Bomb Blast Facility Protection for Security, Risk, and Property Managers

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Today’s Presenters

• Stephen L Morgan PSP
  • Project Director, Innovative Engineering Inc.
  • Education
    • BSCET, Southern Polytechnic State University
    • Security Engineering: USACE Protective Design Center
    • “Design of Blast Resistant Structures” presented by Baker Risk, Houston Texas, Virginia
    • “Blast Resistance by Design” Stone Security Engineering
  • Experience: 16 Years Security Engineering
  • Expertise
    • Risk Assessments
    • Site Layout
    • Physical Security Peer Reviews
    • Blast Design
    • Progressive Collapse
Today’s Presenters

• Scott L Weiland PE SE
  • Principal, Innovative Engineering Inc.
  • Education
    • BSCE University of Michigan
    • Graduate Studies in Structural Dynamics:
      • San Jose State University
      • Georgia Institute of Technology
    • Security Engineering: USACE Protective Design Center
    • Interagency Security Committee (ISC) Risk Management Process: ARA
    • Counter Terrorism Workshop for Improvised Explosive Devices (IED) and Vehicle-Borne Improvised Explosive Devices (VBIED) - Department of Homeland Security (DHS)
  • Registration: PE in 38 States + PR & GU
  • Experience
    • 41 Years Design and Construction
    • 26 Years Physical Security Engineering
Learning Objectives

• Basis for security criteria
• Risk assessment process and how to develop design criteria
• Blast Design fundamentals
• Progressive Collapse prevention
• How to minimize the impact on the cost of new and renovated construction
Physical Security Basics
Physical Security Basics

• Concentric Levels of Protection
  • Progressively reduces the threat as the distance to the asset decreases
  • All of the individual protections form a Protective System
# Protective System

## Protective System Functions

<table>
<thead>
<tr>
<th>Detect</th>
<th>Delay or Defeat</th>
<th>Respond</th>
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</table>
| • Electronic Security System  
  - Intrusion detection  
  - Alarm communication  
  - Alarm assessment  
  - Access control  
  • Security Forces  
  • Security Lighting  
  • Facility Personnel  
  • Responsible Citizens | • Barriers  
  - Fences  
  - Facility roof, walls, and floors  
  - Doors  
  - Windows  
  - Locks  
  • Distance  
  • Vegetation  
  • Procedures | • Interruption  
  - Communication to response force  
  - Deployment of response force  
  - Neutralization |

- *Security Forces*.
- *Security Lighting*.
- *Facility Personnel*.
- *Responsible Citizens*.
- *Barriers* - Fences, Facility roof, walls, and floors, Doors, Windows, Locks.
- *Distance*.
- *Vegetation*.
- *Procedures*.
Development of the Protective System

Prescriptive Criteria

Performance Criteria
Prescriptive Physical Security Criteria

• Prominent Prescriptive Design Criteria
  • DoD Minimum Antiterrorism Standards for Buildings, UFC 4-010-01
  • VA Physical Security and Resiliency Design Manual (PSRDM)
• UFC 4-010-01 and VA PSRDM are both minimum standards deemed acceptable by Risk Assessments previously conducted. There are instances particularly within DoD where risk assessments determined threats beyond the scope of UFC 4-010-01
Risk Assessment Process
Risk Assessment Basics

• Asset
  • Tangible and Intangible
  • Supports building function
  • Degree of debilitating impact if damaged or destroyed.

• Threat
  • Aggressor
    • Existence
    • Capability
    • History
    • Intentions
    • Targeting
  • Weapons, tools and tactics

• Vulnerability
  • Weaknesses that can be exploited
Risk Assessment Basics

- Planning Team
- Identify Assets
- Asset Value
- Identify Aggressor
- Aggressor Likelihood
- Tactics per Asset

- Threat Level by Likelihood
- LOP by Asset Value & Threat Lvl
- Risk Calculation
- Cost Increase
- Acceptability of Risk & Cost
- Design Criteria
Risk Assessment Basics

Planning Team
Identify Assets
Asset Value
Identify Aggressor
Aggressor Likelihood
Tactics per Asset

Risk Calculation
Cost Increase
Acceptability of Risk & Cost
Design Criteria

Protective Design Consultant
Building Owner
Tenant
Security
Site management
Key Function Representatives
Risk Assessment Basics

1. Planning Team
2. Identify Assets
3. Asset Value
4. Identify Aggressor
5. Aggressor Likelihood
6. Tactics per Asset
7. Threat Level by Likelihood
8. LOP by Asset Value & Threat Level
9. Risk Calculation
   - Cost Increase
   - Acceptability of Risk & Cost
10. Design Criteria

- Tangible
- Intangible
Risk Assessment Basics

Planning Team

Identify Assets

Asset Value

Identify Aggressor

Aggressor Likelihood

Tactics per Asset

LOP by Asset Value & Threat Level by Likelihood

Risk Calculation

Cost Increase

Acceptability of Risk & Cost Design Criteria

• Critical to User
• Population Type
• Impact on National Defense
• Replaceability
• Political Sensitivity
• Relative Value to User

• Critical to User
• Population Type
• Impact on National Defense
• Replaceability
• Political Sensitivity
• Relative Value to User
Risk Assessment Basics

- Planning Team
- Identify Assets
- Asset Value
- Identify Aggressor
- Aggressor Likelihood
- Tactics per Asset

Threat Level by Likelihood
- LOP by Asset Value & Threat Lvl
- Risk of Risk & Design Criteria

- Criminals
- Protestors
- Terrorists
- Subversives
Risk Assessment Basics

Planning Team
Identify Assets
Asset Value
Identify Aggressor
Aggressor Likelihood
Tactics per Asset

Threat Level by Likelihood
LOP by Asset Value & Threat Lvl
Risk Calculation
Cost Increase

• Likelihood of Success

Design Criteria
Risk Assessment Basics

- Planning Team
- Identify Assets
- Asset Value
- Identify Aggressor
- Aggressor Likelihood
- Tactics per Asset

Threat Level by Likelihood
LOP by Asset Value & Threat Lvl
Risk Calculation
Cost
Acceptability of Risk & Cost

- Explosives & Incendiary Devices
- Standoff Weapons
- Entry
- Surveillance & Eavesdropping
- Contamination
Risk Assessment Basics

Planning Team
Identify Assets
Asset Value
Identify Aggressor
Aggressor Likelihood
Tactics per Asset

Threat Level by Likelihood
LOP by Asset Value & Threat Lvl
Risk Calculation
Cost Increase
Acceptability of Risk & Cost
Design Criteria

- Severity of Attacks
  - Low
  - Moderate
  - Significant
  - High
Risk Assessment Basics

Planning Team
Identify Assets
Asset Value
Identify Aggressor
Aggressor Likelihood
Tactics per Asset

Threat Level by Likelihood
LOP by Asset Value & Threat Lvl
Risk Calculation
Cost Increase
Acceptability of Risk & Cost
Design Criteria

- Low
- Medium
- High
- Very High
Risk Assessment Basics

Planning Team
Identify Assets
Asset Value
Identify Aggressor
Aggressor Likelihood
Tactics per Asset

Threat Level by Likelihood
LOP by Asset Value & Threat Lvl
Risk Calculation
Cost Increase
Acceptability of Risk & Cost
Design Criteria

Asset Value x Threat Rating x Vulnerability Rating
Risk Assessment Basics

Planning Team

Identify Assets

Asset Value

Identify Aggressor

Aggressor Likelihood

Tactics per Asset

Threat Level by Likelihood

LOP by Asset Value & Threat Lvl

Risk Calculation

Cost Increase

Acceptability of Risk & Cost

Design Criteria

Cost of countermeasures
Risk Assessment Basics

Planning Team
Identify Assets
Asset Value
Identify Aggressor
Aggressor Likelihood
Tactics per Asset

Threat Level by Likelihood
LOP by Asset Value & Threat Lvl
Risk Calculation
Cost Increase
Acceptability of Risk & Cost
Design Criteria

If not acceptable adjust:
• LOP
• Threat
Risk Assessment Process

Risk = Asset Value x Threat Rating x Vulnerability Rating

Source: FEMA 426
Risk Assessment Process

- Prioritize Risk = Asset Value x Threat x Vulnerability
- Identify Mitigation Options
  - Reduce value, threat, vulnerability
- Estimate Cost
- Cost-Benefit Analysis
  - By committee
    - Protective Design Consultant
    - Building Owner
    - Tenant
    - Security
    - Site management
    - Key Function Representatives
    - Others
- Codify Design Criteria

Risk Management Choices

- Do Nothing
  - No Cost
  - Greatest Risk
- Reasonable Measures
  - Some Cost
  - Reduced Risk
- Harden Bldg.
  - Greatest Cost
  - Lowest Risk

Source: FEMA 426
Risk Assessment Standards

• Prominent Standards
  • ISC, The Risk Management Process for Federal Facilities
  • DoD Security Engineering Facilities Planning Manual, UFC-4-020-01

• Other Standards
  • ASIS General Security Risk Assessment Guideline
  • TSA, Recommended Security Guidelines for Airport Planning, Design and Construction

• Results in Physical Security Design Criteria for a given project
Blast Design

Blast Design Primer

By Scott L Weiland PE SE
Tactics Used in Terrorist Attacks 1970 - 2018

- Bombing/Explosion, 1414
- Facility/Infrastructure, 905
- Armed Assault, 346
- Assassination, 134
- Unarmed Assault, 68
- Hijacking, 17

Source: statista
High Energy Explosives - PIES

- **Power**
  - Battery
  - Match
  - Chemical Reaction

- **Initiator**
  - Blasting Cap
  - Light Bulb

- **Explosive**
  - Low Explosive
  - High Explosive
  - Homemade Explosive (HME)

- **Switch**
  - Cell Phone
  - Timer
Minimize Bomb Threat

Explosives Environment - Blast Range Effects

- Luggage
- Automobiles
- Vans
- Trucks

Minimum Stand-off (ft)

Weapon Yield (lbs-TNT)
Pressure Shock Wave
Blast Theory – Time History

- Pressures decay exponentially with time.
- Dynamic, non-linear, time history analysis.
- Dynamic Pressure (Wind)

Source: FEMA 427
Blast Theory – Vehicle Bomb

- Surface Burst (VBIED)
- Pressure Radiates
- Reflected Pressure
- Refracted Pressure
- Side-On Pressure
Blast Theory - Shapes That Affect Blast

- Re-entrant corners
- Overhang
- Round Shape
- Blast Wall
- Berm
- Blast Wall - CFD
Blast Theory - Distance

- Blast Pressure Decays with Distance
**Blast Theory - Distance**

**Murrah Building**
- 4,000 lbs. TNT*
- 15 ft Stand-Off

**Khobar Towers**
- 20,000 lbs. TNT*
- 80 ft. Stand-Off
Blast Theory - Explosion

- Shock Wave
- Reflected Pressure
- Rebound
- Side-On Pressure
Blast Theory - Explosion

- Shock Wave
- Reflected Pressure Wave
- Rebound
Blast Design – Conservation of Energy

Energy Equation

- \( W_P = W_K + W_S \)
  - \( W_P = \text{Blast Energy} \)
  - \( W_K = \text{Kinetic Energy} \)
  - \( W_S = \text{Strain Energy} \)
Blast Design – Kinetic Energy

\[ W_K = \frac{m_e \times V^2}{2} \]
Blast Design – Strain Energy – Ductility

- Regions
- Elastic
- Plastic

Area = Strain Energy
Blast Design – Strain Energy

**Linear Elastic Behavior**

\[ W_{S,el} = \frac{1}{2} K \Delta_{el}^2 \]

- \( \mu = 1.0 \)

**Linear Elastic-Plastic Behavior**

\[ W_{S,pl} = F_{yield} \Delta_{pl} - W_{S,el,max} \]

\[ V_{S,el} = \frac{1}{2} F_{yield} \times \Delta_{el,max} \]

- \( \mu > 2.0 \)
Blast Theory – Energy Absorption

• Laminated Glass
  • 1\textsuperscript{st} Level
    • 2 \frac{1}{2}"
    • Forced Entry Resistant
    • Ballistic Resistant
    • Blast Resistant
  • 2\textsuperscript{nd} & 3\textsuperscript{rd} Level
    • 2"
    • Blast Resistant
Progressive Collapse Prevention

Blast Design Primer
Progressive Collapse

“The spread of an initial local failure from building element to building element, eventually resulting in the collapse of an entire structure or a disproportionately large part of it.”

- Threat Independent
- Not generally required for structures less than 3 stories
- Mitigation provided by:
  - Redundancy
  - Local Hardening
Design and Analysis Techniques

- **Progressive Collapse**
  - Tie Force Method (Indirect Design Procedure)
  - Alternate Path Method (Direct Design Procedure)
Design and Analysis Techniques

• Tie Force Method is based primarily on bay span and the load carried by the floor/roof level under analysis. Horizontal and vertical ties develop tension capacity to tie the building together to enhance continuity and ductility and provide alternate load paths in the event the primary load path is lost.

• Ties members are limited by the amount of end rotation that can be achieved while still being able to resist the tensile tie force. Generally beams and girders are not used as ties as the amount of end rotation is too great for the member to still resist the given loading.

• The tie system consists of internal, peripheral and vertical ties. The internal ties run continuous in each orthogonal direction and are tied to continuous peripheral ties. Vertical ties consist of the building columns or load bearing walls.

• Location, continuity, splicing and anchorage of ties are vital in the design of the tie force resisting system.

• Enhanced local resistance design is required for the columns/load bearing walls to resist required shear and flexural design forces.
Design and Analysis Techniques

- Alternate Path method is a higher fidelity design procedure which follows the same LRFD design concepts used in seismic design. The analysis is typically conducted with 3 dimensional structural design software.

- The alternate path method analysis can be conducted via three approaches. Linear Static Procedure (LSP), Non-Linear Static Procedure (NSP) and Non-Lineal Dynamic Procedure (NDP). Each procedure increases with modeling fidelity and accuracy of predictive results but also increases with complexity of analysis and time associated with the analysis.

- The general procedure is to remove perimeter corner, re-entrant corner, and interior columns/load bearing walls both on the building perimeter and high risk interior area of the building on various levels of the structure and design the primary and secondary members for the resulting force and deformation controlled forces so that progressive collapse will not occur.

- Enhanced local resistance design is required for the columns/load bearing walls to resist required shear and flexural design forces.

- Acceptance, modeling and detailing criteria is highly material dependent.
Implementation of Physical Security Design

Blast Design Primer
Physical Security Involvement

• Some aspect of physical security is required on every project.
• Involvement of a physical security professional should begin at the planning phase of a project with a risk assessment. This ensures that the requirements are clearly in the scope of work and the construction estimate is defined and includes cost for the protective system. Poorly written project scopes that only reference criterion are a major source of change orders and or increased design fees.
• During the initiation of the design phase, the design team should have the physical security professional involved to ensure the scope is clearly defined and understood by all parties involved in the design.
• Early involvement both on the planning and design phases of project ensures that both phases are clear on the requirements and do not require future re-work to incorporate the physical security design.
Project Scope Understanding and Clarity

• Clearly understanding the project scope and requirements is the most critical step in ensuring the delivery of the project on budget. Not fully understanding and clarifying the project scope generally leads to either over or under designed protective systems.

• Key questions regarding physical security that must be answered at the beginning of the project:
  
  Is a risk assessment required? If not is there any outcomes of the risk assessment that would fall outside the scope of the governing criteria? If so, what is the governing risk assessment methodology?

  What is the governing physical security criterion for the project?

  Are there any criteria that are local to the installation/facility or to the government agency that are required for use on the project?
Project Scope Understanding and Clarity

• Is the project new construction or modification/renovation/addition to existing construction?

• What is the mission criticality of the facility?

• Will there be intent on future vertical or horizontal expansion. If so, what impact will that have on the facilities mission criticality. Ensure all interpretations of the scope of work and criteria related to the scope have been confirmed by the agency prior to commencing the design phase.

• There are grey areas within any criteria that can be open to interpretation. However, the agency having jurisdiction is the final say on the criteria.
• USACE Facility
• Primary body of the scope referenced the minimum standards UFC for the AT/FP requirements.
• Small excerpt referenced a Security Risk Analysis which identified a Medium Level of protection
• Medium level of protection is beyond the minimum standards and beyond what was designed for the project.
• Interpretation was not fully confirmed

5.4.3 Loads: See paragraph 6 for site and project specific structural loading criteria. Unless otherwise specified in paragraph 6, use Exposure Category C for wind. If not specified, use Category C unless the Designer of Record can satisfactorily justify another Exposure Category in its design analysis based on the facility Master Plan. Submit such exceptions for approval as early as possible and prior to the Interim Design Submittal in Section "Design After Award". Design the ancillary building items, e.g. doors, window jambs and connections, overhead architectural features, systems and equipment bracing, ducting, piping, etc. for gravity, seismic, lateral loads and for the requirements of UFC 4-010-01, DOD Minimum Antiterrorism Standards for Buildings. Ensure and document that the design of glazed items includes, but is not limited to, the following items under the design loads prescribed in UFC 4-010-01:

(a) Supporting members of glazed elements, e.g. window jamb, sill, header
(b) Connections of glazed element to supporting members, e.g. window to header
(c) Connections of supporting members to each other, e.g. header to jamb
(d) Connections of supporting members to structural system, e.g. jamb to foundation

6.6.8.4 Antiterrorism Force Protection (ATFP)

Design exterior building elements to meet the requirements of UFC 4-010-01. Refer to the Physical Security Risk Analysis in Appendix EE.
Poorly Defined Scope Example

• VA facility
• What is Future Growth?
• Mission criticality went from Life Safety as required by the current project to Mission Critical for the future growth.
• Leads to increased construction and design cost or reduction in programmed space to meet the budget

A/E SCOPE OF WORK

1. This project (minor) will engage an architectural/engineering (A/E) firm to provide a complete design for new construction that creates a new building or addition at the VA Campus. The new site selection and/or addition would need to be designed to provide accommodations for future growth. It also must have the capability to utilize existing floor space into the design, as well as, combine existing common areas. The need for vertical transportation will be dependent on the proposed design. The project will also require extensive phasing with all disciplines, staff and patient needs. The site around the campus slopes steeply and will require extensive site work, in addition the utility services in the area and physical security issues will need to be developed and will be extensive.
Clarity in Construction Documents

• Confusion in the construction documents are generally the biggest attributor to physical security costs and changes during the construction phase of a project.

• The most common issue involves specification of delegated design of vendor products for the protective system. These products are typically windows, doors, glazed curtainwall and non-load bearing light gauge stud wall systems.

• The most prevalent problem is specifying the incorrect blast loading criteria, blast loading response and acceptable testing method.

• Most A/E firms and delegated designers of vendor products are familiar blast requirements of the UFC (DoD) and ISC (GSA). However, with that familiarity comes misuse on another agency’s project such as with the VA. There are instances where these more available designed and tested system will not work for the VA blast requirements.
• VA Facility
• Performance Specifications for blast resistant windows

1.7 PERFORMANCE REQUIREMENTS:
A. Shape and thickness of framing members shall be sufficient to maintain a design wind load of not less than 22 pounds per square feet of supported area with a deflection of not more than 1/375 times the length of the member and a safety factor of not less than 1.63 applied to overall load failure of the units. Provide glazing beads, moldings, and trim of not less than 0.050 inch nominal thickness.
B. Air Infiltration: When tested in accordance with ASTM E 283, air infiltration shall not exceed 0.06 cubic feet per minute per square foot of fixed area at a test pressure of 0.14 pounds per square foot 50 mile per hour wind.
C. Water Penetration: When tested in accordance with ASTM E 531, there shall be no extraneous penetration at a pressure of 8 pounds per square foot of fixed area.
D. Glazing, doors, and louvera shall comply with UFC 4-010-02, Oct 8, 2009, including change of Jan 07, 2007, standard 50 Windows and Skylights, and standard 52 Exterior Doors.

1. Take 6-1/2 stand-off distances for new and existing buildings
2. Buildings Category: Primary Gathering Buildings
3. Applicable Level of Protection: Low
4. Applicable Explosive Weight: 1

2. Table 3-1: Minimum glass thickness selection for insulating glass unit windows
A. Applicable Level of Protection: Low
B. Applicable Explosive Weight: 1
C. Glass Thickness at Conventional Construction Standoff
D. Minimal Interlayer Thickness: 0.50"
Specifications Examples

- VA Facility
- Performance Specifications based on UFC criteria
- 100% incorrect


1. Table B-1: Standoff Distances for New and Existing Buildings
   a. Location: Controlled Perimeter
   b. Building Category: Primary Gathering Building
   c. Applicable Level of Protection: Low
   d. Applicable Explosive weight: 1

2. Table B-3: Laminated Glass thickness Selection for Insulating Glass Unit Windows.
   a. Applicable Level of Protection: low
   b. Applicable Explosive Weight: 1
   c. Glass Thickness at Conventional Construction Standoff Distance: 0.250”
   d. Minimal Interlayer Thickness: 0.030”
Specifications Examples

• VA Project
• Performance Specifications based on the correct VA criteria

1.4 DESIGN REQUIREMENTS

A. All façade fenestration shall be designed to crack but fragments shall enter the occupied space and land on the floor no further than 10 feet (3 m) from the façade in response to the calculated peak pressures and impulses resulting from the design level threat (WL) located at the stand-off distance, but no greater than GPI.”

B. This building should be designed to meet the 2007 VA Physical Security Design Manual for Life Safety Protected Facilities.

C. Minimum Blast Requirements: Minimum blast resistant performance requirements for the exterior walls are specified.

   1. All systems requiring blast resistance shall be designed using established methods and approaches for determining dynamic loads, structural detailing and dynamic response.

   Design and analysis approaches should be consistent with those in the references listed in these specifications.

   D. The glass shall be restrained within the mullions with a sufficient bite or structural silicone adhesive to allow it to develop its post-damage capacity.
Clarity in Construction Documents

• Another prevalent issue in the construction documents is unclear designation of the protective system on the contract drawings.

• Generally, we see issues where window, door and curtain wall is not designated as blast resistant, and the contractor is left to “interpret” which of these systems are required to be blast resistant. If the contractor interprets wrong their pricing will be incorrect, and the pricing is rarely on the high end of the incorrect spectrum.

• Other items that commonly do not get designated on the contract drawings are location of rated vehicle barriers, areas on the site that require no parking designations, incorrect use of straight-line vehicle approaches to the building, incorrect location of drive up drop off canopy structures and correct location of mechanical system intakes to name a few.
• Exterior Glazed openings
• No indication of blast resistance requirements
• Specifications did not indicate blast performance requirements
• All of which lead to changes and cost
• Drawing dedicated to showing the required standoff and that all parking and roadways are beyond the minimum standoff required by the VA criteria

• As a reviewer if this is not shown on a drawing it is the first clue that physical security is not a forefront part of the design
• Note no standoff distance is shown.
• If shown it would be obvious parking is within the minimum VA standoff.
• Straight line approaches are provided with no means to stop a vehicle.
• Involvement by the PSP didn’t happen until well after 65% design phase.
Drawing Examples

- Drawing dedicated to showing adjacencies required by the VA criteria.
- Great not only for the current project but future renovations that likely will occur.
• Note no adjacencies shown.
• Violates the VA criteria.
• Critical issue as it affects every discipline on the project and could cause changes to the look of the facility and increase cost.
Physical Security Do’s and Dont’s

Do’s
• Involve Physical Security Design from the beginning.
• Provide a clear and coordinated project scope
• Fully understand the project scope requirements
• Provide clear and coordinated construction documents.

Dont’s
• Use boiler plate scopes of work unless deemed appropriate by a risk assessment
• Wait until halfway through a project to involve physical security design.
• Leave questions or assumptions regarding the physical security design unanswered or unverified
• Provide ambiguous and uncoordinated construction document requirements.
Other Cost Saving Tips

• Standoff distance is your friend! Maximize it! Maximize standoff distance through means of more land or use of access-controlled parking. The cost of access-controlled parking generally is less than the building hardening if not used.

• Provide building mass to the building envelope. The mass dampens blast effects and is relatively inexpensive compared to additional hardening.

• Physical security design does not equal BUNKER type construction. The building envelope only needs to be hardened to respond to the required level of protection and no more. Overdesign for blast loading is not only more expensive it can be counterproductive.

• Physical security design does not equal Prison/High Security type construction. Use of Crime Prevention Through Environmental Design (CPTED) concepts can provide a more welcome less intrusive facility physical security design. CPTED options are generally less expensive and requires less maintenance and manpower.
Questions/Contact Information

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