

Illinois Department of Transportation

Memorandum

To: ALL BRIDGE DESIGNERS

22.7

From: Jayme F. Schiff

Subject: Noise Abatement Walls

Date: November 10, 2022

A handwritten signature in blue ink that reads "Jayme F. Schiff".

The following memorandum outlines design, detailing, and submittal procedure requirements for ground-mounted and structure-mounted noise abatement walls.

Reference is made to Chapter 26 of the Bureau of Design and Environment (BDE) Manual and the IDOT Highway Traffic Noise Assessment Manual. The policies in the BDE Manual regarding noise analysis, wall placement location, wall materials, etc., should be examined during Phase I, well in advance of application of the policies in this All Bridge Designers (ABD) memorandum. The intent of this ABD memorandum is to provide guidance on structural plan details, not to circumvent any policies in the Bureau of Design and Environment Manual or the IDOT Highway Traffic Noise Assessment Manual.

Noise abatement wall plans are evaluated by the Bureau of Bridges and Structures in two phases: the Phase II Design contract plan review phase, and the Phase III Construction/Fabrication shop drawing review phase. This ABD memorandum provides guidance for these two phases of plan submittal.

The details and design procedures herein are consistent with precast reinforced concrete noise abatement wall panels with steel posts (ground-mounted or structure-mounted) or concrete posts (ground-mounted only). Other systems and materials are available and should be considered as applicable during the Phase I evaluations for the noise abatement wall.

Noise Abatement Wall Phase II Contract Plan Requirements

Issues involving noise abatement wall design and detailing are more easily resolved during Phase II design contract plan review, prior to letting and bidding. A Phase II submittal of the proposed noise abatement wall plans to the Bureau of Bridges and Structures is therefore required at the pre-final stage prior to letting and bidding, preferably six months in advance of the letting. The Bureau of Bridges and Structures will review the contract plans and special provisions for noise abatement walls that will be state-owned. The local agency owner will review the contract plans and special provisions for noise abatement walls that will be local agency owned.

Illinois Licensed Structural Seal Requirements

Depending upon whether the noise abatement wall is ground-mounted or structure-mounted, and the phase of the contract, the following structural seal requirements apply.

Phase	Plan Type	SE Seal & Signature Required?
Phase II	Ground-Mounted NAW Contract Plans	No
	Structure-Mounted NAW Contract Plans	Yes
Phase III	Ground-Mounted NAW Shop Drawings	Yes
	Structure-Mounted NAW Shop Drawings	Yes

For ground-mounted noise abatement walls, no structural design is provided on the Phase II contract plans. The post, panel, and foundation designs for ground-mounted noise abatement walls are all provided during the Phase III shop drawing submittal. Therefore, an Illinois Licensed Structural Engineer seal and signature are not required for the Phase II contract plans for ground-mounted noise abatement walls but are required for the Phase III shop drawings for ground-mounted noise abatement walls.

For structure-mounted noise abatement walls, the effects of the noise abatement wall on the attached structure (bridge or anchorage slab), are considered part of the structural design of the wall and attached structure. The post sizes and connections shall be verified by the Engineer of Record for the noise abatement wall plans. Therefore, the Phase II contract plans for structure-mounted noise abatement walls require the seal and signature of an Illinois Licensed Structural Engineer.

For structure-mounted noise abatement walls, the Phase III shop drawings contain the structural design of wall elements such as panels, clip angles, etc. Therefore, the Phase III shop drawings for structure-mounted noise abatement walls require the seal and signature of an Illinois Licensed Structural Engineer.

Detail Requirements

The intent of the Phase II contract documents, distributed for letting and bidding, is to ensure:

- adequate data is provided to the Contractor to accurately bid the noise abatement wall pay items, and then construct the noise abatement walls during the construction contract.
- adequate data is provided to the noise abatement wall supplier to design and detail the walls, and to provide shop drawings signed and sealed by an Illinois Licensed Structural Engineer.
- for structure-mounted noise abatement walls, the adequacy of the design details for the noise abatement wall mounted on the bridge or anchorage slab, and the structural adequacy of the bridge or anchorage slab itself.

In order to provide this data to the Contractor and wall supplier, the following details and specifications are required in the contract documents. These are listed using numerical indices below and discussed in more detail thereafter.

1. Design Specifications
2. Design Loading
3. Design Stresses
4. Aesthetic Requirements
5. General Plan and Elevation Views
6. Structural Details
7. Noise Reduction Data
8. Soil Data
9. Name Plate Requirements
10. Pay Items, Methods of Measurement, and Bases of Payment

1. *Design Specifications*

The most current version of the AASHTO LRFD Bridge Design Specifications shall be shown on the General Plan and Elevation sheet, under Design Specifications. This provides a record of the design specifications for future engineers in the event of required wall repairs.

Structural design of noise abatement walls is governed by Section 15 of the AASHTO LRFD Bridge Design Specifications, titled Sound Barriers. Guide Bridge Special Provisions #101 and #102 alert the noise wall supplier that this code shall be used in design.

An example of specifying the design specifications is shown in Figure 1.

2. *Design Loading*

Design loads shall be shown on the General Plan and Elevation sheet, under Design Loading.

Factored loadings shall be taken as 35 psf for Strength III or Strength V wind loading and 15 psf for Service I wind loading. These loads are derived from the wind loading formulas in Chapter 15 of the AASHTO LRFD Bridge Design Specifications, and are based upon Open Country wind exposure and a structure height of 33 ft. Use of the Open Country wind exposure category is sufficiently conservative that these loadings are applicable to noise walls in Urban or Suburban areas with heights far exceeding 33 ft., and recalculation of loads is not required.

For structure-mounted noise abatement walls, unfactored wall dead load shall be taken as 65 pounds per square foot. The unfactored 72 in. concrete barrier dead load is 0.98 kips per linear foot. This loading shall be distributed by the slab over the three beams closest to the noise abatement wall. This additional loading shall be accounted for in the DC loading on the interior beam moment table.

When noise abatement walls are required to resist differential earth loading, maximum active earth pressure and live load surcharge loads shall be shown in the design loading. The maximum retained fill shall be 7 ft. Walls requiring greater than 7 ft. of retained fill are defined as retaining walls and will require additional planning, design, and detailing beyond the scope of this memorandum.

An example of specifying the design loading is shown in Figure 1.

3. Design Stresses

The design stresses for materials shall be included on the General Plan and Elevation sheet, under Design Stresses. This will give the Contractor and wall supplier information on the types of materials required on the project, and their required design strengths.

Minimum required design strengths are provided below.

Field Units:

Drilled Shaft Concrete Foundations:	f'_c	=	4,000 psi
Structural Steel (Grade 36):	F_y	=	36,000 psi
Structural Steel (Grade 50):	F_y	=	50,000 psi
Reinforcement:	f_y	=	60,000 psi

Precast Units:

Precast Concrete:	f'_c	=	4,500 psi
Reinforcement:	f_y	=	60,000 psi
Welded Wire Reinforcement:	f_y	=	65,000 psi

An example of specifying the design stresses is shown in Figure 1.

4. Aesthetic Requirements

Aesthetic requirements, such as color, texture, or form liner patterns, shall be shown in the noise wall structure plans. When form liners are utilized, it is desirable to show a drawing of the required pattern on the contract plans to ensure the aesthetic requirements are clearly conveyed to the Contractor and wall supplier. These requirements may be too detailed to be placed on the General Plan and Elevation sheet and/or may be more appropriate to be placed in other locations in the noise abatement wall plans.

5. General Plan and Elevation Sheets

For ground-mounted noise abatement walls, a General Plan and Elevation sheet for the noise abatement wall plans shall be provided.

For structure-mounted noise abatement walls, on either bridges or anchorage slabs, the wall is considered a separate structure and requires plans independent of the

bridge or anchorage slab on which it is mounted. A General Plan and Elevation sheet for the noise abatement wall, independent of the bridge or anchorage slab, shall be provided. Structure-mounted noise abatement walls are not always constructed on the same contract as their supporting structures.

Figures 2 and 3 show Plan and Elevation details for ground-mounted noise abatement walls. Structure-mounted noise abatement wall General Plan and Elevation sheets are similar.

Plan Views

Plan views shall show stations and offsets of the beginning and end of the noise abatement wall, as well as the stations and offsets of any required overlapping wall sections, wall directional changes, adjacent retaining walls or culverts, obstructions, ground modifications such as drainage interference, all overhead and underground utilities, and lighting. The stations and offsets shown in the contract plans and in the shop drawings shall be tied to the project stationing and not to a separate stationing system.

Plan views shall show the station and offset of each boring log included in the plans.

Elevation Views

Elevation views shall show the theoretical top and bottom of noise wall elevations at all necessary locations to ensure the proper shape of the wall is provided.

The theoretical top of wall elevations shown on the contract plans shall meet applicable noise wall height requirements. See Chapter 26 of the Bureau of Design and Environment Manual and the IDOT Highway Traffic Noise Assessment Manual for more information on noise wall height requirements. The noise wall height will be dependent upon the proposed ground surface elevations at the front face of the wall for ground-mounted walls, or the top of slab elevations for structure-mounted walls.

For ground-mounted walls, theoretical bottom of wall elevations shown on the contract plans should be assumed to be eight inches below the proposed ground surface. Theoretical bottom of wall elevations may be decreased as required to accommodate proposed ground conditions such as locations of utilities, earth retention, drainage, etc. The plans shall show both the existing ground elevations and proposed ground profile grade at the face of the wall.

For structure-mounted walls, theoretical bottom-of-wall elevations shown on the plans shall be taken as six inches below the top of parapet elevation. See Figure 4.

For ground-mounted noise abatement walls, the theoretical top and bottom elevations are a minimum envelope to be provided by the supplier. Due to the discrete, stair-stepped nature of the final wall dimensions, the furnished top and bottom wall elevations will vary and exceed the dimensions shown on the plans. For structure-mounted noise abatement walls, the furnished height of the wall should closely match the dimensions shown on the plans such that the loading requirements are not exceeded.

For ground-mounted walls, the maximum post spacing of 20 ft. shall be shown on the elevation view. Exact post locations will be determined by the wall supplier and therefore are not shown on the plans; the intent of the plan view is to aid the supplier in locating available post locations, not to dictate exact post locations. See Figure 3 for an example.

For structure-mounted walls, the exact post locations shall be detailed on both the General Plan and Elevation sheet for the noise abatement wall plans and in the bridge or anchorage slab plans. The maximum post spacing for structure-mounted walls is given in Figure 4.

For ground-mounted walls, when proposed ground surface slopes indicate that ponding at the wall face is a concern, 4 in. diameter weep holes shall be provided at ground level in the bottom panel of the wall at a spacing of 8 ft.

Section Thru Wall

When portions of ground-mounted walls are required to resist soil loading, a section thru the wall showing the maximum height of retained fill shall be provided. The section thru the wall shall show similar granular backfill and pipe underdrain details as a soldier pile retaining wall. See Chapter 3.11 of the Bridge Manual for applicable details. Walls requiring more than 7 ft. of soil retention will require design and detailing beyond the scope of this memorandum.

Details for sections thru walls for structure-mounted walls are given in Figures 4 and 7. Because noise walls require separate plan sheets than the structures they are mounted on, wall details on the bridge or anchorage slab sheets should be marked For Information Only.

Access door or panel locations shall be shown on the elevation view.

6. Structural Details

Figures 4 through 13 show details for structure-mounted noise abatement walls. These details shall be used for noise abatement walls mounted on bridges and anchorage slabs.

Figure 4 shows a standard configuration for a structure-mounted noise abatement wall on a bridge. The wall is mounted to the back of a 72 in. concrete barrier via a post connection bracket. The barrier is mounted on a thickened deck overhang.

The 72 in. concrete barrier for use with structure-mounted noise abatement walls consists of a standard 44 in. constant-slope barrier, with the addition of a vertical 28 in. parapet extension. The vertical extension reduces the rotation of a truck in an impact event, reducing the zone of intrusion of the truck. The vertical extension also reduces salt spray on the face of the noise wall, reducing wall damage due to chloride ingress.

The post connection bracket shape is a steel section that acts as a spacer, placing the front face of the wall 10 in. behind the back face of the 72 in. concrete barrier, further reducing the zone of intrusion of the truck.

When used together, the 72 in. concrete barrier and offset noise wall position the wall such that it is outside the zone of intrusion of the truck. This configuration has been successfully crash-tested, and has been determined to be crashworthy for Test Level 5 criteria for the 2016 Manual for Assessing Safety Hardware.

The deck overhang thickness when a noise abatement wall is used shall be 11.5 in. This additional thickness is required to support the loading from the noise abatement wall and larger parapet. The fillet at the exterior beam section is also thickened such that there is a minimum of 11.5 in. of deck thickness over the exterior beam.

The maximum post spacing for a noise abatement wall mounted on a structure shall be 11 ft. 8 in. The maximum height for a noise abatement wall mounted on a bridge shall be 18 ft. above the deck elevation at the front of the parapet.

Structure-mounted noise abatement wall plans require the CL post locations to be as specified on the bridge or anchorage slab plans. This is to ensure that bridge or anchorage slab reinforcement details are consistent with the anchor rod assemblies and post connection locations on the wall plans. It also ensures that parapet joints are appropriately placed outside the minimum required distance from the CL post to the joint. Post locations for structure-mounted walls cannot be altered by the wall supplier.

Figure 4 also shows a section thru the noise abatement wall anchor rod assembly. This assembly consists of four L-shaped anchor rods, a template plate, and related hardware. More information is given in Figure 12 below.

Figure 5 shows deck overhang and parapet reinforcement details for use with the 72 in. concrete barrier. The reinforcement in the parapet, overhang, and adjacent slab are increased to support the noise abatement wall loading.

Parapet and deck overhang reinforcement used with the 72 in. concrete barrier is increased in “end regions” near full-depth joints and parapet ends. These “end regions” are shown in Figure 5 and are defined as regions within 15 ft. of full-depth joints and parapet ends. Regions outside of this distance are shown as “interior regions” and have lesser reinforcement requirements.

Figure 6 shows dimensions for the standard reinforcement used in the 72 in. concrete barrier and deck overhang.

Figures 7, 8, and 9 show details for noise abatement walls mounted on anchorage slabs. These three figures show similar detail requirements to those required for bridges in Figures 4 through 6.

Figure 10 shows details for aluminum parapet joints and cork parapet joints, for use with the 72 in. concrete barrier.

Figure 11 shows details for an elastomeric debris shield. The intent of this shield is to prevent debris, such as snow and ice, from accumulating between the noise abatement wall and parapet.

Figure 12 shows a plan view of the post, post connection bracket, and parapet section. Dimensions for L-shaped anchor rods are shown in this figure, as well as an anchor rod template plate. The anchor rod template plate is embedded $\frac{1}{4}$ in. into the back face of the parapet, and maintains the positions of the anchor rods during the pouring of the parapet. The template plate will remain in place after the parapet forms are removed, with the connection bracket mounted on the back face of the template plate.

Figure 12 also shows required distance from posts to parapet joints.

Figure 13 shows post connection bracket details, and concrete connection details for post connection brackets.

Figure 14 shows details for Name Plates and name plate mounting locations.

7. Noise Reduction Data

A noise reduction data table shall be shown on the plans. The noise abatement wall supplier is required to meet noise reduction requirements. An example noise reduction table is found below, with instructions on how to fill in the blanks of the table.

Noise Wall Structure Number	Face	From Sta.	To Sta.	Noise Reduction Coefficient	Comments
	front face			Select Value	
	back face			Select Value	

Noise Reduction Data Table

Noise Wall Structure Number:

A noise wall structure number will be issued by the Department and shall be provided in the table. For structure-mounted noise abatement walls, the noise wall structure number is independent of the bridge structure number. The noise wall structure number will have the format CCC-N####, where CCC is the county number, N is an indicator that it is a noise abatement wall, and #### is a four-digit index.

Face:

The intent of this column is to differentiate between the two faces of the wall. Because the two faces may require different treatments, it is important to differentiate between the two such that the contractor does not install a panel in the incorrect orientation.

The terms “front face” and “back face” are used as examples for this memorandum. The designer is encouraged to use as descriptive a term as possible to clarify to the

Contractor the correct installation orientation. Examples include “interstate face,” “frontage road face,” “residential face,” or use of actual roadway names such as “I-55 face”.

From and To Stations:

The noise reduction coefficients may change over the length of the wall. The intent of these columns is to show stations where these changes occur. Additional rows may be added as necessary.

Noise Reduction Coefficient:

The Noise Reduction Coefficient is a measure of how much noise is absorbed by absorptive noise walls. There are three options for this column: Reflective, Absorptive- 0.8 min., and Absorptive- 0.65 min. Instruction is given in BDE Manual Chapter 26 and IDOT Highway Traffic Noise Assessment Manual as to the applicability of each option.

Comments:

Any additional comments may be entered into this column.

8. Soil Data

For ground-mounted noise abatement walls, approximate locations of each boring log included in the contract plans shall be shown in the plan view. Boring logs should be taken every 200 ft., or as close as feasible given issues such as terrain, utilities, right-of-way, etc. All boring logs shall be included in the contract plans. The wall designer will use the data in the boring logs to design the wall foundations. Conservative soil data assumptions are included in the Guide Bridge Special Provisions to ensure that the wall foundations may still be designed should boring logs be omitted or incomplete.

9. Name Plate Details

Name plates shall be provided for all noise abatement walls. Name plate location requirements and lettering details are provided in Figure 14.

10. Pay Items, Methods of Measurement, and Special Provisions

Anchor bolts used for the anchorage assembly for structure-mounted walls shall be paid for as NOISE ABATEMENT WALL ANCHOR ROD ASSEMBLY, with units of Each. This pay item is furnished with the parapet on which the noise abatement wall is mounted. Therefore, it shall be shown on the plans for the bridge or anchorage slab on which the wall is mounted. This pay item shall not be shown on the noise abatement wall plans. Each anchor rod assembly will consist of the four anchor rods, template plate, and associated hardware.

For ground-mounted noise abatement walls, the pay item NOISE ABATEMENT WALL, GROUND MOUNTED shall be used, with units of Sq. Ft. As specified in the special provision, this pay item includes the panels, posts, foundations, connections, and any other items associated with the wall.

For structure-mounted noise abatement walls, the pay item NOISE ABATEMENT WALL, STRUCTURE MOUNTED shall be used, with units of Sq. Ft. As specified in the special provision, this pay item includes the panels, posts, connections, debris shield, and any other items associated with the wall, with the exception of the anchor rod assemblies. This pay item shall be shown on the wall plans only. The bridge or anchorage slab plans shall not show these items. This is to avoid unintentionally doubling the quantities, and to allow for noise walls to be placed on separate contracts, independent of the contract containing the bridge or anchorage slab construction.

Name plates will be paid for at the contract unit cost per each for NAME PLATES.

Methods of measurement for these pay items are found in the applicable Guide Bridge Special Provision.

Three Guide Bridge Special Provisions (GBSP) are available online and shall be inserted into contracts as applicable. These are:

- Noise Abatement Wall, Ground Mounted (GBSP #101)
- Noise Abatement Wall, Structure Mounted (GBSP #102)
- Noise Abatement Wall Anchor Rod Assembly (GBSP #103)

Noise Abatement Wall Phase III Shop Drawing Requirements

The Phase III shop drawings submittal include the site-specific wall design calculations, details, working drawings, and fabrication shop drawings for the proposed noise abatement wall. The structural design includes required post sizes and locations, wall panel designs, baseplate designs, concrete shaft and shaft reinforcement details, steel connections, etc. The Bureau of Bridges and Structures or local agency owner will review the shop drawings submittal for structural and geotechnical adequacy, conformance with code requirements, and additional contract requirements.

Phase III shop drawings shall be sealed and signed by an Illinois Licensed Structural Engineer.

Other Wall Types

Noise abatement walls typically consist of precast reinforced concrete panels, with either steel or precast concrete posts. However, other wall types, such as acrylic and vinyl, have also been utilized by the Department for some applications. While use of these wall types is allowed, the standard details and special provisions outlined in this memorandum are not applicable. Selection of alternate noise wall types is performed during Phase I wall selection. For more information on these wall types, contact the Bureau of Bridges and Structures or the Bureau of Design and Environment.

Implementation

The policies in this memorandum shall be implemented, as soon as practical, on all applicable projects that have not been let.

CAD cells for many of the figures below will be made available on the Details-Design cell library at <https://idot.illinois.gov/Assets/uploads/files/Doing-Business/Specialty-Lists/Highways/Bridges/Cell-Libraries/Bridge/Details-Design.pdf>.

Guide Bridge Special Provisions for Noise Abatement Wall, Ground-Mounted and Noise Abatement Wall, Structure-Mounted and Noise Abatement Wall Anchor Rod Assembly will be made available on the IDOT website at <https://idot.illinois.gov/doing-business/procurements/engineering-architectural-professional-services/Consultants-Resources/guide-bridge-special-provisions>.

For more information, please contact Mark Shaffer, Bridge Design Engineer, by telephone at (217) 782-2125 or email at mark.shaffer@illinois.gov.

Attachments

ABD22.7-20221110

DESIGN SPECIFICATIONS

AASHTO LRFD Bridge Design
Specifications, ___ Edition

DESIGN STRESSES

FIELD UNITS

$f'_c = 4,000 \text{ psi}$

$f_y = 60,000 \text{ psi}$ (Reinforcement)

$f_y = 50,000 \text{ psi}$ (Struct. Steel, M270 Grade 50, posts)

$f_y = 36,000 \text{ psi}$ (Struct. Steel, M270 Grade 36, all
other structural steel)

PRECAST UNITS

$f'_c = 4,500 \text{ psi}$

$f_y = 60,000 \text{ psi}$ (Reinforcement)

$f_y = 65,000 \text{ psi}$ (Welded Wire Reinforcement)

DESIGN LOADS

Strength III or V Wind: 35 psf

Service I Wind: 15 psf

NOISE ABATEMENT WALL
SPECIFICATIONS,
STRESSES, AND LOADS

Figure 1 (ABD 22.7)

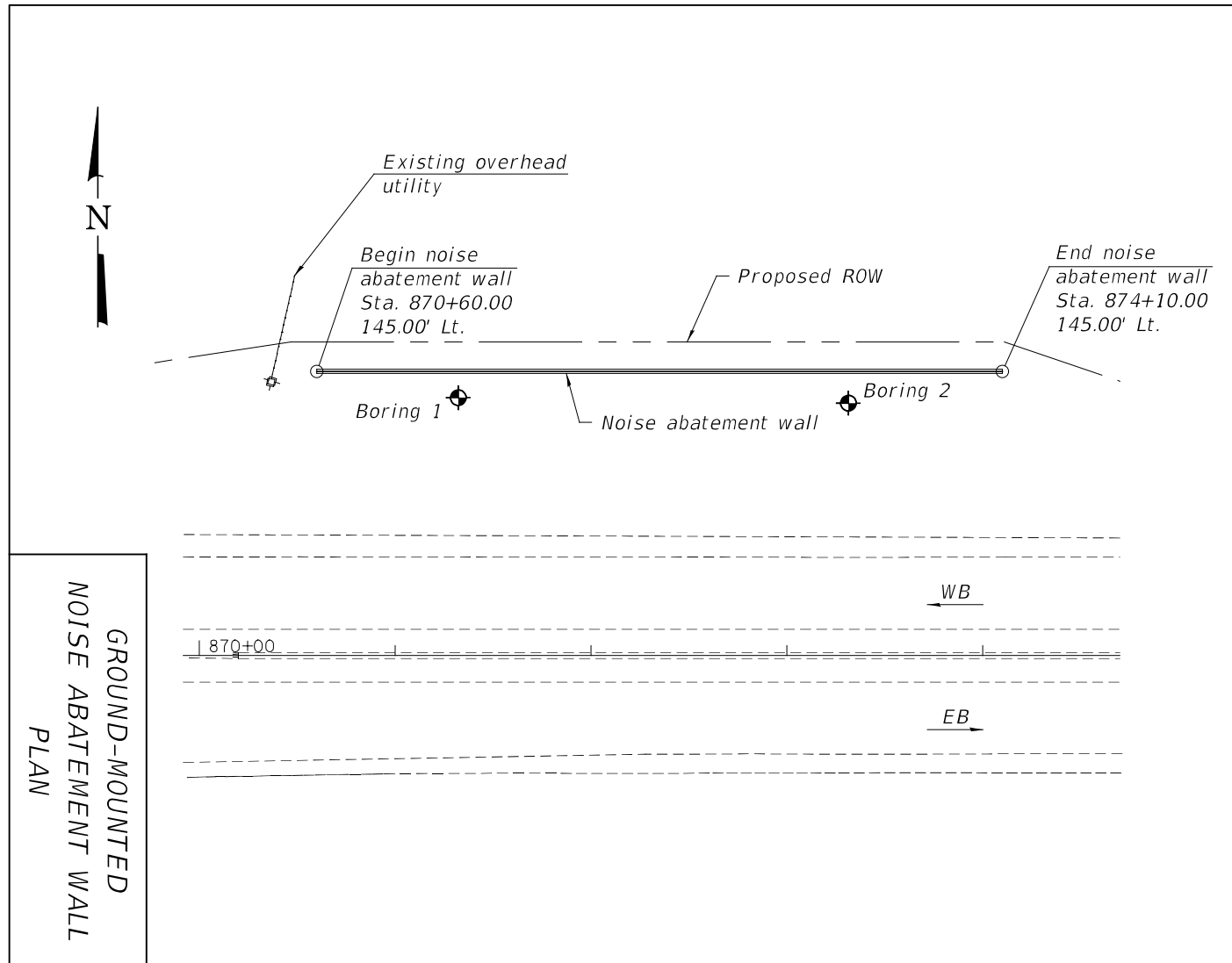


Figure 2 (ABD 22.7)

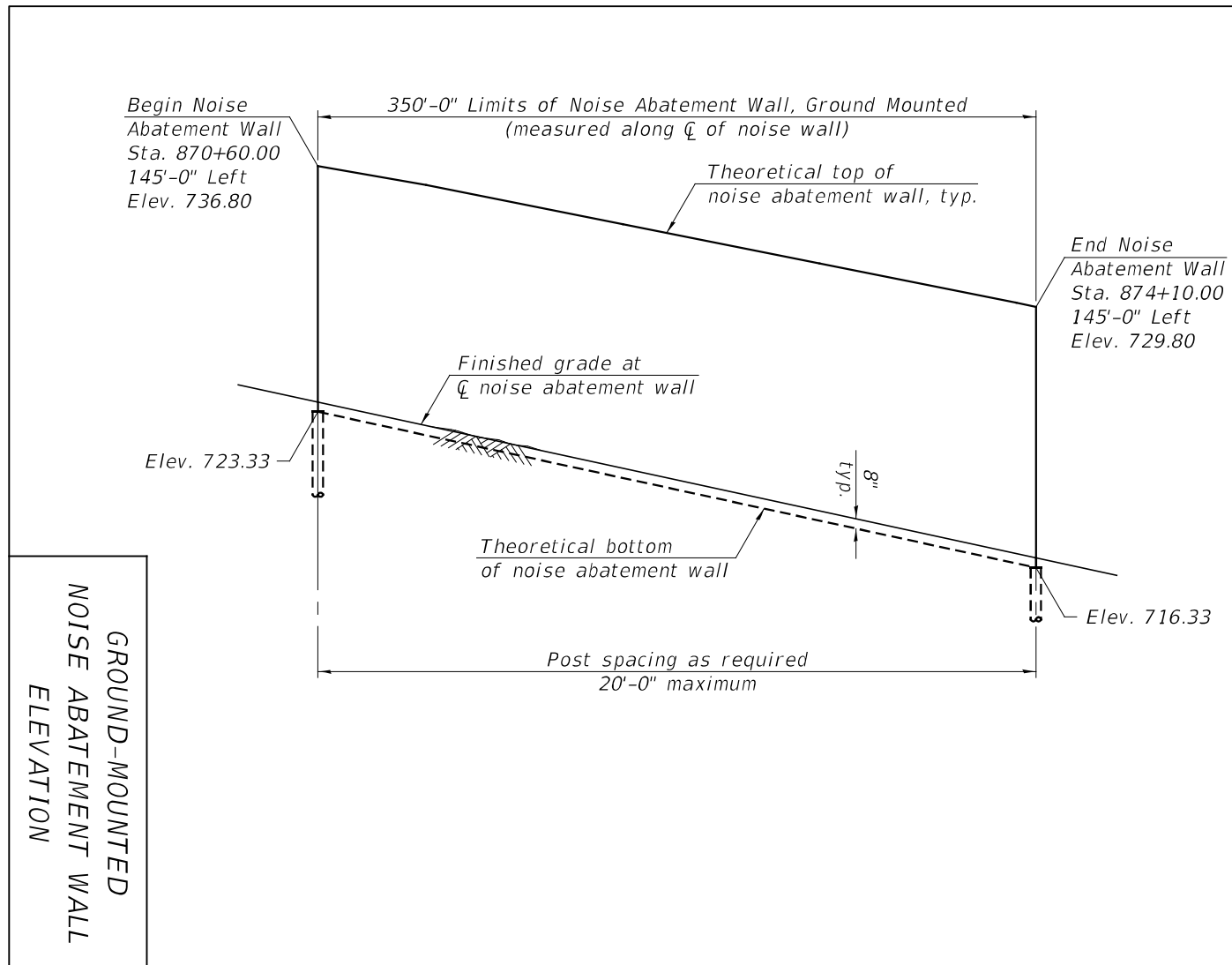


Figure 3 (ABD 22.7)

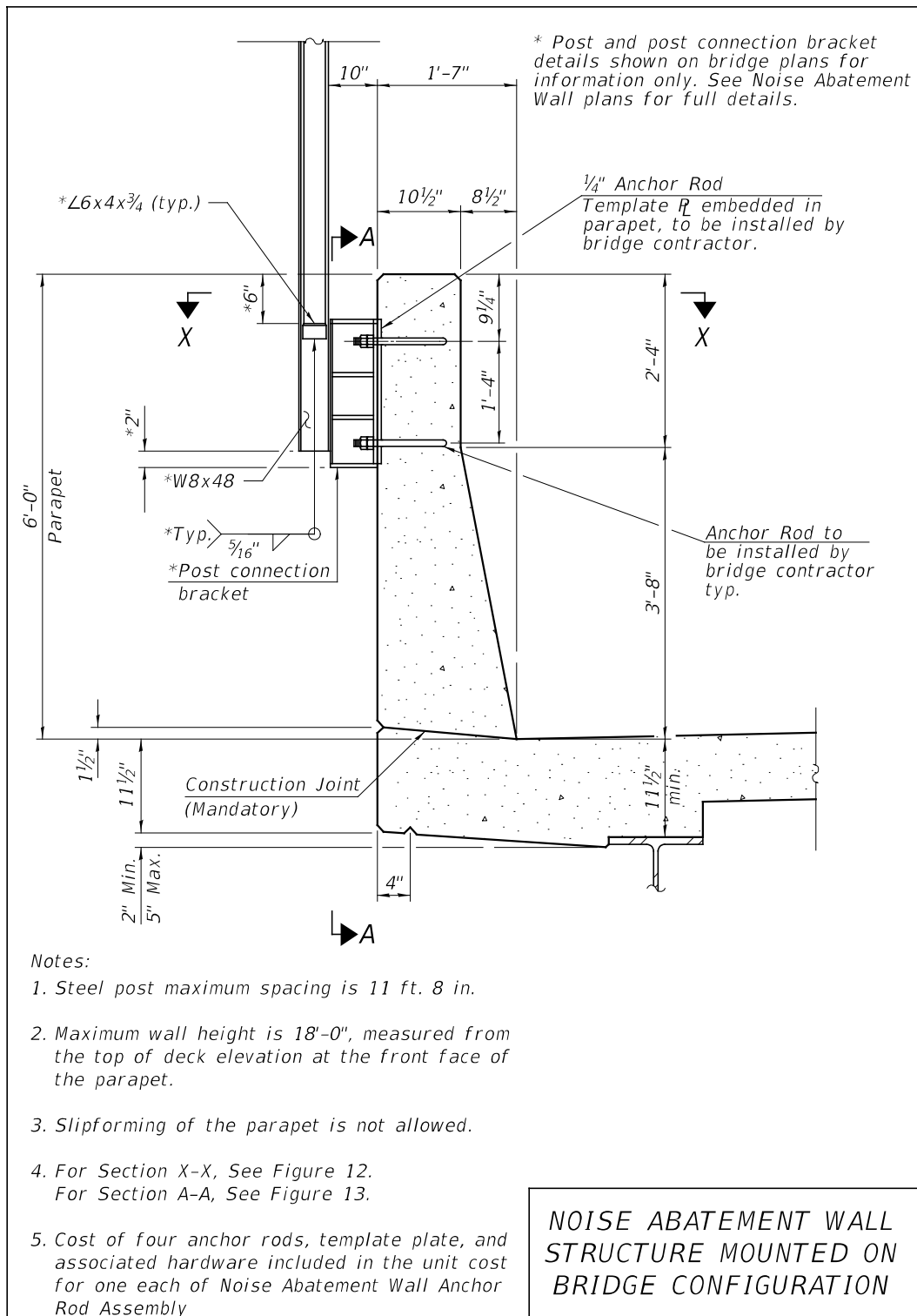


Figure 4 (ABD 22.7)

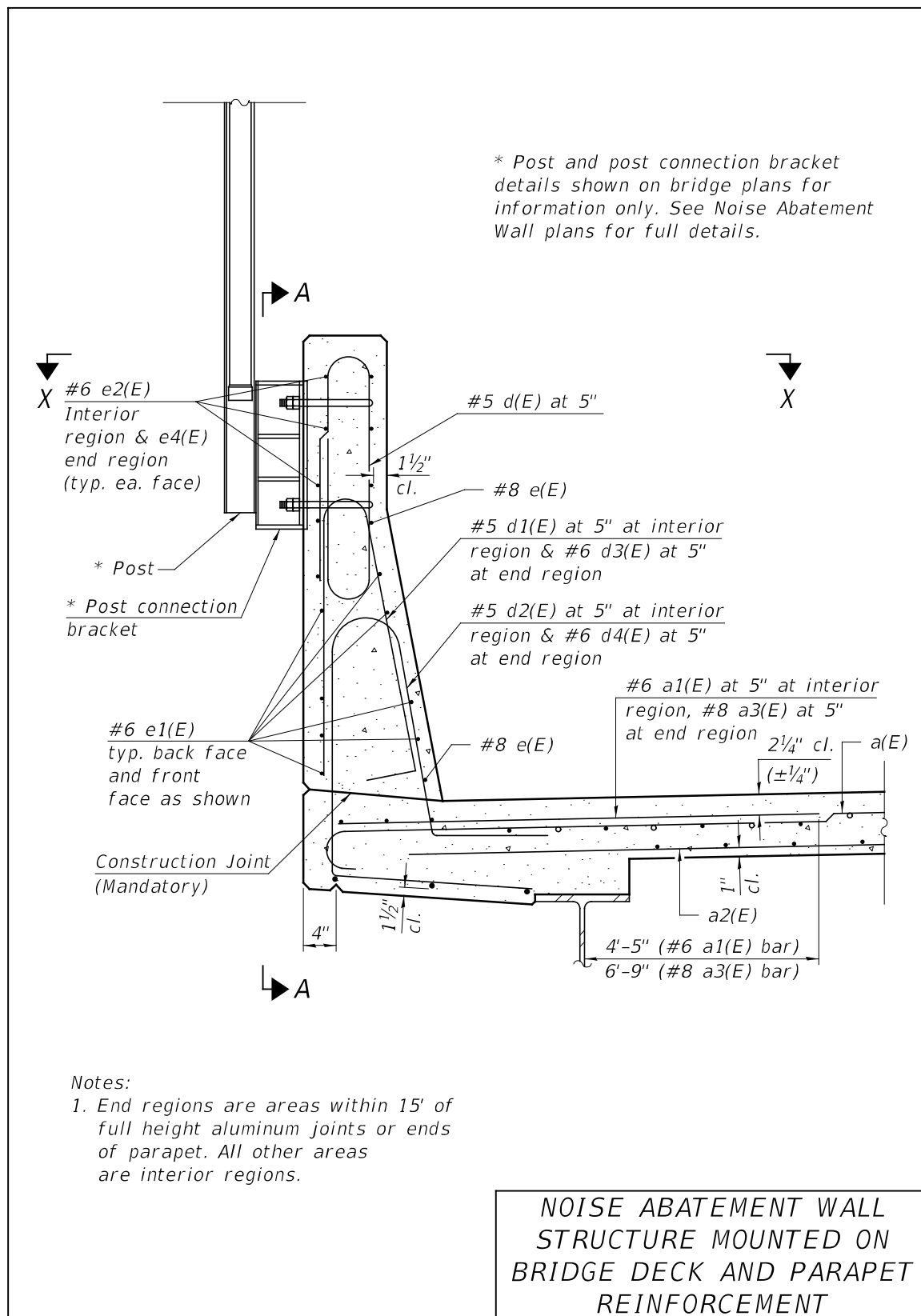
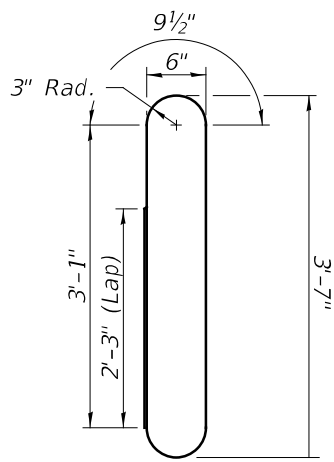
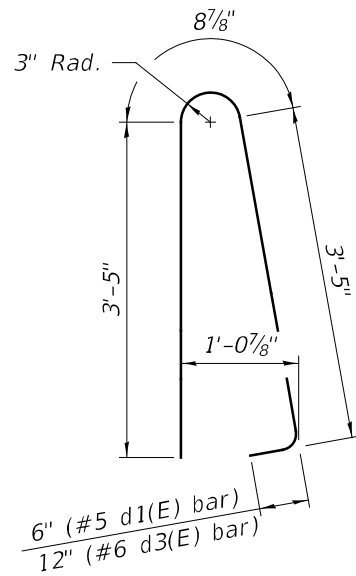


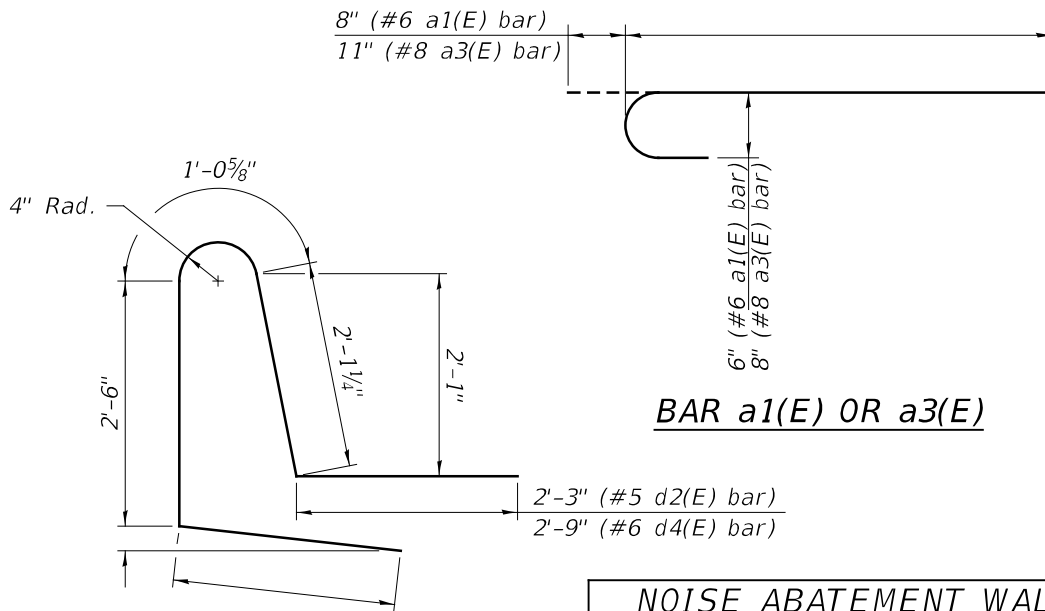
Figure 5 (ABD 22.7)



BAR d(E)



BAR d1(E) OR d3(E)



BAR d2(E) OR d4(E)

BAR a1(E) OR a3(E)

NOISE ABATEMENT WALL
STRUCTURE MOUNTED
ON BRIDGE
REINFORCEMENT DETAILS

Figure 6 (ABD 22.7)

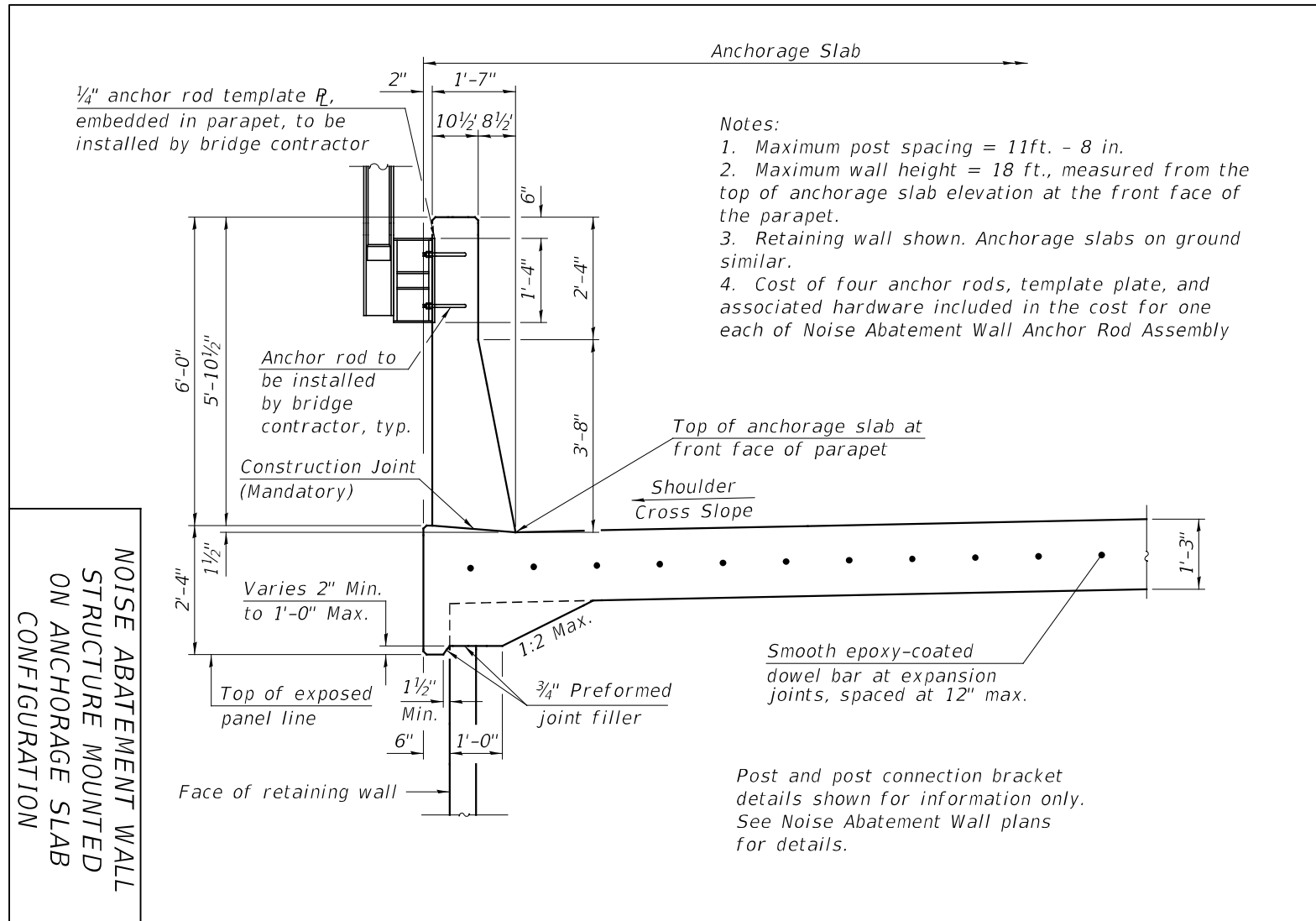


Figure 7 (ABD 22.7)

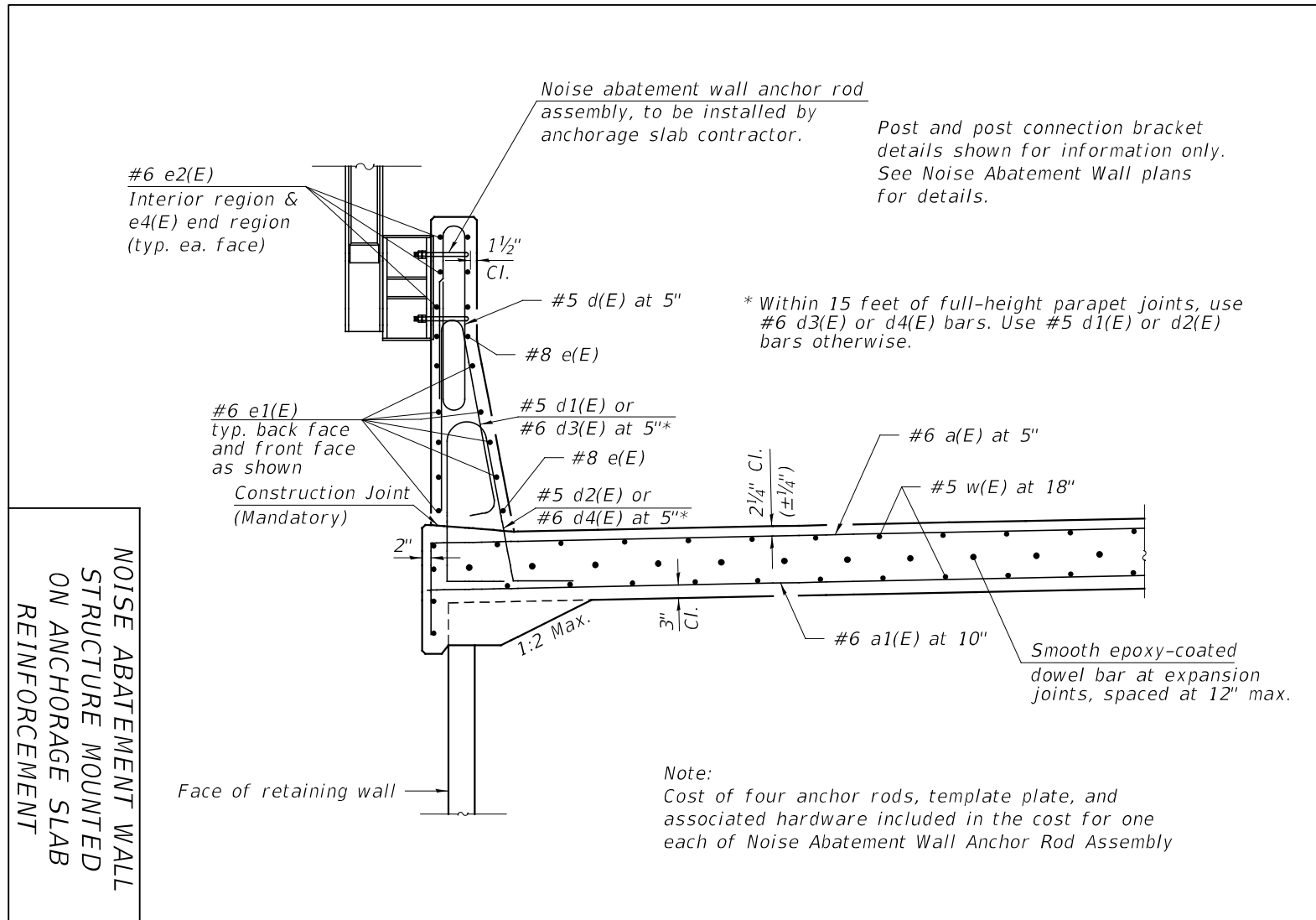
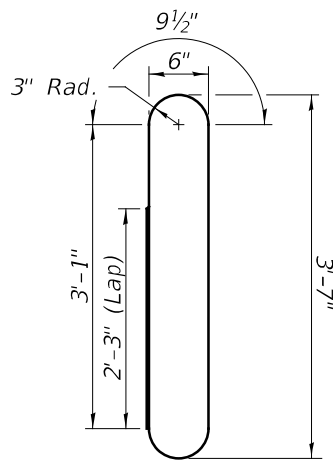
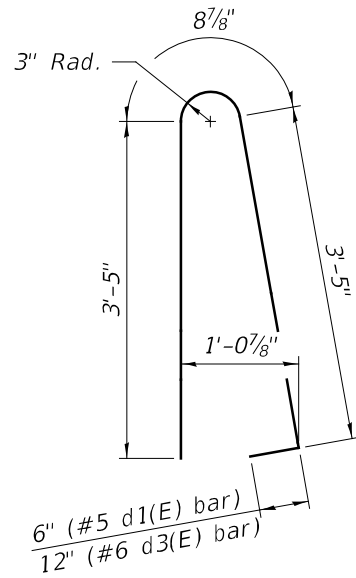


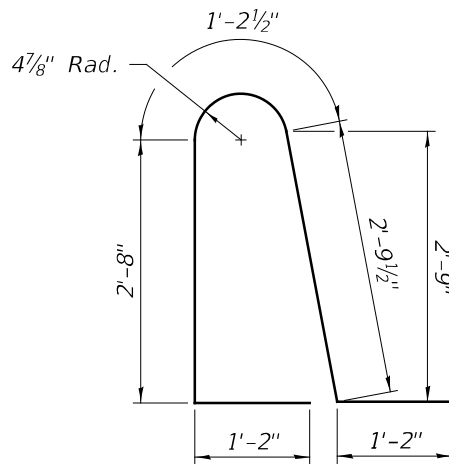
Figure 8 (ABD 22.7)



BAR d(E)



BAR d1(E) OR d3(E)

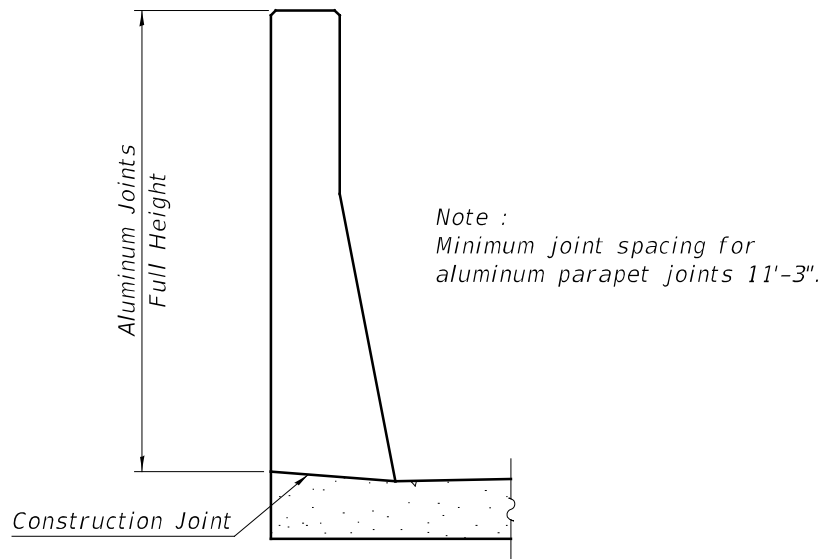


BAR d2(E) OR d4(E)

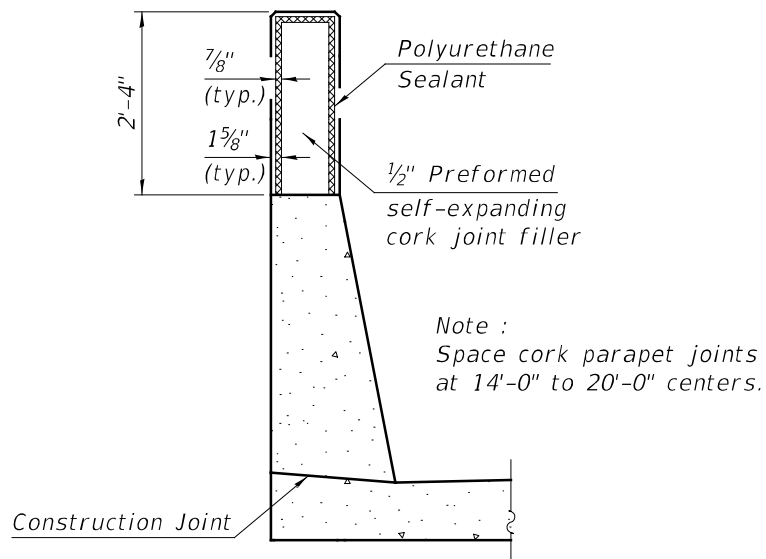
Back leg to extend 9 1/2"
into anchorage slab

NOISE ABATEMENT WALL
STRUCTURE MOUNTED
ON ANCHORAGE SLAB
REINFORCEMENT DETAILS

Figure 9 (ABD 22.7)



ALUMINUM PARAPET JOINT DETAILS



CORK PARAPET JOINT DETAILS

Notes:

1. The $\frac{1}{8}$ " aluminum sheet shall be ASTM B 209 alloy 3303-H14 and coated to minimize reaction with wet concrete. Cost included with Concrete Superstructure.
2. The polyurethane sealent shall be according to Article 1050.04 of the Std. Spec. and the color shall be gray.

NOISE ABATEMENT WALL
STRUCTURE MOUNTED
PARAPET JOINT DETAIL

Figure 10 (ABD 22.7)

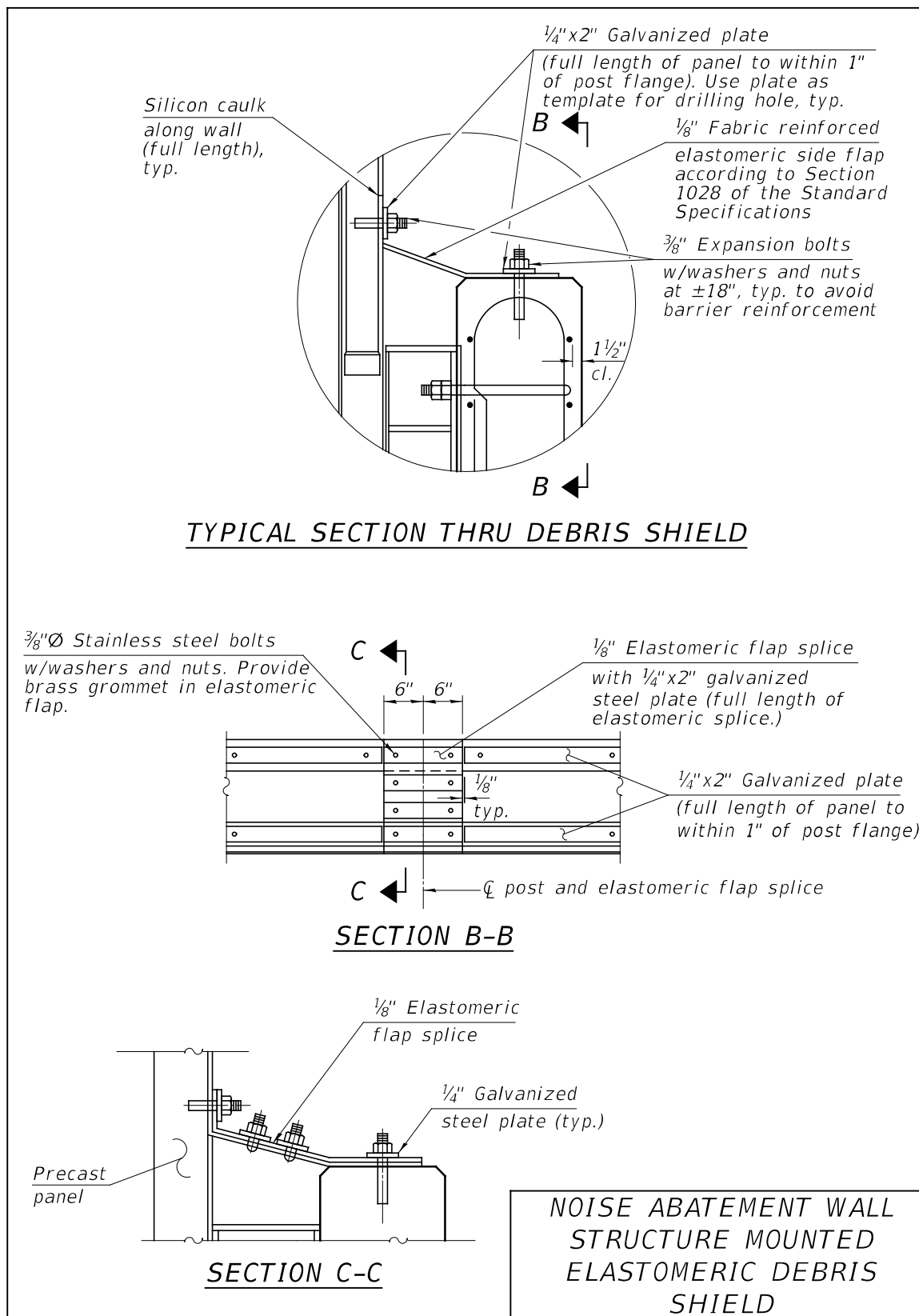


Figure 11 (ABD 22.7)

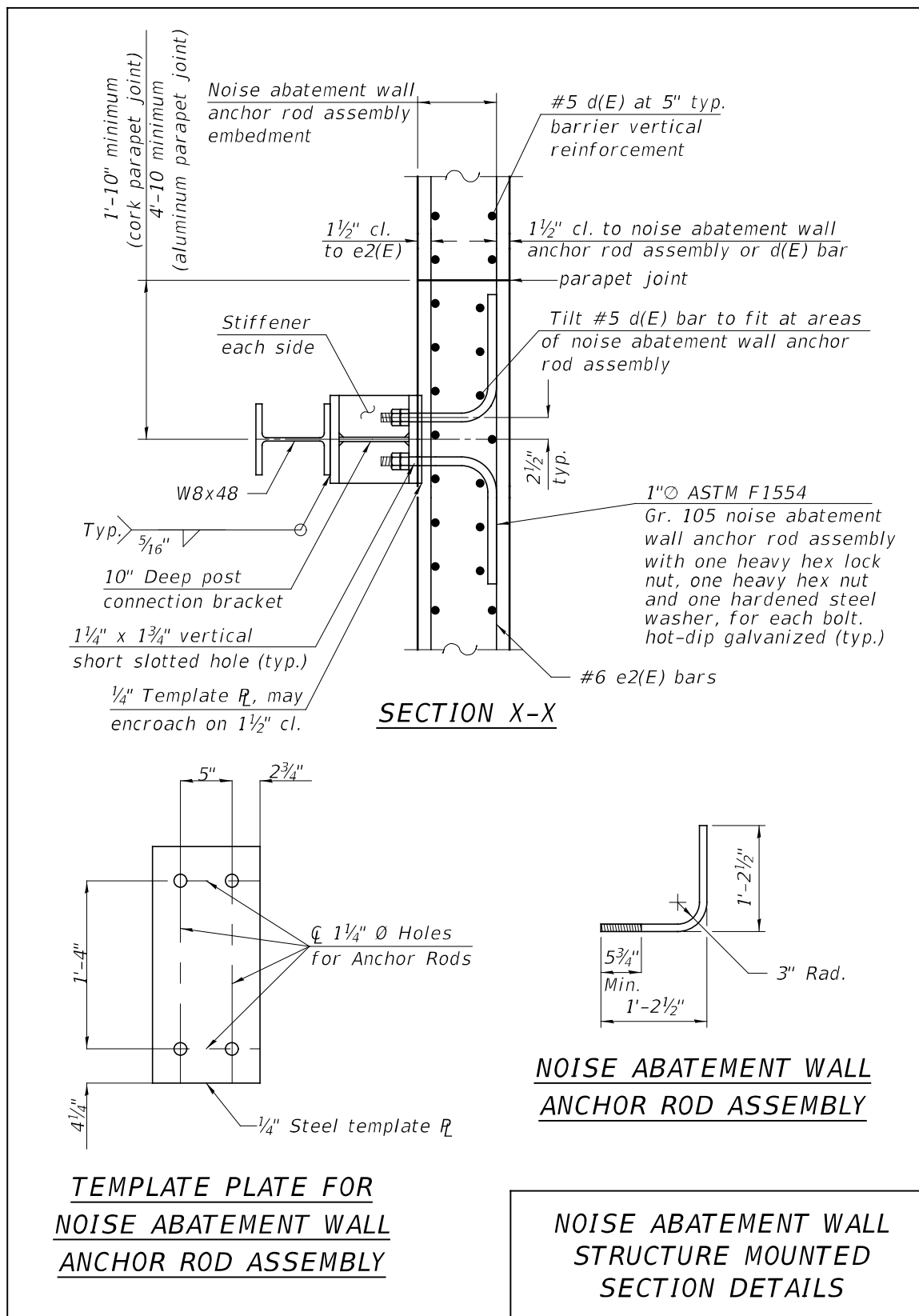
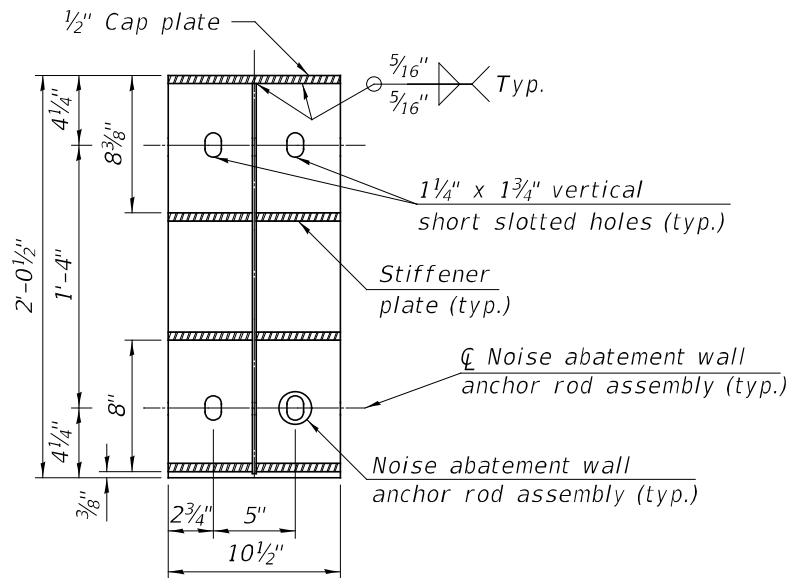
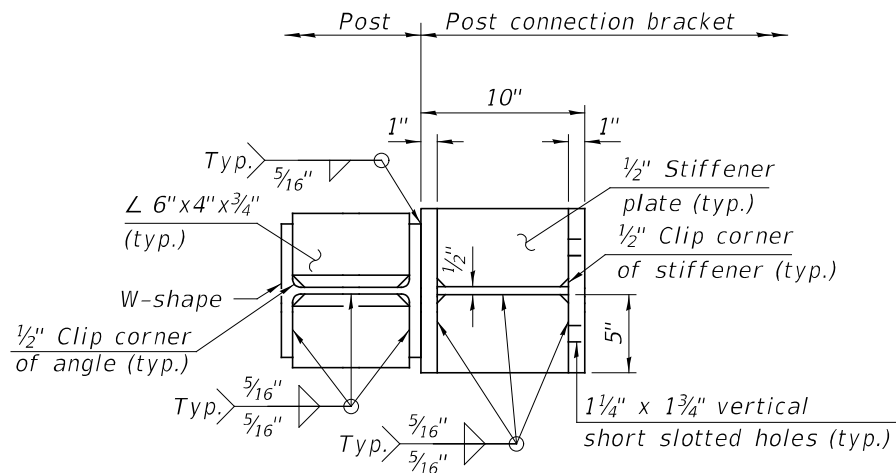


Figure 12 (ABD 22.7)



SECTION A-A

(Showing post connection bracket)



SECTION THRU POST AND POST CONNECTION BRACKET

(Template R_L not shown for clarity)

**NOISE ABATEMENT WALL
STRUCTURE MOUNTED
SECTION DETAILS**

Figure 13 (ABD 22.7)

NOISE ABATEMENT WALL
 BUILT (YEAR) BY
 STATE OF ILLINOIS
 (ROUTE NO. OR LOCAL AGENCY STREET NAME)
 (SECTION NO.)
 FROM STA. (STA. NO.) TO STA. (STA. NO.)
 STRUCTURE NO. (STR. NO.)

NAME PLATE

Items in parentheses to be added by designer.
 Refer all Name Plates to Highway Standard 515001.

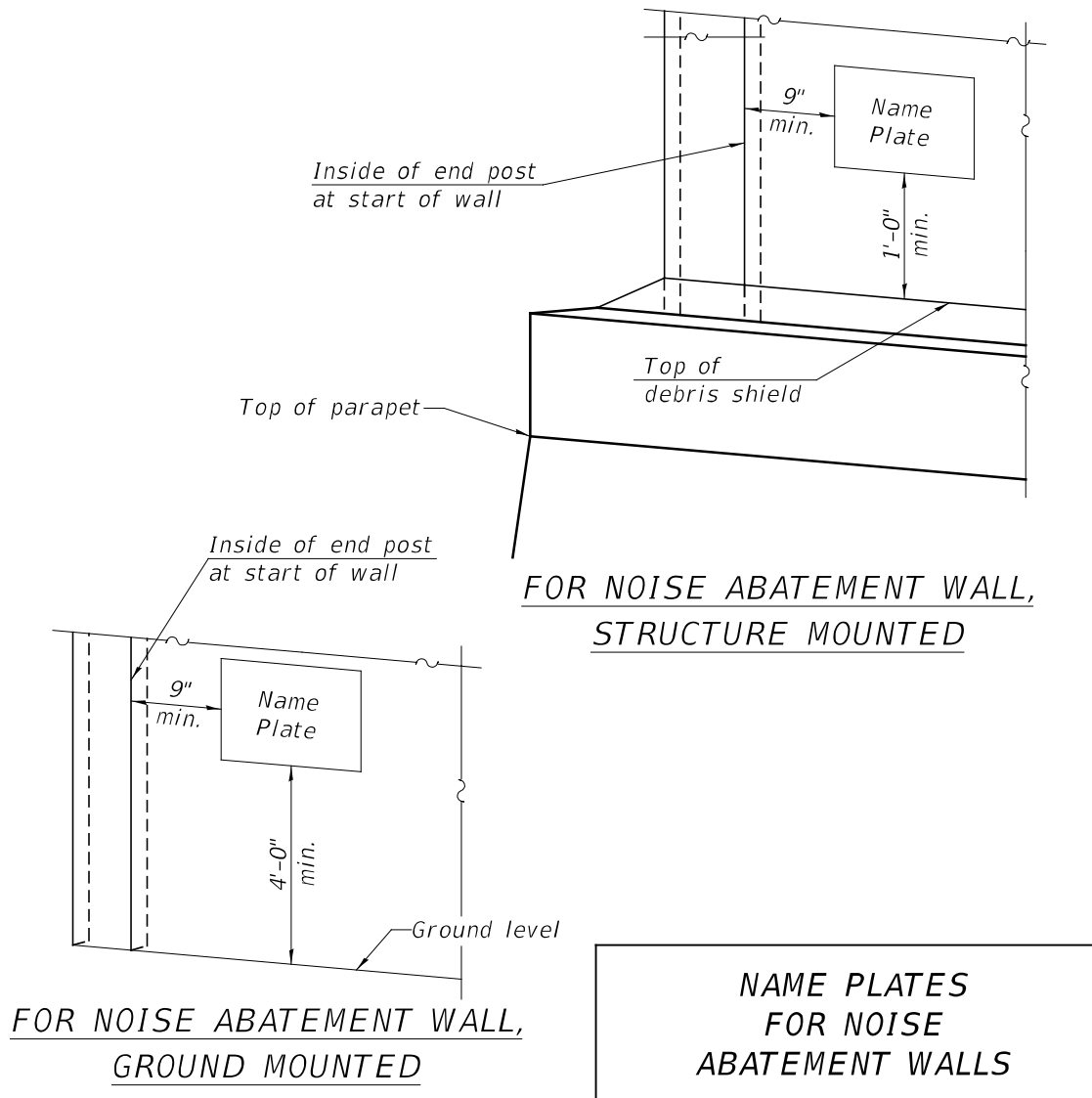


Figure 14 (ABD 22.7)