GENERAL NOTES

1. THE FOLLOWING NOTES ARE APPLICABLE TO ALL CONTRACT DOCUMENTS INCLUDING THE PROJECT SPECIFICATIONS. IN THE INSTANCE OF A DISCREPANCY, NOTIFY THE CONTRACTING OFFICER FOR CLARIFICATION.
2. UNLESS MORE STRINGENT CRITERIA IS SPECIFIED IN THE PROJECT DOCUMENTS, ALL DESIGN, MATERIAL AND WORKMANSHIP SHALL CONFORM TO THE MINIMUM REQUIREMENTS FOUND IN THE GOVERNING CODES AND REFERENCED STANDARDS.
3. ALL ELEVATIONS SHOWN ON DESIGN DRAWINGS ARE REFERENCED TO FINISH FLOOR ELEVATION 100'-0" CORRESPONDING TO A USGS DATUM ELEVATION THAT WILL VARY WITH THE SITE ADAPTATIONS.
4. THE STRUCTURE SHOWN ON THESE DRAWINGS IS STRUCTURALLY SOUND ONLY IN THE COMPLETED FORM. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE STRENGTH AND STABILITY OF THE STRUCTURE DURING ERECTION. CONTRACTOR SHALL PROVIDE TEMPORARY SUPPORTS, SHORING, BRACING AND ANY OTHER STRUCTURAL SYSTEMS AS REQUIRED TO RESIST ALL FORCES THAT MAY OCCUR DURING HANDLING AND ERECTION UNTIL THE STRUCTURE IS FULLY COMPLETED. TEMPORARY SUPPORTS, BRACING AND OTHER STRUCTURAL SYSTEMS REQUIRED DURING CONSTRUCTION SHALL REMAIN THE CONTRACTOR'S PROPERTY AFTER THEIR USE.
5. THE CONTRACTOR SHALL VERIFY THE LOCATIONS OF ALL EXISTING UTILITIES IN THE AREA OF PROPOSED CONSTRUCTION, BY HAND DIGGING IF NECESSARY.
6. CONTRACTOR SHALL VERIFY ALL DIMENSIONS AND EXISTING CONDITIONS BEFORE BEGINNING WORK, ORDERING MATERIAL, AND PREPARATION OF SHOP DRAWINGS. ANY DISCREPANCIES BETWEEN FIELD CONDITIONS AND THE CONTRACT DOCUMENTS SHALL BE BROUGHT TO THE IMMEDIATE ATTENTION OF THE ENGINEER.
7. IT IS THE CONTRACTOR'S RESPONSIBILITY TO FOLLOW OSHA REQUIREMENTS AND OTHER APPLICABLE SAFETY CODES AND REGULATIONS DURING ALL PHASES OF CONSTRUCTION.

CONCRETE NOTES

1. DESIGN, DETAILING AND CONSTRUCTION OF REINFORCED CONCRETE SHALL CONFORM TO THE FOLLOWING ACI PUBLICATIONS UNLESS OTHERWISED NOTED:
   - BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE (ACI 318) LATEST EDITION
   - DETAILS AND DETAILING OF CONCRETE REINFORCEMENT (ACI 315) LATEST EDITION
   - MANUAL OF ENGINEERING AND PLACING DRAWINGS FOR REINFORCED CONCRETE STRUCTURES (ACI 315R) LATEST EDITION
   - SPECIFICATIONS FOR STRUCTURAL CONCRETE FOR BUILDINGS (ACI 301) LATEST EDITION
   - GUIDE FOR CONCRETE FLOOR AND SLAB CONSTRUCTION (ACI 302.1 R) LATEST EDITION
2. UNLESS OTHERWISE NOTED, CONCRETE SHALL BE NORMAL WEIGHT AND SHALL DEVELOP 28 DAY COMPRESSIVE STRENGTH AS FOLLOWS:
   SLABS ON GRADE= 4000 PSI
   FOOTINGS, WALLS AND MISCELLANEOUS INSTALLATIONS= 4000 PSI
3. REINFORCING STEEL SHALL BE DEFORMED BARS CONFIRMING TO ASTM A615, GRADE 60. WELDED WIRE FABRIC SHALL CONFORM TO ASTM A185.
4. CONCRETE EXPOSED TO WEATHER OR FREEZING SHALL BE AIR-ENTRAINED. EXTERIOR FOOTINGS, PEDESTALS, WALLS, SLABS AND ANY CONCRETE CAST DURING COLD WEATHER SHALL BE CONSIDERED AS CONCRETE EXPOSED TO WEATHER AND FREEZING.
5. UNLESS OTHERWISE SHOWN, PROVIDE FOLLOWING COVER FOR REINFORCING STEEL:
   UNFORMED SURFACES IN CONTACT WITH EARTH.........3 IN.
   UNFORMED SURFACES OVER MOISTURE BARRIERS.......2 IN.
   FORMED SURFACES EXPOSED TO EARTH, WEATHER, OR WATERPROOFING/DAMP PROOFING.........................1 1/2 IN.
6. PROVIDE SMOOTH FORMED FINISH ON ALL EXPOSED VERTICAL CONCRETE SURFACES.

FOUNDATION NOTES

1. THE DESIGN OF THE FOUNDATIONS IS BASED UPON THE FOLLOWING ASSUMPTION FOR THE PURPOSE OF SITE ADAPTABILITY:
   i. ALLOWABLE NET SOIL BEARING PRESSURE= 2000 PSF
   -IF FOUND TO BE LESS THAN 2000 PSF AT SITE SPECIFIC LOCATION THEN DESIGN FOR THE ALLOWABLE BEARING PRESSURE OF THE SITE ADAPTATION.
2. NO FOOTING SHALL BEAR DIRECTLY ON ROCK. WHERE ROCK IS LESS THAN 2'-0" FROM THE BOTTOM OF THE FOOTING, UNDERCUT FOOTING A MINIMUM OF 2'-0" BELOW THE BOTTOM OF THE FOOTING AND TWO FEET WIDER THAN THE FOOTING. BACKFILL WITH APPROVED STRUCTURAL FILL.

DESIGN EXPLOSIVE WEIGHTS AND DISTANCES FOR MISSILE PROTECTIVE SHELTERS - GRENADE FAMILIARIZATION RANGE		
	MUNITION	MINIMUM DISTANCE METERS [FEET]
FRAGMENTATION GRENADE	M67	10 [33]

DESIGN EXPLOSIVE WEIGHTS AND DISTANCES FOR MISSILE PROTECTIVE SHELTERS - LIGHT DEMO RANGE		
STATION	MAXIMUM NET EXPLOSIVE WEIGHT (LB. TNT)	MINIMUM DISTANCE METERS [FEET]
WIRE/FENCE CLEARING	7	100 [328]
WIRE/FENCE CLEARING W/ BANGALORE	65	200 [656]
MINE CLEARING	166	100 [328]
MINE CLEARING W/ LIVE M15 MINES	166	314 [1030]
STEEL CUTTING	10	100 [328]
TIMBER CUTTING	70	100 [328]
CONCRETE OBSTACLE	40	100 [328]
CRATERING (MULTIPLE CRATERS)	320	250 [821]
CRATERING (SINGLE CRATER)	48	150 [492]

NOTE:

1. THE SECONDARY FRAGMENTS FROM THE INDIVIDUAL CONCRETE CLEARING, STEEL CUTTING, AND TIMBER CUTTING STATIONS MUST BE CAPTURED AT THE STATION.
2. SHELTER NOT DESIGNED FOR LIVE MINE CLEARING OPERATIONS AND BLAST RESISTANT GLAZING IS INADEQUATE FOR M15 MINES WITHIN THE HAZARDOUS FRAGMENT DISTANCE.
3. IF A BANGALORE TORPEDO IS USED IN ANY OPERATION THEN MINIMUM DISTANCE TO THE FRONT OF THE BUNKER IS 200 M.
4. ANY MUNITIONS NOT ENCOMPASSED BY THE TABLE ABOVE MUST BE SITE ADAPTED AND ACCOUNTED FOR BY THE DESIGNER OF RECORD AND CHECKED BY CEHNC.

DESIGN LOADS

1. BUILDING RISK CATEGORY: II
2. DESIGN LOADS:
   A. FLOOR LIVE LOADS: UFC 3-301-01
      OTHER AREAS: 100 PSF
   B. ROOF LIVE LOADS: UFC 3-301-01
      ROOF: 20 PSF
   C. SNOW LOADS: UFC 3-301-01
      GROUND SNOW LOADS:
   D. WIND LOADS: UFC 3-301-01
      (SITE ADAPT)
   E. EARTHQUAKE DESIGN DATA: UFC 3-301-01
      SEISMIC IMPORTANCE FACTOR: 1.0
      (SITE ADAPT)
      BASIC SEISMIC-FORCE RESISTING SYSTEM:
      ORDINARY REINFORCED CONCRETE SHEAR WALLS
      R=4.0
      (SITE ADAPT)
      ANALYSIS PROCEDURE: ASCE 7-10
      EQUIVALENT LATERAL FORCE PROCEDURE
   F. GEOTECHNICAL REPORT: SITE ADAPT
      ASSUMED ALLOWABLE BEARING PRESSURE: 2000 PSF
3. BLAST ANALYSIS PER UFC 3-340-02.

NOTE:

1. THE DESIGNER SHOULD VERIFY THE STRUCTURE FOR SITE-SPECIFIC LOADING CRITERIA.
2. FOUNDATIONS SHALL BE REVISED TO REFLECT SPECIFIC SITE SOIL CONDITIONS INCLUDING LOCAL SITING, TOPOGRAPHIC CONDITIONS, AND FROST PENETRATION DEPTHS.

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MARK	DESCRIPTION	DATE

ISSUE DATE: APRIL 2018
SOLICITATION NO.:
CONTRACT NO.:
PROJECT NUMBER:

DESIGNED BY: MCP
DRAWN BY: MCP
CHECKED BY: JMU & JRN
SUBMITTED BY: JWC
SIZE: ANSI D

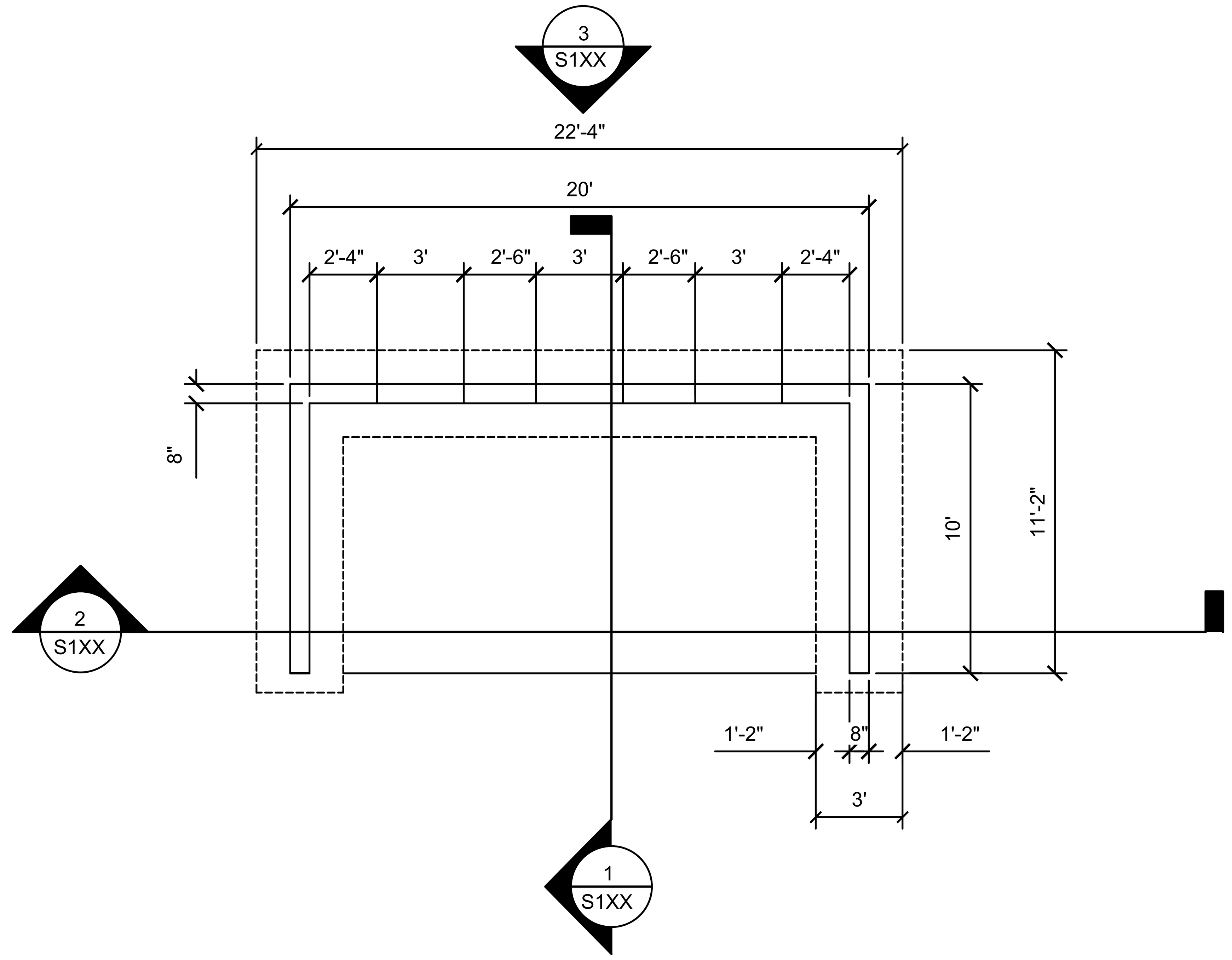
U. S. ARMY CORPS OF ENGINEERS
ENGINEERING & SUPPORT CENTER
HUNTSVILLE, ALABAMA

APRIL 2018

RANGE AND TRAINING LAND PROGRAM
STANDARD DESIGN MANUAL

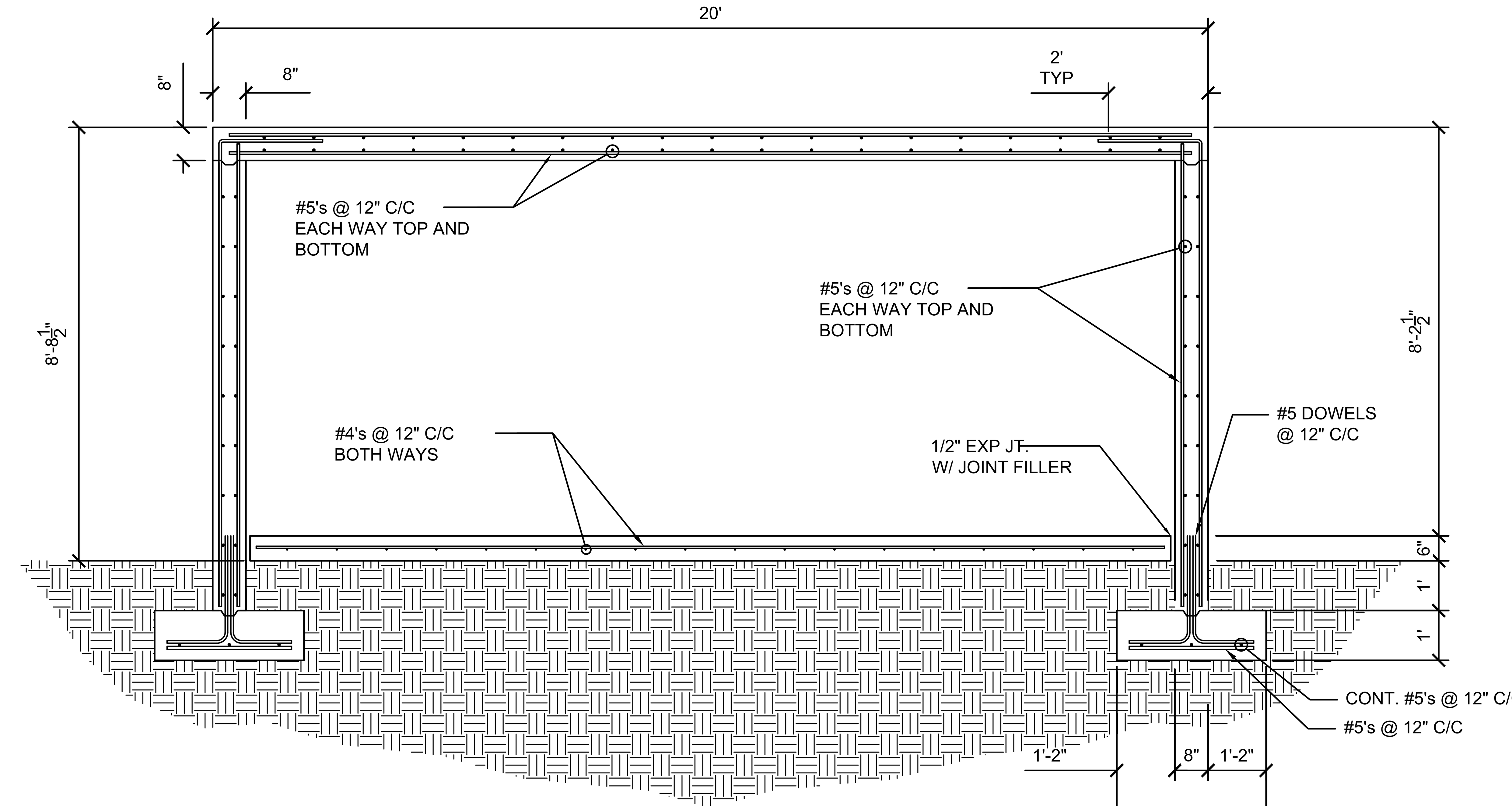
OBSERVATION BUNKER
MISSILE PROOF SHELTER

MPS
SGXX



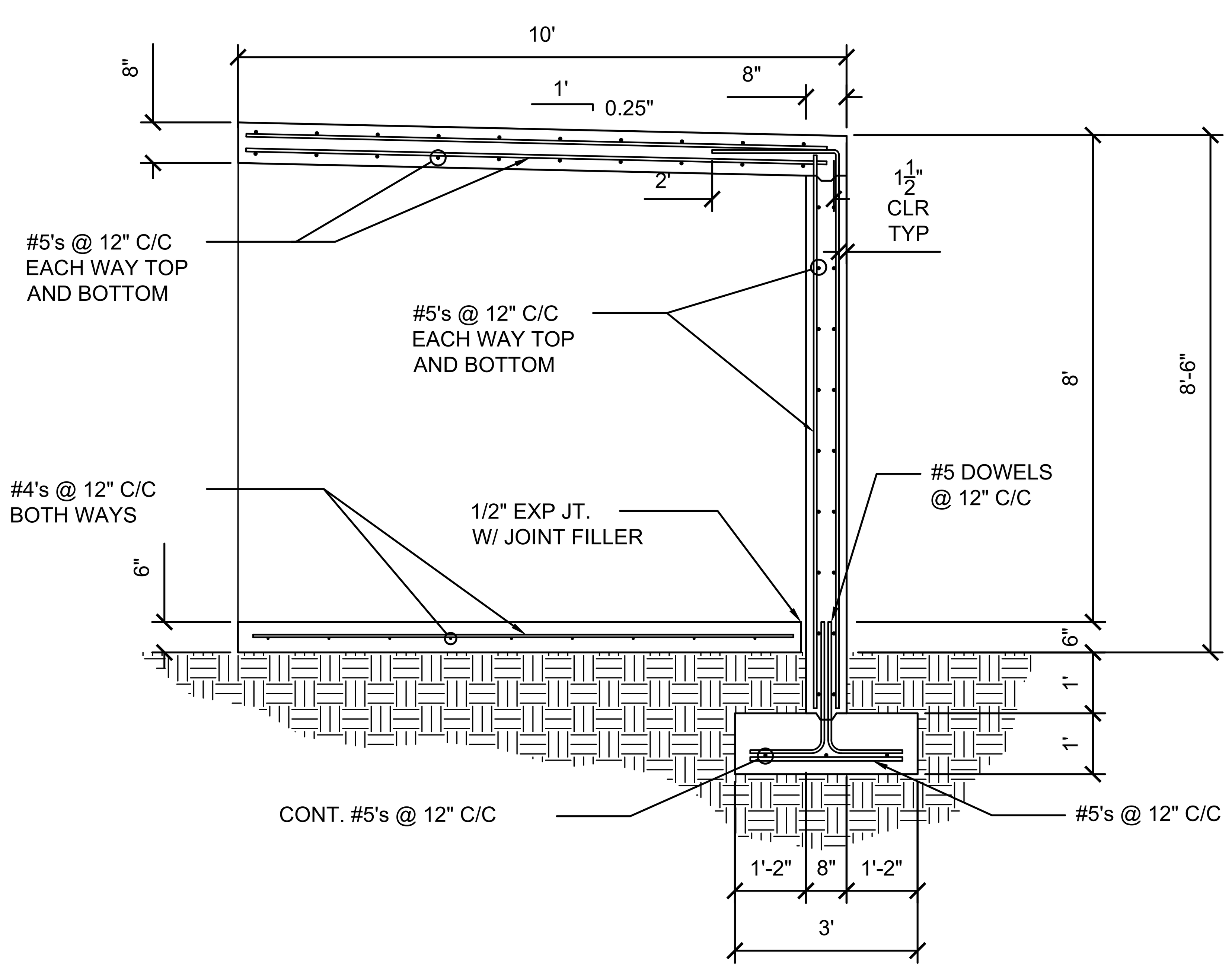
FOUNDATION PLAN

SCALE: 1/4" = 1'-0"



2 S1XX SECTION

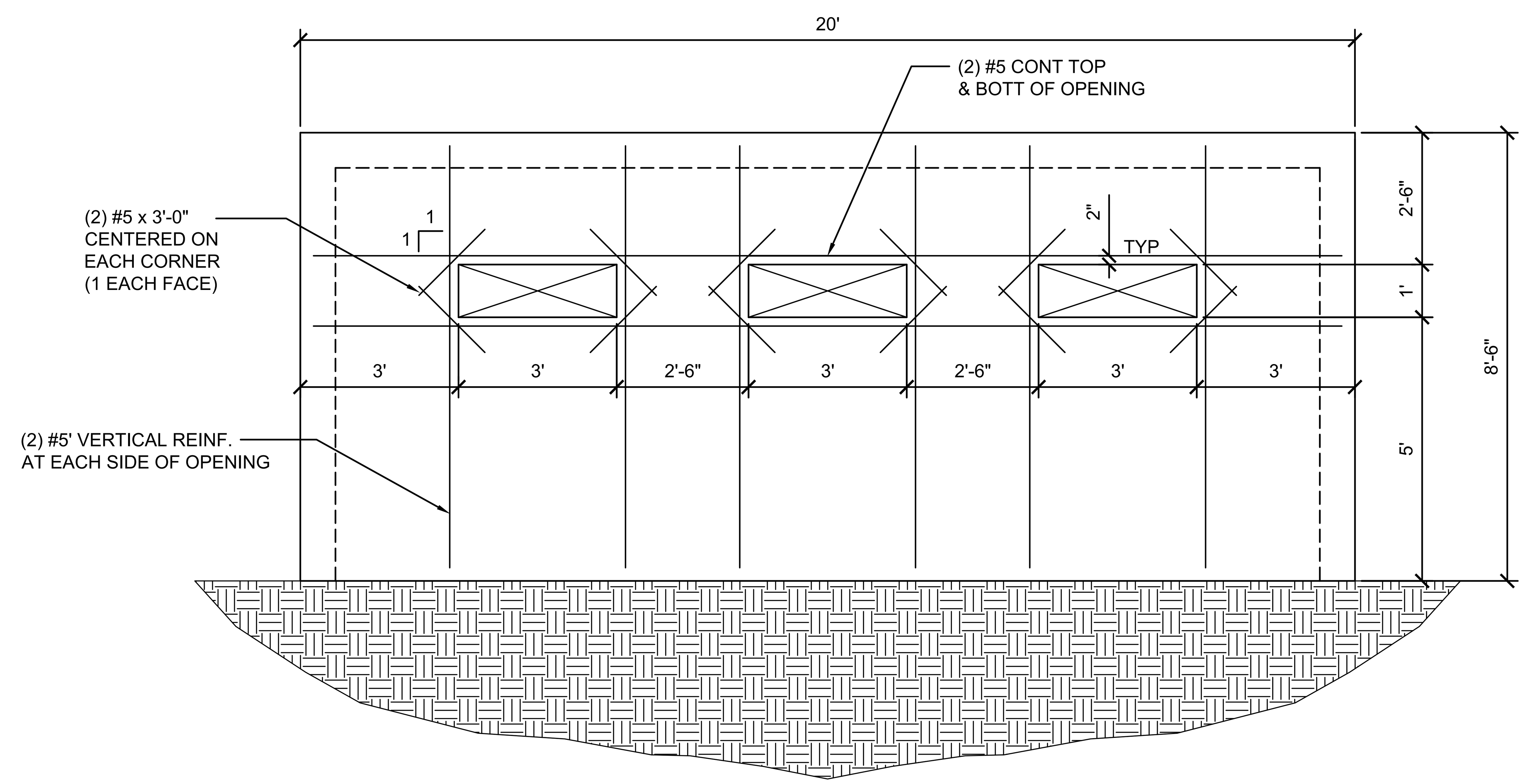
SCALE: 1/2" = 1'-0"



1 S1XX SECTION

SCALE: 1/2" = 1'-0"

NOTE: WHERE FROST DEPTH EXCEEDS 12 INCHES ADEQUATE COVER MUST BE PROVIDED BY DESIGN



3 S1XX FRONT WALL ELEVATION

SCALE: 1/2" = 1'-0"

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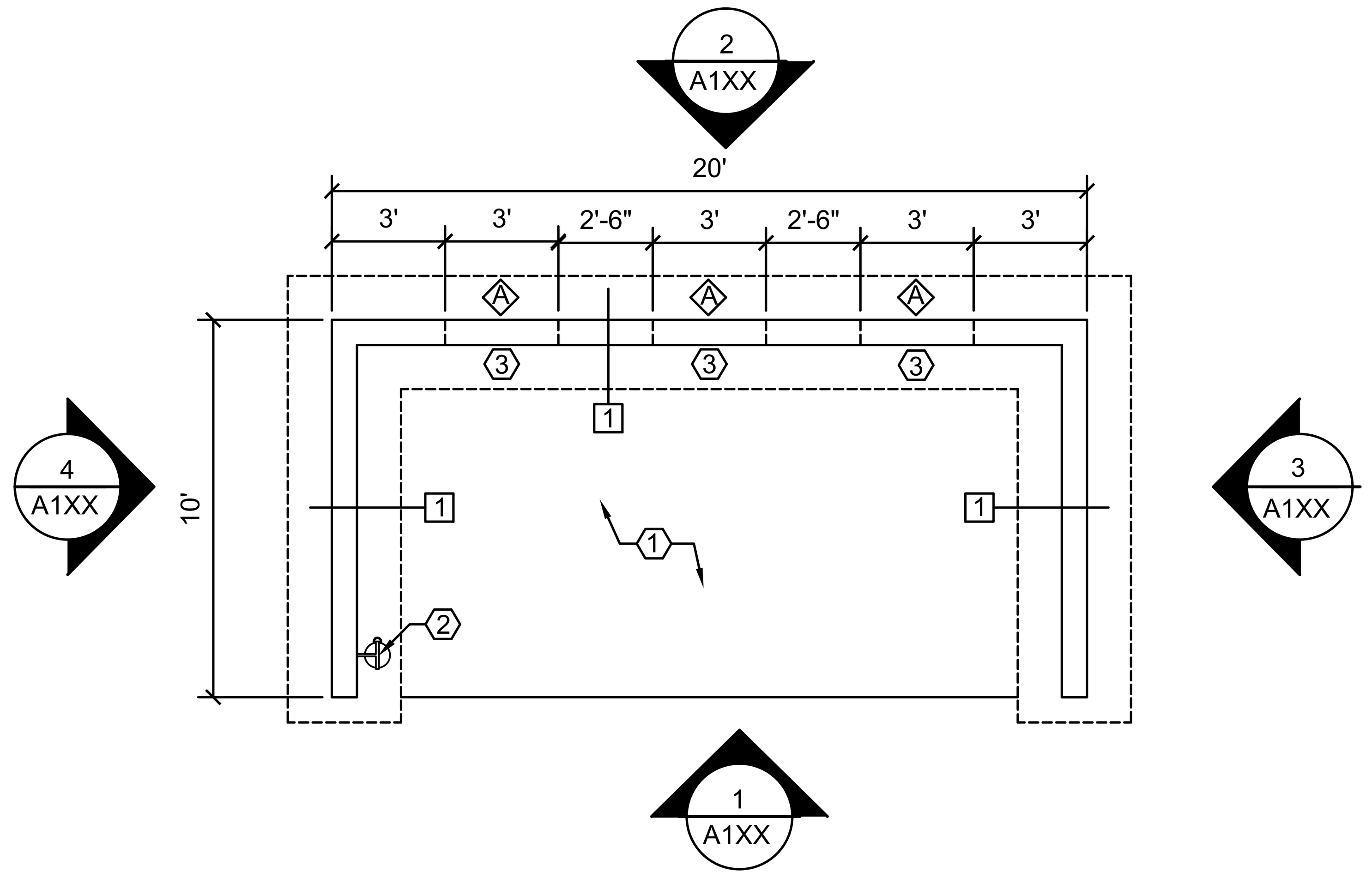
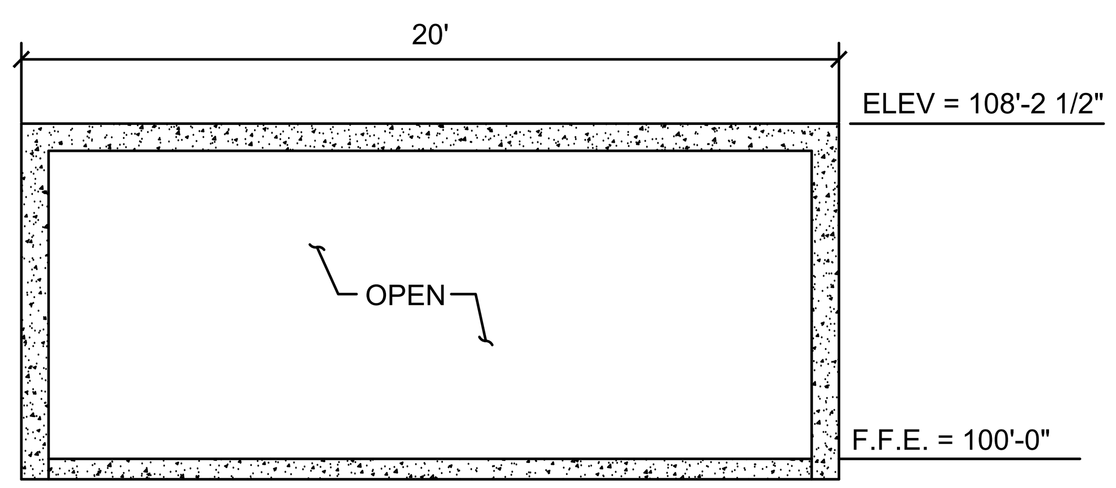
RANGE AND TRAINING LAND PROGRAM
STANDARD DESIGN MANUAL

OBSERVATION BUNKER
MISSILE PROOF SHELTER

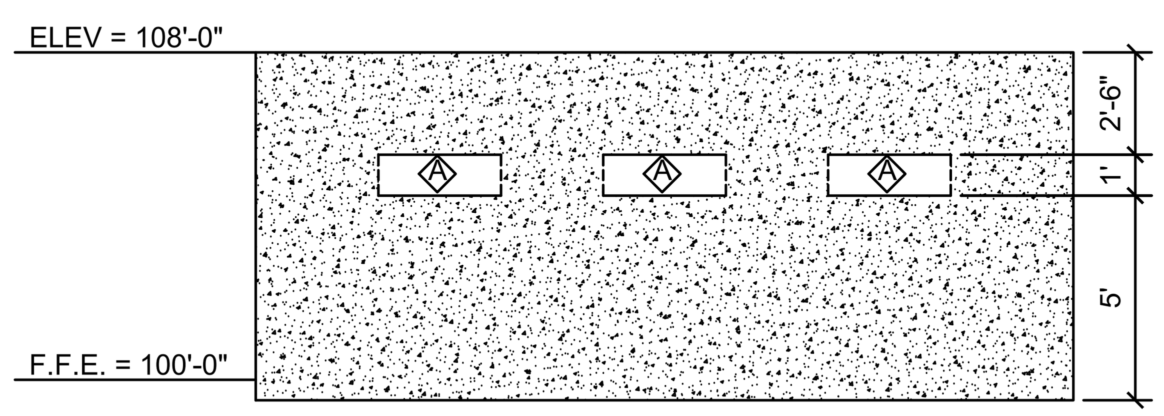
MPS
S1XX



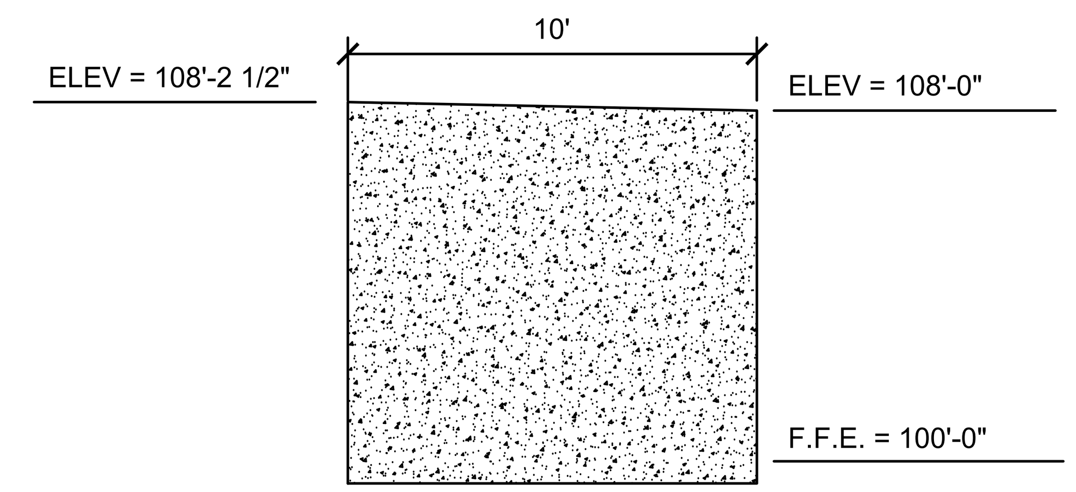
FLOOR PLAN
SCALE: 1/4" = 1'-0"



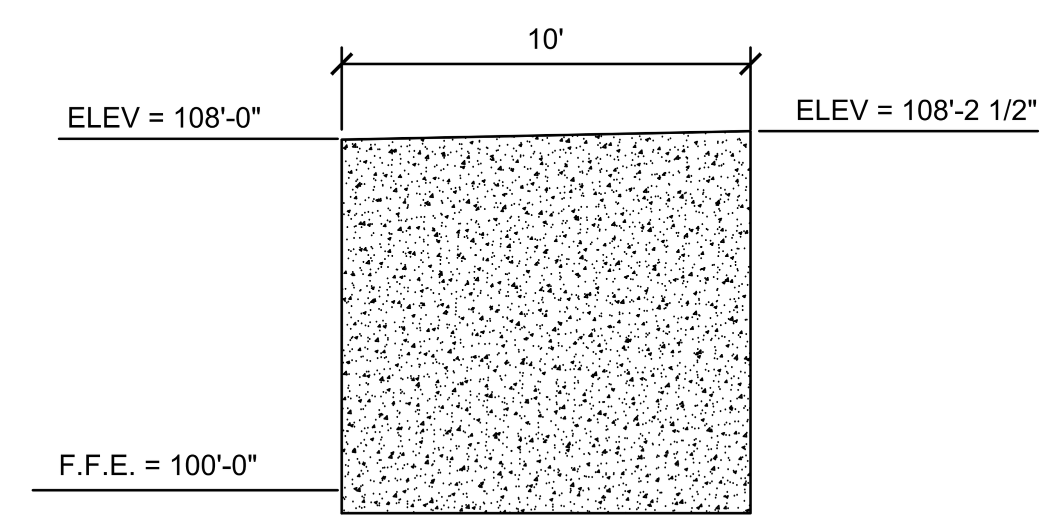
1 / A1XX ELEVATION
SCALE: 1/4" = 1'-0"



2 / A1XX ELEVATION
SCALE: 1/4" = 1'-0"



3 / A1XX ELEVATION
SCALE: 1/4" = 1'-0"



4 / A1XX ELEVATION
SCALE: 1/4" = 1'-0"

GEN NOTES

1. WALL TYPE INDICATED WITH □, REFER TO SHEET A5XX FOR WALL TYPE.
2. WINDOW TYPE INDICATED WITH ◇, REFER TO SHEET A5XX FOR WINDOW TYPE.

FLOOR PLAN TAG NOTES

(1) CONCRETE FLOOR SLAB, REFER TO STRUCTURAL DRAWINGS.

(2) BRACKET MOUNTED FIRE EXTENGUISHER. MOUNT BOTTOM OF UNIT AT 27" A.F.F.

(3) ALUMINUM FRAME WINDOW WITH BULLET RESISTANT GLAZING.

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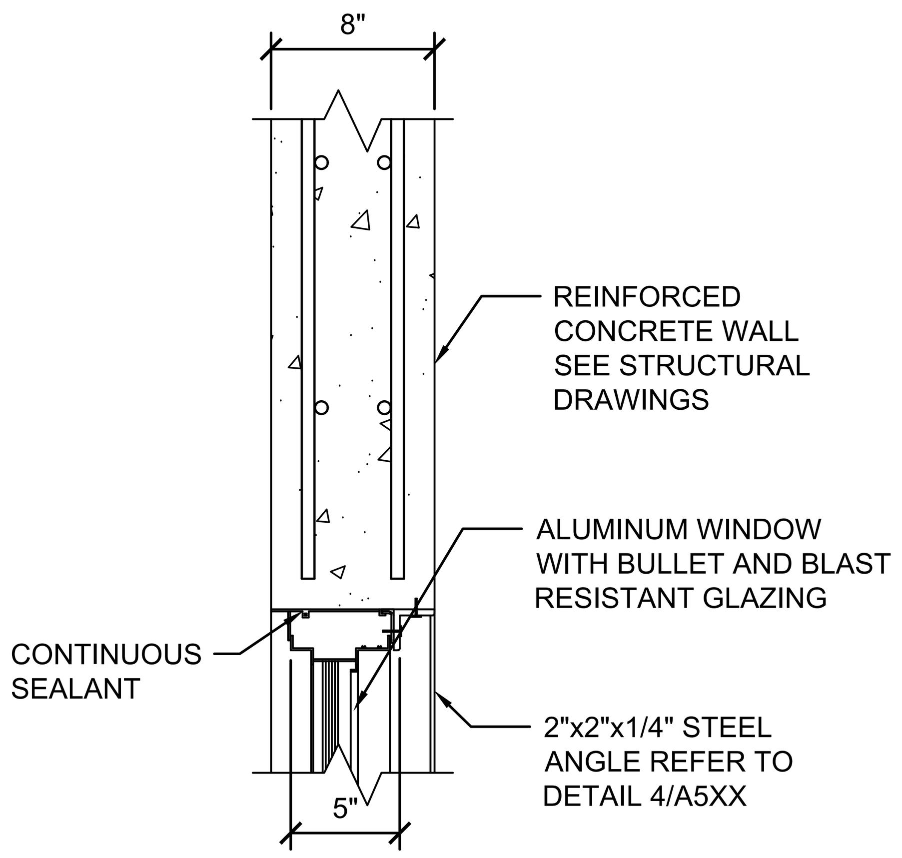
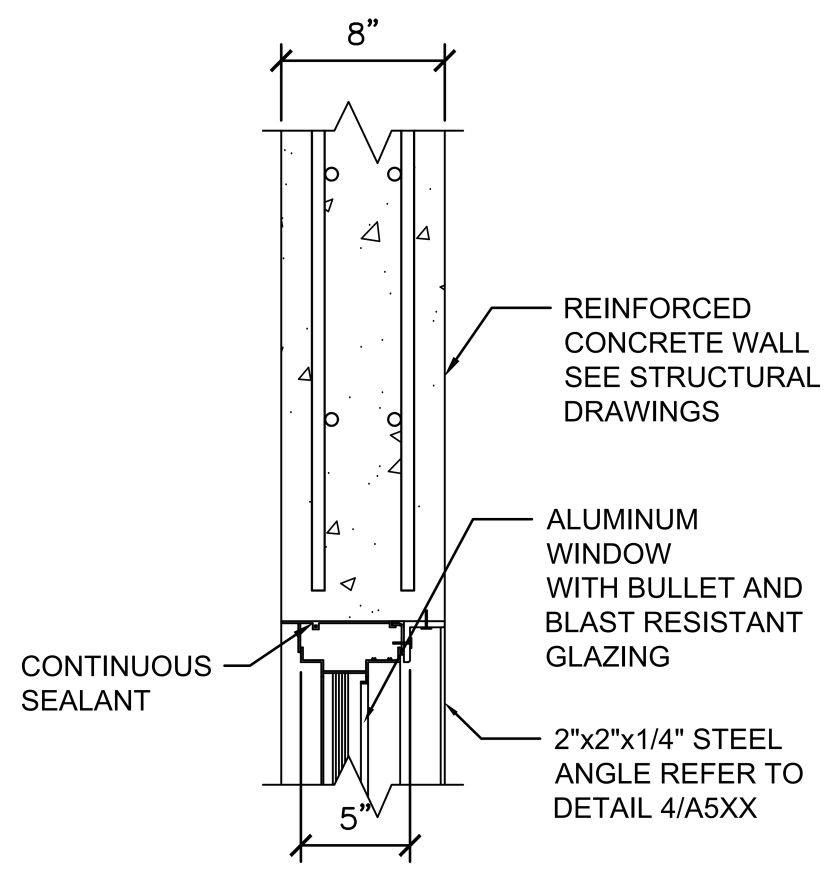
RANGE AND TRAINING LAND PROGRAM
STANDARD DESIGN MANUAL

OBSERVATION BUNKER
MISSILE PROOF SHELTER

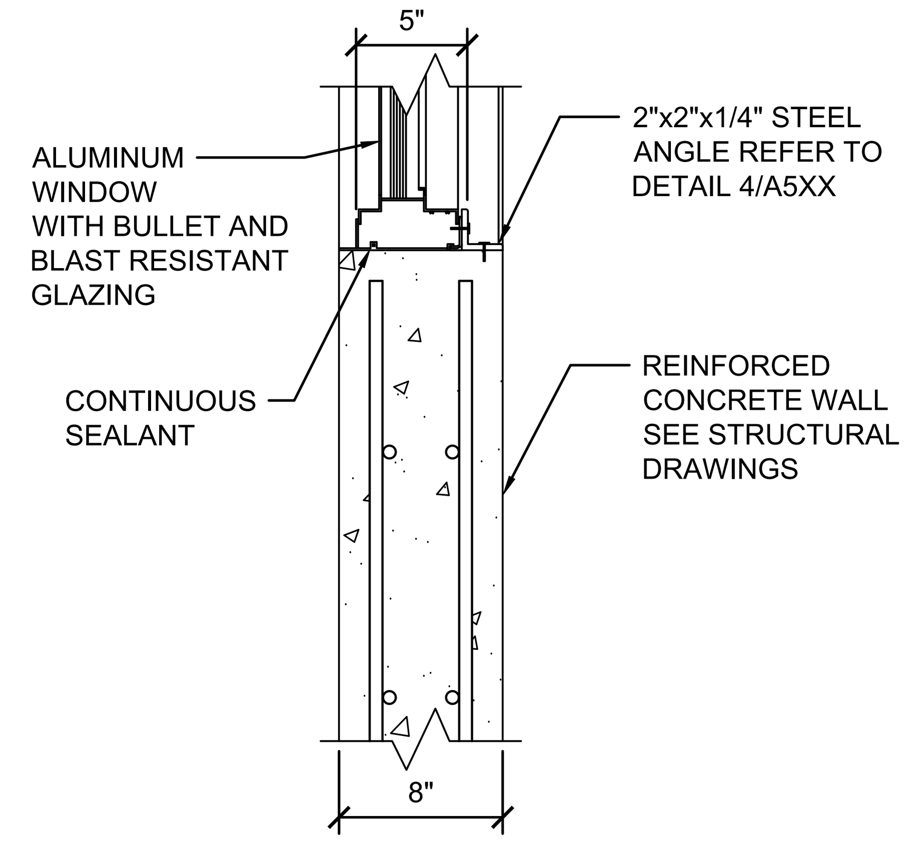
MPS
A1XX



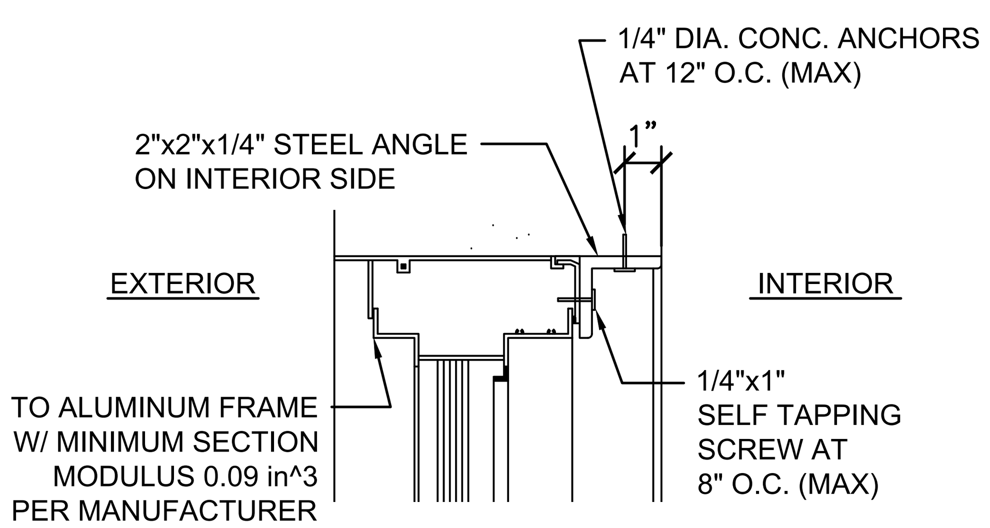
1 A-500 HEAD DETAIL
SCALE: 1 1/2" = 1'-0"



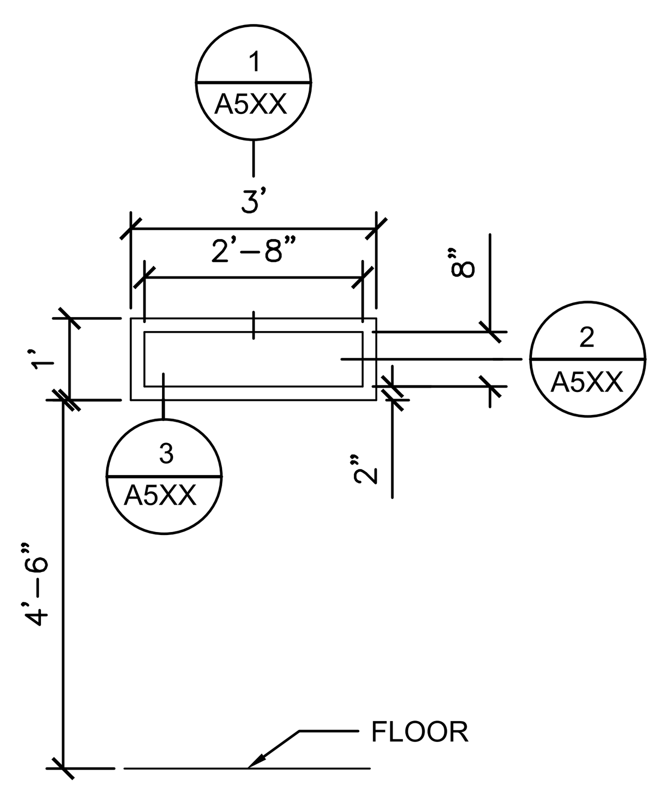
2 A-500 JAMB DETAIL
SCALE: 1 1/2" = 1'-0"



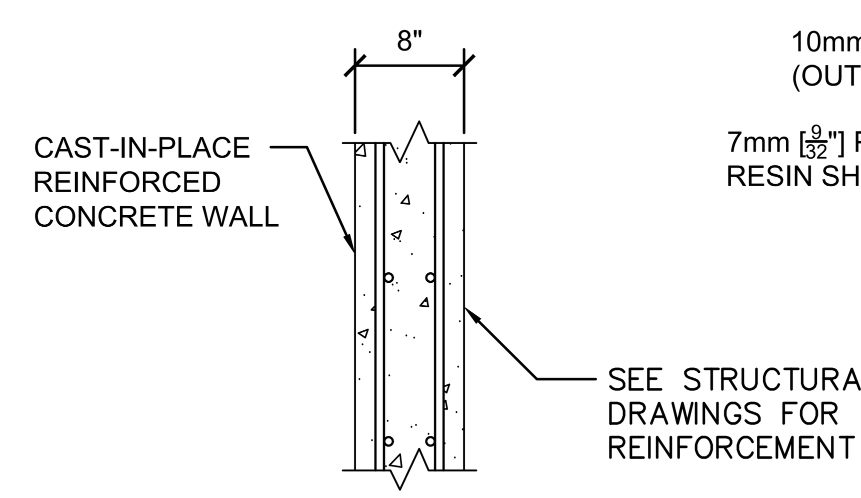
3 A-500 SILL DETAIL
SCALE: 1 1/2" = 1'-0"



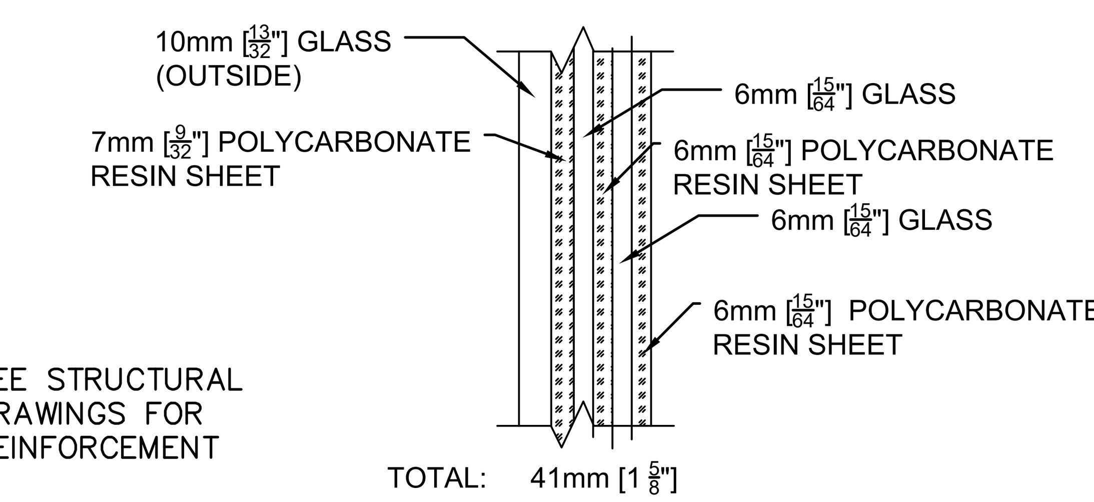
4 A-500 ANGLE DETAIL
SCALE: 3" = 1'-0"



WINDOW TYPE "A"
SCALE: 1/2" = 1'-0"



WALL TYPE "1"
SCALE: 1" = 1'-0"



BULLET RESISTANT AND BLAST GLAZING
SCALE: 6" = 1'-0"

NOTE:
USE 1/2 IN MINIMUM BITE AT ALL SIDES OF WINDOW

NOTE:
ANY DEVIATION FROM THICKNESS OF GLAZING ABOVE MUST MEET UL PROTECTION REQUIRED BY DA PAM 385-63 CHAPTER 5

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ENGINEERING & SUPPORT CENTER
HUNTSVILLE, ALABAMA
APRIL 2018

RANGE AND TRAINING LAND PROGRAM STANDARD DESIGN MANUAL
OBSERVATION BUNKER MISSILE PROOF SHELTER

MPS
A5XX

US ARMY CORPS OF ENGINEERS
Engineering and Support Center, Huntsville

US Army Corps of Engineers

MISSILE PROOF SHELTER & OBSERVATION BUNKER

RANGE AND TRAINING LAND PROGRAM

HNC-EDC-S-18-07
02 APRIL 2018

MISSILE PROOF SHELTER & OBSERVATION BUNKER

Prepared by

Michael Pickett, E.I.T.

02 April 2018

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Reviewed by: ______________________ 02 APR 2018
Jeff Coulston, P.E. — Date
Chief, Structural Branch

Approved by: ______________________ 02 APR 2018
A. Wade Doss, P.E. — Date
Chief, Civil-Structures Division

Executive Summary

A standard design for a Missile Proof Shelter (MPS) and Observation Bunker was requested by the Range and Training Land Program (RTLP) of USACE in coordination with the Reachback Operations Center of USACE for training operations.

Conventional structural design criteria was used to develop the standard using RAM Elements Software, and the guidelines of DoD 6055.09-M, DA-PAM 385-63 and DA-PAM 385-64 were followed to determine adequate safe distances for essential personnel inside of the three-sided bunker. Previous designs of the MPS operated with a minimum safe distance of 100 meters (m). For this reason, the standard design was approached with the intent of maintaining this distance for the purpose of maximizing the usage of land resources while providing proper protection for personnel. The requirement for the MPS to be kept outside of Earth Throw Distance based on a DDESB Technical Paper 16 analysis forced the operation distances to increase higher than the 100 m safe distance. (Reference (D))

The operations being performed by the personnel requiring protection include wire obstacles, mines, steel cutting, timber cutting and road craters.

The governing explosives safety criteria for these operations is found in DoD 6055.09-M which states, "Essential Personnel Minimum Safe Distance (MSD) must be the same as the non-essential personnel MSD in accordance with paragraph V5.E3.2.6., or must provide personnel protection from fragment, thermal, overpressure, noise, and other hazards in accordance with paragraph V1. E9.3.2."

This requires that all fragments be contained or defeated, hearing protection be provided if noise levels exceed limits established in MIL-STD-1474D, thermal flux limited, and blast overpressures limited to less than or equal to 2.3 psi. Using the buried explosive module from DDESB Technical Paper 16 it was found that the distances of Table 1 were required due to the Soil Ejecta Distances of the cratering charges. Using UFC 3-340-02 Figure 2-15, it was determined that the overpressure from the Net Explosive Weights (NEWs) at the distances of Table 1 were sufficiently less than 2.3 psi to conform with this. The requirements of MIL-STD-1474D are met by requiring hearing protection within the MPS at all times of training operations. Spall can be assumed to be negligible at a standoff of 328 feet out in the open with blast pressures significantly less than 2.3 psi. Regarding thermal effects, the fireball diameter for the maximum NEW under consideration is significantly less than the MSD, so thermal effects can be neglected as well.

Table of Contents

1.0 Introduction

A standard design for a Missile Proof Shelter (MPS) and Observation Bunker (OB) was requested by the Range and Training Land Program (RTLP) of USACE in coordination with the Reachback Operations Center of USACE in support of Explosive Ordinance Disposal (EOD) training operations for use on standard light demo and hand grenade familiarization. The intent of the design is to develop a standard that can be replicated with minimal site adaptations to ease the implementation of the MPS/OB at various locations.

2.0 References

a) DoD 6055.09-M "DoD Ammunition and Explosives Safety Standards: General Explosives Safety Information and Requirements," Volumes 1 through 8, Department of Defense, date varies by volume.

b) Department of Defense, DA PAM 385-64 “Ammunition and Explosives Safety Standards,” Department of the Army, 10 October 2013

c) UFC 3-340-02 “Structures to Resist the Effects of Accidental Explosions,” Department of Defense, 5 December 2008, Incorporating Change 2, 1 September 2014.

d) Technical Paper No. 16 “Methodologies for Calculating Primary Fragment Characteristics,” Department of Defense Explosive Safety Board, 19 December 2016.

e) Department of Defense, DA PAM 385-63 “Range Safety,” Department of the Army, 30 January 2012.

3.0 Design Approach

Conventional design criteria was used to develop the standard using RAM Elements Software, and the guidelines of DoD 6055.09-M (Reference (A)), DA-PAM 385-63 (Reference (B)) and DA-PAM 385-64 (Reference (E)) were followed to determine adequate safe distances for essential personnel inside of the three-sided bunker. Previous designs of the MPS operated with a safe distance of 100 meters (m). For this reason, the standard design was approached with the intent of maintaining this distance for the purpose of maximizing the usage of land resources while providing proper protection for personnel.

Overpressures on the structure due to the detonation of the maximum allowable charge weight by Reference (E) of 320 lbs NEW were calculated assuming the previously used 100m safe distance as the minimum standoff, and the structural response was determined using the methodologies found in Reference (C). Due to the low blast pressures at this distance, all structural components remain elastic under blast loading, and conventional loads controlled the structural design.

Earth throw distance calculated from the Buried Explosion Module Version 7.1 of Reference (D) controlled the distance from the bunker to the largest charges analyzed. Any MPS installed must be beyond these distances; therefore, these revised standoffs were assumed for the structural blast analysis.

Fragments were considered using the TP 16 Database Fragment Data Review Forms, and to ensure fragmentation hazards are defeated, the minimum thickness to prevent perforation for both concrete and bullet resistant glass were confirmed to be less than the thickness required by conventional loads and minimum ballistic glazing requirements of Reference (E), respectively. Only the two known munitions, Bangalore Torpedo M1A2 and M67 Fragmentation grenade, were considered and anything outside of the set listed on the drawings must be reviewed using a TP 16 analysis in the future.

4.0 MPS/OB Requirements and Concerns

4.1 MPS/OB Requirements

MPS must provide adequate protection to personnel per Reference (A) and Reference (B). This requires that all fragments be contained or defeated, hearing protection be provided if noise levels exceed limits established in MIL-STD-1474D, thermal flux be limited, and blast overpressures be limited to 2.3 psi or less. Table 1 shows the permitted operations for which the MPS is to be used along with each operation's respective charge weight at standoff limits.

DESIGN EXPLOSIVE WEIGHTS AND DISTANCES FOR MISSILE PROTECTIVE SHELTERS & OBSERVATION BUNKERS		
OPERATION	MAXIMUM EXPLOSIVE WEIGHT (LB. TNT)	MINIMUM DISTANCE (M[ft])
Wire Fence Clearing	7	100 [328]
Wire Fence Clearing w/ Bangalore	65	200 [656]
Mine Clearing	166	100 [328]
Mine Clearing w/ Live M15 Mines	166	314 [1030]
Steel Cutting	10	100 [328]
Timber Cutting	70	100 [328]
Concrete Obstacle	40	100 [328]
Cratering (Multiple Craters)	320	250 [821]
Cratering (Single Crater)	48	150 [492]
M67 Fragmentation Grenade	0.41	10 [32.8]

Table 1

**Note: Any Operations using a Bangalore Torpedo must be done at 200 m [656 ft]*

4.2 MPS/OB Design Criteria & Site Specific Adaptation

Site adaptations must acknowledge and adjust several MPS characteristics to validate the design for site specific parameters. For example, freeze-thaw cycles may require lowering the footings to provide adequate frost depth cover, and seismic values must be checked along with design wind speeds based on site specific locations to determine adequate structural integrity is achieved. Such checks should be performed by a qualified engineer. Any modification to the roof, walls, or windows should be reviewed and approved by CEHNC prior to implementation.

The NEWs shown on the drawings and listed above (Table 1) are the maximums considered for each training operation for the design. These NEWs can not be increased nor the distances from the NEWs reduced for any operation. From Table 1 the worst case blast load was induced by the Mine Clearing operation with a maximum explosive wt of 166 lbs at a distance of 328 ft.

5.0 Design Results

As the MPS will always be well beyond K40 overpressure distances, the design was generally controlled by conventional loads. The structure was designed to have eight inch walls and roof consisting of 4000 psi concrete reinforced with grade 60 #5 bars spaced at 12 inches center-to-center (C/C) in each direction on each face. The ground slab was designed to have a half inch expansion joint between the concrete walls and ground slab. The ground slab is six inches deep and reinforced with #4 bars at 12 inches C/C. A three foot wide continuous footing lines the perimeter of three sides of the structure that ties into the walls with #5 rebar at 12 inches C/C. Openings are reinforced with additional #5 rebar, with the layout of rebar shown on Drawing S1XX to give additional capacity for stress concentration areas.

Due to the exposure of repeated detonation, it is recommended that Range Safety Standard Operation Procedures address periodic visual structural inspections of the shelter.

5.1 Window Design

The MPS/OB is designed to have three viewing windows in the front wall facing the training operations. As such, these windows must be shown to provide adequate protection from all hazards associated with such operations, including overpressure, fragmentation, and thermal hazards.

Section 5-1.b(7(a)) of Reference (E) contains viewing port construction requirements; this criteria has been assumed for blast analysis and consists of six alternating layers of polycarbonate and glass. From the outer/blast face and progressing inward toward the occupied/safe face of the window, these layers are 10mm glass, 7mm polycarbonate, 6mm glass, 6mm polycarbonate, 6mm glass, and 6mm polycarbonate. Using this layup with standard polyvinyl butyral (PVB) laminate, the software program WINGARD PE was used to analyze the 3 foot wide by 1 foot tall windows subjected to the worst case blast pressures assumed for the structural analysis. Results show that the window does not fail and has a maximum displacement of 0.00 inches. Results further show the requirement for a minimum frame bite of 0.50 inches, which is shown on the drawings.

Conservatively assuming the worst-case edge shear reaction load calculated by WINGARD for all edges of the window, minimum framing and anchorage requirements were determined. Using 6063 T6 Aluminum or stronger, a framing member must have a minimum elastic section modulus of 0.09 in^3, which is far less than most conventional framing members for a window of this thickness. The 2x2x$^1/_4$ angle on which the window frame bears has both a higher flexural strength and a higher elastic section modulus. Regarding the anchorage of the window frame into the surrounding structure, ¼" steel bolts spaced at 12" has been shown to be sufficient. The portion of the wall supporting the windows has been shown to be sufficient in the wall structural analysis.

As mentioned in Section 3.0 above, per the various Fragmentation Data Review Forms, the minimum thickness to prevent glass breakage due to fragmentation has been surpassed for all munitions considered. CEHNC should be consulted prior to the use of any munition not listed on the general notes page of the design drawings for the MPS.

Any deviation from the approved window design shown in the design drawings should be analyzed by a competent blast engineer and reviewed by CEHNC prior to installation.

6.0 Conclusion

As demonstrated in the sections above, the MPS/Observation Bunker design described in this report will support the RTLP missions described while providing sufficient protection to personnel from overpressure, fragmentation, debris and thermal hazards in accordance with References (A) (B) & (E). Any deviations to the design described in this report should be reviewed by CEHNC prior to implementation.