

VETERANS ADMINISTRATION  
PALO ALTO, CALIFORNIA

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RECREATIONS FACILITY –  
PHYSICAL SECURITY CD1 NARRATIVE

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WEIDLINGER ASSOCIATES® INC

VA Medical Center, Palo Alto, CA  
New Centers for Ambulatory Care and Polytrauma Rehabilitation  
PHASE 2  
Construction Documents (CD1) Submission – February 15, 2013

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## **EXECUTIVE SUMMARY**

The VA Palo Alto Recreations Facility will be designed for the VA Physical Design Manual for Life Safety Facilities. This narrative summarizes the design team's effort to address the site, façade and structure related protective design issues for the new building.

The site-related portions of the Design Manual, which are not part of the project scope, are identified, including perimeter fencing and vehicle screening.

Schematic designs for glazing and metal framing were produced.

The columns, slabs, and beams were analyzed for the blast loads resulting from the design vehicle charge at the available standoff.

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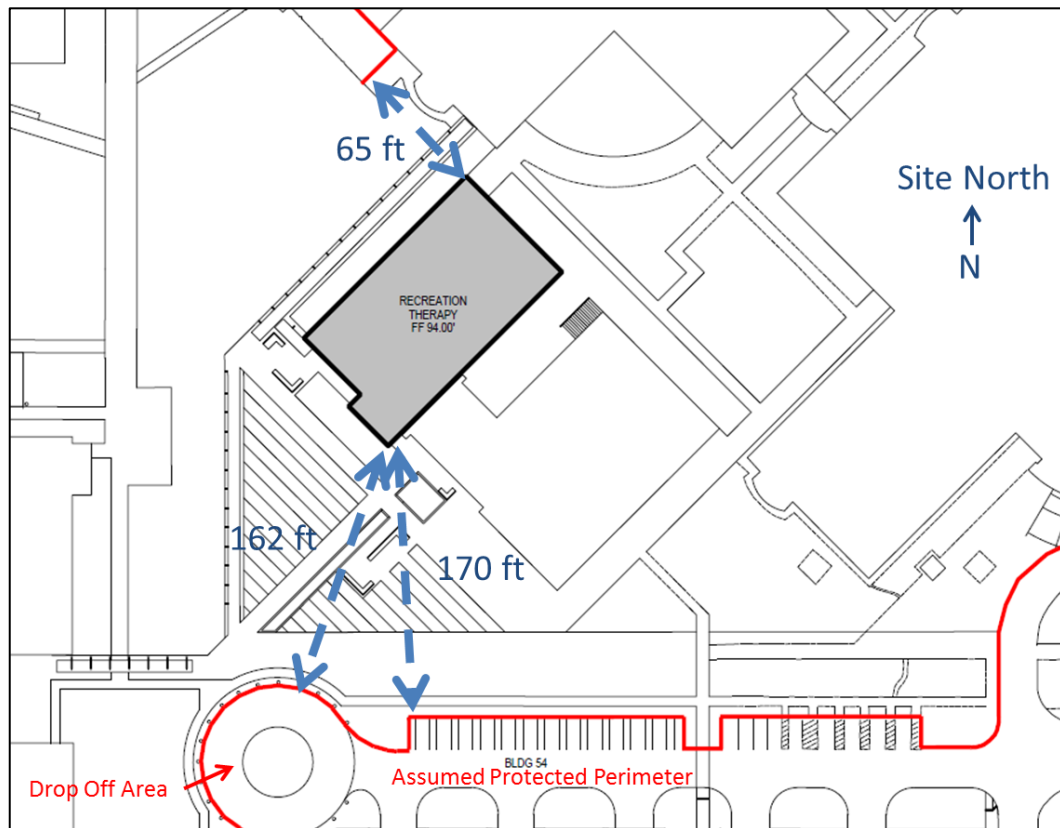
## 1 INTRODUCTION

### 1.1 Project Overview

The VA Palo Alto Recreations Facility building will be designed to satisfy the VA Physical Design Manual for Life Safety Facilities. This narrative summarizes the design team's effort to address the site, façade and structure related protective design issues for the new building.

### 1.2 Project Site

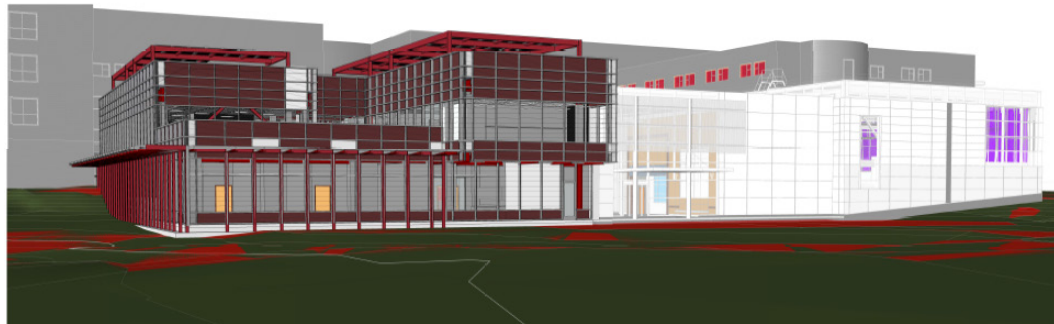
The Recreations Facility is located on the VA Palo Alto campus. The site is bordered by Building 4 and Building 500 Polytrauma and Blind Rehabilitation Center to the west, the Building 101 Administration to the north, Building 100 Hospital to the east, and on-site open parking lots to the south. An overall plan of the Recreations Facility illustrating the proposed site location is provided in Figure 1.



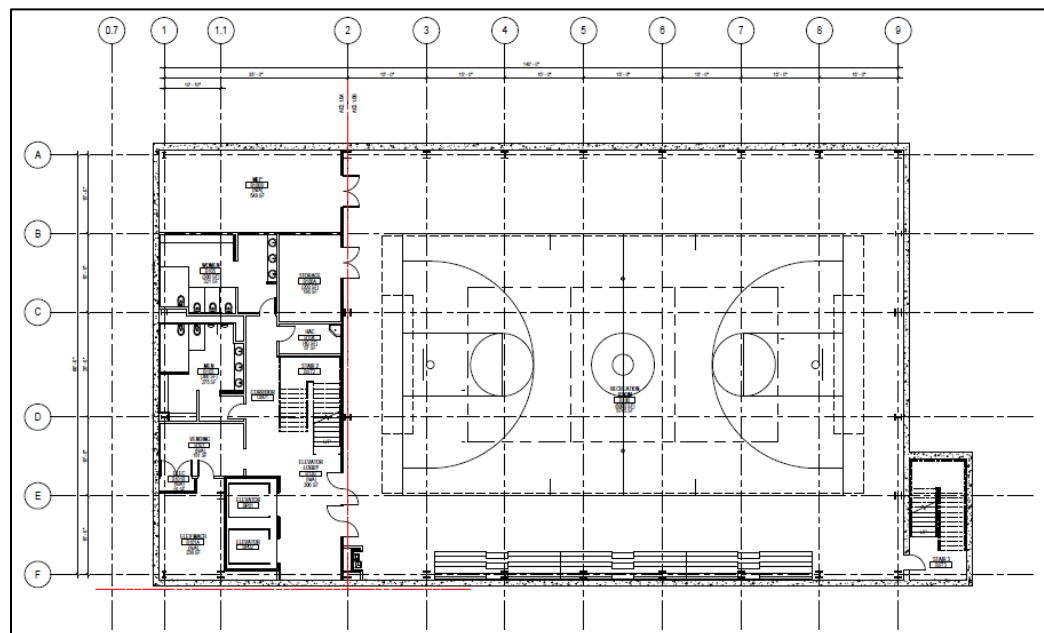
**Figure 1 - Project Site Plan**

### 1.3 Building Description

The Recreations Facility building is a three-story building with one underground level. The building will be of structural steel frame construction, with typical bay spacing of 15 ft. Primary beams are typically spaced at 7.5-ft on center. Floor slabs will consist of light weight concrete fill over metal deck.



**Figure 2 – Architectural Rendering**



**Figure 3 – Typical Floor Plan**

## **2 PHYSICAL SECURITY DESIGN REQUIREMENTS**

The VA Physical Security Design Manual for Life Safety Protected Facilities is followed for this project.

### **2.1 Physical Security Design Manual Requirements**

The physical security requirements satisfied in the design of this project are outlined in the "Life Safety Protected Facilities Physical Security Design Manual for VA Facilities," dated July 2007. The objective of this document is to provide cost effective design criteria that will, when constructed and implemented, provide the appropriate level of physical security to VA's life safety protected facilities.

### **2.2 VA Facilities**

VA provides a mission critical medical and economic infrastructure to the government and population of the United States. Mission critical facilities shall include all VA medical centers and long-term care facilities; major out-patient clinics or in locations where these are the only available health care facilities for a locality; research facilities; COOP (or equivalent) sites; major data processing centers; and other facilities which serve a unique function for the Department.

Life-safety protected facilities shall include all VA facilities designated as not mission critical.

### **2.3 Threat Definition**

The Life Safety Protected Recreations facility will incorporate protective design based on the Physical Security Design Manual for VA Facilities (July 2007). The blast analysis is based on the W1 and W0 charge weights and the GP1 blast loading as directed by the Design Manual. The values for these coded charge weights and blast loads were provided by the VA to the design team.

### **2.4 Site conditions**

This section focuses on security design concepts, elements, and site planning strategies that influence the protection of the built and natural environments.

#### **2.4.1 Standoff Distances**

*No vehicle shall be parked or be permitted to travel closer than 25 feet (7.6 m) to any Life Safety VA facility.*

The Recreations facility is 65 ft from the parking lots to the west, 162 ft from the drop-off area to the south and 170 ft from the parking lots to the south. See Figure 1 for standoff distances to each elevation.

#### **2.4.2 Perimeter Fences**

*Perimeter barriers shall consist of fences, walls, a combination of these, and gates as needed for access. The barrier shall be designed to resist forced or surreptitious entry using hand tools, such as by spreading bars of a fence to provide a passable opening. Fences shall have sufficient lateral support to resist overturning by manual force. Landscaping is permitted within the 33ft*

*unobstructed zone provided that planting in this area is limited to grass, groundcover, and high canopy trees which do not preclude the observation of a threat 6in. in height placed on the ground.*

*The perimeter barrier shall be on or in close proximity to the perimeter of the property.*

*The perimeter barrier shall have at least 8 feet (2.4 m) between potential horizontal footholds or designed with other anti-climb measures.*

The Recreations Facility is part of the VA Palo Alto campus. A perimeter fence is not within the project scope and will not be provided for this facility.

## **2.4.3 Vehicle and Pedestrian Screening**

*No additional physical security requirements.*

Campus interior roadways will be open to the public. Vehicle and pedestrian screening is not within the project scope and will not be provided for this facility. Operational security measures and drop-arm barriers will be utilized to deter unauthorized pedestrian and vehicle access to the building and drop-off area to the south.

## **2.4.4 Vehicle Barriers**

*Passive vehicle barriers shall be selected on the appropriateness of the architecture of the facility and the specifics of the site and natural environment.*

*Stationary (Passive) Barriers shall be located adjacent to vulnerable perimeter fences, protection for site utility equipment, at building entrance, and other areas requiring additional protection from vehicles.*

Anti-ram barriers will be provided near the building entrances and around the building as necessary to protect critical site equipment.

## **2.4.5 Parking**

*Passenger vehicles shall not be parked or permitted to travel closer than 25 feet (7.6 m) to any VA facility.*

Passenger vehicles are designed to be parked in designated parking spaces elsewhere on the campus beyond the 25-0" standoff requirement.

## **2.5 Building Entrances and Exits**

This section provides requirements for public entrances, entrance lobbies, patient drop-offs, and staff entrances.

### **2.5.1 Public Entrances and Lobbies**

*Public access to the facility should be restricted to a single or limited number of entrances.*

The primary building entrance is a pedestrian entrance located on the south elevation of the building.

## **2.5.2 Screening Vestibules**

*The screening vestibule shall have sufficient space and be provided with power, telecommunications, and data connections for installation of access control and screening equipment that may be used should the need arise.*

Design team has requested confirmation from the VA to determine if space and utilities will be provided for the installation of future screening equipment at the building entrance.

## **2.5.3 Patient Drop-offs**

*Drop-offs and waiting areas for unscreened vehicles, including public transportation vehicles, shall be separated from the main building structure by at least 25 feet.*

A drop-off area is located along the south elevation of the Recreations Facility. The drop-off area is located beyond the minimum 25 ft standoff distance.

## **2.6 Functional Areas**

This section discusses the specific spatial functional areas, their relationships, and adjacencies based on physical security requirements.

### **2.6.1 Emergency and/or Stand-by Generator Room**

*If within a main building such as a medical center, the generator room shall not be located closer than 50 feet (15 m) of a loading dock/receiving area or mailroom, and shall not be located beneath such facilities.*

No loading dock/receiving area or mailroom is planned for the Recreations facility and thus, this provision is not applicable.

### **2.6.2 Loading Dock**

*Loading docks may be located immediately adjacent the following areas.*

- Service yard
- Trash containers
- Freight elevators
- Non-critical bulk storage
- Mailroom
- Non-critical support areas such as laundries and maintenance spaces.

*Loading docks shall not be located adjacent to or within 50 feet (15 m) of the following.*

- COOP
- Fire Control Centers
- Security Control Center and Police Command Center
- Emergency or stand-by generators
- UPS



- *Water storage – domestic and fire*
- *Main electrical switchgear*
- *Main utility service entrances*
- *Emergency egress from main building*
- *Childcare/development centers*
- *Flammable liquids or gas storage*
- *Fresh air intakes*

No loading dock/receiving area or mailroom is planned for the Recreations facility and thus, this provision is not applicable.

### **2.6.3 Mail Rooms**

*Mailrooms may be located in the main building or in a separate structure on the site shared with loading dock, storage, and other non-critical functions. Mailrooms within the main building shall be located on an exterior wall.*

A mailroom was not programmed nor planned for the Recreations facility and therefore, this standard is not applicable.

## **2.7 Building Envelope**

This section provides requirements for exterior walls other than load bearing walls; glazed façade fenestration and glazed atria; for roof structures, including skylights; and air intakes and exhausts servicing critical equipment but does not pertain to stacks and wall openings for non-critical equipment. These requirements are in addition to the requirements for conventional façade design, including the provisions for hurricane, earthquake, and any other extreme loading condition required by code. The magnitude of GP1, GP2, W1, and W2 are defined in a separate key and stored separate from this document.

### **2.7.1 Walls**

*Walls shall be designed to suffer damage but sustain a deformation no greater than  $L/30$  in response to the calculated peak pressures and impulses resulting from the design level vehicle threat (W1) located at the protected perimeter, but no greater than GP1.*

The Recreations Facility walls will be designed for the calculated peak pressures and impulses from the design level vehicle threat (W1) located at the protected perimeter, but no greater than GP1. Further discussion of the blast design of the wall system may be found in Section 5.

### **2.7.2 Fenestration**

*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 vehicle threat (W1) located at the protected perimeter, but no greater than GP1. Fenestration shall be constructed using debris mitigating materials such as laminated glass. 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.*

*The mullions shall be designed to accept the design level pressures while sustaining deformations no greater than  $L/30$ .*

*Curtainwall framing members shall span from slab to slab and shall not be attached directly to gravity load bearing elements (such as columns and shear walls) unless an advanced analysis of the load bearing element demonstrates it can accept the maximum forces of the members framing into it without compromising its load bearing capacity*

The Recreations Facility facade fenestration will be designed for the calculated peak pressures and impulses from the design level vehicle threat (W1) located at the protected perimeter, but no greater than GP1. Further discussion of the blast design of the glazing and the framing members may be found in Section 5.

### **2.7.3 Roofs**

*Roof structure shall be designed to withstand the design level vehicle threat (W1) located at the protected perimeter while sustaining a deformation no greater than  $L/30$ . The blast loading shall take into account the presence of parapets, the diffusion of blast waves, and the spatial extent of the roof surface.*

Roof level of the building is located above the minimum 30 ft distance above grade. Blast analysis of the roof structure has confirmed that the framing members required for conventional loading are sufficiently size to resist the design level vehicle threat (W1) located at the protected perimeter is forthcoming.

### **2.7.4 Penthouses Enclosing Critical Equipment**

*Penthouse façade shall be designed to withstand the effects of hurricane wind loads and debris impact. Penthouse enclosures shall also be designed to resist the design level vehicle threat (W1) located at the protected perimeter to be consistent with the hardened intakes and exhausts.*

Current drawings do not indicate a penthouse enclosure and therefore, this provision is not applicable.

*Air intakes and exhausts shall be designed to minimize the blast over pressure admitted into critical spaces to the design level vehicle threat (W1) located at the protected perimeter by means of hardened plenums and structured baffles. The design shall deny a direct line of sight from the design level vehicle threat (W1) located at the protected perimeter to the critical infrastructure within.*

Roof level of the building is located above the minimum 30 ft distance above grade. Blast analysis of the roof structure against the design level vehicle threat (W1) located at the protected perimeter will be worked out during the design process. VA criteria requires a minimum of 100 ft between the air intakes and exhausts and idling vehicles. Location of air intakes and exhausts will be verified to ensure conformity with requirement.

## **2.8 Structural System**

This section provides requirements for blast resistant structures and includes requirements for the prevention of progressive collapse and the hardening of critical columns.

### **2.8.1 Blast Resistance**

*Structures shall be constructed to withstand the actual pressures and corresponding impulses produced by the design level vehicle threat (W1) located at the protected perimeter and the design level satchel threat (W0) that may be delivered to loading docks, mailrooms, lobbies, and below grade parking garages prior to screening. The design shall provide a medium level of protection for which the building damage will be economically repairable and the space in and around damaged area can be used and will be fully functional after cleanup and repairs.*

Blast analysis of the structure against the design level vehicle threat (W1) located at the protected perimeter is forthcoming. Design level satchel threat (W0) will only be considered for the lobby, because screening of the packages is assumed to occur off-site. Blast design approach is further detailed in Section 6.

### **2.8.2 Progressive Collapse**

*Structures shall be designed to minimize the potential for progressive collapse using the Tie Force Method as defined in U.S. Government (USG) guidelines for the prevention of progressive collapse. Structures shall develop peripheral, internal, and vertical tie forces by providing continuous reinforcement and ductile detailing. Consideration shall be given to ductile moment resisting frame lateral systems at the exterior of the building.*

The design of these facilities to meet the threat independent requirements for progressive collapse will be performed by the project Structural Engineer of Record. Please refer to the Structural Narrative for a description of the Progressive Collapse design and analysis.

### **2.8.3 Anti-ram Resistance**

*Both active and passive barriers shall provide an anti-ram resistance capable of stopping a 4,000 pound (1,800 Kg) vehicle at the speed to be interdicted. The speed determining the appropriate kinetic energy resistance shall be 30 miles per hour (48 Km/Hr).*

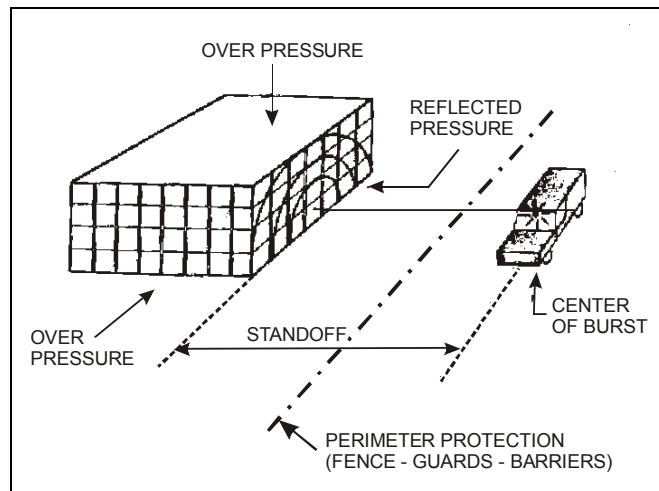
Anti-ram barriers will be provided near the building entrances and around the building as necessary to protect critical site equipment.

## **3 BLAST LOADINGS**

### **3.1 General Blast Principles-Blast Effects**

The intensity of the blast environment on a target structure depends on the explosive weight, composition of the explosive material, and the standoff distance. The standoff is a function of the horizontal distance from the target structure to the center of the blast, the position of the blast (height of burst) relative to the target structure, and the angle of incidence, measured between the point of detonation and the target structure.

The shock wave, or overpressure, diminishes rapidly as it expands as a hemispherical pressure wave from the source of the explosive detonation. The shock wave is characterized by a sudden rise in pressure and a rapid exponential decay, which is followed by a lower intensity negative phase of longer duration. As the blast wave engulfs the target structure it is reflected and diffracted, creating focus and shadow zones on the façade. The magnitude of the peak pressures and impulses are reduced with distance from the source and the resulting patterns of blast loads appear to be concentric rings of diminishing intensity. The effect is analogous to the circular ripples that are created when an object is dropped into a pool of water. These patterns of blast load intensity are complicated as the waves are reflected and diffracted by the structure. The pressures that load the roof, sides and rear of the structure are termed incident pressures, while the pressures that load the façade directly opposite the explosion are termed reflected pressures. See Figure 4 for a diagram of the parameters discussed above.



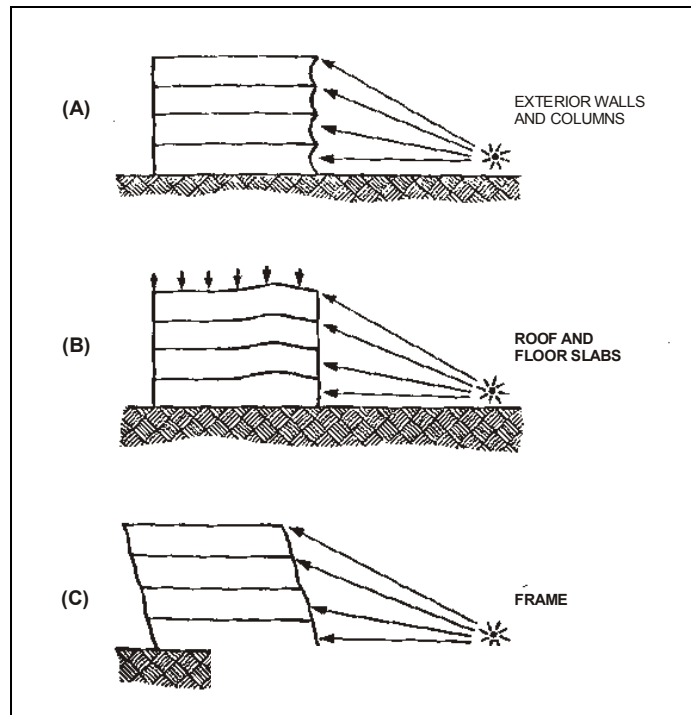
**Figure 4 – Blast Loading Parameters**

From the parameters listed above, the incident overpressures, reflected pressures, incident impulse and reflected impulse can be calculated. These blast loads are then used in determining the response of target components being analyzed. In addition to these basic parameters, other factors such as the neighboring structures and other massive objects may have an effect on the structural damage incurred from a blast. These objects may confine or obstruct the blast energy and thus could intensify or diminish the blast loading applied to a target structure.

The exterior walls and windows facing the blast will be the first components to be loaded by the blast wave. Within milliseconds, the blast wave will sweep over the roof and around the sides of the building. The ability of the target structure or façade to resist the blast pressures will be a function of the structural materials, the section properties of the elements, the structural spans, the connection details, and the structure's period of vibration.

The structure's lateral load resisting system will be subject to the effects of the blast loads many tens of milliseconds later, as these forces are transferred from the cladding to the diaphragms and eventually to the frames and shear walls. These forces must eventually be transferred through the structure to the foundations. This loading sequence is shown in Figure 5. For larger

buildings subject to relatively small explosive threats and short standoffs, the global loads on the lateral load resisting system of the building do not have a significant effect on the building and are not investigated.

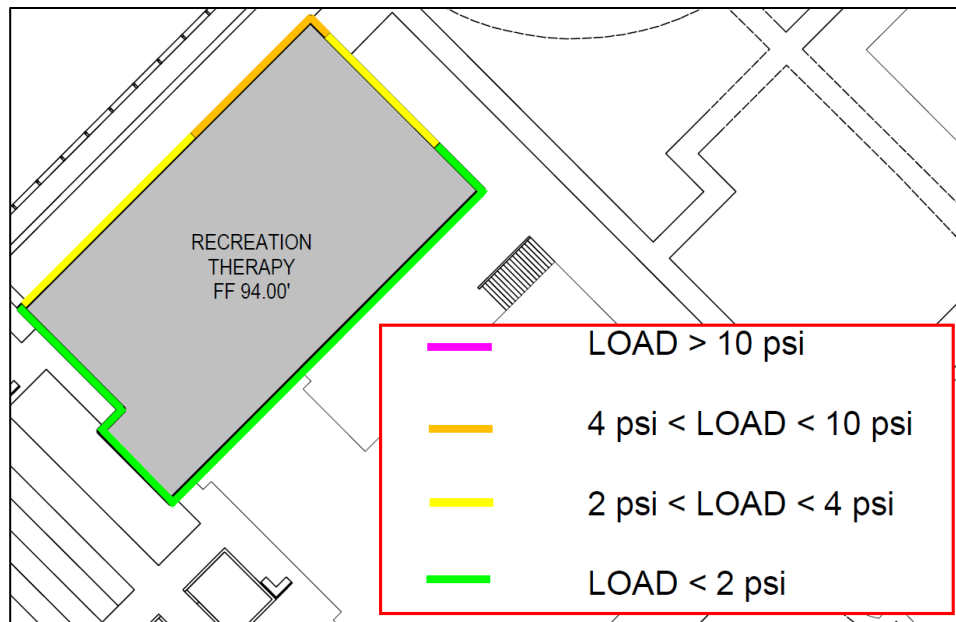


**Figure 5 - Blast Loading Sequence**

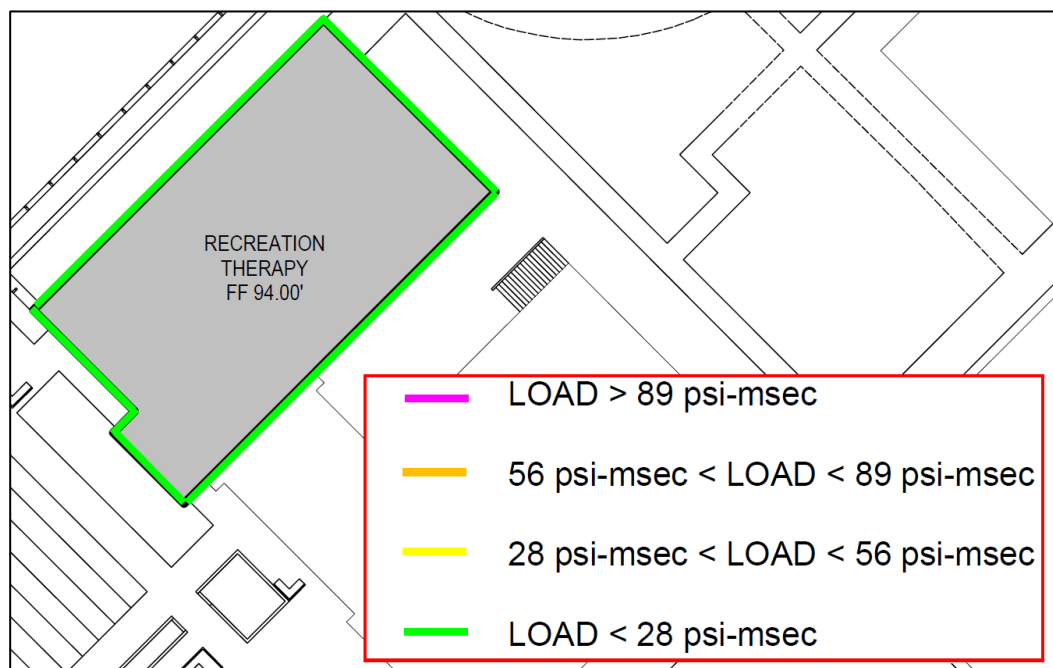
Airblast models were developed using the computer codes ConWep to define the blast load environment for the various regions of the VA Palo Alto facility. ConWep is a collection of conventional weapons effects calculations from the equations and curves provided in TM 5-855-1 "Design and Analysis of Hardened Structures to Conventional Weapons Effects."

### **3.2 Blast Load Environment**

The blast loads utilized in the design of the Recreations Facility were determined using the computer code ConWep. The minimum blast loads utilized in design of the structure was determined by considering the design level vehicle threat (W1) located at the protected perimeter. Table 1 summarizes the explosive threats, standoffs and corresponding peak reflected blast pressures and impulses.



**Figure 6 - Pressure Distribution**



**Figure 7 - Impulse Distribution**

<b>Table 1 – Typical LLOP Design Blast Loads</b>			
Elevation	Minimum Standoff [ft]	Peak Reflected Pressure [psi]	Peak Reflected Impulse [psi-msec]
West	65	5.2	28
South	165	2.2	14
SE Corner	170	2.1	13

#### 4 BLAST DESIGN METHODOLOGY – EXTERIOR FACADE

All exterior facade components of the facility including the glazing, window systems, window connections, storefront systems, window backup frame members and debris mitigation systems are designed for the calculated blast loads provided in Section 3.2 and to meet the performance requirements provided in Section 6.1.

All of the façade elements are designed to exhibit ductile failure modes using dynamic, inelastic analysis. Design material strengths have been increased in these analyses to account for each material's static and dynamic properties as outlined in Table 2. All connections and attachments will be designed using load and resistance factor design (LRFD), treating all blast reactions and forces as factored loads and using the appropriate safety factors ( $\phi$ -factors). When allowable stress design (ASD) is utilized, an equivalent factor of safety was achieved.

<b>Table 2 - Average Strength Factors and Dynamic Increase Factors for Dynamic Analysis</b>			
Material	Average Strength Factor	Failure Mode	Dynamic Increase Factor
Compressive strength of concrete	1.1	Flexure	1.19
		Compression	1.12
		Direct Shear	1.10
Steel yield strength (reinforcing steel)	1.1	Flexure	1.17
		Compression	1.10
		Direct Shear	1.10
		Bond	1.17
Steel yield strength (hot-rolled steel)	1.1	Flexure/Shear	1.19
		Tension/Compression	1.12
Aluminum yield strength	1.0	Flexure/Shear	1.00

##### 4.1 Glazing

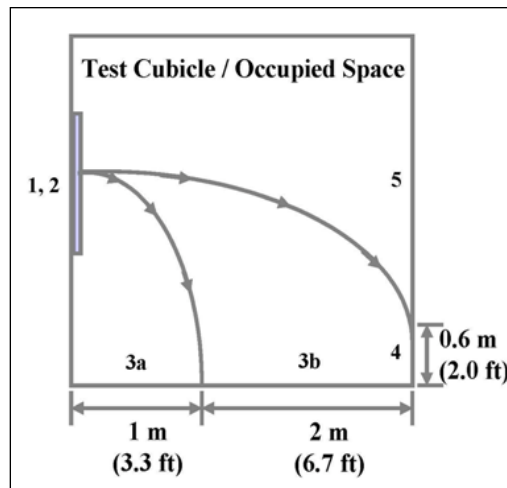
The glazing, a pressure sensitive element, is the first building component likely to fail in response to the initial blast pressure that engulfs the building. Due to the extreme intensity of blast pressures, a considerable amount of glazing on the target structure will be damaged in response to most realistic car bomb threats. However, the hazard associated with the damaged debris may be effectively controlled through the use of protective glazing materials.



Commonly used monolithic annealed (An) glass behaves very poorly when loaded dynamically because the general failure mode for annealed glass creates large sharp edged shards. While typical annealed plate glass is only capable of resisting minimal blast pressure, there exist several other types of glazing capable of resisting larger loads such as heat strengthened glass (HS), fully or thermally tempered glass (FT or TT) and Polycarbonate layups. The most effective protective glazing utilizes lites of glass that are laminated to each other with polyvinyl butyral (PVB) interlayers. For typical double pane Insulated Glazing Units (IGU), only the interior lite would be specified as laminated glass, with a monolithic outer lite which is considered a sacrificial element that adds little resistance to the glazing system. Laminated glass possesses the most desirable post damage behavior in its ability to retain the fragments after the glass fractures, thereby limiting the extent of airborne shards that are projected into occupied space.

The protection is further enhanced if the bite of the window frame is designed to retain the sheet of damaged laminated glass in the window frame or a structural silicone sealant is used to adhere the laminated glass to the frame. Structural silicone adhesive is used along the four-sides of the glass and is preferably a two-part shop-glazed application of DOW 983 structural silicone or a one part field-glazed application of DOW 995 structural silicone. This attention to the size of the bite and/or the sealant attachment will prevent the entire sheet of damaged laminated glazing and the shattered outer lite from flying free and becoming projectiles. In addition, it will prevent the glazing from detaching from the frames and permit the system to develop the full capacity of the glass.

For a this facility, the VA guidelines permit glazing to fracture and come out of the frame, enter the occupied space and land on the floor no further than 10 feet (3 m), corresponding to a Low Hazard Rating as defined by ASTM F1642 (see Figure 8).



**Figure 8 – ASTM F1642 Glass Hazard Rating**

The performance of the glazing subjected to the design blast loads was determined using GSA-developed WINGARD 5.5.1 PE glass hazard response software. WINGARD 5.5.1 PE dynamically analyzes various glazing layups for given window geometries and blast loads. The



glazing Performance Condition and dynamic edge reactions can be generated in WINGARD for use in the dynamic analysis of supporting mullions.

#### **4.2 Window Mullion and Frame Design**

Equally important to the design of the glass is the design of the frames and attachments to the structure. The effectiveness of the lamination and adhesives may be compromised if the window frames themselves are not designed to remain attached to the structure when subjected to high intensity blast loads. To secure the glazing in the frames, a deformation limit for the frames and mullions equal to  $L/30$  is used if structural silicone is used to adhere the glass to the frame. Similarly, a deformation limit of  $L/60$  is imposed if structural silicone is not used. The mullions and window frame members were designed using WABLAST, a software package developed by WAI for the blast analysis of flexural elements. This software package incorporates single-degree-of-freedom (SDOF) dynamic analysis principles presented by John M. Biggs in "Introduction to Structural Dynamics" to determine the dynamic response of the analyzed component. Using the SDOF software, the section properties of the various mullions were designed to meet the specified performance limits. A yield strength equal to 25ksi was assumed in the design of the window aluminum mullions and window frame members. Material over-strength factors were assumed as specified in Table 2.

### **5 EXTERIOR FAÇADE BLAST DESIGN**

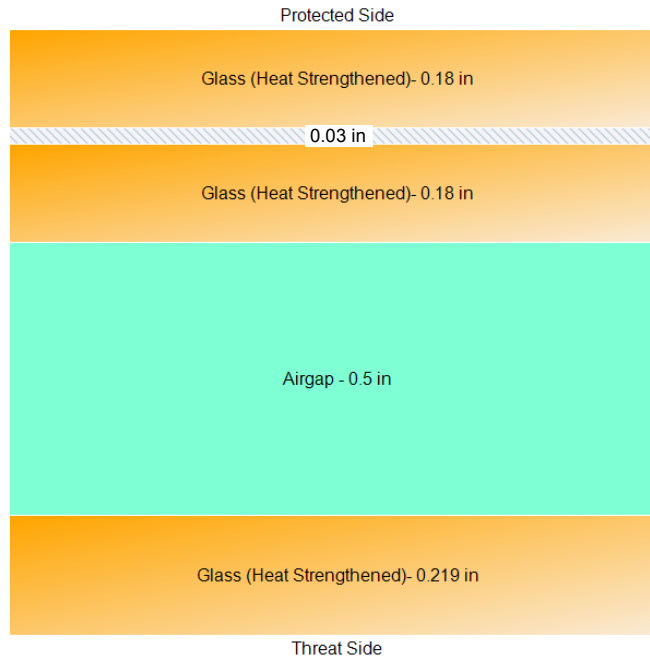
#### **5.1 Façade Overview**

The Recreations Facility exterior façade system includes glazed curtainwall systems and ribbon window systems.

#### **5.2 Window Frame and Glazing Design**

##### **5.2.1 Exterior Glazing**

Designs for the typical punched windows and storefront systems were completed for the baseline design loads (see Table 1) and in Recreations Facility in accordance with Section 3.4 of this report. The glazing was designed such that after glass breakage occurs in response to design blast loading glass fragments that enter the space will land on the floor no further than 3.3ft from the window, consistent with a Low Hazard performance condition (Performance Condition 3b). The glazing layup provided in Figure 9 was determined to satisfy the glazing hazard performance requirements for the typical punched window types for the calculated design blast loads provided in Table 1. For this glazing layup a  $1/2$ " mechanical frame bite and a  $1/4$ " continuous bead of structural silicone was determined to be sufficient to retain the glazing in the frame and develop the required capacity of the glass laminate.



**Figure 9 - Typical Punched Window Glazing Layup**  
**( 1/4" HS Outer-lite + 1/2" Air gap + 3/16" HS + 0.03" PVB + 3/16" HS Inner-lite)**  
**HS = Heat Strengthened**

Note that the glazing makeup has only been checked for blast requirements only. The architect and glass contractor will verify that the selected glass makeup will meet all other project performance requirements such as wind, thermal, manufacturing, handling and any others.

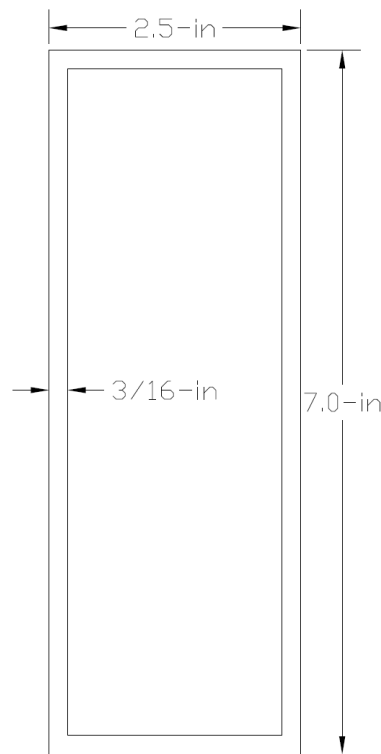
## 5.2.2 Typical Curtainwall

The design load for the Life Safety Recreations Facility building is GP1, as outlined in the VA Guidelines. The glass fragment hazard software WINGARD version 5.5.1 was utilized to design the glazing to achieve an ISC Performance Condition 3b response or better, for the GP1 load. Condition 3b is defined as the glazing breaks, glass fragments enter space and land on floor no further than 10-ft (3-m) from the window. A typical curtainwall window lite is 116-in tall by 72.0-in wide. Based on the prescribed load, the following glass makeup was found to satisfy the performance requirements for the GP1 load: 1/4" HS Outer Lite + 1/2" Air Gap + (3/16" HS + 0.030 PVB + 3/16" HS) Inner laminated Lite. (note: HS = heat strengthened glass; PVB = polyvinyl butyral laminate interlayer)

WAI determined the dimensions of the aluminum curtainwall mullion required to meet the rotation limit of 4° (L/30) in response to the GP1 loads. The baseline mullion was assumed to be 2.5-in wide with a wall thickness of 3/16-in. The depth of the mullion was varied as necessary to satisfy dynamic response limits. Utilizing tributary analysis, the typical curtainwall mullion dimensions are nominally 2.5-in wide by 7.0-in deep by 3/16-in thick. These dimensions are based on a rectangular aluminum tube with the following section properties:

- Area (A) = 3.4 in<sup>2</sup>
- Moment of Inertia (I) = 20.0 in<sup>4</sup>
- Elastic Section Modulus (S) = 5.7 in<sup>3</sup>
- Plastic Section Modulus (Z) = 7.3 in<sup>3</sup>

See Figure 10 for typical curtainwall mullion frame profile. Note that the indicated mullion depth is measured from the inside surface of the glass to the back of the mullion.



**Figure 10 – Typical Curtainwall Mullion**

### 5.2.3 Typical Stud Wall System

The wall system was analyzed for blast loads. WAI determined the minimum structural requirements for the studs to have acceptable performance in response to a GP1 load. The flexural performance of the wall is assumed to be based on the performance of the steel studs only. The mass of the wall system, which includes the weight of the terracotta, the aluminum support framing and the gypsum board, were incorporated into the dynamic analysis. Based on a tributary analysis, the stud wall that supports the rain screen shall consist of 6" deep, 16-gage studs, Grade 50 (600S162-54-50), spaced 8" o/c, with 1/2" fiberglass-matted exterior sheathing to satisfy the VA guidelines under the GP1 loads. The purpose of the fiberglass-matted exterior sheathing is to help mitigate debris hazard.

## 6 STRUCTURAL PROTECTION

The Physical Security Design Manual provides requirements for blast resistant structures and includes requirements for the prevention of progressive collapse and the hardening of critical columns. The following section summarizes the analysis of the building components requiring blast resistance.

### 6.1 Performance Requirements

Structures shall be constructed to withstand the actual pressures and corresponding impulses produced by the design level vehicle threat (W1) located at the protected perimeter and the design level satchel threat (W0) that may be delivered to loading docks, mailrooms, lobbies, and below grade parking garages prior to screening. The design shall provide a medium level of protection for which the building damage will be economically repairable and the space in and around damaged area can be used and will be fully functional after cleanup and repairs.

This qualitative definition of medium level of protection loosely translates into quantitative performance requirements for structural and non-structural components as defined by "Single Degree of Freedom Structural Response Limits for Antiterrorism Design," U.S. Army Corps of Engineers Protective Design Center Technical Report PDC-TR 06-08 Revision-1 dated January 7, 2008. Table 3 provides the ductility and rotation response limits for typical structural and non-structural members relevant to the blast design of this project.

<b>Table 3 – LLOP Response Limits</b>		
<b>Member</b>	<b><math>\mu</math> (Ductility)</b>	<b><math>\theta</math> (Rotation)</b>
Window Mullions (wet glaze)	-	3
Window Mullions (dry gasket)	-	2
Structural Steel Framing Members (Beams)	3	3
Structural Steel Framing Members (Columns)	3	3
Concrete Slab	-	4

### 6.2 Loading dock and mailrooms

The Physical Security Design Manual requires that, when located within the building, structural columns passing through the mailroom and loading dock, and the floor slabs above them should be structurally hardened to sustain an explosion within the mailroom or loading dock inspection areas from the design charge weight (W1).

There is no mailroom or loading dock in the Recreations facility. It is assumed that no unscreened mail or packages will be delivered to the building.

### 6.3 Column protection

The Physical Design Manual requires that primary structural elements, such as columns, exposed to blast loading be hardened or isolated to resist the effects of the design level vehicle threat (W1)

at the available standoff distance, and the design level satchel threat (W1) that may be delivered to loading docks, mailrooms, lobbies, and below grade parking prior to screening.

There is no loading dock, mailroom or below grade parking for unscreened vehicles programmed for the Recreations facility.

Perimeter columns may be subject to the blast effects of a vehicle W1 explosive charge. Columns are required to meet a ductility limit of 3 and a rotation limit of 3°. Dynamic analysis of the perimeter columns has indicated that the existing column sizes as shown on the structural drawings satisfy the performance limits. The attached appendix includes the corresponding blast calculations for select conditions.

#### **6.4 Slabs and framings**

The Physical Security Design Manual requires that the secondary structural elements, such as floor beams and slabs, be constructed to withstand the actual pressures and corresponding impulses produced by the design level vehicle threat located at the available standoff distance. The Design Manual requires a level of protection where building damage will be economically repairable and the space in and around the damaged area can be used and will be fully functional after cleanup and repairs.

Slabs and framing were analyzed for the blast overpressures generated by the W1 threat located at the available standoff distance. Dynamic analysis of the slabs and framing has indicated that the existing framing as shown on the structural drawings satisfies the performance limits. The attached appendix includes the corresponding calculations for select conditions.

#### **6.5 Progressive Collapse Prevention**

The Physical Security Design Manual requires the structures to be designed to minimize the potential for progressive collapse using the Tie Force method.

The design of these facilities to meet the threat independent requirements for progressive collapse will be performed by the project Structural Engineer of Record. Please refer to the Structural Narrative for a description of the Progressive Collapse design and analysis.