempered glass** are the type of windows for most office buildings.

Annealed glass, also known as float, plate, or sheet glass, is the most common glass type used in commercial construction. Annealed

INSTRUCTOR NOTES	**CONTENT/ACTIVITY**
	glass is of relatively low strength and, upon failure, fractures into razor sharp, dagger-shaped fragments (see slide -- the right photo is annealed glass failing during an actual explosive test and the left photo is a close-up of the shards). Annealed glass breaks at about 0.2 psi (incident pressure). **Heat strengthened glass** (HS), also known as double strength glass, is used where wind loading starts becoming a problem. It breaks like annealed glass, but at about 0.4 psi (incident pressure). **Fully thermally tempered glass** (TTG) is typically four to five times stronger than annealed glass. Instead of shards, TTG breaks into pellets that can be stopped by a regular suit coat. It breaks at about 0.8 psi (incident pressure. **Laminated glass** is a pane with multiple glass layers and a pliable interlayer material (usually made from polyvinyl butyral (PVB)) between the glass layers. This interlayer should have a thickness of 30 mils [30 thousandths of an inch] (minimum) or 60 mils (recommended). Do not use an interlayer of 15 mils. **Thermoplastic polycarbonates** are very strong and suitable for blast- and forced entry-resistant window design. They are usually laminated in 3 or more layers with glass on the outside to prevent environmental degradation of the plastic (yellowing) and to aid in cleaning (avoid scratches). **Wire-reinforced glass** is a common glazing material. It consists of annealed glass with an embedded layer of wire mesh. It is usually used for fire resistance and as a forced entry barrier. It is not recommended for blast design.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-32



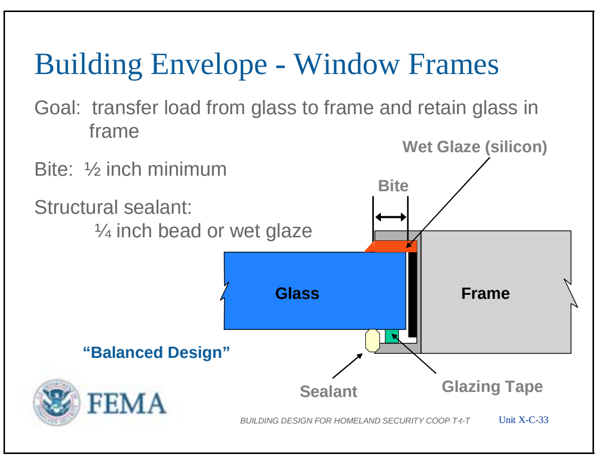
Building Envelope – Windows

GSA Glazing Performance Conditions

Table 3-1, page 3-21, in FEMA 426 presents six GSA glazing protection levels based on how far glass fragments would enter a space and potentially injure its occupants (known as a flight model). This slide depicts how far glass fragments could enter a structure for each GSA performance condition. The divide between performance conditions 3a and 3b can be equated to the "threshold of injury." The divide between performance conditions 4 and 5 can be equated to the "threshold of lethality." A person standing in the room has a potential of being hit in the upper body/head area by glass fragments that are traveling fast enough to penetrate the body.

The GSA glazing performance conditions shown will correlate with the DoD levels of protection presented in **Table 3-2, page 3-22, in FEMA 426** as shown previously in Unit VII, Explosive Blast.

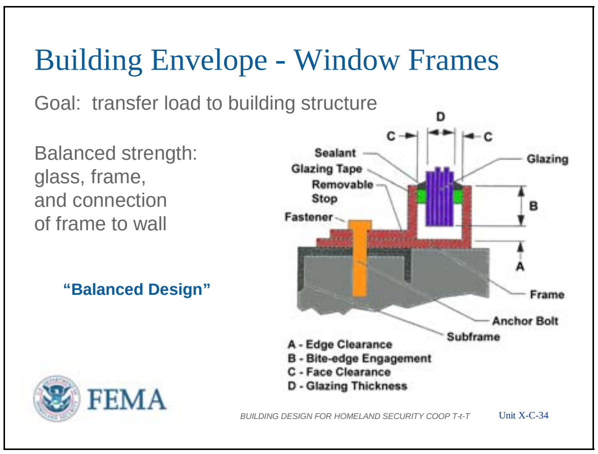
VISUAL X-C-33



Building Envelope -- Window Frames

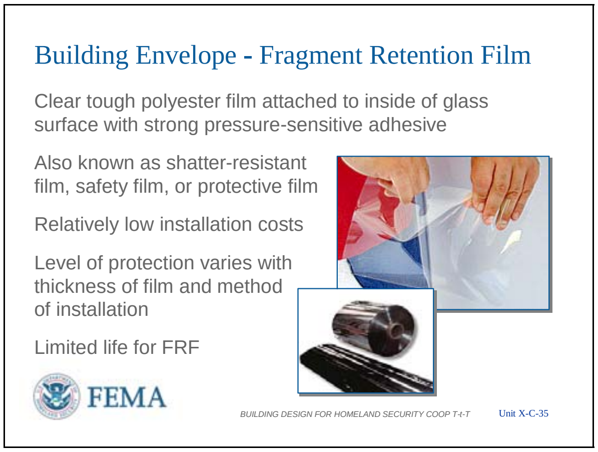
Window frames need to retain the glass so that the entire pane does not pull out (glass flexes and can pull out of frame during the blast) and also should be designed to resist the breaking stress of the window glass.

The window bite (i.e., the depth of window captured by the frame) needs to be at least ½ inch. DoD criteria call for a minimum 3/8-inch bite if silicon sealant is applied, but call for a 1-inch bite if no silicone sealant is used. Butt-glazed strip windows can require even more bite with or without sealant, since there is bite only on the top and bottom of the window.

INSTRUCTOR NOTES	**CONTENT/ACTIVITY**
	To retain the glass in the frame, a minimum of a ¼-inch bead of structural sealant (i.e., silicone or polyvinyl butyral) should be used around the inner perimeter of the window. This should be done on all four sides of the window. Since strip windows with butt glazing can only apply sealant on the top and bottom, they are not good options for blast as the bite must be large, even with sealant.
VISUAL X-C-34  	**Window Frames** The frame must not flex during the blast loading and cause the glass to pop out. The blast loading across the glass and frame now transfers to the frame connections to the building. These connections must handle the <u>shear</u> and <u>tensile</u> stresses and the <u>bending moments</u> of the connection design. The frame members connecting adjoining windows are referred to as mullions. These members may be designed using a static approach when the breaking strength of the window glass is applied to the mullion, or a dynamic load may be applied using the peak pressure and impulse values. Because mullions only connect at their top and bottom ends to the building structure, the mullion must handle the transferred blast loading from both adjacent windows. Other considerations for windows must balance the amount of light, energy conservation, noise transmission, venting of fumes, and emergency egress in addition to blast response and CBR protection.

INSTRUCTOR NOTES

VISUAL X-C-35
Hidden Slide



When obscuration of rooms cannot be handled by site and layout design, one alternative is to install glazing with mirrored finishes or add fragment retention film that is mirrored. This works fairly well with single pane windows, but double pane windows may overheat with the mirrored fragment retention film – consult window manufacturer if there is a question. Realize, however that the mirrored finishes work best during daytime ambient light (room light less bright compared to ambient light). At night time or on overcast days, observation into the room is possible if interior lights are on. Shades or Venetian blinds can provide obscuration during low ambient light.

CONTENT/ACTIVITY

Building Envelope – Fragment Retention Film (FRF)

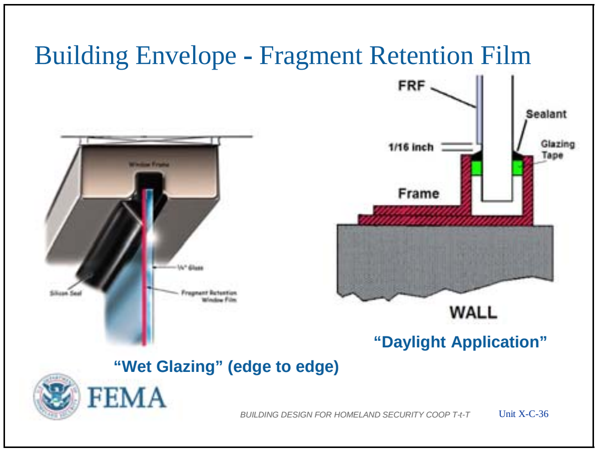
Another treatment used for mitigating the effects of an explosive attack is **security window film.** The polyester film used in commercial products is commonly referred to as fragment retention film (FRF), safety film, security film, protective film, or shatter-resistant film. These films adhere to the interior surface of the window to provide fragment retention and reduce the overall velocity of the glass fragments at failure. The film greatly increases the tensile strength of thin annealed glass and limits the deflection of the glass under blast loading.

Fragment retention film combines a strong pressure sensitive adhesive with a tough polyester layer. It should be limited to use in retrofit applications due to degradation of the film and adhesive by ultraviolet light. Do not use for new construction and it is of little to negative benefit on thicker, higher strength glass. For example, applying FRF to 3/8-inch thermally tempered glass will INCREASE the stand-off required for a given bomb size as the film will hold the glass together, acting like a sail and increasing the distance that the glass will fly into the test room.

Note that fragment retention film can be justified for multiple reasons – blast protection, physical security (smash and grab), and energy conservation (mirrored or tinted). Thus, justification can be based upon the multiple benefits derived for little difference in cost.

INSTRUCTOR NOTES

VISUAL X-C-36



CONTENT/ACTIVITY

Building Envelope – Fragment Retention Film

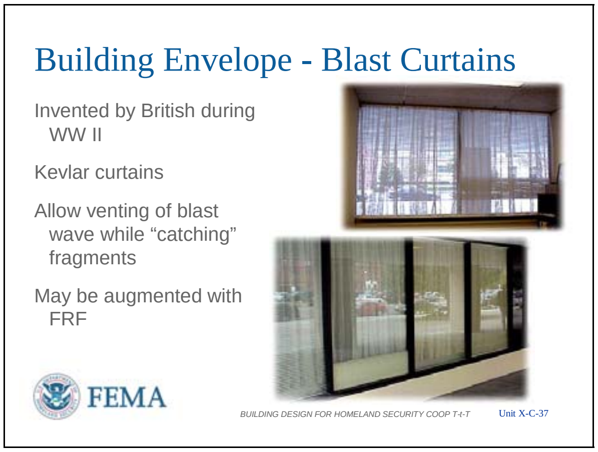
Fragment retention film behaves similarly to relatively thin laminated and polycarbonate glazing in terms of fragmentation. It is available in common thicknesses of 2, 4, 7, and 10 mils. Also found up to 15 mils. The Navy recommends 10 mils.

Fragment retention film improves the performance of the glass under blast loading to varying degrees, depending on the thickness, quality, and type of film installation. Note a daylight application will leave a 1/16 inch space around the edge of the FRF where water used to apply the FRF is squeegeed out. Daylight application of FRF to very thin glass can reduce the stand-off distance in half for a given level of protection. The best performance is achieved when the film is installed into the bite of the glazing or is connected to the frame (mechanically or with chemical sealants).

Fragment retention film can also be purchased with tinted, mirrored, or solar versions that provide energy conservation benefits when using air conditioning.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

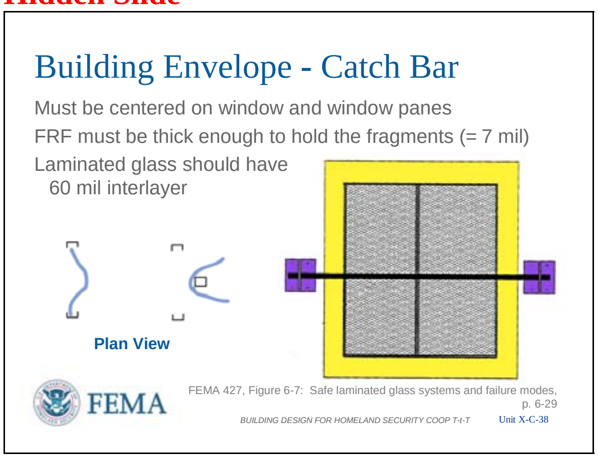
VISUAL X-C-37
Hidden Slide



Building Envelope – Blast Curtains

- Can now see out of these curtains as opposed to the "blackout" curtains from WWII -- uses Kevlar or other high strength fibers. In fact it is easier to see out of sheer black curtains than sheer white curtains.
- They allow venting of the blast wave while "catching" glass fragments
- May be augmented with FRF (British only specify them with FRF)
- Connections of curtains or blast shields to building frame are critical.

VISUAL X-C-38
Hidden Slide



Building Envelope – Catch Bar

Increased safety for fragment retention can be obtained in the event of catastrophic failure from an explosive blast by placing a decorative catch bar or grillwork on the interior of the glazing. Note, catch bars must be mounted across the center of mass of each window pane (vision area of glass) to be effective. A catch bar is ineffective with 4 mil FRF as the FRF will just tear (shear) on the catch bar. This is also another reason why the Navy recommends 10 mil.

Catch bars are usually considered with a retrofit of fragment retention film to not only catch the glass, but also catch the existing window frame that may not be adequately connected to the wall. They can also be considered for laminated glass.

INSTRUCTOR NOTES

VISUAL X-C-39

Building Envelope – Best Window Practices

No windows adjacent to doors

Minimize number and size of windows - watch building code requirements

Laminated glass for high-occupancy buildings

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

Steel versus aluminum window framing

FEMA BUILDING DESIGN FOR HOMELAND SECURITY COOP T-t-T Unit X-C-39

CONTENT/ACTIVITY

Building Envelope – Best Window Practice

Windows adjacent to doors allow easy access to the locking mechanism on the door by just breaking the window and reaching in.

Smaller windows are stronger against blast for a given window material and less expensive as well. Using fewer windows also reduces cost. However, building codes may specify the square footage of windows required based upon the total square footage of the floor level the windows are on.

Laminated glass is required for high-occupancy buildings by DoD. For life cycle costing and blast resistance, especially at the lower end of weapon yield, laminated glass is the best choice.

Life safety/fire codes may require operable windows as an escape route in certain occupancies (dormitories, for example). Recommend sliding or swing-out windows for better blast performance.

Heavy duty aluminum frames have performed well, although steel should be specified if design basis threat is large.

INSTRUCTOR NOTES	CONTENT/ACTIVITY

VISUAL X-C-40

Building Envelope – Doors

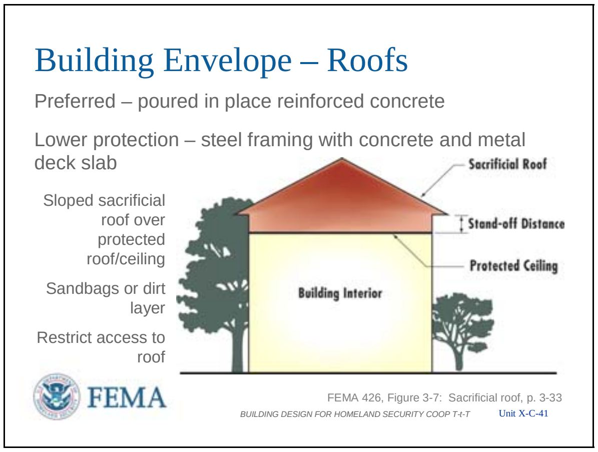
A door system includes the door, frame, and anchorage to the building. As part of a balanced design approach, exterior doors in high risk buildings should be designed to withstand the maximum dynamic pressure and duration of the load from the design threat explosive blast. Other general door considerations are as follows:

Provide hollow steel doors or steel-clad doors with steel frames.
Provide blast-resistant doors for high threats and high levels of protection.
Limit normal entry/egress through one door, if possible.
Keep exterior doors to a minimum while accommodating emergency egress.
Ensure that exterior doors open outward from inhabited areas. If inward opening the locking mechanism must handle the blast loading [A 3 foot by 7 foot door has 3 x 7 x 144 = 3,024 square inches of surface area. A reflected blast pressure of 2 psi puts <u>3 tons of force</u> on that locking mechanism.] If outward opening the whole door frame takes the blast loading.
Replace externally mounted locks and hasps with internally locking devices because the weakest part of a door system is the latching component.
Install doors, where practical, so that they present a blank, flush surface to the outside to reduce their vulnerability to attack.
Locate hinges on the interior or provide concealed hinges to reduce their vulnerability to tampering. [Ask students if they see anything wrong with the door in the photo – exterior hinges. However, there is a balanced magnetic switch on the inside of the door connected to the security alarm which mitigates the exterior hinges.
Install emergency exit doors so that they facilitate only exiting movement.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

Equip any outward-opening double door with protective hinges and key-operated mortise-type locks.
Provide solid doors or walls as a backup for glass doors in foyers.

VISUAL X-C-41



Building Envelope – Roofs

For an explosive threat, especially for thrown explosives (e.g., satchels, hand grenades, and even mortars), the primary loading on the roof is downward over-pressure. The stand-off to the protected ceiling provides the protection. The sloped roof tends to cause the explosive to roll off and away from the building. For explosions at ground level, secondary loads include upward pressure on the protected ceiling and roof due to the blast penetrating through openings and upward suction during the negative loading phase. The upward pressures may have an increased duration due to multiple reflections of the air blast internally. It is conservative to consider the downward and upward loads separately.

The preferred system is to use poured-in-place reinforced concrete with beams in two directions. If this system is used, beams should have stirrups along the entire span spaced not greater than one half the beam depths. Steel pan formwork provides additional protection as the formwork mitigates falling debris, but since load reversals may occur, the concrete in the steel pan formwork should have steel in both faces (symmetrical reinforcement).

Less desirable systems include metal plate systems without concrete, and precast and pre/post tensioned systems.

Precast roof panels are problematic because of the tendency to fail at the connections, like pre-cast curtain walls.

INSTRUCTOR NOTES	CONTENT/ACTIVITY

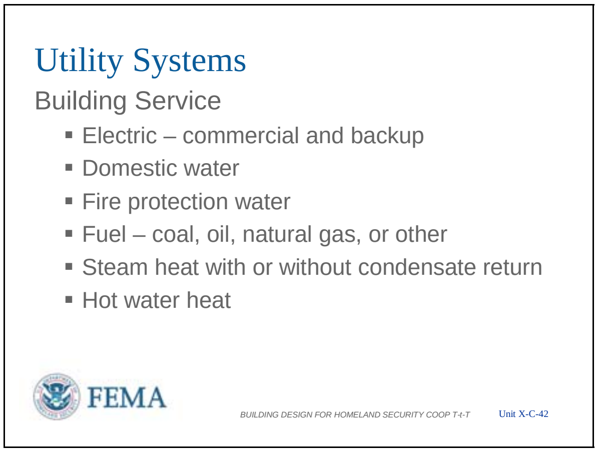
Pre/post tensioned systems tend to fail in a brittle manner if stressed beyond their elastic limit and they also are not able to accept upward loads without additional reinforcement.

Standard construction found in the Middle East, for example, uses soil/dirt as insulation in the roof at a thickness of 18 inches or so. The soil is placed on a waterproofed concrete poured-in-place deck and covered with 1-meter square concrete panels that are waterproofed and sloped to roof drains. With two layers of standard sand bags (about 8 inches in total deep) on top, this roof, has a high level of protection.

Many conventional roof designs will provide a suitable blast response for most buildings, considering minimum Design Basis Threats. The intent here is to point out what roofs may be a problem and why. For higher Design Basis Threats and tactics involving the roof, the protected ceiling and sacrificial roof concept applies.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-42



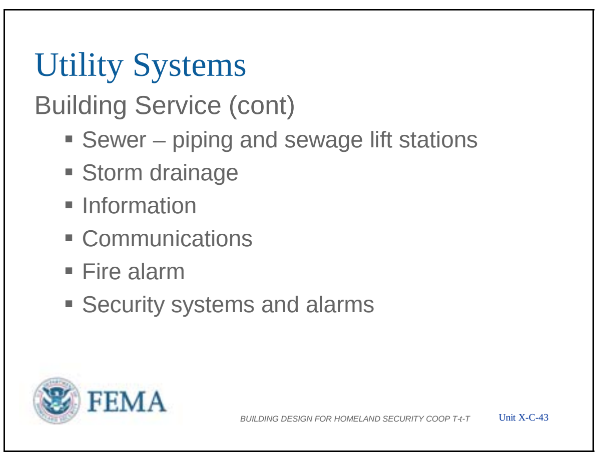
Utility Systems

Building Service

While Utility Systems are first and foremost considered under Site and Layout Design, they have a direct impact on the building envelope based upon where and how they enter the building to provide service to that structure. While most will think of what is brought into a building, it is equally important to note what needs to be taken out of the building to maintain function and operation.

For example, steam heat may be provided by a central boiler plant on the site/campus that requires condensate to be returned for energy efficiency. But steam heat purchased from a commercial steam heat company in an urban environment is usually dumped to drain to prevent contaminants beyond the steam heat company's control from fouling their boilers.

VISUAL X-C-43



Utility Systems

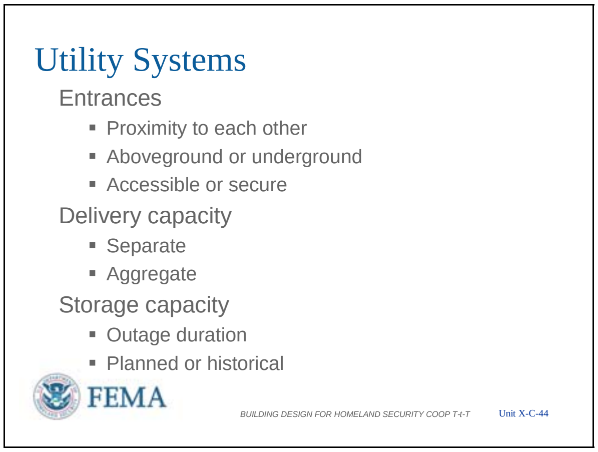
Building Service (cont.)

Thus, anything feeding into and out of the building should be considered due to its impact on the building envelope and building operations if damaged.

For example, water service into a building balances against sewer service to get it out of the building. A sewage lift pump or station that is not on backup power results in raw sewage backing up into the building.

INSTRUCTOR NOTES

VISUAL X-C-44



CONTENT/ACTIVITY

Utility Systems

Service entrances of utilities into buildings take on the following concerns:

- Reduce the number of utility openings, manholes, tunnels, air conditioning ducts, filters, and access panels into the structure. Balance this with having two well separated service entrances for each utility.
- Proximity: How close are the service entrances to each other and can a single event affect more than one utility – for example all utilities entering along the loading dock ramp because the utility room is adjacent or underneath the loading dock.
  - o Locate utility systems away from likely areas of potential attack, such as loading docks, lobbies, and parking areas. The alternative is hardening.
- Above or below ground: Below ground is preferred, but gas meters and pressure regulators, electric meters and transformers, and tankage may be aboveground. By building code gas lines must come above ground before entering a building to prevent gas leaks from following the piping into the building and reaching explosive concentrations in a basement.
- Can someone outside the building access the utility where it enters the building or use it as a way of getting into the building?
  - o Use lockable systems for utility openings and manholes where appropriate. Infrequently used utility covers/manholes can be tack-welded as an inexpensive alternative to locking tamper-resistant covers.

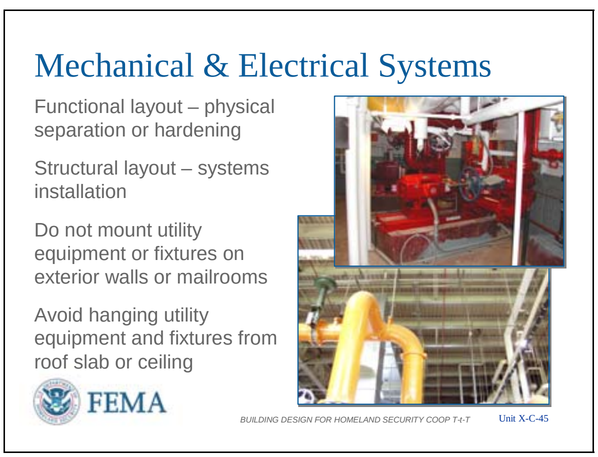
Delivery capacity is an operational consideration before and after an incident:

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

- Will each service entrance handle 50% of the total building needs or 100% (like hospitals require for electric service). Emergency operations plans should consider all contingencies for losing either or both service entrances for each given utility.

Storage capacity is a concern during:
- Evacuation (i.e., How long will the emergency lighting system continue to operate?)
- Orderly shutdown of a computer system (battery backup for uninterruptible power supply)
- Continued operations (fuel stored for emergency generator use to last as long as historically longest commercial outage or until contingency contracts in place can refuel the generator on an acceptable schedule).

VISUAL X-C-45



Mechanical and Electrical Systems

The major security functions of an electrical are to maintain power to essential building services, provide lighting and surveillance to deter criminal activity, and provide emergency communications.

The primary goal of a mechanical and electrical system after a terrorist attack should be to continue to operate key life safety and evacuations systems.

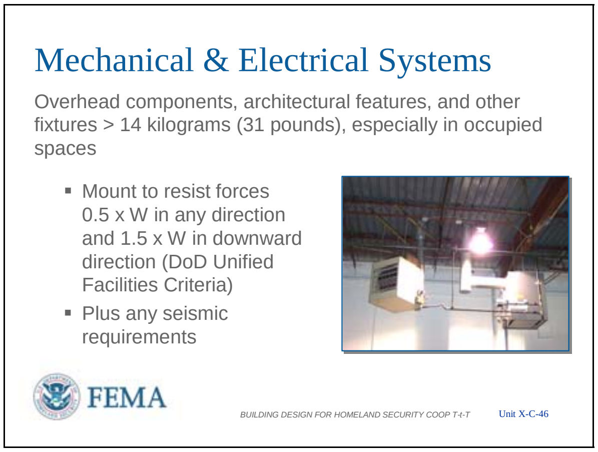
The following suggestions attempt to protect the mechanical and electric systems during an explosive blast event:

- Do not mount plumbing, electrical fixtures, or utility lines on the inside of exterior walls, but, when this is unavoidable, mount fixtures on a separate wall at least 6 inches from the exterior wall face.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

- Avoid suspending plumbing fixtures and piping from the ceiling or roof slab. Remember the upheaval if the blast wave gets inside the building.
  - The roof slab is part of the building envelope.
  - The ceiling is less sturdy than the floor above.
- When the above cannot be done, add ductility, additional supports, and hardening to achieve some level of protection.

VISUAL X-C-46
Hidden Slide



Mechanical and Electrical Systems

Nonstructural Elements

False ceilings, light fixtures, Venetian blinds, ductwork, air conditioning components, and other equipment may become flying debris in the event of an explosion once the building envelope is breached. Marques and other exterior nonstructural elements must also be considered since upward blast pressure will be much greater.

Wherever possible, it is recommended that the design be simplified to limit these hazards. Placing heavy equipment such as air conditioners near the floor rather than the ceiling is one idea; using curtains rather than Venetian blinds, and using exposed duct work as an architectural device are others.
When using seismic requirements added to the above will require about a Seismic Zone 4 (old system) [highest level] design. For example, 30 years ago 2-foot 4-foot light fixtures in drop ceilings required additional support (other than the drop ceiling support) on two opposing corners using 9-gauge wire. Seismic Zone 4 would consider threaded rod on all four corners to satisfy the requirement.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-47

Mechanical and Electrical Systems

Distribution – similar to comments about utility systems previously

- Multiple risers and looping on each floor with isolation valving or switches adds redundancy
- As high voltage and low voltage electricity is separated from communications circuits due to capacitive coupling and fault tolerance situations, other systems should not share the same pipe chases or provide vertical separation to overcome secondary effects of leakage.

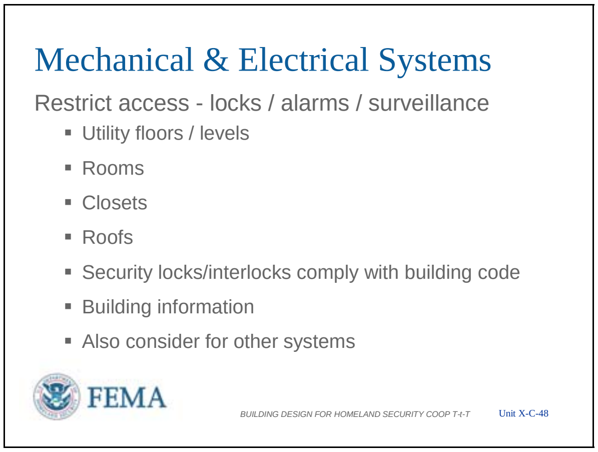
Locations of emergency equipment also figure into redundancy:

- Locate components in less vulnerable areas such as away from loading docks, entrances and parking. Seek 50-foot separation as a minimum.
- Placing emergency switchgear and commercial switchgear in the same room allows one event in either system to affect the other.
- Fuel tanks should be mounted near the emergency generator(s) and be given the same protection as the generator. Separating them puts the fuel distribution at greater risk due to the distance of the separation.
- If an emergency generator cannot be justified, consider running conduits with conductors through a manual transfer switch to a quick disconnect on the outside of the building. A rental generator / company can be prearranged to provide rapid backup power as required without major rewiring. This would be equivalent to a Siamese water connection for adding fire fighting water to a sprinkler system.
- Similarly, placing electric fire pumps and diesel fire pumps side-by-side allows one

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

event to affect both primary and backup systems. The event is not just loss of commercial power.

VISUAL X-C-48

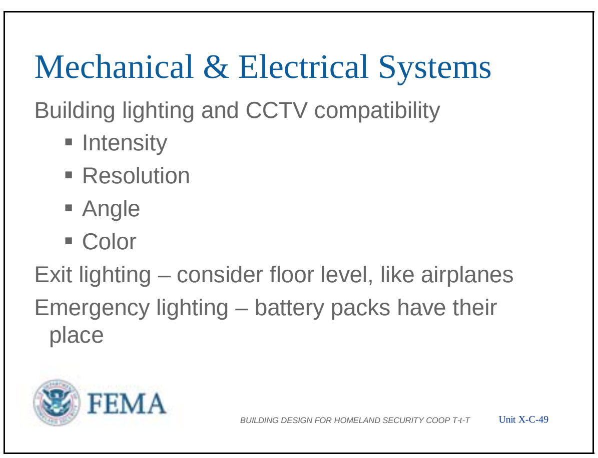


Mechanical and Electrical Systems

Restrict Access

- Physical security for utility rooms, closets, etc., should be implemented to prevent tampering with the systems and to prevent the direct introduction of hazardous materials into heating, ventilating, and air conditioning (HVAC) ducts that distribute air to portion(s) of the building.
- Public access to building roofs should be prevented. Access to the roof may allow entry to the building and access to air intakes and HVAC equipment (e.g., self-contained HVAC units, laboratory or bathroom exhausts) located on the roof.
- Access to information on building operations (including mechanical, electrical, vertical transport, fire and life safety, security system plans and schematics, and emergency operations procedures) should be strictly controlled.

VISUAL X-C-49



Mechanical and Electrical Systems

Closed circuit television/security cameras and building lighting must be worked as a system to ensure compatible operation:

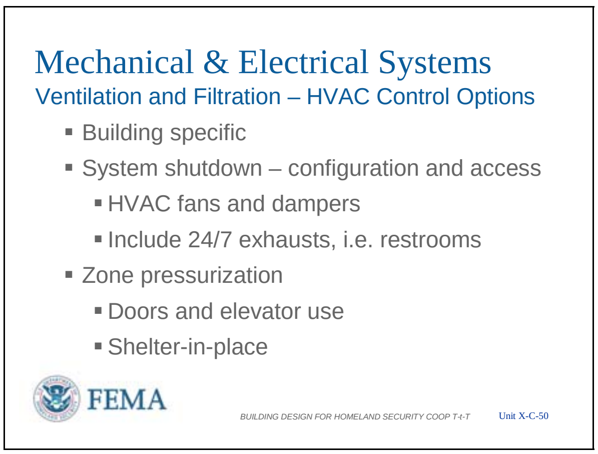
- The intensity, angle, and color of the lighting affect camera resolution, including low-light and infra-red
  - o Detection for response versus identification for police/legal action
- Exit lighting has traditionally been at top of door level shining downward to floor or along halls. After incidents smoke, heat, and toxic fumes are normally lighter than air so traditional exit lighting is obscured. Putting exit lighting at floor level works

INSTRUCTOR NOTES	CONTENT/ACTIVITY

whether walking upright or crawling.

- Emergency lighting from a distribution system with central batteries and backup generator is one design approach, but distributed emergency lighting with self-contained battery packs along the egress route ensures operation during a wider range of potential incidents. Do not forget restrooms in the emergency lighting scheme.

VISUAL X-C-50



NOTE to instructor: Added egress and CBR considerations

- Provide clear design guidance for entrances, exists, and lighting
- Mobilization of people with disabilities should be carefully considered
- Egress routes should be accessible and well marked
- Egress (stairs and elevators) should take into consideration hardening (structural, fire, water, overpressure, and CBR filtration) and size of potential flows
- Egress should allow dedicated paths for first responders (less likely, unless elevators) or be adequate to accommodate counter flow of emergency responders (more likely if stairs)

Mechanical and Electrical Systems

Ventilation and Filtration – HVAC Control Options

Available options are specific to the building as HVAC equipment and configuration, building functions, continuing operations, and other factors affect what can be done.

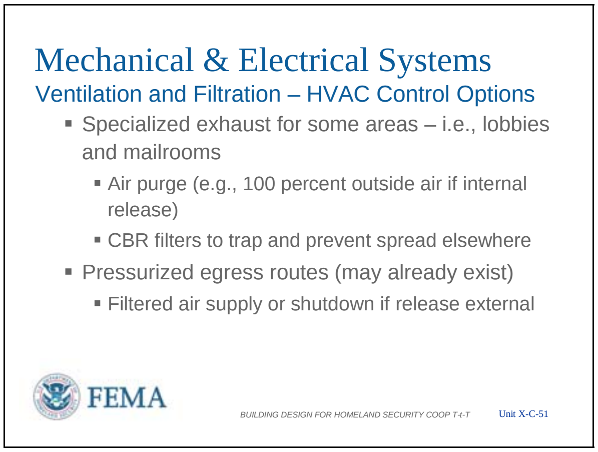
- HVAC control may not be appropriate in all emergency situations. Protection from CBR attacks depends upon the design and operation of the HVAC system and the nature of the CBR agent release.
  - Ducted returns (vice using hallways as returns) offer limited access points to introduce a CBR agent. The return vents can be placed in conspicuous locations, reducing the risk of an agent being secretly introduced into the return system.
  - Large buildings usually have multiple HVAC zones, with each zone served by its own air handling unit and duct system.
- Complete system shutdown of all HVAC systems is the simplest initial approach to handle either external or internal releases
  - Since speed is critical, a single shutdown point is desirable, but the larger the system(s) the difficult this becomes.
  - A rapid response may involve closing

INSTRUCTOR NOTES	**CONTENT/ACTIVITY**

various dampers, especially those controlling the flow of outdoor air (in the event of an exterior CBR release).
    - Consideration should be given to installing low leakage fast acting dampers to minimize this flow pathway. Fast acting dampers close much faster than in 30 seconds.
  - Must include all air handling systems, such as restroom exhausts that run continuously.
- Ensure there is no unintended leakage into or out of the ventilation system – filters sealed to channel all air through them vice taking the path of least resistance and dampers fully functional – Good Maintenance
- If zone pressurization is designed into the system (for fire fighting as an example, where the fire floor is ventilated to remove heat and adjacent areas are overpressurized to keep smoke and gases contained), then realize that opening and closing doors or operating elevators will change the zone pressurization being attempted.
  - Even without zone pressurization, opening and closing doors and operating elevators will affect the flow of air and spread smoke, toxic fumes, and CBR agents within the building.
  - Consider "shelter-in-place" rooms or areas where people can congregate in the event of an outdoor release and, in some cases, indoor releases.
    - Without pressurization the goal is to create areas where outdoor air infiltration is very low.
    - With pressurization requires a filtered air supply from an installed or portable unit with filters suitable for the agent released.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-51



Mechanical and Electrical Systems

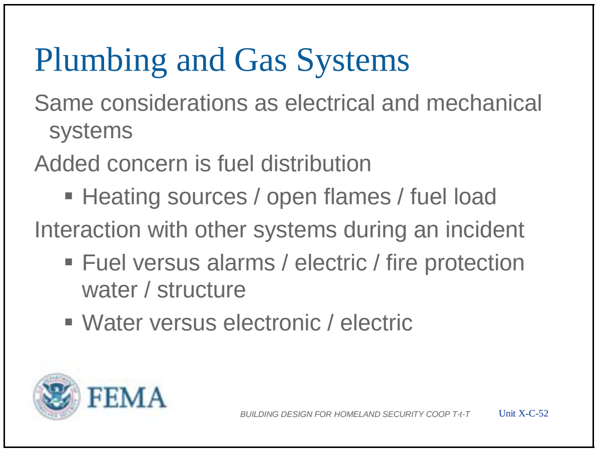
Ventilation and Filtration – HVAC Control Options

- To prevent widespread dispersion of a contaminant released within lobbies, mailrooms, and loading docks, their HVAC systems should be isolated and the areas maintained at a negative pressure relative to the rest of the building, but at positive pressure relative to the outdoors.
  - Air purge is suitable for removal of smoke and toxic fumes from fire or explosive blast
  - If a CBR release, an air purge would not be suitable as it would just spread the agent vice controlling it unless CBR filters are installed on exhaust to trap the agents and prevent spreading them.
  - Another consideration is <u>glazing</u> in these areas.
    - If <u>not hardened</u>, then windows will be blown out during an internal blast which lessens the need for air purge. This is a good design example for a frangible panel that vents pressure and reduces pressure on the walls shared by the rest of the building.
    - If <u>hardened</u>, then smoke and gases are trapped and air purge is beneficial. However, all walls will required additional hardening because of the increased internal blast pressures.
- Egress routes (stairwells) are normally pressurized to prevent smoke from internal fire from entering the stairwells. An external CBR release would be pulled into the stairwells by this system. Thus, either the pressurization system must be turned

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

off during an external release or a filtering system must engage to provide clean air to the stairwells.

VISUAL X-C-52



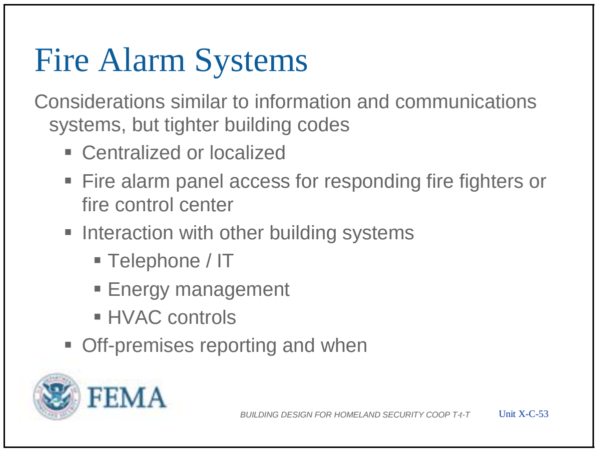
Plumbing and Gas Systems

All systems distributed throughout the building have similar consideration. There are other concerns based upon “What-If” scenarios, such as leaks occurring in plumbing or gas systems.

- Look at the physical relationship between the systems (which also includes utilities as they enter the building)
  - Will a leak in a fuel system reach a heat source and will the fuel distribution system aid in spreading the fire throughout the building?
  - Will leaks from water or fuel systems fall upon electrical systems and equipment?
    - For example, standard underground construction always puts water systems above sewer systems so that a sewer leak will have less chance of contaminating the water system.
    - Additionally, are flammable systems like fuel/natural gas separated from mass notification/communication systems so that an initial fire incident does not disable the mass notification system?

INSTRUCTOR NOTES

VISUAL X-C-53



CONTENT/ACTIVITY

Fire Alarm Systems

Similar concerns as with communications systems to be covered next, but building codes based upon National Fire Protection Association standards are more prescriptive

- First alarm to evacuate, then call the fire department
  - If localized, alarm bells sound to evacuate the building, then automatically calls fire department
  - If centralized (hotels for example), a response would verify fire before sounding evacuation and calling fire department from manned location
- Fire alarm panels are normally near main entrances of buildings so first responder fire fighters can determine which zone of the building alarmed if fire location is not obvious
  - Fire control centers are normally manned and fire department should know where they are located
- Interaction with other systems should confirm wiring of the fire alarm system, whether it is combined with any other system for information flow, and whether or not an alarm activation also initiates actions through other systems, like energy management, SCADA (Supervisory Control and Data Acquisition), or HVAC controls.
- Finally, as explained above, how is off-premises reporting done – direct telephone line to fire department, reporting to a commercial central security/fire company who contacts the fire department, centralized system manned in building which then triggers a call to the fire department or calls 911, autodial to someone else, etc.

INSTRUCTOR NOTES

VISUAL X-C-54

NOTE to instructor: The Government Emergency Telecommunications Service (GETS) is a White House-directed emergency phone service provided by the National Communications System (NCS) in the Information Analysis and Infrastructure Protection Division of the Department of Homeland Security.

- GETS provides emergency access and priority processing in the local and long distance segments of the Public Switched Telephone Network (PSTN). It is intended to be used in an emergency or crisis situation when the PSTN is congested and the probability of completing a call over normal or other alternate telecommunication means has significantly decreased.
- The result is a cost-effective, easy-to-use emergency telephone service that is accessed through a simple dialing plan and Personal Identification Number (PIN) card verification methodology. It is maintained in a constant state of readiness as a means to overcome network outages through such methods as enhanced routing and priority treatment. See **NOTE** to instructor under Visual X-C-55.

CONTENT/ACTIVITY

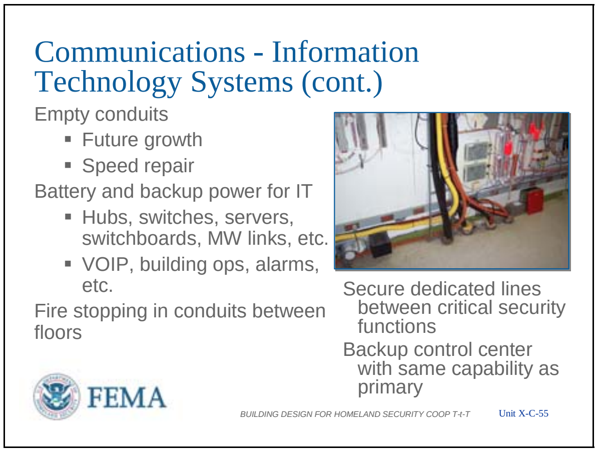
Communications – Information Technology Systems

Distribution considerations are the same as for other systems, especially to ensure some communications capability if an incident affects communication lines

- Redundancy is always a consideration and technology selected has pros and cons
  - Copper easier to tap through electromagnetic signals
  - **Cell phones** get tied up during major incidents, especially analog voice (which locks bandwidth), but walkie-talkie and text features on phones or Blackberrys use packet transmission when bandwidth is available so there is more capability as found during Hurricane Katrina
  - **Handheld radios** have blind spots both in dispersed campuses and high-rise buildings, necessitating use of repeaters or distributed antennas to maintain coverage. Consider a base radio communication system with antenna(s) installed in stairwells, and portable sets distributed on floors.
  - **Alarm and information systems.** Should not be collected and mounted in a single conduit, or even collocated. Circuits to various parts of the building should be installed in at least two directions and/or risers
  - **NOTE**: The red phone shown is a telephone connected to the local telephone company and powered by the telephone company. It is the backup to VOIP phones throughout the campus.
- Mass notification to building occupants can take many approaches, but must ensure system capability or redundancy for the range of potential incidents. Keeping occupants informed as response requirements change is vital to save lives.

INSTRUCTOR NOTES	**CONTENT/ACTIVITY**

VISUAL X-C-55



NOTE to instructor: Wireless Priority Service (WPS) allows authorized National Security/Emergency Preparedness personnel to initiate calls during an emergency when cellular networks may be congested.

- WPS gives authorized NS/EP personnel priority cellular access before subscriber who do not have WPS.
- WPS will not preempt calls in progress and does not guarantee call completion.
- In addition, WSP is complementary to, and can be used in conjunction with the Government Emergency Telecommunications Service (GETS) card. This ensures a high probability of call completion in both the landline and cellular portions of the Public Switched Network (PSN).
- Not all wireless providers currently offer the WSP feature.

NOTE to instructor: Two way pagers are also "low tech" solutions during situations that clog communication lines, especially during wide area disasters.

Communications – Information Technology Systems (cont.)

The one thing about information is that it is ever expanding, thus future load growth should always be considered, especially extra conduits that assist repairs and allow additional capability as needed.

- These conduits are for future dedicated electrical circuits, updated information systems, and additional security systems. The last being the quickest way to provide reduction in risk.

Note that battery backup and emergency power must be at or link to all distributed equipment in the IT system to keep system functional

- If other capabilities like VOIP (Voice Over Internet Protocol) telephones, building operations, or alarms on IT Systems increases need for the electric backup

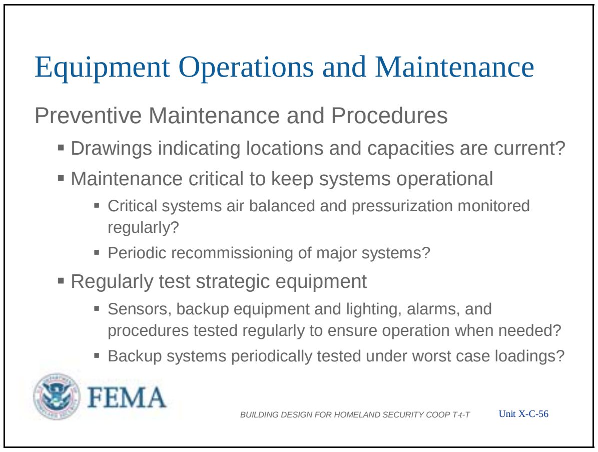
Historically, communications systems have been installed without consideration for other building codes – for example, conduits between floors must have fire stopping installed to prevent spread of fires, fuel leaks, gas leaks, defeat of zone pressurization, or spread of CBR agents and other toxic materials.

Security information and flow of information to building occupants is critical before, during, and after an incident. Dedicated communication lines between security functions – such as central security control and entry control stations keeps information current, especially during deter and detect situations. Control centers for security, fire, and emergency operations may have backup locations depending upon the size of the organization or site. Communications

INSTRUCTOR NOTES	CONTENT/ACTIVITY

capability should be replicated at the backup site, or if alternative methods are used, staff must be trained for both primary and backup procedures and equipment.

VISUAL X-C-56



Equipment Operations and Maintenance

- Keeping drawings up to date and ensuring capacities meet current needs as functions and infrastructure changes occur are necessary for proper maintenance and operation
- An emergency system that will not function properly when called upon will result in increased damage and casualties
  - In the past, US military installations in a foreign country tested their Class B generator plant (sized to support the complete installation when commercial power lost) at 5:00 am on Sunday morning to avoid inconveniencing people. Class A plants are prime power and used where there is no reliable commercial power. Class C units are also backups but of smaller size and distributed at the critical loads and buildings. One engineer knew that this did not ensure operation when needed and convinced decision makers to run the test during the peak electrical load of the month (units were tested once a month for two hours). It took almost six months of incremental repair before the plant could run for the full 2 hours. Six moths later a country-wide power outage occurred. This installation was the only US installation that stayed fully operational for the whole commercial power outage.
- Bottom line: Preventive maintenance and testing that ensures the systems will work in all required modes, including emergency situations, must be done to ensure proper functioning when they are called upon.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-57

Equipment Operations and Maintenance

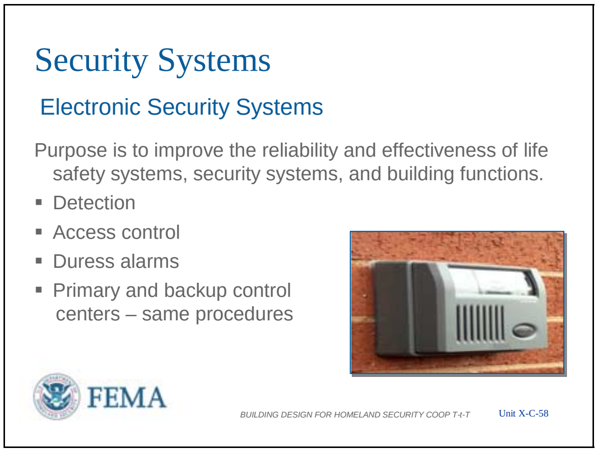
Maintenance Staff Training

Since emergency systems, especially HVAC, are not standard building components, the staff must receive training in how the upgraded mechanical systems are designed to work, how they should be operated, and how they should be maintained and tested.

- A high-rise in Chicago was designed to have all lights burning 24 hours a day in the winter as part of the heating system design. A new manager demanded the lights be turned off and the staff could not explain why so they were turned off. A cold snap hit and the small supplemental boiler in the basement and the lights turned back on took 4 days to bring the building back to desired office temperatures.
- Maintenance and operational staff must have the training in the operational procedures for all potential situations in how the building will be reconfigured, especially for CBR events outside and inside the building.
- Another point based upon experience, is that maintenance staff will be more likely to perform maintenance, repairs, and testing if the equipment is accessible. The more difficult it is to perform these actions the less likely they will be done.
  - Example – steam boiler in penthouse of 3-story building required weekly replenishment of water treatment chemicals. An elevator got the heavy chemicals to the third floor, but to get to the penthouse required winding through offices and then carrying them up a vertical ladder to a roof hatch. The building was originally designed for a location with water that did not need water treatment.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-58



Chapter 3 of FEMA 426 is not a design guide for Electronic Security Systems (ESS). The following criteria are only intended to stress those concepts and practices that warrant special attention to enhance public safety. Consult design guides pertinent to the specific project for detailed information about electronic security. A description of Electronic Security Systems is provided in **Appendix D of FEMA 426.**

Security Systems

Electronic Security Systems

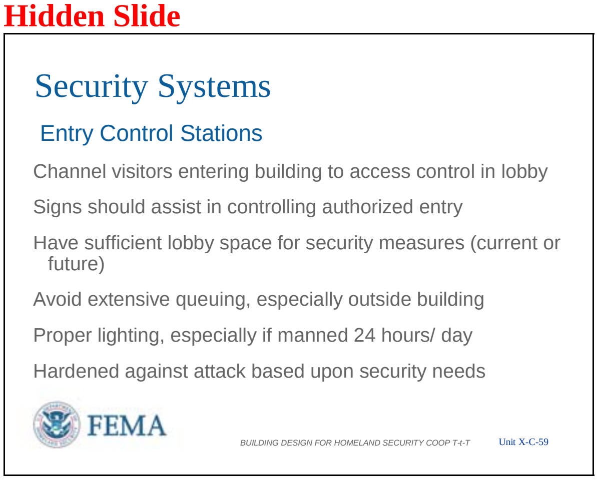
The purpose of electronic security is to improve the reliability and effectiveness of life safety systems, security systems, and building functions. When possible, accommodations should be made for future developments in security systems.

- Basic intrusion detection devices should be provided: magnetic reed switches for interior doors and openings, glass break sensors for windows up to scalable heights, and balanced magnetic contact switch sets for all exterior doors, including overhead/roll-up doors. Roof intrusion detection should be reviewed.
- A color CCTV surveillance system with recording capability should be provided to view and record activity at the perimeter of the building, particularly at primary entrances and exits.
- Consider duress alarms at Entry Control Stations, where the general public has contact, and other locations as deemed necessary from threat or past history. Also call boxes in parking areas for similar function.
- The Operational Control Center (OCC), Fire Command Center (FCC), and Security Control Center (SCC) may be collocated. If collocated, the chain of command should be carefully pre-planned to ensure the most qualified leadership is in control for specific types of events. Secure information links should be provided between the OCC, FCC, and SCC.
- A Backup Control Center (BCC) should be provided in a different location, such as a manager's or engineer's office. If

feasible, an off-site location should be considered.
- A fully redundant BCC should be installed (this is an alternative to the above).
- An on-site monitoring center should be used during normal business hours and be operational 24 hours. When not manned the monitoring center responsibility can be transferred to an off-site location

These criteria primarily address access control design, including stair and lobby design, because access control must be considered when design concepts for a building are first conceived. Although fewer options are available for modernization projects, some designs can be altered to consider future access control objectives.

VISUAL X-C-59
Hidden Slide



Security Systems

Entry Control Stations

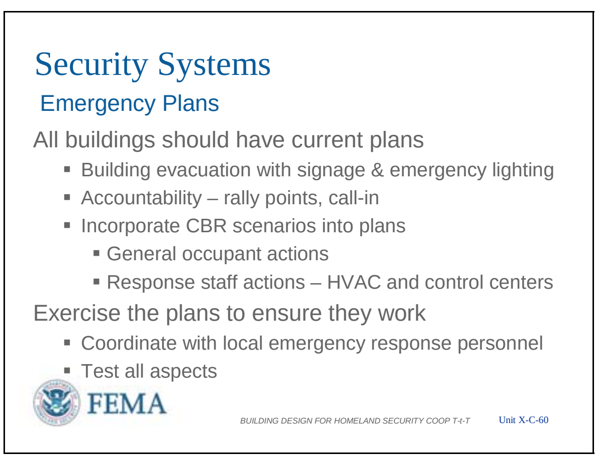
Entry control stations should be provided at main perimeter entrances of the building where security personnel are present (see **Figure 3-12, page 3-48, of FEMA 426**). In addition, entry control stations should be located close to the perimeter entrance to permit people inside the entry control station to maintain constant surveillance over the entrance and its approaches. Note that many of the considerations for entry control stations listed here are appropriate for Site and Layout Design as discussed in **Chapter 2 of FEMA 426**. Additional considerations at entry control stations include:

- Channel visitors to access control with appropriate signage to differentiate between visitors and building occupants / tenants
- Additional space is needed for metal

INSTRUCTOR NOTES	CONTENT/ACTIVITY

detectors and x-ray machines. If not installed initially, allow future space in case they may be installed later.
- Queuing should be limited, i.e. access control should have sufficient throughput to avoid having a high concentration of personnel at the entrance at any time. Queuing that takes the line outside the building should be avoided at all costs.
- Lighting, with CCTV should assist in identification and access control.
- Entry control stations should be hardened against attacks according to the type of threat. The methods of hardening may include:
    - Reinforced concrete or masonry
    - Steel plating
    - Bullet-resistant glass
    - Commercially fabricated, bullet-resistant building components or assemblies
- Entry control stations adjacent to the building but not inside should have appropriate environmental support (heat / air conditioning), lighting, and sufficient glassed area to afford adequate observation for people inside.

VISUAL X-C-60



Security Systems

Emergency Plans

All buildings should have current **emergency plans** to address fire, weather, and other types of emergencies.

In light of past U.S. experiences with anthrax and similar threats, these plans should be updated to consider CBR attack scenarios and the associated procedures. Emergency plans should have procedures for communicating instructions to building occupants, identifying suitable shelter-in-place areas (if they exist), identifying appropriate use and selection of

INSTRUCTOR NOTES	CONTENT/ACTIVITY

personal protective equipment (i.e., clothing, gloves, respirators), and directing emergency evacuations.

Building design should be able to ensure the optimal operation of the emergency plans. The emergency plans should not default to only what can be done after the building is constructed. In other words, like security and homeland defense, emergency planning should be an up-front design consideration that gets incorporated into the planning, budgeting, and design of the building.

Note that bomb threats have been used in the past by terrorists to evaluate evacuation procedures and determine where the evacuees congregate after leaving the building. Consider multiple rally points (A, B, and C) and vary their use so that a pattern cannot be determined by terrorist surveillance.

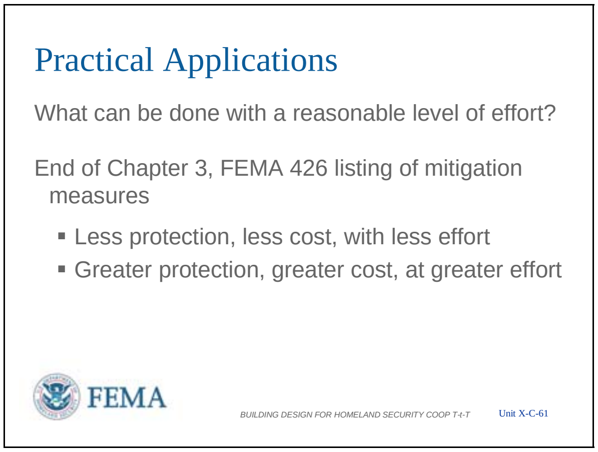
Then the plans must be tested to ensure they work in all situations, that what is written can actually be done, especially at the speed required, and that the plans and equipment operation work in agreement.

Note that walking egress routes are not always down a single stairwell, especially in high-rise building as in the World Trade Center Complex. Recommend exercising an annual evacuation exercise to ensure most people know the egress routes (primary and alternate) and can negotiate them in a speedy manner. Signage and lighting along the whole route should also be evaluated at the same time.

Additionally, all security locking arrangements on doors used for egress must comply with requirements of the National Fire Protection Association (NFPA) 101, Life Safety Code.

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-61



Direct students to **Table 2-1 in FEMA 426** and arrow listing on **pages 3-51 and 3-52 of FEMA 426.**

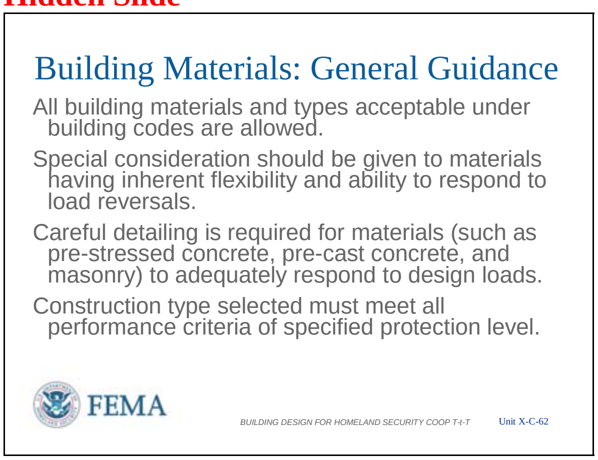
Practical Applications

What can be done with a reasonable level of effort?

Consult **Table 2-1, page 2-54, of FEMA 426** to understand the benefit of various mitigation efforts against a range of terrorist tactics.

There is a range of FEMA 426 mitigation efforts at a range of cost. Consult **pages 3-51 and 3-52 of FEMA 426** to see the range of relative costs for most situations.

VISUAL X-C-62
Hidden Slide

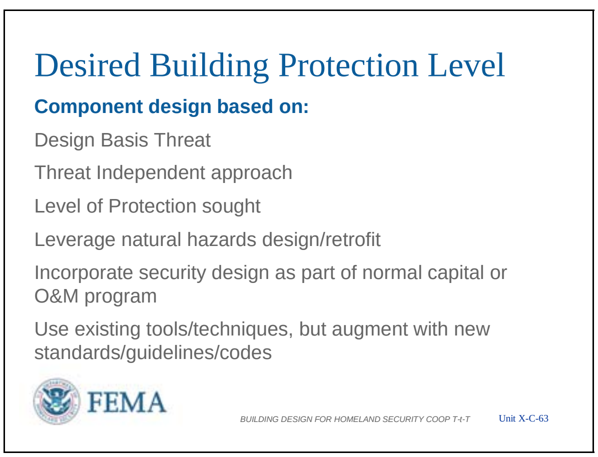


Building Materials: General Guidance

- All building materials and types acceptable under model building codes are allowed (except unreinforced masonry – brick and/or CMU (concrete masonry unit) – concrete block.
- Special consideration should be given to materials that have inherent flexibility and that are better able to respond to load reversals (i.e., cast in place reinforced concrete and steel construction).
- Careful detailing is required for material such as pre-stressed concrete, pre-cast concrete, and masonry (brick and concrete masonry unit) to adequately respond to the design loads. Even calling out seismic connections may not be adequate as the workforce may not be familiar with the changes from their norm; thus detailing is very important.
    - For example, aluminum wiring is not used in homes in the US because copper trained electricians over-

INSTRUCTOR NOTES | **CONTENT/ACTIVITY**

VISUAL X-C-63



Establishing the design basis threat early in the design cycle reduces cost, has synergies with other requirements – seismic and wind, and should never be an afterthought of the design. Even for a low threat, there is value

torqued the connections, causing cold flow, loose connections, and fires. Great Britain took path to put copper on the outside of aluminum, taking advantage of the less expensive aluminum without getting the cold flow problem.

  - Another example, plastic water pipe initially installed by copper-trained plumbers were not twisted 90 degrees to spread the glue as this was not needed when soldering copper. Imperfections in the plastic would scrape the glue away resulting in leaks. Plumbers now know this procedure and we still use plastic water piping.

- The construction type selected must meet all performance criteria of the specified level of protection.
- The designer must bear in mind that the design approaches are, at times, in conflict. These conflicts must be worked out on a case by case basis.

Desired Building Protection Level

The assessment process to this point should determine the level of protection sought for the building structure based upon the threat / hazard specific to the facility. Explosive blast threats usually govern building structural design for high risk buildings.

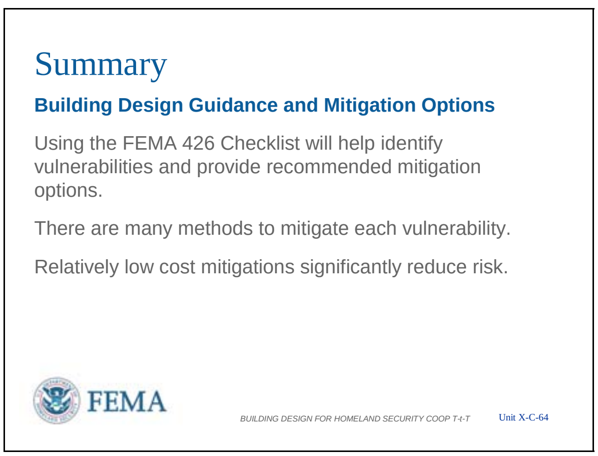
Some design approaches are threat independent, such as progressive collapse. Other approaches depend upon an identified Design Basis Threat. The design basis threat is the terrorism hazard equivalent to the natural hazards design basis which is based upon recorded history, measurement methods to determine the magnitude of the hazard and have been established as building codes based on the weather and geological conditions of the locality.

INSTRUCTOR NOTES

in providing certain minimum features to the site and building design. This allows adjustment to the level of protection if the level of threat changes. This is the current philosophy of the Department of Defense.

Even if no design changes result, the understanding in going through the assessment process, especially in the data collection and identifying Points of Contact, is beneficial if future man-made hazards threaten or occur.

VISUAL X-C-64



CONTENT/ACTIVITY

Whenever there are projects to accomplish in a building, seek to leverage natural hazard upgrades, energy conservation upgrades, and other capital improvement or O&M (Operations and Maintenance) work to achieve synergies at less cost to achieve HVAC upgrades and building hardening.

In every design situation, the intent is to seek a balance between all the different requirements to include in the design (e.g., antiterrorism, energy conservation, building code, seismic, wind, snow loading, handicap access, adjacent architecture, etc.).

Summary

To summarize:

This unit provides a foundation for a systematic approach to assessing the vulnerabilities of a building to manmade hazards.

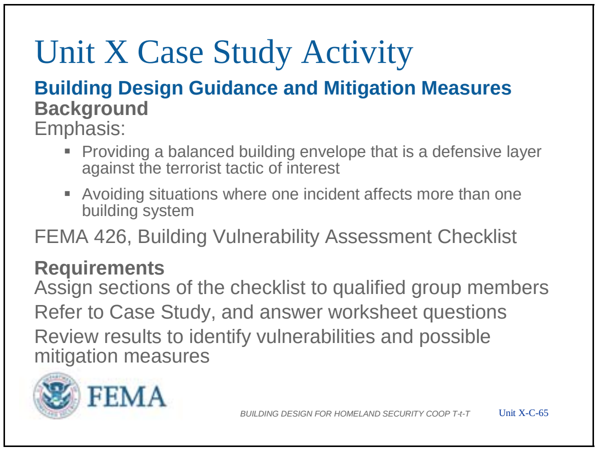
The **Building Vulnerability Assessment Checklist in FEMA 426** can provide an excellent framework for the identification of mitigation options that will, over time, significantly reduce the vulnerability of a building to manmade hazards.

Note that there are many different techniques to mitigate each vulnerability. They have different costs and may increase, reduce, or have no effect on risk for other tactics. Thus, each mitigation measure needs to be compared to every threat / hazard tactic for the building particulars.

Antiterrorism assessment teams that have been operating over 5 years indicate that historically about 80 percent of mitigation recommendations are low cost /no cost

INSTRUCTOR NOTES

VISUAL X-C-65



Refer participants to **FEMA 426**, the Unit X Case Study activity in the Student Manual.

Members of the instructor staff should be available to answer questions and assist groups as needed.

At the end of 45 minutes, reconvene the class and facilitate group reporting. Take 15 minutes to review group results.

There are <u>25 questions</u> to answer by the team and then confer. With an average of 7 team members this means each member answers about 4 questions or about <u>7 minutes per question</u> during their 30 minutes of research.

CONTENT/ACTIVITY

planning and procedural changes.

Student Activity

The **Building Vulnerability Assessment Checklist in FEMA 426** can be used as a screening tool for vulnerability assessment of an existing building or a preliminary design.

The checklist includes questions that determine if critical systems will continue to function to enhance deterrence, detection, denial, and damage limitation, and emergency systems function during a threat or hazard situation.

Activity Requirements

- Continue working is small groups.
- Assign sections of the checklist to the group members who are most knowledgeable and qualified to perform an assessment of the assigned area. There are 49 questions so that with 7 students (working group size sought), each student would need to answer 7 questions in about 30 minutes (4-5 minutes per question) leaving 15 minutes to discuss results as a group.
- Refer to the Case Study to determine answers to the worksheet questions.
- Then review results as a team to identify vulnerabilities and possible mitigation measures.

Take 45 minutes to complete this activity. Solutions will be reviewed in plenary group.

Transition

Unit XI will cover Electronic Security Systems.

UNIT X (C) CASE STUDY ACTIVITY: BUILDING DESIGN GUIDANCE (COOP Version)

In this student activity, the emphasis is identifying vulnerabilities in the building design. The **Building Vulnerability Assessment Checklist in FEMA 426 (Table 1-22, pages 1-46 to 1-93)** provides a tool for vulnerability assessment of the proposed and existing sites and buildings.

Requirements

Assign sections of the checklist to group members who are most knowledgeable and qualified to perform an assessment of the assigned area. Refer to the Appendix C Case Study to determine answers to the questions. Then review results as a team to identify vulnerabilities and possible mitigation measures.

Activity # 1: Complete the selected vulnerability checklist questions in the following Vulnerability Questions table.

> **Note**: There are **25 questions** below (**9** in Section 2, **4** in Section 3, **1** in Section 4, **3** in Section 6, **3** in Section 8, **3** in Section 9, and **2** in Section 10), so it is recommended that the team split up the questions among themselves taking 3-5 questions each and review the Appendix C Case Study for answers. Apportion the available time for gathering the answers and then provide each other the answers while performing the actions below.

Activity # 2: Upon completion of the questions refer back to the vulnerability ratings determined in the Unit IV (C) Student Activity. Based on this more detailed analysis, decide if any vulnerability rating needs adjustment. Adjust the Risk Matrix poster accordingly for any changes in vulnerability rating.

Activity # 3: Select mitigation measures to reduce vulnerability and associated risk from the building perspective. Concentrate on the three highest risk ratings on the Risk Matrix poster as adjusted by Activity # 2. Use the Building Design Mitigation Measures table found at the end of this unit to capture this information.

Activity # 4: Consider the mitigation measures of Activity #3 to be installed, estimate the new vulnerability ratings as if these measures were in place, and calculate the new risk ratings. Capture your information in the Building Design Mitigation Measures table.

Section	Vulnerability Question	Guidance	Observations
2	**Architectural**		
2.7	Is access control provided through main entrance points for employees and visitors? (lobby receptionist, sign-in, staff escorts, issue of visitor badges, checking forms of personal identification, electronic access control systems)	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	***Visitor access control is handled in the lobby by the receptionist, who signs the visitors in and contacts staff to provide escort. Employees use electronic access control to enter the building.*** ***Access control at other companies within the complex is unknown.***
2.9	Is access to elevators distinguished as to those that are designated only for employees and visitors?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	***No elevators in building.***
2.10	Do public and employee entrances include space for possible future installation of access control and screening equipment?	These include walk-through metal detectors and x-ray devices, identification check, electronic access card, search stations, and turnstiles. Reference: *GSA PBS-P100*	***Yes, lobby / reception area within building could accommodate space-saving screening equipment. Interior office space also has adequate room for such equipment.***
2.15	Are critical assets (people, activities, building systems and components) located close to any main entrance, vehicle circulation, parking, maintenance area, loading dock, or interior parking? Are the critical building systems and components hardened?	Critical building components include: Emergency generator including fuel systems, day tank, fire sprinkler, and water supply; Normal fuel storage; Main switchgear; Telephone distribution and main switchgear; Fire pumps; Building control centers; Uninterruptible Power Supply (UPS) systems controlling critical functions; Main refrigeration and ventilation systems if critical to building operation; Elevator machinery and controls; Shafts for stairs, elevators, and utilities; Critical distribution feeders for emergency power. Evacuation and rescue require emergency systems to remain operational during a disaster and they should	***Electrical service is provided through two buried transmission lines from two separate pad-mounted transformers outside the building near the rear loading dock. Emergency power is provided by a single diesel generator, located in a shed in the rear parking lot, also near the loading dock. The generator has a 250-gallon day tank, maintained at 80 percent capacity. The 2,000-gallon main tank is buried under the parking lot, near the generator.*** ***The batteries to support the UPS are in a small room next to the UPS room.***

Section	Vulnerability Question	Guidance	Observations
		be located away from potential attack locations. Primary and backup systems should be separated to reduce the risk of both being impacted by a single incident if collocated. Utility systems should be located at least 50 feet from loading docks, front entrances, and parking areas. One way to harden critical building systems and components is to enclose them within hardened walls, floors, and ceilings. Do not place them near high-risk areas where they can receive collateral damage. Reference: *GSA PBS-P100*	***Natural gas enters the building through two meters under the loading dock staircase and goes overhead to the mechanical and electrical (M&E) room at the building's southwest corner.*** ***The Communications Center has an outside wall as does the Electrical/Mechanical Room. Both can be reached from the rear parking area.*** ***Due to the size of the building, separation of critical assets away from higher threat areas is very limited.*** ***Most of the critical utilities are either in the rear parking area or near the loading dock or both.*** ***None of the critical assets has any hardening or special considerations.***
2.16	Are high-value or critical assets located as far into the interior of the building as possible and separated from the public areas of the building?	Critical assets, such as people and activities, are more vulnerable to hazards when on an exterior building wall or adjacent to uncontrolled public areas inside the building. Reference: *GSA PBS-P100*	***People are located along the exterior wall at the front of the building. The Secure Space, Secure Office Space, and Conference Room have the best interior space location – not on an exterior wall. The remaining office space acts as the buffer between the critical functions in the back and the public area of the building at the main entrance.*** ***M&E room is located on an exterior wall.*** ***The Business Center can be considered a public use area, with some restrictions. The secure areas are separated from the public areas by walls and doors with access controls.***

Section	Vulnerability Question	Guidance	Observations
2.19	Are loading docks and receiving and shipping areas separated in any direction from utility rooms, utility mains, and service entrances, including electrical, telephone/data, fire detection/alarm systems, fire suppression water mains, cooling and heating mains, etc.?	Loading docks should be designed to keep vehicles from driving into or parking under the building. If loading docks are in close proximity to critical equipment, consider hardening the equipment and service against explosive blast. Consider a 50-foot separation distance in all directions. Reference: *GSA PBS-P100*	***No, the loading dock connects directly into interior space, critical functions, and infrastructure. A commercial power transformer, the natural gas meters, and the M&E rooms are within 50 feet of the loading dock.*** ***The Communications Center is separated from the loading dock as is the telephone and telecommunications lines.***
2.20	Are mailrooms located away from building main entrances, areas containing critical services, utilities, distribution systems, and important assets? Is the mailroom located near the loading dock?	The mailroom should be located at the perimeter of the building with an outside wall or window designed for pressure relief. By separating the mailroom and the loading dock, the collateral damage of an incident at one has less impact upon the other. However, this may be the preferred mailroom location. Off-site screening stations or a separate delivery processing building on site may be cost-effective, particularly if several buildings may share one mailroom. A separate delivery processing building reduces risk and simplifies protection measures. Reference: *GSA PBS-P100*	***CI/BC has no mail room. Incoming mail is normally processed by the receptionist in the foyer inside the front door. Large packages are delivered to the loading dock.*** ***The foyer, where mail is delivered, is of standard office construction. Explosive blast inside the foyer would affect exterior walls (glazing) and interior walls (gypsum board on metal studs) about equally.***
2.23	Are stairwells required for emergency egress located as remotely as possible from high-risk areas where blast events might occur? Are stairways maintained with positive pressure or are there other smoke control systems?	Consider designing stairs so that they discharge into other than lobbies, parking, or loading areas. Maintaining positive pressure from a clean source of air (may require special filtering) aids in egress by keeping smoke, heat, toxic fumes, etc. out of the stairway. Pressurize exit stairways in accordance with the National Model Building Code.	***Stairways are located in the interior of the building, away from the perimeter walls. They are part of the steel mezzanine design and are towards the front of the building. Multiple exits are located around the building and from both the front and rear. Emergency stairways from mezzanine are located on opposite ends of the non-Information Division spaces***

Section	Vulnerability Question	Guidance	Observations
		Reference: *GSA PBS-P100 and CDC/NIOSH, Pub 2002-139*	***Stairways are open and not designed with any fire protection features, such as a positive pressure system.***
2.26	Are emergency systems located away from high-risk areas?	The intent is to keep the emergency systems out of harm's way, such that one incident takes out all capability – both the regular systems and their backups. Reference: *FEMA 386-7*	***The high risk areas are the front entrance and the rear loading dock. Emergency / backup generator is located over 50 feet away from main power supply lines, loading dock, and M&E room. UPS is located inside the building's high bay area, but probably within 50 feet of the loading dock.***
3	**Structural Systems**		
3.1	What type of construction? What type of concrete and reinforcing steel? What type of steel? What type of foundation?	The type of construction provides an indication of the robustness to abnormal loading and load reversals. A reinforced concrete moment-resisting frame provides greater ductility and redundancy than a flat-slab or flat-plate construction. The ductility of steel frame with metal deck depends on the connection details and pre-tensioned or post-tensioned construction provides little capacity for abnormal loading patterns and load reversals. The resistance of load-bearing wall structures varies to a great extent, depending on whether the walls are reinforced or unreinforced. A rapid screening process developed by FEMA for assessing structural hazards identifies the following types of construction with a structural score ranging from 1.0 to 8.5. A higher score indicates a greater capacity to sustain load reversals. Wood buildings of all types - 4.5 to 8.5 Steel moment-resisting frames - 3.5 to 4.5 Braced steel frames - 2.5 to 3.0 Light metal buildings - 5.5 to 6.5	***Located in a suburban office complex, the CI/BC office building comprises a 19,000-square foot main floor for offices and computers, and a 3,300-square foot executive mezzanine (a second floor over part of the office).*** ***The building is an office building of standard construction.*** ***The walls are made of concrete blocks (CMU-concrete masonry units) with a brick veneer on the outside. Steel framework supports the structure, and exposed interior columns are enclosed in gypsum wallboard. The roof is a metal deck with gravel on top and insulation underneath. It is slightly angled to allow water to drain. The roof overhangs the front entrance by 8 feet. This provides a covered area for employees to stay dry on rainy days. Cylindrical columns support the overhang.***

Section	Vulnerability Question	Guidance	Observations
		Steel frames with cast-in-place concrete shear walls - 3.5 to 4.5 Steel frames with unreinforced masonry infill walls - 1.5 to 3.0 Concrete moment-resisting frames - 2.0 to 4.0 Concrete shear wall buildings - 3.0 to 4.0 Concrete frames with unreinforced masonry infill walls - 1.5 to 3.0 Tilt-up buildings - 2.0 to 3.5 Precast concrete frame buildings - 1.5 to 2.5 Reinforced masonry - 3.0 to 4.0 Unreinforced masonry - 1.0 to 2.5 References: *FEMA 154 and Physical Security Assessment for the Department of Veterans Affairs Facilities*	
3.5	Will the structure suffer an unacceptable level of damage resulting from the postulated threat (blast loading or weapon impact)?	The extent of damage to the structure and exterior wall systems from the bomb threat may be related to a protection level. The following is for new buildings: Level of Protection Below Antiterrorism Standards - Severe damage. Frame collapse/massive destruction. Little left standing. Doors and windows fail and result in lethal hazards. Majority of personnel suffer fatalities. Very Low Level Protection - Heavy damage. Onset of structural collapse. Major deformation of primary and secondary structural members, but progressive collapse is unlikely. Collapse of non-structural elements. Glazing will break and is likely to be propelled into the building, resulting in serious glazing fragment injuries, but fragments will be reduced. Doors may be propelled into rooms, presenting serious hazards. Majority of	***The standard construction techniques used to build the site CI/BC occupies do not create buildings that withstand explosive blasts. Terrorist threat was not a part of design consideration.***

Section	Vulnerability Question	Guidance	Observations
		personnel suffer serious injuries. There are likely to be a limited number (10 percent to 25 percent) of fatalities. Low Level of Protection - Moderate damage, unrepairable. Major deformation of non-structural elements and secondary structural members and minor deformation of primary structural members, but progressive collapse is unlikely. Glazing will break, but fall within 1 meter of the wall or otherwise not present a significant fragment hazard. Doors may fail, but they will rebound out of their frames, presenting minimal hazards. Majority of personnel suffer significant injuries. There may be a few (<10 percent) fatalities. Medium Level Protection - Minor damage, repairable. Minor deformations of non-structural elements and secondary structural members and no permanent deformation in primary structural members. Glazing will break, but will remain in the window frame. Doors will stay in frames, but will not be reusable. Some minor injuries, but fatalities are unlikely. High Level Protection - Minimal damage, repairable. No permanent deformation of primary and secondary structural members or non-structural elements. Glazing will not break. Doors will be reusable. Only superficial injuries are likely. Reference: *DoD UFC 4-010-01*	
3.6	Is the structure vulnerable to progressive collapse?	Design to mitigate progressive collapse is an independent analysis to determine a system's ability to resist structural collapse upon the loss of a major	***Since the CI/BC building is a one story building with a mezzanine, progressive collapse is not a great concern. Loss of a perimeter***

Section	Vulnerability Question	Guidance	Observations
	Is the building capable of sustaining the removal of a column for one floor above grade at the building perimeter without progressive collapse? In the event of an internal explosion in an uncontrolled public ground floor area, does the design prevent progressive collapse due to the loss of one primary column? Do architectural or structural features provide a minimum 6-inch stand-off to the internal columns (primary vertical load carrying members)? Are the columns in the unscreened internal spaces designed for an unbraced length equal to two floors, or three floors where there are two levels of parking?	structural element or the system's ability to resist the loss of a major structural element. Design to mitigate progressive collapse may be based on the methods outlined in ASCE 7-98 (now 7-02). Designers may apply static and/or dynamic methods of analysis to meet this requirement and ultimate load capacities may be assumed in the analyses. Combine structural upgrades for retrofits to existing buildings, such as seismic and progressive collapse, into a single project due to the economic synergies and other cross benefits. Existing facilities may be retrofitted to withstand the design level threat or to accept the loss of a column for one floor above grade at the building perimeter without progressive collapse. Note that collapse of floors or roof must not be permitted. Reference: *GSA PBS-P100*	***column would result in localized collapse as would loss of a column holding up the mezzanine.***
3.10	Will the loading dock design limit damage to adjacent areas and vent explosive force to the exterior of the building?	Design the floor of the loading dock for blast resistance if the area below is occupied or contains critical utilities. Reference: *GSA PBS-P100*	***The loading dock is the weakest part of the exterior rear wall. There are no hardened walls between the loading dock and the rest of the building as the plan shows only standard gypboard and metal stud walls.*** ***Thus the loading dock will not limit any damage into the building and anything occurring on the loading***

Section	Vulnerability Question	Guidance	Observations
			dock will directly affect the building interior. ***Fortunately, the vehicles only back up to the loading dock and the vehicles do not enter the building.***
4	**Building Envelope**		
4.2	Is there less than 40 percent fenestration per structural bay? Is the window system design on the exterior façade balanced to mitigate the hazardous effects of flying glazing following an explosive event? (glazing, frames, anchorage to supporting walls, etc.) Do the glazing systems with a ½-inch (¾-inch is better) bite contain an application of structural silicone? Is the glazing laminated or is it protected with an anti-shatter (fragment retention) film? If an anti-shatter film is used, is it a minimum of a 7-mil thick film, or specially manufactured 4-mil thick film?	The performance of the glass will similarly depend on the materials. Glazing may be single pane or double pane, monolithic or laminated, annealed, heat strengthened or fully tempered. The percent fenestration is a balance between protection level, cost, the architectural look of the building within its surroundings, and building codes. One goal is to keep fenestration to below 40 percent of the building envelope vertical surface area, but the process must balance differing requirements. A blast engineer may prefer no windows; an architect may favor window curtain walls; building codes require so much fenestration per square footage of floor area; fire codes require a prescribed window opening area if the window is a designated escape route; and the building owner has cost concerns. Ideally, an owner would want 100 percent of the glazed area to provide the design protection level against the postulated explosive threat (design basis threat– weapon size at the expected stand-off distance). However, economics and geometry may allow 80 percent to 90 percent due to the statistical differences in the manufacturing process for glass or the angle of incidence of the blast wave upon upper story windows (4th floor and higher).	***All windows are in the office space area of the building (complete in the front and half of one side). In that area the fenestration is more than 40%.*** ***Fenster is German for window.*** ***The window system is standard commercial construction and thus, the glass, framing, and anchorage are expected to be insufficient for the design basis threat at the available stand-off. One benefit is that there are windows only on two sides of the building.***

Section	Vulnerability Question	Guidance	Observations
		Reference: *GSA PBS-P100*	
6	**Mechanical Systems (HVAC and CBR)**		
6.1	Where are the air intakes and exhaust louvers for the building? (low, high, or midpoint of the building structure) Are the intakes and exhausts accessible to the public?	Air intakes should be located on the roof or as high as possible. Otherwise secure within CPTED-compliant fencing or enclosure. The fencing or enclosure should have a sloped roof to prevent the throwing of anything into the enclosure near the intakes. Reference: *GSA PBS-P100 states that air intakes should be on the fourth floor or higher and, on buildings with three floors or less, they should be on the roof or as high as practical. Locating intakes high on a wall is preferred over a roof location.* Reference: *DoD UFC 4-010-01 states that, for all new inhabited buildings covered by FEMA 426, all air intakes should be located at least 3 meters (10 feet) above the ground.* Reference: *CDC/NIOSH, Pub 2002-139 states: "An extension height of 12 feet (3.7 m) will place the intake out of reach of individuals without some assistance. Also, the entrance to the intake should be covered with a sloped metal mesh to reduce the threat of objects being tossed into the intake. A minimum slope of 45° is generally adequate. Extension height should be increased where existing platforms or building features (i.e., loading docks, retaining walls) might provide access to the outdoor air intakes."* Reference*: LBNL Pub 51959: Exhausts are also a concern during an outdoor release, especially if exhaust fans are not*	***Outside air is brought in through a vent in the wall. The vent is alarmed to prevent intruder access.*** ***A screened exhaust duct is on the roof.***

Section	Vulnerability Question	Guidance	Observations
		in continuous operation, due to wind effects and chimney effects (air movement due to differential temperature).	
6.3	Are there multiple air intake locations?	Single air intakes may feed several air handling units. Indicate if the air intakes are localized or separated. Installing low-leakage dampers is one way to provide the system separation when necessary. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	***No, there is only one air intake.***
6.4	What are the types of air filtration? Include the efficiency and number of filter modules for each of the main air handling systems. Is there any collective protection for chemical, biological, and radiological contamination designed into the building?	MERV – Minimum Efficiency Reporting Value HEPA – High Efficiency Particulate Air Activated charcoal for gases Ultraviolet C for biologicals Consider mix of approaches for optimum protection and cost-effectiveness. Reference: *CDC/NIOSH Pub 2002-139*	***The air used to heat or cool the building is filtered in the HVAC room using standard industrial grade MERV 8 filters.*** ***There is no CBR protection designed into the building.***
8	**Electrical Systems**		
8.1	Are there any transformers or switchgears located outside the building or accessible from the building exterior? Are they vulnerable to public access? Are they secured?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	***The two 12.47KV feeders lead to two separate transformers outside the building, one near the north side by the loading dock, and the other near the south side by the M&E room.*** ***These transformers are in the rear parking lot, accessible to the public and secured only by a heavy duty lock.***
8.4	Are critical electrical systems collocated with other building systems?	Collocation concerns include rooms, ceilings, raceways, conduits, panels, and risers.	***Yes, the electrical system is located adjacent to the main telecommunication and server closet. The HVAC***

Section	Vulnerability Question	Guidance	Observations
	Are critical electrical systems located in areas outside of secured electrical areas? Is security system wiring located separately from electrical and other service systems?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	***room is also located adjacent to the electrical distribution room.*** ***Commercial and backup switchgear are both in the M&E room. Wiring is run as inexpensively as possible to minimize rental costs, which means in same pipe chases or adjacent conduit.***
8.6	Does emergency backup power exist for all areas within the building or for critical areas only? How is the emergency power distributed? Is the emergency power system independent from the normal electrical service, particularly in critical areas?	There should be no single critical node that allows both the normal electrical service and the emergency backup power to be affected by a single incident. Automatic transfer switches and interconnecting switchgear are the initial concerns. Emergency and normal electrical equipment should be installed separately, at different locations, and as far apart as possible. Reference: *GSA PBS-P100*	***Yes, emergency backup power exists and can be routed to all areas of the building. The automatic transfer switch in the M&E room is a single point vulnerability in the system.*** ***Critical computer systems are backed up by an UPS (uninterruptible power supply) that is maintained separately from the site's generator back-up power.*** ***All individual computers / monitors have small (~750va) UPSs.***
9	**Fire Alarm Systems**		
9.1	Is the building fire alarm system centralized or localized? How are alarms made known, both locally and centrally? Are critical documents and control systems located in a secure yet accessible location?	Fire alarm systems must first warn building occupants to evacuate for life safety. Then they must inform the responding agency to dispatch fire equipment and personnel. Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	***The building fire alarm system is centralized. The fire alarm is routed over telephone lines directly to the fire department. No intermediate monitoring agency is required for notification. An intermediate monitoring system is only used for the security alarm. However, this intermediate security monitoring agency also monitors the fire alarm system and contacts the fire department as a backup to the directly connected fire alarm.***

Section	Vulnerability Question	Guidance	Observations
9.2	Where are the fire alarm panels located? Do they allow access to unauthorized personnel?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	***The fire alarm panels are located in the building portion adjacent to CI/BC. The CI/BC security manager has a key to that part of the building for access to the fire alarm panels. However, the panels are accessible to the occupants / tenants of that building portion.***
9.3	Is the fire alarm system standalone or integrated with other functions such as security and environmental or building management systems? What is the interface?	Reference: *Physical Security Assessment for the Department of Veterans Affairs Facilities*	***The fire alarm system is standalone and separate from the security system. The system uses the telephone circuits to place a call to the local fire department.***
10	**Communications and IT Systems**		
10.5	Are there redundant communications systems available?	Critical areas should be supplied with multiple or redundant means of communications. Power outage phones can provide redundancy as they connect directly to the local commercial telephone switch off site and not through the building telephone switch in the main telephone distribution room. A base radio communication system with antenna can be installed in stairwells, and portable sets distributed to floors. References: *GSA PBS-P100 and FEMA 386-7*	***No, there are no installed redundant communication systems available as part of any building system. The only redundant communications are cell phones which operate throughout the building.***
10.15	Is there a mass notification system that reaches all building occupants? (public address, pager, cell phone, computer override, etc.)	Depending upon building size, a mass notification system will provide warning and alert information, along with actions to take before and after an incident if there is redundancy and power. Reference: *DoD UFC 4-010-01*	***The telephone system has a building-wide announcing feature that can be activated by pressing one button at any phone. It reaches all users within audible distance of a phone.*** ***This system will continue to***

	Will one or more of these systems be operational under hazard conditions? (UPS, emergency power)		***operate on the UPS and/or backup generator power.***

Building Design Mitigation Measures (COOP Version)

NOTE: There is too much variance in student answers compared to a "school solution" to populate this table with information that can be compared to the various team answers.

Asset-Threat/Hazard Pair	Current Risk Rating	Suggested Mitigation Measure	Revised Risk Rating

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