# DDESB TECHNICAL PAPER 15 UPDATE & STANDARD ECM DESIGNS

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# TECHNICAL PAPER 15 (TP 15) BACKGROUND

- “Approved Protective Construction”
- Documents origin and evolution of protective construction design and associated criteria

- Original version dated February 2001
  - Developed, maintained by Eric Deschambault (DDESB) until retirement
- Current version is Rev 3, dated May 2010

- CEHNC funded to develop new revision (Rev 4)

# FORMAT & CONTENT

- Chapter 1: Introduction
- Chapter 2: Magazine History
- Chapter 3: ECM Descriptions
- Chapter 4: Magazine Listings
- Chapter 5: Underground Ammo Storage Facilities
- Chapter 6: Barricades & Containment Structures
- Chapter 7: Barricaded Module Storage
- Chapter 8: Airfield Associated PC/Mitigation
- Chapter 9: Other Non-Storage Related PC
- Appendix AP1: Magazine Listings
- Appendix AP2: Operational Field Storage

# FORMAT & CONTENT

Appendix AP1 Tables

- AP1-1: 7-Bar & 3-Bar ECM Approved for New Construction
- AP1-2: 7-Bar & 3-Bar ECM No Longer Approved for New Construction, But Still in Use
- AP1-3: Undefined ECM
- AP1-4: Magazines (Earth-Covered and Aboveground) and Containers with Reduced NEWs and/or Reduced QD

# KEY TP 15 CONTENT

- ECM history & basis of validation
- Approved ECM tables
- List of detonation chambers/vessels and approval caveats
- Airfield reduced MCE & QD



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# REV 4 UPDATES

- Magazine History (Chapter 2) content
- Incorporate recent approvals/criteria updates, e.g.:
  - detonation chamber approvals
  - legacy flat roof ECM siting
  - updated MTC guidance
  - Noble Eagle Reduced MCEs & QD
- General edits for format/wording

- **Table AP1-1 ECM List Update/Reduction**

# LONG-TERM INTENT FOR TP 15

- Create a “living document”
  - Regularly updated
  - Hosted online
- Users can access support documents from online database
  - Construction drawings
  - Approval memoranda
  - Technical reports, etc.

- No set timeline currently

# 7-BAR ECM APPROVED FOR NEW CONSTRUCTION (TABLE AP1-1)

- Army Designs:
  - 421-80-01
  - 421-80-03
  - 421-80-05
  - 421-80-07
  - 421-80-08
  - 421-80-09
- Navy Designs:
  - Type M
  - Type C
  - Type D
  - MSM
- Other:
  - 33-15-74 (Korean)

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# 421-80-01

| DRAWING NO. (NOTE 1) | DRAWING DATE | DESCRIPTION (1) | DESIGN AGENT | DDESB APPROVAL DATE | ECM DESIGNATION | COMMENTS: (Notes 2 and 3) |
|---|---|---|---|---|---|---|
| 421-80-01 | 5-Feb-88 | Steel, Semi-circular Arch | COE | 28-Jun-88 | 7-Bar | Replaced 33-15-64. Drawing permits the use of a 2" deep or 5.5 " deep corrugated steel arch. Internal width and heigth dimensions are approximately 26' wide by 13' 6" high. The minimum internal length is 19', expandable up to the most commonly used magazine length of 89'. The magazine has a single entrance with 2 size options with sliding steel doors: a) 8'0" wide by 8'0" high (8'10" wide by 8'3" high door), or b) 10'0" wide by 10'0" high (10'10" wide by 10'3" high door). |

- Steel corrugated arch, semi-circular (2” or 5.5” corrugation)
- Dimensions:
  - 19’ to 89’ length
  - 26’ width
  - 13.5’ max height
- Built-up steel door w/ 2 size options
  - 8’x8’
  - 10’x10’
- Design validation
  - Predecessor (AW 33-15-64) tested in steel arch test (1962-63) & ESKIMO I (1971)
  - Door & headwall originally from 33-15-73, tested in ESKIMO III (1974)
- Electrical updates at DDESB for review
- Will be replaced by **421-80-12** in coming months

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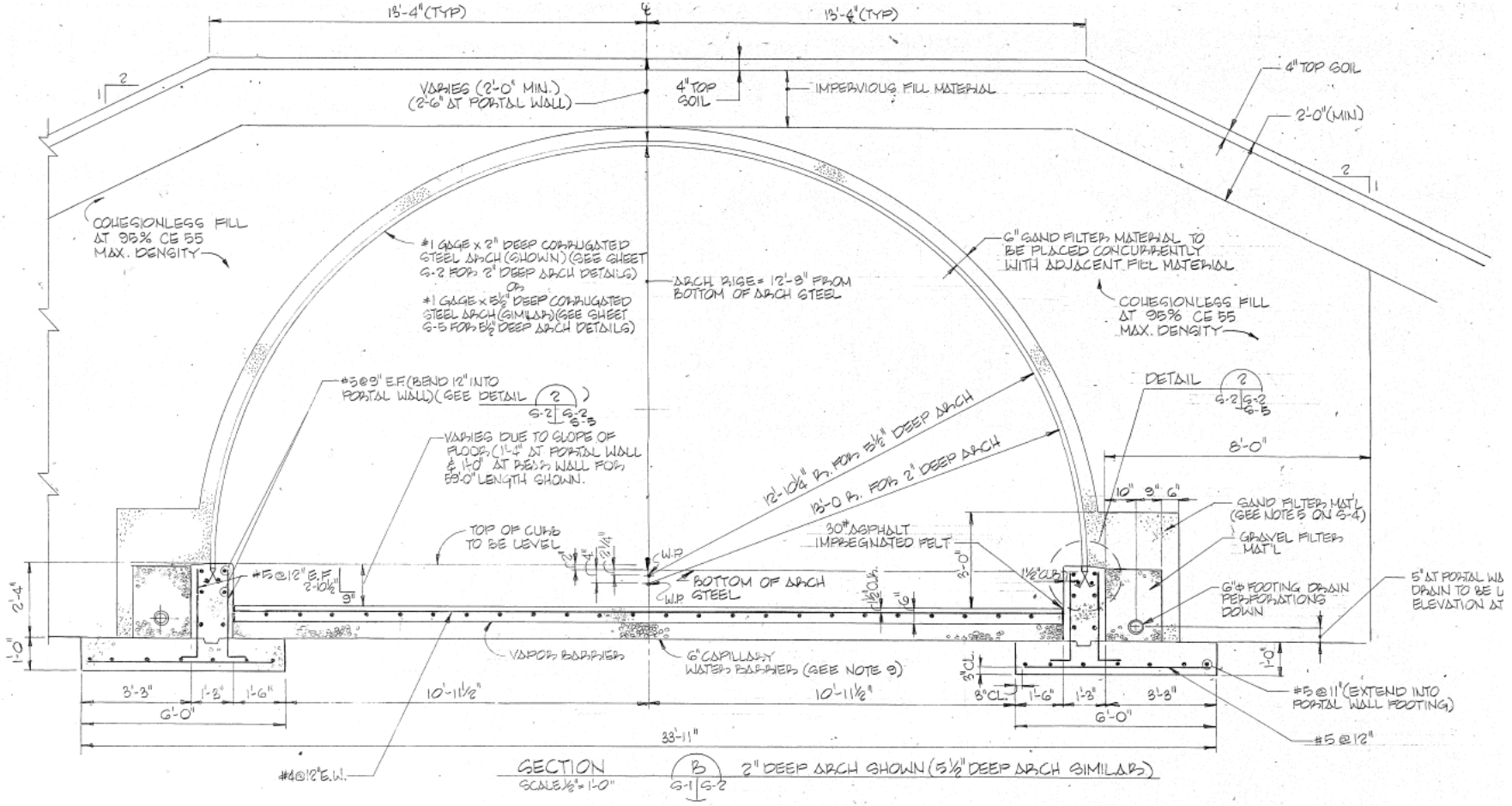
# 421-80-01

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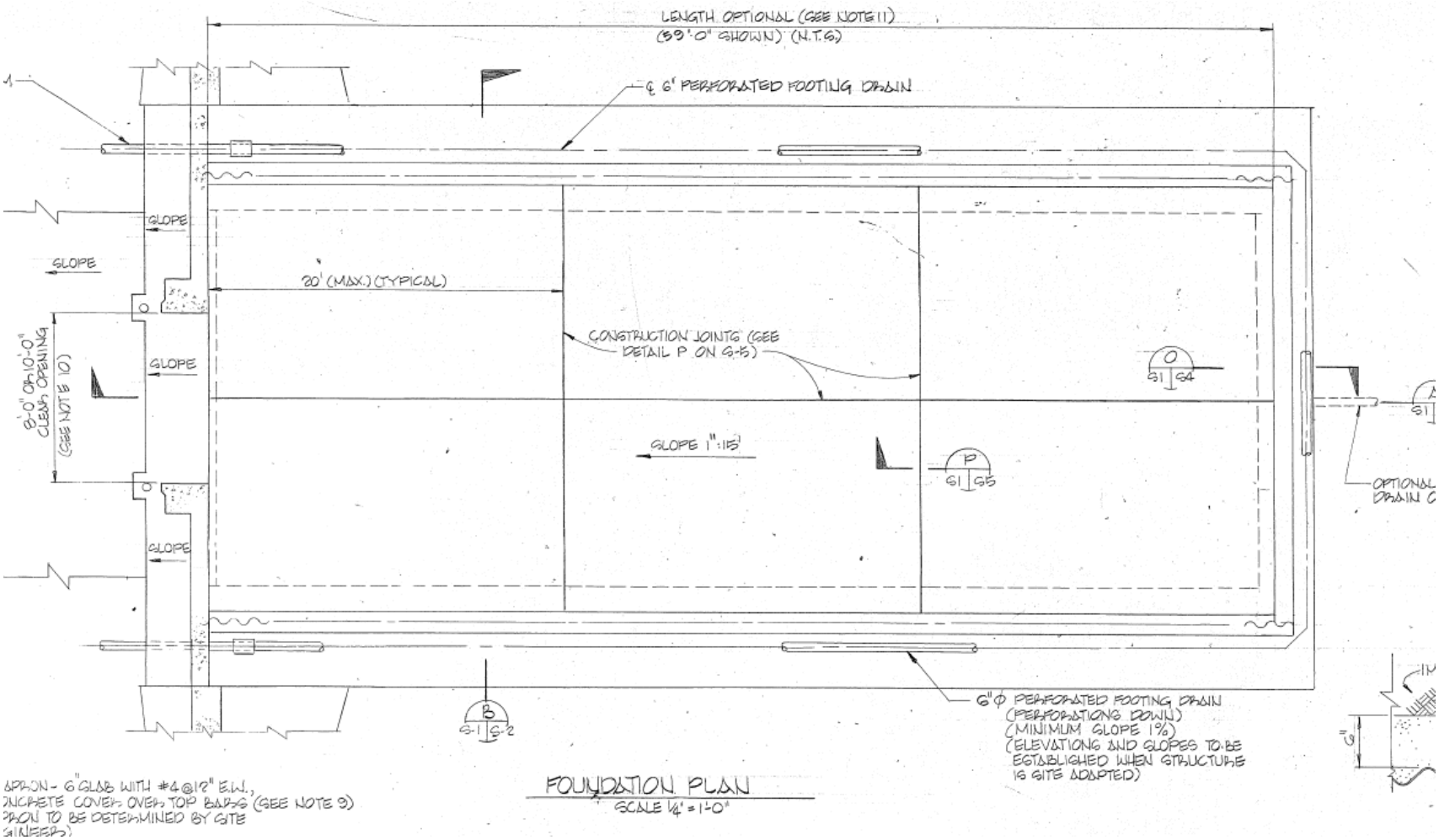
# 421-80-01

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# 421-80-03

| DRAWING NO. (NOTE 1) | DRAWING DATE | DESCRIPTION (1) | DESIGN AGENT | DDESB APPROVAL DATE | ECM DESIGNATION | COMMENTS: (Notes 2 and 3) |
|---|---|---|---|---|---|---|
| 421-80-03 | 30-Oct-92 | Steel, Oval Arch | COE | 28-Dec-92 | 7-Bar | Replaced 33-15-73. Arch design composed of a 1 gage (0.280 inch) corrugated steel arch. Internal dimensions are 24' wide (measured from base of steel arch) by 21' (minimum) to 89' maximum length. Arch height is 14' 5". The magazine has a single entrance with 2 size options with sliding steel doors: a) 8'0" wide by 8'0" high (8'10" wide by 8'3" high door), or b) 10'0" wide by 10'0" high (10'10" wide by 10'3" high door). DDESB approval signature of 28 Dec 1992 on drawings. Thirty-nine ECM based on this design drawing were constructed at Camp Leatherneck, Afghanistan, using the CONTECH SUPER-SPAN Mode1102A15-24 High Profile Arch. DDESB approval memo DDESB-PE of 6 Oct 2010 approved the use of this arch as meeting the arch requirements of 421-80-03, thereby considering the ECM as 7-bar structrues. |

- Steel corrugated oval-arch
- Dimensions:
  - 21’ to 89’ length
  - 24’ width
  - 14.5’ max height
- Built-up steel door w/ 2 size options
  - 8’x8’
  - 10’x10’
- Design Validation
  - Predecessor (33-15-73) tested in ESKIMO III (1974)
- Electrical updates at DDESB for review
- Will eventually be replaced by modernized design

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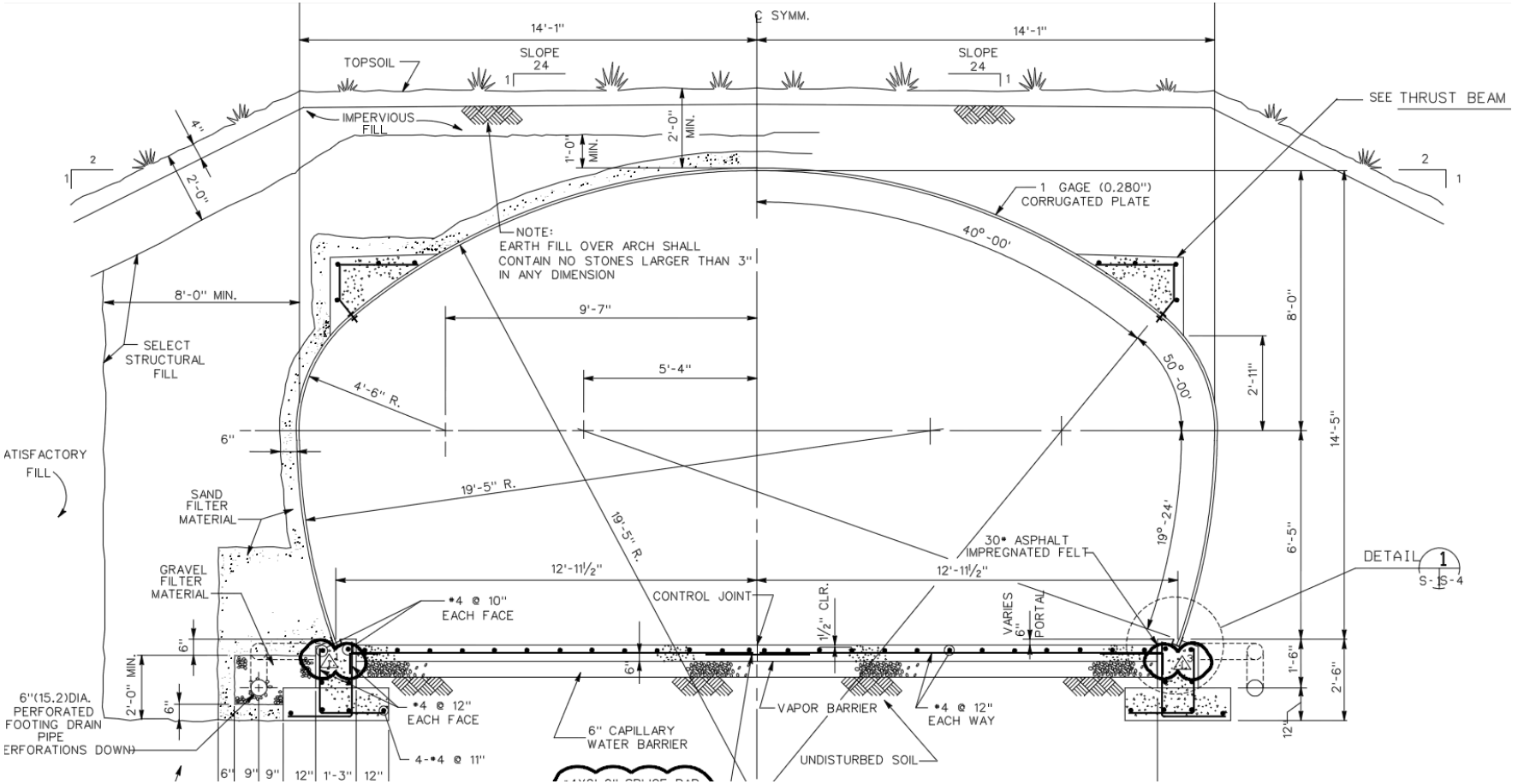
# 421-80-03

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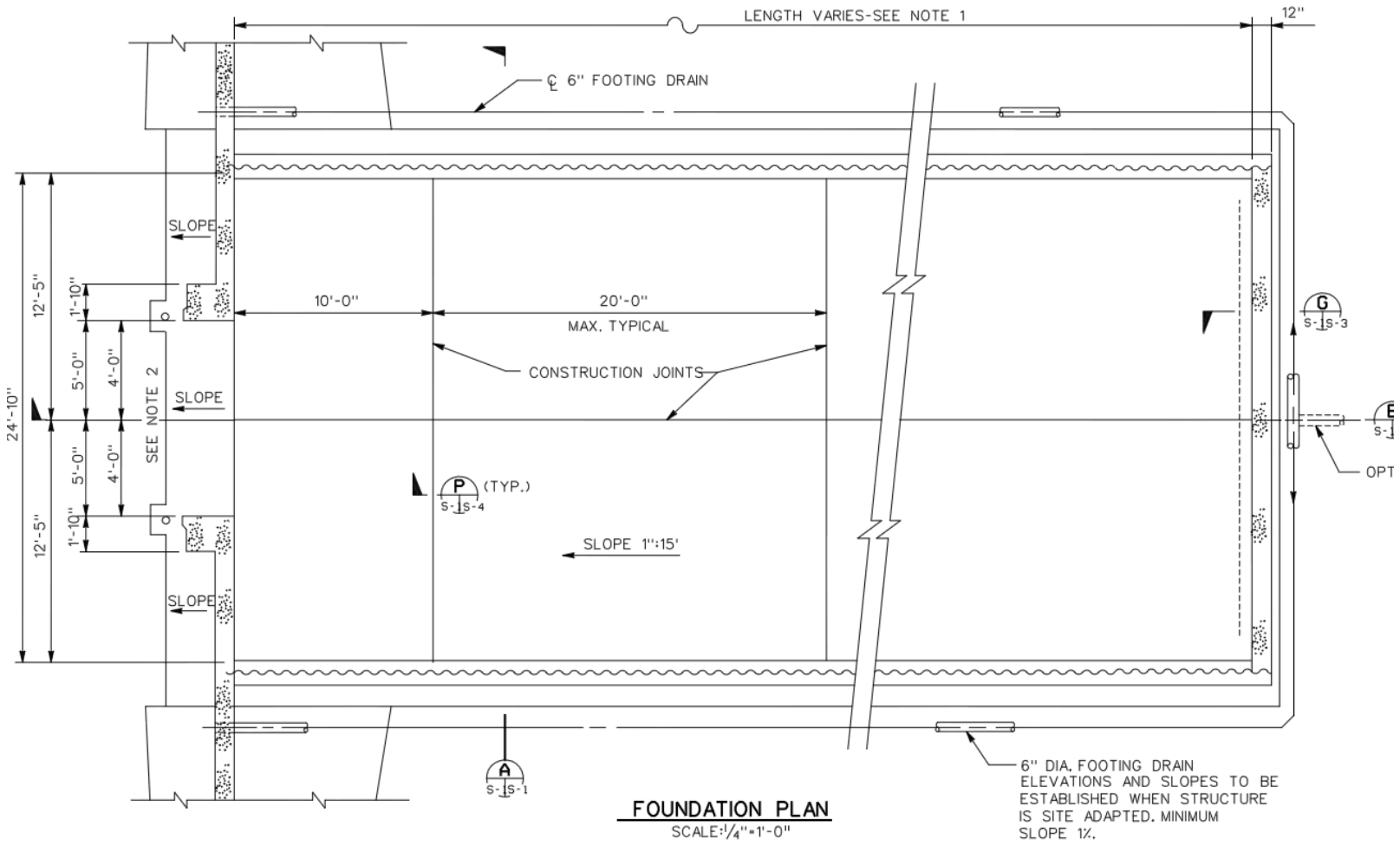


FOUNDATION PLAN
SCALE: 1/4"=1'-0"

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# 421-80-05

| DRAWING NO. (NOTE 1) | DRAWING DATE | DESCRIPTION (1) | DESIGN AGENT | DDESB APPROVAL DATE | ECM DESIGNATION | COMMENTS: (Notes 2 and 3) |
|---|---|---|---|---|---|---|
| 421-80-05 | 1-Sep-98 | RC Arch | COE | 8-Sep-98 | 7-Bar | Constructed using the Techspan Precast Concrete System, developed by the Reinforced Earth Company, for arch construction. The headwall and door are derived from 33-15-74. Internal dimensions are 25' 11" wide by 90' maximum (normally length is 60' or 80') by 14' high (largest clearance at center of magazine). The magazine has a single entrance with 2 size options with sliding steel doors: a) 8'0" wide by 8'0" high (8'10" wide by 8'3" high door), or b) 10'0" wide by 10'0" high (10'10" wide by 10'3" high door). |

- Precast concrete arch, semi-circular (Techspan proprietary system)
- Dimensions:
  - 60’ to 90’ length
  - 26’ width
  - 14.5’ max height
- Built-up steel door w/ 2 size options
  - 8’x8’
  - 10’x10’
- Design validation
  - No direct validation of arches (approval based on previous RC arch testing?)
  - Current door & headwall originally from 33-15-73, tested in ESKIMO III (1974)
- Will be replaced by **421-80-11** in coming months

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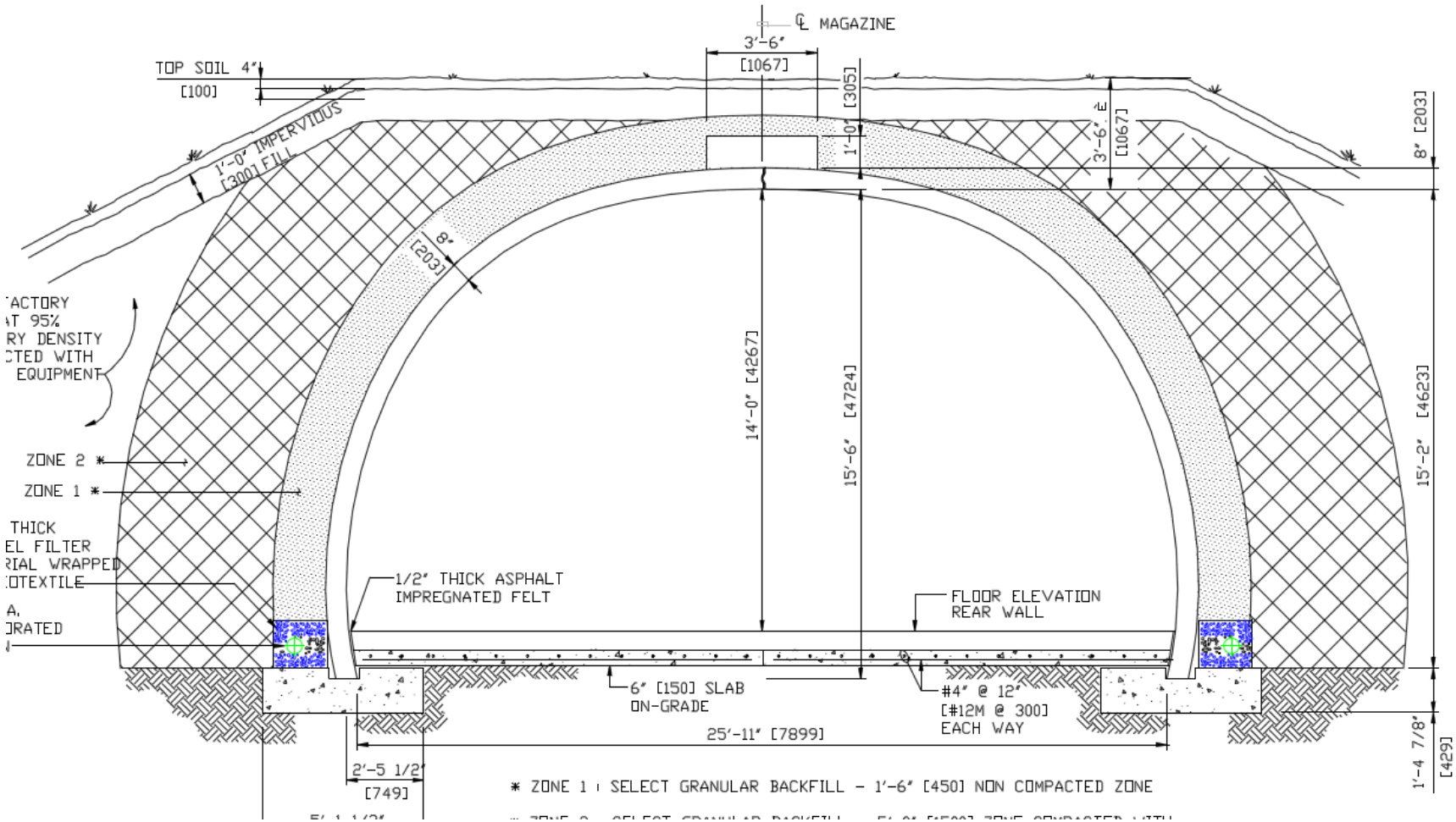
# 421-80-05

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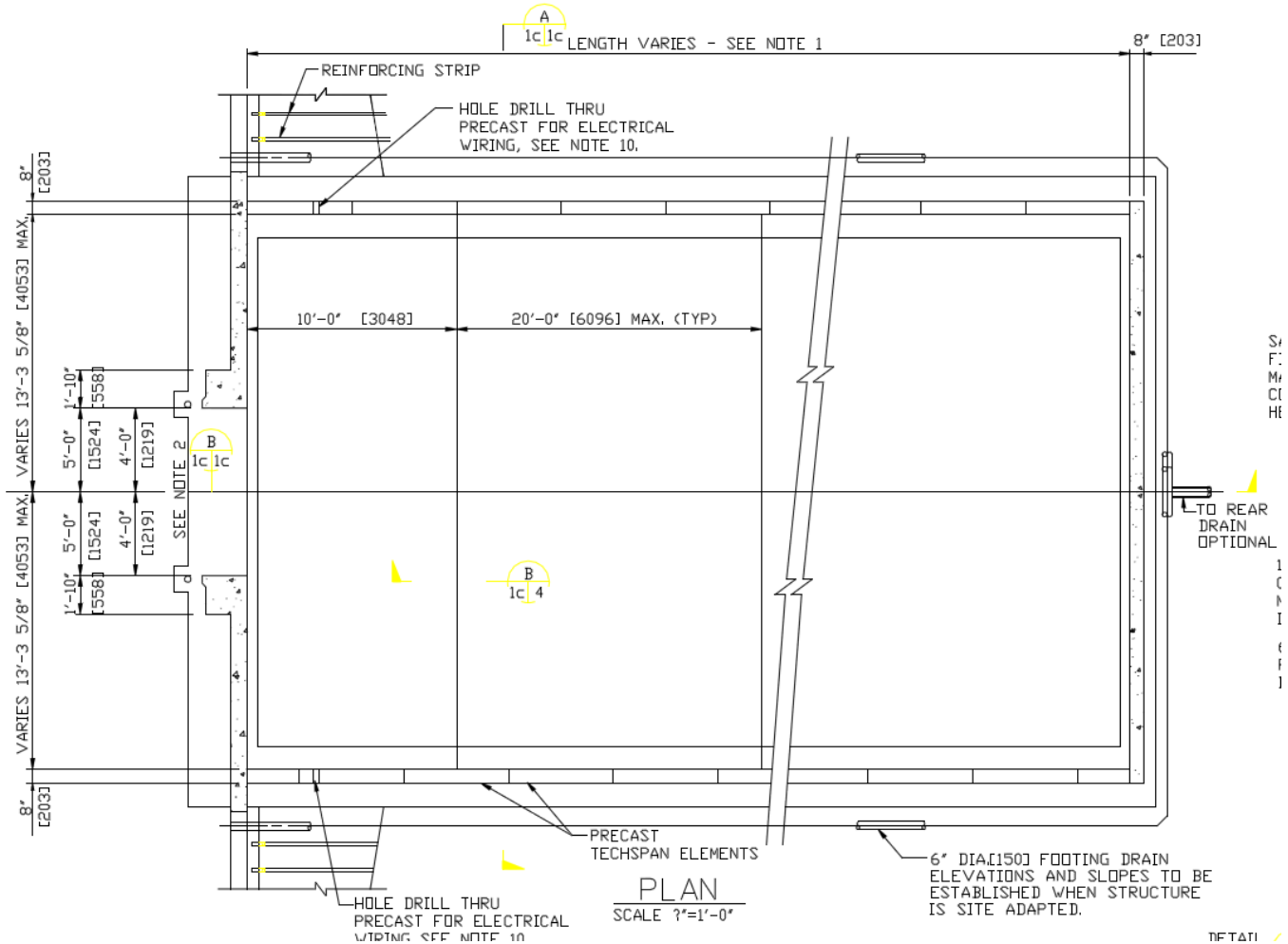
# 421-80-05

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# 421-80-07

| DRAWING NO. (NOTE 1) | DRAWING DATE | DESCRIPTION (1) | DESIGN AGENT | DDESB APPROVAL DATE | ECM DESIGNATION | COMMENTS: (Notes 2 and 3) |
|---|---|---|---|---|---|---|
| 421-80-07 | 2-Dec-11 | RC Box, MSM | COE | 27-Dec-11 | 7-Bar | This design supersedes 421-80-06 (modified). This series updates the drawings to meet current AEC CAD standards, improved plan readability, constructability, and correct omissions within the construction drawings. Internal dimensions are 25'0" wide by 20'0" minimum length to 80'0" maximum length by 11'0" high. The front wall consists of two hinged doors, each measuring 12'2" wide by 10'8" high. The door opening measures 24'0" wide by 10'4" high. The magazine can be sited for 500,000 lbs NEW. |

- Precast concrete box, “modular storage magazine (MSM)”
- Dimensions:
  - 20’ to 80’ length
  - 25’ width
  - **11’ height**
- Double swinging door, built-up steel
  - 24’x10’4” door opening
- Design validation
  - 1988 modular igloo test validated all components but roof
  - Redesigned roof validated in 1992 HEST test
- Superseded 421-80-06 (modified) in 2011

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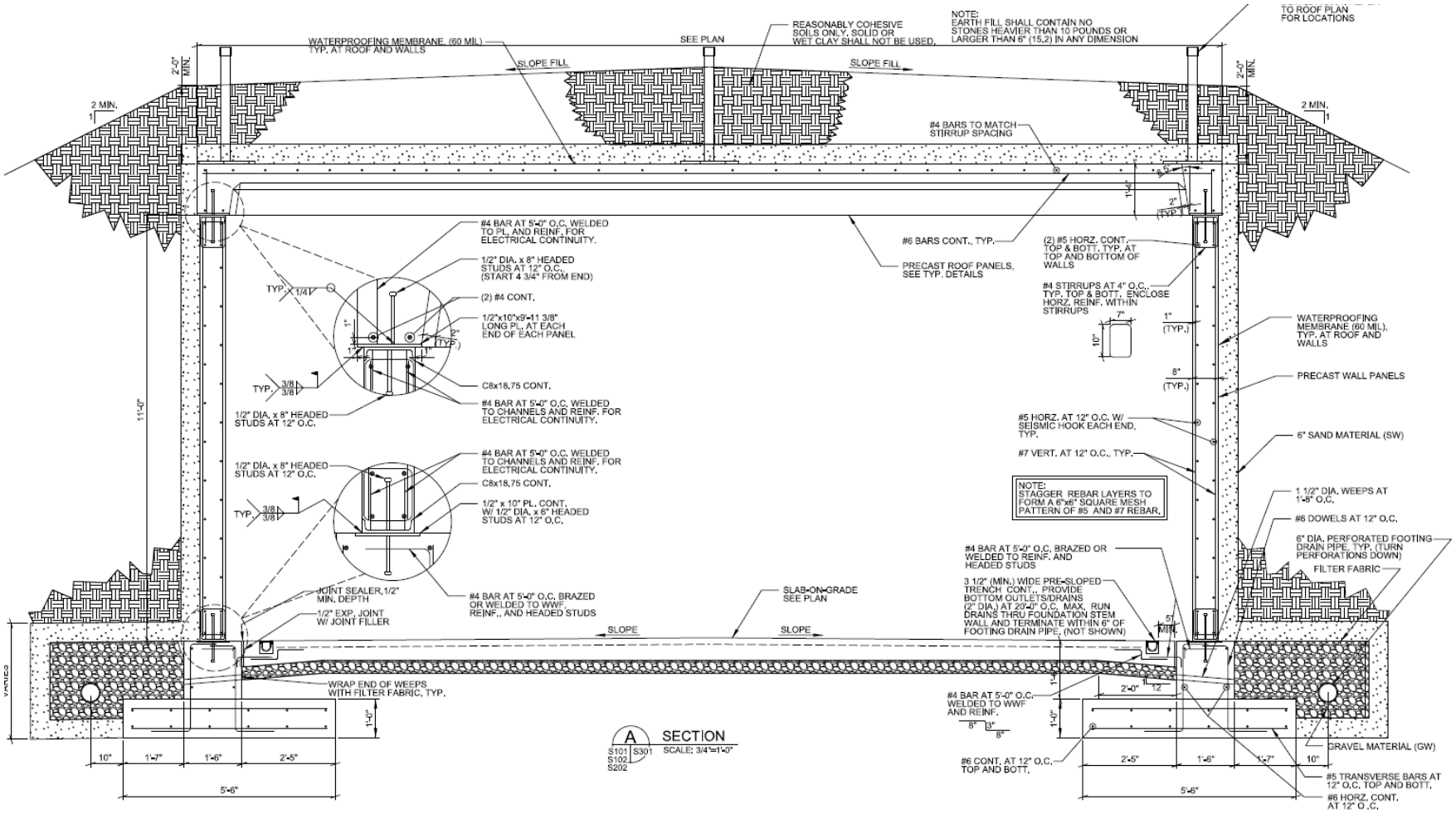
# 421-80-07

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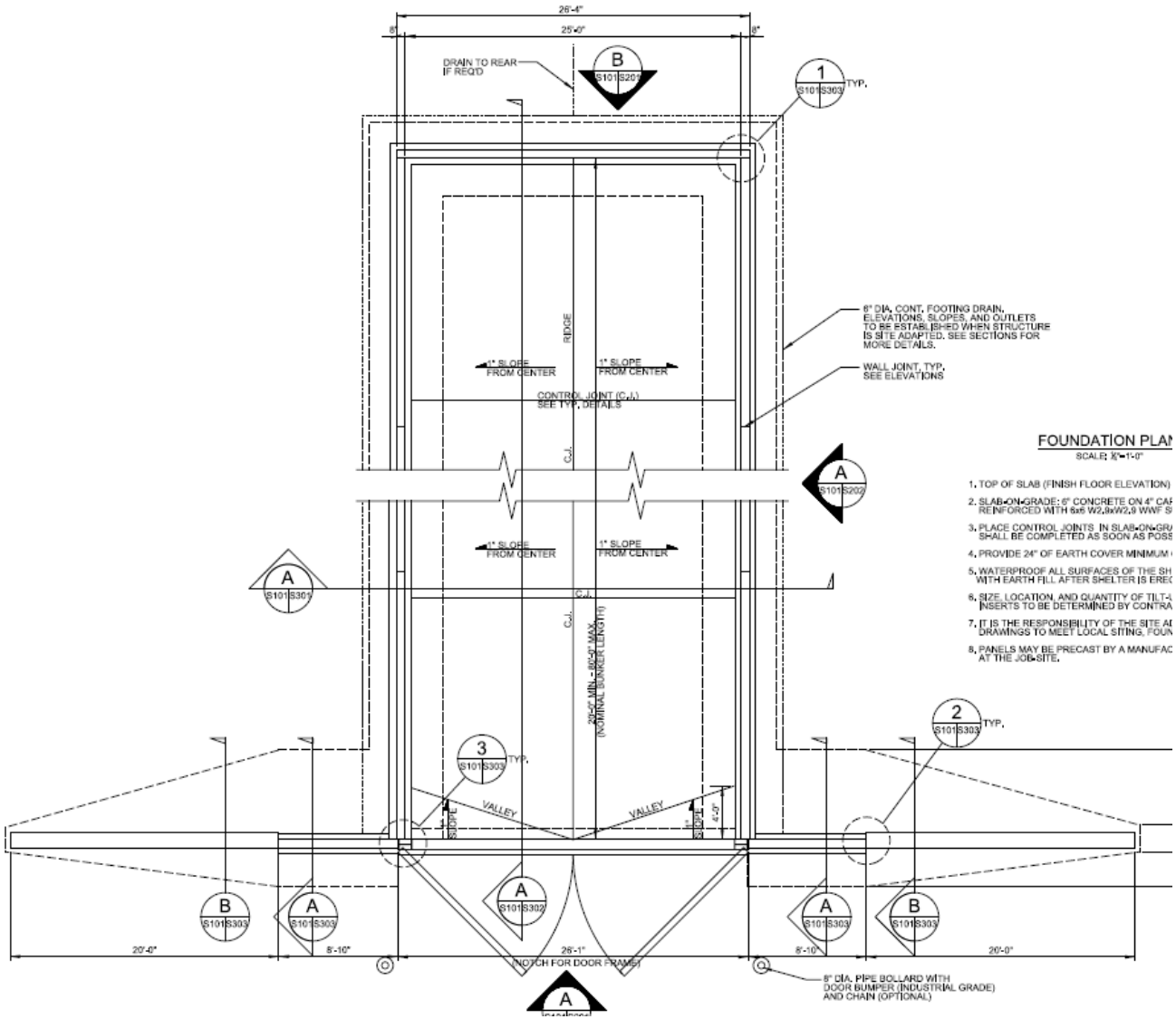
# 421-80-07

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# 421-80-08

| DRAWING NO. (NOTE 1) | DRAWING DATE | DESCRIPTION (1) | DESIGN AGENT | DDESB APPROVAL DATE | ECM DESIGNATION | COMMENTS: (Notes 2 and 3) |
|---|---|---|---|---|---|---|
| 421-80-08 | Jun-13 | RC Box, MSM | COE | 15-Jul-13 | 7-Bar | This design supersedes the Munitions Storage Magazine (MSM) as designed for Hill AFB. This series updates the drawings to meet current AEC CAD standards, and features improved plan readability, constructability, and corrects omissions within the construction drawings. Internal dimensions are 25'0" wide by 20'0" minimum length to 80'0" maximum length by 14'8" high. The front wall consists of two hinged doors, each measuring 12'1-1/4" wide by 13'5-1/2" high. The door opening measures 24'0" wide by 13'11" high. The magazine can be sited for 500,000 lbs NEW. |

- Precast concrete box, “modular storage magazine (MSM)”
- Dimensions:
  - 20’ to 80’ length
  - 25’ width
  - **14’8” height**
- Double swinging door, built-up steel
  - 24’x13’11” door opening
- Design validation
  - See MSM testing from 421-80-07 slide
  - Analysis of door performed by EASE, Inc. to verify larger door has “at least equivalent strength” as original MSM door
- Superseded Hill AFB MSM in 2013

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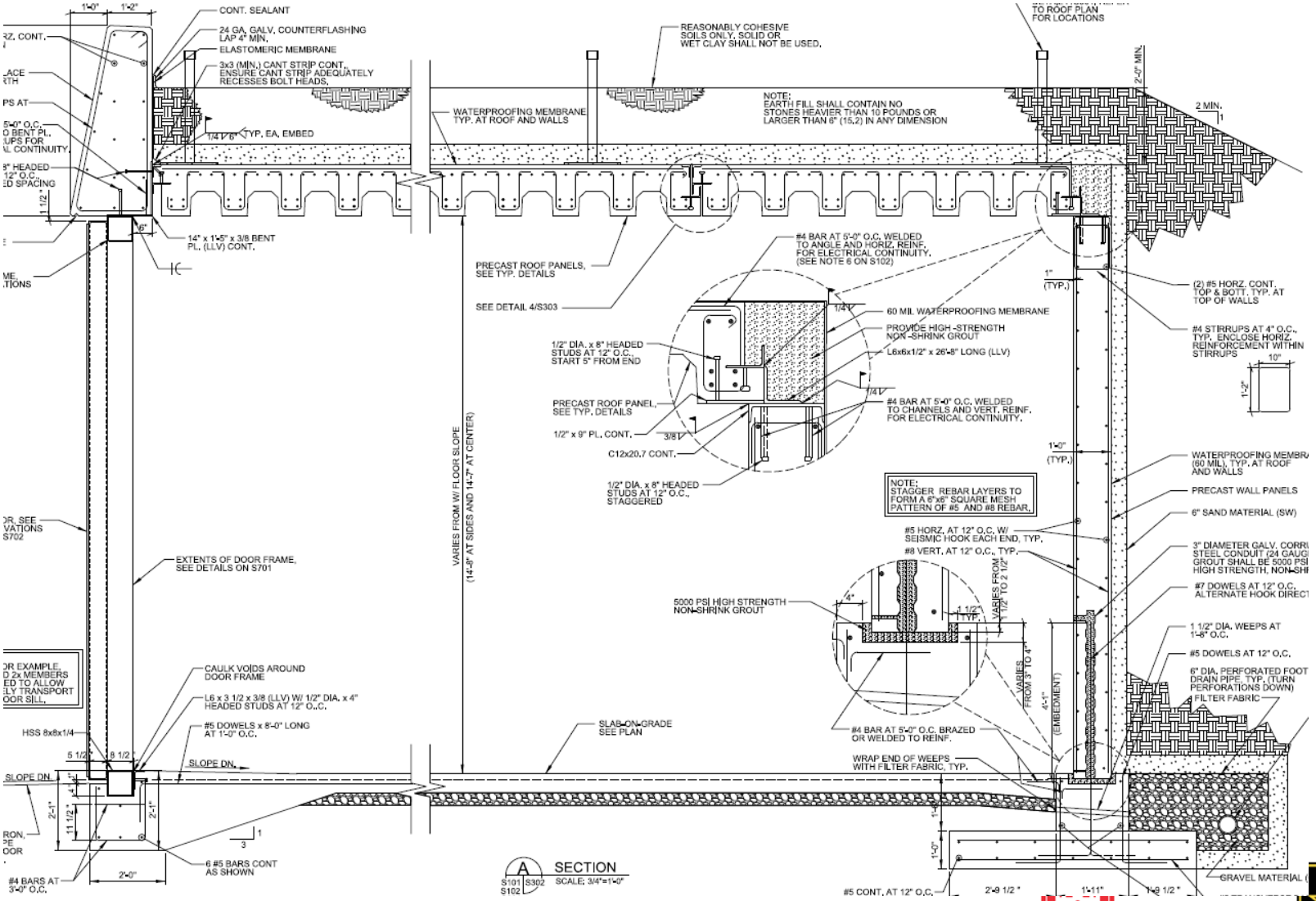
# 421-80-08

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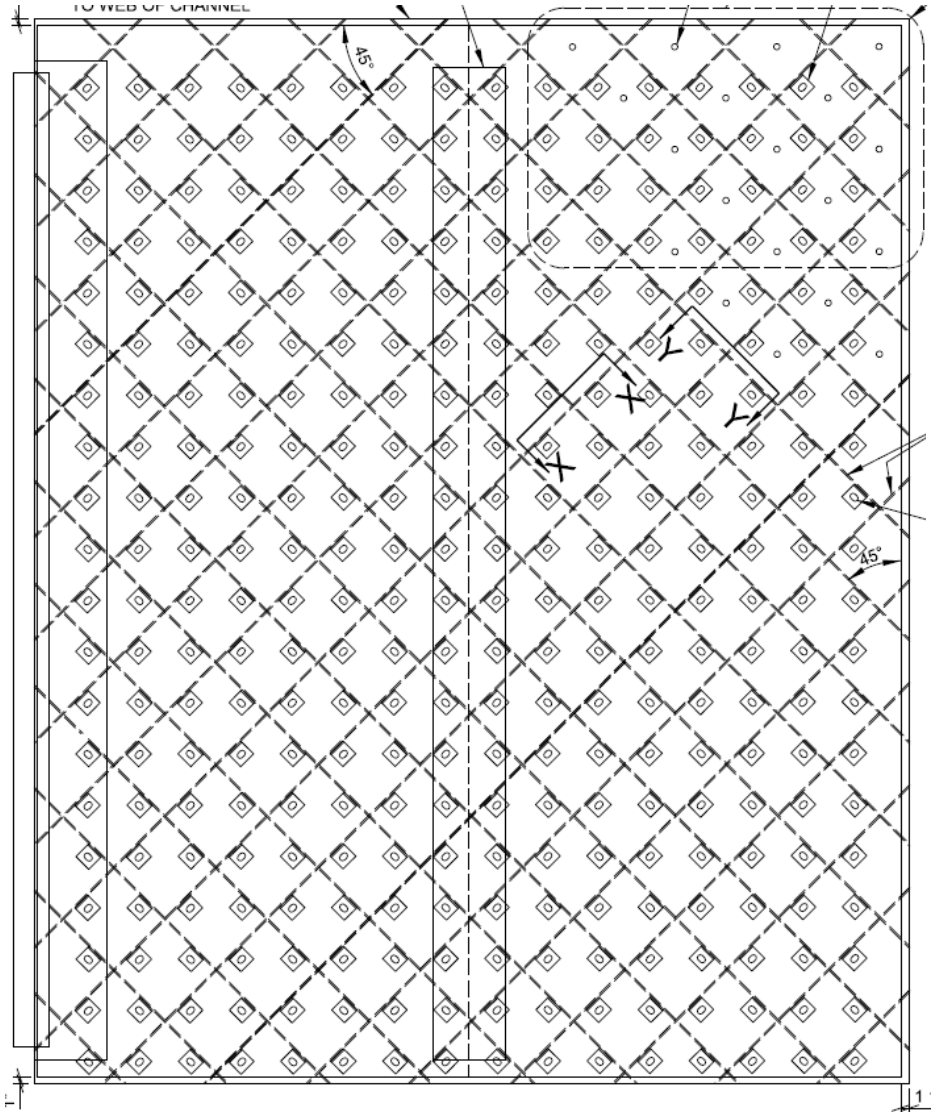
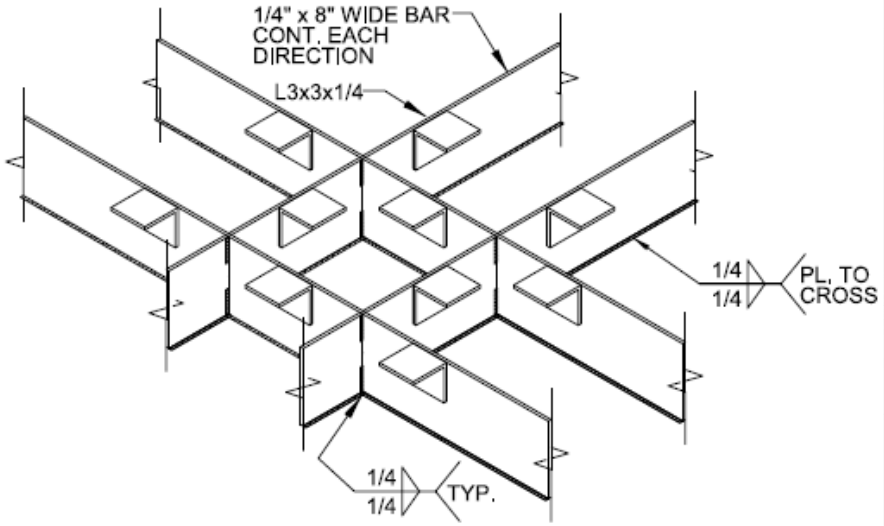
# MSM (421-80-07 & 421-80-08) DOORS

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# 421-80-09

| DRAWING NO. (NOTE 1) | DRAWING DATE | DESCRIPTION (1) | DESIGN AGENT | DDESB APPROVAL DATE | ECM DESIGNATION | COMMENTS: (Notes 2 and 3) |
|---|---|---|---|---|---|---|
| 421-80-09 | Sep-13 | RC FRELOC Stradley | COE | 10-Oct-13 | 7-Bar | This design supersedes 33-15-74. This series updates the drawings to meet current AEC CAD standards, improves plan readability, constructability, and corrects omissions within the construction drawings. Headwall components have been re-analyzed under the 7-bar blast loading from DoD 6055.09-M using the methodology of UFC 3-340-02. The remaining components are as originally designed. Internal dimensions are 25'0" wide by 20'0" minimum length to 90'0" maximum length by 14'0" maximum arch height. The magazine has a single entrance with 2 size options with sliding steel doors: a) 8'0" wide by 8'0" high (8'10" wide by 8'3" high door), or b) 10'0" wide by 10'0" high (10'10" wide by 10'3" high door). |

- Reinforced Concrete arch, FRELOC Stradley
- Dimensions:
  - 20’ to 90’ length
  - 25’ width
  - 14’ max height
- Built-up steel door w/ 2 size options
  - 8’x8’
  - 10’x10’
- Design validation
  - Predecessor (33-15-13) tested in ESKIMO V (1977)
  - Door & headwall originally from 33-15-73, tested in ESKIMO III (1974)
- Superseded 33-15-74 in 2013

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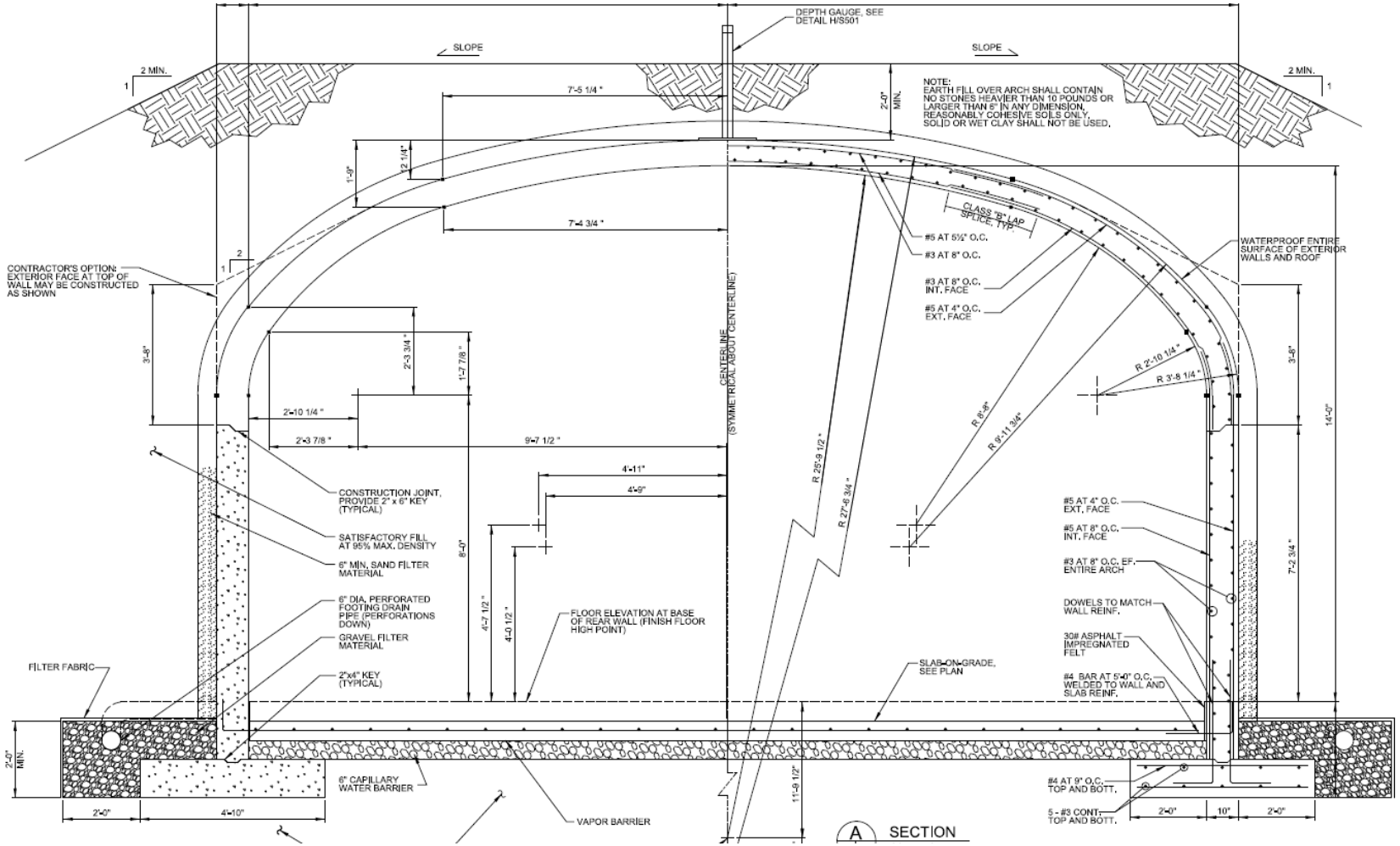
# 421-80-09

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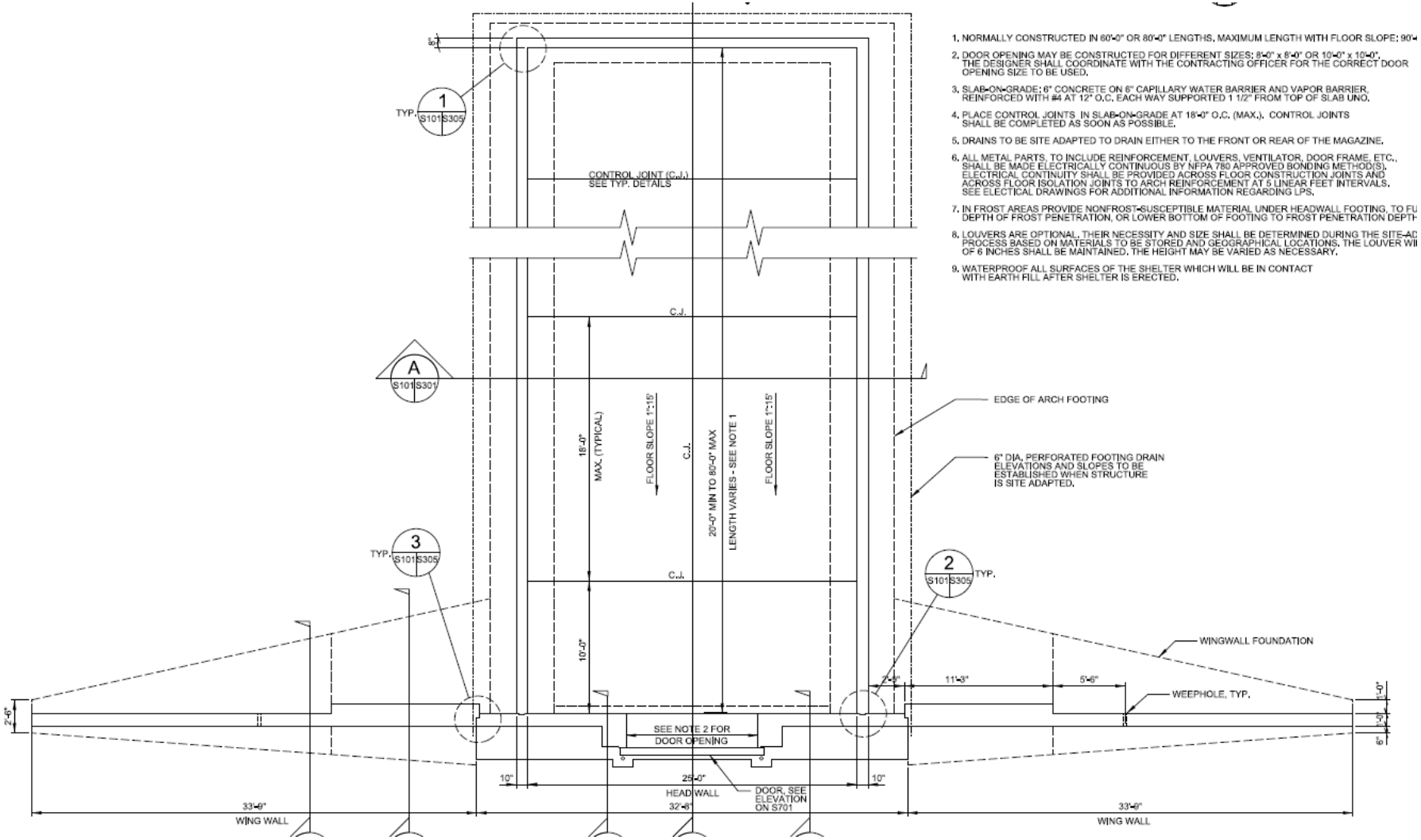
# 421-80-09

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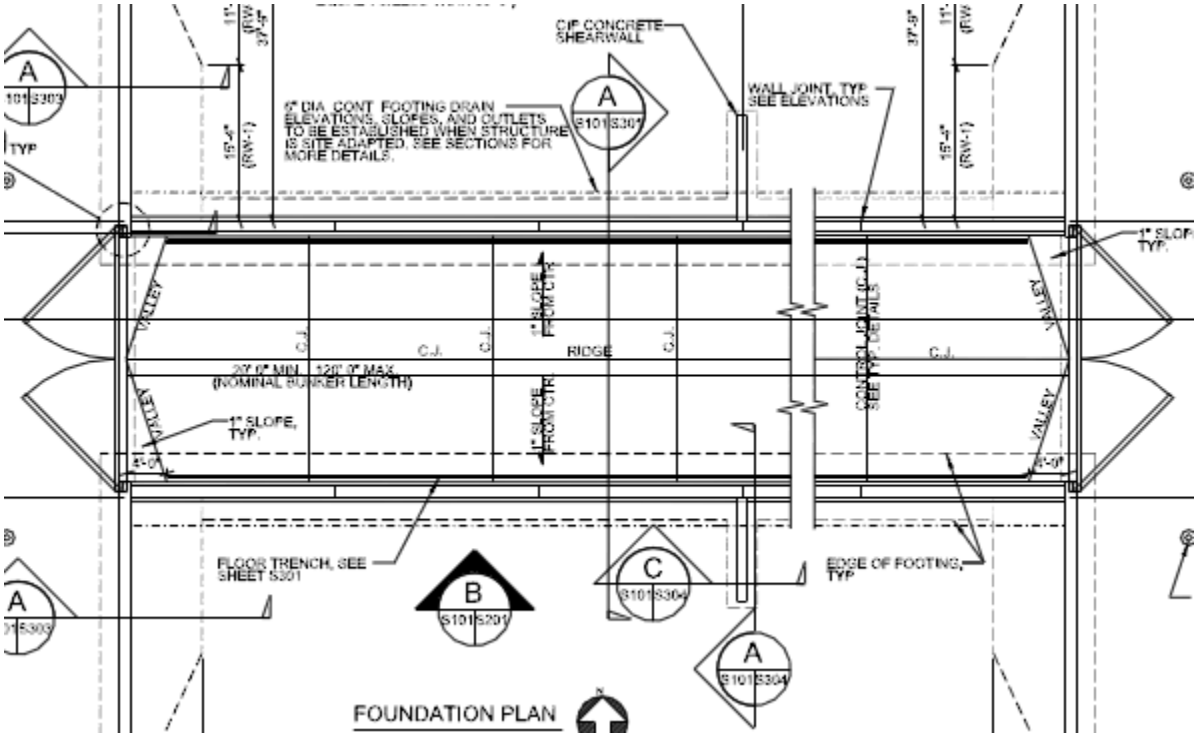
# 421-80-10 (PENDING)

- “Flow-through” MSM
- Similar to 421-80-08, but with two front sides

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# NAVY TYPE M (10400001 THROUGH 10400027)

| DRAWING NO. (NOTE 1) | DRAWING DATE | DESCRIPTION (1) | DESIGN AGENT | DDESB APPROVAL DATE | ECM DESIGNATION | COMMENTS: (Notes 2 and 3) |
|---|---|---|---|---|---|---|
| 10400001 through 10400027 | 5-Jan-04 | RC Box, Type M | NAVFAC | 1-Dec-99 | 7-Bar | Internal dimensions are 81' wide by 124' long by 24' 6" high (measured at interior face at each side wall). The design provides for 2 entrances on the headwall. Each door measures 14' 8" wide by 14' 2" high over 14'0" by 14'0" openings. The design provides for internal magazine access by rail and truck. Sited for 350,000 pounds NEW. This drawing number represents the most recent design of three versions of the Box Type M Magazine that have been constructed. The initial design was approved by DDESB-KO memo of 9 Apr 93 for construction at NAVWPNSTA Seal Beach. Two subsequent design variations were approved by DDESB-KO memo of 1 Dec 99, for construction at NAVWPNSTA Yorktown. All new construction of Box Type M ECM will be in accordance with drawings 10400001 through 10400027. |

- Reinforced concrete box, Type M
- Dimensions:
  - 124’ length
  - 81’ width
  - 24.5’ height
- 2 separate built-up steel, sliding doors on headwall
  - 14’x14’ openings
- Design validation
  - 1991 NCEL BODD (Seal Beach)
  - 1999 Mason & Hanger Calculations (Yorktown)

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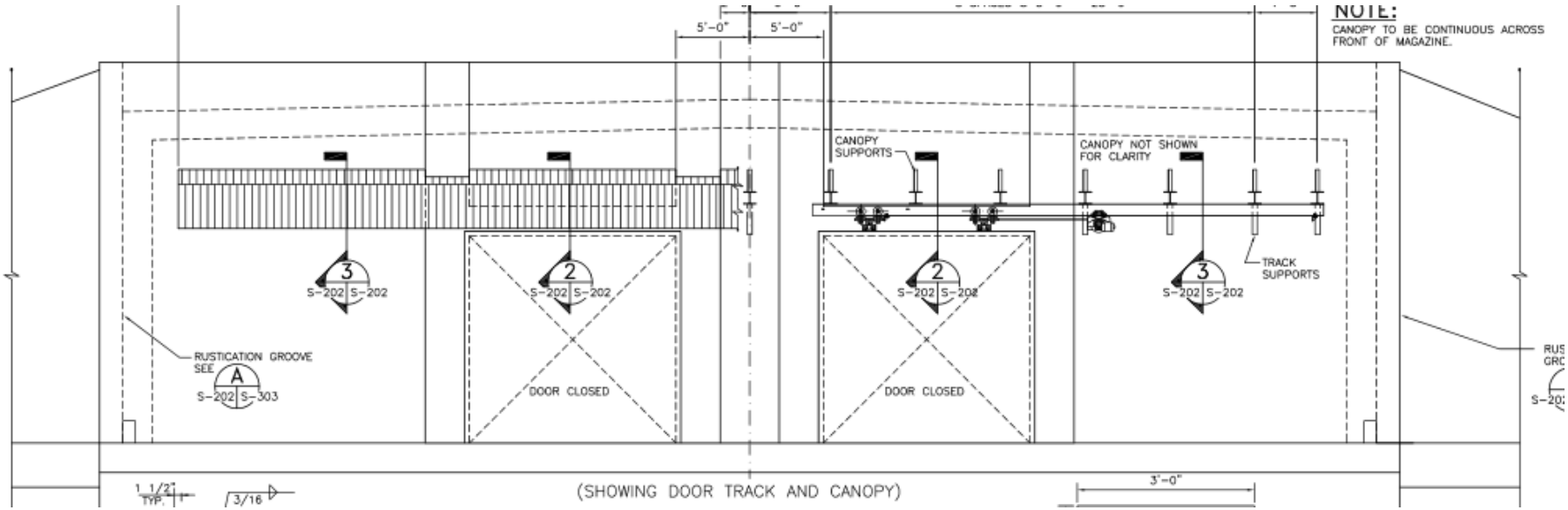
# NAVY TYPE M (10400001 THROUGH 10400027)

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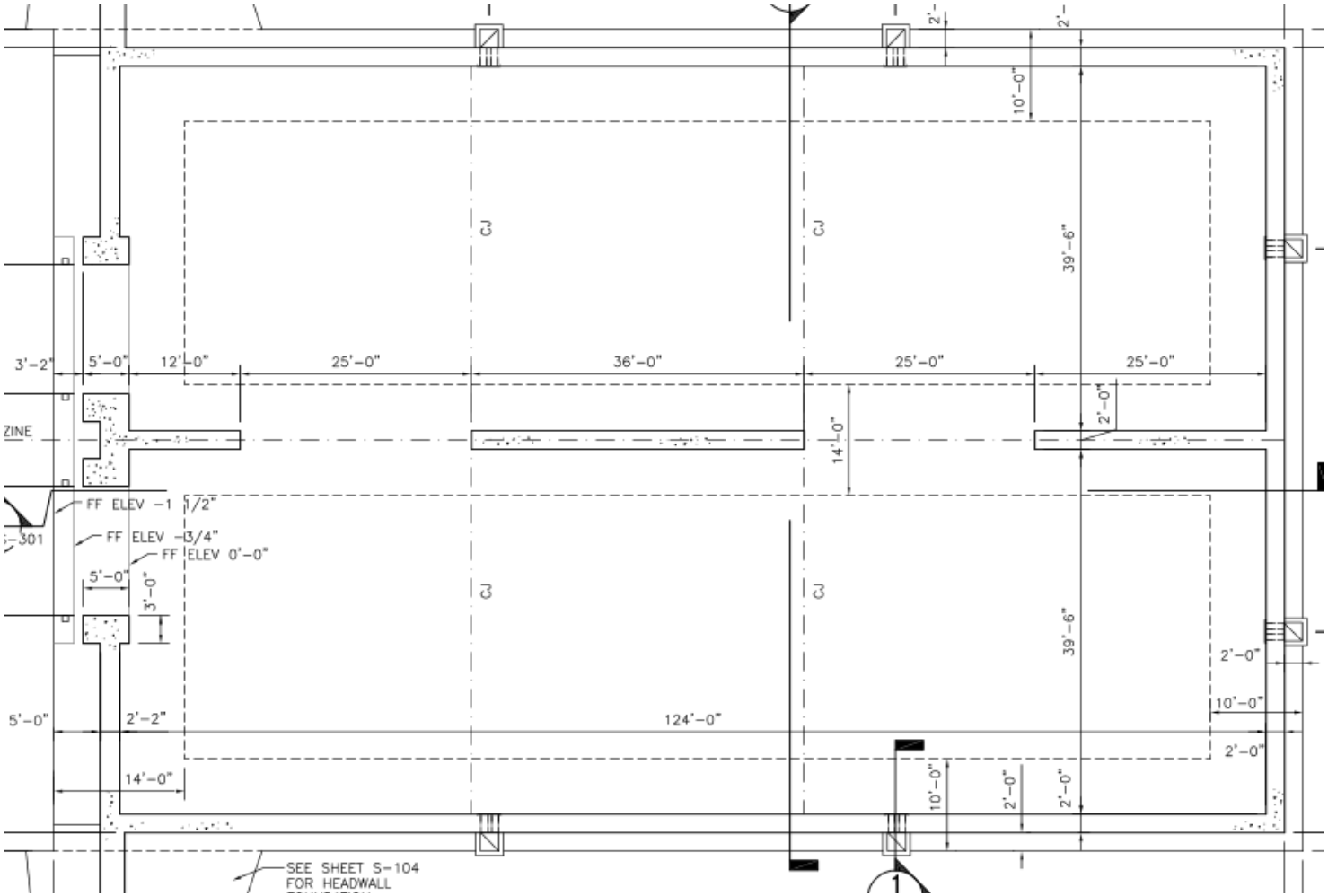
# NAVY TYPE M (10400001 THROUGH 10400027)

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# NAVY TYPE C (14004689 THROUGH 14004720 AND 14005091 THROUGH 14005122)

| DRAWING NO. (NOTE 1) | DRAWING DATE | DESCRIPTION (1) | DESIGN AGENT | DDESB APPROVAL DATE | ECM DESIGNATION | COMMENTS: (Notes 2 and 3) |
|---|---|---|---|---|---|---|
| 14004689 through 14004720, (without loading dock) and 14005091 through 14005122, (with loading dock) | 10-May-17 | RC Box, Type C | NAVFAC | 25-Sep-17 | 7-Bar | This design supercedes the previous version of 14004689 through 14004720 and 14005091 through 14005122 dated 15 December 2010. Revision dates on drawings vary, so the DDESB approval memo references the drawing date of 10 May 2017. Internal dimensions are 50' deep by 94' 8" wide by 13' 8" (rear of magazine) to 15' 10" (front of magazine) high. Three (3) entrances are provided on the headwall. Each of the 3 sliding doors measures 26' 6" wide by 12' high over 25'0" wide by 11'0" high openings. Sited for 350,000 pounds NEW. Original DDESB approval of the Type C magazine was documented in a memo dated 11 May 85. DDESB memo of 2 February 2006 approved an increase of the maximum, allowable NEW to 500,000 lbs of HD 1.1. This revision incorporates lessons learned from recent projects, including increases to rebar splice and development lengths and changing light fixtures to LEDs. |

- Reinforced concrete box, Type C
- Dimensions:
  - 50’ length
  - 94’8” width
  - 13’8” height
- 3 separate built-up steel, sliding doors on headwall
  - 25’x11’ openings
- Design validation
  - Designed by Navy IAW UFC 3-340-02

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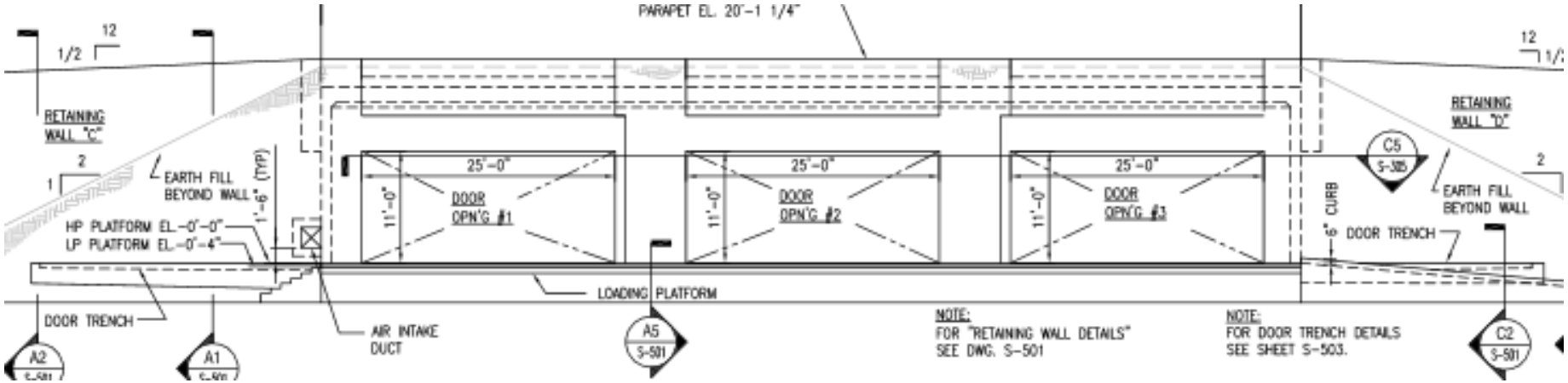
# NAVY TYPE C (14004689 THROUGH 14004720 AND 14005091 THROUGH 14005122)

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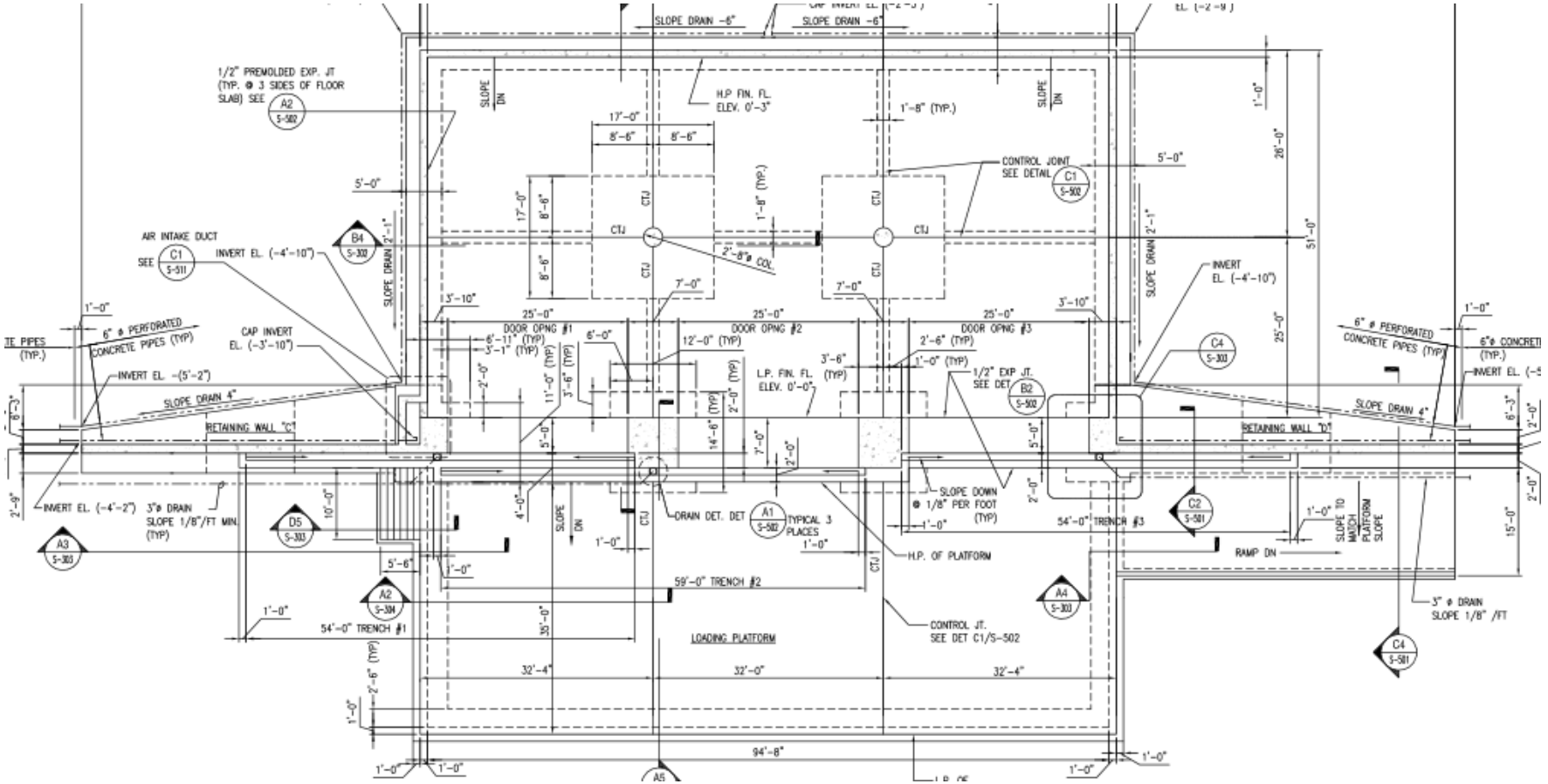
# NAVY TYPE C (14004689 THROUGH 14004720 AND 14005091 THROUGH 14005122)

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# NAVY TYPE D (14021368 THROUGH 14021404 AND 14021406 THROUGH 14021444)

| DRAWING NO. (NOTE 1) | DRAWING DATE | DESCRIPTION (1) | DESIGN AGENT | DDESB APPROVAL DATE | ECM DESIGNATION | COMMENTS: (Notes 2 and 3) |
|---|---|---|---|---|---|---|
| 18232899 through 18232936, (without platform) and 18232939 through 18232978, (with platform) | May-17 | RC Box, Type D, Rev. 1 | NAVFAC | 19-Jul-17 | 7-Bar | Superceded NAVFAC 14021368 through 14021404 and 14021406 through 14021444. Internal dimensions are 50' deep by 158' 8" wide by 13' 8" (rear of magazine) to 15' 10" (front of magazine) high. Five (5) entrances are provided on the headwall. Each of the 5 sliding doors measures 26' 3" wide by 12'0" high over 25'0" wide by 11'0" high openings. Sited for up to 500,000 pounds NEW. This revision incorporates lessons learned from recent projects, including increases to rebar splice and development lengths and changing light fixtures to LEDs. |

- Reinforced concrete box, Type D
- Dimensions:
  - 50’ length
  - 158’8” width
  - 13’8” height
- 5 separate built-up steel, sliding doors on headwall
  - 25’x11’ openings
- Design validation
  - Designed by Navy IAW UFC 3-340-02

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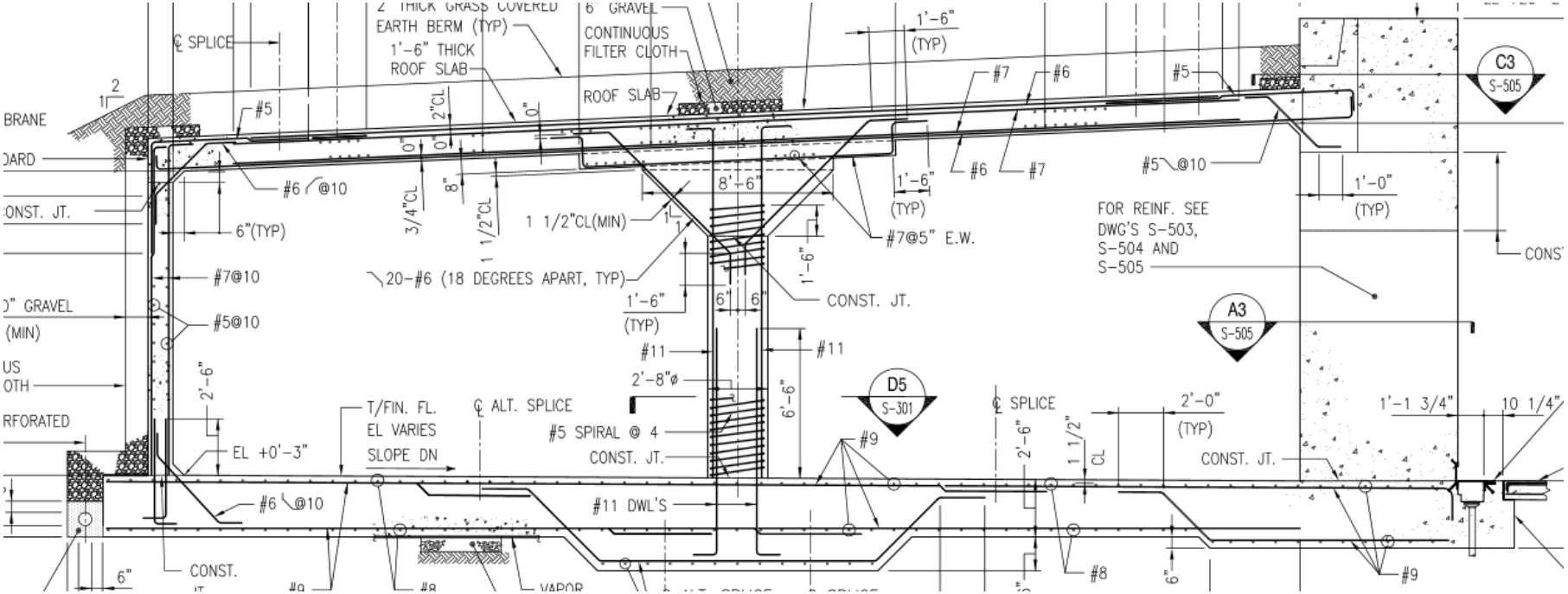
# NAVY TYPE D (14021368 THROUGH 14021404 AND 14021406 THROUGH 14021444)



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# NAVY MSM (14026988 THROUGH 14027031)

| DRAWING NO. (NOTE 1) | DRAWING DATE | DESCRIPTION (1) | DESIGN AGENT | DDESB APPROVAL DATE | ECM DESIGNATION | COMMENTS: (Notes 2 and 3) |
|---|---|---|---|---|---|---|
| 14026988 through 14027031 | 31-May-13 | RC Box, MSM | NAVFAC | 31-Jul-13 | 7-Bar | The standard is based on the design of the Hill AFB Munitions Storage Magazine (see Table AP1-2) with the following changes: The new standard includes a sliding door and an option for environmental controls. Internal dimensions are 25'0" wide by 80'0" long by 14'8" high. The allowable HD 1.1 explosive limit is 500,000 lbs. The design is presented in metric units. This magazine has higher seismic limits than other MSMs. It also is equipped with a robust sliding steel door with concrete fill, providing a greater level of physical security. The door opening measures 25'0" wide by 14'8" high. The design includes an optional air conditioning room with associated equipment. |

- Precast concrete box, “modular storage magazine (MSM)”
- Dimensions (presented in metric):
  - 80’ length
  - 25’ width
  - **14’8” height**
- Sliding steel door w/ concrete fill **(for higher physical security)**
  - 25’x14’8” door opening
- Design validation
  - See MSM testing from 421-80-07 slide
  - Designed IAW UFC 3-340-02 by NAVFAC EXWC
- Greatly **increased seismic limits** ($S_s$=1.95, $S_1$=0.75)
- Includes optional air conditioning room/penetrations

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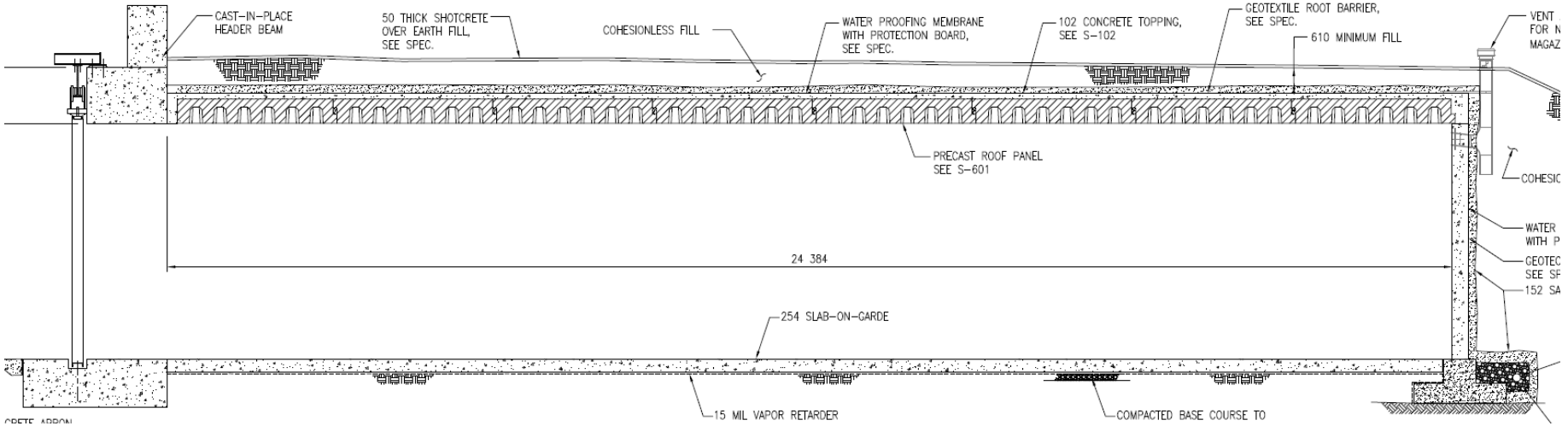
# NAVY MSM (14026988 THROUGH 14027031)

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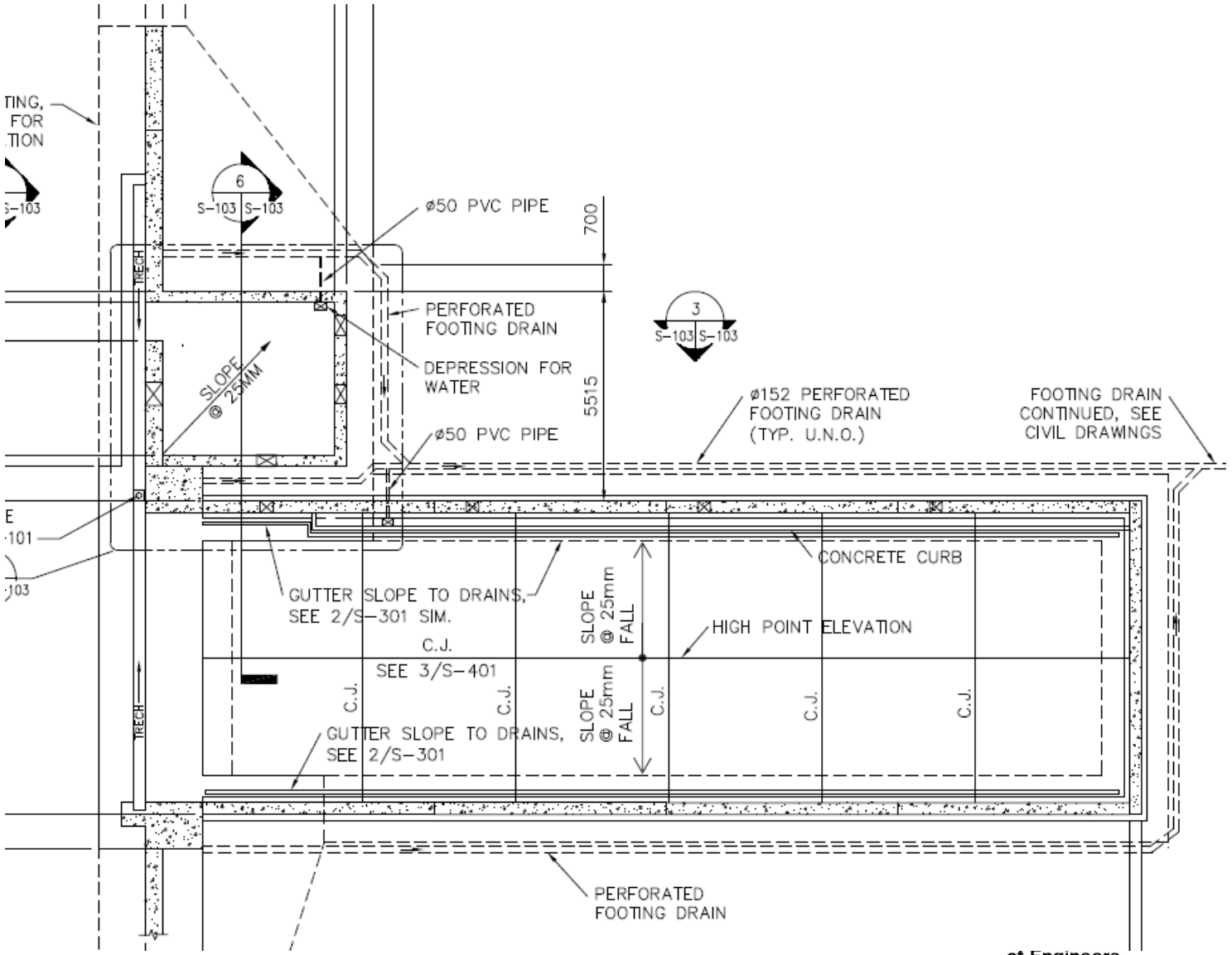

# 33-15-74 (KOREAN VERSION)

| DRAWING NO. (NOTE 1) | DRAWING DATE | DESCRIPTION (1) | DESIGN AGENT | DDESB APPROVAL DATE | ECM DESIGNATION | COMMENTS: (Notes 2 and 3) |
|---|---|---|---|---|---|---|
| 33-15-74 (Korean Version) | August 2000/modified March 2006 | RC FRELOC Stradley | Korean Ministry of Defense | 23 Sep 2003 and 26 July 2006 | 7-Bar | This design is the approved version of the Republic of Korea Army (ROKA) drawing for 33-15-74, Igloo Type Storage (63 Pyung). The original basis for the Korean version was U.S. Army COE 33-15-74. The Korean drawings assure that all reinforcing steel is electrically continuous. The design specifies the use of a single sliding door which measures 10' 10" wide by 10' 3" high over an opening that measures 10'0" by 10'0". The previous version of this drawing was approved by the DDESB as a 7-Bar magazine on 25 May 2002. DDESB-PD Memorandum of 26 July 2006 approved design changes which added a mechanical room and several penetrations for the addition of air conditioning. |

- Reinforced Concrete arch, FRELOC Stradley
- **Metric** version of 33-15-74 (predecessor of **421-80-09**)
- Dimensions:
  - 90’ length
  - 25’ width
  - 14’ max height
- Built-up steel door (10’x10’)
- Design validation
  - Predecessor (33-15-13) tested in ESKIMO V (1977)
  - Door & headwall originally from 33-15-73, tested in ESKIMO III (1974)
- 2006 modification added option for air conditioning room/penetrations

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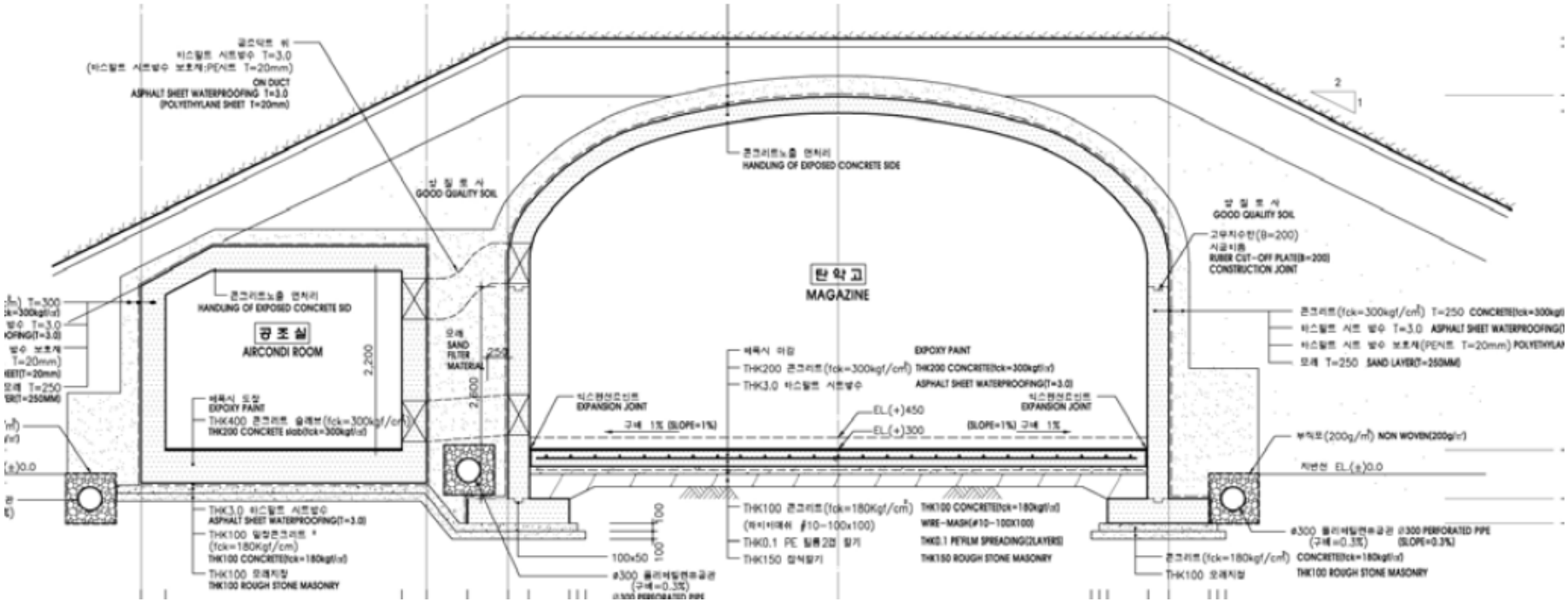


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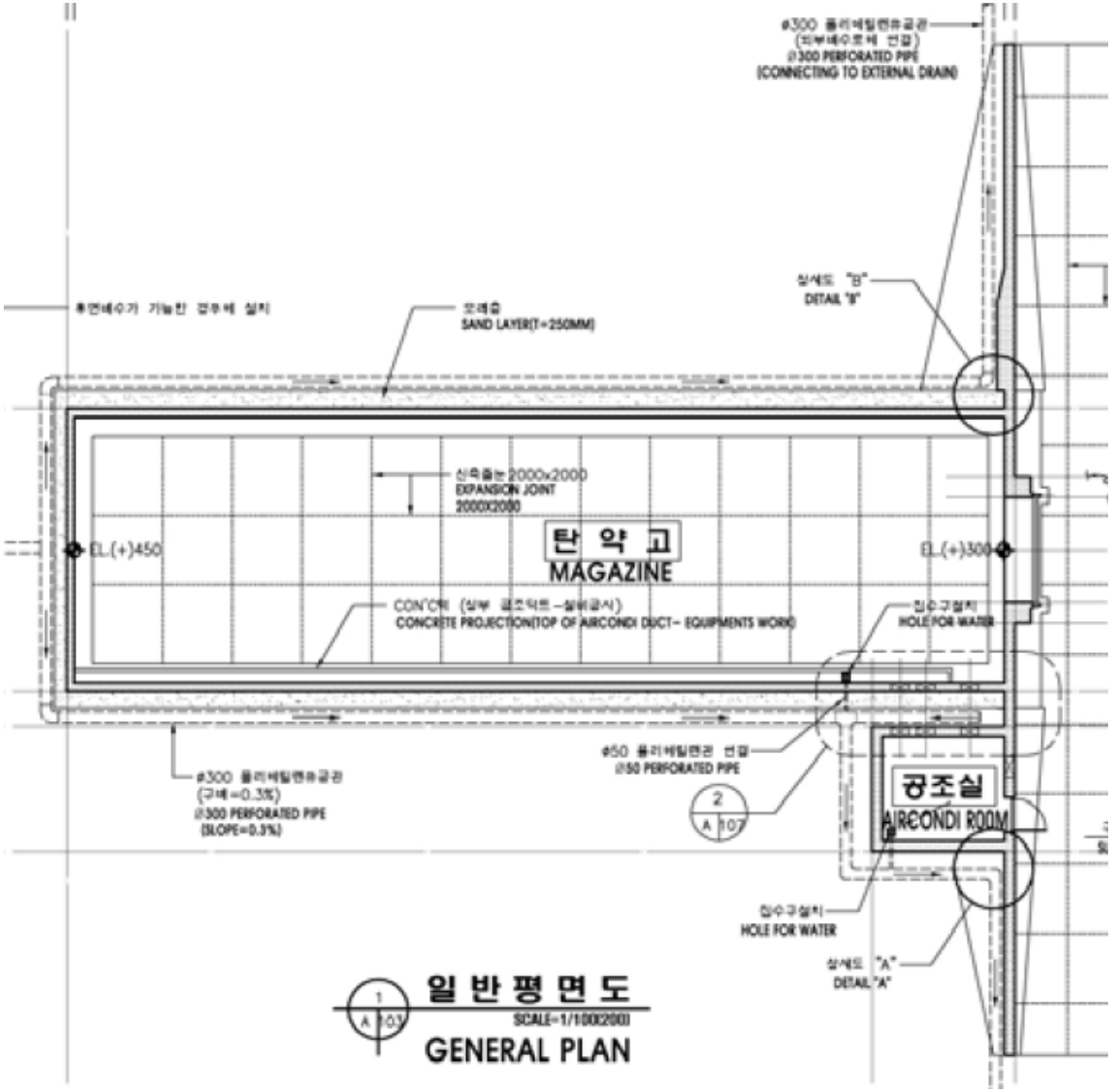


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